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A New Strategic Tool for Internal Audit of the Company Based on Fuzzy Logic

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Abstract. Since the internal audit of the company is essential to supply information needed for the effective management and improvement of the competitive position, the purpose of this paper is to introduce an innovative strategic management tool for the assessment of internal organizational factors that overcomes some limitations of traditional appraisal methods, and also enables more comprehensive evaluation of the company's internal environment. Although the classical Internal Factor Evaluation matrix (IFE matrix) is widely used, it has some constraints, such are lack of considering the ambiguity and vagueness of the internal factors. An original method – FSIF (Fuzzy Synthesis of Internal Factors) represents a systematic approach that incorporates fuzzy logic in order to better describe real situation. Proposed FSIF method well serves the needs of modern Management information system because it provides monitoring of internal development of an organization through time and also comparing different organizations taking into account various factors and weights.

Keywords: Internal factors, fuzzy sets, IFE, FSIF.

1. Introduction

Effective performance of any organization in a modern competitive environment significantly depends on a detailed analysis of internal factors. This is a complex and very important activity for management, since the information obtained in this way might give insight into the current state of resources and overall capabilities of the organization. It represents the basis of any effective strategy and a way of understanding organizational capabilities. The main step in conducting function-by-function analysis is to construct a relevant strategic tool for assessment of major internal factors in

the functional areas of business (e.g. finance, marketing, production/services, human recourse management, research and development, information systems).

In connection to this, a strategy for an organization has to be built from what that organization is. “Neglect of this basic step can result in strategies which appear well founded in relation to the market and the assessments of the future environment, but which cannot be implemented because of ill-founded implicit assumptions about organization itself” (Jenster, Hussey 2001, p. 11 [7]).

Since the internal factors analysis is a vital requirement of strategic thinking, the question of choice of the appropriate method is inevitable. As a qualitative assessment of internal factors cannot give a satisfactory degree of precision, management of the organization should pay a special attention to methods that provide a comparative, quantitative measurement; such that the objects of assessment that are expressed in the form of attributes can be transformed into a quantitative form, expressed as a quantitative variable.

This article is organized as follows. In Section 2, related work is elaborated. In Section 3 original FSIF model is presented. In Section 4 a case illustration is given on which FSIF method and IFE matrix method are compared and discussed and in Section 5 a conclusion is given.

2. Related Work

There are various methods for organizational appraisal aimed to ease some of the subjectivity by introducing weights and ratings into the model. One of the most popular and useful strategic management tool for auditing key internal factors in functional areas of a business is the Internal Factor Evaluation matrix (IFE matrix) proposed by Fred R. David [2,3].

IFE method summarizes internal factors (strengths and weaknesses of the organization) and also provides a basis for identifying and evaluating relationships among the functional areas of a business.

According to David [2,3], IFE matrix answers four major questions about organization:

- What are the organization’s key strengths and weaknesses?
- What is the relative importance of each strength and weakness to the organization’s overall performance?
- Does each factor represent: a major weakness, a minor weakness, a minor strength, a major strength?
- What is organization’s total weighted score resulting from the analysis of the IFE?

IFE matrix can be developed in five steps:

1. Major strengths and weaknesses are listed (all factors should be stated objectively and their number should be from 10 to 20).
2. A weight that indicates relative importance of the factor is assigned (weight should ranges from 0.0 – not important, to 1.0 – all important, and the sum of all weights must equal 1.0).
3. A 1 to 4 rating to each factor is assigned (a major weakness (rating = 1), a minor weakness (rating = 2), a minor strength (rating = 3), a major strength (rating = 4)).
4. Each factor's weight is multiplied by its rating.
5. The weighted scores to determine total weighted score for the organization is calculated (total weighted score well below 2.5 indicate internally weak position of the organization, and scores significantly above 2.5 indicate a strong internal position).

It is important to notice that a factor could present both: a strength and a weakness. In that case, the factor should be included twice in the IFE matrix.

Similar to the IFE matrix is IFAS (Internal Factor Analysis Summary) approach introduced by Wheelen and Hunger [12]. As they pointed out "IFAS table is one way to organize the internal factors into generally accepted categories of strengths and weaknesses as well as to analyze how well a particular company's management is responding to these specific factors in light of the perceived importance of these factors to the company" (Wheelen and Hunger, 2007, p. 129 [12]).

Still, there are limitations of these methods. Assigned four degrees rating to each factor is not always appropriate to real situation (a finer rating is often necessary). Besides, vagueness of the factors is not considered. In addition, the total number of internal factors is limited to 10-20.

In this paper, a new method based on fuzzy logic, for analysis of corporate internal factors is developed to overcome these limitations. Proposed FSIF method illustrates some of the possibilities of fuzzy logic through a simple and easy understandable model that does not require advanced mathematical knowledge.

Although fuzzy set theory and fuzzy logic, as useful tools to grasp uncertainty, have already been exploited in several papers in solving various problems of strategic management ([4], [5], [8], [9], [13]), in this paper we propose original approach to the internal scanning process that can be easily implemented and is adjustable by the user.

The main contribution is that FSIF method enables managers to be better informed about every important aspect of the company's internal environment which leads to the increased effectiveness of the decision making process.

3. Fuzzy synthesis of internal factors - model FSIF

The first step in applying the proposed FSIF method is, similarly as in the classical IFE method, determination of all the relevant internal factors of the organization.

Identification of the most important factors is based on the Company audit questionnaire proposed by Jenster and Hussey [7]. Their questionnaire covers six key functional areas of the organisation, and that is reason why the questions in the questionnaire are listed in the six broad categories: finance, marketing, production, human recourse management and management effectiveness, research and development, and information systems.

In fuzzy model for the internal assessment, questions from the Company audit questionnaire are used as a basis of which we have derived the same number of factors. It stems that derived factors serves only to provide relevant basic inputs for proposed fuzzy appraisal method which enables completely different process of assessment.

It is valuable to notice that importance of the factors can immensely vary between different types of industry, and different sizes of organization within each industry, so it is recommended that management of the organization adjust the list of factors to fit their business.

An advantage of the FSIF method for assessment of the internal factors (in comparison with classical IFE and IFAS methods) is that the number of factors is not restricted, so that managers can use factors according to the situation of their business and evaluate those factors that have strategic influence to the company.

In FSIF method, we propose the use of interval [0,5] in order to keep a certain similarity with the existing techniques of assessment of the organization (IFE), in which it is possible to choose one of four options: 1, 2, 3 or 4. Moreover, the proposed fuzzy model does not limit the total number of internal factors [which is 10-20 in the IFE method], because it does not request the additivity condition.

Let $F_i, i=1,...,n$ be factors that are determined as relevant factors for an organization *O*. Their estimated value is $v_i, i=1,...,n$. This value belongs to interval [0,5]. Four fuzzy sets[1] are defined:

$\overline{MJW}$ – „Major weakness“,

[1] A fuzzy set is a mapping from a set to [0,1] real interval. A function value represents degree of membership of an element to the fuzzy set.

$\overline{MNW}$ – „Minor weakness“,
$\overline{MNS}$ – „Minor strength“ or
$\overline{MJS}$ – „Major strength“.

Depending on the values of factors, the degree of membership of every factor to each of the four fuzzy sets is calculated.

Graphic presentations of the defined fuzzy sets are given in Figure 1. As in the standard method, we can notice the fact that a factor may be at the same time a factor of minor weakness and a factor of minor strength (in different degrees). Factor F_i in Fig. 1 belongs to the set $\overline{MJW}$ with the degree of membership μ_{1i}, while it belongs to set $\overline{MNW}$ with the degree μ_{2i}.

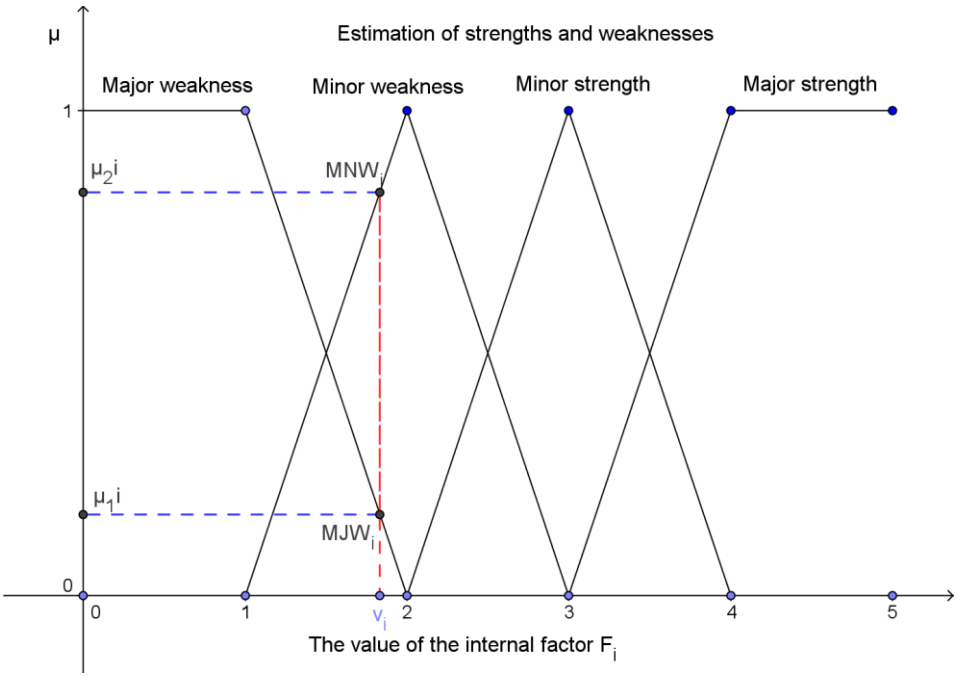


Fig. 1. Estimation of strengths and weaknesses of an organization

Theorem 1. The sum of all the obtained degrees of membership for every factor must be equal to 1. For every factor F_i

$$\sum_{k=1}^{4} \mu_{ki} = 1 \qquad (1)$$

.

Proof. Since we use the triangular fuzzy sets, for a factor F_i with a value *x* membership function μ_{1i} is equal to 1 for x belonging to the interval [0,1]. Further, $\mu_{1i}(x) = -x+2$ is valid for *x* in interval [1,2], and it is equal to 0 in interval [2,4]. Similarly, $\mu_{2i}(x) = x-1$ is valid for *x* in interval [1,2], and also $\mu_{2i}(x) = -x+3$ for x in interval [2,3]. It is equal to 0 for *x* outside interval [1,3]. Similarly we obtain the formulas for other two membership functions.

If the value of the factor is from 0 to 1, the degree of membership to fuzzy set $\overline{MJW}$ is 1, and to all the other fuzzy sets it is 0. If the value belongs to the interval [1,2], then by the symmetry of graphs of functions representing fuzzy sets $\overline{MNW}$ and $\overline{MJW}$ with respect to the line μ=0.5, the degree of membership to fuzzy set $\overline{MJW}$ is equal to 1 minus the degree of membership to fuzzy set $\overline{MNW}$, and the degree related to the remaining two fuzzy sets is equal to 0. We can prove this fact also using the formulas above for fuzzy sets representing the $\overline{MJW}$ andand $\overline{MJW}$. In example, for a factor F_i with the value x belonging to interval [1,2], we obtain:

$$\mu_{1i}(x) + \mu_{2i}(x) = (-x+2)+(x-1) = 1.$$

Analogously, we notice that in the interval [2,3], only two degrees are different from 0 ($\overline{MNW}$ and $\overline{MNS}$) and their sum is equal to 1. In the interval [3,4], the graphs of functions $\overline{MNS}$ and $\overline{MJS}$ are symmetric with respect to the line μ=0.5, therefore sum of related two degrees is equal to 1 and remaining two degrees are equal to 0. We can prove the later two statement also using the formulas for triangular fuzzy sets. Finally, in the interval [4,5] only $\overline{MJS}$ degree is equal to 1 and all others to 0. Therefore over the whole domain, the sum of the degrees is 1. ■

The same procedure is applied to all the relevant factors $F_i, i = 1,...,n$. Each of the factors belongs with a certain degree of membership to $\overline{MJW}$, $\overline{MNW}$, $\overline{MNS}$ and $\overline{MJS}$.

The importance of relevant factors is also taken into account. Here we propose weight to be taken from [0,2] interval, obtaining the ponder that increase or decrease the influence of some of the factors on the overall level of state of the internal environment of the organization. The influence of a factor is decreased if the weight is from the interval [0,1), and it is increased if

the weight is from the interval (1,2]. If the weight is 1, it has no impact on the value of the factor. The obtained data are presented in Table 1.

Table 1. Degrees of membership of internal factors to fuzzy sets

Internal factor	$\overline{MJW}$	$\overline{MNW}$	$\overline{MNS}$	$\overline{MJS}$	Weight
F_1	μ_{11}	μ_{21}	μ_{31}	μ_{41}	α_1
F_2	μ_{12}	μ_{22}	μ_{32}	μ_{42}	α_2
F_3	μ_{13}	μ_{23}	μ_{33}	μ_{43}	α_3
…	…	…	…	…	…
F_n	μ_{1n}	μ_{2n}	μ_{3n}	μ_{4n}	α_n

Multiplying the corresponding degrees of membership of factors F_i to the observed fuzzy sets with the weights of these factors, we obtain the weighted fuzzy membership degrees (Table 2).

Table 2. Weighted fuzzy membership degree

Internal factor	$\overline{MJW}$	$\overline{MNW}$	$\overline{MNS}$	$\overline{MJS}$
F_1	$\alpha_1\mu_{11}$	$\alpha_1\mu_{21}$	$\alpha_1\mu_{31}$	$\alpha_1\mu_{41}$
F_2	$\alpha_2\mu_{12}$	$\alpha_2\mu_{22}$	$\alpha_2\mu_{32}$	$\alpha_2\mu_{42}$
F_3	$\alpha_3\mu_{13}$	$\alpha_3\mu_{23}$	$\alpha_3\mu_{33}$	$\alpha_3\mu_{43}$
…	…	…	…	…
F_n	$\alpha_n\mu_{1n}$	$\alpha_n\mu_{2n}$	$\alpha_n\mu_{3n}$	$\alpha_n\mu_{4n}$

In order to determine the state of the internal environment of the organization as a whole, we find the weighted arithmetic mean of the degrees of membership of factors to fuzzy sets $\overline{MJW}$, $\overline{MNW}$, $\overline{MNS}$ and $\overline{MJS}$. For the first two sets, the degree is taken with a negative sign [because it is the weaknesses of the organization] and for the other two fuzzy sets with a positive sign [because it is the strength of the organization]. Moreover, the degrees of membership to $\overline{MJW}$ and $\overline{MJS}$ are multiplied with 1.5, increasing their influence in the total sum, because it shows a great weakness and a great strength (Table 3). The factor 1.5 is an empirical value that is chosen to emphasize the major weakness and strength of the factors.

Summing up the values in the last row, we obtain a number I^O that indicates the current state of the internal environment of the organization O:

$$I^O = -(1.5)\sum_{i=1}^{n}\frac{\alpha_i\mu_{1i}}{n} - \sum_{i=1}^{n}\frac{\alpha_i\mu_{2i}}{n} + \sum_{i=1}^{n}\frac{\alpha_i\mu_{3i}}{n} + (1.5)\sum_{i=1}^{n}\frac{\alpha_i\mu_{4i}}{n} \quad (2)$$

Value I^0 is a real number from the interval [-3,3]. If the resulting number is positive, the organization has more strengths than weaknesses, and as the number is greater, the state of the organization is better. If the resulting number is negative, the organization has more weakness than strengths, and less number means that the condition of the organization is worse.

Table 3. Weighted arithmetic mean of the degrees of membership

Internal factor	$\overline{MJW}$	$\overline{MNW}$	$\overline{MNS}$	$\overline{MJS}$
F_1	$\alpha_1\mu_{11}$	$\alpha_1\mu_{21}$	$\alpha_1\mu_{31}$	$\alpha_1\mu_{41}$
F_2	$\alpha_2\mu_{12}$	$\alpha_2\mu_{22}$	$\alpha_2\mu_{32}$	$\alpha_2\mu_{42}$
F_3	$\alpha_3\mu_{13}$	$\alpha_3\mu_{23}$	$\alpha_3\mu_{33}$	$\alpha_3\mu_{43}$
…	…	…	…	…
F_n	$\alpha_n\mu_{1n}$	$\alpha_n\mu_{2n}$	$\alpha_n\mu_{3n}$	$\alpha_n\mu_{4n}$
	$-(1.5)\sum_{i=1}^{n}\frac{\alpha_i\mu_{1i}}{n}$	$-\sum_{i=1}^{n}\frac{\alpha_i\mu_{2i}}{n}$	$\sum_{i=1}^{n}\frac{\alpha_i\mu_{3i}}{n}$	$(1.5)\sum_{i=1}^{n}\frac{\alpha_i\mu_{4i}}{n}$

4. A case illustration and discussion

In an observed organization, management have used the list of 29 factors proposed by Jenster and Hussey, but only 15 factors were extracted as relevant for the condition of their specific internal environment. In this phase, experiences and competencies of managers were vital for selection of the most important factors.

For the fuzzy assessment of the internal factors specially designed questionnaires (based on the company audit questionnaire, by Jenster and Hussey) were used.

Managers could use examples in the questionnaire as an aid in assessing the questions. It is important to notice that these are only sample responses, i.e. examples derived from various organizations and therefore, they may not be applicable to every organization. Part of the questionnaire for the fuzzy analysis used in this study is shown in Figure 2.

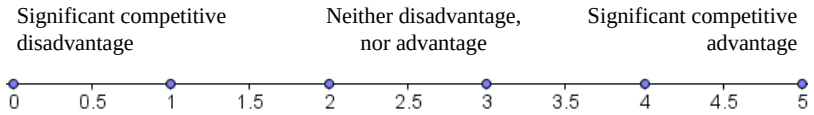
Questionnaire for the fuzzy analysis of the internal organizational factors

– Method FSIF–

Marketing

Factor: Marketing budget

In light of your assessment, how do you evaluate its competitive impact on the organisation?



Examples:

- **0 - 1.5**
  We don't have separate budget for marketing efforts.
- **1.5 - 2.5**
  When production costs are covered and depreciation is determined, we decide how much marketing we can afford.
- **2.5 - 3.5**
  For old products we decide a fixed percentage for marketing. For new products, we have separate budget.
- **3.5 - 5**
  The budget is determined by relative profit margins of products, position in the product life cycle, competitive activity and market potential for each product.

Please, rate the importance of this internal factor to your organisation, from 0 - „low importance" to 2 - „high importance"

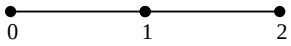


Fig. 2. Questionnaire for the fuzzy analysis

Applying these questionnaires, the following information on the factors identified by the management of the organization were obtained (Table 4).

In Table 5, IFE matrix for the observed case is presented.

Table 4. Values of internal factors, membership degrees and weights of the factors in application of FSIF model

Internal factor	Value	$\overline{MJW}$	$\overline{MNW}$	$\overline{MSN}$	$\overline{MNS}$	Weight
Financial resources	2.84	0	0.16	0.84	0	0.5
Long-range financial planning	2.37	0	0.63	0.37	0	1.3
Accounting system	1.83	0.17	0.83	0	0	0.4
Quality of products/services	4.2	0	0	0	1	1.7
Corporate reputation	3.23	0	0	0.77	0.23	1.1
Pricing policy	3	0	0	1	0	1.9
Systematic market analysis	2.86	0	0	0.86	0.14	2
Distribution channels	1.58	0.42	0.58	0	0	2
Marketing budget	2.16	0	0.84	0.16	0	0.5
Outsourcing prospective	0.5	1	0	0	0	0.3
Material work flow	1.51	0.49	0.51	0	0	0.8
Internal communication/Information systems	3.33	0	0	0.67	0.33	1
HRM procedures	3.59	0	0	0.41	0.59	0.9
Management effectiveness	3.72	0	0	0.28	0.72	1.8
Organization's R&D activity	3.87	0	0	0.13	0.87	1

Table 5. IFE matrix

Internal factor	Rating	Weight	Weighted score
Financial resources	3	0.03	0.09
Long-range financial planning	2	0.08	0.16
Accounting system	2	0.02	0.04
Quality of products/services	4	0.10	0.40
Corporate reputation	3	0.06	0.18
Pricing policy	3	0.11	0.33
Systematic market analysis	3	0.12	0.36
Distribution channels	2	0.12	0.24
Marketing budget	2	0.03	0.06
Outsourcing prospective	1	0.02	0.02
Material work flow	2	0.04	0.08
Internal communication/Information systems	3	0.06	0.18
HRM procedures	4	0.05	0.20
Management effectiveness	4	0.10	0.40
Organization's R&D activity	4	0.06	0.24
	Total:	1	2.98

In this case illustration, we can notice that use of [0,5] interval enable better assessment of factors and thus also a better evaluation of the degree of their weakness and strength, than the use of four integers 1, 2, 3 or 4. By the interval approximation, we obtain additional information about the degree of membership of factors to each of the sets „Major weakness“, „Minor weakness“, „Major strength“ „Minor strength“ while in IFE matrix only a strict membership to sets is determined (belonging in classical sense: it belong to a set or it does not belong to a set).

Applying the weights in FSIF model, the data in Table 6 have been obtained.

Table 6. Weighted fuzzy membership degree

Value of Internal factor	$\overline{MJW}$	$\overline{MNW}$	$\overline{MSN}$	$\overline{MNS}$
2.84	0	0.08	0.42	0
2.37	0	0.819	0.481	0
1.83	0.068	0.332	0	0
4.2	0	0	0	1.7
3.23	0	0	0.847	0.253
3	0			0
2.86	0	0	1.72	0.28
1.58	0.84	1.16	0	0
2.16	0	0.42	0.08	0
0.5	0.3	0	0	0
1.51	0.392	0.408	0	0
3.33	0	0	0.67	0.33
3.59	0	0	0.369	0.531
3.72	0	0	0.504	1.296
3.87	0	0	0.13	0.87

The results in Table 7 are obtained by calculation of the weighted arithmetic mean.

Table 7. Weighted arithmetic mean

$\overline{MJW}$	$\overline{MNW}$	$\overline{MSN}$	$\overline{MNS}$
-0.16	-0.22993	0.372929	0.526

In case of IFE method, regardless of whether a factor is of major or minor weakness or strength, it has the same influence on the final result. In case of FSIF method, a factor is further weighted by multiplying the degree of

membership of internal factors to major weakness to -1.5, and to major strength to 1.5. This increases the impact of these factors on the overall state of internal functional areas of the organization. Moreover, by displaying the obtained values that represent the weakness of organization by negative numbers, it is more evident which of the sets has more influence to the final result.

Finally, by summing up the obtained weighted arithmetic mean, in this case we obtain:

$$I^O = 0.509 .$$

Since the obtained value is positive, the observed organization has more advantages than disadvantages. However, as the value is relatively low (in comparison with maximum value 3) , it is possible to introduce some changes to improve its condition.

In the case of IFE method, the resulting value of 2.98 (in comparison with maximum value 4) would indicate that the state of organization is better then it is shown by FSIF method. First of the reasons is that the influence of factors representing minor and major weakness as well as minor and major strength to the final result is equal. Second reason is the fact that during rounding, some numbers between major weakness and minor weakness got value 2 (minor weakness) and others, which are between minor strength and major strength got value 4 (major strength). Some factors that in some degree have both roles: of minor strength and of minor weakness got values of minor strength (value 3). In case of FSIF method this difference is clearly indicated and therefore the final result is more precise and accurate.

5. Conclusion

This paper is focused on internal aspects of corporation, and further on a new measure, which is developed by using an original method of an internal assessment based on fuzzy logic.

Classical mathematical disciplines which are based on two valued logic could not be satisfactorily used in investigation of human behavior, which is an argument for the implementation of fuzzy logic in solving specific problems in the internal organizational environment.

Fuzzy set theory and fuzzy logic, as a mathematical approach to solving problems of analysis of internal functional areas of the organization allows overcoming some of the problems faced by managers of organizations. The paper points to some limitations of IFE matrix method and propose a way to eliminate them. Simple features of symmetric triangular fuzzy sets are used as well as graphics and elementary arithmetic operations.

An advantage of fuzzy-analytical methods in quantification of the organization's internal factors proposed in this paper, compared with IFE and other commonly used methods is in using fuzzy sets by which vague information is better assessed and described.

Besides, the scales used in this paper are not graduated, as is the scale used for measuring internal factors in IFE-matrix method. The scales considered here can take any value from an interval, which better describes real situation. Grades of weakness or strength of factors are represented by four fuzzy sets and our choice of symmetric triangular fuzzy sets enables easy calculations and understanding of the new tool. The importance of relevant factors is also taken into account using a weight from a real interval obtaining the ponder that increase or decrease the influence of factors.

Another advantage is that the additivity condition required in the mentioned IFE and IFAS methods is overcome in this fuzzy framework. The disadvantage of additivity setting is that if the importance of one internal factor is increased, then automatically importance of other internal factors must be reduced. Another disadvantage of known methods is the fact that a number of factors should be limited which is also overcome by this method.

The data obtained in a process of internal screening can be clearly presented and analyzed using the method proposed in this paper. For each organization a new fuzzy matrix can be produced taking into account variation of internal factors and difference in degree of influence of factors to the performance of organization.

The information obtained can be easily compared and interpreted, regardless of the organization observed, thereby increasing the diagnostic value of the proposed method.

Therefore, application of the FSIF method enables implementing more precise and more up-to date information system that assist managers in reaching a better understanding of the overall company's competitiveness.

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