Modeling of the Liquidity Evaluation on Stock Markets

Boris Zhelezko [1], Olga Siniavskaya [2]

1) Head of the Economic Informatics Department of Belarus State Economic University, 220070 Partisan Ave 26, Minsk, Republic of Belarus, e-mail: boriszh@yandex.ru, http://ramonak.ru/itm/en1.html

2) Deputy Head of the Economic Informatics Department of Belarus State Economic University, 220070 Partisan Ave 26, Minsk, Republic of Belarus, e-mail: olechka_si@mail.ru

Abstract: *In the article the technology of securities rating creation is worked out. The peculiarities of this technology are fuzzy classification of particular liquidity indices, their subsets picking out and joint significance calculation. These peculiarities allow smoothing of extreme values influence in the generalized rating. The rating model is based on the multicriteria analysis by means of Choquet integral calculation. Method of such analysis is adapted to economic informatics processing. A numeric example of share rating creation with using of Belarus stock market data is represented.*

***Keywords*:** liquidity, rating, security, fuzzy classification.

1. INTRODUCTION

Different ratings have an important theoretic and practical meaning in economic investigations. They are the base of decision making and of economic objects comparison. Ratings illustrate changes in objects condition in dynamic and allow analyzing elements of the economic area, as well as all this area. In the international practice following types of ratings are known: sovereign credit ratings, financial organizations ratings, securities ratings ad others [1-7]. Securities ratings are intended to investment decision making and emitter's condition evaluation [1,4,7].

Ratings become very popular in economic practical and scientific researches in 70th years of XX century in Western Europe and in the end of 90th years of XX century in Russia, Belarus, Ukraine and other countries of Commonwealth of Independent States [1, p.5]. Rating agencies appear which create and support the system of different economic objects ratings in a world scale. Standard and Poor's [6], Moody's Investors Service и Fitch IBCA are the dominant organizations in this sphere. There are also national rating agencies which have the same functions in a country scale, such as «Interfax», «Expert RA», «AK&M» in Russia.

In the Republic of Belarus rating construction and monitoring are the function of some scientific organizations [2] and ministries [5]. For example, Belarus State University realizes rating evaluation of banking sphere, regions investment potential, education service, etc. The methodology of rating evaluation of informatization in education sphere was worked out by the Ministry of Education [5] and implemented in UNESKO activity. In Belarus State Economic University ratings are constructed and investigated on the Economic Informatics Department. Since 2009 a branch of Ukrainian rating agency "Credit-Rating" is functionate which calculates national credit ratings of countries, ratings of reliability of deposits and bond emitters and others [7]. Creation of national rating agency with joint participation of existed ones is very urgent.

The service of international credit rating conferment is very expensive (about 45 000 $) and reasonable only for states, big corporations, banks [1, p. 163]. International ratings methodologies are closed, only results of their using are accessible. That's why ratings by independent experts and scientific organizations are urgent which are calculated by means of public methodology.

Practical need in ratings incentivates the development of corresponding scientific direction in economics. Works of L.N. Andrianova, A.M. Karminsky, A.A. Peresecky, A.E. Petrov, V.I. Lyashenko, C. Mar Molinero, P. Apellaniz Gomes, C. Serano Cinca and other scientists are devoted to ratings in economics, and, in particular, to securities ratings [1, 3, 4, 8].

The authors of this article carried out a number of investigations in the sphere of ratings in economics:

— the technologies of investment decision making on stock market are worked out for conditions of low securities price volatility: the technology of securities scoring which uses new methods of the normalization of values of the factors, of multi-criteria curtailment, of the adduction of qualitative and quantitative factors values in comparable state, by means of fuzzy logic rules; the portfolio optimization technology, which differs from known technologies by that investment risk is described in it not as standard deviation of the time series, but it is taken into account in aggregate index through the indices of financial condition and solvency of the emitter, and risk aversion is defined through significance degree of risk, return and liquidity for the investor [9-12];

— the technologies of sovereign credit ratings construction by means of statistical analysis of macroeconomic data were working out [13];

— the investigations devoted to ratings of banks, insurance organizations, dairy enterprises were carried out with the use of information-analytical decision support systems [9, 10, 14].

Sometimes ratings are calculated by one criterion (for instance, goods ratings by sales volume). But aggregate ratings based on the hierarchical set of indices are more popular. They are created by means of multicriteria analysis.

In this area the problem accounting in ratings of synergetic influence of the indices sets is insufficiently investigated. Synergetic influence appears when medium values of a number of particular indices give better results then high values of some indices and low of others

In this article mentioned problem is illustrated and decided on the example of share liquidity rating, which develops the earlier research [9-12, 14-16]. Shares market in the Republic of Belarus is characterized by low

volatility and liquidity, especially in comparison with stock markets of Russia, USA and some of European Union countries. The most of the shares are not liquid in spite of advantageous profitability characteristics (a value of dividends) and price stability. Consequently, investor may have a trouble to sell a share because of absence of demand for it. That's why shares liquidity rating has a great importance in investment decision making. Liquidity may be described by several particular indices which characterize frequency and volume of trade transactions. Thus, analysis of joint significance of liquidity indices in shares rating is very urgent.

2. STATEMENT OF A PROBLEM AND CHOICE OF RESEARCH METHODS

The goal of the given article is modeling of liquidity evaluation on stock markets and working out of the technology of share liquidity rating creation with taking into account the difference joint significance of particular liquidity indices. In this research the indices of trade transactions volume and frequency will be analyzed under conditions of low volatility on the stock market.

For this goal achievement following methods are chosen for use:

1. the method of rating calculation by means of Choquet integral [17], which will be adapted to financial-economic information peculiarities, such as difference in measuring and poor comparability of indices.
2. fuzzy classification methods for attaining of liquidity indices comparability;
3. methods of Fishburn value and decision theory for indices significance evaluation [18].

In practice there are many situations when medium evaluations of several indices is a better result then very high evaluations of some indices and very low of others. In such cases methods of linear multiplicative curtailment of indices is not effective because they take into accounting weights of each index separately and not take into account joint significance of pair or set of indices. For this problem decision the technology of rating creation is suggested, which is adapted to economic information processing specific.

An algorithm of Choquet integral calculation includes 2 following stages [17].

1. Particular evaluations $c_{(i)}(x)$ of object x are ordering by decreasing:

$$c_{(1)}(x) \le c_{(2)}(x) \le \ldots \le c_{(n)}(x) \qquad (1)$$

2. Choquet integral is calculating by formula (2):

$$C = \sum_{i=1}^{n} (c_{(i)}(x) - c_{(i-1)}(x))\mu(J_{(i)}) \qquad (2)$$

where $J_{(i)} = \{c_{(i)}, \ldots, c_{(n)}\}$, $c_{(0)}(x)=0$ for each x.

Fuzzy classification methods assume picking out of intervals in the determination area, which correspond to quality evaluations, for example "high", "medium", "low" and interstitial intervals, such as "below medium", "above medium". In one's turn, an integer scale, for example, from 1 to 5, may correspond to these evaluations. This principle allows discretizing of financial-economic information, which became convenient for processing.

Fishburn's method of significance determining consists in following. If there is a chain of indices ordered by decreasing their significance is calculated by formula (3):

$$p_i = \frac{2(N - i + 1)}{(N + 1)N}, i = 1..N \qquad (3)$$

where **N** – a quantity of indices,

i – a number of an index in the chain.

Described methods allow working out of the technology for share liquidity rating creation.

3. TECHNOLOGY OF SHARE RATING CREATION BY THE LIQUIDITY CRITRION

In general the methodology of share liquidity rating creation includes the following stages:

1. Picking up of the data about shares' liquidity and choice of the indices, which will be used in the rating.
2. Evaluation of indices significances by means of formula (3).
3. Evaluation of significances of values' pairs. If shares liquidity may be assessed as high (or as low) by 2 indices, then significance of this tendency the higher if the correlation between indices' values the less. A significance of indices' pair in this case is calculated by the model (4):

$$p_{x1,x2} = 1 - \rho_{x1,x2} \qquad (4)$$

where $\rho_{x1,x2}$ – correlation coefficient between x1 and x2 indices.

4. Fuzzy classification and discretizing of the values of indices for it comparability achievement.

4.1. Picking out of the intervals which characterize indices' quality, appropriation of quality and number evaluations to this interval.

4.2. Construction of the histograms of indices' values distribution in the determination area.

4.3. Value discretizing as suggested in work [19].

5. Liquidity rating index calculation by means of Choquet integral.
6. Share rating creation by liquidity aggregate index ordered by decreasing.

4. AN EXAMPLE OF LIQUIDITY SHARE RATING CREATION

Let us consider the quantitative example of creation of liquidity share rating on the data of Belarussian open joint-stock companies from January 2010 (table 1).

1. Data about trade transactions with securities are continually published on the web-site of Belarussian Currency-Stock Exchange [20]. The reports about Belarussian open joint-stock companies activity are periodically published in the "Stock market" journal. Share liquidity may be characterized by 3 following indices:

x1 – a quantity of trade transactions with emitter's shares in analyzing period;

x2 – volume of trade transactions with emitter's shares in analyzing period, expressed in shares;

x3 – volume of trade transactions with emitter's shares in analyzing period, expressed in terms of money.

Table 1. Data about liquidity of different emitters' shares

Emitter's number	Emitter (open joint-stock company)	x1, trans-actions	x2, shares	x3, thousands of BYR
1	Priorbank	2	5 318	18799
2	Amkodor	1	130	5200
3	Mogilyov Groceries	1	1 124	1461
4	BELZAVODSTROI SM	1	189	472
5	Belinvestbank	2	6 299	1165
6	Belschettechnika	2	119	1995
7	Belhoztorg-1M	1	364	473
8	Bereza Motor Repair Plant	15	146	4923
9	BPS-Bank	13	472	448
10	Brest-Service	2	1 000	4000
11	Gomeldalyavtotrans	1	250	1000
12	Gomelzhilproekt	2	3 239	25912
13	Mercury$K	8	1 330	2992
14	Minskpromstroi	1	1 606	4015
15	NIKA	1	474	14575
16	Olivaria Brewery	11	1 294	914999
17	Pinsk Experimental Mechanical Plant	1	34 530	1144911
18	Food service, Grodno	1	7 447	299965
19	Promtovari-Pinsk	10	7 050	42300
20	Promelectro-montazh	1	628	14758
21	Arbat Restaurant	24	2 918	55295
22	Santechelectro-montazh	2	4 824	125424
23	Soligorsk Plant of Technologic Equipment	3	587	21880
24	Soyuzpromtech-montazh	1	38 424	192120
25	Tatsiana	2	5 712	11995
Indices' significance		0,5	0,33	0,17

Picked out indices are relatively independent from each other, though in some cases during separate periods correlation between them may be significant. But in general the volume of trade transactions is independent from their quantity. Volume of large number of small transactions may be essentially less than volume of one or several big transactions (both in terms of money and in shares). At the same time transactions volumes in shares and in monetary units relatively independent from each other also because of essential difference in share prices. For example, in January 2010 share prices were varied from 185 BYR (*Belinvestbank*) to 750000 BYR (*Olivaria Brewery*).

The indices aren't comparable (they are measured in transactions, shares, monetary units). Increasing of each index absolute value testifies to the liquidity increasing and this is a positive tendency.

2. Indices significance will be evaluated by means of Fishburn method. x1 index is the most significant because transactions quantity better than their volume characterizes the liquidity. From the volume indices a volume in shares is more significant because a volume in monetary units is dependent from price which is no liquidity criterion. As a result we have following chain of indices' significances: x1>x2>x3. Indices' significances, which were calculated by formula (3), and initial data from the web-site of Belarussian Currency-Stock Exchange [20] are represented in table 1.

3. Correlation coefficients which calculated with using the data from table 1 and significances of indices' pairs, calculated by model (4), are represented in table 2.

Table 2. Correlation and joint significance of the indices

Indices' pair	Correlation coefficient	Significance of indices' pair
x1 and x2	-0,17	0,83
x1 and x3	0,03	0,97
x2 and x3	0,55	0,45

4. For achievement of indices comparability their it is necessary to discretize them.

4.1. In a diapason of each index values 5 quality intervals "low", "below medium", "medium", "above medium", "high" are picked out. They characterize a level of liquidity. Quantitative values from 1 to 5 correspond for each of them accordingly. x1 value s are distributed very irregular on interval from 1 to 24. There were 1 or 2 transactions with shares of most emitters, but more than 29 transactions took place with shares of *Arbat Restaurant*. That's why division of the interval [1; 24] on 5 equal pars for liquidity indices discretizing is inadmissible. Also it is incorrect to normalize values by division on maximum from the range, because in this case most of normalized values will be closed to zero. The same conclusions may be made after consideration of x2 and x3 indices. Thus. analysis of indices values' series allows determining of qualitative and quantitative values accordance, as that shown in table 3.

Table 3. Fuzzy classification of values

Quality level of value	Quantitative evaluation	x1			x2			x3		
		Value intervals	Finding of index value in the interval		Value intervals	Finding of index value in the interval		Value intervals	Finding of index value in the interval	
			cases	in %		cases	in %		cases	in %
low	1	[0; 3]	19	76%	[0; 300]	5	20%	[0; 1000]	4	16%
below medium	2	[4; 8]	1	4%	[301; 1000]	6	24%	[1000,01; 10000]	8	32%
medium	3	[9; 12]	2	8%	[1001; 5000]	7	28%	[10000,01; 100000]	8	32%
medium	4	[13; 20]	2	8%	[5001; 10000]	5	20%	[100000,01; 300000]	3	12%
high	5	[20; +∞]	1	4%	[10000; +∞]	2	8%	[300000; +∞]	2	8%

4.2. Histograms of indices' values distribution in determining areas are represented on figures 1-3.

4.3. Discrete values are represented in table 4.

5. 14 emitters from 25 have ordered by increasing liquidity indices values. Liqudity values of other emitters must be ordered. Calculation of aggregate liquidity index is made by formula (2). For example, for Belinvesbank (x'1=1, x'2=4, x'3=2) the chain of values was ordered by increasing (x'1=1, x'3=2, x'2=4) and aggregate index will be equal $(1-0)\times1+(2-1)\times0,45+(4-2)\times0,33=2,11$.

6. Liquidity shares' rating is represented in table 4. In column 7 of this table qualitative characteristics of liquidity are shown.

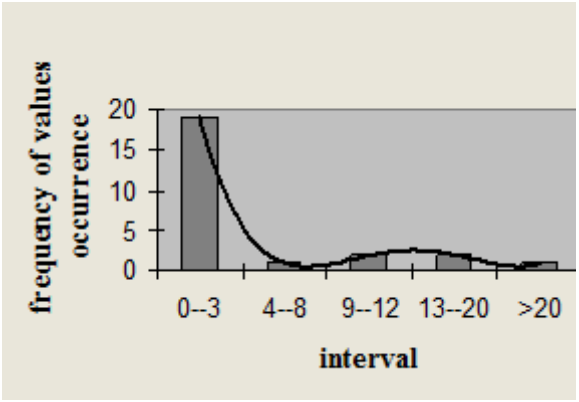

Fig. 1 – Distribution of $x_1$values

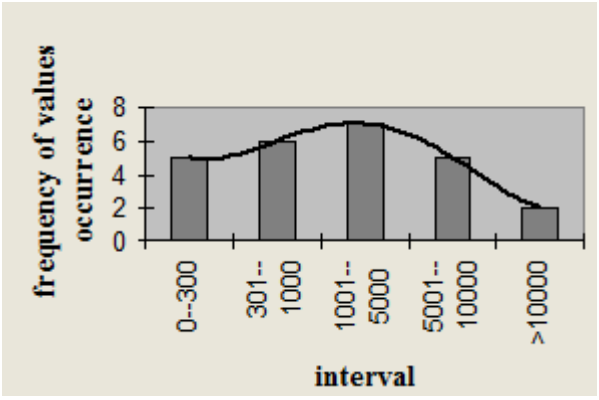

Fig. 2 – Distribution of $x_2$values

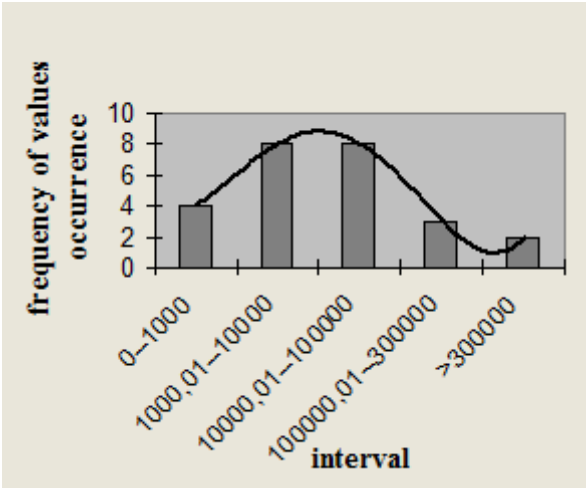

Fig. 3 – Distribution of $x_3$values

Graph of shares' distribution by liquidity levels is represented on figure 4.

Analysis of obtained rating shows that only 1 emitter (*Arbat Restaurant*) has relatively liquid shares, though some others (*Olivaria Brewery; Pinsk Experimental Mechanical Plant; Food service, Grodno; Soyuzpromtechmontaz; Tatsiana*) have high values of particular liquidity indices. Liquidity of most emitters' shares is below medium, thus, liquidity of stock market relatively low in general.

Table 4. Liquidity shares rating

Emitters number	Emitter (open joint-stock company)	x1, transactions	x2, shares	x3, thousands of BYR	Rating index	Qualitative liquidity evaluation
1	*2*	*3*	*4*	*5*	*6*	*7*
1	Arbat Restaurant	5	3	3	4	above medium
2	Olivaria Brewery	3	3	5	3,34	medium
3	Promtovari-Pinsk	3	4	3	3,33	
4	Bereza Motor repair plant	4	1	2	2,97	
5	BPS-Bank	4	2	1	2,83	
6	Pinsk Experimental Mechanical Plant	1	5	5	2,8	
7	Soyuzpromtech-montaz	1	5	4	2,68	
8	Food service, Grodno	1	4	4	2,35	below medium
9	Tatsiana	1	4	4	2,35	
10	Mercury$K	2	3	2	2,33	
11	Priorbank	1	4	3	2,23	
12	Belinvestbank	1	4	2	2,11	
13	Santechelectro-montazh	1	3	4	2,07	
14	Gomelzhilproekt	1	3	3	1,9	
15	Mogilyov Groceries	1	3	2	1,78	
16	Minskpromstroi	1	3	2	1,78	
17	NIKA	1	2	3	1,62	
18	Promelectro-montazh	1	2	3	1,62	
19	Soligorsk Plant of Technologic Equipment	1	2	3	1,62	
20	Brest-Service	1	2	2	1,45	low
21	Belhoztorg-1M	1	2	1	1,33	
22	Amkodor	1	1	2	1,17	
23	Belschettechnika	1	1	2	1,17	
24	BELZAVODSTROI SM	1	1	1	1	
25	Gomeldalyavtotrans	1	1	1	1	

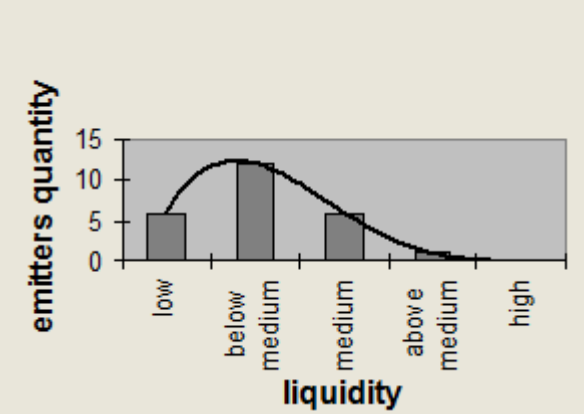

Fig. 3 – Distribution of the securities on the liquidity levels

5. CONCLUSION

In the article conceptual development of economic ratings as urgent scientific direction in intellectual

decision making [7-16, 19] is suggested. It is illustrated on the practical example of liquidity shares rating. The technology of securities rating creation based on liquidity criterion and the model of joint significance of indices was worked out. The technology may be used not for shares only but for bonds evaluations modeling also. Thus, the goal of this research is achieved.

Scientific novelty of the suggested technology is determined by a model of joint significance calculation for indices' pairs on the base of its correlation, and by Choquet integral adaptation to economic information processing.

The peculiarity of liquidity evaluation modeling is fuzzy classification of indices which allows smoothing of extreme values influence on aggregate evaluations.

The suggested technology has practical meaning in investment decision making for choice the stocks with high liquidity (in short-time trading) and with high or medium liquidity (in long-time investment). the technology may be an addition to securities scoring technology, which was working out in previous works [9-16].

Perspective development of this research is adaptation of the suggested technology to the cases when liquidity is characterized by more than 3 indices and liquidity evaluation in dynamics.

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