Chapter

The Fuzzy Logic Methodology for Evaluating the Causality of Factors in Organization Management

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Abstract

The paper is concerned with solving the problem of factor causality using the tools of the fuzzy set theory. The paper formulates the problem of causal relations in a broad sense and analyzes the methods for its solution with an emphasis on the socioeconomic aspects. For this purpose, the system approach, comparative experiment, economic and mathematical modeling, and other general scientific methods are used. The authors suggest that the causality of factors be studied based on the theory of fuzzy binary relations using the mathematical tools of Goguen's fuzzy implication. As an example, the paper describes the effect of organizational culture indicators under the Denison's model on the key performance indicators of an organization.

Keywords: factor causality, fuzzy evaluation, causality, fuzzy binary relations, corporate culture, balanced scorecard

1. Introduction

The three well-known mathematical theories concerned with the modeling of economic systems under uncertainty are the theory of probability, the theory of possibilities, and the fuzzy set theory. Fuzzy mathematical models represent a new and promising trend in applied mathematics and are increasingly being used in various applied fields in situations involving various kinds of uncertainties where these cannot be strictly formalized by the methods of probability theory and mathematical statistics. These uncertainties can be of various types: those caused either by the inability to determine the values of parameters with mathematical precision or by the impossibility of finding their exact numerical limits.

The main idea of this tool is that any economic indicator is interpreted as an integral one and is thus defined not by an absolute number but by a certain interval (i.e., fuzzified) which corresponds to the real-life situations where only the limit values of the analyzed indicator within which it can vary are known with sufficient precision, but there is no quantitative or qualitative information about the possibilities or probabilities that its various values will be implemented within a given interval. That is, when using the mathematical apparatus of the fuzzy set theory, it is necessary to formalize one's vision of the possible values that the indicator in question can take and specify the set of its values and the degree of uncertainty that each of these values will be assumed. Once the input economic indicators are formalized, we may calculate the possibility distribution of a generalized indicator or a system of desired output characteristics by the "level principle of generalization" or "Zadeh's generalization principle." After such calculation and having built the so-called inference engine for the main economic indicators, it is necessary to defuzzify and interpret them based on the system of rules set by the researcher.

Development of such models for economic system management makes it possible to address the uncertainty in economic agents' behavior and, thus, to minimize the "human-sized" risks of decision-making.

2. Analyzing the mechanisms of management factor causality in organizations

The central goal of most scientific research is to elucidate the cause-and-effect relationships among variables or events. For millennia, the issues of "causality" have enjoyed great interest among representatives of many sciences: philosophy, psychology, economics, physics, chemistry, etc. In social and economic sciences, the "cause-and-effect relationship" issues are associated with the new term "causality" which is increasingly used. Causality (Lat. *causalis*) is a cause-and-effect relationship: a causal interdependence of events in time [26]. To establish the causal relations among the variables (synonyms "deterministic," "causal") is, probably, one of the most important problems in the scientific research. Indeed, any scientist seeks to identify a cause-and-effect relationship and implement the most effective mechanism to achieve the desired outcome. The broad application scope of the causality concept dictates the diversity of approaches to its study [3, 28].

In a broad sense, the causality theory essentially answers the simple question associated with verifying the statement that "event X generates event Y." In this case, X is called the cause or a causal factor, and Y is the consequence, response, or the resultant factor. Mathematically speaking, X is a necessary condition for Y, and Y is a sufficient condition for X. The problem of the causality theory is presented in the form of a graph below (see **Figure 1**).

Based on the studies [27, 28], the problems of causal relations among factors can be formulated as follows:

1. The problem of X directly affecting Y: does factor X actually affect factor Y directly, or is there some indirect impact that factor X exerts on factor Y through some factor Z?

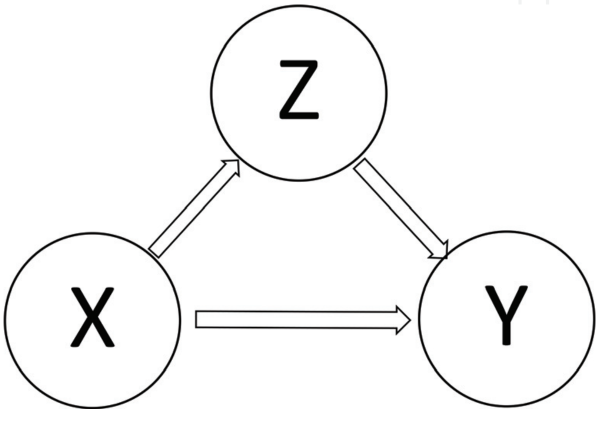

Figure 1.
Basic factor causality graph.

2. The problem of delayed or retrospective causality: did factor X actually affect the resultant factor Y, or was this effect random, and is the change in factor Y due to other reasons? Delayed causality comes into play when factor Y is measured after some time has passed since factor X, and when factor Y is measured at a given moment in time based on retrospective measurements of factor X, this is commonly referred to as retrospective causality.

3. The problem of functionality of causal relations consists of finding a solution to dichotomy: is the relation deterministic or probabilistic? In the first case, we can talk of a law, principle, etc. in the area of interest, while in the second case, it is a stable, strong, or weak relation for a certain class of objects.

The three interrelated scientific problems of causal relations can be represented in the form of a causal field. In this case, we are exploring all adjacent relationships, i.e., the set of variables {X} capable of affecting the outcome Y, the set of other resultant variables {Y} dependent on X, and the set of variables {Z}.

A causal field characterizes a set of factors that, on the one hand, provide a sufficiently complete description of the subject and make it possible to explain the obtained or predicted results based on the established interrelationships, on the other. The structure of the causal field is commonly built on the basis of substantive considerations and the experimental results, and the alleged causality is either confirmed, and hypotheses about the nature of the given and associated relationships are suggested or refuted.

The issues of causal relations in economics and management are discussed in many works by Nobel laureates who build their models on the assumption that if *Y* could exist, then *X* could have had an effect, and a situation could arise where *X* caused *Y*. That is, the authors essentially reveal the significant patterns in the causal field, test them against examples, and summarize them into economic laws. G. Akerlof argues that the simple Pareto efficient equilibrium market trading results could be radically changed if we considered buyers and sellers with a certain assumed degree of information asymmetry. Thus, G. Akerlof's model is a causal field: unless the asymmetry of market information is taken into account, the behavior of buyers and sellers will provide a less reliable description of the real market situation, and, therefore, a new theory of market behavior will need to be developed. Another prominent example in this matter is the theory of segregation. According to Schelling's theory, a causal field is a combination of at least three factors: targeted state policy, preferences of an individual market agent, and segregation. The causal relations that he established counter the commonly accepted view that segregation can only result in the targeted government policies or strong segregation preferences.

The probabilistic and statistical models involving, above all, the study of events occurring in the course of experiments are considered as the fundamental economic and mathematical models of causal relations among factors.

The first group of models implements correlation and regression analysis. Within this group of models, we should note S. Wright's structural equations and diagrams [13, 16], the Neyman-Rubin causal models [15], Pearl's functional models [14], David's dynamic models [3], and various graph models. Anyway, all these models employ different types of correlation analysis as a measure of determination and calculate a coefficient of correlation. In case of assurance that the data have a normal distribution and are of interval nature, the Pearson correlation coefficient is used; in the event of dichotomy and the use of ranks, the rank correlation coefficient or the point-biserial one is used. To identify causality, parametric and nonparametric single-factor analyses of variance are also used, and the chi-square value of the contingency coefficient in the crosstab tables is calculated and analyzed.

If an indirect effect needs to be identified, the authors, as a rule, suggest using the various modifications of the two-factor analysis of variance and the multiple regression implementation technology, where the regression line inclination is taken as a characteristic of the causal relation strength.

Structural modeling proves to be very useful in determining the significance of an indirect effect. This usually involves the comparison of two models, and their coefficients are used to estimate the indirect, direct, or ambivalent effect of factors.

The second group of models received a general name of confirmatory analysis [10, 24]. Confirmatory factor analysis, or the measurement model, relies on the assumption that relationship among several explicit variables results from the common cause of their joint variability, i.e., a factor as a latent variable. The measurement model makes it possible to test the assumption that this set of indicators is sufficient to measure the latent construct and to determine what contribution each indicator makes to its evaluation. The confirmatory factor analysis based on the method of maximum likelihood is a special case of the modeling method using linear structural equations. Unlike the exploratory factor analysis, it correlates the isolated factor structure with the one already known to or assumed by the researcher and determines the reliability of this correlation. The researcher here needs to have some idea of the test variables structure and of the causal field in general. Such idea can be defined by some theoretical principles tested in the experiment or obtained by exploratory factor analysis.

The methodology of confirmatory analysis is to a greater extent based on deductive (confirmatory) logic than on the inductive (exploratory) one. Deductive logic starts from building a structural model of directional and nondirectional relations between the given constructs with a view to its further verification for consistency with the empirical data and adjustment by means of data analysis.

The basic idea of confirmatory analysis is not only to single out a certain set of factors but also to correlate this solution with the one established previously. The starting point for this procedure is the following vector algebra equation:

$$\mathrm{C}_{kk} = L_{kf} C_{ff} L'_{fk} U_{kk}. \tag{1}$$

where C_{kk} is a covariance matrix for k variables; alternatively, a correlation matrix can be used; C_{ff} is the covariance matrix for f factors. Generally, this matrix is assumed to be diagonal, i.e., factors do not correlate with each other. L_{kf} is the factor loading matrix, and L'_{fk} is its transposed version. U_{kk} is a diagonal covariance matrix for the variable-specific factors. The presence of this parameter obviously indicates that the maximum likelihood procedure is based on the common factor model.

Several examples of how the methods described above that were used in various studies are provided below.

In her study, Yudaeva discusses the causal relation between the process of Russia's accession to the WTO and the implications thereof. The causal field is an acyclic graph whose nodes are events and arcs are information flows evaluated in a probabilistic form. Based on the expert knowledge processed by the method of randomized probabilities, a forecast is made, and the strength of relations in the acyclic graph is established on the example of the Russian electricity sector. Further, the study discusses the scenarios of possible consequences based on processed expert opinions and constructs a decision tree. Based on the aggregated expert knowledge, a method has been obtained to estimate the probability that certain alternatives will be implemented which the author interpreted as the effect of Russia's accession to the WTO on the electricity industry segment.

Since one of our key objectives is to identify and evaluate the effect of implicit factors on organizational performance, in our study we will consider the existing models and methods for evaluating the impact of such implicit factor as organizational culture [23].

It should be noted that the number of foreign and domestic studies on evaluating the impact that organizational culture has on company performance is extremely small so far and does not reflect the business needs in this respect.

The main foreign studies are the *Corporate Culture and Performance* by Kotter and Heskett [11], *Built to Last* by Collins and Porras [2], *The Balanced Scorecard* by Kaplan and Norton [20], and *Practice What You Preach: What Managers Must Do to Create a High Achievement Culture* by Maister [21]. As to research by Russian scientists, there are the studies by Solomandina, Zhuravleva, and Zhukov, who also tried to evaluate from different perspectives the effect of organizational culture on various aspects of company performance in the Russian context.

The most systematic research in this area was performed by the US scientist D. Maister, who tried to formalize the causal relationship between "organizational culture and company performance" based on the conceptual provisions of Kaplan and Norton.

Maister highlighted the following factors or elements of organizational culture: development; coaching; psychological climate in the team; high standards by which he understood the personal qualities of employees, commitment, and high performance; long-term orientation; empowerment; fair compensation; and employee satisfaction.

This set of organizational culture indicators is not accidental. From the author's point of view, it determines the financial success of an organization. The author, relying on the above works, proves this on practice by studying a fairly large number of different companies over a number of years.

Of interest is also the logic behind Maister's causal relations which is expressed as the following chain: financial indicators, product quality, and employee satisfaction (high standards, support, coaching, and empowerment) (system of fair compensation, employee commitment, and enthusiasm; coaching) (long-term orientation, interest and enthusiasm of employees). Note that some elements of the chain contain not one but two or more variables that are in turn related to each other.

Financial component of organizational performance, according to Maister, is an integral weighted convolution of the four indicators: profit per employee, revenue growth over the past 2 years, profit growth over the past 2 years, and return on sales.

By the statistical analysis of financial performance for 139 offices employing 5589 people, Maister proved that there are two factors that have the greatest influence on financial success—i.e., profit growth (0.81) and profit per employee (0.53). The remaining factors have a significantly lower impact: 0.27 and 0.24, respectively.

The relationship between financial performance and organizational culture can be analyzed using Maister's flowchart (see **Figure 2**). The respondents rate each indicator of the organizational culture on a 1–6 scale. The average score is then used for the analysis, and the relation coefficients expressed as parameter b represent an amount of change in the variable that would result from a one-unit change in another variable.

The weakness of this research lies in the use of econometric apparatus: the author assumes that connections are linear and evaluates their strength; moreover,

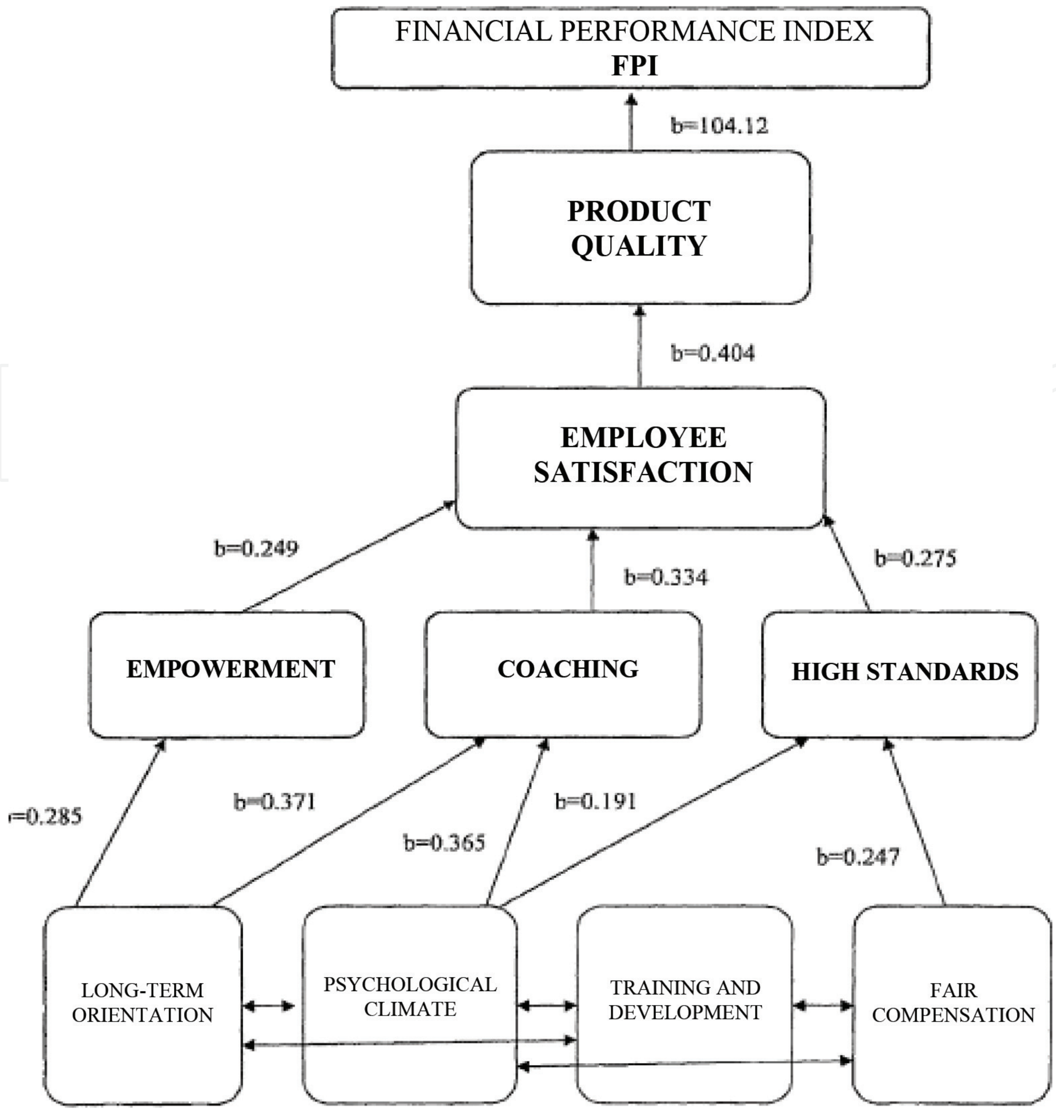

Figure 2.
Financial performance index vs. organizational culture elements [21].

the established hierarchy structures the relationships within the corporate culture factors considerably and essentially leaves out the possibility of their simultaneous independent change. In general, Maister gives a sufficiently complete and objective evaluation of the impact that the organizational culture has on the firm's financial success.

The next stage in the development of the "organizational culture vs. company performance" dual relationship was the model suggested by Professor Denison at the International Institute for Management Development in Lausanne, who, based on statistical data from more than 1000 firms, made another attempt to describe logical chains between the components of organizational culture and main performance indicators of an organization. According to this model, organizational culture is a synergistic sum of four dimensions: involvement, consistency, adaptability, and mission. Each dimension is broken down further in accordance with the research; in particular, the mission determines the strategy, goals, and objectives, as well as the company's vision; consistency involves coordination/integration, agreement, and core values; involvement comprises team orientation, capability development, and empowerment; and adaptability involves creating change, customer focus, and organizational learning [18].

In the Denison's model, the set of financial performance indicators of an organization has also been significantly expanded: in addition to financial indicators, he suggests using a wide range of key measurable and qualitative performance indicators such as assets and investments, sales and product quality, employee satisfaction and innovation, creativity and customer focus, sales growth, and market share gain. This approach provides a more complete reflection of the relationship between organizational culture and performance in the broad sense. That is, Denison's model combines the ideas of Kravetz, Thompson, and Maister and contains its own new features, being a more accurate tool to determine what impact the organizational culture has on company performance. In essence, Denison suggested his own original causal field of factors that link organizational performance with culture.

Denison found that mission and consistency have a greater impact on financial indicators, such as ROA (return on assets), ROI (return on investment), and ROS (return on sales). The value of the mission and consistency indices of three to four usually indicates a high return on investment, assets, and sales, as well as the operational strength of an organization.

Consistency and involvement (internal focus) affect quality, employee satisfaction, and return on investment. Similarly, the value of these indices from 3 to 4 indicates high product quality, smaller percentage of scrap and rework, proper resource allocation, and a higher level of employee satisfaction.

Involvement and adaptability influence product development and innovation. When these parameters have an index of three to four, it means a high level of innovation in manufacturing and service, creativity, and a quick response to the changing desires and needs of both clients and their own wage workers.

Adaptability and mission (external focus) influence revenues, sales growth, and market share. When the values of these parameters range from 3 to 4, the organization is likely to see a steady sales growth and market share gain.

Denison's method for index calculation is based on statistical estimates that get recalculated when a new object of research is added to the knowledge base and refines the impact standard derived from changes in the data set.

In the Russian research of recent years, we can note the study by Zhuravleva who developed her own impact evaluation model (causal field) with regard to the specifics of the Russian business activity (**Figure 3**).

As know-how of her model, the author suggests using the structural elements of "effective leadership," "horizontal management structure," and "loyalty and creativity at work" influencing such performance indices as the product quality, sales growth, employee turnover, labor productivity, and the number of labor misconducts. From the author's point of view, organizational culture can also be evaluated using the following indices: creativity factor, innovation level, coefficient of satisfaction with the organization, rate of knowledge and skill implementation, worker qualification factor, professional competence factor, and responsibility factor [22].

Given the specifics of the Russian economy and the socio-morphic nature of the organizational culture (OC) phenomenon, Russian scientists note its influence on the product quality, sales growth, employee turnover, labor productivity, number of labor misconducts while evaluating OC through the creativity factor, the level of innovation, the coefficient of satisfaction with the organization, and the factors of knowledge and skill implementation, employee qualification, professional competence, and responsibility.

In her study, Pervakova [25] builds the following flowchart of influence that the organization culture has on business performance and labor productivity (**Figure 4**).

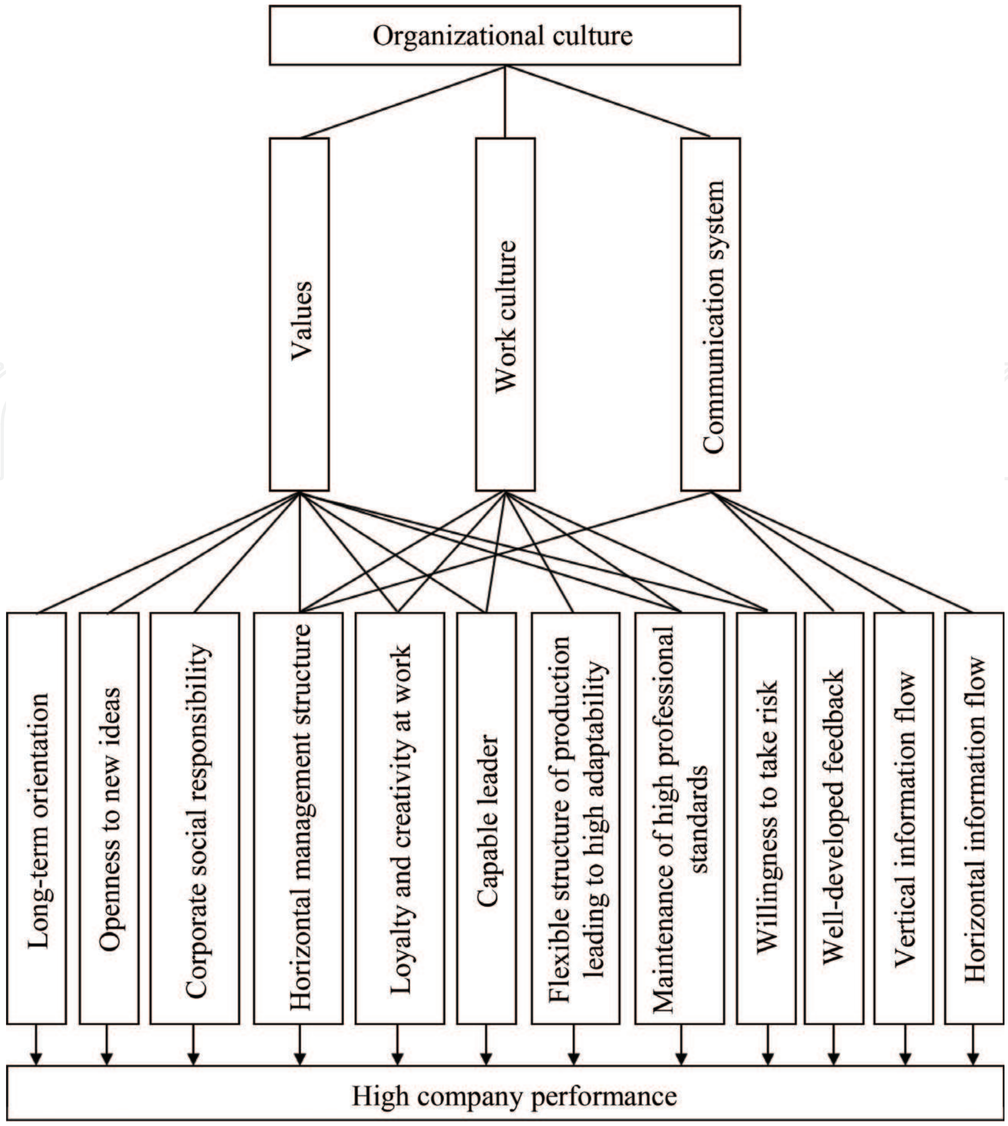

Figure 3.
Structural elements of the organizational culture which determine the company's performance [19].

The literature review once again proved the scale of the problem being addressed. The research revealed a sufficiently large number of parameters and factors of influence and determined their principles and mechanisms. The authors of all models, both domestic and foreign, only determine the dichotomous effect of organizational culture on the key performance indicators describing the qualitative influence (a typical example is with an effective organizational culture, the turnover rate is low) while not trying to formalize it in order to answer the question of both how and to what degree (weakly, neutrally, strongly) the level of OC affects the parameters of interest. Note also that even when quantitative estimates are used in the studies, they are based on econometric relationships and, therefore, assume the existence of a serious database of accumulated results. And finally, one of the most important observations: a number of authors believe the organizational culture components to have a direct impact on financial and economic performance, while others are confident that this impact is indirect. We adhere to the latter point of view, and our evaluation model will be based on this very assumption.

The experience of foreign researchers and practitioners who studied how the organizational culture affects business performance suggests that:

1. The organizational culture has a *direct* prevailing effect on *employee satisfaction*, *job involvement*, and *ethics of customer communication*. These factors in turn

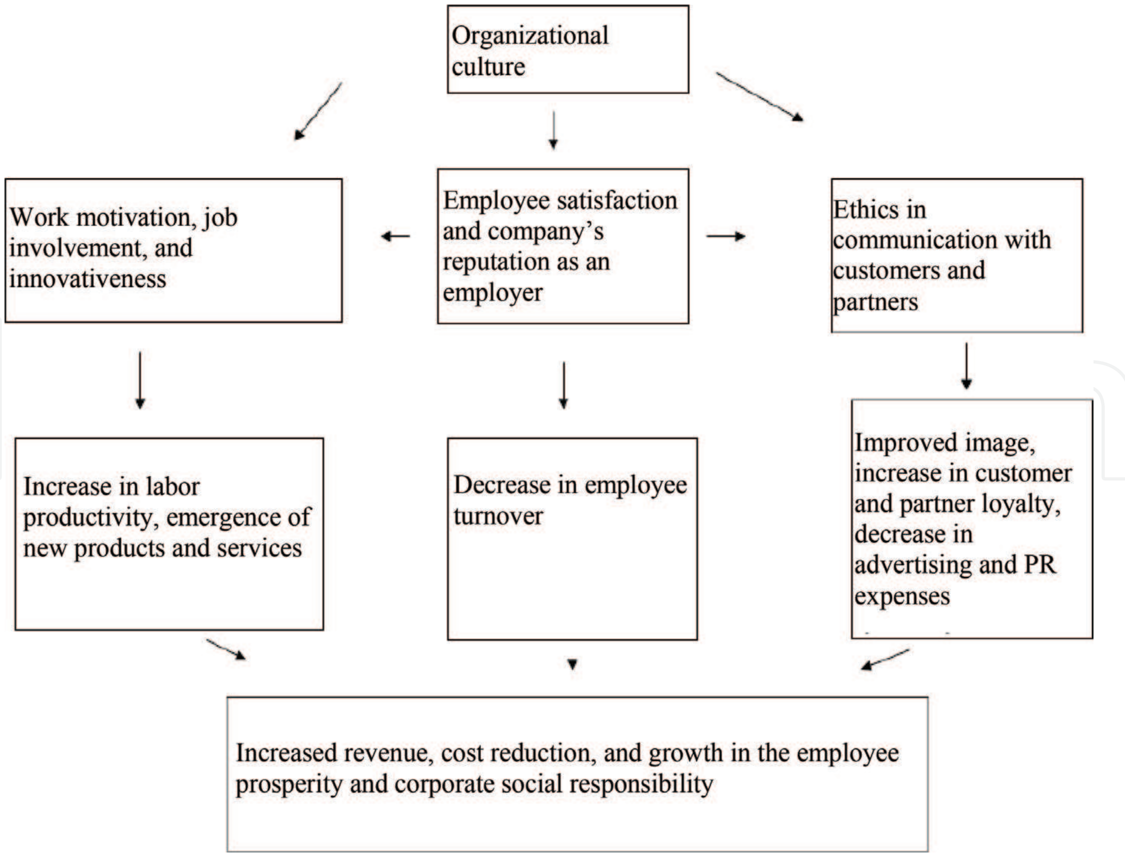

Figure 4.
Flowchart of the OC impact on business performance.

affect the financial and market performance of companies which they interpret as customer satisfaction and loyalty and labor productivity and profitability [4–7, 9].

2. The types of organizational culture also affect the financial and market performance of companies, for example, in the Cooke and Rousseau model [26], the cooperation and competition types are most favorable to the financial and market performance.

3. Relying on the OSP model of organizational culture, Sheridan and Chatman discovered that some of its components such as "respect for people" and "team orientation" have a much greater effect on job involvement, employee satisfaction, and decrease in staff turnover, than the others [1].

4. The most advanced in this respect is the Denison model. It was his practical experience that allowed him to identify those components of organizational culture that affect performance indicators of a generalized business unit.

The key difference of our methodology lies in formalizing a factor as a linguistic variable and in using standard fuzzification and defuzzification techniques to come to a conclusion based on fuzzy logic procedures.

The search for and interpretation of the information related to building a causal field, to the identification of factors, and to the meaningful evaluation of obtained result remain beyond the scope of the literature reviewed above. The model of the causal field being suggested by the author is an acyclic graph, and the strength of relations is calculated from processing the expert judgments by traditional graph-matrix techniques.

3. Fuzzy model to evaluate the causality of organization's performance factors

Linguistic variable [12] as a special tool in the fuzzy set theory allows us to formalize the verbal description of a balanced scorecard and its structural properties but disregards the strength of relations between indicators and factors within it. Therefore, in our opinion an adequate model to evaluate the impact of implicit factors on economic processes should be developed based on a combination of the fuzzy set theory concepts and objectification of the expert judgments.

The following model allows us to find the degree to which an implicit factor influences the measurable ones, i.e., those whose values can be obtained quantitatively by introducing an indirect factor into the model.

To develop a model, one needs at least to explore the three sub-models that make up the economic system. For each sub-model, we introduced the following designations: A, implicit factors; B, indirect indicators; and C, quantitatively measurable indicators.

The general plan for model development consists of two steps:

First step: to develop sub-models

Second step: to combine sub-models into a general model, to analyze it, and to address the problem in question

Sequence of operations at the first step:

- Initial determination of a set of numerical indicators for each sub-model
- Lists of sets of numerical indicators

Sequence of operations at the second step:

- Evaluation of the mutual influence among indicators in pairs (A, B), (A, C), and (B, C)
- Finding the indirect effects of model A indicators on model C indicators
- Interpretation of the obtained results

3.1 Sub-model development

The set of selected implicit factors will be considered as a carrier set of sub-model A, that of indirect factors as sub-model B and that of the measurable factors as sub-model C.

Sub-models A, B, and C can be represented by the sets of indicators:

$$A = \{a_1, a_2, \dots, a_n\},$$
$$B = \{b_1, b_2, \dots, b_m\}, \qquad (2)$$
$$C = \{c_1, c_2, \dots, c_k\}.$$

3.2 Combination of sub-models into a general model and its analysis

To identify the latent, B-mediated effects of A indicators on C indicators, one can use a combination of a hierarchy analysis method and the fuzzy relation theory.

In this case, we are interested in fuzzy binary relations:

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$$\begin{aligned} a\rho_1 b &: a \text{ affects } b,\ (a,b)\in A\times B,\\ b\rho_2 c &: b \text{ affects } c,\ (b,c)\in B\times C,\\ a\rho_3 c &: a \text{ affects } c,\ (a,c)\in A\times C \end{aligned} \tag{3}$$

The fuzzy relation theory can be applied to identify and evaluate the implicit effects. Relations are given by the matrices J_{AB}, J_{AC}, and J_{BC}, whose elements are the values of membership for the corresponding pair of elements in a binary relation. The definition of membership functions is known to be the most difficult part of the fuzzy set theory. This is where the hierarchy analysis method can be of help.

Assume, for example, that matrix J_{AB} is given as

$$J_{AB} = \begin{pmatrix} s_{11} & s_{12} & \dots & s_{1m} \\ s_{21} & s_{22} & \dots & s_{2m} \\ \dots & \dots & \dots & \dots \\ s_{n1} & s_{n2} & \dots & s_{nm} \end{pmatrix}, \tag{4}$$

where $s_{ij}\left(0\le s_{ij}\le 1;\quad i=1,2,\dots,n;\ \ j=1,2,\dots,m\right)$is the strength of effect that indicator a_i has on indicator b_j.

The s_{ij} values are usually determined by experts. The analytic hierarchy process (AHP) can be used here for the purposes of consistency and clarification and to increase the validity of expert judgments related to s_{ij} values.

The diagram of hierarchies in this case has the following form (**Figure 5**).

Calculated by the standard procedure, the normalized estimates of the priorities vector for each b_j should be written in jth column of the J_{AB} matrix: $\left(s_{1j}, s_{2j}, \dots, s_{nj}\right)^{\mathrm{T}}$.

However, remember that the resulting J_{AB} matrix would only reflect the expertly established effect of indicator a_i on indicator b_j if all the normalized estimates of each priority vector meet the chosen consistency measure. Otherwise, either the models A and B themselves or the expert judgments will need to be revised.

The J_{AC} and J_{BC} matrices are composed in a similar way:

$$J_{AC} = \begin{pmatrix} z_{11} & z_{12} & \dots & z_{1k} \\ z_{21} & z_{22} & \dots & z_{2k} \\ \dots & \dots & \dots & \dots \\ z_{n1} & z_{n2} & \dots & z_{nk} \end{pmatrix}, J_{BC} = \begin{pmatrix} u_{11} & u_{12} & \dots & u_{1k} \\ u_{21} & u_{22} & \dots & u_{2k} \\ \dots & \dots & \dots & \dots \\ u_{m1} & u_{m2} & \dots & u_{mk} \end{pmatrix}, \tag{5}$$

where $z_{ij}\ (0\le z_{ij}\le 1;\quad i=1,2,\dots,n;\quad j=1,2,\dots,k)$ is the strength of effect that indicator a_i has on indicator c_j and
$u_{ij}\ (0\le u_{ij}\le 1;\quad i=1,2,\dots,m;\quad j=1,2,\dots,k)$ is the strength of effect that indicator b_i has on indicator c_j.

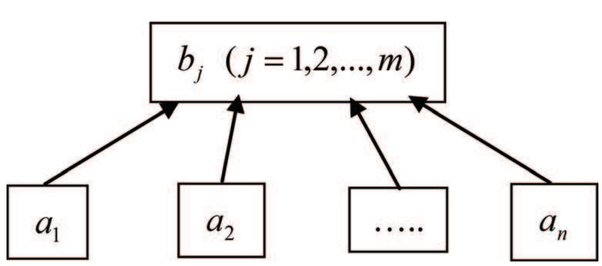

Figure 5.
The diagram of hierarchies in AHP.

The latent, B-mediated effects of sub-model A indicators on those of sub-model C can be established and evaluated as follows (**Figure 6**).

The strength of direct effect that a_i has on c_i is determined by matrix element z_{i1}. Similarly, the strength of direct effect that a_i has on $c_2, \dots, c_k$ is set by the numbers $z_{i2}, \dots, z_{ik}$ in this matrix. In addition to direct impact, the indicator a_i affects $c_1, \dots, c_k$ through the mediating element b_i, a sub-model B indicator. The strength of b_i-mediated *indirect* impact of a_i on $c_1, \dots, c_k$ is set to $z^*_{i1}, z^*_{i2}, \dots, z^*_{ik}$ values that represent the minimums of s_{ij} and correspond to $u_{j1}, u_{j2}, \dots, u_{jk} : z^*_{i1} = \min(s_{ij}, u_{j1}), z^*_{i2} = \min(s_{ij}, u_{j2}), \dots, z^*_{ik} = \min(s_{ij}, u_{jk})$. The a_i element can affect each of the $c_1, \dots, c_k$ elements not only through the "mediator" b_i but also through any element of sub-model B (**Figure 7**).

The cumulative mediated effect of element a_i on c_j is set equal to the maximum effect mediated through all the elements of sub-model B:

$$z^*_{ij} = \max(\min(s_{i1}, u_{1j}), \min(s_{i2}, u_{2j}), \dots, \min(s_{im}, u_{mj})), \tag{6}$$

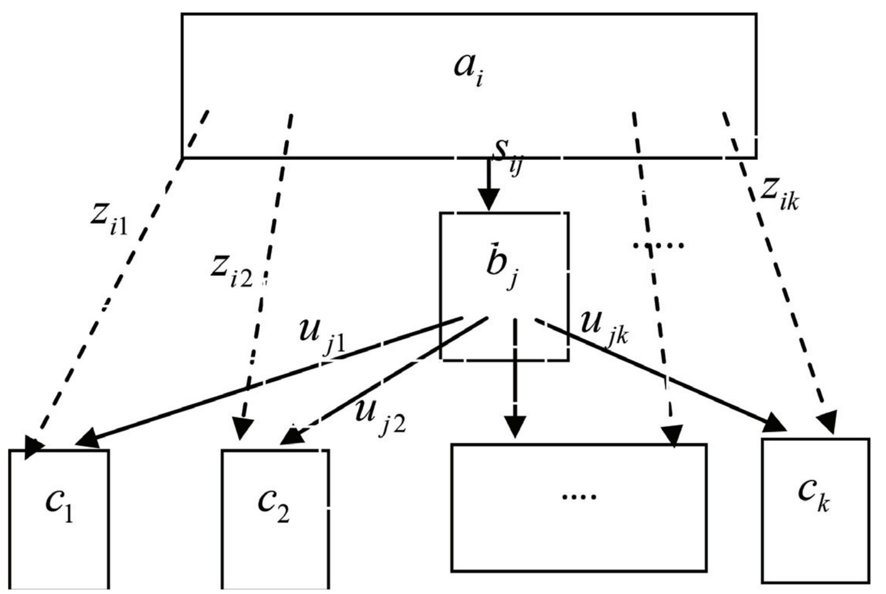

Figure 6.
Direct and b_j*-mediated impact of* a_i *on sub-model* C *elements.*

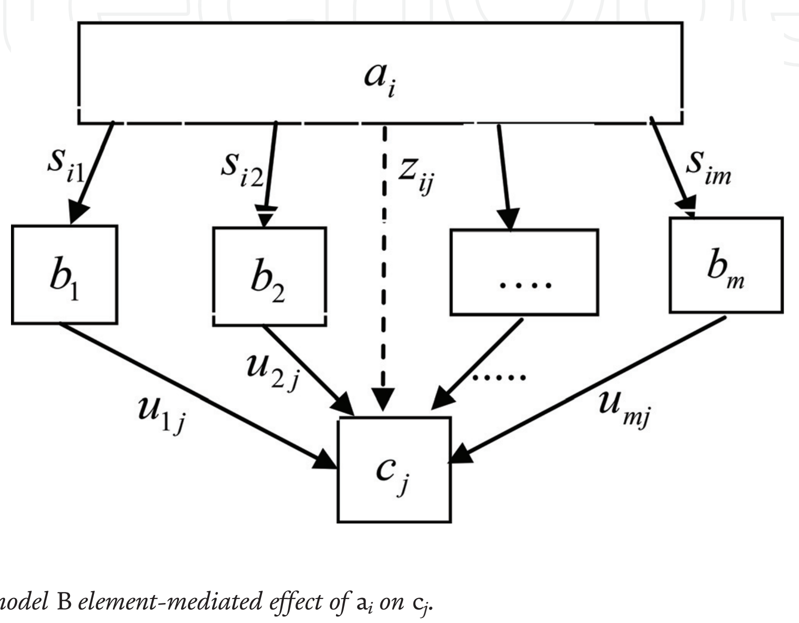

Figure 7.
Direct and sub-model B *element-mediated effect of* a_i *on* c_j*.*

Considering the operation "min" as multiplication and "max" as an addition, it appears that all the B-mediated effects of A on C are defined in the product of matrices J_{AB} and J_{BC}:

$$J_{AC}^{*} = J_{AB} \cdot J_{BC} = \begin{pmatrix} z_{11}^{*} & z_{12}^{*} & \dots & z_{1k}^{*} \\ z_{21}^{*} & z_{22}^{*} & \dots & z_{2k}^{*} \\ \dots & \dots & \dots & \dots \\ z_{n1}^{*} & z_{n2}^{*} & \dots & z_{nk}^{*} \end{pmatrix}, \tag{7}$$

where z_{ij}^{*} is defined by Eq. (1).

All the values of $s_{ij}, \; u_{ij}, \; z_{ij}$ are expertly determined.

If the strength of direct effect of A on C expertly determined by the analytic hierarchy process exceeds the indirect one, then there is no point in accounting for it. If the inequality $z_{ij}^{*} - z_{ij} > 0$ holds, then an indirect (and not recognized by experts) effect of the ith implicit factor on the jth resulting index is found. Moreover, the difference $z_{ij}^{*} - z_{ij}$ can be considered an estimated strength of such effect.

The developed model makes it possible to find and evaluate the strength of the indirect effect that implicit factors have on the system's key measurable indicators. It combines two mathematical techniques, i.e., the analytic hierarchy process and the theory of fuzzy binary relations. Each of these techniques is quite widely used, but we have not found their combination in the available literature. The quantitative and qualitative conclusions derived from this model are easy to interpret and verify in practice.

The developed model makes it possible to expertly find and evaluate the strength of the indirect effect of implicit factors on the system's key measurable indicators. In the thesis, we suggest that the estimated effects be obtained using Goguen's fuzzy logic inference, as it is the one that satisfies the logic of defining the mutual effects among indicators within the sub-models A, B, and C.

Step 1. At this step, the effect matrices $J_{AB}; J_{BC}$ are structurally and quantitatively defined according to the rules R1 and R2:

$$\text{R1}: J_{AB} = \{x_{ij}\} = \left(min\left\{1, \frac{b_j}{a_i}\right\} \right), \text{ where } i = 1..n, j = 1..m. \tag{8}$$

$$\text{R2}: J_{BC} = \{y_{jk}\} = \left(min\left\{1, \frac{c_k}{b_j}\right\} \right), \text{ where } j = 1..m, \; k = 1..k. \tag{9}$$

The resulting matrix that estimates the effects between sub-models A and C is found by the rule of minimax matrix products:

$$J^{*} = J_{AB} \cdot J_{BC} \tag{10}$$

Step 2. At this step, the indicators of sub-models A* and C* are recorded after the implicit factor is changed, while the effect matrices defined by Eqs. (3), (4), and (5) remain the same (the strength of effects does not change).

Step 3. Calculation of the quantifiable indicators of sub-model $\text{C}_{\text{estimate}}$:

$$\text{C}_{\text{estimate}} = J^{*} \cdot A^{*}, \tag{11}$$

where A^{*} is a set of numerical values of the implicit factor measured and recorded after the change.

Assume that C^* is the set of numerical values for the measurable indicators of sub-model C after the implicit factor is changed. The paper suggests that the $C_{estimate}$, C^* indicator sets be defuzzified by Mamdani algorithm into $dC_{estimate}$, dC^* and the relative error be found for the defuzzified difference values. The $\frac{dC^* - dC_{estimate}}{dC_{estimate}}$ indicator will be the desired estimated effectiveness of the proposed impact evaluation. Relations are given by matrices J_{AB}, J_{BC}, J_{AC} whose elements are the values of membership of the corresponding pair of elements in a binary relation.

4. Implementation of the fuzzy model to evaluate the causality of organization's performance factors

Using the reflexive selection procedure, a causal field was built, and indicators were divided into three groups according to the model. The expert distribution is presented in the form of **Table 1**.

We have found that KK_1 (adaptability) has little direct effect on OP_1, OP_2, and OP_3 but a strong OP_1-mediated one on PP_4. Other indirect effects were identified in a similar way.

As for the mathematical model, we introduced the following notation: fuzzy set $A = \{KK_1, KK_2, KK_3, KK_4\}$ describes the indicators of the IT company's organizational culture, fuzzy set $B = \{PP_1, PP_2, PP_3, PP_4\}$ describes indirect indicators, and fuzzy set $C = \{OP_1, OP_2, OP_3\}$ comprises the IT company's key performance indicators.

Note that the indicators chosen for the purposes of model implementation have different units of measurement. Therefore, they need to be modified by being presented as a fuzzy set. In our model, after looking into different normalizing methods to represent each sub-model's indicators as a fuzzy set, we found little to no variation in results as a function of the data normalizing method, and, therefore, each sub-model was assigned the membership function obtained by normalizing the intra-sub-model indicator values by means of dividing them by the maximum indicator. The obtained estimates are interpreted as a degree to which the indicators influence each other within the set. At the same time, we should understand that all these indicators (within each sub-model) must be measured in the same units (rubles, percent, fractions, etc.).

Therefore, in the course of the experiment, we selected performance indicators of the target organizations, revised their structures using reflexive selection model, and built their causal field with regard to the structure defined above.

A fuzzy evaluation of the effect that an implicit factor has on organization's key performance indicators will be obtained using the fuzzy logic rules, algorithms, and

Organizational culture indicators (implicit factor) (sub-model *A*)	Indirect (intermediary) indicators (sub-model *B*)	Key performance indicators of an IT company (sub-model *C*)
KK_1: adaptability KK_2: mission KK_3: cooperation KK_4: involvement	PP_1: percentage of innovative solutions in services and sales PP_2: percentage of projects performed on time PP_3: percentage of proceeds from each customer PP_4: percentage of innovations per employee	OP_1: net profit OP_2: sales of products and services OP_3: rate of return

Table 1.
System of IT company performance indicators divided into three groups.

procedures, but J. Goguen's[1] fuzzy implication will be taken as a basis since it satisfies the logic of relations among our indicators within the developed causal model.

The fuzzy inference rules by which we will evaluate the strength of relations among indicators as elements of fuzzy sets [17] that we defined in **Table 1** can be written as follows:

R1: If $KK_1 = a_1$ and $KK_2 = a_2$ and $KK_3 = a_3$ and $KK_4 = a_4$, then $PP_1 = b_1$ and $PP_2 = b_2$ and $PP_3 = b_3$ and $PP_4 = b_4$.

R2: If $PP_1 = b_1$ and $PP_2 = b_2$ and $PP_3 = b_3$ and $PP_4 = b_4$, then $OP_1 = c_1$ and $OP_2 = c_2$ and $OP_3 = c_3$.

According to the theory of fuzzy binary relations, each rule can be represented in the form of matrix:

$$R1 : J_{AB} = \{x_{ij}\} = \left(min\left\{1, \frac{b_j}{a_i}\right\}\right) \text{where } i = 1..4, j = 1..4. \tag{12}$$

$$R2 : J_{BC} = \{y_{jk}\} = \left(min\left\{1, \frac{c_k}{b_j}\right\}\right) \text{where } j = 1..4, k = 1..3. \tag{13}$$

The final impact evaluation matrix can be found according to the minimax matrix product principle:

$$J^* = J_{AB} \cdot J_{BC} \tag{14}$$

This matrix shows the extent to which implicit factor indicators influence key performance indicators of an organization. Using this matrix, we can estimate the cost of improving the implicit factor (in our case, OC) based on changes in the key performance indicators of the organization.

Note that all the indicators (a_i, b_j, c_k) necessary to evaluate the strength of relation are based on the current state of business in the respective organizations from time to time.

Using the web service named "Implicit Factors Impact Evaluation" (bi.usue.ru), we will present the results of this technique being applied to all three organizations under study.

Application of the mechanism through which the implicit factors affect the key performance indicators of an organization is described through the example of OOO nanoinform. **Table 2** shows the performance indicators of OOO nanoinform for October-November 2014. Based on these indicators, the membership functions were constructed.

To obtain the values of the fuzzy set membership functions (**Tables 4** and **5**) that characterize OOO nanoinform's performance indicators, we divided each indicator in each indicator group by the maximum value for this group and obtained the values characterizing each indicator's membership degree (**Table 3**). Interpretation of the obtained results is simple and clear—it is the degree to which the indicators within a group affect each other, which meets the purpose of our model.

For the final model value for a fuzzy set *C* that characterizes the key performance indicators, we made a Mamdani fuzzy inference. It characterizes the

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[1] J. Goguen's fuzzy implication or simply a fuzzy proposition implication in the form of ("if, then") is a binary logical operation resulting in a fuzzy proposition, the truth of which can take on the value defined by the formula:
$T(X \rightarrow Y) = \min\{1, T(Y)/T(X)\}$ where $T(X) > 0$.

Sub-model	Indicator	Value
A	KK_1, score	4.25
	KK_2, score	3.35
	KK_3, score	4.56
	KK_4, score	4.40
B	PP_1, %	20
	PP_2, %	15
	PP_3, %	17
	PP_4, %	12
C	OP_1, RUR	33,200
	OP_2, RUR	102,700
	OP_3, RUR	5100 (13%)

Table 2.
Performance indicators of OOO nanoinform for October-November 2014.

Sub-model	Indicator	Membership function value
A	KK_1	0.93
	KK_2	0.73
	KK_3	1
	KK_4	0.96
B	PP_1	1
	PP_2	0.75
	PP_3	0.85
	PP_4	0.6
C	OP_1	0.3
	OP_2	1
	OP_3	0.05

Table 3.
Membership functions based on performance indicators of OOO nanoinform.

A×B	1	0.75	0.85	0.6
0.93	1	0.81	0.91	0.65
0.73	1	1	1	0.82
1	1	0.75	0.85	0.6
0.96	1	0.78	0.89	0.63

Table 4.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indicators of an implicit factor (organizational culture) and indirect indicators of OOO nanoinform for October-November 2014, obtained using model formulas.

composite indicator obtained from the estimate indicators—the main ones for evaluating the company's performance. The rule is if $OP_1 = c_1$ and $OP_2 = c_2$ and $OP_3 = c_3$, then the composite indicator = c^*.

Such representation would be very convenient, as it would allow us to calculate the effect resulting from changes in implicit indicators.

After taking a number of measures aimed at improving the indicators, their new values were obtained (**Table 7**).

To summarize the above, we pooled the final indicators according to the model and the actual indicators (**Table 8**).

In general, the data presented in **Table 8** indicate the reliability of selected model, since the error was only 3%. To give a more accurate estimate of the implicit parameters' quantitative impact on the organization's key performance indicators is hardly possible, as their impact is partial and would be hard to formalize and, most importantly, to separate from other impacts. To calculate even an approximate impact, we had to "fuzzify" the intermediate indicators twice in order to prevent reevaluation of the effect that the organizational culture factors have on indicators of interest.

B×C	1	0.3	0.05
1	1	0.3	0.05
0.75	1	0.4	0.07
0.85	1	0.35	0.06
0.6	1	0.5	0.08

Table 5.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indirect indicators and key performance indicators of OOO nanoinform for October-November 2014, obtained using model formulas.

A×C	1	0.3	0.05
0.93	1	0.5	0.08
0.73	1	0.5	0.08
1	1	0.5	0.08
0.96	1	0.5	0.08

Table 6.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indicators of the implicit factor (organizational culture) and key performance indicators of OOO nanoinform for October-November 2014, obtained using model formulas.

Indicator	Indicator value before taking measures aimed at improving the indicators of the implicit factor (organizational culture), score	Membership function value before taking measures aimed at improving the indicators of the implicit factor (organizational culture)	Indicator value after taking measures aimed at improving the indicators of the implicit factor (organizational culture), score	Membership function value after taking measures aimed at improving the indicators of the implicit factor (organizational culture)
KK_1	4.25	0.93	4.29	0.96
KK_2	3.35	0.73	3.36	0.76
KK_3	4.56	1	4.45	1
KK_4	4.4	0.96	4.44	1

Table 7.
Values of the organizational culture indicators for OOO nanoinform and of the membership functions before and after taking measures aimed at improving the organizational culture indicators.

The similar studies were conducted for two other companies.

The results of research for OOO Invest Water Technology, with the first study and measurements performed in May 2014 and the final ones in December 2014, are presented in **Tables 9–14**.

Indicator designation	Indicator value before taking measures aimed at improving the indicators of the implicit factor (organizational culture), RUR	Indicator value after taking measures aimed at improving the indicators of the implicit factor (organizational culture) under the proposed model, RUR	Actual indicator value, RUR
OP_1	33,200	51,300	48,334
OP_2	102,700	102,700	112,000
OP_3	13%	18%	18%
Composite indicator	80,926	85,494	88,303
Model error, %	—	3	—

Table 8.
Comparison of the actual and model-based values for the OOO nanoinform key performance indicators.

Sub-model	Indicator	Value
A	KK_1, score	0.76
	KK_2, score	0.78
	KK_3, score	0.76
	KK_4, score	0.75
B	PP_1, %	14
	PP_2, %	12
	PP_3, %	10
	PP_4, %	9
C	OP_1, RUR	3,230,000
	OP_2, RUR	6,458,000
	OP_3, RUR	712,300 (6%)

Table 9.
Performance indicators of OOO Invest Water Technology for March 2014.

A×B	1	0.86	0.71	0.64
0.97	1	0.89	0.73	0.66
1	1	0.86	0.71	0.64
0.97	1	0.89	0.73	0.66
0.96	1	0.9	0.74	0.67

Table 10.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among the indicators of an implicit factor (organizational culture) and indirect indicators of OOO Invest Water Technology for March 2014, obtained using model formulas.

B×C	0.5	1	0.11
1	0.5	1	0.11
0.86	0.58	1	0.13
0.71	0.7	1	0.15
0.64	0.78	1	0.17

Table 11.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indirect indicators and key performance indicators of OOO Invest Water Technology for March 2014, obtained using model formulas.

A×C	0.5	1	0.11
0.97	0.7	1	0.17
1	0.7	1	0.17
0.97	0.7	1	0.17
0.96	0.7	1	0.17

Table 12.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indicators of the implicit factor (organizational culture) and key performance indicators of OOO Invest Water Technology for March 2014, obtained using model formulas.

Indicator	Indicator value before taking measures aimed at improving the indicators of the implicit factor (organizational culture), score	Membership function value before taking measures aimed at improving the indicators of the implicit factor (organizational culture)	Indicator value after taking measures aimed at improving the indicators of the implicit factor (organizational culture), score	Membership function value after taking measures aimed at improving the indicators of the implicit factor (organizational culture)
KK_1	0.76	0.97	0.81	1
KK_2	0.78	1	0.81	1
KK_3	0.76	0.97	0.63	0.78
KK_4	0.75	0.96	0.78	0.96

Table 13.
Values of the organizational culture indicators for OOO Invest Water Technology and of the membership functions before and after taking measures aimed at improving the organizational culture indicators.

Indicator designation	Indicator value before taking measures aimed at improving the indicators of the implicit factor (organizational culture), RUR	Indicator value after taking measures aimed at improving the indicators of the implicit factor (organizational culture) under the proposed model, RUR	Actual indicator value, RUR
OP_1	3,230,000	4,522,000	3,686,345
OP_2	6,458,000	6,458,000	6,814,123
OP_3	6%	15%	686,558 (14%)
Composite indicator	5,061,973	5,490,329	5,345,735.40
Model error, %	—	3	—

Table 14.
Comparison of the actual and model-based values for the OOO Invest Water Technology key performance indicators.

The results of research for the Regional Office of OOO SAP SNG in Yekaterinburg, with the first study and measurements performed in May 2014 and the final ones in December 2014, are presented in **Tables 15–20**.

Sub-model	Indicator	Value
A	KK_1, score	0.78
	KK_2, score	0.78
	KK_3, score	0.76
	KK_4, score	0.75
B	PP_1, %	15
	PP_2, %	20
	PP_3, %	15
	PP_4, %	14
C	OP_1, RUR	4,530,000
	OP_2, RUR	7,378,000
	OP_3, RUR	933,500 (10%)

Table 15.
Performance indicators of the Regional Office of OOO SAP SNG in Yekaterinburg for May 2014.

A×B	0.75	1	0.75	0.7
1	0.75	1	0.75	0.7
1	0.75	1	0.75	0.7
0.97	0.77	1	0.77	0.72
0.96	0.78	1	0.78	0.73

Table 16.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among the indicators of an implicit factor (organizational culture) and indirect indicators of the Regional Office of OOO SAP SNG in Yekaterinburg for May 2014, obtained using model formulas.

B×C	0.61	1	0.13
0.75	0.81	1	0.17
1	0.61	1	0.13
0.75	0.81	1	0.17
0.7	0.87	1	0.19

Table 17.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indirect indicators and key performance indicators of the Regional Office of OOO SAP SNG in Yekaterinburg for May 2014, obtained using model formulas.

Thus, the experimental studies demonstrated that our model satisfies actual practice requirements and provides the composite value with an error not exceeding 3%. Using simulation technology, we established that in 93% of cases, the model error does not exceed 3%.

A×C	0.61	1	0.13
1	0.75	1	0.19
1	0.75	1	0.19
0.97	0.77	1	0.19
0.96	0.78	1	0.19

Table 18.
Goguen's fuzzy logic rules establishing the fuzzy binary correspondences among indicators of the implicit factor (organizational culture) and key performance indicators of the Regional Office of OOO SAP SNG in Yekaterinburg for May 2014, obtained using model formulas.

Indicator	Indicator value before taking measures aimed at improving the indicators of the implicit factor (organizational culture), score	Membership function value before taking measures aimed at improving the indicators of the implicit factor (organizational culture)	Indicator value after taking measures aimed at improving the indicators of the implicit factor (organizational culture), score	Membership function value after taking measures aimed at improving the indicators of the implicit factor (organizational culture)
KK_1	0.78	1	0.80	0.99
KK_2	0.78	1	0.81	1
KK_3	0.76	0.97	0.70	0.86
KK_4	0.75	0.96	0.80	0.99

Table 19.
Values of the organizational culture indicators for the Regional Office of OOO SAP SNG in Yekaterinburg and of the membership functions before and after taking measures aimed at improving the organizational culture indicators.

Indicator designation	Indicator value before taking measures aimed at improving the indicators of the implicit factor (organizational culture), RUR	Indicator value after taking measures aimed at improving the indicators of the implicit factor (organizational culture) under the proposed model, RUR	Actual indicator value, RUR
OP_1	4,530,000	5,546,428	4,986,345
OP_2	7,378,000	7,378,000	7,734,123
OP_3	10%	16%	16%
Composite indicator	5,898,078	6,292,497	6,209,014.86
Model error, %	—	1	—

Table 20.
Comparison of the actual and model-based values for the Regional Office of OOO SAP SNG in Yekaterinburg key performance indicators.

5. Methods of interpreting and making managerial decisions to improve organizational performance with regard to factor causality

Business performance management (BPM) is a closed process consisting of four interrelated steps (strategy development, planning, monitoring and analysis, actions and adjustment) that transform business strategy into actions. The architecture of performance management system consists of a business component and a technical one. The common framework that binds these two components together is the measurements that define the leading, lagging, and diagnostic business performance indicators serving as performance monitoring and organization managing tools. At the present stage, the methodology of business performance management (BPM) and balanced scorecard of an organization recommends using lead indicators as they provide a wider overview of the future, expected performance, and allow managing people, processes, and technologies with lower risk. Performance management architecture is typically implemented as a panel of indicators within the balanced scorecard in the form of a multilayer application based on the business analysis and data integration infrastructure that allows the organizations to measure and monitor performance indicators more effectively and to control them.

Our proposed technique for making and interpreting managerial decisions is based on business analysis of the organization's processes, i.e., the tools and technologies necessary to transform data into information and information into knowledge and plans that ensure effective business conduct and use the following system of principles that we synthesized based on domestic and foreign experience in [8].

The overlap principle is implemented by introducing a new indicator into the model, namely, the fuzziness index that reflects the inconsistency in respondents' opinions. The use of this fuzziness index to process the respondents' answers gives us at least two advantages: the first one is due to the fact that this index is sensitive to the spread of their opinions and not sensitive to the number of respondents. This allows us to conduct these experiments even in small companies and to obtain adequate results.

The principle of openness to text is implemented in the interpretation model itself which is based on the fuzzy logic apparatus and relevant algorithms but has the field- and time-proven Denison questionnaire as its core part.

There is also the principle of effective history at work, the meaning of which lies in semantic essence of the model obtained and improved as a result of an in-depth scientific research in the global and domestic economics and mathematics.

Drawing the critics' attention to the obtained unconventional results, it is worth noting that we developed our mathematical model for calculating and interpreting data using the principle of common lexicon that allowed us to frame our own vision of results based on the available and time-proven lexicon, not contradictory in a broad sense to the conventional vision obtained under Denison's model.

The principle of lived experience and a similar principle of hermeneutic circle allow us to get completely new interpretations for the obtained data from the existing context by going "from particulars to generals" and vice versa, by going from data to information and knowledge and thus increasing the value of the obtained information due to similarity of model lexicons.

The principle of data intellectualization involves not only interpretation but also development of the specialized intelligent algorithms that can optimally transform data into information and knowledge suitable for making effective decisions.

The principles listed above are powerful tools for turning companies into self-learning organizations, where decisions that ensure progress toward strategic goals are made on the basis of facts generated using the business analysis procedures, namely, *from data to information* (turns feedstock (data) into various information products collected and aggregated as data banks), *from information to knowledge* (analytical tools identify trends, patterns, and deviations and turn information into a new product, i.e., knowledge), *from knowledge to rules* (rules that form new management institutions are formulated on the basis of laws, models, and schemes discovered by analytical tools), and *from rules to actions* (plans are developed that allow the rules to be implemented as actions of a business user).

By using the formulated principles to interpret the results obtained in the course of work, we can formulate the rules for their application to making managerial decisions and essentially obtain new formal managerial institutions for a given type of organizations.

The results of the study demonstrated that one of conditions for effective performance in the field of information technology is the existence of a mature implicit factor such as organizational culture that has a positive effect on the organization's performance. Such a strong positive relationship between implicit factor and business processes is primarily due to the fact that all indices under the Denison model are of either higher or high level achieved by a clear understanding by the staff in all the studied organizations of what for and why "they are here and now" (see **Figures 8** and **9**).

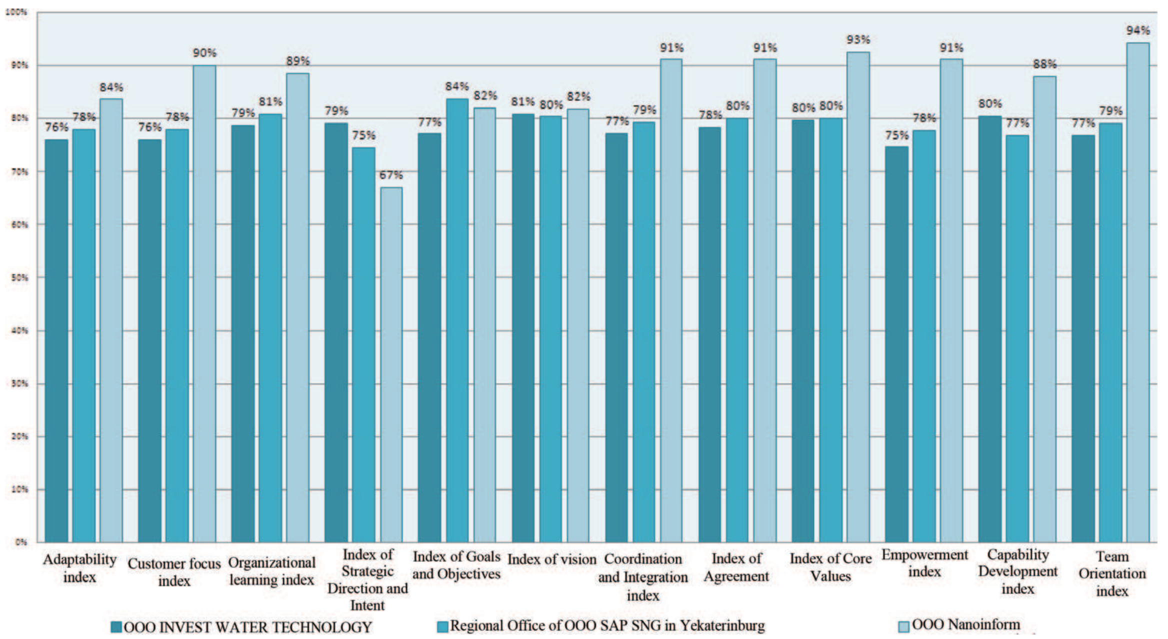

Figure 8.
Comparison of results for the Denison model indices (across the selected organizations).

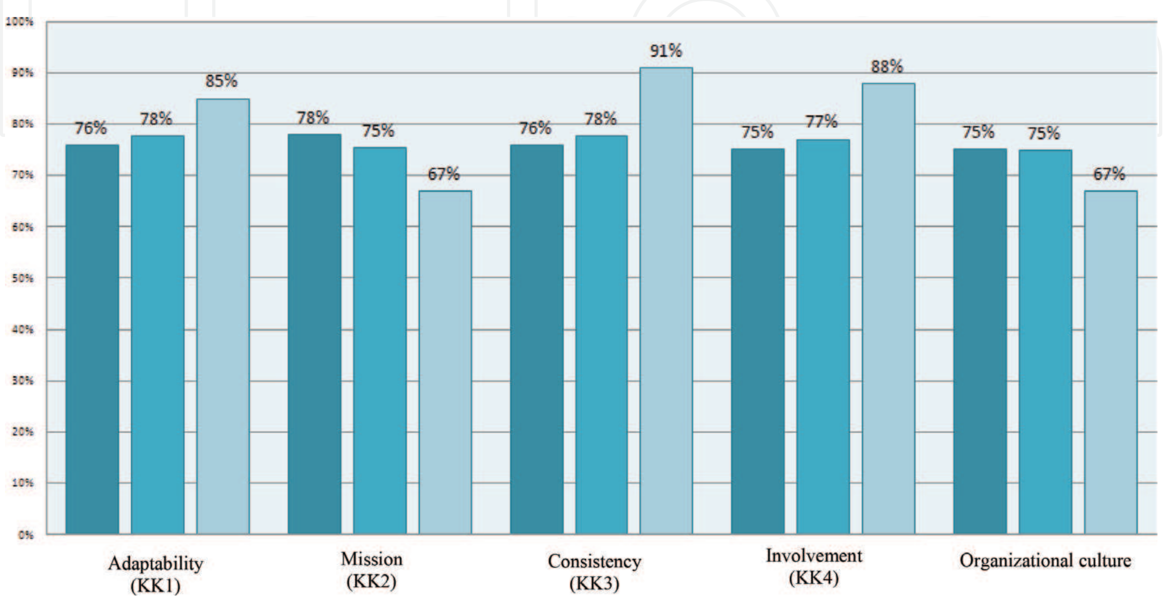

Figure 9.
Comparison of results for the final Denison model components (across the selected organizations).

They have a clear goal from which specific strategic objectives are built, thus ensuring a high degree of their involvement in the business process. Each employee feels involved in making any important decisions in the course of business that pursue a single common goal: to conduct business as efficiently as possible and to achieve a high level of income for the company in general and for each employee personally. A high degree of adaptability, which also plays an important role in shaping the organizational culture, is manifested in relationships with customers and employees and in mission understanding. The management of the surveyed organizations that position themselves as innovative prepares the employees of all levels to make decisions, to predict risks, and to be responsible for the outcome to some extent.

Therefore, for OOO Invest Water Technology, the main strengths are its mission understanding and consistency. For the Regional Office of OOO SAP SNG in Yekaterinburg, it is the increased adaptability and consistency, and for OOO nanoinform it is the consistency and staff involvement in business processes. But in general, the study demonstrated that there is no big gap in the values of indices across all the parameters and that organizational culture is economically effective in all three companies.

The causal fields of factors and performance indicators obtained for the organizations operating in the field of information technologies allow us to formulate the following rules that differ from those obtained by Denison:

1. Adaptability together with an increase in innovation has a major impact on net income and sales.

2. The system of employee involvement that determines the level of performance discipline has a great impact on sales and services.

Such formalization makes it possible to identify latent indirect effects that the implicit factor has on the key performance indicators of an organization using a mathematical tool, i.e., the fuzzy binary correspondences. The study revealed the most significant indirect effects. They can be interpreted as follows: "Implicit factor (organizational culture) has a significant effect on degree of innovation and on the quality of goods and services (influence coefficient 0.9), which in turn affect the increase in net profit and sales volumes."

On the one hand, this confirms the already known conclusions, and on the other hand, it allows adjusting the mental, statistical, and instrumental operation patterns in the studied organizations based on the close connection between the made decisions and management effectiveness.

So, the developed mechanism that evaluates the impact of an implicit factor on key performance indicators of an organization increases the effectiveness of organization management and evaluates them not only expertly but also by obtaining valid model parameters for the values of performance indicators.

Now we can see how our model can help the selected organizations to make informed managerial decisions. Note that traditional balanced scorecard offers no mechanism to verify the correctness of the quantitative estimates established for the indicator values in the planes (projections). The organization's management only sets the threshold estimates in getting a certain threshold result. For example, the amount of organization's net profit should be increased by no less than 24%, which is obviously set by experts, i.e., by managers of various levels by analyzing performance monitoring data over some period of time. A fragment of a strategic map in projection "finance" is considered, and the model-derived and raw information is summarized in **Tables 21–23**. Note that for each organization in question, a

Indicator designation	Indicator value before taking measures aimed at improving the implicit factor, RUR	Indicator value after taking measures aimed at improving the indicators of the implicit factor under the proposed model, RUR	Change in the indicator value, %	Initial indicator value according to the organization's strategic goal set when building a strategic map
OP_1	33,200	51,300	55%	Not less than 24%
OP_2	102,700	102,700	0%	Over 13%
OP_3	13%	18%	5%	Growth 15%
Composite indicator	80,926	85,494	6%	

Table 21.
Fragment of a strategic map for OOO nanoinform.

Indicator designation	Indicator value before taking measures aimed at improving the implicit factor, RUR	Indicator value after taking measures aimed at improving the indicators of the implicit factor under the proposed model, RUR	Change in the indicator value, %	Initial indicator value according to the organization's strategic goal set when building a strategic map
OP_1	3,230,000	4,522,000	40%	Not less than 24%
OP_2	6,458,000	6,458,000	0%	Over 13%
OP_3	6%	15%	9%	Growth 15%
Composite indicator	5,061,973	5,490,329	8%	

Table 22.
Fragment of a strategic map for OOO Invest Water Technology.

Indicator designation	Indicator value before taking measures aimed at improving the implicit factor, RUR	Indicator value after taking measures aimed at improving the indicators of the implicit factor under the proposed model, RUR	Change in the indicator value, %	Initial indicator value according to the organization's strategic goal set when building a strategic map
OP_1	4,530,000	5,546,428	22%	Not less than 24%
OP_2	7,378,000	7,378,000	0%	Over 13%
OP_3	10%	16%	6%	Growth 15%
Composite indicator	5,898,078	6,292,497	7%	

Table 23.
Fragment of a strategic map for the Regional Office of OOO SAP SNG in Yekaterinburg.

composite indicator calculated using the Mamdani fuzzy inference algorithm was introduced in projection "finance" in the form of a defuzzified value to characterize the overall change in situation for this projection after taking measures to achieve the strategic goals.

The calculated data obtained from the model can be interpreted by correlating it with the goal thresholds set in the strategic map of OOO nanoinform:

1. In general, after taking measures to improve the implicit factor (organizational culture), the composite indicator in projection "finance" increased by 6% indicating a positive dynamic.

2. Net profit increased by 55%, which is significantly higher than the expertly defined 24%; i.e., the goal is in fact achieved.

3. The maximum expenditure limit for the measures taken to improve the implicit factor will in this case be no more than RUR 18,100.

4. To improve other indicators in projection “finance,” a number of other management activities are necessary to increase the value of selected indicators in the strategic map to an acceptable level. For example, profitability was increased by 5%, which fails to meet the 15% target level.

The calculated data obtained from the model can be interpreted by correlating it with the goal thresholds set in the strategic map of OOO Invest Water Technology:

1. In general, after taking measures to improve the implicit factor (organizational culture), the composite indicator in projection “finance” increased by 8% indicating a positive dynamic.

2. Net profit increased by 40%, which is significantly higher than the expertly defined 24%, i.e., the goal is in fact achieved.

3. The maximum expenditure limit for the measures taken to improve the implicit factor will in this case be no more than RUR 1,292,000.

4. To improve other indicators in projection “finance,” a number of other management activities are necessary to increase the value of selected indicators in the strategic map to an acceptable level. For example, profitability was increased by 9%, which fails to meet the 15% target level.

The calculated data obtained from the model can be interpreted by correlating it with the goal thresholds set in the strategic map of the Regional Office of OOO SAP SNG in Yekaterinburg:

1. In general, after taking the measures to improve the implicit factor (organizational culture), the composite indicator in projection “finance” increased by 7% indicating a positive dynamic.

2. Net profit grew by 22%, which is close to the expertly defined 24%; however, the taken measures appeared to be insufficient, and other factors need to be identified in the organization’s performance that would help achieve the set strategic goal. At the same time, this means that the organization in question has a fairly high level of organizational culture and should not spend money on boosting it at this stage.

3. The maximum expenditure limit for the measures taken to improve the implicit factor will in this case be no more than RUR 1,016,428.

4. To improve other indicators in projection “finance,” a number of other management activities are necessary to increase the value of selected indicators in the strategic map to an acceptable level. For example, profitability was increased by 6%, which fails to meet the 15% target level.

The analysis of the obtained results and their interpretation according to the principles outlined above constitutes the final stage of the organization management process at which real actions are performed and plans are adjusted. At this stage, monitoring of the developed indicator panel plays a key role as they warn the management of potential problems and provide it with additional details and recommendations that facilitate the making of fast and adequate managerial decisions.

The developed management and managerial decision-making mechanism proved that the change (improvement or degradation) in the implicit factor (organizational culture) that was initially overlooked by all managers as a factor conductive to improving key performance indicators does in fact influence the organizational performance. At the same time, the proposed model offers a means to compare the level of expenditure on implicit factor transformation with the expected improvements in specific performance indicators and, therefore, in performance in general.

6. Conclusion

The methodology for making integrated evaluation of the impact exerted by the organizational culture based on fuzzy set descriptions has demonstrated:

1. The adequacy of our assumption that when presented as a linguistic variable, it requires that the temporal nature of its components be taken into account in that they can change over time (new ones added, old ones modified by assigning them new meaning).

2. The connection between the evolution of opinions in the organizational culture research with its implicit nature expressed in the direction in which its various components have been identified with varying degree of relevance depending on the period in the development of economic thought.

3. The multilevel and temporal nature of the effect that the organizational culture has on the organization's performance.

An instrumental analysis based on implementation of this methodology in the form of a web application allowed us to conduct multiple experiments and provided the statistical confirmation for our conclusions.

Under the proposed methodology for evaluating the organizational culture framed on the basis of the one proposed by Daniel Denison to evaluate the corporate culture of an organization, the main differences of the author's model are demonstrated and include the fuzzy inference implemented as a way to quantitatively compare and classify organizations by their level of organizational culture, which made this research less exclusive and more accessible not only for the large but also for the medium and especially small businesses.

In addition, the methodology described above implements:

1. A nonconventional interpretation of results in the study of organizational culture that identifies the levels of organizational culture as linguistic variable terms and addresses its causal character under the balanced scorecard methodology accepted in management theory and practice.

2. Not only the *qualitative* impact evaluation normally offered by various authors and scientific schools emphasizes the unconditioned direct relationship between the level of organizational culture development and the organization's

performance but also a *quantitative* one that answers the question of how much would a change in a given direction of organizational culture (under Denison's model) affect the key performance indicators of an economic entity, by the indirect effect evaluating technology that uses fuzzy binary correspondences and a fuzzy logical inference (according to Goguen).

3. Impact evaluation makes it more understandable for application in the organization management practice. In addition, this approach can strengthen the proposed model by distinguishing several levels of impact: a direct effect of various human resource management practices such as evaluation, career, training, and the resulting phenomena (involvement, loyalty, job satisfaction, turnover, etc.) on employment behavior, the effect on labor productivity of individual employees, and, finally, the effect on the overall performance of an organization and, hence, on its bottom-line performance.

Such approach may make the business interested in the organizational culture research as it can predict economic performance directly. By economic performance here, we mean the financial component of any business improvement, as well as a number of nonfinancial indicators improved incidentally. For science, this model is of interest primarily due to the fact that instead of organizational culture, it can work with any other implicit factor of an organization's performance that may not even be currently recognized by the theory and practice of an organization's business processes management.

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