Measuring Subjective Poverty: Methodological and Application Aspects

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Abstract The aim of the research is to propose a procedure for the construction of a synthetic measure of subjective household poverty. The proposed procedure takes into account the aggregation of factors describing the past, present, and future, making it easier to discern the issue of the sense of deprivation of needs. To this end, methods based on the fuzzy set theory were used. The fuzzy TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method was applied to the construction of the synthetic measure of subjective household poverty. The procedure also uses fuzzy hierarchical analysis to calculate the weight system of variables. The proposed procedure was used to assess the level of subjective household poverty in Poland one year after the start of the COVID-19 pandemic. The research was based on data collected using the CAWI (Computer-Assisted Web Interview) method in April 2021. The use of the fuzzy approach for the assessment of subjective poverty makes it possible to define its level more precisely than with the standard measurement. The proposed synthetic measure of subjective poverty is an attempt to explain poverty from the perspective of the poor. The quantitative measurement of subjective poverty at the micro (household) level is an important tool for assessing anti-poverty policy. Moreover, the subjective poverty measure can also be used as a measure of poverty sensitivity and can be the basis for formulating policies and strategies for reducing poverty.

Keywords Subjective poverty · Synthetic measure · Fuzzy TOPSIS method · Fuzzy hierarchical analysis

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1 Introduction

Research on poverty has been conducted for more than 120 years, yet despite great interest, no unified concept of its measurement has been developed. Ever since the seminal studies by Rowntree (1901), the definition of poverty has been constantly changing. However, despite such a long history of research, there is still no uniform definition of poverty. There are a number of approaches to studying the phenomenon—objective, relative, and subjective (Kalinowski, 2015). Each of these has its advantages as well as disadvantages. Regardless of the measurement method, an individual is classified as poor if they lack sufficient resources to meet their needs. As Shaw (1996) points out, the complexity of the problem of poverty is due to its multifaceted nature and the overlapping of a number of behavioural, social and economic factors, which are reinforced by the actions of state institutions. The importance of the actions taken by public institutions is also stressed by Darby (1996), pointing to the instrumentality of the authorities' response.

Although there are a number of causes of poverty, those considered most important are character flaws, restricted opportunities, and "Big Brother" (Schiller, 1972). Bradshaw (2007) suggests that it is the effect of individual deficiencies, geographical disparities, and cumulative and circumstantial origins. However, Brady (2009) and Royce (2015) point out that it is not the result of individual inability, but rather structurally determined. Some researchers, however, point out that it is not social structures or systems but the deprivations of the poor that contribute to poverty (e.g. Spencer, 1851; Lewis, 1969). Despite the many factors involved in recent instances of poverty, COVID-19 appears to be the most significant. The coronavirus has become a critical factor in shaping the situation of households as well as entire economies (Gupta et al. 2021; Kalinowski and Łuczak, 2021a). Rowntree's (1901) dynamic theory of poverty presents it as a multidimensional, changing phenomenon. This approach is extremely useful because it captures people's experience of how and why their situation changes (Smith, Middleton, 2007; McBride, Smith, 2021), which, when overlaid with other past and present problems, and predicted future changes, can influence the assessment of the current situation.

The essence of poverty is inequality, expressed in both income and consumption expenditure. However, this inequality can also be reflected in the level, structure, and perception of needs. In this context, the objective dimension of poverty can be far removed from the subjective one. It is not difficult to imagine that despite a relatively high income an individual may feel a deprivation of needs, and conversely, some people may not feel deprived despite a relatively low income. Such a statement is nothing new—Zapf (1984) noted that there is a discrepancy between feelings and the actual economic situation.

With our research, we wanted to draw attention to the discrepancy between the objective and subjective dimensions of poverty. According to our approach, poor people do not necessarily feel deprived of needs, and vice versa. While stressing that both dimensions of poverty are equally important, we want to emphasise that knowledge about subjective poverty allows us to identify the areas that contribute to

the feeling of poverty. It allows us to pay attention to the nature of deprivation and all its dimensions. Like Pouw (2020), we wanted to use the subjective approach to highlight the importance of maximising individual well-being.

We assumed that subjective poverty is a consequence of the emphasis on relative need deprivation discussed by Townsend (1979, 1985) and Runciman (1966). Following Townsend, we assumed that poverty is the inability to fulfil the standards set by a given society. Although Townsend's definition refers to a relative dimension, as a simple consequence it is reflected in the subjective expectations of individuals, especially given their aspirations.

Using Deleeck's questions (Deleeck, Van Den Bosch, 1989; Ghiatis, 1989), related to the assessment of the possibility of "making ends meet", we wanted to indicate that poverty itself is a category of consciousness. We assumed that it is a conscious feeling of insufficient resources to meet one's needs in relation to one's socioeconomic status (income and current financial situation, level of education and occupation, place of residence, lifestyle and leisure activities) and one's aspirations to achieve and maintain a desired standard of living. The validity of this approach can be demonstrated by the words of Mollie Orshansky, who wrote as early as 1969 that "poverty, like beauty, lies in the eye of the beholder" (Orshansky, 1969). Indeed, our research was conducted in this context.

For these reasons, the aim of the research is to propose a procedure for the construction of a synthetic measure of subjective household poverty. Our proposed approach goes far beyond the existing proposals, describing the subjective assessment of household poverty as a multidimensional self-assessment of households using multiple criteria decision-making (MCDM) methods. The proposed approach is based on the households' feelings about their own poverty in the past, present and future. Our procedure was used to assess the level of subjective household poverty in Poland. The research was based on primary data collected using the computer-assisted web interview (CAWI) method in April 2021.

The paper is structured as follows. Sect. 2 presents the procedure of construction for the subjective household poverty index. An application to a real dataset is provided in Sect. 3. Some results and remarks on the proposed approach are given in Sect. 4.

2 Construction Procedure for the Subjective Household Poverty Index

We propose a procedure for the subjective assessment of household poverty as a multidimensional self-assessment by respondents using fuzzy multiple criteria decision-making methods. Our paper using the general idea of a construction of synthetic measure introduced by Hellwig (1968, 1972), and developed by Hwang and Yoon (1981). The proposed approach is based on the fuzzy TOPSIS method, which was developed by Chen (2000). The process of constructing a subjective

poverty household index (synthetic measure) is a multi-stage one and includes the following steps:

- Step 1: Selection of variables describing subjective poverty
- Step 2: Determination of the nature of the variables in relation to subjective poverty
- Step 3: Transformation of ordinal categories of variables into triangular fuzzy numbers
- Step 4: Development of a system of variable weights
- Step 5: Normalisation of the variable values
- Step 6: Calculation of the positive and negative ideal solutions and distances of each object from them
- Step 7: Calculation of a subjective household poverty index
- Step 8: Identification of types of subjective household poverty.

One of the most important steps is the selection of variables (step 1). These describe subjective poverty based on respondents' feelings about the past, present and future. On the one hand, households' perceptions of their own poverty may influence their future self-assessment, even after objective poverty has decreased. On the other hand, earlier experience of poverty may also cause the household to feel better than it actually is, and vice versa (Ravallion and Lokshin 2002). It should be added that the assessment of the household's condition is also influenced by the actual poverty dynamics (Alem et al. 2014).

In step 2, variables are divided into stimulants, destimulants, and nominants. A stimulant is a benefit variable that increases the level of subjective poverty, while a destimulant is a cost variable that decreases that level. A nominant is a special variable type that is stimulant in one variable range and a destimulant in another. Variables defined as destimulants should then be converted into stimulants.

Then, in step 3, the categories of ordinal variables are transformed into triangular fuzzy numbers:

$$\tilde{x}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right), \tag{1}$$

where $\tilde{x}_{ij}$—the fuzzy value of the j-th variable in the i-th household, $i = 1,\ldots, N$; N—the number of households; $j = 1,\ldots, K$, K—the number of variables.

Table 1 presents the formulas for determining the parameters of the triangular fuzzy numbers. The parameters of the triangular fuzzy numbers can be scaled by a selected constant value, freely determined by the researcher. The triangular fuzzy numbers can be summarised in matrix $\widetilde{\mathbf{X}} = \left[\tilde{x}_{ij}\right]$.

One of the most common ways to set a weight system is to treat all indicators equally (Aaberge and Brandolini 2015). However, not all variables are equally important in this process. Their importance can be determined by assigning weights to them (step 4). There are three ways to create weights: statistical, content, or integrated. The weights are determined by an expert method or by using computational algorithms based on the information contained in the data. A method based on both of these approaches combined can also be used (Walesiak 2011). The statistical approach uses

Table 1 Formulas for the parameters of triangular fuzzy numbers

Categories	Parameters of a triangular fuzzy number		
	a_{ij}	b_{ij}	c_{ij}
1	0	0	$\frac{1}{2(m-1)}$
2	$\frac{1}{2(m-1)}$	$\frac{1}{(m-1)}$	$\frac{1}{(m-1)} + \frac{1}{2(m-1)}$
…	…	…	…
m-1	$1 - \frac{3}{2(m-1)}$	$1 - \frac{1}{(m-1)}$	$1 - \frac{1}{2(m-1)}$
m	$1 - \frac{1}{2(m-1)}$	1	1

information of variables only from the data matrix. These methods are based on the analysis of the variability of variables and the analysis of the correlation between the variables or only one of these analyses. The main disadvantage of this approach is the statistical mechanical calculation of weight. It should be noted that a variable with a high coefficient of variation does not have to be important in the substantive sense. The substantive approach is an alternative to the statistical approach to determining the system of weights. This approach can use expert assessments of the importance of the variables. In this paper we propose to calculate the expert system of weights:

$$\tilde{w}_j = \left(a_j^{(w)}, b_j^{(w)}, c_j^{(w)}\right), j = 1, \ldots, K \tag{2}$$

using fuzzy hierarchical analysis (FHA) (see Csutora and Buckley 2001; Buckley et al. 2001).

Then, the values of the variables should be normalised (step 4), as follows

for a stimulant:

$$\tilde{z}_{ij} = \left(a_{ij}^{(z)}, b_{ij}^{(z)}, c_{ij}^{(z)}\right) = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right) \tag{3}$$

where $\tilde{z}_{ij}$—the fuzzy value of the *j*-th normalised variable in the *i*-th household, $i = 1,\ldots, N$; $j \in P_s$, P_s—a set of stimulant indexes, $c_j^+ = \max_i(c_{ij})$, $c_j^+ \neq 0$,

for a destimulant:

$$\tilde{z}_{ij} = \left(a_{ij}^{(z)}, b_{ij}^{(z)}, c_{ij}^{(z)}\right) = \begin{cases} \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \text{for } a_{ij}, b_{ij}, c_{ij} \neq 0 \\ (0, 0, 0) \text{for } a_{ij}, b_{ij} = 0, c_{ij} \neq 0 \end{cases} \tag{4}$$

where $\tilde{z}_{ij}$—the fuzzy value of the *j*-th normalised variable in the *i*-th household, $i = 1,\ldots, N$; $j \in P_D$, P_D—a set of destimulant indexes, $a_j^- = \min_i(a_{ij})$.

Normalised values of variables are summarised in matrix $\tilde{\mathbf{Z}} = \left[\tilde{z}_{ij}\right]$ and multiplied by the weights and form the matrix $\tilde{\mathbf{R}} = \left[\tilde{r}_{ij}\right] = \left[\tilde{z}_{ij} \otimes \tilde{w}_j\right] = \left(a_{ij}^{(z)}, b_{ij}^{(z)}, c_{ij}^{(z)}\right) \otimes$

$\left(a_j^{(w)}, b_j^{(w)}, c_j^{(w)}\right)=\left(a_{ij}^{(z)} a_j^{(w)}, b_{ij}^{(z)} b_j^{(w)}, c_{ij}^{(z)} c_j^{(w)}\right) = \left(a_{ij}^{(r)}, b_{ij}^{(r)}, c_{ij}^{(r)}\right)$, $\otimes$—denotes the operation of multiplication on fuzzy numbers.

In step 6, the positive ideal solution (PIS) and negative ideal solution (NIS) are calculated:

$$\text{PIS} : \tilde{A}^{+} = \left(\max_i(\tilde{r}_{i1}), \max_i(\tilde{r}_{i2}), \ldots, \max_i(\tilde{r}_{iK})\right) = \left(\tilde{r}_1^{+}, \tilde{r}_2^{+}, \ldots, \tilde{r}_K^{+}\right) \quad (5)$$

$$\text{NIS} : \tilde{A}^{-} = \left(\min_i(\tilde{r}_{i1}), \min_i(\tilde{r}_{i2}), \ldots, \min_i(\tilde{r}_{iK})\right) = \left(\tilde{r}_1^{-}, \tilde{r}_2^{-}, \ldots, \tilde{r}_K^{-}\right) \quad (6)$$

where $\tilde{r}_j^{+} = \left(a_j^{(r)+}, b_j^{(r)+}, c_j^{(r)+}\right)$, $\tilde{r}_j^{-} = \left(a_j^{(r)-}, b_j^{(r)-}, c_j^{(r)-}\right)$, $j = 1, \ldots, K$.

The positive ideal and negative ideal solutions are the basis for calculating the distance between them and the fuzzy values of normalised variables for the households assessed, as follows (Chen 2000):

$$d_i^{+} = \sum_{j=1}^{K} \sqrt{\frac{1}{3}\left[\left(a_{ij}^{(r)} - a_j^{(r)+}\right)^2 + \left(b_{ij}^{(r)} - b_j^{(r)+}\right)^2 + \left(c_{ij}^{(r)} - c_j^{(r)+}\right)^2\right]} \quad (7)$$

$$d_i^{-} = \sum_{j=1}^{K} \sqrt{\frac{1}{3}\left[\left(a_{ij}^{(r)} - a_j^{(r)-}\right)^2 + \left(b_{ij}^{(r)} - b_j^{(r)-}\right)^2 + \left(c_{ij}^{(r)} - c_j^{(r)-}\right)^2\right]} \quad (8)$$

Then, in step 7, subjective household poverty index is calculated using the formula (Hwang and Yoon 1981):

$$S_i = \frac{d_i^{-}}{d_i^{+} + d_i^{-}} \quad (9)$$

The higher the value S_i, the higher is the level of subjective household poverty. Values of the subjective household poverty index are normalised to the range from 0 to 1, where S_i equals 0 for an anti-pattern household and 1 for a pattern household.

Finally, types of subjective household poverty are identified (step 8). The values of the index were averaged within the criteria examined—class of locality of a household: for the country, village and city, as well as divided into: small town up to 20,000 residents, urban area with 20,000–99,000 residents, urban area with 100,000–499,000 residents, urban area with 500,000 or more residents.

The types of the subjective poverty level can be distinguished in an arbitrary manner, e.g. by adopting numerical ranges of the value of the measure S_i(Table 2). Based on the levels of the synthetic measure, theoretical types of poverty were also proposed—poverty profiles (Table 2). The state of poverty or deprivation is not dichotomous, and households cannot be classified as poor or non-poor. There are many shades of being poor, ranging from no poverty to extreme poverty. Hence,

Table 2 Values of the subjective poverty index and theoretical types of poverty

S_i	Level	Types of household poverty
[0.00; 0.10)	Extreme low	No poverty
[0.10; 0.20)	Very low	Very mild poverty
[0.20; 0.40)	Low	Poverty risk
[0.40; 0.60)	Medium	Moderate poverty
[0.60; 0.80)	High	Strongly advancing poverty
[0.80; 0.90)	Very high	Severe poverty
[0.90; 1.00]	Extreme high	Ultra poverty

households may be characterised by a different degree of poverty (cf. Betti et al., 2008; Montrone et al. 2010).

3 Results of the Empirical Research

The analyses used data from primary household surveys in Poland (Kalinowski and Łuczak 2021b). The research was carried out using the CAWI (Computer-Assisted Web Interview) method. The research sample consists of 1,499 households. Imputation of data values was designed to handle the problem of missing data. Moreover, post-stratification according to the main criteria of population (sex, class of locality of a household, level of education of a respondent) was used in order to preserve population structures.

In step 1, variables describing the subjective situation of households were selected: *feelings of the present situation*: life satisfaction (x_1), degree of current fulfilment of own household needs through own income (x_2), assessment of own household income compared to other households (x_3), assessment of the change in the satisfaction of food needs over a year compared to previous years (x_4), assessment of the situation of one's own household, whether it can make ends meet with the current income (x_5), *feelings of the future situation*: assessment that one's own household situation may worsen in the near future (x_6), degree of possible loss of income (x_7), degree of possible loss of financial stability (x_8), degree of possibility of losing job (x_9), assessment of the possibility of a change in the financial situation of one's own household in the next 12 months (x_{10}), *feelings of past situations*: degree of satisfaction of the needs of one's own household by income a year ago (x_{11}), feelings of being poor in the past (x_{12}).

Variables x_1, x_3, x_4, x_6—x_{10}, x_{12} were measured on a five-point scale, x_2 and x_{11}—on an eight-point scale (prosperity ladder), x_5 (Deleeck's question)—a three-point scale. We assumed that all variables are stimulants (step 2). In the primary research, variables are usually selected in such a way as to positively correlate with this phenomenon. In our research, the higher the partial assessment, the higher was the level of subjective poverty. The ordinal categories of variables were transformed

Table 3 Examples of categories of ordinal variables and fuzzy triangular numbers

Categories of variable		Level of variable	Fuzzy triangular number		
Life satisfaction	Degree of possibility of losing job		*a*	*b*	*c*
Definitely yes	Definitely not	1	0.000	0.000	0.125
Yes	No	2	0.125	0.250	0.375
Maybe	Maybe	3	0.375	0.500	0.625
No	Yes	4	0.625	0.750	0.875
Definitely not	Definitely yes	5	0.875	1.000	1.000

into triangular fuzzy numbers (step 3). Examples of the categories of ordinal variables and the corresponding triangular fuzzy numbers are presented in Table 3.

In step 4 a system of weights for variables was developed using fuzzy hierarchical analysis (Table 4). Next, the variables were normalised using the formula (3) and multiplied by the weights (step 5). The normalised values of the variables made it possible to determine the distances of each surveyed household from the PIS and NIS (step 6) by applying Eqs. 7−8. The PIS values were established assuming maximum values of variables, while those of NIS was based on the minimum values of their variables (Eqs. 5−6). Next, in step 7, the values of the subjective household index were calculated using Eq. 9 and averaged according to criteria (Figs. 1, 2 and 3). Types of subjective household poverty were identified in an arbitrary manner on the basis of the index values (step 8).

Research has shown that in 2020, during the COVID-19 pandemic, the level of perception of poverty in households in Poland was close to the upper limit of the low level (0.398) (Fig. 1). The feelings in the group of females surveyed were slightly worse (0.409) than those of the males (0.386). However, there are clear differences between the village and the city, with, the value of subjective poverty being medium (0.459) in villages and low (0.355) in urban areas.

However, it should be noted that in urban areas there was quite a large variation in the value of the synthetic index (from 0.288 for urban area with 500,000 and more residents to 0.473 for small town up to 20,000 residents) (Fig. 2). It is worth noting that one year after the start of the pandemic households in small towns of up

Table 4 Fuzzy triangular weights of variables

Variables	Fuzzy weights	Variables	Fuzzy weights
x_1	(0.020, 0.037, 0.056)	x_7	(0.005, 0.009, 0.012)
x_2	(0.121, 0.245, 0.249)	x_8	(0.013, 0.034, 0.043)
x_3	(0.027, 0.058, 0.077)	x_9	(0.007, 0.014, 0.020)
x_4	(0.105, 0.231, 0.240)	x_{10}	(0.006, 0.013, 0.019)
x_5	(0.053, 0.113, 0.151)	x_{11}	(0.111, 0.150, 0.189)
x_6	(0.014, 0.047, 0.055)	x_{12}	(0.049, 0.050, 0.084)

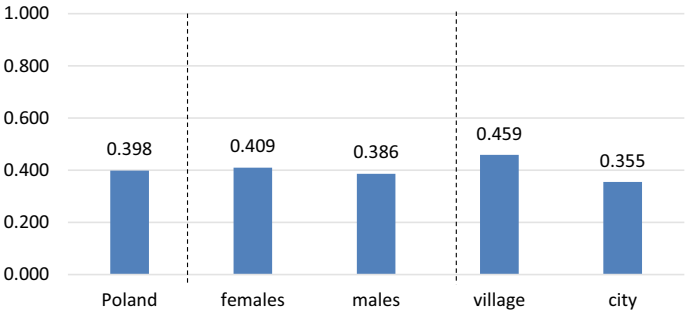


Fig. 1 Values of the subjective household index in Poland and by sex and type of area

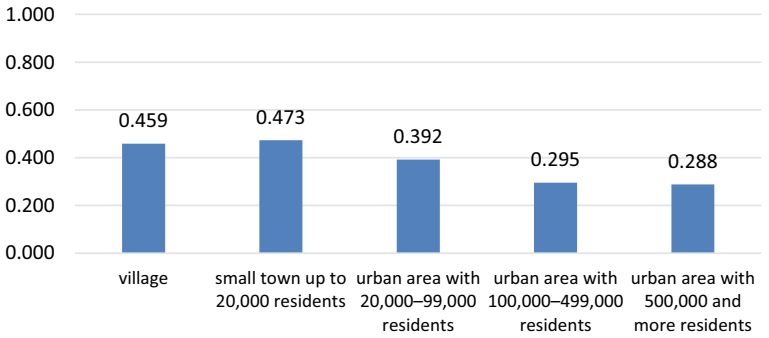
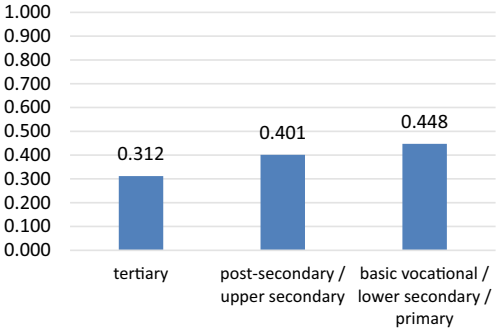


Fig. 2 Values of the subjective household index by class of locality of a household

Fig. 3 Values of the subjective household index by level of education of a respondent



to 20,000 residents had the worst situation among towns and cities. The greater the number of residents in a city, the lower was the level of subjective poverty. Moreover, the situation in small towns was worse than in villages. It can be stated that only households in rural areas and small towns were affected by moderate poverty during

the pandemic. Households in urban areas with 20,000 or more residents were at risk of poverty. The smaller the number of residents, the greater was the risk of poverty.

It is also worth noting that the level of education has a significant impact on the level of subjective poverty (Fig. 3). The higher the level of education of the respondents, the more does the level of poverty perception decrease. Group of respondents with a basic vocational education or lower was most concerned with fears about the future related to the deterioration of their household's situation and possible loss of income. The x_6 and x_7 medians equalled 4, meaning that these respondents felt high levels of apprehension and anxiety about the future situation of their households.

4 Summary

The methodological proposal shows new possibilities for research into multidimensional subjective poverty. The subjective poverty index is an attempt to explain poverty from the perspective of the poor. Households experience and feel poverty to different degrees. It is worth noting that most methods of measuring self-assessment of poverty in households only divide the respondents into poor or non-poor. The advantage of our proposal is that it determines the degree of poverty of the households surveyed. The subjective poverty index takes account of perceptions of feelings in various aspects regarding the current situation of the household, but also their past situation and predictions for the future.

Our research showed the importance of the economic stratification of the population among classes of locality, as well as levels of education. The smaller the number of residents in a city, and also the lower the level of education of the respondents, the higher was the level of subjective poverty. Moreover, villages had a similar situation to the small towns. Their poverty level can be described as medium. In big cities with 100,000 or more residents, the subjective poverty level was low.

The quantitative measurement of subjective poverty at household level is an important tool for assessing anti-poverty policy. In addition, the subjective poverty index can also be used as a measure of poverty sensitivity and can be the basis for formulating anti-poverty strategies.

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