Evaluation of Farmers' Risk Behavior Using a Simplified Multi-Criteria Analysis (ANP)

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Abstract

In the management of livestock farms, many decisions are made about the production cycle. Often these decisions are taken intuitively or on the basis of partial information based on the farmer's experience. The decisions that are made depend on many factors, the mutual influence that is difficult to assess intuitively. Analytic network process is a multi-factor decision model that can be useful in managing livestock farms. The article shows the essence of the model as well as its practical application based on a sheep farm.

Key words: multifactor analysis, Analytic network process, decision making

Оценка на рисковото поведение на фермерите с използването на опростен мултикритериен анализ (ANP)

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Резюме

При управлението на животновъдните ферми се взимат множество решения, свързани с производствения цикъл. Често тези решения се взимат интуитивно или на базата на частична информация, на база на опита на фермера. Решенията, които се взимат, са зависими от множество фактори, взаимното влияние на които е трудно да се оцени интуитивно. Analytic network process е мултифакторен модел за вземане на решение, който може да бъде полезен при управлението на животновъдните ферми. В статията се показва същността на модела, възможността за опростяването, както и практическото му приложение на база на животновъдна ферма за овце.

Ключови думи: мултифакторен анализ, Analytic network process, вземане на решение

1. Multi-criteria Approach

Analytic Hierarchy Process and Analytic Network Process are a part of multi-criteria approach as a decision making models constructed for synthesis of information. Their main benefits are when one have to solve problems that does not have clear quantitative measure, especially when the problem is related to social elements, subjective opinions, etc. The application of both models can be complicated and often requires a complex methodology. Their use in scientific researches is justified, but its application to farmers' business practice is uncomfortable and irrational. Therefore, the main purpose of this article is to provide an opportunity to simplify the AHP and introducing a methodology to use it as a method for assessment of the risk of farmer behavior.

Both the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP) were introduced and their theoretical frame were developed by T. Saaty (Saaty, 2001). Historically and logically the AHP is the first model that appears (Saaty, 1980). AHP can help with weighing of various alternatives according to a set of criteria, when the influences between alternatives and criteria are hierarchical. At the top of the hierarchy is the decision-making goal (Fig. 1).

The Analytic Network Process is a model that allows for considerably greater complexity. It recreates a system that allows dependences not only from a higher to a lower hierarchy toward the alternatives. When using the Analytic Network Process it is possible that dependences are in both directions – from components[1] to alternative or from alternative or from alternatives to the components. Additional dependences between components are possible. That creates a system that is much more complex and is capable to describe in much more details the economic systems, dependences between different players on the market, etc. (Fig. 2)

[1] The term component is used as a synonym to the term cluster.

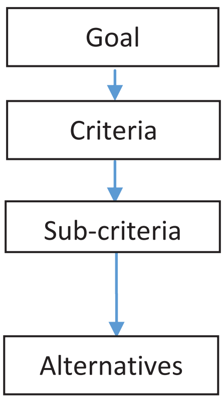

Fig. 1. Analytic Hierarchy Process

In addition, the components may be constituted by elements. When evaluating the influence of components and elements on the alternatives, it is necessary to make pairwise comparisons between the individual elements. These comparisons are maid on a scale from 1/9 to 9, where 1 means that both elements have equal influence on the alternatives, 9 means that the factor on the row has very strong influence and the factor on the column has no influence, 1/9 means that the factor on the column has very strong influence and the factor on the row has no influence. In table 1 are summarized possible scores and their explanation for the estimation of the elements.

Possible applications of ANP can be very wide. It can be successfully used for solving decision problems in private corporations, public issues, military and conflict decisions, forecasting, market share estimation (Saaty, Vargas, 2006)

2. Application of ANP Farm Management Model

While using ANP it is very important the definition of the alternatives. We decided to use as alternatives the Gross Margin. To demonstrate how it can be useful we are going to use a sheep farm

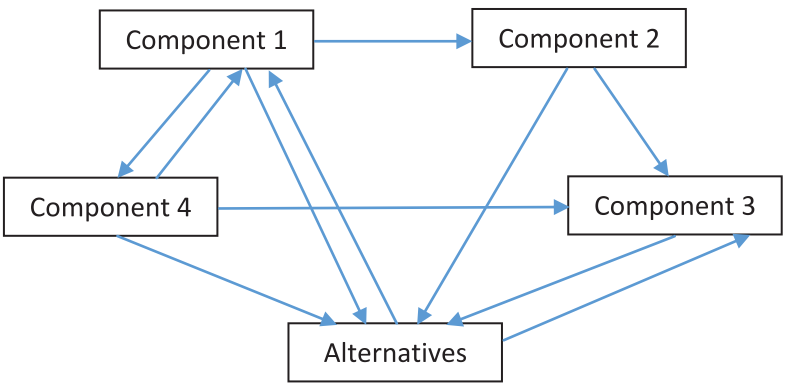

Fig. 2. Analytic Network Process

Table 1. The scale for estimation (Saaty, Vargas, 2006)

Numerical	Intensity of Importance	Definition Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

as an example. During application of the model it is faced a very practical problem. If it is used a large number of alternatives, which is above 4 or 5 the number of estimations that the farmer have to make later grows significantly. That is why the final decision about the number of alternatives are 3 and they are:

• Alternative 1: Nominal Gross Margin – that is the GM calculated from the farmer based on his real results;

• Alternative 2: Pessimistic Gross Margin – that is the GM calculated from Nominal GM minus certain % of the GM (the % is defined by the farmer);

• Alternative 3: Optimistic GM – that is the GM calculated from Nominal GM + certain % of the GM.

The second step is to arrange the components or clusters of dependencies and the elements of the components. After a series of consultations with sheep farming specialists we have defined the following components: income, food, work.

Although there is other important groups of influences, we have decided to show only these 5, which have highest influence from the point of view of GM of a sheep farm. The clusters and their dependences are shown on Figure 3. As it is shown the alternatives depends form all clus-

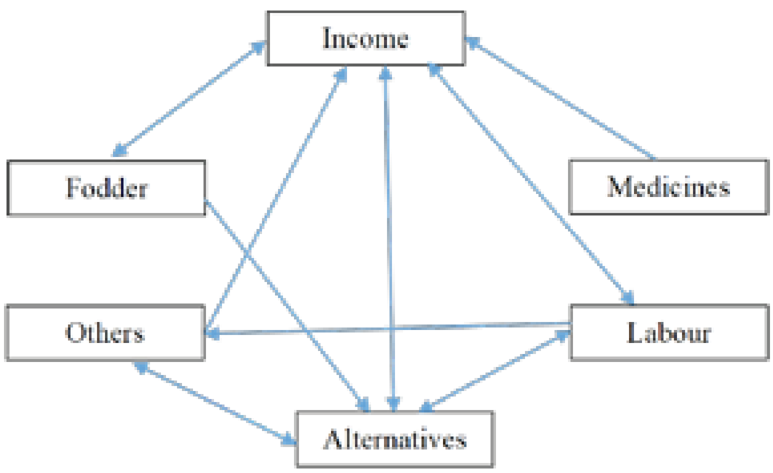

Fig. 3. Application of an Analytic Network Process in a sheep farm

ters but also some of the clusters depends from the alternatives (Income). One can observe that from the arrow. If the arrow points in both directions that means that cluster influences alternative and the alternative influences the cluster too. In our particular case if we take for example the Income cluster. It is obvious that the level of income can influence the alternatives (i.e. Gross Margin). From other point of view if the farmer requires higher Gross Margin he should be aware of the amount of the incomes. That is how the influence can go from clusters to the alternatives and back.

It is observed not only dependences between alternatives and clusters but between clusters too. On Figure 3 they are shown as arrows between clusters. The direction of the arrows shows the direction of dependence. If it is in one direction the dependence goes from one cluster to the other. If the arrow goes in both directions then the dependence goes from one cluster to the other but the second influences the first too (that kind of influence exist between clusters Income ↔ Fodder and Income ↔ Labor in that particular case shown on Figure 3).

Once clusters have been defined, the elements of each cluster have to be defined too. For example the cluster Income has the elements: direct sales, sales of a processed milk and dairy milk. The elements of all clusters are shown in Table 2.

Every element in any cluster can influence any other element in all clusters. The influence of the elements over the other elements of the network can be represented by a matrix, which is known as a supermatrix. The supermatrix of a sheep farm is represented in Table 3. Not all cells of the supermatrix have to be filled in with estimations. We have to create only the matrixes of dependences between clusters and elements that we find an influence. These are the same influences that we have outlined in Figure 3.

• The colored leading rows and columns represent different clusters and elements. The gray area inside are the matrixes that have to be estimated.

Cluster numbers are: 1 – Income, 2 – Food, 3 – Medicines, 4 – Labor, 5 – Other, 6 – Alternatives;

Element numbers are: 1A – Direct sales; 1B – Sales of a processed milk; 1C – Dairy milk; 2A – Coarse feed; 2B – Concentrated food; 2C – Juicy food; 4A – Farmer; 4B – Employees; 5A – Utility costs; 5B Milk Processing; 6A – GM -10%; 6B – GM; 6C – GM +10%.

There is a problem of a practical nature here. Each arrow, which can be seen in Figure 3, must be evaluated with a series of matrixes, which are represented in Table 3 with cray area. If the arrow is in both directions – the number of matrices is doubled. The number of matrixes depends form the number of elements in the clusters. Additionally each matrix consists of multiple estimations. For example if we evaluate the matrix of the dependences between Income and Alternative clusters we will have 6 different matrix to evaluate. Each matrix consist from 3 independent estimations. As you can imagine the number of evaluations grows exponentially with number of clusters and dependences between them. For our case that means that 31 matrixes that should be created, every matrix with a number of estimations (Table 3). Our opinion is that in practice the farmers will not make so much estimations or will make estimation automatically which can make the estimation invalid.

In order to solve this problem, we decided to further assess the dependencies between clusters and classify them as strong and weak dependen-

Table 2. Elements of the components (clusters)

Income	Food	Medicines	Labor	Other
Direct sales	Coarse feed		Farmer	Utility costs
Spot market	Concentrated food		Employees	Milk processing
Dairy products	Juicy food			

cies. After the assessment we classified as strong only 3 clusters (besides the alternatives): Income, Food and Labor and the influences between them are shown of Figure 4.

After the creation of the supermatrix with reduced number of clusters, the number of matrices for estimation lowers to 22 (Table 4).

Cluster numbers are: 1 – Income, 2 – Food, 3 – Labor, 4 – Alternatives;

Element numbers are: 1A – Direct sales; 1B – Sales of a processed milk; 1C – Dairy milk; 2A – Coarse feed; 2B – Concentrated food; 2C – Juicy food; 4A – GM -10%; 4B – GM; 4C – GM +10%.

If the supermatrix is solved in this way, that means all clusters have an equal weight. It is logical to assume that clusters have a different weight in the final evaluation of alternatives. Therefore,

Table 3. Visualization of the cluster matrix

		1			2			3	4		5		6		
		1A	1B	1C	2A	2B	2C		4A	4B	5A	5B	6A	6B	6C
1	1A														
	1B														
	1C														
2	2A														
	2B														
	2C														
3															
4	4A														
	4B														
5	5A														
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6	6A														
	6B														
	6C														

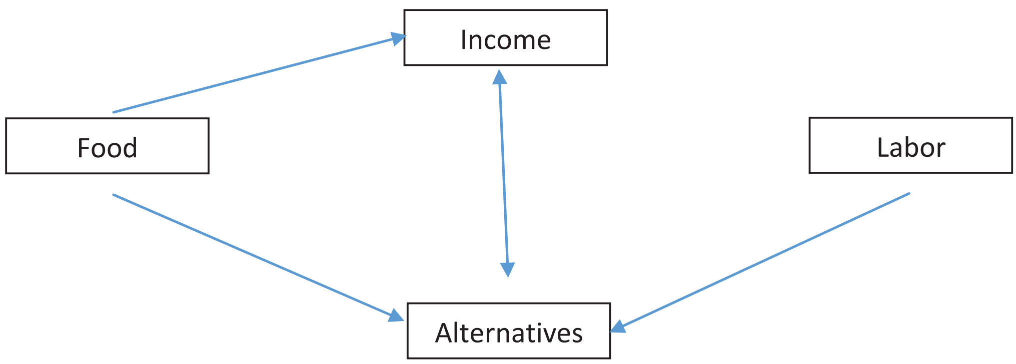

Fig. 4. Clusters and dependences of a sheep farm with reduced number of clusters

Table 4. The reduced number of dependences between clusters and elements

		1			2			3	4		
		1A	1B	1C	2A	2B	2C	3A	4A	4B	4C
1	1A										
	1B										
	1C										
2	2A										
	2B										
	2C										
3	3A										
4	4A										
	4B										
	4C										

a cluster matrix is created that assesses the degree of impact of individual clusters. The cluster matrix is assessed by experts and is not set by the farmers. The cluster matrix for a sheep farm is shown on Table 5.

After calculating the cluster matrix, the initial supermatrix is weighted with the farmer's estimates and the final weights of the alternatives are calculated (Table 6). According to the answers of the farmers the optimistic GM (GM + 10%) gets 54%, the nominal GM is 24% and pessimistic GM is 21%.

If we look only at the results, we would not be able to make a meaningful conclusion. That is why we propose a procedure and assessment scale based on these results to assess the farmers' score and to assess the degree of risk behavior of the farmer.

For this purpose we first estimate the difference between the expected and the nominal gross margin. The nominal gross margin is calculated on the basis of the results of a real sheep farm. In our example it is 0.37 lv. The expected gross margin we estimate based on the weights of the alternatives in Table 6. The value of expected GM is 0.3821 lv.

Indicator	Deviation	Value	Weighted GM
GM	-10%	0.33 lv.	0.07 lv.
GM	nominal	0.37 lv.	0.09 lv.
GM	+10%	0.41 lv.	0.22 lv.
		Expected GM	0.38 lv.

The next question we need to answer is whether the deviation between nominal and expected GM is high or low. For that purpose we estimate the difference between estimated and nominal GM as a present using the formula:

Table 6. The weights of the alternatives after solving the supermatrix

Pessimistic GM -10%	21%
Nominal GM	24%
Optimistic GM +10%	54%

$$D = \frac{GM_n - GM_e}{GM_n} \quad (1)$$

Where,

D is the % difference between expected and nominal GM;

GM_n is the nominal gross margin;

GM_e is the expected gross margin.

Using formula (1) we can calculate D:

D = (0.3821 – 0.37)/0.37 = 3.3%

We can estimate whether the behavior is risky or not using the scale in Table 7. According to it the D = 3.3% the behavior of the farmer is risk free.

Based on the answers of the farmers and its aggregation from the ANP model we can say

Table 7. The assessment scale for estimating the risk profile of a farmer

Deviation (D)	Risk profile
Less then – 50%	Extremely risky behavior
From -50% to -30%	Very risky behavior
From -30% to -10%	Moderate risky behavior
From -10% to +10%	Risk free behavior
From +10% to +30%	Moderate risky behavior
From +30% to +50%	Very risky behavior
More than +50%	Extremely risky behavior

Table 5. Cluster matrix of a sheep farm

	Income	Food	Labor	Alternatives
Income	0,396901	0,172716	0,162601167	0,310524
Food	0,187244	0,31685	0,315887249	0,252453
Labor	0,293933	0,363205	0,180932795	0,278464
Alternatives	0,121921	0,147229	0,34057879	0,158559

that the farmer is well aware with the technology for managing the sheep farm. The different options related with the operative management of the sheep farm probably will not bring risk to the farm.

3. Conclusions

The present research studies the possibility of using ANP to assess the risk behavior of the farmers. One of the main problems for using ANP is its complexity, which leads to its relative incomprehensibility and time consuming practical application. The article addresses that problem and proposes a simplified methodology for the application of ANP. The methodology is based on gross margin measurement and estimating the expected gross margin based on the answers given by the farmers. The difference between the nominal and expected gross margin can be interpreted as a risk. A scale for estimating the risk from farmer behavior has been introduced. The scale consist from four degrees from extremely risky to risk free behavior.

The model can be used for estimation of the risky behavior of the farmer from different credit institutions, state institutions, researchers, etc.

The application of ANP can be very difficult from empirical point of view. It requires deep understanding of the model, complicated mathematical calculations and management experience. The simplification of the model that we apply here makes the model usable and easy for understanding.

Additionally, there exist softwares that can help the empirical application of the model, for example GoMo: www.gomo.bg

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