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APPLICATION OF GENERALIZED DISTANCE MEASURE TO THE CONSTRUCTION OF A SYNTHETIC INDEX OF SUBJECTIVE SENSE OF FINANCIAL SECURITY OF FARMERS' HOUSEHOLDS

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Abstract: The article aimed to construct a synthetic evaluation of the subjective sense of financial security among the Polish farmers' households in 2015. The research drew on microdata from Household Budget Survey conducted by the Central Statistical Office in 2015. Due to the ordinal character of simple features the construction employed Generalized Distance Measure (GDM) with TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method. Calculations were performed by clusterSim package of the R program.

Keywords: generalized distance measure GDM, TOPSIS method, financial security, farmers' households

INTRODUCTION

The procedure by which a synthetic feature is constructed follows a number of steps with decisions to be made at each of them on selection of simple features, a weighting system, normalization, but also on a measure of object similarity. The measure employed most commonly is the Euclidean distance [Wysocki 2010 p. 64], but its scope is limited to quantitative features. Measuring distance becomes complicated with other types of features (such as the ordinal ones) and even more so with a mixture of different types. Hence, a distance measures must then be employed that allows for such a case and the Generalized Distance Measure (GDM) stands out as the most universal among them.

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The GDM was used in construction of the synthetic index of subjective sense of financial security of farmers' households. The idea of financial security applied to a household has a complex and multidimensional nature but is commonly described as the ability to satisfy current and future needs of its members, to discharge its obligations, and to weather financial shocks without major stress to its standard of living [Jacobsen, Furst-Nichols 2011]. The subjective sense of a household's financial security is based on self-evaluation made by its head as expressed in form of several assessments of its current financial condition or money management, but also of future perspectives for a change in financial situation [Hacker 2011, Economic Security 2013, Espinosa et al. 2014, Raczkowski 2014, Diagnoza Społeczna 2015]. Those assessments were measured on an ordinal scale.

Household financial security, both objectively and subjectively, is highly diverse not just between socio-economic groups but also within them. Farmers' households are a very particular group with elevated levels of income risk factors and consequently lower financial security [Kozera et al. 2016b]. Most volatile of these factors are understandably related to the agricultural character of their main income source and include farm profitability sensitivity to weather conditions, incidence of pests and diseases, seasonality of revenues, or market price fluctuations [Kahan 2013, Wołoszyn 2013]. The farmers, deeply attached to their land, are also far less mobile professionally than workers or entrepreneurs. They are hard put to find alternative income sources necessary to cope with potential financial shocks. The diversity of farm sizes, types of economic activity or education of farm operators also add to the diversity of financial security within this group.

The article's main objective was a synthetic evaluation of the level of Polish farmers' households' subjective sense of financial security in 2015. Additionally, socio-economic characteristics that determine different levels of the financial security were identified.

SOURCES AND METHODS

The research drew on microdata from Household Budget Survey conducted by the Polish Central Statistical Office in 2015 and calculations were performed with clusterSim package of the R program. The study proceeded in two stages. First, the synthetic index of farmers' households' financial security was constructed with TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)[1] method [Hwang, Yoon 1981, Wysocki 2010]. Then, the second stage followed with identification of social and economic characteristics that determined different levels of that index. In the article only subjective sense of financial

[1] It is a modification of the linear ordering method of Hellwig [Hellwig 1968, Bąk 2016].

security was studied, hence the "subjective sense of" clause was dropped from the main body of the paper without fear of misunderstanding.

Stage I consisted of six steps. First, simple features were selected subject to data availability and following appraisal of their merits. As a result, the selected features reflected needs satisfaction score and estimation of the past, current, but also of the future financial condition, the last one being a possible indicator of household's preparedness for income shocks as well as future covering of the needs of its members [cf. Kozera et al. 2016a]. Consequently, the following questions and responses of the household's head from the HBS survey passed the selection procedure:

1. How do you assess the present financial situation of your household?
   - very good – 1,
   - rather good – 2 ,
   - neither good nor bad – 3,
   - rather bad – 4,
   - bad – 5.
2. How does the financial situation of your household now compare with what it was 12 months ago?
   - much better – 1,
   - a little better – 2,
   - no change – 3,
   - a little worse – 4,
   - much worse – 5.
3. Which of these statements best describes the present situation of your household?
   - we can afford some luxury – 1,
   - we have enough without special saving – 2,
   - we have enough for everyday living, but we have to save for greater purchases – 3,
   - we have to live economically everyday – 4,
   - we have not enough even for basic needs – 5.
4. How do you think the financial situation of your household will change over the next 12 months?
   - much better – 1,
   - a little better – 2,
   - no change – 3,
   - a little worse – 4,
   - much worse – 5.

In the second step all the simple features were deemed destimulants of the financial security level (the higher values of the features the lower the level) and transformed into stimulants. Usually, normalization follows in the third step, but all the simple features were being measured on the same ordinal scale, and no normalization procedures were necessary. Next, the coordinates of the positive (A+) and negative (A-) ideals were taken to be the maximum and minimum values of the features over the set of all N=1681 objects (households). These coordinates were needed for the fifth step: the calculation of the distance between objects and the ideals.

With a set of features measured on an ordinal scale the Euclidean distance cannot be used for object similarity measure. One solution is to choose instead the Generalized Distance Measure (GDM) as the most universal one when dealing with qualitative or mixed-type data. GDM is based on the notion of generalized correlation coefficient, which derives from Pearson linear and Kendall-tau rank correlation coefficient [Walesiak 2002, 2016]. GDM distance of the i-th object (i=1,…,N) to the positive ideal (N+1) and negative ideal (N+2) is given by the following formula (Walesiak 2016):

$$d_{ij}^{(*)} = \frac{1}{2} - \frac{\sum_{k=1}^{K} a_{ijk} b_{ijk} + \sum_{k=1}^{K} \sum_{l=1}^{N+2} a_{ilk} b_{jlk}}{2\left[\left(\sum_{k=1}^{K} a_{ijk}^2 + \sum_{k=1}^{K} \sum_{l=1,l\neq i,j}^{N+2} a_{ilk}^2\right) \cdot \left(\sum_{k=1}^{K} a_{ijk}^2 + \sum_{k=1}^{K} \sum_{l=1,l\neq i,j}^{N+2} a_{ilk}^2\right)\right]^{\frac{1}{2}}}, \tag{1}$$

where i=1, …, N, j=N+1, N+2, (*) denotes either positive or negative ideal.
For ordinal scale the distance indicator is calculated in the following way:

$$a_{iuk}\left(b_{jtk}\right) = \begin{cases} 1 & x_{ik} > x_{uk}\left(x_{jk} > x_{tk}\right) \\ 0 & x_{ik} = x_{uk}\left(x_{jk} = x_{tk}\right) \\ -1 & x_{ik} < x_{uk}\left(x_{jk} < x_{tk}\right) \end{cases} \tag{2}$$

where: x_{ik} (x_{jk} , x_{lk} , x_{uk}, x_{tk}) is the i-th (j-th, l-th, u-th, t-th) observation of k-th feature.
In step 6 the values of the synthetic index were calculated in the usual way of the TOPSIS method:

$$q_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (i = 1, 2, \ldots, N), \tag{3}$$

where $0 \leq q_i \leq 1$
During the second stage some social and economic variables were identified that might determine the level of financial security among the farmers' households.

First, four distinct typological classes of the security level were isolated based on the mean and standard deviation of the synthetic index:

- class I (*high*): $q_i \geq \overline{q} + s_q$
- class II (*medium high*): $\overline{q} \leq q_i < \overline{q} + s_q$
- class III (*medium low*): $\overline{q} - s_q \leq q_i < \overline{q}$
- class IV (*low*): $q_i < \overline{q} - s_q$

Then, the isolated classes were described using simple features that formed the synthetic index as partial indices (so called *active features*) followed by selected social and economic determinants of the financial security (*passive variables*).

RESULTS

Classification results of farmers' households according to the level of their subjective sense of financial security are presented in Table 1. Below, Table 2 shows fractions of the households with particular levels of active features across four typological classes. Further down, passive social and economic passive variables, determining the level of financial security, appear in Table 3.

Conducted research found substantial diversity of financial security among farmers' households in 2015. High level marked 20.1% of all the households (class I), while low level – 17.9% (class IV). Most numerous class II formed the households with medium high level (46.9%) (Table 1).

Table 1. Classification results of Polish farmers' households according to their level of financial security in 2015

Values of synthetic index	Typological class	Level of financial security	Farmers' households	
			Number	Share (%)
<0.74, 1.00>	I	*high*	338	20.1
<0.52, 0.74)	II	*medium high*	789	46.9
<0.30, 0.52)	III	*medium low*	253	15.1
<0.00, 0.30)	IV	*low*	301	17.9
Total			1681	100

Source: own calculations based on data from HBS conducted by the Central Statistical Office in 2015

The households of class I, those of high level of financial security, usually judged their financial situation as rather good (74% of this class), did not notice any difference from the previous year (82%) or only some change for the better (17%). They also predicted no change in the future year (85%) or only minor improvement (12%). They considered their current budget to be sufficient for

everyday living, but most (64%) needed to save for a major purchase, while a minority of 32% did not (Table 1).

Table 2. Simple (active) features of the financial security across its typological classes in 2015 (median values)

Questions - Answers		Typological classes of financial security				Total
		I *high*	II *medium high*	III *medium low*	IV *low*	
How do you assess the present financial situation of your household	very good	22.5	1.4	0.0	0.0	5.2
	rather good	73.7	3.4	1.6	0.0	16.7
	neither good nor bad	3.8	95.2	91.3	44.2	67.1
	rather bad	0.0	0.0	5.5	44.5	8.8
	bad	0.0	0.0	1.6	11.3	2.2
	Total	100.0	100.0	100.0	100.0	100.0
How does the financial situation now compare with what it was 12 months ago?	much better	0.6	0.0	0.0	0.0	0.1
	a little better	17.2	3.8	0.8	0.0	5.4
	no change	82.0	92.5	71.1	31.2	76.2
	a little worse	0.3	3.7	24.5	55.8	15.5
	much worse	0.0	0.0	3.6	13.0	2.8
	Total	100.0	100.0	100.0	100.0	100.0
Which of these statements best describes the present situation of your household?	we can afford some luxury	4.1	0.6	0.0	0.0	1.1
	we have enough without special saving	31.7	3.2	2.8	0.0	8.3
	we have enough for everyday living. but we have to save for greater purchases	63.9	92.1	49.4	20.9	67.3
	we have to live economically everyday	0.3	4.1	47.0	74.1	22.3
	we have not enough even for basic needs	0.0	0.0	0.8	5.0	1.0
	Total	100.0	100.0	100.0	100.0	100.0
How do you think the financial situation of your household will change over the next 12 months?	much better	2.7	0.3	0.0	0.0	0.7
	a little better	12.4	6.0	2.0	3.0	6.1
	no change	84.9	92.3	77.5	44.5	80.0
	a little worse	0.0	1.5	18.6	47.2	12.0
	much worse	0.0	0.0	2.0	5.3	1.2
	Total	100.0	100.0	100.0	100.0	100.0

Source: own calculations based on data from HBS conducted by the Central Statistical Office in 2015

Almost all of class II (medium high level of financial security) households described their financial situation as neither good nor bad (95%), and assessed their

resources adequate for everyday living, but not without the need of saving for major purchases (92%). With few exceptions this entire (92%) class also believed their financial situation would not change in the next year, a highest percentage of all the four classes (Table 2).

Class III was formed by just 15% of all households, and its members viewed their level of financial security as medium low. Unlike in previous classes a substantial fraction of these households believed their financial condition worsened in the last 12 months (25%) and were pessimistic about future (10%). Nearly half of them had to live economically every day, while the other half needed to save for a major purchase (Table 2).

Class IV of low level of financial security was also half split between the households that viewed their financial condition as average and those that considered it rather bad (44% both). Most of the class had to be very economical (74%), and one in twenty declared they were lacking even the basics. Moreover, almost no household believed their future to improve with 45% thinking it would be even worse (Table 2).

Table 3. Selected social and economic (passive) variables across the classes of (subjective sense of) financial security

Specification		Typological classes of financial security				All
		I *high*	II *medium high*	III *medium low*	IV *low*	
Equivalent* disposable income (zł/month)		2724	1720	1365	1140	1798
Equivalent* expenditures (zł/month)		1626	1269	1231	1178	1328
Savings rate (%)		40.3	26.2	9.8	-3.3	26.1
Share of essential expenditures (food and housing) in total expenditures (%)		45.0	51.5	53.0	54.0	50.3
Farm average size (ha)		30.2	14.6	14.6	10.7	17.1
Education of the household head (%)	*junior high school or lower*	10.4	15.1	22.5	23.3	16.7
	vocational	39.9	53.6	48.2	52.2	49.8
	high school	38.8	26.0	27.3	21.6	28.0
	higher	10.9	5.3	2.0	3.0	5.5
	Total	100.0	100.0	100.0	100.0	100.0

*modified OECD scale was used

Source: own calculations based on data from HBS conducted by the Central Statistical Office in 2015

Objective or subjective, household financial security depends on many social and economic determinants, such as income, education, or socioeconomic

group affiliation, among many others. Selected determinants are presented in Table 3. The research found that farmers' households' financial security was highly correlated with their equivalent disposable income. Its average level in class I reached 2,724 zł and was the highest value of all classes while in class IV dropped to the lowest mark of 1,140 zł. Further correlation was discovered with aggregated savings rate: highest in class I (40%) and lowest in class IV (-3%). The last finding confirmed subjective opinion that the received income did not cover all basic needs in this class. Estimation of bad financial condition of this class was further reinforced by the fact that essential expenditures (food and housing) amounted to 54% of their household budget, compared to 50% for average farmers' household.

The study also found other determinants more loosely related to disposable income: educational level of the household's head and the farm size. The percentage of households with their head's low educational level (junior high or lower) was rising with the falling level of financial security (from 10% in class I to 23% in class IV). The opposite was true for the percentage of households with their head's high school or higher educational levels. For high school level it was falling from 39% in class I to 22% in class IV, and for higher educational level it was falling from 11% in class I to 3% in class IV.

As to the farm size, the average size of the farm in the first class was above 30 ha, while in the fourth class only 11 ha, the medium classes having average farm size of about 15 ha each (Table 3).

CONCLUSIONS

Due to the ordinal character of a majority of diagnostic variables, the Generalized Distance Measure was employed in the construction of a synthetic index of subjective sense of farmers' households' financial security, a construction that drew on opinions of the households' heads. The study showed that in 2015 on in every five farmers' households exhibited high level of the financial security, one in two – medium high, and one in three – at most medium low.

Moreover, the self-evaluation was largely determined by the households' objective financial security, especially by disposable income and savings rate, and to a smaller degree by share of essential expenditures. Furthermore, households of high level financial security farmed on average on 30ha, an area three times the size of farmsteads of low level households. Another determinant found in the study was educational level of households' head. Every second household of high level financial security was headed by a person with at least high school education, while three out of four low level households – with at most vocational education.

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