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USING FUZZY NUMBERS IN FACTOR EVALUATION DEVELOPMENT OF LIVESTOCK FARMS IN NORTH-EAST ROMANIA

Abstract: *The attention given to the cattle/ cow breeding and exploitation derives from the capacity of producing one of the most important and complex food: milk and dairy products.*

Generally, animal breeding and particularly, cattle breeding come with serious structural issues due to the excessive fragmentation of the property, low levels of productivity and last, but not least, to the high values recorded by the self-consumption within the farms.

All these difficulties were mirrored by the dramatic decrease in the livestock registered between 1990 and 2013, from 6.3 million to merely 2 million cattle. However the dynamics of milk production recorded values inversely proportional to the livestock dynamics as the medium production obtained increased from 2.063 l per cow fed in 1990 to 3.529 l per cow fed in 2013.

Keywords: livestock farms, North-East Region, PEST analysis, fuzzy number, uncertainty analysis, Global unit method, Maximax method, Wald method.

JEL: Q01; Q12; Q13.

Introduction

The attention given to the cattle/ cow breeding and exploitation derives from the capacity of producing one of the most important and complex food: milk and dairy products.

Cow's milk is a complete food, containing 20 amino acids, 16 fatty acids, 45 minerals, especially calcium and phosphorus, and 25 of the vitamin. Cow's milk has a high biological value, containing per liter on average 125g dry weight: 37g fat, 33g protein, 8g 47g lactose and minerals. (G. Georgescu, 2007)

We must not forget the fact that ending a cow's productive life does not happen in a farm but in a slaughter house, so the milk cows slaughtered for meat stand for 1/3 of the beef consummed by humans.

Due to this feature as well as to the rising adaptability they have proven so far, at a global level, the taurine livestock have been continually growing. It is true that they do not have an even distribution, but the most significant cattle livestock can be found in America (511 million cattle), Asia (520 million cattle) and Africa (301 million cattle).

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The dynamics of the cattle and milk production

According to FAO data recorded between 1990 and 2013, the most significant cattle increase was registerd in Africa (59.12%), followed by Asia (30.01%), Oceania (26.16%) and America (18.9%). The only continent that does not obey the general dynamics and where the cattle have decreased to almost half (–49.77%) the number registered in 1990 is Europe.

This may be caused by the reforms which took place in the former Eastern communist block of the Soviet Union, but also by a bigger concern about the improvement and refinement of the breeds. The second supposition originates from explaining the general trend as the cattle increase was mainly recorded in emergent countries from Africa, South America and Asia, and where the animal growth was encouraged to the detriment of individual performances.

About Romania, the animal increase, in general, and cattle increase, particularly, has major shortcomings related to unresolved structural issues caused by property splitting, low level of productivity and high levels of self-consumption within the farms.

The low level of performance is caused by the lessened level of labour productivity and deficit recorded by the agrifood balances. At the moment the zootechnical sector is going through a rough time marked by a series of transformations which have conveyed an uncertainty state of mind among the farmers.

In Romania, the downward trend of cattle livestock was partly caused by specific factors, among which we can name the following:

– the market monopolisation by several economic agents

– the low organizational training of the farmers

– the underfunding of the zootechnical sector due to the practically non-existent interest of the banks towards this branch of economy.

All these hardships have been reflected in the continuous dramatic decrease of cattle between 1990 and 2013, from 6.3 million to 2 million. Still the dynamics of the milk production showed significant progress as the ratio is in inverse proportion to the values of cattle dynamics (the medium production obtained increased from 2.063 l per cow fed in 1990 to 3.529 l per cow fed in 2013).

The natural environment of the North East region

The North-East region, a crucial part of the old historical area of Moldavia, is formed from the following counties: Bacău, Botoşani, Iaşi, Neamţ, Suceava and Vaslui. The area is of 36.850 km^2, covering 15.46% of the Romania's surface. Geographically, the region can be divided into 3 important zones: the mountain zone – The Carpathian Mountains in the west (28%), the Subcarpathian zone (12%) and the plateau zone – Moldavian Plateau in the southeast (60%).

Hydrographically, the region has 8 major water streams which cross it from north to south, all being part of the hydrographic basin of Prut and Siret rivers.

The pedographic coating is characterized by a multitude of categories and soil types due to the geomorphological, climatic conditions and geological sublayer.

In the Carpathian Mountains find the following types of soil: rendzinas, eutricambo soils districambosoluri, podzols and andisol.

In the Carpathian foothills and hill following soil types are present: regosols, luvisols, faeozems and vertisols.

In the lower areas, depressions and river meadows we can find two types of soil: alluvisols, chernozems, gleisols, solonetz and histosols.

Analysis of the factors of development of livestock farms in the North East Romania

In light of the development factors of the zootechnical farms from the North-East of Romania we shall analyze the zonal potential in relation to 4 factor categories: political background, economic environment, social and technological environments as well. To achieve this we have employed PEST analysis which is a vital instrument for understanding the rise and fall registered by a market and which also aims to outline the trend imprinted by the economic activity. To substantiate PEST analysis in the North-East region and identify the specific features of milk cow exploitations we have used the data given by ANARZ offices as well as data obtained by field trips to some farms acknowledged as representative for our study[2].

The political background, although it does not act directly upon the milk cow farms, affects considerably the market where these farms run their activity. Therefore the numerous political crises and repeated changes of the legal and institutional framework had a negative impacy upon the good running of the zootechnical sector. *The complex legislative and institutional framework, instable and ill-adjusted to the farmer's needs (F1)* has favoured the growing reticence of the farmers about the programmes made for relaunching the zoothechnical sector in Romania.

A major change occurred when the regulation OUG no. 3/2015 regarding subvention payment for 2015-2020 was approved. This readjusts the framework where the direct payments in agriculture will be made and thus achieving the transposition of the Commune Agricultural Policy of the European Union in the Romanian legislation. The most significant change is the introduction of redistributive payment which represents nothing else but a stimulative payment granted for achieving land pooling. The regulation enacts the definition of the active farmer for the purpose of avoiding

[2] PEST is an acronym derived from the name of the factors the andysis is made of politic, economic, social, tehnologic.

hilarious situations that occurred in the past, among which we would like to bring forward the example of the airports which received subventions for the lawns held in property. It can only be regarded as an active farmer that person or individual who proves beyond any doubt he runs an agricultural activity once he has applied for the subvention grant. (http://www.madr.ro/)

The amplification of the geopolitical and regional crises (F2), materialized by restraining the access to the Russian market at the same time with eliminating the milk quota resulted in a dramatic decline of the milk price. Practically, the efforts of the Romanian farmers are higher than any other European farmers which is also determined by the differences registered between the production per cow fed in Romania as compared to that achieved in EU.

A special attention requires the communication methods employed by the political environment: consultancy, internship programmes, training courses and professional development.

The excessive bureaucracy related to the obtaning of non-refundable financing (F3) resulted in placing Romania on the last position in the EU countries with an absortion degree of the non-refundable funds under 60% between 2007-2013. According to the press releases made by the chief of European Commission in Romania, Angela Filote, these facts can only be avoided if "the thicket of bureaucracy regarding the access procedures for the European funding" disappears and also, if "a change of the play rules while playing" emerges, things which were asked for by many of those who tried to access European funds.

The economic environment has an important impact upon the factors which develop on the dairy products market because it is in close connection with the purchasing power of the consummers. It is true that the market of agrifood products is not a flexible one but, when it comes to higher amounts of income, the clients will go for the products of superior quality and show an increasing interest in the goods purchased and consummed.

To present the actual state and the evolution of the economic indicatives that characterize the economic status of the region we have come up with the following indicatives: gross domestic income (GDI), gross domestic income per inhabitant, gross value added.

Table 1

The evolution of regional GDP, compared to the national GDP

Indicator	2005	2006	2007	2008	2009	2010	2011
Ro GDP, mln	288 954.6	344 654.6	416 006.8	514 700	501 139.4	523 693.3	557 348.2
Real GDP growth rate Ro	4.1%	7.9%	6%	7.1%	–7.1%	–1.3%	2.2%
Reg GDP, mln lei	33 265.8	38 429.9	45 990.1	55 021.9	54 408.4	55 669	57 082.7
Real GDP growth rate reg	0.73%	4.51%	5.1%	3.57%	–5.64%	–3.3%	–1.53%

Source: National Regional Accounts 2006–2012, INS, BNR.

As it is noticed in Table 1, the total growth rate of GDP (gross domestic product) between 2005 and 2011 was positive but had a value under the one recorded at national level. Also, the absolute value of the regional GDP has increased over 70% following the national trend.

This state of facts can only be explained by 2 factors: a work productivity at an inferior level compared to the one recorded at national level and a higher ponderance of the population working in agricultural sector as compared to the national ponderance.

The reticence towards the association concept (F4).

The economic development at regional level has occurred as a consequence of a few favourable circumstances that resulted in an increase of investments and exports.

The social environment is defined by the medium age, life style, cultural and educational level of the population under study. The particularity of the social environment is the one that can provide actual data regarding the system evolution as well as the future directions of its development. In the following table we can notice the evolution of population for 2005–2013.

Table 2

Population growth rate (%)

	2005	2006/ 2005	2007/ 2006	2008/ 2007	2009/ 2008	2010/ 2009	2011/ 2010	2012/ 2011	2013/ 2012
Romania	**21 623 849**	**–0.18**	**–0.21**	**–0.15**	**–0.16**	**–0.18**	**–0.35**	**–0.17**	**–0.23**
Urban	11 879 897	0.28	–0.30	–0.35	–0.09	–0.20	0.60	–0.41	–0.11
Rural	9 743 952	–0.75	–0.10	0.09	–0.23	–0.14	–0.05	0.10	–0.37
North East Region	**3 734 546**	**–0.05**	**–0.15**	**–0.20**	**–0.13**	**–0.17**	**–0.31**	**0.09**	**0.16**
Urban	1 620 437	0.54	–0.65	–0.63	–0.20	–0.36	–0.74	0.30	0.46
Rural	2 114 109	–0.50	0.22	0.12	–0.08	–0.02	0	–0.07	–0.07

Source: Romanian Statistical Yearbook, INS.

At a national level we can see a continuous decline of the total population. Except for 2006 when it was recorded an increase of the inhabitants' number at urban level, greatly due to the transformation of some communes into towns, on the whole, there is a downward trend related to the urban population. If we compare all these to the North-East region, the same downward trend is visible until 2012, when it is recorded a slight increase as a result of the coming back of some Romanian citizens who had worked and lived in other EU member states.

A major issue that challenges the well-being of the North-East region is the high unemployment rate which emerged as a problem once the market economy was adopted. This state of facts is caused by the lack of capital for investments, practically, born from the desperate attempt to increase the work

productivity by gradually laying off the personnel. In 2013 the monthly income of a household in the North-East region was in amount of 2303,47 lei, which means 2.5 times less than the one recorded by a household from Bucureşti Ilfov region. (www.insse.ro).

The low level degree of modernization of the road and railway network (F5) derives from the data provided by the National Institute of Statistics. So, 81% of the roads from the North-East region are represented by county and communal roads and their degree of modernization is of 16% only. Nevertheless, there are major differences registered regarding the level of modernization among counties, such as 3% in Neamț and up to 34% in Suceava (www.insse.ro)

This state of facts is also reflected by the alarming rise of the car accidents (+ 222%) during 2007–2011 in counties crossed by the road corridors. The only strong feature is represented by the modernized European highway E85, which crosses the region.

The lack of qualified work force (F6): As we can notice in Table 3, the graduates of agricultural, mountain agriculture and veterinary highschools of 1990 represented 23.5% of the total of highschool graduates, while in 2012 they represented merely 0.6%.

Table 3

Graduates of high schools in the North East

Training levels	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012
Agricultural High Schools	20 190	835	310	274	289	349	291	429	283	330
Agro-mountain High Schools	–	82	62	44	53	23	–	–	–	19
Veterinary High Schools	–	190	200	87	24	49	194	127	194	116
TOTAL graduates	85 764	85 764	86 626	92 278	99 136	94 155	87 375	83 562	71 908	71 693

Source: Romanian Statistical Yearbook, INS.

The demographic decline and aging of the population mainly in the rural environment (F7) is relevant due to the ponderance analysis held by the following age categories: 0–14 years old, 15–64 years old and over 65 years old. From 2003 until present days the North-East region has annually registered negative values of the population growth. The migration process recorded (from urban to the rural) although positive, could not compensate for the decline of the rural population.

The technological environment is the one which leaves its hall-mark directly upon the activities of the farm, gathering the science of management, conducting and improving all the production factors. The management of the milk cow farms in the North-East region is mainly achieved in an intensive or semi-intensive system.

The lack of investments in new technologies (F8) has a negative effect reflected in achieving a low productivity that is felt as a severe disability in a competitive market.

Rising the anthropic pressure upon the environment and bio-diversity (F9) has already begun to show its side effects. The pressures exercised have a various character: the irrational usage of pesticides and chemical fertilizers, agricultural works made improperly, the deficient management of waste, etc., reasons for which the zootechnical farms can represent significant sources of pollution if they neglect this risk factor.

The analysis of uncertainty by using Fuzzy numbers

Many decisions reached by farmers in the management of the farm do not have a scientific substantiation based on actual facts. In most cases they are based on past experiences and on the spot convictions. If you were to interview farmers about the decision process and basis, they would use phrases of the sort: "My experience tells me that I am most probably right in this matter". The problem surfaces when we have to allocate a probability percentage to this type of statement.

In order to avoid this state of uncertainty we have done, by triangular fuzzy numbers, a classification of the risk factors determined through PEST analysis.

We have practically made and applied a questionary for getting actual data about the risk level which each and every factor could generate. The questionary has been applied to the farm management under the current study and also to the members of two specialist groups (scientific researchers of "Gheorghe Zane" Institute and USAMV Iasi), which have graded each risk factor. They gave grades between 0 and 10 each risk factor; 0 assuming risk with minimal impact and 10 the maximum impact.

The medium values of the grades obtained as a result of the application of the questionaries on the 3 experts' groups are shown in the **Table 4**: *The Initial Model (the matrix of the grades)*, where we have marked by F the risk factors and by E the zootechnical exploitations studied.

In the table, opposite each risk factor are passed vertically three components that form the triangular fuzzy numbers that average mark and center of gravity.

In order to calculate the center of gravity (real number associated), I used the following formula: $a_G = \ < \tilde{a} > \ = \frac{a_1 + 2a_2 + a_3}{4}$, thus obtaining the following results:

$$\frac{5+2\cdot 6+8}{4} = \frac{25}{4} = 6,25\,; \quad \frac{5+2\cdot 5+6}{4} = \frac{21}{4} = 5,25\,;$$

$$\frac{8+2\cdot 8+10}{4} = \frac{34}{4} = 8,5 \quad \ldots \quad \frac{4+2\cdot 5+6}{4} = \frac{20}{4} = 5$$

Table 4

The initial model (matrix of notes)

	Weight	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
E1	150	5	5	8	4	4	6	3	**1**	3	2
	0	6	5	8	8	6	7	6	2	4	4
	0	8	6	**10**	**10**	7	9	8	5	7	7
	0	*6.25*	*5.25*	*8.5*	*7.5*	*5.75*	*7.25*	*5.75*	*2.5*	*4.5*	*4.25*
E2	90	6	5	3	5	5	7	**2**	3	3	3
	0	6	5	6	8	8	7	4	7	5	5
	0	8	7	7	9	**10**	8	7	8	6	7
	0	*6.5*	*5.5*	*5.5*	*7.5*	*7.75*	*7.25*	*4.25*	*6.25*	*4.75*	*5*
E3	100	7	4	4	3	7	5	5	4	4	**2**
	0	7	5	5	8	7	6	7	6	5	4
	0	9	6	7	**10**	9	7	8	7	5	8
	0	*7.5*	*5*	*5.25*	*7.25*	*7.5*	*6*	*6.75*	*5.75*	*4.75*	*4.5*
E4	70	6	3	2	**1**	5	4	4	2	4	4
	0	7	4	5	9	7	5	6	5	5	6
	0	7	5	7	**9**	8	7	8	6	5	8
	0	*6.75*	*4*	*4.75*	*7*	*6.75*	*5.25*	*6*	*4.5*	*4.75*	*6*
E5	208	8	5	7	5	6	2	3	**1**	2	2
	0	8	5	7	8	8	5	5	3	4	4
	0	**10**	7	9	**10**	9	7	7	5	6	6
	0	*8.5*	*5.5*	*7.5*	*7.75*	*7.75*	*4.75*	*5*	*3*	*4*	*4*
E6	72	6	4	4	**1**	6	2	5	5	4	5
	0	8	4	7	7	7	5	6	6	6	5
	0	**9**	5	8	8	**9**	7	**9**	6	7	8
	0	*7.75*	*4.25*	*6.5*	*5.75*	*7.25*	*4.75*	*6.5*	*5.75*	*5.75*	*5.75*
E7	30	4	**3**	4	**3**	5	**3**	**3**	5	**3**	**3**
	0	6	5	4	8	6	6	4	5	3	5
	0	6	6	7	**8**	**8**	**8**	6	7	7	5
	0	*5.5*	*4.75*	*4.75*	*6.75*	*6.25*	*5.75*	*4.25*	*5.5*	*4*	*4.5*
E8	20	2	3	4	**1**	6	5	4	4	2	3
	0	5	4	6	9	7	7	7	7	4	5
	0	7	5	6	**10**	9	9	8	7	5	7
	0	*4.75*	*4*	*5.5*	*7.25*	*7.25*	*7*	*6.5*	*6.25*	*3.75*	*5*
E9	160	6	4	6	6	5	4	4	**1**	3	4
	0	8	5	7	7	7	5	5	3	5	5
	0	**9**	6	**9**	**9**	8	8	7	6	6	6
	0	*7.75*	*5*	*7.25*	*7.25*	*6.75*	*5.5*	*5.25*	*3.25*	*4.75*	*5*
E1-	45	5	4	5	**2**	7	5	3	**2**	**2**	6
	0	7	4	6	8	8	7	4	6	4	6
	0	7	6	6	**9**	**9**	**9**	7	7	6	7
	0	*6.5*	*4.5*	*5.75*	*6.75*	*8*	*7*	*4.5*	*5.25*	*4*	*6.25*
E11	101	7	5	5	**2**	6	3	4	3	**2**	3
	0	8	5	7	7	8	4	5	6	4	4
	0	8	5	**9**	**9**	8	8	8	6	6	6
	0	*7.75*	*5*	*7*	*6.25*	*7.5*	*4.75*	*5.5*	*5.25*	*4*	*4.25*

Table 4 (continued)

	Weight	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**
E12	30	5	3	2	**1**	4	6	5	3	**1**	4
	0	6	5	5	9	6	6	7	5	4	5
	0	8	5	8	**10**	7	8	7	8	6	6
	0	*6.25*	*4.5*	*5*	*7.25*	*5.75*	*6.5*	*6.5*	*5.25*	*3.75*	*5*

Once accomplished matrix of triangular fuzzy numbers to their ordering we went through three methods: global unity, metooda maxi-max and Wald method.

a) Global utility method

In order to use this method must be done to normalize the operation of the lines, by interpolating the unit interval [0,1], thus resulting matrix of unit $(u_{ij})_{\substack{i=\overline{1,m}\\ j=\overline{1,n}}}$.

This shall be done simultaneously on all 12 ∗ 3 = 36 components (real) of each line using the following formula:

$$u_{ij} = \frac{N_i^{\max} - N_{ij}}{N_i^{\max} - N_i^{\min}} \quad ,(\forall) i = \overline{1,m} \,, \qquad \text{where:} \qquad N_i^{\max} = \max_{1\le j\le n} \mathrm{N_{ij}} \text{ and } N_i^{\min} = \min_{1\le j\le n} \mathrm{N_{ij}}$$

The application of relationship is as follows:

$$N_1^{\min} = \min(5;6;8;5;5;6;8;8;10;4;8;10;4;6;7;6;7;9;3;6,8;1;2;5;3;4;7;2;4;7) = 1$$

$$N_1^{\max} = \max(5;6;8;5;5;6;8;8;10;4;8;10;4;6;7;6;7;9;3;6,8;1;2;5;3;4;7;2;4;7) = 10$$

In the table each line 2 extreme elements are bold.

$$N_{1x} \to \frac{N_1^{\max} - N_{1x}}{N_1^{\max} - N_1^{\min}} = \frac{10 - N_{1x}}{10 - 1} = \frac{10 - N_{1x}}{9}$$

$$5 \to \frac{10-5}{9} = \frac{5}{9} \approx 0.556 \,; \qquad 6 \to \frac{10-6}{9} = \frac{4}{9} \approx 0.444 \,;$$

$$8 \to \frac{10-8}{9} = \frac{2}{9} \approx 0.222 \qquad \tilde{u}_{11} = (0,\ 222;\ 0{,}444;\ 0.556)_{0{,}417} \,.$$

The positions of the three components were sorted in ascending order, all other utilities were similarly calculations.

Table 5

The matrix of utilities

	Weight	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
E1	0.139	0.222	0.444	0	0	0.333	0.111	0.222	0.556	0.333	0.333
	0	0.444	0.556	0.222	0.222	0.444	0.333	0.444	0.889	0.667	0.667
	0	0.556	0.556	0.222	0.667	0.667	0.444	0.778	1	0.778	0.889
	0	0.417	0.528	0.167	0.278	0.472	0.305	0.472	0.834	0.611	0.639

Table 5 (continued)

	Weight	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
E2	0.084	0.25	0.375	0.375	0.125	0	0.25	0.375	0.25	0.5	0.375
	0	0.5	0.625	0.5	0.25	0.25	0.375	0.75	0.375	0.625	0.625
	0	0.5	0.625	0.875	0.625	0.625	0.375	1	0.875	0.875	0.875
	0	0.438	0.563	0.563	0.313	0.281	0.344	0.719	0.469	0.656	0.625
E3	0.093	0.125	0.5	0.375	0	0.125	0.375	0.25	0.375	0.625	0.25
	0	0.375	0.625	0.625	0.25	0.375	0.5	0.375	0.5	0.625	0.75
	0	0.375	0.75	0.75	0.875	0.375	0.625	0.625	0.75	0.75	1
	0	0.313	0.625	0.594	0.344	0.313	0.5	0.406	0.531	0.656	0.688
E4	0.065	0.25	0.5	0.25	0	0.125	0.25	0.125	0.375	0.5	0.125
	0	0.25	0.625	0.5	0	0.25	0.5	0.375	0.5	0.5	0.375
	0	0.375	0.75	0.875	1	0.5	0.625	0.625	0.875	0.625	0.625
	0	0.281	0.625	0.531	0.25	0.281	0.469	0.375	0.563	0.531	0.375
E5	0.193	0	0.333	0.111	0	0.111	0.333	0.333	0.556	0.444	0.444
	0	0.222	0.556	0.333	0.222	0.222	0.556	0.556	0.778	0.667	0.667
	0	0.222	0.556	0.333	0.556	0.444	0.889	0.778	1	0.889	0.889
	0	0.167	0.5	0.278	0.25	0.25	0.584	0.556	0.778	0.667	0.667
E6	0.067	0	0.5	0.125	0.125	0	0.25	0	0.375	0.25	0.125
	0	0.125	0.625	0.25	0.25	0.25	0.5	0.375	0.375	0.375	0.5
	0	0.375	0.625	0.625	1	0.375	0.875	0.5	0.5	0.625	0.5
	0	0.156	0.594	0.313	0.406	0.219	0.531	0.313	0.406	0.406	0.406
E7	0.028	0.4	0.4	0.2	0	0	0	0.4	0.2	0.2	0.6
	0	0.4	0.6	0.8	0	0.4	0.4	0.8	0.6	1	0.6
	0	0.8	1	0.8	1	0.6	1	1	0.6	1	1
	0	0.5	0.65	0.65	0.25	0.35	0.45	0.75	0.5	0.8	0.7
E8	0.019	0.333	0.556	0.444	0	0.111	0.111	0.222	0.333	0.556	0.333
	0	0.556	0.667	0.444	0.111	0.333	0.333	0.333	0.333	0.667	0.556
	0	0.889	0.778	0.667	1	0.444	0.556	0.667	0.667	0.889	0.778
	0	0.584	0.667	0.5	0.306	0.305	0.333	0.389	0.417	0.695	0.556
E9	0.149	0	0.375	0	0	0.125	0.125	0.25	0.375	0.375	0.375
	0	0.125	0.5	0.25	0.25	0.25	0.5	0.5	0.75	0.5	0.5
	0	0.375	0.625	0.375	0.375	0.5	0.625	0.625	1	0.75	0.625
	0	0.156	0.5	0.219	0.219	0.281	0.438	0.469	0.719	0.531	0.5
E1-	0.042	0.286	0.429	0.429	0	0	0	0.286	0.286	0.429	0.286
	0	0.286	0.714	0.429	0.143	0.143	0.286	0.714	0.429	0.714	0.429
	0	0.571	0.714	0.571	1	0.286	0.571	0.857	1	1	0.429
	0	0.357	0.643	0.465	0.322	0.143	0.286	0.643	0.536	0.714	0.393
E11	0.094	0.143	0.571	0	0	0.143	0.143	0.143	0.429	0.429	0.429
	0	0.143	0.571	0.286	0.286	0.143	0.714	0.571	0.429	0.714	0.714
	0	0.286	0.571	0.571	1	0.429	0.857	0.714	0.857	1	0.857
	0	0.179	0.571	0.286	0.393	0.215	0.607	0.5	0.536	0.714	0.679
E12	0.028	0.222	0.556	0.222	0	0.333	0.222	0.333	0.222	0.444	0.444
	0	0.444	0.556	0.556	0.111	0.444	0.444	0.333	0.556	0.667	0.556
	0	0.556	0.778	0.889	1	0.667	0.444	0.556	0.778	1	0.667
	0	0.417	0.612	0.556	0.306	0.472	0.389	0.389	0.528	0.695	0.556

Weighted utilities are obtained by multiplying the estimated weight depending on farm size (milk cows heads).

Table 6

Fuzzy values of specific indicators for global unity method

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
$\tilde{U}_j$	0.128	0.434	0.149	0.018	0.13	0.208	0.243	0.416	0.424	0.345
	0.283	0.581	0.373	0.21	0.279	0.478	0.511	0.618	0.62	0.603
	0.409	0.639	0.53	0.732	0.494	0.67	0.726	0.887	0.827	0.788
	0.276	*0.559*	*0.356*	*0.293*	*0.296*	*0.459*	*0.498*	*0.635*	*0.623*	*0.585*

Table 7

Fuzzy matrix of weighted utilities

	Weight	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
E1	0.139	0.031	0.062	0	0	0.046	0.015	0.031	0.078	0.046	0.046
	0	0.062	0.078	0.031	0.031	0.062	0.046	0.062	0.124	0.093	0.093
	0	0.078	0.078	0.031	0.093	0.093	0.062	0.108	0.139	0.108	0.124
	0	0.058	0.074	0.023	0.039	0.066	0.042	0.066	0.116	0.085	0.089
E2	0.084	0.021	0.031	0.031	0.01	0	0.021	0.031	0.021	0.042	0.031
	0	0.042	0.052	0.042	0.021	0.021	0.031	0.063	0.031	0.052	0.052
	0	0.042	0.052	0.073	0.052	0.052	0.031	0.084	0.073	0.073	0.073
	0	0.037	0.047	0.047	0.026	0.024	0.029	0.06	0.039	0.055	0.052
E3	0.093	0.012	0.046	0.035	0	0.012	0.035	0.023	0.035	0.058	0.023
	0	0.035	0.058	0.058	0.023	0.035	0.046	0.035	0.046	0.058	0.07
	0	0.035	0.07	0.07	0.081	0.035	0.058	0.058	0.07	0.07	0.093
	0	0.029	0.058	0.055	0.032	0.029	0.046	0.038	0.049	0.061	0.064
E4	0.065	0.016	0.033	0.016	0	0.008	0.016	0.008	0.024	0.033	0.008
	0	0.016	0.041	0.033	0	0.016	0.033	0.024	0.033	0.033	0.024
	0	0.024	0.049	0.057	0.065	0.033	0.041	0.041	0.057	0.041	0.041
	0	0.018	0.041	0.035	0.016	0.018	0.031	0.024	0.037	0.035	0.024
E5	0.193	0	0.064	0.021	0	0.021	0.064	0.064	0.107	0.086	0.086
	0	0.043	0.107	0.064	0.043	0.043	0.107	0.107	0.15	0.129	0.129
	0	0.043	0.107	0.064	0.107	0.086	0.172	0.15	0.193	0.172	0.172
	0	0.032	0.096	0.053	0.048	0.048	0.113	0.107	0.15	0.129	0.129
E6	0.067	0	0.033	0.008	0.008	0	0.017	0	0.025	0.017	0.008
	0	0.008	0.042	0.017	0.017	0.017	0.033	0.025	0.025	0.025	0.033
	0	0.025	0.042	0.042	0.067	0.025	0.059	0.033	0.033	0.042	0.033
	0	0.01	0.04	0.021	0.027	0.015	0.036	0.021	0.027	0.027	0.027
E7	0.028	0.011	0.011	0.006	0	0	0	0.011	0.006	0.006	0.017
	0	0.011	0.017	0.022	0	0.011	0.011	0.022	0.017	0.028	0.017
	0	0.022	0.028	0.022	0.028	0.017	0.028	0.028	0.017	0.028	0.028
	0	0.014	0.018	0.018	0.007	0.01	0.013	0.021	0.014	0.023	0.02
E8	0.019	0.006	0.01	0.008	0	0.002	0.002	0.004	0.006	0.01	0.006
	0	0.01	0.012	0.008	0.002	0.006	0.006	0.006	0.006	0.012	0.01
	0	0.017	0.014	0.012	0.019	0.008	0.01	0.012	0.012	0.017	0.014
	0	0.011	0.012	0.009	0.006	0.006	0.006	0.007	0.008	0.013	0.01

Table 7 (continued)

	Weight	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
E9	0.149	0	0.056	0	0	0.019	0.019	0.037	0.056	0.056	0.056
	0	0.019	0.074	0.037	0.037	0.037	0.074	0.074	0.112	0.074	0.074
	0	0.056	0.093	0.056	0.056	0.074	0.093	0.093	0.149	0.112	0.093
	0	0.024	0.074	0.033	0.033	0.042	0.065	0.07	0.107	0.079	0.074
E10	0.042	0.012	0.018	0.018	0	0	0	0.012	0.012	0.018	0.012
	0	0.012	0.03	0.018	0.006	0.006	0.012	0.03	0.018	0.03	0.018
	0	0.024	0.03	0.024	0.042	0.012	0.024	0.036	0.042	0.042	0.018
	0	0.015	0.027	0.02	0.014	0.006	0.012	0.027	0.023	0.03	0.017
E11	0.094	0.013	0.054	0	0	0.013	0.013	0.013	0.04	0.04	0.04
	0	0.013	0.054	0.027	0.027	0.013	0.067	0.054	0.04	0.067	0.067
	0	0.027	0.054	0.054	0.094	0.04	0.08	0.067	0.08	0.094	0.08
	0	0.017	0.054	0.027	0.037	0.02	0.057	0.047	0.05	0.067	0.064
E12	0.028	0.006	0.016	0.006	0	0.009	0.006	0.009	0.006	0.012	0.012
	0	0.012	0.016	0.016	0.003	0.012	0.012	0.009	0.016	0.019	0.016
	0	0.016	0.022	0.025	0.028	0.019	0.012	0.016	0.022	0.028	0.019
	0	0.012	0.018	0.016	0.009	0.013	0.011	0.011	0.015	0.02	0.016

b) Method Maxi-Max

Specific indicators Maxi-Max method is calculated by the following formula: $\max\limits_{1\le i\le m} u_{ij}$

M_j indicator Max Maxi-specific method is obtained by choosing the largest utilities column.

Fuzzy numbers will be chosen with maximum levels on columns Table 7, using their weight compared centers:

$$\tilde{M}_1 = \max_{1\le i\le 12} \tilde{u}_{i1} = \max(\tilde{u}_{11},\tilde{u}_{21},\tilde{u}_{31},\tilde{u}_{41},\tilde{u}_{51},\tilde{u}_{61},\tilde{u}_{71},\tilde{u}_{81},\tilde{u}_{91},\tilde{u}_{101},\tilde{u}_{111},\tilde{u}_{121}) =$$

$$= \tilde{u}_{11} = (0.031,\ 0.062,\ 0.078)_{0.058}$$

.....

$$\tilde{M}_{10} = \max_{1\le i\le 12} \tilde{u}_{i12} = \max(\tilde{u}_{110},\tilde{u}_{210},\tilde{u}_{310},\tilde{u}_{410},\tilde{u}_{510},\tilde{u}_{610},\tilde{u}_{710},\tilde{u}_{810},\tilde{u}_{910},\tilde{u}_{1010},\tilde{u}_{1110},\tilde{u}_{1210}) =$$

$$= \tilde{u}_{510} = (0.086,\ 0.129,\ 0.172)_{0.129}$$

Table 8

The values of specific indicators fuzzy ranking method maxi-max

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
$\tilde{M}_j$	0.031	0.064	0.035	0	0.046	0.064	0.064	0.107	0.086	0.086
	0.062	0.107	0.058	0.043	0.062	0.107	0.107	0.15	0.129	0.129
	0.078	0.107	0.07	0.107	0.093	0.172	0.15	0.193	0.172	0.172
	0.058	*0.096*	*0.055*	*0.048*	*0.066*	*0.113*	*0.107*	*0.15*	*0.129*	*0.129*

Centralization of the 12 fuzzy numbers are found in, where we can observe the following hierarchy of risk factors:

$$0.150 > 0.129 = 0.129 > 0.113 > 0.107 > 0.096 > 0.066 > 0.058 > 0.055 > 0.048$$

$$\mathbf{F8 > F9 > F10 > F6 > F7 > F2 > F5 > F1 > F3 > F4}$$

The maxi-max method risk factor with minimal impact on the holding by F4 and with the highest risk factor is represented by F8.

c) Method Wald

The indicator is calculated Wald specific method through formula: $\min_{1 \le i \le m} u_{ij}$

W_j indicator Wald's specific method is obtained by choosing the smallest utilities column.

Minimum fuzzy numbers are either choose the columns comparing Table 6 centers of gravity:

$$\tilde{W}_1 = \min_{1 \le i \le 10} \tilde{u}_{i1} = \min(\tilde{u}_{11}, \tilde{u}_{21}, \tilde{u}_{31}, \tilde{u}_{41}, \tilde{u}_{51}, \tilde{u}_{61}, \tilde{u}_{71}, \tilde{u}_{81}, \tilde{u}_{91}, \tilde{u}_{101}, \tilde{u}_{111}, \tilde{u}_{121}) =$$

$$= \tilde{u}_{61} = (0,\ 0.008,\ 0.025)_{0.01}$$

.....

$$\tilde{W}_{10} = \min_{1 \le i \le 10} \tilde{u}_{i12} = \min(\tilde{u}_{110}, \tilde{u}_{210}, \tilde{u}_{310}, \tilde{u}_{410}, \tilde{u}_{510}, \tilde{u}_{610}, \tilde{u}_{710}, \tilde{u}_{810}, \tilde{u}_{910}, \tilde{u}_{1010}, \tilde{u}_{1110}, \tilde{u}_{1210}) =$$

$$= \tilde{u}_{810} = (0.006,\ 0.01,\ 0.014)_{0.01}.$$

Table 9

The values of specific indicators fuzzy ranking method Wald

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
$\tilde{W}_j$	0	0.01	0.008	0	0.002	0.002	0.004	0.006	0.01	0.006
	0.008	0.012	0.008	0.002	0.006	0.006	0.006	0.006	0.012	0.01
	0.025	0.014	0.012	0.019	0.008	0.01	0.012	0.012	0.017	0.014
	0.01	*0.012*	*0.009*	*0.006*	*0.006*	*0.006*	*0.007*	*0.008*	*0.013*	*0.01*

By ordering descending indicator values give the following hierarchy of risk factors:

$$0.013 > 0.012 > 0.010 > 0.010 > 0.009 > 0.008 > 0.007 > 0.006 > 0.006 > 0.006$$

$$\mathbf{F9 > F2 > F10 > F1 > F3 > F8 > F7 > F6 > F5 > F4}$$

The interpretation given by Wald's method shows that factor F4 it has the lowest risk and factor F9 has the highest risk.

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