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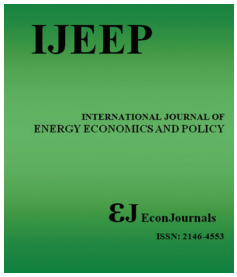

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Energy Enterprise Risks Analysis using Fuzzy Logic Methods

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ABSTRACT

In Russia's contemporary conditions, enterprises fail to make the full use of the state-of-the-art financial risks management toolkit. Both diagnosing methods and criterial norms within the mechanism of managing the energy enterprises are not adapted to the current crisis conditions of economic management, which renders it essential to develop the financial management tools that will take into account the industry-related specific nature and anti-crisis constituent of the organizations. In the work, the opportunity of applying the fuzzy logic method for analyzing the financial risks of energy enterprises in Russia is explored. For this purpose, the analysis and assessment of financial situation have been performed for a modeled energy enterprise and bankruptcy risk of the enterprise has been analyzed using the fuzzy logic method. It is demonstrated that the process of managing financial risks at the enterprise using the fuzzy sets approach is relevant in the contemporary conditions of energy enterprises functioning in Russia. There has been found the problem of having to improve the integrated risk management of energy enterprises.

Keywords: Energy Enterprise, Risk, Business Activity Indicator, Concept of Economic Value Added, Fuzzy Logic Methods
JEL Classifications: O13, P28, P48

1. INTRODUCTION

The relevance of the research problem is associated with enhancing the efforts in implementing risk management at enterprises under uncertainty and crisis trends developing in Russia's economy. Managers of energy enterprises understand that promptly taking measures in relation to risks contributes to achieving the strategic goals of the enterprises considerably while also improving the results of their activity. Moreover, the risk-related "space" of both world and Russian economy is currently expanding and deepening: The global competition increases, the freedom of trading and investing on a worldwide scale is improved, the management systems get reformed, and new technologies are propagated quite rapidly. On the one hand, these phenomena make higher the chances for production to develop successfully, while on the other hand, they generate a threat of losses emerging and even collapse of enterprises. There is one more important aspect of the necessity of implementing the risk management systems at energy enterprises: It is essential for going to IPO, obtaining the corporate rating, as well as conforming to whatever requirements of external regulators that may be relevant (Medvedeva, 2011).

Under the regular cyclicality of social and economic systems functioning, the risk of their crisis financial state being generated both at macro- and at micro-level is highly probable. However, the Russian practice shows that enterprises fail to make the full use of the contemporary toolkit for managing the financial risks (Komissarova, 2013; Lebedeva and Rogulenko, 2017; Medvedeva, 2011; Klosowski and Gola, 2016; Solodukha et al., 2016). Moreover, the situation is aggravated by the fact that diagnosing methods and criterial norms within the mechanism of managing the energy enterprises in Russia are not adapted to the current crisis conditions of economic management, which renders it essential to develop the financial management tools that will take into account

the industry-related specific nature and anti-crisis constituent of the organizations.

During processing and analyzing the data, the set of economic research methods was used that share the systemic approach to studying the problem, with the analytical, economic and statistical, abstract and logical, comparative methods and tools of financial mathematics employed.

In the work, it is stated that there are some objectively existing problems which, on the one hand, hinder the risks management implementation process and, on the other hand, make relevant the research that deals with developing the techniques and tools of risk management and focuses on their practical utility. The techniques, procedures and tools of risk management developed within the integrated (integral) approach that has been the prevailing one for the latest decade have not been systemized clearly enough so far. They are frequently controversial, and in a number of cases (this refers first of all to the integrated diagnostics of industrial enterprise risks), they are quite little fit for being used in practice (Medvedeva, 2011).

Currently, most Russian enterprises realize the importance of the "upgrade," of the financial state risks analysis, of the necessity of the new toolkit and new indicators emerging that can reflect the level of stability of the company and the probability of the onset of risks. Using the new tools and mechanisms for sustainable development of Russian energy enterprises in the field of managing the financial risk would allow identifying the general criterion for assessing the stability of organizations that could characterize both the financial situation and the probability of financial losses and the event of bankruptcy. With regard to this, production activity is one of the most risk-hazardous kinds of the economic activity due to the impact of such factors aggravating the financial risks as high capital intensity, difficulties in organizing the ready products distribution channels, burdening tax policy, high competition, and inflation (Gusareva et al., 2018; Medvedeva, 2011; Klosowski and Gola, 2016).

The interest of the research consists in shaping and scientifically justifying the theoretical and methodological as well as practical focus areas of developing a mechanism for anti-crisis financial management at organizations, with successful elaboration of the areas to allow enhancing the quality of the latter. Results of the research consist in improvement of the process of managing financial risks at the energy enterprise using the fuzzy sets approach.

2. LITERATURE REVIEW

During the work, the authors studied the scientific works by the following Russian and foreign researchers dealing with the problems range of strategic management of enterprises based on analyzing the financial risks in conditions of the turbulent environment: Belkaoui and Picur (1991), Draskovic et al. (2017), Grant (2003), Rezaul (2014).

The financial risks management problems were studied by Andryushchenko et al. (2017).

In Russia's contemporary market economy, the question of managing the economic risks and risks of insolvency and bankruptcy of enterprises have become relevant, with such Russian authors as Maloletko et al. (2017) exploring the problems.

Individual questions detailing the necessity and advantages of financial risk management for industrial enterprises are represented in works by such scholars as Prichina et al. (2017), Valko et al. (2017).

The problems of qualitative analysis of risks were explored by Sanchez-Cazorla et al. (2016), Podvesovsky et al. (2009). Wang et al. (2018) studied the management of risks within the managerial decision-making system.

The tools and methods for managing risks of enterprises were also studied by Larson and Gray (2011), Abdelgaward and Fayek (2012) and other researchers.

When using the scenarios method in project management, many authors think it possible to identify the general probability of operations chain fulfillment using the technique suggested by Abdelgaward and Fayek (2012) as a certain scenario of the particular project is fulfilled.

In project management, the assessment risks analysis (JRAP) is frequently practiced that relies on shaping the project schedule using the system of formalization of its most essential links. This method allows elaborating flexible managerial decisions in order to achieve the maximum satisfaction of temporal and financial parameters of the capital budget that were adopted earlier (Leach, 2000).

Many researchers (Medvedeva, 2011; Abdelgaward and Fayek, 2012; Andryushchenko et al., 2017; Solodukha and Gusareva, 2017) believe that in analyzing the risks one has to use a combination of methods and ways of quantitative analysis because each way of analysis has its own advantages and disadvantages in practical use.

3. MATERIALS AND METHODS

The main objective of the research consists in the improvement of the process of managing financial risks at energy enterprises of Russia. In the work, theoretical aspects of the problem of managing financial risks of energy enterprise are detailed, the contemporary methods of assessing the financial risks of enterprises and the techniques for analyzing the financial risks based on fuzzy algorithms and economic value added (EVA) are studied.

For fulfilling the objective, the opportunities of using the fuzzy logic method for analyzing the financial risks of energy enterprises in Russia were studied. In order to do this, the financial state of the modeled energy enterprise was analyzed and assessed, and so was the enterprise bankruptcy risk, using the fuzzy logic method. It is demonstrated that the process of managing financial risks at the enterprise using the fuzzy sets approach is relevant in the contemporary conditions of the energy enterprises functioning

in Russia. The problem of having to improve the integrated risk management has been found as well.

When analyzing risks in project management, traditionally, they use the methods of qualitative and quantitative analysis. The analysis of hierarchies (AHP) and risks mapping are referred to the qualitative analysis methods (Kosko, 1986). For identifying the threats, SWOT analysis is used (Nakhratova and Zotova, 2017). Among the quantitative analysis methods, there are the fuzzy logic one, the method of graphs, the Monte Carlo method, the method of failure modes and effects assessment, the event tree analysis, and the fault tree analysis (Larson and Gray, 2011).

Fuzzy logic is a new combined model of risks assessment using both the quantitative and qualitative approaches in market economy. Fuzzy logic allows high-quality ranking the quantitative indicators on the basis of statistical data, it features greater specifics from the qualitative standpoint and flexibility from the quantitative one when assessing risk. In production enterprises, this method allows identifying weaknesses in management (Gusareva et al., 2018; Prichina et al., 2017). Applying it at the energy enterprise, one will be able to say with confidence which indicator is significant in the area of risk and bears in it a greater extent of risk than others. It is even more important as using individual qualitative and/or quantitative methods in risk management may yield controversial results.

4. RESULTS AND DISCUSSION

In any economic sphere of activity, one has to have the complete idea about functioning of the organization in order to apply any risk management methods, so the integrated financial and economic analysis of its activity had to be performed (Gusareva et al., 2018. p. 49). Let the bankruptcy risk of this modeled energy enterprise be analyzed using the fuzzy logic methods. Profitability indicators are an important element in financial analysis when estimating risk as they show the level of return on and attractiveness of the activity.

In this case, for the enterprise under study for the years of 2015-2017, it can be said that it mainly has a negative dynamic of all the profitability indicators except earnings per share and financial investments. In 2017, the profitability of production made 34.95% as compared to 54.62% of 2015; this indicator characterizes reduction of profitability throughout the entire activity of the company and reduction of returns too.

For the analysis with fuzzy logic method, let two groups of indicators be created that affect the bankruptcy risk and let the normality ranges of these indicators be set. The data are presented in Tables 1-3.

Let all factors from Table 3 characterizing the economic activity for group A be denoted as:

1. Return on assets – a1;
2. Profitability of circulating assets – a2;
3. Profitability of production assets – a3;
4. Inventory turnover ratio – a4;
5. Receivables turnover – a5.

Let all factors from Table 4 characterizing the financial activity for group B be denoted as follows. It is suggested to measure the financial activity (B) proceeding from the following basic factors (indicators):

1. Absolute liquidity ratio – b1;
2. Profitability of sales – b2;
3. Current liquidity ratio – b3;
4. Intermediate (quick) liquidity ratio – b4;
5. Ratio of covering the circulating assets by own formation sources – b5.

Now let the linguistic variable "indicator level" with term-set of values "very low," "low," "medium," "high," "very high" be introduced. For describing the subsets of the term-set, let the system of five corresponding membership functions of trapezoidal kind be introduced. Let these membership functions be represented as 1-5.

Table 1: Values of group A economic activity indicators for years 2015-2017

Group A indicators	Values			Optimum value ranges
	2015	2016	2017	
Return on assets	2.93	2.86	2.08	$0<X\leq3.5$
Profitability of circulating assets	49.31%	30.46%	36.38%	$0\%<X<60\%$
Profitability of production assets	53.88%	42.95%	38.87%	$0\%<X<75\%$
Inventory turnover ratio	2.32	2.24	2.16	$0.2\leq X\leq3$
Receivables turnover	24.52%	20.03%	14.58%	$9\%X<40\%$

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 2: Values of group B financial activity indicators for years 2015-2017

Group B indicators	Values			Optimum value ranges
	2015	2016	2017	
Absolute liquidity ratio	3.56	3.92	3.19	$0\leq X\leq4$
Profitability of sales	35.11%	31.22%	25.60%	$3\%<X<40\%$
Current liquidity ratio	8.61	7.58	6.48	$1<X\leq10$
Intermediate (quick) liquidity ratio	4.20	4.53	3.77	$0.7\leq X\leq5.5$
Ratio of covering the circulating assets by own formation sources	0.87	0.85	0.88	$0.1\leq X\leq1$

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

$$\mu_1(x)=\begin{cases}1, 0 \le x < 0.15\\ 10(0.25-x), 0.15 \le x < 0.25\\ 0, 0.25 \le x \le 1\end{cases} \quad (1)$$

$$\mu_2(x)=\begin{cases}0, 0 \le x < 0.15\\ 10(x-0.25), 0.15 \le x < 0.25\\ 1, 0.25 \le x < 0.35\\ 10(0.45-x), 0.35 \le x < 0.45\\ 0, 0.45 \le x \le 1\end{cases} \quad (2)$$

$$\mu_3(x)=\begin{cases}0, 0 \le x < 0.35\\ 10(x-0.35), 0.35 \le x < 0.45\\ 1, 0.45 \le x < 0.55\\ 10(0.65-x), 0.55 \le x < 0.65\\ 0, 0.65 \le x \le 1\end{cases} \quad (3)$$

$$\mu_4(x)=\begin{cases}0, 0 \le x < 0.55\\ 10(x-0.55), 0.55 \le x < 0.65\\ 1, 0.65 \le x < 0.75\\ 10(0.85-x), 0.75 \le x < 0.85\\ 0, 0.85 \le x \le 1\end{cases} \quad (4)$$

Table 3: Transition from actual values to values for calculation of economic group A for years 2015-2017

Indicators	Years		
	2015	2016	2017
Return on assets	0.84	0.82	0.61
Profitability of circulating assets	0.82	0.51	0.61
Profitability of production assets	0.72	0.59	0.52
Inventory turnover ratio	0.76	0.73	0.70
Receivables turnover	0.50	0.35	0.18

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 4: Transition from actual values to values for calculation of economic group B

Indicators	Years		
	2015	2016	2017
Absolute liquidity ratio	0.94	1.00	0.89
Profitability of sales	0.80	0.71	0.56
Current liquidity ratio	0.84	0.73	0.61
Intermediate (quick) liquidity ratio	0.73	0.79	0.63
Ratio of covering the circulating assets by own formation sources	0.85	0.83	0.86

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

$$\mu_5(x)=\begin{cases}0, 0 \le x < 0.75\\ 10(x-0.75), 0.75 \le x < 0.85\\ 1, 0.85 \le x \le 1\end{cases} \quad (5)$$

Let the integral factors be evaluated for the enterprise bankruptcy analysis in Tables 5-12 for each year from 2015 through 2017.

A2015=0.84*(0.1*0.70+0.84*0.9)+0.82*(0.3*0.7+0.7*0.9) +0.72*0.7*1+0.76*(0.9*0.7+0.1*0.9)+0.5*0.5*1

A2016=0.82*(0.3*0.7+0.7*0.9)+0.51*1*0.5+0.59*(0.6*0.5 +0.4*0.7)+0.73*1*0.7+0.35*1*0.3

A2017=0.61*(0.4*0.5+0.6*0.7)+0.61*(0.4*0.5+0.6*0.7) +0.52*1*0.5+0.7*1*0.7+0.18*(0.7*0.1+0.3*0.3)

B2015=0.94*1*0.9+0.8*(0.5*0.7+0.5*0.9)+0.84*(0.1*0.7 +0.9*0.9)+0.73*1*0.7+0.85*1*0.9

B2016=1*1*0.9+0.71*1*0.7+0.73*1*0.7+0.79*(0.6*0.7 +0.4*0.9)+0.83*(0.2*0.7+0.8*0.9)

B2017=0.89*1*0.9+0.56*(0.9*0.5+0.1*0.7)+0.61*(0.4*0.5 +0.6*0.7)+0.63*(0.2*0.5+0.8*0.7)+0.86*1*0.9

Let the integrated indicators A and B be evaluated in comparison for 3 years and let the data be presented in Table 11.

Let the situation of the enterprise be presented in Table 12 below according to the results of integrated evaluation of indicators of its economic and financial activity for the years 2015-2017.

As the analysis of bankruptcy risks for the energy enterprise under study using the fuzzy logic methods has shown, the enterprise was at the low range level according to its economic activity level as of 2017. Therefore, economic activity needs more attention than the financial one. This indicator is a more risk-laden factor than the financial indicators so the economic activity factor demands more attention on the part of the management for applying the risks management methods to it. The enterprise has to use the risk management algorithm and risks neutralization methods.

Although the concept of EVA is broadly employed abroad, the Russian energy companies currently use it little. The main reason for that is the complexity of applying the concept.

Table 5: Matrix for evaluating the integral factor characterizing the economic activity of the energy enterprise for the year 2015

Factors	Significance	Membership functions for levels of the constituent factors				
		Very low	Low	Medium	High	Very high
a1	0.84	0	0	0	0.1	0.9
a2	0.82	0	0	0	0.3	0.7
a3	0.72	0	0	0	1	0
a4	0.76	0	0	0	0.9	0.1
a5	0.50	0	0	1	0	0
Nodal points		0.10	0.30	0.50	0.70	0.90

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 6: Matrix for evaluating the integral factor characterizing the economic activity of the energy enterprise for the year 2016

Factors	Significance	Membership functions for levels of the constituent factors				
		Very low	Low	Medium	High	Very high
a1	0.82	0	0	0	0.3	0.7
a2	0.51	0	0	1	0	0
a3	0.59	0	0	0.6	0.4	0
a4	0.73	0	0	0	1	0
a5	0.35	0	1	0	0	0
Nodal points		0.10	0.30	0.50	0.70	0.90

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 7: Matrix for evaluating the integral factor characterizing the economic activity of the energy enterprise for the year 2017

Factors	Significance	Membership functions for levels of the constituent factors				
		Very low	Low	Medium	High	Very high
a1	0.61	0	0	0.4	0.6	0
a2	0.61	0	0	0.4	0.6	0
a3	0.52	0	0	1	0	0
a4	0.70	0	0	0	1	0
a5	0.18	0.7	0.3	0	0	0
Nodal points		0.10	0.30	0.50	0.70	0.90

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 8: Matrix for evaluating the integral factor characterizing the financial activity of the energy enterprise for the year 2015

Factors	Significance	Membership functions for levels of the constituent factors				
		Very low	Low	Medium	High	Very high
b1	0.94	0	0	0	0	1
b2	0.80	0	0	0	0.5	0.5
b3	0.84	0	0	0	0.1	0.9
b4	0.73	0	0	0	1	0
b5	0.85	0	0	0	0	1
Nodal points		0.10	0.30	0.50	0.70	0.90

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 9: Matrix for evaluating the integral factor characterizing the financial activity of the energy enterprise for the year 2016

Factors	Significance	Membership functions for levels of the constituent factors				
		Very low	Low	Medium	High	Very high
b1	1.00	0	0	0	0	1
b2	0.71	0	0	0	1	0
b3	0.73	0	0	0	1	0
b4	0.79	0	0	0	0.6	0.4
b5	0.83	0	0	0	0.2	0.8
Nodal points		0.10	0.30	0.50	0.70	0.90

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 10: Matrix for evaluating the integral factor characterizing the financial activity of the energy enterprise for the year 2017

Factors	Significance	Membership functions for levels of the constituent factors				
		Very low	Low	Medium	High	Very high
b1	0.89	0	0	0	0	1
b2	0.56	0	0	0.9	0.1	0
b3	0.61	0	0	0.4	0.6	0
b4	0.63	0	0	0.2	0.8	0
b5	0.86	0	0	0	0	1
Nodal points		0.10	0.30	0.50	0.70	0.90

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

5. CONCLUSION

The need of energy enterprises in risk management that allows enhancing the efficiency of their activity by reducing the potential expenses for losses vs. risks and increasing the earnings generated by chances vs. risks is confirmed by the results of analyzing the world and domestic experience. The course for upgrading the economy and its innovation surge adopted in Russia urges for improving the scientific and methodological bases of the integral management of production and entrepreneurial risks, which affords

Table 11: Evaluation of integrated indicators "A" of the economic activity and "B" of the financial activity

Integrated indicator	2015	2016	2017
A	2.684	1.902	1.535
B	3.501	3.238	2.660

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

Table 12: The result of evaluating the integrated indicators and the situation of the enterprise broken down to years for 2015-2017

Integrated indicator	A	B
Ranges of the integrated indicators of membership		
Very low (0.5-1.3)		
Low (1.3-2.1)	2016; 2017	
Medium (2.1-2.9)	2015	2017
High (2.9-3.7)		2015; 2016
Very high (3.7-4.5)		

Source: Compiled by the authors on the basis of performance indicators of the energy enterprise under analysis

ground for believing the research problem to be relevant in terms of both theory and application.

The authors consider it a promising research focus area to develop an efficient while at the same time flexible system of managing the financial risks of energy enterprises in the RF.

It is under uncertainty that using the genetic algorithm and fuzzy sets in the combined way will enable the directors and top management of an organization to obtain a timely and objective picture of the situation that has formed at the enterprise and to identify the risk level of managerial decisions. The tools used in the work can respond to the change of economic situation at the enterprise quickly and flexibly, in a completely relevant manner, the latter being the most important; the software supporting the technique features a clear and simple interface. In its turn, this will enable the managers to timely respond to any change of situation and make the necessary decisions for correcting it.

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