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An Alternative Criteria Research Methodology for Selecting a New Product

Milan Nikolić[1], Zvonko Sajfert[1] and Branka Nikolić[2]

[1]University of Novi Sad, Mihajlo Pupin Technical Faculty, 23000 Zrenjanin, Djure Djakovića bb, Serbia and Montenegro, bmnikolic@ptt.yu; z.sajfert@eunet.yu
[2]Sonja Marinković Primary School, 23000 Zrenjanin, Teplička 7, Serbia and Montenegro, bmnikolic@ptt.yu

Metodologija za analizo kriterijev alternativ ob izbiri novega proizvoda

Prispevek obravnava metodologijo uporabljeno pri raziskavi kompleksnih problemov pri poslovnem odločanju: določitev relativne pomembnosti kriterijev ob izboru novega proizvoda. Metodologija podpira generiranje predlogov za definicijo relativne pomembnosti kriterijev in podkriterijev za izbiro novega proizvoda glede na trenutno situacijo v podjetju (ki izbira nov proizvod) in stanje. Z uporabo predlagane metodologije lahko določimo vpliv relativne pomembnosti kriterijev za izbor novega proizvoda na stopnjo uspešnosti podjetja. Zaradi omenjenega ima celotna procedura dinamičen značaj in je lahko uporabljena v različnih situacijah ter ob različnih časih opazovanja. Oblikovani predlogi predstavljajo vhodne podatke ter podporo sledečemu večkriterijskemu rangiranju alternativ za nove proizvode.
Metodologija je potrjena v praksi vendar pričujoči prispevek ne podaja podrobnosti v zvezi s tem, saj je cilj prispevka predstavitev raziskovalne procedure na področju določitve kriterijev pri izboru novega proizvoda kakor tudi opredelitev pomembnosti le-te. Poleg tega je uporabljena procedura pomembna zaradi svoje univerzalnosti saj jo lahko uporabimo pri opredelitvi kriterijev v drugih odločitvenih situacijah z ali brez dodatnih sprememb.

Ključne besede: metodologija, raziskave, kriteriji za izbiro novega proizvoda

1 Introduction

One of the most significant problems in business decision-making is the selection of a new product, which usually has to be performed on the basis of a larger number of criteria. That is why various multi-criteria analysis methods are frequently applied (AHP, PROMETHEE, and others). Selecting a new product is not only important for the survival and future of every company, but it also presents an extremely complex task because of the range of this problem area and a large number of influential values which are of a prevailingly stochastic character. Complexity and subjectivity are particularly prominent in the procedure of assigning relative values to criteria when selecting a new product.

Existing research of the criteria for selecting a new product (indices of the future success of a product) mainly deal with singling out several such indices and determining the intensity of their influence. Then potentially new products are compared with these indices, and the product with the best assessments is adopted. This is the basic idea in much important research which has been carried out in this way, for example (Cooper & Kleinschmidt, 1987; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1987; Parry & Song, 1994).

However, it is very difficult, almost impossible, to make a universal model (a model which could be suitable for a large number of companies) for defining the relative importance of criteria when selecting a new product. In the research carried out in (Nikolić, 2004), the initial hypothesis was that every company is a multi-dimensional system, with its specificities and characteristics which have direct influence on assigning certain levels of importance to individual criteria. As a consequence of this, there is the question of variability of the importance of individual criteria that depend on numerous characteristic features of the company, and above all, the company's degree of success. Furthermore, if one takes into account the fact that a company is a dynamic system in which there are constant numerous changes, as well as changes in its setting, then there is the question of variability of importance of some criteria in time, for one and the same company.

Furthermore, it must not be overlooked that the existing research, for example (Cooper & Kleinschmidt, 1987; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1987), mainly refers to countries with developed economies. Hence, it follows that the results of this research especially favour the indices related to the originality and attractiveness of a product, user's needs and the like, whereas indices related to the very capacities of the company, above all financial, are largely ignored. As a consequence of this, similar research in the countries in transition must take into account more seriously the financial capacities of both the company and the market.

Because of all this, a special research methodology has been developed to research the relative importance of the criteria for selecting a new product, taking into account the above-mentioned difficulties. This methodology is essentially based on expert methods and fuzzy sets theory.

2 Alternative research methodology of criteria for selecting a new product

The main difference between this methodology and some existing research, for example, (Cooper & Kleinschmidt, 1987; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1987; Parry & Song, 1994), is that the methodology proposed here highlights the importance of defining precisely at the start the criteria for selecting a new product, and that they are fixed. Therefore, the objective of the research is not to determine which criteria are important and to what level they are important, but to research the importance of predetermined criteria depending on the characteristics of a company and its setting. What has contributed to such formulation is the concept that the criteria are generally the same and that they can be defined on the grounds of existing knowledge, and that a more significant problem is that these criteria do not have the same importance for all companies and in all conditions. So, the stress is laid on establishing the dependence of importance of criteria for selecting a new product on the company's degree of success and the conditions in its setting. What characterizes the proposed methodology is that the research can be repeated and realized for different groups of criteria when it is necessary, or in the case of a different approach. The ultimate objective is to determine the recommendations on the basis of which every company could define the importance (relative weights) of the criteria according to its own characteristics at a given point of time.

The proposed research methodology of the criteria for selecting a new product foresees an eight-step procedure. Detailed descriptions of each step follow.

Step One: Selection of criteria and sub-criteria for selecting a new product

In this step, the criteria for selecting a new product are defined . These criteria are researched in the further procedure. The methodology that is presented here also foresees defining the sub-criteria for each criterion (one can also work without any sub-criteria).

Step Two: Selection of parameters which influence the selected criteria and sub-criteria

In step two the parameters which have influence on the selected criteria and sub-criteria for selecting a new product are identified . These parameters are in reality the characteristics of companies influencing the importance of a particular criterion. Certain parameters can simultaneously influence a larger number of the selected criteria. The parameters have the greatest importance in the last step, step eight, as well as when applying the results of the research, which will also be discussed in a further presentation.

Table 1 was formed with the aim of illustrating mutual dependence between the criteria for selecting a new product and the parameters which describe these criteria.

Table 1: Mutual dependence of the criteria for selecting a new product and the parameters that describe these criteria

	Criteria				
	C_1	C_2	C_3	...	C_p
Parameters which describe the selected criteria	X_{11}	X_{21}	X_{31}	...	X_{p1}
	X_{12}	X_{22}	X_{32}	...	X_{p2}
	X_{13}	X_{23}	X_{33}	...	X_{p3}
	...	...	...	...	...
	X_{1n}	X_{2n}	X_{3n}	...	X_{pn}

Labels in Table 1 have the following meanings:

C_i – criterion for selecting a new product, where: i = 1, 2, 3, ..., p – the number of the observed criterion

X_{ij} – j-th parameter which describes the i-th criterion, where j = 1, 2, 3, ..., n – the number of the observed parameter. It should be pointed out that the parameter numbers which describe particular criteria (represented by 'n') do not have to be in any way equal for all the criteria. The number of these parameters depends on the criterion itself.

Step Three: Polling of experts in the field of product development (Survey 1)

Each criterion is described with a certain number of influential parameters. However, the importance of these parameters (within each criterion) does not have to be the same and it is usually not the same: some parameters have a greater influence, and some less. For this reason, it is necessary to determine relative weights of the selected parameters within the framework of each criterion separately. These weights are used in step eight when determining the similarity value of the companies which belong to the same classes, as when applying the models.

Relative weights of the selected parameters which influence the criteria and the sub-criteria for selecting a new product are determined on the basis of the opinion given by the experts in the field of product development. The necessary opinions are collected through the survey (Survey 1). The polled are asked to evaluate each parameter with an assessment in the intervals between 0 and 10. This assessment should represent the quantitatively expressed strength of influence of a particular parameter on the importance of the observed criterion for selecting a new product.

In view of the fact that some parameters can have influence on more criteria, such parameters ought to be assessed more than once. In other words, the same parameter can have a different influence on the importance of different criteria.

The research related to determining the relative weights of the parameters for each criterion should be entrusted to experts from scientific institutions and to experts from the companies who deal with the problems of company development, and especially product development. Those polled should be organization engineers, managers, mechanical engineers, economists, technichians, etc .

Step Four: Determining relative weights of the selected parameters for each criterion

In this step, processing of the data provided in the previous step is carried out. All the parameter assessments (given by the experts) are translated into fuzzy assessments, or the interval [0, 1], through the function $y = x / 10$, where: $x \in [0, 10]$. Fuzzy assessments of each parameter for a particular criterion are observed. A set is formed from these fuzzy assessments, and processing is performed with this set by determining the average value of the set. The obtained average values represent the final fuzzy assessments of all the parameters for each criterion.

The final fuzzy assessment of the parameters within one criterion represent the input data for determining the relative weights of the parameters for that criterion. In the process, one of numerous procedures can be applied; like, for example (Leskinen, 2000; Noghin, 1997; Podinovski, 2002) and others. An original approach is applied in (Nikolić, 2004), which is also presented in (Nikolić & Sajfert 2004). In this way relative weights of parameters within each criterion are obtained separately. These are values w_{ij} – relative weight of the j-th parameter for the i-th criterion (item 2.1.). They are applied in step eight, and also when applying the research results (item 3.).

Step Five: Polling company managers (Survey 2)

This is the step in which polling of company managers in certain companies is carried out (Survey 2). The basic characteristics of polling in this case are:

1. *Company Type.* In order to focus on the problem, it is necessary to select the subject of the research in the form of the type of company which will be researched. In (Nikolić, 2004), a research which applied the proposed methodology was carried out for the companies in the food processing industry. The rationale is that food industry is the most vital part of the economy of Serbia and Montenegro, in addition to being the part of economy with the greatest potential.
2. *The Polled*. The polled must be at high-level leading positions in companies so that they can have insight in the company's business results, its development strategy, and the like. It is assumed that they are university-educated, and are by vocation economists, managers, mechanical engineers, technologists and similar. In a further text, those polled who answer questions in Survey 2 will be called 'managers'.
3. *Number of Managers*. For the scope of getting reliable and relevant data, it is foreseen that it is necessary to poll N = 150 - 200 managers.
4. *Research Domain in Geographical Terms.* Research must also include the plan of the area in which the research would be carried out.

The research requires asking two groups of questions:

1. Questions that can provide the data about all the identified parameters (characteristics) of the company describing the selected criteria. Those polled will be required to quantitatively assess the required parameters in the assessment range between 0 and 10. It is very important that those polled assess the parameters according to the current state of the company.
2. Questions which provide the data on all the selected criteria and sub-criteria. Those polled will be asked to quantitatively assess the importance of the criteria and sub-criteria with one single assessment in the range between 0 and 10. It is also very important that the subjects assess the criteria and sub-criteria according to the current state in that company and its setting.

The primary objective of this survey is to establish the mutual dependence between parameters and criteria. That is why stress is laid on the subjective opinion of an individual (manager), and the company is in the background serving as the framework in which an individual forms his/her opinion.

Step Six: Ranking of companies into classes according to the relative importance of the criteria

Ranking of companies into classes is carried out at the level of a single criterion, i.e., for each criterion separately. It is essential that the ranking be carried out according to the size of the relative importance of the observed criterion in relation to other criteria.

The managers, according to their opinion, quantitatively assess the importance of the criteria with one assessment ranging from 0 to 10 (step five). These assessments are translated into the interval [0, 1] by means of the function $y = x / 10$, where $x \in [0, 10]$ (columns $FA(C_i)$ in Table 2). Determining the criterion's relative importance for a manager is carried out according to the fuzzy assessment ($FA(C_i)$). In order to do this, one of the following procedures can be applied (Leskinen, 2000; Noghin, 1997; Podinovski, 2002) and others (original approach is applied in (Nikolić, 2004), which is also presented in (Nikolić & Sajfert 2004)). This is repeated for every polled manager separately (columns w_{Ci} in Table 2).

Then, companies (managers' opinions) are ranked according to the size of the relative importance of the observed criterion, starting from the highest to the lowest. The total number of companies is divided by the desired number of classes and the number of companies in one class is obtained. For example, if 150 managers were surveyed in companies, and we want to rank them into three classes, then the number of companies in each class is 50. The first 50 companies make up the first class, the second 50 companies the second, and the third 50 companies make up the third class for the observed criterion. This procedure is carried out for each criterion separately. The companies are thus divided into three classes according to each criterion separately:

Class I – Companies whose managers assigned a high fuzzy assessment to the observed criterion in relation to the other criteria, as a result of which the relative importance of the observed criterion is great (for these managers, the observed criterion has a great importance in relation to the other ones),

Class II – Companies whose managers assigned an average fuzzy assessment to the observed criterion in relation to other criteria, as a result of which the relative importance of the observed criterion is average (for these managers, the observed criterion has an average importance in relation to the other ones),

Class III – Companies whose managers assigned a low fuzzy assessment to the observed criterion in relation to other criteria, as a result of which the relative importance of the observed criterion is low (for these managers, the observed criterion has an average importance in relation to the other ones).

The classification is carried out according to the relative weights of the criteria, and not according to the fuzzy assessments of the criteria because the managers can use different parts of the 0–10 scale. Therefore, what is important is the position of the observed criterion in relation to other criteria, and not only its initial fuzzy assessment.

In a general case, the procedure of ranking the managers into classes is shown in Table 2. The columns with values w_{Ci} are ranked according to the size for each criterion separately.

Table 2: Ranking of managers into classes for all the criteria

Managers	Criterion assessment according to the managers' opinion with calculation of the criteria relative weights for each manager individually									
	FA(C_1)	w_{C1}	FA(C_2)	w_{C2}	FA(C_3)	w_{C3}	…	…	FA(C_p)	w_{Cp}
M_1										
M_2										
M_3										
…										
M_N										

Labels in Table 2 have the following meaning:
M_k – the k-th polled manager, where k = 1, 2, 3, ..., N – ordinal number of the observed manager,
FA(C_i) – fuzzy assessments of the i-th criterion for each manager from k = 1, 2, 3, ..., N,
w_{Ci} – the relative weight of the C_i criterion for each manager from k = 1, 2, 3, ..., N.

It is proposed here that the number of classes be S = 3. When determining the number of classes it was certain that the number of classes ought to be an odd one in order to have the category *"average"* and several qualitative values on both sides of the average. Seven classes would be far too many, so that the main dilemma was whether the number of classes ought to be three or five. Considering the fact that the planned number of polled managers was N = 150–200 , the number of classes S = 3 is more appropriate, since there would be 50 to 60 companies within one class, which represent a sufficient number for drawing certain conclusions. It would require considerably more managers to form five classes.

Since managers form their opinions on the basis of the characteristics and potentials of their respective companies, the next conclusion is that the companies in one class must have significant mutual similarities. For groups of similar companies within one criterion, it is possible to carry out objective statistical processing of the data obtained.

Step Seven: Statistical processing of the data within each class for each criterion separately

Statistical processing of the data provided by polling company managers (Survey 2) is carried out in this step. All the assessments obtained by Survey 2 are translated into fuzzy assessments, that is, the interval [0, 1]. Processing is carried out within each class for each criterion separately. Data processing is carried out in two segments:

1. Determining the criteria fuzzy assessments

Values from one w_{ci} column (Table 2) are ranked according to their size and are divided into the desired number of classes (it is proposed that S = 3 classes), as with dividing into classes (step six). For each class the average of values, w_{ci}, in that class (values $w_{Ci,av,cl}$) is found . The ranking is carried out for each criterion separately, and the average of respective values, w_{ci}, is found for each class within each criterion. It is obvious that in the first class there will always be the highest average, and in the third the lowest. Then follows the fuzzification of these average relative weights for every class of every single criterion. The fuzzification is carried out by applying the function shown on Figure 1.

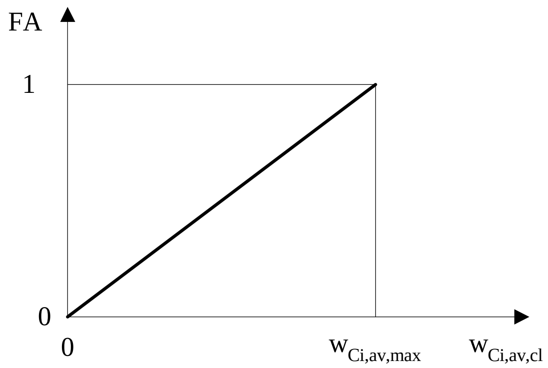

Figure 1: Fuzzification of average relative weights of the criteria for each class

On the graph abscissa on Figure 1 the average criteria relative weights for each class are plotted . The value in relation to which fuzzification is carried out is labelled as $w_{Ci,av,max}$, and it indicates the criterion's maximum average relative weight, for all the criteria average relative weights in all the classes (values $w_{Ci,av,cl}$). Fuzzification is carried out for every average of every class. For example: if there are 12 criteria in a model, and within each criterion the companies are divided into 3 classes, then it is necessary to carry out fuzzification of 36 values. These fuzzy assessments represent the fuzzy assessments of each class of a single criterion, and they are used in the application of the model (described in item 3).

2. Determining the sub-criteria relative weights for each criterion separately

Managers follow their opinion when they quantitatively evaluate the importance of the sub-criteria with one of the assessments from the 0–10 range (step five). These assessments are translated into the [0, 1] interval by means of the function $y = x / 10$, where: $x \in [0, 10]$. The sub-criteria relative weights are determined for each criterion separately, that is, for each class of companies within each criterion separately. In Table 3, an example of the s-th class of the C_i criterion is given. The assessments given by the managers from the s-th class to the sub-criteria of the i-th criterion (columns M_{sik} in Table 3) are entered first. After that, the average value of the fuzzy assessment for each sub-criterion (the column with averages in Table 3) is determined. The sub-criteria relative weights are calculated on the basis of fuzzy assessments of these sub-criteria for each class of that criterion separately. To do that, one of the procedures can be applied, for example: (Leskinen, 2000; Noghin, 1997; Podinovski, 2002) and others. An original approach is applied in (Nikolić, 2004), which is also presented in (Nikolić & Sajfert 2004).

Table 3: Determining relative weights of the C_i criterion sub-criteria for the s-th class

		Managers whose assessments belong to the sth class for the C_i criterion					Average	Relative weight
		M_{si1}	M_{si2}	M_{si3}	…	M_{siH}		
C_i criterion sub-criteria (s-th class)	SC_{i1}				…			
	SC_{i2}				…			
	SC_{i3}				…			
	SC_{i4}				…			
	…				…			
	SC_{iq}				…			

Labels in Table 3 have the following meaning:

M_{sik} – the k-th polled manager from the s-th class for the i-th criterion, where k = 1, 2, ..., H – the number of the polled company from the s-th class for the i-th criterion, H = N / S – the number of managers in one class,

SC_{ir} – the r-th sub-criterion of the i-th criterion, where: r = 1, 2, 3, ..., q – the number of the observed i-th criterion's sub-criterion.

Step Eight: Determining of the company-representative for each class

Step eight is necessary because of the possibility of application of the calculated recommendations in a concrete case.

All the parameter assessments obtained in the fifth step are translated into fuzzy assessments, in other words, into the [0, 1] interval, with the function $y = x / 10$, where: $x \in [0, 10]$. If the assessments obtained for the parameters which affect a single criterion in one company are observed, then these assessments actually represent a fuzzy set of characteristics of the company observed which have influence on a certain criterion and its sub-criteria for that company (C_{ksi} columns on Table 4). Observed at the level of one single criterion for all the companies, there are N fuzzy sets, where N is the the number of analyzed companies.

Note: What is meant as 'company' here is the opinion expressed by the manager which was formed on the basis of the situation in his/her company. That is why the term *company* is used in further text, which is more convenient than the term *manager* for this presentation.

The essence of this step is to determine for each class those companies which are 'most similar' to the companies of its class (within a given criterion). These companies are representatives of their class. The class representatives have parameter values which all other companies of that class aim at. It is adopted that for each class there are three representatives. In this way, greater stability of the results is expected than in the case of each class having one representative. On the other hand, by further increasing the number of the class representatives, a decrease in the representativeness of these representatives can occur.

Table 4: Tabular presentation of fuzzy sets for the companies of the s-th class according to the i-th criterion

Class CL_{si}		Companies of the CL_{si} class				
		C_{1si}	C_{2si}	C_{3si}	...	C_{Hsi}
Parameters which describe the i-th criterion	X_{1i}	μ_{1s1i}	μ_{2s1i}	μ_{3s1i}	...	μ_{Hs1i}
	X_{2i}	μ_{1s2i}	μ_{2s2i}	μ_{3s2i}	...	μ_{Hs2i}
	X_{3i}	μ_{1s3i}	μ_{2s3i}	μ_{3s3i}	...	μ_{Hs3i}
	...	...	...	...	...	...
	X_{ni}	μ_{1sni}	μ_{2sni}	μ_{3sni}	...	μ_{Hsni}

Labels in Table 4 have the following meaning:

X_{ji} – the parameter which describes the i-th criterion, where j = 1, 2, 3, ..., n – the number of the observed parameter,

C_{ksi} – the k_{th} surveyed company from the s-th class for the i-th criterion, where k = 1, 2, ..., H – the number of the company surveyed from the s-th class for the i-th criterion,

μ_{ksji} – degree of membership (fuzzy assessment) of the k-th company from the s-th class, for the j-th parameter, according to the i-th criterion.

Table 5: Determining the similarity measure of each fuzzy set with each other, between the companies belonging to one class

CL_{si} Class		CL_{si} Class Companies					$\sum_{j=1, j\neq k}^{H} m_{kji}$	m_{srk}
		C_{1si}	C_{2si}	C_{3si}	...	C_{Hsi}		
Companies in the PI_{si} subinterval	C_{1si}	-	m_{12i}	m_{13i}	...	m_{1Hi}	$\sum_{j=1, j\neq k}^{H} m_{1ji}$	m_{sr1}
	C_{2si}	m_{21i}	-	m_{23i}	...	m_{2Hi}	$\sum_{j=1, j\neq k}^{H} m_{2ji}$	m_{sr2}
	C_{3si}	m_{31i}	m_{32i}	-	...	m_{3Hi}	$\sum_{j=1, j\neq k}^{H} m_{3ji}$	m_{sr3}
	...	...	...	...	-	...		...
	C_{Hsi}	m_{N1i}	m_{N2i}	m_{N3i}	...	-	$\sum_{j=1, j\neq k}^{H} m_{Hji}$	m_{srH}

Labels in Table 5 have the following meaning:

C_{ksi} – the k-th polled company from the s-th class for the i-th criterion, where k = 1, 2, ..., H – the number of the company surveyed from the s-th class for the i-th criterion,

m_{kji} – the similarity measure of the k-th company to the j-th company, according to the i-th criterion. The similarity measure takes its value from the [0, 1] interval. In the process, equality $m_{kji} = m_{jki}$ still applies.

$\sum_{j=1, j\neq k}^{H} m_{kji}$ - sum total of the measures of similarity of the k-th company in relation to the other companies from the s-th class,

m_{srk} – average similarity measure of the k-th company in relation to the other companies from the s-th class. It is calculated in the following way:

$$m_{srk} = \frac{\sum_{j=1, j\neq k}^{H} m_{kji}}{H-1} \qquad (1)$$

The method of processing in step eight can be represented with Tables 4 and 5. For each class of companies (the companies in which the observed criterion is equally important), there is H of fuzzy sets, where H – the number of companies (managers) in one class. This is shown in Table 4.

After forming Table 4, the similarity measures of each fuzzy set to each other within the companies of one class are determined, and the results are entered in Table 5. The companies are compared with themselves. The expression (3) is used to determine the degree of similarity.

The class representatives are three companies which have the highest average similarity measures in relation to the other companies from the same class, which is manifest from the last column in Table 4. The procedure is repeated for all the classes within one criterion, and the same is then repeated for all other criteria.

2.1 Fuzzy measure selection and defining

The right selection of the fuzzy measure that will be applied in the research represents a special problem. When defining the corresponding fuzzy measure, the references which treat the area of multi-criteria decision-making and fuzzy sets (Pedrycz & Gomide, 1998; Royo & Verdegay, 2000; Triantaphyllou, 2000) were particularly useful. On the basis of this, and based on the needs and specificities of the given research, a fuzzy measure was defined which rests on Hamming's distance:

$$m_{abi} = 1 - \frac{\sum_{j=1}^{n} \left| X_{jai} - X_{jbi} \right|}{n_i} \quad (2)$$

where:

m_{abi} – the similarity measure of the a-th company to the b-th company according to the i-th criterion,

X_{jai} – fuzzy assessment of the j-th parameter for the a-th company according to the i-th criterion,

X_{jbi} – fuzzy assessment of the j-th parameter for the b-th company according to the i-th criterion,

n_i – the parameter number of pairs, that is, the number of parameters which describe the i-th criterion.

The subtrahend in expression (2) represents, in fact, the average difference (distance) between the a-th and the b-th company according to the i-th criterion.

In order to determine more objectively the similarity measure, expansion of the previous expression is introduced, which takes into account the relative weights of individual parameters within the same criterion.

$$m_{abi} = 1 - \frac{\sum_{j=1}^{n} \left| X_{jai} - X_{jbi} \right| \cdot W_{ij}}{n_i} \quad (3)$$

where:

W_{ij} – proportional (expanded) relative weight of the j-th parameter for the i-th criterion.

$$W_{ij} = w_{ij} \cdot n_i \quad (4)$$

where:

w_{ij} – the relative weight of the j-th parameter for the i-th criterion. These weights for all the parameters within all the criteria are obtained in the step four, on the basis of Survey 1 (step three).

In the expression (3), W_{ij} values must be used, because in this case there is no unreal increase in the similarity measure. If the w_{ij} values were used, there would be unreal decrease in the average difference, and with it the unreal increase in the degree of the similarity measure.

2.2 Presentation of the final research results

The final results of the research can be presented in table form (Table 6). A table showing elements contained in Table 6 is formed is created for each criterion.

Table 6: Presentation of the final research results in a general case (for the C^i criterion)

CL_{si} Class	Parameter values of all the representatives of the C_i class criterion (determined in step eight)				C_i criterion fuzzy assessments for each class (determined in step seven)	Relative weights of all the C_i criterion sub-criteria for each class (determined in step seven)			
	X_{i1}	X_{i2}	...	X_{in}		SC_{i1}	SC_{i2}	...	SC_{iq}
I									
II									
III									

3 Application of th research results

What is understood under ‘application of the research results’ of the criteria and sub-criteria is the procedure of determining the fuzzy assessments of all the criteria and relative weights of their sub-criteria for a concrete company (the company which is selecting a new product) in the current conditions. The procedure is the following:

1. The managers from a concrete company assess their own company according to all the required x_{ij} parameters (like the managers in the first part of Survey 2 - step five did). The assessments are awarded for the current state in the company and its setting. These are the n_{ji} values, which are entered in the last row of Table 7.
2. Fuzzy sets are formed from the given assessments for each criterion separately (elements of these fuzzy sets are parameter values for a corresponding criterion). Then, the fuzzy set for one single criterion is compared with the fuzzy sets of representatives of all the classes within that criterion through the selected fuzzy measure, expression (3). The similarity measures are added up for every three representatives of each class (the Sm_{si} values in the last column in Table 7). The class within this criterion with which the concrete company has the highest collective similarity measure is finally adopted. This procedure is shown in Table 7.

Table 7: Determining the highest collective similarity measure of a concrete company (CC) with the representatives of all the C^i criterion classes

Class CL_{si}	Parameter values of all the C_i criterion class representatives with				Similarity measures of a CC and representatives of all the C_i criterion class representatives	Collective simil. measures of the i-th criterion’s s-th class
	X_{i1}	X_{i2}	...	X_{in}		
	W_{i1}	W_{i2}	...	W_{in}		
I	μ_{1I1i}	μ_{1I2i}	...	μ_{1Ini}	$m_{1,I,i}$	$\Sigma m_{I,i}$
	μ_{2I1i}	μ_{2I2i}	...	μ_{2Ini}	$m_{2,I,i}$	
	μ_{3I1i}	μ_{3I2i}	...	μ_{3Ini}	$m_{3,I,i}$	
II	μ_{1II1i}	μ_{1II2i}	...	μ_{1IIni}	$m_{1,II,i}$	$\Sigma m_{II,i}$
	μ_{2II1i}	μ_{2II2i}	...	μ_{2IIni}	$m_{2,II,i}$	
	μ_{3II1i}	μ_{3II2i}	...	μ_{3IIni}	$m_{3,II,i}$	
III	μ_{1III1i}	μ_{1III2i}	...	μ_{1IIIni}	$m_{1,III,i}$	$\Sigma m_{III,i}$
	μ_{2III1i}	μ_{2III2i}	...	μ_{2IIIni}	$m_{2,III,i}$	
	μ_{3III1i}	μ_{3III2i}	...	μ_{3IIIni}	$m_{3,III,i}$	
CC – Concrete Company	ν_{1i}	ν_{2i}	...	ν_{ni}		

The labels in Table 7 have the following meaning:

X_{ij} – the j-th parameter which describes the i-th criterion, where: j = 1, 2, 3, ..., n – the number of the observed parameter,

W_{ij} – Extended relative weight of the j-th parameter for the i-th criterion, where: : j = 1, 2, 3, ..., n – the number of the observed parameter,

μ_{ksji} – fuzzy assessment of the k-th representative in the s-th C_i criterion class for the j-th parameter,

ν_{ji} –fuzzy assessment of the k-th representative in the s-th C_i criterion class for the j-th parameter,

m_{ksi} – the similarity measure of a concrete company to the k-th representative of the s-th C_i criterion class.

3. In the last column in Table 7 is required maximum value $S\mu_{si}$ – collective similarity measure of the i-th criterion s-th class. In this way, it is determined which class of companies the concrete company is most similar to according to the observed criterion. A concrete company adopts the recommendations on fuzzy assessment of the observed criterion and relative weights of their sub-criteria (which is obtained by data processing in the Seventh step) for the class of companies it is most similar to. To do this, the structured data from Table 6 are used. The same procedure is repeated for all the criteria. In this way, a concrete company determines the values of fuzzy assessments of all the criteria and the relative weights of their sub-criteria.

The only thing left is to determine the relative weights of the basic criteria. The values of fuzzy assessments of all the criteria serve as the starting point for determining the criteria relative weights. To do this, we can use some of the procedures such as: (Leskinen, 2000; Noghin, 1997; Podinovski, 2002) and others; original approach is applied in (Nikolić, 2004), which is also presented in (Nikolić & Sajfert 2004). With the data on the relative weights of all the criteria and sub-criteria, the procedure of multi-criteria selection of a new product is entered by applying one of the multi-criteria analysis methods.

If it is assumed that there are 12 criteria for selecting a new product which are researched, and that within each criterion there are 3 classes of companies, (like in Nikolić, 2004), then a concrete company can get recommendations for one of $3^{12} = 531441$ possibilities of defining the relative weights of the basic criteria.

4 Examples

4.1 Example of criteria, sub-criteria, and parameters

Example of criteria (Nikolić, 2004):

C_1 - Company Business Policy,

C_2 - Management of spatial capacities,

C_3 - Possession of technological knowledge (know-how),

C_4 - Management of production capacities (machinery, tools, equipment),

C_5 - Supply of Raw Materials,

C_6 - Personnel Potentials,

C_7 - Product Potentials (originality, attractiveness, value for the user and the like),

C_8 - Market Size,

C_9 - Market Needs,

C_{10} - Market Growth and Prospects,

C_{11} - Strength of Competition,

C_{12} - Time period of return of invested funds.

Example of sub-criteria of criterion C_9 - Market Needs (Nikolić, 2004):

SC_{91} - Evaluation of the demand for the new product on the local market,

SC_{92} - Evaluation of the demand for the new product on the national market,

SC_{93} - Evaluation of the demand for the new product on the international market.

Example of some parameters of criterion C_9 - Market Needs (Nikolić, 2004):

X_{91} - Timeliness and reliability of information from the market,

X_{92} - Continuity in information inflow from the market,

X_{93} - Degree of change in consumers' needs,

X_{94} - Degree of acquaintance and awareness of consumers' needs,

X_{95} - Consumers' satisfaction with company's existing products, etc.

4.2 An example of application of the research results

A shortened example of application of the results obtained by the research is shown in Table 8. The example refers to a single criterion (criterion C_i is viewed here). In Table 8 are shown:

- parameter values for all the three representatives of each C_i criterion class (determined in Step 8),
- values of extended relative weights of all the criterion C_i parameters (expression 4),
- C_i criterion fuzzy assessments (FA) for all classes (determined in Step 7, segment 1),
- relative weights of the C_i criterion sub-criteria for each class (determined in Step 7, segment 2), and
- parameter values for a CC (Concrete Company) (to be assigned by the decision-maker in the company which is selecting a new product).

By applying the procedure from item 3 of the paper, one can determine which class is a CC most similar to according to the observed criterion C_i. In this way, recommendations are obtained on fuzzy assessments of the C_i criterion, and the relative weights of the C_i criterion sub-criteria. In the example given in Table 8, it can be seen that the CC is most similar to the criterion C_i I class. The same procedure is repeated for all the criteria in the model. The criteria relative weights are obtained on the basis of the recommended fuzzy assessments for each criterion. Some of the quoted procedures can be used in the process.

5 Conclusion

Criteria for selecting a new product do not have equal importance (relative weights) for all companies and all settings. There is a mutual dependence between the importance of the criteria for selecting a new product and the company's degree of success and the situation in its setting. That is the reason why an original methodology of research of the criteria for selecting a new product was developed. It enabled obtaining recommendations on the importance of criteria and sub-criteria for selecting a new product, but depending on the current characteristics of a company and its setting.

The most significant characteristic and advantage of the proposed methodology is that with a change of certain conditions inside the company and its setting, there are corresponding changes of exiting the model (recommendations for each criterion) For all this, the whole procedure has a dynamic character and the possibility of application in different situations and at different moments of observation. The company which is selecting a new product obtains the recommendations according to its current state and situation in its setting. The recommendations are obtained in the form of fuzzy assessments of the importance of the criteria and their sub-criteria relative weights. The obtained recommendations represent important input data and support for multi-criteria ranking of the alternatives for new products.

The proposed methodology also has its practical value. In (Nikolić, 2004) research of the criteria in food industry was carried out. The research was carried out on the territory of Serbia and Montenegro, more precisely on the territory of Vojvodina and in the Belgrade metropolitan area. The obtained results have significance primarily

Table 8: An example of application of the research results of criterion C_i

Class CL_{si}	Value of parameters of all representatives of classes of criterion C_i: X_{i1} ($w_{i1} = 0.4$, $W_{i1} = 1.2$)	X_{i2} ($w_{i2} = 0.35$, $W_{i2} = 1.05$)	X_{i3} ($w_{i3} = 0.25$, $W_{i3} = 0.75$)	Measures of similarity with CC	FA of criterion C_i for every class	Rel. weights of all crit. C_i sub-criteria for every class: SC_{i1}	SC_{i2}	SC_{i3}
I	0.6	0.7	0.8	0.86	0.9824	0.3142	0.3716	0.3142
	0.7	0.5	0.6	0.9				
	0.5	0.6	0.7	0.88				
	$\Sigma m_{I,i}$			2.64				
II	0.6	0.4	0.6	0.825	0.7083	0.3405	0.3743	0.2852
	0.5	0.6	0.5	0.83				
	0.5	0.5	0.7	0.845				
	$\Sigma m_{II,i}$			2.5				
III	0.4	0.5	0.6	0.78	0.5022	0.3388	0.3885	0.2727
	0.4	0.5	0.4	0.73				
	0.5	0.4	0.4	0.735				
	$\Sigma m_{III,i}$			2.245				
CC	0.8	0.6	0.7					

for the food industry in Serbia and Montenegro, but could also be significant for other countries in transition. With certain alterations, above all at the criteria, sub-criteria and parameter defining stage, the proposed methodology can be applied to research the criteria for selecting a new product in other economies and economic conditions as well. The concrete results of the research are not presented here because of the size of the paper, and above all because of the desire to point to the very procedure of work, its significance, and its universality.

The results obtained by applying the proposed methodology are primarily significant for medium-sized and large companies, although their application in small companies should not be ruled out. In this way, all categories of new products can be ranked: completely new products, products that are new for the company observed, innovated existing products, etc. The results of the research are already applied in the concrete situations of selecting a new product. The products that have been selected in this way achieve very good results on the market and positively influence the company's business. These claims have been confirmed in 12, up to now, situations analyzed.

Additional importance of the methodology presented in this paper is in that its basic principles, with adequate modification, can be used for researching other problems and phenomena in industrial engineering, management, but also in other areas.

Regarding drawbacks of the given methodology, the most prominent is the fact that it is essential to define the criteria and sub-criteria for selecting a new product, as well as the influential parameters. This subjectivity is real, but the stress is laid on the validity of the procedure itself, which can be repeated and realized for different sets of criteria and parameters if necessary. The observed drawback can be significantly reduced, or completely overcome if one uses those criteria which have been identified as the key ones in one of the known research projects. In this respect, the research method of the criteria for selecting a new product proposed here could be accepted as a continuation and addition to similar research.

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Milan Nikolić graduated from the University of Novi Sad, Mihajlo Pupin Technical Faculty in Zrenjanin. He received his master's degree at the same institution in 2001. In 2004 he defended his PhD thesis entitled: "*Quantitative model for selecting a new product with research into relevant criteria*" at the University of Belgrade, Faculty of Mechanical Engineering, Department of Industrial Engineering. In 2005 he became an assistant professor at the same faculty. His basic fields of interest are using quantitative methods and software tools in management with a particular stress on the processes of winning new products and business decision making. He has published more than 30 papers in these fields.

Zvonko Sajfert graduated from the Faculty of Organizational Sciences, University of Belgrade in 1989. From the same faculty, he received his master's degree in 1992, and his doctorate in 1994 with the thesis "*Exploring the influence of the structure of the managers' life aims on the management*". He is currently associate professor at University of Novi Sad, Mihajlo Pupin Technical Faculty in Zrenjanin. He is the author of eleven university level text-books and several secondary school text-books. He has published approximately 60 scientific and expert works. His specific field of interest is human resource management.

Branka Nikolić graduated in 1998 from the University of Novi Sad, Faculty of Science and Mathematics, Department of Mathematics, with a specialization in teaching mathematics. In 2002 she obtained her Master's degree from the University of Novi Sad, Mihajlo Pupin Technical Faculty in Zrenjanin, Department of Computer Science. The title of her Master's thesis was "*Comparison of norms in fuzzy reasoning*". Currently, she works as a mathematics teacher at the Sonja Marinković Primary School in Zrenjanin. She has published approximately 15 papers in the field of fuzzy sets.