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Table of Contents



1	Alexander Alexandrovich GRESKO, Kirill Igorevich LAVRENYUK, Konstantin Sergeevich SOLODUKHIN, Andrei Yakovlevich CHEN Fuzzy Multi-Period Model for Selecting Mixed Types of Stakeholder Engagement Strategies of the Company Taking into Account the Interrelations of Stakeholders	1847
2	Farkhanda SHAMIM, Bora AKTAN, Mohamed Sayed Abou ELSEOUD, Mohammed Ataaiaat Alla ABDULLA, Hayam Mohie ALSAYED Efficiency in Dual Banking System: A Non-Parametric Analysis	1859
3	Foluso. A. AKINSOLA, Nicholas M. ODHIAMBO Financial Development and Monetary Policy in Sub-Saharan Africa. Dynamic Panel Analysis	1870
4	Elena MIDLER, Valentin FILONICH The Resource Potential of the Region and Tritorial differentiation in the System of the Emerging Markets	1882
5	Andrej GREBENC Mathematical Model of Technology Transition	1888
6	Juliya Sergeevna TSERTSEIL, Viktoriya Vladimirovna KOOKUEVA, Natalya Vladimirovna GRYZUNOVA, Chuluundorj KHASHCHULUUN Analysis and Prospects of Infrastructure Development of Innovation Regional Clusters in Russia through the Example of Specific Economic Zones of Industrial Production and Technology Innovation Types	1896
7	Jiří POSPÍŠIL, Hana VOMÁČKOVÁ Net Assets Valuation in Transformations of Czech Companies	1906
8	Tomáš VALENTINY, Jaroslav GONOS, Veronika TIMKOVÁ, Martina KOŠÍKOVÁ Impact of Selected Factors on the Formation of Regional Disparities in Slovakia	1918



- | | | |
|----|---|------|
| 9 | Alexey A. NEDELKIN, Sergey V. NOVIKOV, Valery A. TITOV, Dmytro V. SANNIKOV, Anna V. MIKHAILOVA, Lyudmila N. POPOVA
Development of Human Resources of Agro-Industrial Complex | 1932 |
| 10 | Olga SHVETSOVA
The Profile of an Expatriate in South Korea: Evidence from the Korean TNC's Employee's Survey | 1943 |
| 11 | Halil Dincer KAYA
Small Business Owners' Optimism on the Economy: Are Certain Owners More Optimistic than the Others? | 1956 |
| 12 | Mikhail Yakovlevich VESELOVSKY, Marina Alekseevna IZMAILOVA, Alexey Valentinovich BOGOVIZ, Svetlana Vladislavlievna LOBOVA, Alexander Nikolaevich ALEKSEEV
Business Environment in Russia and its Stimulating Influence on Innovation Activity of Domestic Companies | 1967 |
| 13 | Marwa BILTAGY, Mariam MAHROUS, Mayar SAID, Menna KAMEL
Entrepreneurship, Unemployment and Economic Growth: Evidence from Egypt | 1982 |
| 14 | Sergei Aleksandrovich NOVOSADOV, Tatiana Aleksandrovna BURTSEVA, Natalia Victorovna REPETSKAIA, Sergey Vyacheslavovich NOVIKOV
The Formation Prospects of the Command Culture of the Organization Management Thinking in the New Paradigm of Social and Economic Development of the Society | 1996 |
| 15 | Pavla MACUROVÁ, Ladislav LUDVÍK, Martina ŽWAKOVÁ
The Driving Factors, Risks and Barriers of the Industry 4.0 Concept | 2003 |
| 16 | Roman SIDORCHUK
Study of the Relationship between Value Orientations and Consumer Preferences of Young Consumers in Russia | 2012 |
| 17 | Monika SOBEKOVA MAJKOVA, Aleksandr KLJUČNIKOV
Insolvency Risk and Problems with Receivables Payments in the Environment of the Slovak Small and Medium-sized Enterprises and Young Entrepreneurs | 2028 |



18	Dona PRIMASARI, Abdul ROHMAN, FUAD Analysis of Using Accrual Based Accounting System by the Theoretical Approach of Technology Acceptance Model 3	2039
19	Adilet Rashiduly KONGYRBAY, Galymzhan Mustahimuly DUISEN, Lazat Seitkazievna SPANKULOVA Analysis of Kazakhstan's Transport Infrastructure in the Context of the Silk Road Economic Belt Development	2050
20	Fajar SUPANTO, Yuntawati FRISTIN Community-Based Acceleration Model of Entrepreneurship Growth and Development on Telematics Creative Industries in Malang Raya Indonesia	2061
21	Ergin AKALPLER, Huseyin OZDESER, Sagiru MAT Trade-Volatility Relationship in the light of Nigeria and the Euro Area	2074
22	Ludmila Aleksandrovna KORMISHKINA, Evgenii Danilovich KORMISHKIN, Dmitrii Aleksandrovich KOLOSKOV Investments of Innovative Type as the Most Important Condition for the Neoindustrial Development of the Russian Economy	2085
23	Beby Karina Fawzee SEMBIRING, Ami DILHAM, Fivi Rahmatus SOFIAH, Ilyda SUDRADJAT Effect of Marketing Strategy and Experiential Value on Behavior Intention of Community in Dealing with ASEAN Economic Society	2101
24	Pavel KOZLOV, Yulia FINOGENOVA, Irina KHOMINICH On Equilibrium of the Financial Flows within the System of Compulsory Pension Insurance in the Russian Federation	2118
25	Pedro Gabriel DEGIOVANNI, Luis Marcelo FLORENSA, María Luisa RECALDE Latin American Integration Effects on Trade Relationships: Survival, Growth and Initial Volume	2129

Fuzzy Multi-Period Model for Selecting Mixed Types of Stakeholder Engagement Strategies of the Company Taking into Account the Interrelations of Stakeholders

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Abstract

The article describes a fuzzy multi-period model for selection of mixed types of stakeholder engagement strategies of the company taking into account the interrelations of stakeholders. Characteristics of relations between the organization and its stakeholder groups are verbally assessed and transformed into fuzzy sets in the model. A set of scenarios is set that define the dynamics of changing relations between the organization and stakeholders, as well as between stakeholders. At the same time, it is assumed that changing the properties (attributes) of stakeholders entails changes in the organization's expectations for each of them in varying degrees, depending on the degree of mutual influence between them. "Ideal" and "real" fuzzy values of the appropriateness of the use of strategy types are calculated based on the evaluation of the characteristics of relations using fuzzy set operations. Then the Hamming distances between the "ideal" and "real" values of the appropriateness of strategies application are calculated, and the strategy of organization engagement with each stakeholder is chosen on its basis. Due to the fact that the corresponding characteristics of the relationship may differ significantly for various resource components involved in the resource exchange, a situation may emerge in which for different sets of resources, the organization should maintain strategies of different types in relation to the same stakeholder. Due to this, the article proposes a method of forming mixed types of strategies.

Key words: stakeholder groups; engagement strategies; fuzzy model; multi-period model; mixed strategies

JEL Classification: C69; L29

Introduction

The stakeholder theory (stakeholder concept) is one of the most popular theories of firms today. Technically, the stakeholder theory of firm can be considered as an independent area in the general and strategic management research. The flow of publications of the relevant subject matter and content, persistent for more than a third of a century, demonstrates a theoretical and practical significance of this approach and its incompleteness and partial inconsistency at the same time (Tambovtsev 2008).

The starting point for the emergence of a stakeholder concept (as a full-scale, detailed theory) is generally considered to be the publication of a book by R.E. Freeman "Strategic management: A stakeholder approach" in 1984. In the book, the author introduces a new concept of a stakeholder, gives its definition (as "any individuals, groups or organizations that have a significant influence on decisions made by a firm and/or influenced by these

decisions" (Freeman 1984) or as "any group or individual, who can influence or be influenced by the achievement of the organization's goals" (Freeman 1984)) and suggests an original model for consideration, in which the company and its environment (external and internal) represent a set of parties interested in its activities, whose interests and demands must be taken into consideration and met by managers as formal (explicit) company representatives. R.E. Freeman has been following this definition until today (Freeman, Wicks and Parmar 2004).

This article appeared not without reason. Even earlier, in the works of other authors, there was a mention that the goals of the company were much broader than the creation of profit or wealth for owners (shareholders) and also care about welfare of a much wider range of agents (individuals and groups) (which, in fact, was the starting point of the theory). First of all, these were the works of Dodd (1932) and Simon (1952).

The theory took on a new lease of life after the publication of the work of Post, Preston and Sachs (2002), which in fact summed up the five-year (1995-2000) project "Rethinking the corporation," supported by a grant from the Sloan Foundation, and laid the foundations for a "new stakeholder approach". According to the authors of the book, the modern corporation acts as a center of a network of interrelated elements (stakeholders), each of which contributes to its performance (voluntarily or compulsorily) and expects some benefit (or at least no uncompensated damage). As such, the "stakeholder system" first appears as an attribute of a corporation (and not just as a set of elements, whose interaction with the corporation must be taken into consideration) (Blagov 2003).

The popularity of this theory has been growing rapidly in recent years and is closely associated with the significant growth of uncertainty in the economy, which leads to the practical impossibility of proper setting of optimization tasks (maximizing profits, sales, *etc.*) and forces firms to use the satisfaction approach and solve the problems of finding strategic solutions acceptable to stakeholders (Gurkov and Saidov 2012). Multiple and conflicting interests of stakeholders has to be taken into consideration when solving such problems. In this case, the lack of ways to choose the proportions of meeting the competing interests of stakeholders (efficient distribution of value created with their participation) remains one of the key problems of the stakeholder theory.

The concept of stakeholders as "contributors" to the firm's resources has been gaining popularity in the last couple of decades. This allows to substantiate their claims for a direct or indirect impact on the company's strategic decisions prior to making these decisions, while the remaining actors of the strategic process protect their interests after making decisions, in the course of their implementation [ibid]. Due to this, the acceptability of strategic decisions for stakeholders (and for a firm) is usually interpreted from the standpoint of the sustainability of resource exchange between them (Gurkov 2011).

In the course of supplying the firm with resources and with aim to maximize the ratio of benefits from interacting with the firm to the costs incurred, stakeholders gain the ability to decide whether the company will receive resources and to determine how the firm will use the resources received. Having proposed the typology of the "stakeholder-company" relationships, which is based on the interdependence of stakeholders and firms (power over each other), J. Frooman formulated four types of strategies of the influence of stakeholders on the firm (Frooman 1999).

The strategy of the firm's actions in relation to the stakeholders is based on the same typology (Gurkov 2011) (as well as on the approach of Scholes (1998)).

The idea that the organization should not just use various strategies for interaction with various stakeholders but also different strategies for the same stakeholder at different times (Jawahar and McLaughlin 2002) is also based on the resource approach. It is assumed that at any stage of the organization's life cycle, some stakeholders have higher resource potential to meet the company's critical needs, and therefore will be more important than others. In this case, the relative importance of each stakeholder will change over time, along with the strategy of interaction. As a result, at each stage of the organization's life cycle – birth (creation), growth, maturity, revival (Drazin, and Kazanjian 1990, Gorshkova, Trifonov and Poplavskaya 2014, Miller and Friesen 1984, Su, Baird, and Schoch 2013), – an attempt is made to assign one of the four strategies proposed by Carroll (1979) – response, protection, adaptation and anticipation – to each of important stakeholders.

Another set of strategy types of interaction between the organization and stakeholders is proposed in the article (Solodukhin 2009): satisfaction of demands, protection, impact, cooperation. They are based on the typology of "stakeholder-company" relationships, which is based not only on the interdependency of stakeholders and firms

(power over each other), but also the mutual desire for changes in relationships. It must be noted that the meaning of "desire for change" is close to "urgency" that is one of the three key attributes of stakeholders in the well-known Mitchell model (Agle, Mitchell and Sonnenfeld 1999, Mitchell, Agle and Wood 1997). However, in this case, not only the desire for change (urgency) of the stakeholder in relation to the company is considered, but also the desire for the firm's changes in relation to the stakeholder. At the same time, the degree of desire for change is a function of satisfaction with resource exchange and expectations about the counterparty.

The article (Gresko and Solodukhin 2015) describes the nature of each of the proposed strategy types in detail, substantiates the advantages of the proposed set of strategy types in comparison with the strategies of A. Carroll, and shows that the strategies of different types can come one after another. Later, the proposed set of strategy types was supplemented by the fifth type – restraint (Gorbunova, Gresko and Solodukhin 2016a).

Choosing the set of strategies of interaction with each stakeholder is determined by the organization's pursuance of long-term balance in relationships with all its stakeholders, for which the organization can consciously allow violation of the balance of relationships with any particular interested party in the short term. It must be noted that in the long term, pursuing the interests of one of the stakeholders to the detriment of other classes of stakeholders can lead to extremely negative consequences (such consequences are described in detail in the work (Gurkov 2011).

In its pursuance of long-term balance in relations with all stakeholders, the company cannot fail to take into consideration the relationships that have developed between the stakeholders. Possible changes in these relations (including in the resource exchange) can directly affect stakeholders' relations with the organization. Accounting for these relationships will allow the organization to choose the appropriate type of strategy for each group of stakeholders more reasonably.

According to the logic described above, when the choice of the strategy of the organization's interaction with the stakeholder is determined by the characteristics of the relationships that have developed between them and are associated with the resource exchange between them in one way or another, the fact is missed that the company and stakeholders are exchanging bundles of resources in reality. At the same time, the corresponding characteristics of relationships (dependence, satisfaction, expectations, desire for change) can differ significantly for each resource component included in the bundle. Due to this, a situation may emerge in which the organization should maintain different strategy types for different sets of resources for the same stakeholder. As such, it becomes necessary to form the mixed strategies from the basic type strategies.

Relationships between an organization and stakeholders (as well as between stakeholders) change over time. Characteristics of the relationship (dependence, desire for change) may weaken or intensify, and not always monotonously. Due to this, a need emerges to develop multi-period models that allow to choose the most appropriate types of strategies for company interaction with each group of stakeholders.

The authors developed such multi-period models of two types earlier. *Firstly*, they are multi-period models that allow to choose the most appropriate strategy types for company interaction with each group of stakeholders, taking into consideration the relationships between stakeholders (Gorbunova, Gresko and Solodukhin 2015a). *Secondly*, they are multi-period models of the choice of mixed strategy types for the organization interaction with stakeholders (Gorbunova, Gresko and Solodukhin 2016b, Gorbunova, Gresko and Solodukhin 2015b). At the same time, the models of the first type did not consider differences in the characteristics of relationships between the organization and stakeholders by certain resource components, which prevented the formation of mixed strategies. The models of the second type, on the contrary, did not take possible changes in the relationships between stakeholders into consideration.

The purpose of this article is to develop a fuzzy multi-period model of the selection of mixed strategy types for interaction between the organization and stakeholders, taking into account the relationships between the stakeholders.

The use of fuzzy set tools in the development of the model is associated with the fact that the strategies are usually chosen in conditions of high uncertainty, lack of relevant information that is of nonprobabilistic nature (with a huge amount of ambiguous information that must be taken into consideration during decision-making at the same

time). In addition, measuring the characteristics of relationships in linguistic scales greatly facilitates the work of experts and increases the accuracy of their estimates and forecasts.

1. Model

The authors outlined the following characteristics of relationships between the organization and stakeholder groups (SGs) in their previous works: degree of desire for change (which is a function of satisfaction and expectations in relation to the counterparty), degree of influence (on the counterparty).

These characteristics are fuzzy, unclear concepts, the values of which are strongly influenced by the expert's judgments, perceptions and emotions. As such, it is often more difficult to evaluate the characteristics of relationships quantitatively than qualitatively (verbally). Let's evaluate the characteristics of relations verbally and transform them into fuzzy sets. To do this, let's represent the characteristics of relationships in the form of linguistic variables Q_i, \dots, Q_s described by fuzzy numbers defined on the set x – a certain segment of the scale of dimensionless units of measurement (score):

$$Q_i = \{(x, \mu(x)): x \in X, \mu(x) \in [0; 1]\}, i = \overline{1, s}, \tag{1}$$

where x is a value of the score on the set X ; $\mu(x)$ are values of the fuzzy number membership function Q_i on X .

It is assumed that the set X is discrete; *i.e.* its elements are only integer values of score. This assumption greatly simplifies the calculations necessary to perform operations with fuzzy sets while maintaining sufficient accuracy of results. Tables 1 and 2 show possible linguistic scales and the corresponding fuzzy set membership functions.

Table 1. Transformation of verbal estimates of the characteristic "degree of mutual influence" into fuzzy sets

Verbal estimate of the degree of mutual influence	x values										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
$\mu(x)$ values											
SGs influence on the organization is incomparably greater than the organization's influence on SGs	1	1	0.4	0	0	0	0	0	0	0	0
SGs influence on the organization is significantly greater than the organization's influence on SGs	0.4	1	1	0.4	0.1	0	0	0	0	0	0
SGs influence on the organization is moderately greater than the organization's influence on SGs	0	0.4	1	1	0.2	0	0	0	0	0	0
SGs influence on the organization is insignificantly greater than the organization's influence on SGs	0	0	0.4	1	1	0.4	0.1	0	0	0	0
Mutual influence of SGs and organization is much the same	0	0	0	0.2	0.9	1	0.9	0.2	0	0	0
Organization's influence on SGs is insignificantly greater than the SGs influence on the organization	0	0	0	0	0.1	0.4	1	1	0.4	0	0
Organization's influence on SGs is moderately greater than the SGs influence on the organization	0	0	0	0	0	0	0.2	1	1	0.4	0
Organization's influence on SGs is significantly greater than the SGs influence on the organization	0	0	0	0	0	0	0.1	0.4	1	1	0.4
Organization's influence on SGs is incomparably greater than the SGs influence on the organization	0	0	0	0	0	0	0	0	0.4	1	1

Considering expectations as a characteristic of relationships between the organization and SGs, two configurations of expectations can be mentioned: the first reflects the expectations of the organization aimed at SGs, the second reflects the expectations of SGs from the organization. However, when considering these configurations, one cannot ignore the fact that there are also relationships between SGs, the changes in which can have a direct impact on mutual expectations between the organization and SGs. Since the properties of SGs in the system of resource exchange have direct impact on the quality and quantity of resource that each group will receive,

it can be said that changes in the properties SG2, SG3, ..., SGn will lead to changes in the resource exchange between them and SG1 (Figure 1).

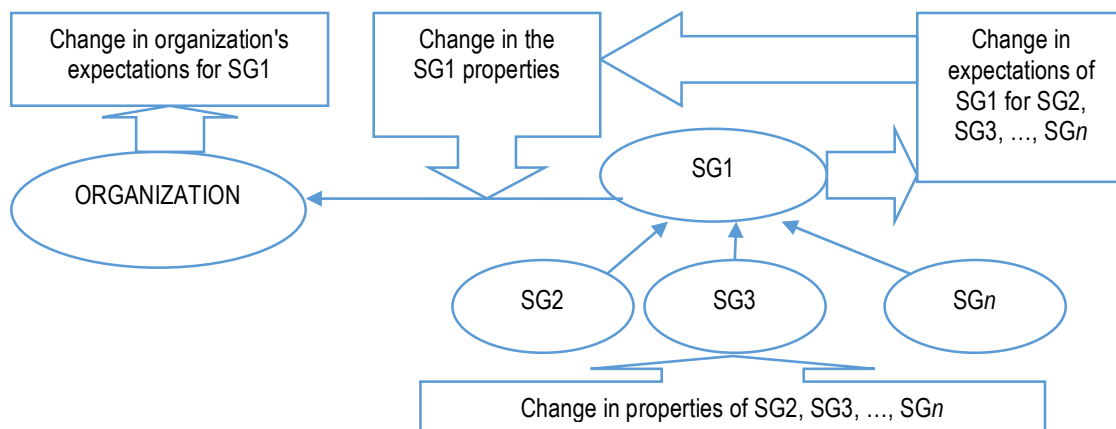
Table 2. Transformation of verbal estimates of the characteristic "degree of desire for change in relationships" into fuzzy sets

Verbal estimate of the degree of desire for change in relationships	x values										
	0	1	2	3	4	5	6	7	8	9	10
	$\mu(x)$ values										
Absent	1	0.5	0.1	0	0	0	0	0	0	0	0
Insignificant	0.6	1	0.8	0.2	0	0	0	0	0	0	0
Small	0.1	0.4	0.8	1	1	0.8	0.1	0	0	0	0
Average	0	0	0.1	0.6	1	1	1	0.6	0.1	0	0
Above average	0	0	0	0	0.2	0.8	1	1	0.4	0	0
Large	0	0	0	0	0	0.1	0.4	0.9	1	0.9	0.1
Very large	0	0	0	0	0	0	0	0.2	0.8	1	1

In turn, changes in this resource exchange will lead to change in the expectations of SG1 to SG2, SG3, ..., SGn. This, in turn, will lead to a change in the SG1 properties, which define the quality and quantity of resources received by the organization from SG1, and therefore the organization's expectations for SG1 will change. At the same time, it is assumed that the SG1 properties depend on the properties of SG2, SG3, ..., SGn (Gresko and Solodukhin, 2014a).

Similar cause-effect relationships also exist for the expectations of stakeholders from the company. This means that changes in the properties of SG2, SG3, ..., SGn will lead to a change in the expectations of SG1 towards the organization.

Figure 1. Impact of changes in the properties of SG2, SG3, ..., SGn, which define the resource exchange between them and SG1, on the organization's expectations for SG1



Due to the fact that the SG properties impact the quantity and quality of the resources received by the organization to a varying degree, some "weights" can be assigned to them (Solodukhin 2009).

As such, it is necessary to examine to what extent the organization's expectations for the resources received from each stakeholder will change in case of change in the properties of other stakeholders; and vice versa, how the expectations of each stakeholder for the company will change in case of change in the properties of other stakeholders.

Table 3 shows a fragment of the table of values of the linguistic variable for the change in expectations of the organization or the stakeholder, taking into consideration the change in some property of the counterparty (for example, another stakeholder) and taking into account the linguistically assigned estimate of the degree of mutual influence (Gresko and Solodukhin 2011).

Table 3. Values of the linguistic variable for the change in expectations of the organization or the stakeholder, taking into consideration the change in the property of the counterparty and taking into consideration the given estimate of the degree of mutual influence

Estimate of the degree of mutual influence	Estimate of the change in property	Will worsen significantly	Will worsen	Will worsen slightly	Will worsen insignificantly	Will not change
SGs influence on the organization is incomparably greater than the organization's influence on SGs	Estimate of the change in expectations	Will worsen significantly	Will worsen significantly	Will worsen significantly	Will worsen significantly	Will not change
SGs influence on the organization is significantly greater than the organization's influence on SGs		Will worsen significantly	Will worsen significantly	Will worsen significantly	Will worsen significantly	Will not change
SGs influence on the organization is moderately greater than the organization's influence on SGs		Will worsen significantly	Will worsen significantly	Will worsen significantly	Will worsen	Will not change
SGs influence on the organization is insignificantly greater than the organization's influence on SGs		Will worsen significantly	Will worsen significantly	Will worsen	Will worsen slightly	Will not change
Mutual influence of SGs and organization is much the same		Will worsen significantly	Will worsen	Will worsen slightly	Will worsen insignificantly	Will not change

Let's consider a case, when n properties influence the organization's or stakeholder's expectations for the counterparty. First of all, it is necessary to find out, what value a linguistic variable of change in expectations for a resource change will take at a given estimate of the degree of mutual influence for each individual property, and translate this value into a fuzzy set. In the next step, a convex combination of n fuzzy sets obtained is calculated. A convex combination of fuzzy sets A_1, A_2, \dots, A_n is a fuzzy set A with a membership function:

$$\mu_A(x_1, x_2, \dots, x_n) = z_1 \cdot \mu_{A_1}(x_1) + z_2 \cdot \mu_{A_2}(x_2) + \dots + z_n \cdot \mu_{A_n}(x_n), \tag{2}$$

where z_1, z_2, \dots, z_n are nonnegative numbers, the sum of which is 1. In our case, weights of properties are used as z_1, z_2, \dots, z_n .

The obtained membership function will reflect the change in the expectations of the organization or the stakeholder for the counterparty resulting from the change in its properties and taking into consideration the weights of the properties and given estimates of mutual influence for each property.

Table 4. Resources received by the university from employees and their properties

Resources received by the university from employees	Properties of employees (weight of a property)	Change in the properties	Estimate of the degree of influence
Knowledge, skills, competences	1. Qualification level (0.8); 2. Performance discipline (0.2)	1. Will improve slightly; 2. Will not change;	Organization's influence on SGs is moderately greater than the SGs influence in organization
Possibility of expanding the range of products	1. Initiative (0.3); 2. Professionalism (0.7).	1. Will worsen; 2. Will improve slightly;	SGs influence on the organization is moderately greater than the organization's influence in SGs
Well-established business processes	1. Professionalism (1)	1. Will improve insignificantly;	Organization's influence on SGs is incomparably greater than the SGs influence on organization
Corporate culture	1. Corporate thinking (0.4) 2. Loyalty to university (0.6)	1. Will not change 2. Will worsen insignificantly	Organization's influence on SGs is moderately greater than the SGs influence in organization

Resources received by the university from employees	Properties of employees (weight of a property)	Change in the properties	Estimate of the degree of influence
Research and development, other intellectual creations	1. Qualification level (0.5) 2. Professionalism (0.5)	1. Will worsen insignificantly 2. Will worsen insignificantly	Organization's influence on SGs is moderately greater than the SGs influence in organization
Organizational and management resources	1. Professionalism (1)	1. Will improve insignificantly	Organization's influence on SGs is significantly greater than the SGs influence in organization
Time worked (man-hours)	1. Performance discipline (1)	1. Will not change	Organization's influence on SGs is incomparably greater than the SGs influence in organization

Let's demonstrate the dependence of the change in the expectations of the university for resources received from this group of stakeholders on the changes in the properties of the group at given degrees of mutual influence for each resource by the example of the university and its employees. The source data are provided in Table 4. It must be noted that changes in the properties of this group result from the changes in the properties of other stakeholders (by changing the expectations of employees to these other stakeholders). The corresponding calculations are similar and omitted for clarity and simplicity of perception.

Taking Table 3 and formulas (2) into consideration, the membership functions of the change in the expectations of the university for the resources obtained can be calculated and normalized (Table 5). The membership functions of changes in the employees' expectations for the resources received from the university can be calculated in a similar way. Then the fuzzy degrees of desire for changes of the organization (university) and the group of stakeholders (employees) in relation to each other can be recalculated.

As already noted in previous works, a certain type of engagement strategy (the most suitable one, all other things being equal) can be chosen for each group of stakeholders, based on the analysis of relationship characteristics: satisfaction of demands, protection, impact, cooperation, restraint. In order to define what type of strategy should be applied to the stakeholder in the current situation, each type is assigned a fuzzy weighting factor that reflects the appropriateness of application of a strategy of this type. The appropriateness of application of the strategy of the l -th type ($l = \overline{1, 5}$) in relation to the k -th SG (w_l^k) is calculated using the following formulas:

$$w_1^k = \frac{5+G_1^k-V^k}{20}, w_2^k = \frac{10-|G_1^k-5|-V^k}{15}, w_3^k = \frac{5+G_2^k+V^k}{20}, w_4^k = \frac{25-G_1^k-G_2^k-|V^k|}{25}, w_5^k = \frac{10-|G_2^k-5|+V^k}{15}, \quad (3)$$

where V^k is the degree of mutual influence of the organization and k -th SG, G_1^k is the degree of desire for changes of the k -th SG in relation to the organization, G_2^k is the degree of desire for changes of the organization in relation to the k -th SG.

Table 5. Membership functions of the change in the expectations of the university for the resources obtained

Resources received by the university from employees	x values										
	-5	-4	-3	-2	-1	0	1	2	3	4	5
	$\mu(x)$ values										
Knowledge, skills, competences	0	0	0	0.05	0.23	0.25	0.23	0.05	0.4	1	1
Possibility of expanding the range of products	0.43	0.43	0.17	0.2	0.9	1	0.9	0.2	0	0	0
Well-established business processes	0	0	0	0	0	0	0	0	0.4	1	1
Corporate culture	0	0	0	0.2	0.9	1	0.9	0.2	0	0	0
Research and development, other intellectual creations	0	0.4	1	1	0.2	0	0	0	0	0	0
Organizational and management resources	0	0	0	0	0	0	0	0	0.4	1	1
Time worked (man-hours)	0	0	0	0.2	0.9	1	0.9	0.2	0	0	0

Assume there are d scenarios of changes in the external environment, in result of which the relations of the organization with the k -th SG change in some way in each of the t periods. Possible changes in the properties of the stakeholder groups that cause changes in the organization's expectations for stakeholders and stakeholders' expectations for the organization are taken into account within each scenario, when assessing the characteristics of the relationships for each j -th period ($j = \overline{1, t}$).

Based on the received estimates of the characteristics of the relationships, the ratios of the appropriateness of application of the l -th strategy type are calculated in relation to the k -th SG (w_{ij}^k) in the framework of the i -th scenario ($i = \overline{1, d}$) (Table 6).

Table 6. Ratios of the appropriateness of application of the l -th strategy type in relation to the k -th SG

Scenarios	Periods			
	Period 1	Period 2	Period t
Scenario 1	w_{i11}^k	w_{i12}^k	w_{i1t}^k
Scenario 2	w_{i21}^k	w_{i22}^k	w_{i2t}^k
....
Scenario d	w_{in1}^k	w_{in2}^k	w_{int}^k

Ratios of the appropriateness of application of the l -th strategy type in relation to the k -th SG within each scenario are reduced to one integral ratio (w_{ii}^k):

$$w_{ii}^k = \frac{\sum_{j=1}^t w_{ij}^k \cdot q_{ij}^k}{\sum_{j=1}^t q_{ij}^k}, \tag{4}$$

where t is number of periods, i is a number of the scenario, q_{ij}^k is a ratio reflecting the degree of confidence of the expert (or of the decision-maker (DM)) in the ratio of appropriateness of application of the l -th strategy type in relation to the k -th SG received for the j -th period within the i -th scenario.

The properties of the ratios q_{ij}^k , which are significant from the point of view of multi-period modeling, are described in detail in the work (Gresko and Solodukhin, 2014b). The integral ratios of the appropriateness of application of the strategy types are calculated using the following fuzzy set operations:

- operation of adding fuzzy numbers $A + B = C = \{z, \mu_c(z)\}$, where A and B are fuzzy numbers with membership functions $\mu_A(x)$ and $\mu_B(y)$, $\mu_c(z) = \sup_{z=x+y} \{min\{\mu_A(x), \mu_B(y)\}\}$ is a membership function of the addition result;
- operation of subtracting fuzzy numbers $A - B = C = \{z, \mu_c(z)\}$, where A and B are fuzzy numbers with membership functions $\mu_A(x)$ and $\mu_B(y)$, $\mu_c(z) = \sup_{z=x-y} \{min\{\mu_A(x), \mu_B(y)\}\}$ is a membership function of the subtraction result;
- operation of dividing fuzzy numbers $A \div B = C = \{z, \mu_c(z)\}$, where A and B are fuzzy numbers with membership functions $\mu_A(x)$ and $\mu_B(y)$, $\mu_c(z) = \sup_{z=x \div y} \{min\{\mu_A(x), \mu_B(y)\}\}$ is a membership function of the division result;
- operation of calculating the absolute value of the fuzzy number $|A| = \{z, \mu_{|A|}(x)\}$, where $\mu_{|A|}(x) = \begin{cases} \max(\mu_A(x), \mu_A(-x)), & \text{for } x \geq 0, \\ 0, & \text{for } x < 0. \end{cases}$

First, fuzzy "ideal" values of the appropriateness of application of strategies $w_1^{uk}, w_2^{uk}, w_3^{uk}, w_4^{uk}, w_5^{uk}$ are calculated. To do so, the fuzzy characteristics of the relations are chosen, under which the weighting factors of the appropriateness of application of the strategy types reach their maximum values (in accordance with the chosen linguistic scales).

Then, "real" fuzzy values of the appropriateness of application of strategies $w_1^{pk}, w_2^{pk}, w_3^{pk}, w_4^{pk}, w_5^{pk}$ are calculated on the basis of real estimates of the characteristics of relationships.

At the last stage, the Hamming distance between the "ideal" and "real" value of the appropriateness of application of the strategy is calculated for each type of strategy, using the following formula:

$$\rho(w_{li}^{uk}, w_{li}^{pk}) = \int_{-\infty}^{+\infty} \left| \mu_{w_{li}^{uk}}(x_h) - \mu_{w_{li}^{pk}}(x_h) \right| dx, \tag{5}$$

where $\mu_{w_{li}^{uk}}(x_h)$ and $\mu_{w_{li}^{pk}}(x_h)$ are membership functions of the "ideal" and "real" appropriateness of application of the strategy types, respectively.

The choice should be made in favor of the strategy type that will correspond to the shortest Hamming distance between the "ideal" and "real" appropriateness of application of the strategy.

2. Results

In the example under consideration, the Hamming distances were calculated for the integral weights of the appropriateness of application of strategy types in three scenarios (Table 7). A detailed description of the scenarios can be found in the works (Gresko and Solodukhin 2014b; Gorbunova, Gresko and Solodukhin 2016a).

As it was noted before, a situation may emerge in which for different sets of resources, the organization should maintain strategies of different types in relation to the same stakeholder. As such, the need emerges to form mixed strategies from the basic strategy types. As a result, the so-called "physical mixes of strategies" appear (Rozen 2002).

In our case, it is necessary to define the shares (weights) of resource components, for which application of a certain strategy is the most appropriate, and then use the method of forming the mixed strategy types.

In similar tasks, the outcome for the decision-maker when choosing an alternative $s = \overline{1, r}$ is a random variable of the following form: $\xi_s = \begin{bmatrix} a_s^1 & \dots & a_s^m \\ p_1 & \dots & p_m \end{bmatrix}$, where $(a_s^1 \dots a_s^m)$ is a payoff vector; $(p_1 \dots p_m)$ is a payoff probability vector. If the decision-maker uses a mixed strategy $x = (x_1, \dots, x_r)$, then the outcome corresponding to this mixed strategy will be a random variable $\xi = \sum_{s=1}^r x_s \xi_s$.

Table 7. Hamming distances

Scenarios (probabilities)	Types of engagement strategies				
	Satisfaction of demands	Protection	Impact	Cooperation	Restraint
Scenario 1 (0,2)	0.88	0.8	0.6	0.7	0.44
Scenario 2 (0,5)	0.76	0.58	0.82	0.64	0.65
Scenario 3 (0,3)	0.61	0.61	0.83	0.59	0.68
Expectation	0.739	0.633	0.779	0.637	0.617
Standard deviation	0.095	0.084	0.089	0.038	0.089

Expectation of this random variable can be found using the following formula:

$$M\xi = M(\sum_{s=1}^r x_s \xi_s) = \sum_{s=1}^r M\xi_s = \sum_{s=1}^r x_s M_s. \tag{6}$$

For the deviation of the random variable ξ from its expected value, the condition $\xi - M\xi = \sum_{s=1}^r x_s \xi_s - \sum_{s=1}^r x_s M_s = \sum_{s=1}^r x_s (\xi_s - M_s)$ is met, whence we obtain the expression for the variance:

$$D\xi = M(\xi - M\xi)^2 = M[(\sum_{s=1}^r x_s (\xi_s - M_s))(\sum_{z=1}^r x_z (\xi_z - M_z))] = \sum_{s,z=1}^r x_s x_z M[(\xi_s - M_s)(\xi_z - M_z)] \tag{7}$$

In this case, the risk of application of mixed strategy types will be less than the risk of using "pure" strategies.

The Hamming distances for all types of engagement strategies were calculated for each resource component participating in the resource exchange between the university and its group of stakeholders

"Employees", for each of the three scenarios. Tables 8 and 9 provide expectations of Hamming distances (taking the probability of scenarios into consideration).

Table 8. Hamming distances for resources received by employees from the university

Resources received by employees from the university	Weight of the resource	Strategy type	
		Satisfaction of demands	Protection
Salary	0.36	0.82	0.95
Social security	0.21	0.68	0.35
Comfortable working conditions	0.11	0.98	0.89
Status in society	0.11	0.98	0.9
Moral satisfaction from work	0.18	0.93	0.89
Easier access to educational programs	0.04	0.96	0.98

Table 9. Hamming distances for resources received by the university from employees

Resources received by the university from employees	Weight of the resource	Strategy type	
		Impact	Restraint
Knowledge, skills, competences	0.23	0.63	0.32
Possibility of expanding the range of products	0.05	0.85	0.97
Well-established business processes	0.12	0.64	0.31
Corporate culture	0.1	0.73	0.44
Research and development, other intellectual creations	0.25	0.63	0.41
Organizational and management resources	0.2	0.65	0.31
Time worked (man-hours)	0.05	0.65	0.27

3. Discussion

It can be easily seen (Table 8) that it is more appropriate to follow the strategy of satisfaction of demands for resources "Salary" and "Easier access to educational programs" with a total weight of 0.4. For other resources with a total weight of 0.6, it is better to follow the strategy of protection. As such, a probability vector of the mixed strategy can be defined (0.4, 0.6). Calculating expectation and standard deviation for the given mixed strategy, the following results are obtained: $M = 0,67$, $\sigma = 0,08$. The value of expectation turned out to be greater than with the pure type of "protection" strategy (which would obviously have been chosen, if the choice was limited to pure strategies only), but significantly less than with the pure type of the strategy of "satisfaction of demands" (Table 7). At the same time, the risk indicator (standard deviation) turned out to be lower in comparison with both types of strategies.

It is necessary to maintain the strategy of impact for the resource "Possibility of expanding the range of products" with a weight of 0.05, because the Hamming distance for this type of strategy is substantially smaller in comparison with the strategy of restraint (Table 9). However, the Hamming distance for the restraint strategy for all other resources with a total weight of 0.95 was smaller than with the strategy of impact, *i.e.* it is better to follow the strategy of restraint for these resources. As such, a probability vector of the mixed strategy can be defined (0.05, 0.95). Calculating expectation and standard deviation for the given mixed strategy, the following results are obtained: $M = 0,625$, $\sigma = 0,089$. The value of expectation turned out to be slightly worse than with the pure type of the strategy of "restraint", but much better than with the pure type of the strategy of "impact" (Table 7). The value of risk (standard deviation) has changed for the better, but very insignificantly (as was expected with such a probability vector).

Conclusion

The developed fuzzy model for selecting mixed types of stakeholder engagement strategies of the organization taking into account the interrelations of stakeholders allows to:

- take the possible changes in the relationships between stakeholders and the resulting changes in stakeholder relationships with the organization in consideration, when choosing the engagement strategies of the organization for each group of stakeholders;

- take the heterogeneity of the organization's relationships with each stakeholder (difference in the characteristics of the relationships for various resource components) into consideration; and
- form the strategies of a mixed type with a lower risk of use.

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