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Assessment of Sustainable Development Levels in Russian Organizations Using Fuzzy Sets Theory

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ABSTRACT

In practice, the analysis of the sustainable development level of organizations can be carried out using different approaches. At the moment, there are more than twenty methods of numerical integrated assessment of the financial conditions of organizations that can indicate the level of sustainable development. At the same time, such models are developed for economic conditions that are significantly different from those prevailing in Russia. Therefore, Russian organizations are faced with the task of choosing the optimal approach for evaluating sustainable development levels that are suitable to their economic conditions. One of these approaches is the assessment of the level of sustainable development of organizations using the fuzzy sets theory, developed by L. Zadeh, which allows adequately and quickly to analyze complex indicators that can lead to sustainable development of the organization. Therefore, the problem of using the fuzzy sets theory to assess sustainable development of Russian organizations is the basis of this article. The authors note that using the fuzzy sets theory in relation with 11 financial indicators that are related to sustainable development will give objective results about the current condition of the organizations and their potential to achieve sustainable development in the future.

Keywords: Russia, Fuzzy sets theory, Sustainable development, Financial indicators, Organizations, Lotfi Zadeh.

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تقييم مستويات التنمية المستدامة في المنظمات الروسية باستخدام نظرية المجموعات الضبابية

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ملخص

إن تقييم التنمية المستدامة في المنظمات التجارية يتم بأساليب عدة. وفي الوقت الحاضر، يوجد أكثر من عشرين أسلوباً من أساليب التقييم للأوضاع المالية للمنظمات التي تدل على مستوى التنمية المستدامة المتحققة. لكن هذه الأساليب تم تطويرها في ظروف اقتصادية تختلف اختلافاً جوهرياً عن الظروف الاقتصادية السائدة في روسيا. ولهذا كان لزاماً على المنظمات الروسية إيجاد الأسلوب الأمثل الذي يسمح لها بتقييم مستوى التنمية المستدامة بما يتلاءم مع ظروفها الاقتصادية. وأحد هذه الأساليب استخدام نظرية المجموعات الضبابية التي طورها العالم لطفي زاده والتي تسمح بتقييم واقع التنمية المستدامة في المنظمات بشكل موضوعي. من هنا، فإن دراسة استخدام نظرية المجموعات الضبابية في تقييم واقع التنمية المستدامة في المنظمات الروسية هو هدف هذه الدراسة. وتوصلت الدراسة إلى أن استخدام هذه النظرية في تقييم أحد عشر مؤشراً مالياً مرتبطاً بتحقيق التنمية المستدامة في المنظمة سيعطي نتائج موضوعية عن الوضع المالي للمنظمة وقدرتها على تحقيق التنمية المستدامة في المستقبل.

الكلمات الدالة: روسيا، نظرية المجموعات الضبابية، التنمية المستدامة، المؤشرات المالية، الشركات، لطفي زاده.

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INTRODUCTION

A number of criteria can assess the financial condition of any organization over a certain period, which could be estimated by means of indicators characterizing various aspects of organizational activities. The result can be as follows: prosperous, stable, unstable, insolvency or bankruptcy.

The use of fuzzy sets theory in analyzing the financial condition of organizations was reflected in the works of many mathematicians and economists, such as Peters, E.E., Nesvetailov, V.F., Pankov, V.V., Pakhomov, E. A., Nedosekin, A.O., Kozlovsky, A.N. and other scientists who have explored general questions related to the application of the fuzzy sets theory and considering its industrial dimension (Kozlovsky and Nedosekin, 2017).

This article considers the possibility of using the fuzzy sets theory in evaluating the financial indicators related to sustainable development of organizations.

Objectives

This study aims at achieving the following objectives:

- Considering the basics of fuzzy sets theory.
- Offering a set of related baseline indicators characterizing the financial condition of an organization.
- Assessing the level of sustainable development depending on the financial indicators.

Hypothesis

Using fuzzy sets theory in evaluating financial indicators will objectively allow assessing the level of sustainable development of organizations.

Problem of the Study

In practice, evaluation of sustainable development of an organization can be carried out using different approaches. Stochastic models and methods that have been used for a long time and proved useful in the modeling of various aspects of economic activity, including the formation of scenario forecasts, are actively used in strategic management accounting (SMA). However, due to a significant element of uncertainty, such an assessment will not always be informative enough for the current recognition of the state of a business. The internal state of a company, as well as the characteristics of its external environment, can be described in depth in the category of probability and random processes. However, it is more effective and correct to describe them using the fuzzy sets theory (Nedosekin, 1999). Using mathematical tools of fuzzy sets seems more reasonable, through which changes in the controlled parameters of the control process can be expressed by interval, linguistic assessment of multidirectional changes in economic indicators in addition to comprehensive assessment of the combined integrated quantitative and digitized non-financial information. This approach allows focusing not only on the assessment of sustainable development, but also on the identification of trends in its changes, without affecting the probabilistic nature of the underlying processes. Currently, in Russian, there is a certain practice of research on control systems using the tool of the fuzzy sets theory (Nedosekin, 1999). One of the important research areas that are adequately recently developed is the recognition and identification of negative trends in the financial condition of the organization, which can lead to bankruptcy (Nedosekin, 2002).

The problem of forecasting bankruptcy is certainly significant for Russian organizations and is of great interest. However, not less important is the task of analyzing and assessing the level of sustainable development in an environment, where the organization is not only in a normal economic situation, but also has a certain ability to grow and

develop. Investors often do not need to forecast chances of bankruptcy, but rather to assess the possibility of sustainable development to compare the actual results with the forecast, especially at the beginning of the life cycle of the organization.

On the other hand, within the framework of the existing management system, a qualified shareholder or investor often needs to perform an objective assessment of the quality of management of work. Such assessment could be carried out with multidirectional changes in financial and non-financial indicators with a critical attitude to the growth of certain parameters in the face of uncertainty of the changing assessment of emerging risks. A successful organization is an organization that succeeds in achieving competitive advantages.

Not less than twenty methods of numerical integrated assessment of the financial condition of organizations exist currently, which can lead to sustainable development. Some of these methods are actively used, including; assessment of financial condition in terms of W. Beaver and R. Lisa model for assessing financial condition, assessment of the probability of bankruptcy based on Altman's Z-account, R-model of bankruptcy risk forecast, R. Taffler's forecast model and D. Fulmer's model. In addition, there are the methods of diagnostics of possible bankruptcy, which were developed by Russian scientists, such as O. Zaitseva, R. Saifullina-Kadykova and others.

In the Taffler's model, forecasting financial insolvency is determined by the following weighted formula:

$$Z = 0.53X_1 + 0.13X_2 + 0.18X_3 + 0.16X_4$$

where: X_1 = Gross profits / Current deebits; X2 = Current assets / Total debits; X3 = Current debits /Total assets; X4 = Income from sales/ Total assets. For this model, the probability of bankruptcy depends on the value of Z, which is determined as follows: $Z > 0.3$ means that the company has good long-term prospects; $Z < 0.2$ means that bankruptcy is more than likely (Borodkin, 2002).

Such models are developed in economic conditions that are significantly different from the Russian economic conditions. Therefore, the automatic application of indicators with the proposed values of weight coefficients to Russian companies leads to incorrect conclusions.

As an alternative, it is possible to consider models with weights corresponding to Russian conditions, but this approach rests on the lack of sufficient data and the relativity of such information to Russian businesses. Therefore, it is believed that such an analysis conducted on Russian organizations will be subjective and may not allow the opportunity to draw the right conclusions.

Taking the above-mentioned points into account, the authors offer a different algorithm for Russian organizations, which is based on the use of the weighted average sum of key financial indicators using the fuzzy sets theory.

Literature Review

The conceptual foundations of the fuzzy sets theory were laid out in the late 60s of the last century in the works of the American scientist-mathematician Lotfi Zadeh. The research conducted by Lotfi Zadeh was a result of the ineffectiveness in the experts' systems. His work, "Fuzzy Sets", published in 1965 in the journal "Information and Control", set out the foundation for modeling human intellectual activity and became the initial impetus for the development of a new mathematical theory. He also introduced the name "fuzzy logic" as a new field of science - (fuzzy – fuzzy blurred and soft) (Pegat, 2009).

Further research conducted in the area of application of the theory of fuzzy subsets provided more insights into the field. Using an algorithm based on the use of weighted average values of sums of key

financial performance indicators for the application of the theory of fuzzy sets allows to estimate the change in the financial and economic conditions of organizations, such as the integrated indicator of efficiency of use of various resources. This approach is based on the idea of additive convolution of indicators in a single interval with a linguistic assessment of the result at a specific time t_o. This allows to abandon the subjective determination of the weight of individual indicators in evaluating the level of sustainable development while using the forecast balance sheet; we get the primary reliable indicators depending on the method of Pankov, V. and Nesvetailov, F. (Pankov, 2000).

Assessment of the economic and financial conditions of an organization using relative indicators, calculated on the basis of financial statements, may include the following groups of indicators: liquidity and solvency, financial stability, profitability, business activity and others (Nesvetailov, 2012).

Strategic Indicators of Sustainable Development SISD

In the proposed model, the authors consider the state of changes in strategic indicators of sustainable development S_{ISD} - as a complete set, covering all objects of a certain class, consisting of a fuzzy subset of values of the indicator of sustainable development I_{SD} and a fuzzy subset of the indicator of innovative development I_{ID},

where: $I_{SD} \in S_{ISD}$ and $I_{ID} \in S_{ISD}$, $S_{ISD} = I_{SD} \oplus I_{ID}$

and where: $\oplus$ is a sign of combining these indicators. This model provides management information about sustainable development and innovative improvement.

$S_{ISD} = \{(\mu_{ISD}(k_1), k_1), (\mu_{ISD}(k_2), k_2), (\mu_{ISD}(k_3), k_3), \ldots\ldots (\mu_{ISD}(k_{11}), k_{11}), (\mu_{ID}(m_i), m_i)\}$

Or $S_{ISD} = (\mu_{ISD}(k_i), k_i), (\mu_{ID}(m_i), m_i)$

In the absence of an innovative contour, a complex indicator of sustainable development is determined within the framework of a fuzzy subset's conditions and depends on the values of financial indicators k_i (comprehensive financial indicators covering all aspects of the financial management system) (Nesvetailov and Kechumova, 2012), which are taken for conditions related and sufficient to each other, as shown in Table (1).

Table 1. Comprehensive Financial Indicators

Indicator	The name of the indicator
k_1	autonomy ratio
k_2	ratio of working capital to own sources of financing
k_3	ratio of financial stability
k_4	absolute liquidity ratio
k_5	quick liquidity ratio
k_6	ratio of accounts receivable to accounts payable
k_7	ratio of current assets to short-term liabilities
k_8	return on sales ratio
k_9	return on equity ratio
k_{10}	turnover of current assets
k_{11}	turnover of non-current assets

Changes of I_{SD} are represented by a fuzzy set with a carrier K_i. Let's consider k_i as a linguistic variable, at each moment of time, determined by the values of the membership function $\mu_{ISD}(k_i)$ with interval

quantitative value [0,1], where k_i K_i.

Linguistic variable k_i is determined by the method proposed by L. Zadeh (Zadeh, 1965) as:

$$k_i = < k_i, T(k_i), K_i, G, L >,$$

where: k_i: Linguistic variable; in our case k_i is a comprehensive financial indicator.

T (k_i): Degree of membership function variable k_i with carrier K_i;

K_i: Ideal value of comprehensive financial indicator;

G: Syntax rule for the formation of variable names;

L: Semantic rule for associating each value with its concept.

The significant values of the elements for the intervals of financial indicators, which lead to sustainable development of the organization, were determined on the basis of practical observations and theoretical provisions carried out by Pankov, V. and Nesvetailova, F. (Nesvetailov, 2012), as shown in Table (2).

Table 2. Significance of Membership Functions of Financial Indicators Corresponding to I_{SD}

Value of I_{SD}	**Interval of values of μ_{ISD} (k_i)**
Very High	$[0.95] \leq \mu_{ISD}(k_i) \leq [1]$
High	$[0.72] \leq \mu_{ISD}(k_i) < [0.95]$
Very Good	$[0.52] \leq \mu_{ISD}(k_i) < [0.72]$
Good	$[0.5] < \mu_{ISD}(k_i) < [0.52]$
Low	$\mu_{ISD}(k_i) \leq [0.5]$

Taking the influence of the stochastic component of the indicator of sustainable development and the degree of disorganization of the controlled and control systems into account, setting the boundaries of the parameters in the formation of fuzzy rules I_{SD} interval-linguistic classifier is presented in Table (2). The point [0.5] in fuzzy sets theory is called the transition point, which identifies a low level of sustainable development, while the upward trend occurs at the interval value μ_{ISD} (k_i)>[0.5] and a high level of sustainable development at μ_{ISD} (k_i) ≥ [0.72].

The value of [0.5] is the transition point for the Hurst indicator used to analyze the persistence of time series when the stock price changes on the stock exchange (Peters, 2004), which indicates that using this transition point in our measurement is not a coincidence, but a hypothesis confirmed by many examples.

The sum of the interval values of the membership functions of the financial indicators, which leads to sustainable development, can be calculated as follows:

$$\sum_{i=1}^{i=11} (\mu_{ISD}(k_i), K_i) = I_{SD},$$

where: $I_{SD} = \{(\mu_{ISD}(k_i), k_i) \mid k_i \in K_i\}$, knowing that: $\forall I_{SD} \in [0, 1]$. Fuzzy subset I_{SD} determined by a set of pairs (μ_{ISD} (k_i), k_i), where: μ_{ISD} (k_i) ∈ [0, 1] is the grade of membership of element k_i, carrier K_i. The degree of membership is a number in the range [0, 1], expressed as $k_i \in K_i$. The higher the degree of membership, the more the element of the universal set corresponds to the properties of the fuzzy set K_i.

After introducing these basic concepts, the authors define a method of combining linguistic assessments, aggregation of numerical and non-numerical information. The level of sustainable development depends on the quantitative numerical information provided in the current mode by the membership function $\boldsymbol{\mu}_{ISD}$ **(k_i),** which itself is a fuzzy subset of the states of the multi-criteria membership function of numerical financial indicators:

$$(\boldsymbol{\mu}_{ISD}(k_i), k_i) = \{(\boldsymbol{\mu}_{ISD}(k_1), k_1), (\boldsymbol{\mu}_{ISD\,p}(k_2), k_2), (\boldsymbol{\mu}_{ISD}(k_3), k_3), \ldots\ldots\ldots, (\boldsymbol{\mu}_{ISD}(k_{11}), k_{11})\}$$

This membership function could be considered by assigning a value to each financial indicator ki,

statistically deriving a unified approach to the creation of a linguistic variable and interval quantitative values. The results are compared with the optimal evaluation, thus establishing the assessment of the importance of the indicators. This option is used in determining the distance separating the organization from bankruptcy (Nedosekin, 2002).

Methodology

The study adopted a descriptive field analytical methodology. The authors analyzed changes in the financial statements for previous periods of a commercial Russian organization, which works in retail trade and has a network of grocery stores (most of them have the format of "shop at home"). As of June 30, 2018, the company's network included 16,960 stores; 12,503 stores of them in the format "at home", 244 hypermarkets, 213 supermarkets and 4,000 stores for cosmetics. Outlets are located in 2808 settlements of the Russian Federation. The company has its own fleet of about 6 thousand cars. To date, the total number of employees is more than 270 thousand people. The owner equity in 2016 was 196 billion ₽.

The authors formed a forecasted balance sheet calculated according to the conditions of maximum revenue and maximum efficiency in the framework of the strategy for five years, which gave the possibility to identify all of the indicators in the initial period **to**. The results of the analysis are represented in Table (3).

Table 3. Comprehensive Financial Indicators for the Years 2012 - 2016

The name of the indicator	Indicator k_i (comprehensive financial indicator)	2012	2013	2014	2015	2016
autonomy ratio	k1	0.97	0.97	0.96	0.88	0.98
ratio of working capital to own sources of financing	k2	0.91	0.78	0.97	0.97	0.88
ratio of financial stability	k3	0.40	0.70	0.30	0.20	0.90
absolute liquidity ratio	k4	0.60	1.14	0.73	0.4	1.13
quick liquidity ratio	k5	0.82	1.10	0.79	0.80	1.2
ratio of accounts receivable to accounts payable	k6	0.15	0.14	0.13	0.11	0.16
ratio of current assets to short-term liabilities	k7	0.45	0.69	0.55	0.44	0.75
return on sales ratio (net profit)	k8	0.90	0.70	0.80	0.68	0.75
return on equity ratio	k9	0.88	0.75	0.85	0.70	0.80
turnover of current assets	k10	0.75	0.85	0.82	0.67	0.90
turnover of non-current assets	k11	0.74	0.70	0.81	0.65	0.72

Indicators shown in Table (3) allow obtaining a balanced objective assessment of the financial and economic activity of the commercial organization, which helps evaluate the level of sustainable development for each year linguistically.

The year 2012 will be considered the base year, which will be used to identify the membership functions for other years, assuming that the membership function for the base year is 0.52, depending on the forecasted balance sheet that the authors formalized.

Depending on the base year and the theory of Pankov and Nesvetailov (Pankov, 2000) which uses the fuzzy sets theory to normalize the potential of the organization, the authors conducted a linear transformation of quantitative estimates for the next

years membership functions in intervals [0,1]. The results of the estimates of interval and linguistic values in the years 2012-2016 are shown in Table (4).

Table 4. Values of Membership Functions of the Comprehensive Financial Indicators to Evaluate I_{SD}

The name of the indicator	Indicator / Membership function	Base year 2012	2013	2014	2015	2016
autonomy ratio	k_1	0.97	0.97	0.96	0.88	0.98
	$\mu_{ISD}(k_1)$	0.52	0.52	0.51	0.47	0.53
ratio of working capital to own sources of financing	k_2	0.91	0.78	0.97	0.97	0.88
	$\mu_{ISD}(k_2)$	0.52	0.45	0.55	0.55	0.50
ratio of financial stability	k_3	0.40	0.70	0.30	0.20	0.75
	$\mu_{ISD}(k_3)$	0.52	0.91	0.40	0.26	0.98
absolute liquidity ratio	k_4	0.60	1.14	0.73	0.4	1.13
	$\mu_{ISD}(k_4)$	0.52	0.99	0.63	0.35	0.98
quick liquidity ratio	k_5	0.82	1.10	0.79	0.80	1.2
	$\mu_{ISD}(k_5)$	0.52	0.80	0.50	0.51	0.76
ratio of accounts receivable to accounts payable	k_6	0.15	0.14	0.13	0.11	0.16
	$\mu_{ISD}(k_6)$	0.52	0.49	0.45	0.38	0.55
ratio of current assets to short-term liabilities	k_7	0.45	0.69	0.55	0.44	0.75
	$\mu_{ISD}(k_7)$	0.52	0.80	0.64	0.51	0.87
return on sales ratio (net profit)	k_8	0.90	0.70	0.80	0.68	0.75
	$\mu_{ISD}(k_8)$	0.52	0.40	0.46	0.39	0.43
return on equity ratio	k_9	0.88	0.75	0.85	0.70	0.80
	$\mu_{ISD}(k_9)$	0.52	0.44	0.50	0.41	0.47
turnover of current assets	k_{10}	0.75	0.85	0.82	0.67	0.90
	$\mu_{ISD}(k_{10})$	0.52	0.59	0.57	0.46	0.62
turnover of non-current assets	k_{11}	0.74	0.70	0.81	0.65	0.72
	$\mu_{ISD}(k_{11})$	0.52	0.49	0.55	0.46	0.51
$\sum_{i=1}^{i=11} \mu_{ISD}(k_i)$		5.72	6.88	5.76	4.75	7.20
I_{SD}		0.52	0.63	0.52	0.43	0.65
Linguistic evaluation of I_{SD}		**Very Good**	**Very Good**	**Very Good**	**Low**	**Very Good**

The membership function for every year is calculated depending on the base year; for example, $\mu_{ISD}(k_1)$ for 2015 = $\mu_{ISD}(k_1)$ for 2012 * k_1 for 2015 / k_1 for 2012, where $[0.95] \leq \boldsymbol{\mu}_{ISD}(k_i) \leq [1]$ is the optimal financial indicator, which indicates the best level of sustainable development status in the organization.

The indicator of sustainable development I_{SD} is the weighted average of the sum of membership function of every financial indicator for every year. In 2012, $\sum_{i=1}^{i=11}(\mu_{ISD}(k_i, k_i) = 5.72$ and considering that $I_{SD} = [0.52]$ and I_{SD} – «Very Good», then in 2013 $I_{SD} = 0.52*6.88 / 5.72 = [0.63]$, then I_{SD} – «Very Good» while in 2014 $I_{SD} = 0.52*5.76 / 5.72 = [0.52]$, then I_{SD} – «Very Good». In 2015, $I_{SD} = [0.43]$, which is a «low» level of sustainable development. In 2016, $I_{SD} = [0.65]$, which is a «Very Good» level of sustainable development.

The dynamics of the integral indicator of

sustainable development allows to say that the organization has a tendency toward sustainable development in the future. However, for the year 2015 the owner has justifications for decreasing the motivations that are given to managers because of their poor performance in many financial indicators, resulting in a «LOW» level of sustainable development for the organization.

Conclusion

Using eleven related integrated indicators and models of fuzzy sets theory allowed to assess the financial condition and the presence of trends in sustainable development of the investigated organization. It should be noted that the general traditional compatibility allows shareholders and managers to conduct a subjective analysis of individual indicators and their multidirectional change while a comprehensive integrated indicator of sustainable development I_{SD} allows them to objectively assess the quality of management.

The proven methodology on the basis of official financial statements allows for eliminating the influence of the "human" (expert) factor on drawing conclusions about the sustainable development of the organization. The result can be ranked as providing a more objective way of evaluating the performance of an organization through different years and objectively comparing its performance with those of other organizations.

Thus, it is necessary to consider two key advantages of applying the fuzzy sets theory on Russian organizations when evaluating the level of sustainable development. First, additive convolution in a single interval with a linguistic assessment of the result allows abandoning the subjective determination of the weights of individual indicators in a comprehensive assessment of the efficiency of the organization. Second, the use of fuzzy sets theory allows managers and investors to determine the permissible parameters of interrelated transformations of controlled indicators, pre-establishing the adjusted rules of formation of judgment on the integrated assessment of financial changes in the organization.

Recommendations

The fuzzy sets theory could be used to objectively evaluate the highly important non-financial information for any organization to achieve its optimal performance, which leads to a better level of sustainable development. Such non-financial information is exposed to many difficulties of calculation, evaluation and usage. Therefore, the authors recommend developing the formula of the strategic indicators of sustainable development S_{ISD} to include those non-financial information and indicators to attain a better evaluation of sustainable development in any organizations. This study showed that the innovation contour was ignored despite its significant importance for any organization. Therefore, it is recommended for any further studies to explore the innovative contour to disclose its indicators to attain what could be called (Strategic Sustainable Development) and to improve the formula that was given in the study $S_{ISD} = (\mu_{ISD}(k_i), k_i), (\mu_{ID}(m_i), m_i)$.

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