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Expert System for Risk Assessment of M&A-Projects

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Abstract: The study researches the application of several fuzzy logic concepts to evaluating risk rating of M&A projects undertaken by a large Russian Metallurgic Holding: maxmin compression, fuzzy relationship of preferences, additive compression, linguistic vector estimates. The way of expert answer treatment is presented for the possibility of further fuzzy logic methods application. The 20 M&A projects are used as the empirical basis for the research. The methods applied show consistency in final estimates proving the ability of their use in MA deals' risk outcomes evaluation. The findings suggest fuzzy logic is a useful tool to evaluating gross risk of M&A projects. The gross risk estimate obtained enables to forecast the outcome of M&A deal, adjust the key financials and make the decision on whether to proceed with the deal or not during the first stage of M&A process. The proposed algorithm of M&A deals gross risk evaluation at OJSC Magnitogorsk Metallurgy Plant has proven its applicability and might be advised for further implementation at industrial enterprises.

Key words: Fuzzy logic, fuzzy set, membership functions, rule matrix, linguistic variables, risk, M&A, metallurgy, Russia

INTRODUCTION

The researches outlines proposals to create information data base of the integration activities concerning regions of the Russian Federation that is adjusted to modern conditions in the Russian market of mergers and acquisitions of economic entities. It also enables a comprehensive review of the national integration system (Polikarpova, 2011, 2012). However, currently M&A is one of the most solicited ways of developing an industrial enterprise. Though, M&A deals embed material risks they are efficient to achieve the objectives that are unattainable given other long-term development strategies (Shalenkova, 2003).

Being highly risky M&A deals often result in losses for the acquirer. As McKinsey found in 2008 ca. 70% of M&A resulted in business value destruction. Same time Russian M&A differ in several ways from abroad ones:

- No common regulator and no unique pricing procedure exist
- Market is rather closed, no unified statistics available
- There legal blank points enabling raider activity, etc
- Legal system drawback in corporate conflicts resolution (Bogatikov, 2010)

Generally, the corporate culture to dealing with M&A deal consequences is not well worked out. As the M&A deal associated risks need to be dealt with, the paper has its objective to present the way of evaluating M&A risks based on fuzzy logic concept.

MATERIALS AND METHODS

A case-study of a Russian metallurgical holding: M&A deal realization passes three stages of its live-cycle:

- Project integration (negotiation process)
- Company reorganization (sales-and purchase agreement execution)
- Company integration (incl. corporate cultures)

The majority of M&A deals are subject to UK common law, including deals taking place in off-shore jurisdictions.

When working out methodological principles of M&A deal risks evaluation for an industrial enterprise considering metallurgic holding as an example industry-specifics should be accounted for:

- Geographic distance of integrated companies and their corporate cultures difference
- High capital-intensity of metallurgy, demand for huge initial investments, long period of investment pay-back
- Acquisition of current and developing new plants is subject to external groups of interest influence

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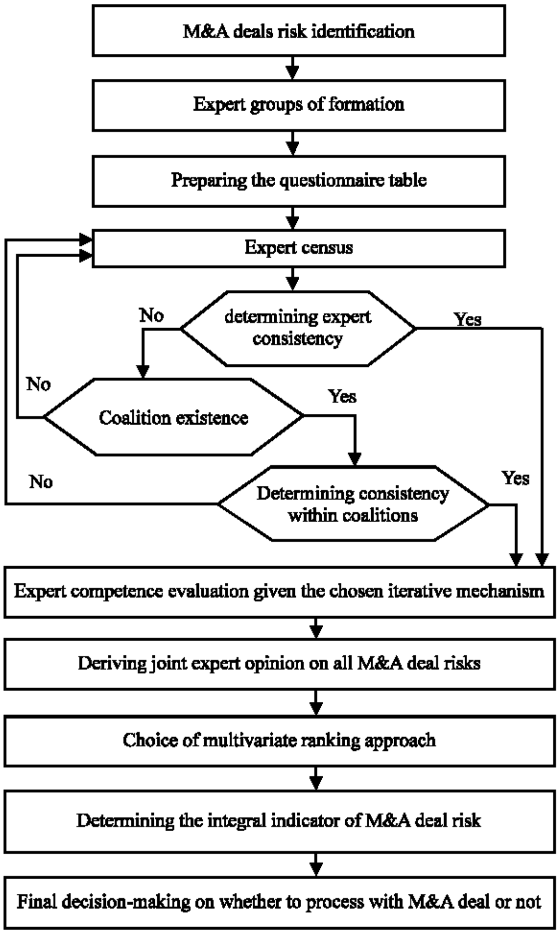

Fig. 1: Adaptive process of M&A deal gross risk evaluation

- Dealing with them is of objective necessity
- All large metallurgy plants in Russia provide employment for whole cities implying high social responsibility of M&A projects
- Technological similarity needs to be accounted for when merging metallurgical companies

The M&A process complexity is driven by a high number of involved parties. Thus, different stakeholders' possible actions were analyzed to account for most of the M&A deal risks.

Figure 1 presents the worked out process of project gross risk evaluation. The mechanism is self-adaptive and self-regulative. As risks at each of the stages are difficult to qualify fuzzy logic is used to evaluate gross risk. The fuzzy logic permits us to treat heterogeneous factors given lack of sufficient quantitative data.

According to the proposed mechanism individual risks were evaluated based on expert judgments for alternative investment projects.

Table 1: Risk grades used

Risk estimate	Risk description
1	Very low
3	Low
5	Medium
7	High
9	Very high
2, 4, 6, 8	Intermediate values

Statistical analysis of expert judgments on risks associated with M&A deals: The research is based on expert judgments for 20 M&A deals of one of the largest Russian metallurgy enterprises. The 51 risk criteria have been chosen. The 9 top-managers were questioned to obtain their expert judgments.

As expert judgment might are subjective and are reasonably different from manager to manager the Delfi Method is used to iteratively process the filled-in questionnaires (Table 1).

When ranking alternatives experts tend to provide different opinions. Therefore, it becomes necessary to estimate consistency on expert judgments (the degree of expert concordance). Arriving at the quantitative measure of expect non-concordance helps to analyze the reasons for differences in opinions. To measure expert judgments degree of concordance following measures are often used (Mood, 1950; Schervish, 1995; Shmoilova *et al*., 2003):

- Spearman rank correlation coefficient
- Dispersion concordance coefficient (Kendall rank correlation coefficient)
- Entropy concordance coefficient

Non-parametric module of Statistics software was used to estimate experts concordance within identified criteria of M&A deals risks. The χ^2 Pearson criteria for Kendall rank correlation coefficient was used (Bilodeau and Brenner, 1999). For all risk criteria the following holds: $\chi^2_{Ha\delta\pi} \geq \chi^2_{kp}$ (0.05; 19). Thus, the null hypothesis of expert judgments being consistent is not rejected.

Expert competence coefficients were estimated given ex post data on questionnaire output (MISiS Publishing House, 2009). Rykov iterative algorithm was used to obtain competence coefficients (Fig. 2).

Let's take as an example the case of country risk at the third statge of M&A deal estimation. Firstly take a look at the ranks of all M&A deals for each expert.

Secondly, at zero stage prior expert competence coefficients are estimated: $K^0_i = 1/m = 1/9$. Then average group estimated are calculated:

$$x^1_j = \sum_{i=1}^{m} K^0_i \times x_{ij}$$

Then adjusted expert competence coefficients were obtained given the Eq. 1:

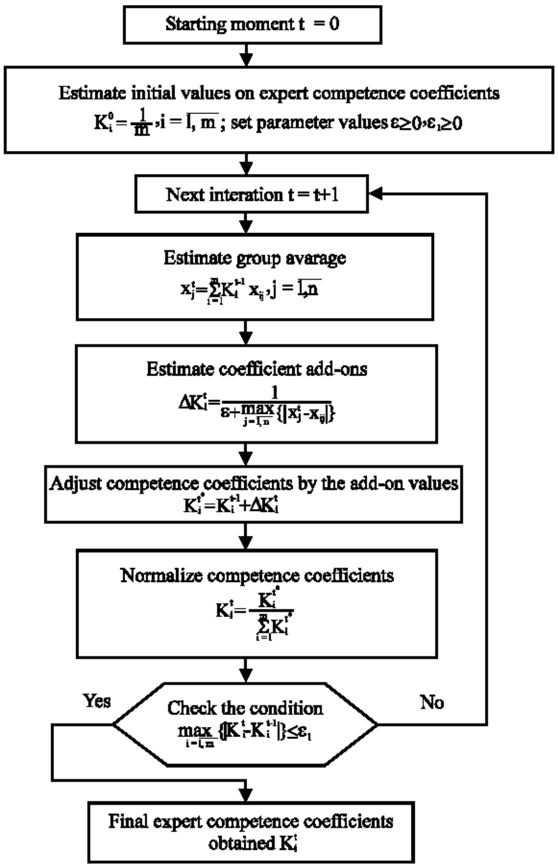

Fig. 2: Scheme of competence coefficients determination based on Rykov algorithm

$$\Delta K_i^1 = \frac{1}{\varepsilon + \max\limits_{j=1,n}\left\{\left|x_j^1 - x_{ij}\right|\right\}}, i = \overline{11,m}, \varepsilon = 0,001 \quad (1)$$

Coefficient add-ons were based on the values of $|x_j^1 - x_{ij}|$. Additive approach was used to estimate adjusted competence coefficients:

$$K_i^{1^*} = K_i^0 + \Delta K_i^1 \quad (2)$$

As the sum of coefficients needs to equal to unity, the obtained values were normalized using the following Eq. 3:

$$K_i^1 = \frac{K_i^{1^*}}{\sum\limits_{i=1}^{9} K_i^{1^*}} \quad (3)$$

Final estimates are presented in Table 2. When the 1st iteration is accomplished, the following condition was checked:

$$\max\limits_{i=1,m}\left\{\left|K_i^1 - K_i^0\right|\right\} \le 0.0001 \quad (4)$$

Table 2: The 1st iteration results for Rykov algorithm are presented

Interation results

1	2	3
$\Delta K^1_1 = 0.196$	$K^{1*}_1 = 0.307$	$K^1_1 = 0.139$
$\Delta K^1_2 = 0.117$	$K^{1*}_2 = 0.228$	$K^1_2 = 0.103$
$\Delta K^1_3 = 0.108$	$K^{1*}_3 = 0.219$	$K^1_3 = 0.099$
$\Delta K^1_4 = 0.105$	$K^{1*}_4 = 0.216$	$K^1_4 = 0.098$
$\Delta K^1_5 = 0.120$	$K^{1*}_5 = 0.231$	$K^1_5 = 0.105$
$\Delta K^1_6 = 0.099$	$K^{1*}_6 = 0.211$	$K^1_6 = 0.095$
$\Delta K^1_7 = 0.142$	$K^{1*}_7 = 0.253$	$K^1_7 = 0.114$
$\Delta K^1_8 = 0.153$	$K^{1*}_8 = 0.264$	$K^1_8 = 0.119$
$\Delta K^1_9 = 0.171$	$K^{1*}_9 = 0.283$	$K^1_9 = 0.128$

As condition (Eq. 4) does not hold, then 1st iteration steps are repeated once more. To accomplish the procedure 11 steps were needed. Final output by iteration is presented in Table 3. Expert competence coefficients on other risks were estimated similarly.

Generalized rank is obtained accounting for expert competence based on the ranking of risk sums for all objects (competence coefficients are used as the weights):

$$\text{Risk}^k(j) = \sum_{i=1}^{9} K_i \times \text{Risk}_i^k(j), \quad k = \overline{1,51}, \; j = \overline{1,20} \quad (9)$$

Based on the proposed adaptively regulating mechanism of gross risk evaluation next step would be to estimate the M&A deals gross risk.

Fuzzy logic application to M&A deals gross risk estimation: Fuzzy logic concept is an approach enabling to process information when purely quantitative data in not available (Fuzzy logic was actively applied after, Zadeh, 1965) published his article in 1965. The motivation for the paper was to process complex and difficult-to-formalize real-world problems that conventional methods of systemic analysis fail to deal with). To mention it is possible to proceed from conventional models in theory of probability and expert judgments to fuzzy sets descriptions. As an example, traditional distribution can be substituted by a distribution with fuzzy parameters. Expert judgments might be interpreted like membership functions that form the fuzzy classificatory (Zadeh, 1965, 1973, 1979).

Consequently membership functions for 51 criteria were formulated (expert values of [1; 9] were mapped to unit interval [0; 1]). As the risk criteria was a monotonically increasing function, the following transformation took place:

$$\tilde{x} = \frac{x - x_{min}}{x_{max} - x_{min}} = \frac{1}{8}(x - 1) \quad (6)$$

As a result risk was scaled to [0; 1] values where the minimal ones corresponded to minimum risk and vice versa. Four methods of fuzzy sets orderings were used in the paper based on:

Table 3: Rykov algorithm application for expert competence coefficients estimation for country risk

Iteraion No.	Deviation from previous iteration	Expert competence coefficients								
		K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9
1	0.02768	0.139	0.103	0.099	0.098	0.105	0.095	0.114	0.119	0.128
2	0.01208	0.151	0.099	0.093	0.091	0.102	0.087	0.116	0.124	0.137
3	0.01294	0.138	0.103	0.099	0.097	0.107	0.096	0.113	0.120	0.126
4	0.01255	0.150	0.100	0.093	0.091	0.103	0.088	0.115	0.124	0.136
5	0.00534	0.156	0.098	0.089	0.087	0.102	0.084	0.116	0.127	0.141
6	0.00235	0.158	0.097	0.087	0.086	0.102	0.082	0.116	0.128	0.143
7	0.00111	0.159	0.097	0.086	0.085	0.102	0.081	0.116	0.129	0.144
8	0.00056	0.159	0.096	0.086	0.085	0.102	0.080	0.117	0.130	0.145
9	0.00027	0.159	0.096	0.086	0.085	0.102	0.080	0.117	0.130	0.145
10	0.00015	0.159	0.096	0.086	0.085	0.102	0.080	0.117	0.130	0.145
11	0.00009	0.159	0.096	0.086	0.085	0.102	0.080	0.117	0.130	0.145

Table 4: Table of indicator significance

Degree of significance	Definition	Description
1	Equal significance	Both indicators equally contribute to the outcome
3	Immaterial significance dominance of parameter	One ofthe indicators is somewhat more important, though it is immaterial
5	Strong significance	Clear evidence is to choose on of the indicators
7	Very strong significance	Strong evidence exists to prefer one indicator to another
9	Absolute significance	One indicator should be definitely preferred to another
2, 4, 6, 8	Intermediary values	-
Inverse to values presented above	When ith indicator is compared to jth indicator the above presented values are assigned when on opposite jth indicator is compared to ith the inverse of the above values are assigned	

- Maxmin compression
- Fuzzy relationship of preferences
- Additive compression
- Linguistic vector estimates

Multivariate choice of alternatives based on maxmin compression: Let trace the algorithm for M&A deals ranking based on fuzzy logic (Andreichikov and Andreichikova, 2002). As the maximum values of membership function should correspond to the best alternative, it was transformed as follows:

$$\mu_{c_j}(a_i) = 1 - \mu_{c_j}^{ucx}(a_i)^1 \tag{7}$$

"To mention new membership functions produce the non-riskiness measure". Relative importance coefficients ω_j are obtained on the basis of the first eigenvalue of the rule matrix. Rule matrix is produced with respect to the indicator hierarchy. The degree of indicator significance is determined according to the principles presented in Table 4.

$$\omega_j = m\alpha_j^2 \tag{8}$$

where, α_j eigenvalue of the first eigenvector. The alternatives ranking rule given different indicator significance is determined as the fuzzy sets intersection:

$$D = C_1^{\omega_1} \cap C_2^{\omega_2} \cap ... \cap C_m^{\omega_m} \tag{9}$$

Several approaches can be used to intersect the fuzzy sets. Nevertheless, mostly the minimum is taken:

$$\mu_D(a_i) = \min_{j=1,m}(\mu_{c_j}(a_i))^{\omega_j}, i = \overline{1,n} \tag{10}$$

The best alternative a_i^* is characterized by the highest value:

$$\mu_D(a_i^*) = \max_{i=1,n} \mu_D(a_i) \tag{11}$$

The values of $\mu_D(a_i^*)$ correspond to non-riskiness level of M&S deals. Considering our objective of risk measurement the inverse values should be taken:

$$\mu_D^{FINAL}(a_i^*) = 1 - \mu_D(a_i^*) \tag{12}$$

Then the higher is $\mu_D^{FINAL}(a_i^*)$ value, the higher is the risk of deal. When characteristic equation was solved, first eigenvalue for the rule matrix was $\lambda_1 = 63.386$. Solving for the Eq. 8 relative importance coefficients ω_j were also obtained.

Having analyzed the outcome of ω_j expert values third stage risks as the most important. Inter alia country risk, risk of the duties not accomplishment and risk of company goods price decrease were considered to be the most important with the respective values assigned $\omega_{46} = 7.0895$, $\omega_{50} = 7.0648$, $\omega_{49} = 6.0752$.

Finally, all projects were ranked based on $\mu_D^{FINAL}(a_i^*)$. First place c orresponds to the highest risk, last to the minimal. Maxmin compression-based ranking of projects is presented in Table 5.

Table 5: Output for M&A deal ranking by risk based on max min compression method

M&A deal	Risk estimate	Risk rank
MMK-Atakash (Turkey)	1.0000	4
Belon	0.8690	5
Interkos-4	0.5897	20
Pakistan	1.0000	1
Gurievsk met.plant	0.8690	6
Tulachermet	0.6791	15
Prioskolsk Mining	0.6107	17
Mikhailovsk GOC	0.6107	18
Maxi-Group	0.6107	19
Vyksunsk metallurgy plant	0.6791	16
Plant "KMA-ore"	0.7902	14
Volga pipe plane	0.8633	12
Taganrog metallurgy plant	0.8690	7
Chelyabinsk pipe-producing plant	0.8690	8
Oskolsk electro-metallurgy plant	0.8690	9
First Ural New pipe plant	0.8690	10
STW (Germany)	1.0000	2
Bashmetalltorg	0.8075	13
Astrakhan port	0.8690	11
Canada	1.0000	3

Multivariate choice of alternatives based on fuzzy relationship of preferences: When the alternatives are compared with respect to preference relataionship, it is logical to assume non-dominating alternatives to be preferred. Mathematically, speaking the problem converges to tracing out nondominating subset of alternatives within the fuzzy set. Given R three corresponding fuzzy relationship can be formulated (Borisov *et al*., 1989). Fuzzy relationship of indifference:

$$\mu_{R_j}(a_p,a_i)=\max\begin{Bmatrix}\min\{1-\mu_{C_j}(a_p),1-\mu_{C_j}(a_i)\},\\ \min\{\mu_{C_j}(a_p),\mu_{c_j}(a_i)\}\end{Bmatrix} \quad (13)$$

Fuzzy relationship of quasi-equivalence:

$$\mu_{R_j}(a_p,a_i)=\min\{\mu_{C_j}(a_p),\mu_{C_j}(a_i)\} \quad (14)$$

Fuzzy relationship of strong preference:

$$\mu_{R_j}(a_p,a_i)=\begin{cases}\mu_{C_j}(a_i)-\mu_{C_j}(a_p),\text{if } \mu_{C_j}(a_i)\geq\\ \mu_{C_j}(a_p)0,\text{if } \mu_{C_j}(a_i)<\mu_{C_j}(a_p)\end{cases} \quad (15)$$

As the obtained alternatives are non-dominated given the available information, they are considered to be the best.

Let, there is A set and each alternative has several features $j=\overline{1,m}$. Information on pairwise comparison for all alternatives is presented in R_j relationship. The the rational choice needs to be done given m relationships R_j on A set.

Matrixes of fuzzy relationships are formulated for all the fuzzy relationship R_1, R_2, ..., R_m according to Eq. 15. Fuzzy realtionship Q_1 is constructed that symbolizes the intersection of relationships $Q_1 = R_1 \cap R_2 \cap .... \cap R_m$:

$$\mu_{Q_1}(a_p,a_i)=\min\begin{Bmatrix}\mu_{R_1}(a_p,a_i),\mu_{R_2}(a_p,a_i),\\ ...,\mu_{R_m}(a_p,a_i)\end{Bmatrix} \quad (16)$$

Subset of non-dominated alternatives is chosen {A, μ (Q_1)} for all p and i $(i=\overline{1,n};p=\overline{1,n})$:

$$\mu_{Q_1}^{ND}(a_p)=1-\sup_{a_p\in A}\begin{Bmatrix}\mu_{Q_1}(a_p,a_i)-\\ \mu_{Q_1}(a_i,a_p)\end{Bmatrix}\forall p,i,p\neq i \quad (17)$$

Fuzzy relationship Q_2 is obtained:

$$\mu_{Q_2}(a_p,a_i)=\sum_{j=1}^{m}\omega_j\mu_{R_j}(a_p,a_i) \quad (18)$$

Subset of non-dominated alternatives is found for {A, μ (Q_2)} for all p and i $(i=\overline{1,n};p=\overline{1,n})$. Final subset of non-dominating alternatives is found as the intersection of subsets {A, $\mu(Q_1)$} and {A, $\mu(Q_2)$}:

$$\mu^{ND}(a)=\mu_{Q_1}^{ND}\cap\mu_{Q_2}^{ND}=\min(\mu_{Q_1}^{ND},\mu_{Q_2}^{ND}) \quad (19)$$

The most rational alternative to choose is the one having the highest degree of non-dominance:

$$a^{ND}=\left\{a\,|\,a\in A,\mu^{ND}(a)=\sup_{a'\in A}\mu^{ND}(a')\right\} \quad (20)$$

To note not only a^{ND} alternatives are the best, sometimes weekly dominated alternatives might be of interest, i.e., the ones belonging to $\mu^{ND}(a)$ given the degree of confidence is no less then preapproved.

For 20 alternatives' membership functions 51 matrixes R_1, R_2, ..., R_{51} of fuzzy relationship were constructed. Based on Eq. 16 Q_1 fuzzy relationship was obtained as the intersection $Q_1 = R_1 \cap R_2 \cap ... \cap R_m$. Based on Eq. 17 subset of non-dominated alternatives was found {A, $\mu(Q_1)$}. Referring to principle (Eq. 20) the final set was obtained.

Similar to maxmin compression four deals were considered as the most risky being assigned respective values of riskiness: Canada (μ^{ND} (a_{20}) = 0.9593), Germane (μ^{ND} (a_{17}) = 0.9335), Pakistan ($\mu^{ND}(a_4)$ = 0.8870), Turkey (μ^{ND} (a_1) = 0.7915).

Multivariate choice of alternatives based on additive compression: Current method presents expert judgments as fuzzy numbers having membership functions of triangular form.

To estimate the importance parameters ω_j linguistic variables are used: "not very important", "important", "very important". Linguistic variables are represented by the fuzzy numbers from the membership functions of triangular form (Bellman and Zadeh, 1970). Respectively, not very important (HOB):

$$\mu_{HOB} = \left\{\frac{0}{0};\frac{1}{0,2};\frac{0}{0,4}\right\}$$

Important (B):

$$\mu_{B} = \left\{\frac{0}{0,3};\frac{1}{0,5};\frac{0}{0,7}\right\}$$

Very important (OB):

$$\mu_{OB} = \left\{\frac{0}{0,6};\frac{1}{0,8};\frac{0}{1,0}\right\}$$

To estimate criteria R_{ij} linguistic variables are also used: "very low risk", "low risk", "medium risk", "high risk", "very high risk". Respectively: Very low risk (OH):

$$\mu_{OH} = \left\{\frac{1}{0};\frac{0}{0,2}\right\}$$

Low risk (H):

$$\mu_{H} = \left\{\frac{0}{0};\frac{1}{0,2};\frac{0}{0,4}\right\}$$

Medium risk (C):

$$\mu_{C} = \left\{\frac{0}{0,2};\frac{1}{0,4};\frac{0}{0,6}\right\}$$

High risk (B):

$$\mu_{B} = \left\{\frac{0}{0,4};\frac{1}{0,6};\frac{0}{0,8}\right\}$$

Very high risk (OB):

$$\mu_{OB} = \left\{\frac{0}{0,6};\frac{1}{0,8};\frac{0}{1,0}\right\}$$

Criteria values for alternatives and their importance parameters are recorded. Weighted estimates R_1 are obtained as follows:

$$R_i = \sum_{j=1}^{m} \omega_j \times R_{ij}, i = \overline{1,n}, j = \overline{1,m} \quad (21)$$

When weighted estimates R_i are obtained, objects are compared. For the purpose fuzzy set I is introduced with values following the below rule:

$$\mu_I(a_i) = \sup_{r_p \geq r_i} \min_{i=\overline{1,n}} \mu_{R_i}(r) \quad (22)$$

The best alternative is the one having the highest μ_I (a_i) value. I function values are interpreted as the alternative level of riskiness.

Similarly to the previous approaches the metallurgy holding experts would treat the following projects as the most risk: Pakistan ($\mu(a_4) = 1$), Canada ($\mu(a_{20}) = 0.9260$), Turkey ($\mu(a_1) = 0.9240$), Germany ($\mu(a_{17}) = 0.9200$).

Multivariate choice of alternatives based on linguistic vector estimates: Another questionnaire was used asking to mark not the values from 1-9 (Table 1) for various risks but to assign the linguistic level of risk: very low (OH), low (H), medium (C), high (B), very high (OB). Consequently, linguistic vector estimates method was used to handle these answers. Preference of each alternative to the rest is evaluated.

Output values of c_j are presented by fuzzy numbers that are a part of some base set. The set of linguistic variables TS can be formed in the following manner: TS = {OH (very low), H (low), C (medium), B (high), OB (very high)} (Yih-Guang *et al*., 1999). Below is presented the way of alternatives ordering based on linguistic vector estimates:

- Membership functions are constructed for values of the set TS
- The matrix C^* presents the linguistic vectors
- For each alternative a_i preference estimate with respect to another alternative is calculated. Similar to maxmin approach firstly the worst values are obtained a_i (μ<) and only afterwards the inverse to them ($\mu\geq$), the largest of which is taken

For each of criteria c_j the following is computed:

$$\sum_{\xi=1}^{k} \mu_{c_j}(a_i) \quad (23)$$

where, k number of elements in the value (term) of the TS set. The degree of preference for alternative a_i for all criteria c_j is produced:

$$\mu_<(c_j(a_1), c_j(a_2), \ldots, c_j(a_n)) = \sum_{\gamma=1}^{s} (\upsilon^{\gamma}_{c_j}(a_i) \prod_{\substack{l=1 \\ l\neq i}}^{n} (1 - \sum_{\gamma=1}^{s} \upsilon^{\gamma}_{c_j}(a_l))) \quad (24)$$

Where:

$$\upsilon^{\gamma}_{c_j}(a_i) = \frac{\mu^{\gamma}_{c_j}(a_i)}{\sum_{\xi=1}^{Л} \mu_{C_j}(a_i)} \quad s = \min k$$

The m relationships $\mu_{\geq}(c_j(a_1), c_j(a_2), ..., c_j(a_n))$ is obtained as follows:

$$\mu_{\geq}(c_j(a_1), c_j(a_2), ..., c_j(a_n)) = 1 - \mu_{<}(c_j(a_1), c_j(a_2), ..., c_j(a_n)) \quad (25)$$

The degree of alternative a_i preference equals to minimum of the above m Eq. 25. The best of n alternatives is the one a_i having the maximum degree of preference. As experts used the scale of 9 scores the following membership functions were proposed for TS set values:

$$OH = \left\{\frac{1,0}{1}; \frac{0,8}{2}; \frac{0,4}{3}\right\}$$

$$H = \left\{\frac{0,8}{1}; \frac{0,9}{2}; \frac{0,5}{3}\right\}$$

$$C = \left\{\frac{0,3}{3}; \frac{0,7}{4}; \frac{1,0}{5}; \frac{0,8}{6}\right\}$$

$$B = \left\{\frac{0,8}{7}; \frac{0,9}{8}; \frac{0,7}{9}\right\}$$

$$OB = \left\{\frac{0,2}{7}; \frac{0,7}{8}; \frac{1,0}{9}\right\}$$

Matrix C' of linguistic vector estimates for alternatives for TS values was constructed. Table 6 presents the example of preference estimate result for the first M&A alternative (MMK-Atakash, Turkey) based on Eq. 23-25. Results of M&A project ranking based on linguistic vector estimates are presented in Table 7.

The linguistic vector estimate approach produced result comparable to those of the previously regarded approached. The most risks for the metallurgy holding are associated with M&A deals in Pakistan, Turkey, Canada and Germany.

Table 8 summarizes the ranking for all four approaches of fuzzy logic application. It is evident that

Table 6: Example of preference estimate calculation for MMK-Atakash (Turkey) M&A deal

Risk criteria	$\mu_{<}(c_j(a_1), c_j(a_2), ..., c_j(a_{20}))$	$\mu_{\geq}(c_j(a_1), c_j(a_2), ..., c_j(a_{20}))$
Risk of operational interference during M&A process	0.000047	0.999953
Risk of management being forced to make certain decisions	0.000306	0.999694
Risk of information drain	0.000868	0.999132
Risk of non-accounting for material determinants of integration	0.000433	0.999567
Risk of wrong integration efficiency estimation	0.000192	0.999808
Risk of target company incomes over-estimation	0.000839	0.999161
Risk of under-estimation of target companies costs	0.000457	0.999543
Risk of underestimation of target company staff and rent costs	0.000119	0.999881
Risk of non-accounted tax liabilities	0.000045	0.999955
Risk of M&A deal being not approved	0.000036	0.999964
Risk of asset loss during restructuring period	0.003232	0.996768
Risk of approved price change given the preliminary terms are met	0.000106	0.999894
Risk the integration structure discouraging conditions are created	0.000040	0.999960
Country risks	0.000009	0.999991
Risk of raw material prices increase	0.000018	0.999982
Risk of consumer demand decrease	0.000012	0.999988
Risk of company goods prices decrease	0.000008	0.999992
Risk of duties not accomplished	0.000077	0.999923
Risk the M&A deals terms contradict the principles of corporate governance	0.000032	0.999968
	Min	0.995332

Table 7: Output for projects ranking giving the linguistic vector estimation approach

M&A Deal	Risk estimate	Risk rank
MMK-Atakash (Turkey)	0.9953	2
Belon	0.9951	7
Interkos-4	0.9929	11
Pakistan	0.9953	1
Gurievsk met.plant	0.9947	8
Tulachermet	0.9952	5
Prioskolsk Mining	0.9929	12
Mikhailovsk GOC	0.9929	13
Maxi-Group	0.9939	10
Vyksunsk metallurgy plant	0.9773	19

Table 7: continue

M&A Deal	Risk estimate	Risk rank
Plant "KMA-ore"	0.9773	20
Volga pipe plane	0.9891	14
Taganrog metallurgy plant	0.9947	9
Chelyabinsk pipe-producing plant	0.9891	15
Oskolsk electro-metallurgy plant	0.9891	16
First Ural New pipe plant	0.9952	6
STW (Germany)	0.9953	4
Bashmetalltorg	0.9891	17
Astrakhan port	0.9802	18
Canada	0.9953	3

Table 8: Output on gross risk estimation based on 4 fuzzy logic approaches

	Fuzzy logic model based on							
	Maxmin compression		Fuzzy relationship of preferences		Additive compression		Linguistic vector estimates	
M&A Deal	Risk estimate	Risk rank	Risk estimate	Risk rank	Risk estimate	Risk rank	Risk estimate	Risk rank
MMK-Atakash (Turkey)	1.0000	4	0.7915	4	0.9240	3	0.9953	2
Belon	0.8690	5	0.2781	15	0.6030	18	0.9951	7
Interkos-4	0.5897	20	0.2628	17	0.6290	11	0.9929	11
Pakistan	1.0000	1	0.8870	3	1.0000	1	0.9953	1
Gurievsk met.plant	0.8690	6	0.3805	7	0.6590	6	0.9947	8
Tulachermet	0.6791	15	0.2829	14	0.6280	13	0.9952	5
Prioskolsk Mining	0.6107	17	0.2550	18	0.6020	19	0.9929	12
Mikhailovsk GOC	0.6107	18	0.2707	16	0.6260	14	0.9929	13
Maxi-Group	0.6107	19	0.2429	19	0.6090	16	0.9939	10
Vyksunsk metallurgy plant	0.6791	16	0.2916	13	0.6290	12	0.9773	19
Plant "KMA-ore"	0.7902	14	0.3385	9	0.6460	8	0.9773	20
Volga pipe plane	0.8633	12	0.3142	11	0.6040	17	0.9891	14
Taganrog metallurgy plant	0.8690	7	0.3957	5	0.6480	7	0.9947	9
Chelyabinsk pipe-producing plant	0.8690	8	0.3458	8	0.6790	5	0.9891	15
Oskolsk electro-metallurgy plant	0.8690	9	0.1201	20	0.6010	20	0.9891	16
First Ural New pipe plant	0.8690	10	0.3902	6	0.6390	9	0.9952	6
STW (Germany)	1.0000	2	0.9335	2	0.9200	4	0.9953	4
Bashmetalltorg	0.8075	13	0.3080	12	0.6300	10	0.9891	17
Astrakhan port	0.8690	11	0.3283	10	0.6170	15	0.9802	18
Canada	1.0000	3	0.9593	1	0.9260	2	0.9953	3

ranking converge. Differences arise from non-similar ways of information presentation and different principles of decision-making.

Fuzzy logic uses the principles of pairwise comparison of alternatives when using normalized weighting coefficients. Maxmin compression and method of linguistic vector estimates correspond to pessimistic approach when the best alternative is the one having the least deficiencies by all criteria. Additive compression on opposite corresponds to optimistic approach when low marks have similar weights like the high ones.

CONCLUSION

The findings suggest fuzzy logic is a useful tool to evaluating gross risk of M&A projects. The gross risk estimate obtained enables to forecast the outcome of M&A deal, adjust the key financials and make the decision on whether to proceed with the deal or not during the first stage of M&A process.

Currently risk-management becomes an invaluable resort of strategic planning of Russian industrial enterprises that impacts the company value and might imply the rise of productivity. The proposed algorithm of M&A deals gross risk evaluation at OJSC Magnitogorsk Metallurgy Plant has proven its applicability and might be advised for further implementation at industrial enterprises in order to:

- Identify and classify risks mostly impacting M&A deal outcome
- Provide complex and regular work on risk-management when running M&A deal to separate the duties within the Divisions and Levels of Management
- Improve the KPIs of M&A deals by decreasing the associated risks and optimizing costs to handle risk minimization
- Increase the efficiency of M&A project management by introducing additional criteria for decision-making and by receiving and analyzing feedback on M&A deals realization
- Support the growth in market capitalization, increase in credit and investment ratings
- Achieve the most beneficial state and to protect the current market niche

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