8
Microsituation Concept in GMES Decision Support Systems

8.1 Situational modeling for decision making in emergent situations

Situational modeling for GMES represents branch of system-analytical activity where modeling objects are defined such in relation to which the strict, exhaustive description is impossible. Thus, the situational simulations can be compared with the general theory of artificial intelligence in some way.

Nevertheless, in a general view the situation is understood as a combination of characteristics of problem area and prototype system where such characteristics represent interference model of such object with a subject domain. Thus various characteristics of a prototype system and a subject domain of studying of such object can be considered as separate levels of representation of research problem area that allows to speak about separate situations in such modeling (Figure 136).

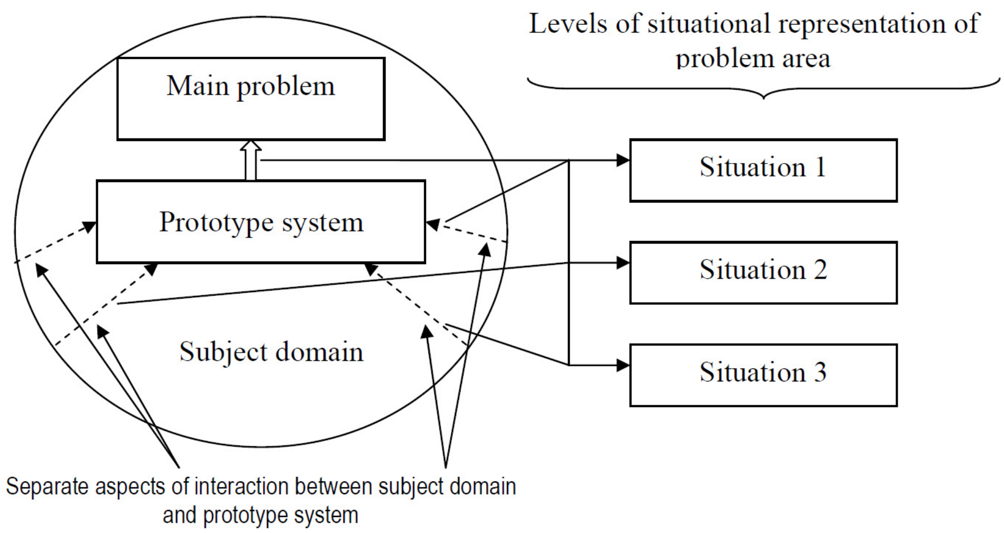


Figure 136. Generalization of separate situations of prototype system

Due to inability to describe whole model, it appears many levels of situational representations of subject domain that involves usage of methods of artificial intelligence for its better understanding. This leads us to speak, that each situation could be represented as a set of microsituations of prototype system. Such assumption is based on idea, that in process of studying object happens superposition of several interaction aspects between subject domain and prototype system due to set of objective reasons. Therefore, for example, if we study reasons of snow avalanches, it is hard to separate influence of environment temperature from influence of snow cover and hill's declivity. In the same time, for example, studying economical dynamics processes of banks we should take into account a great set of factors, which form such dynamics.

A set of situation representation levels of subject domain naturally increases in emergent situations. This is connected with increased influence of subject domain factors on prototype system, independently of emergency conditions. Therefore, for emergent situations of possible snow avalanches microsituations could differ of small differences of temperature or changes in wind speed [Kuzemin and Lyashenko, 2007b], [Kuzemin et al, 2007a; b]. Development of financial crisis as emergency economic situation is characterized by separate characteristics of microsituations of different facilities, involved in economical process [Kuzemin and Lyashenko, 2007a].

Hence, situation includes a set of separate microsituations, each describing properties of prototype system in some characteristic category of its subject domain. Such categories for subject domain could represent internal and external processes, characteristics, advices both from prototype system's point of view and from set of factors, which influence from subject domain to prototype system. Separate set of such characteristics without interconnections could hardly precisely describe a situation, because such characteristics are interconnected with each other, involved in different process of prototype system studying.

In some kind situation could be presented as hierarchy of separate microsituations using oriented graph, built on group descriptor. This allows represent situation as a set of n microsituations c_i:

$$C = \{c_i\},\ i = 1,...,n;\ c_i = \langle e_i R_e \rangle \quad (1)$$

where part of situation, represented by pair $c_i = \langle e_i R_e \rangle$, will be called microsituation, connected with some characteristic of prototype system.

Such representation of situation allows operating with situational model in terms of separate microsituations, which increases effectiveness of decision taking.

A general idea of calculating distance between microsituations is separating common part of two objects being compared and calculating how much each of them differs from common part. For example if we compare two microsituations c_1 and c_2, first of all their common part $c_1 \cap c_2$ is calculated. If microsituation c_1 is connected with some solution D, we should calculate how microsituations c_1 and c_2 match, in order to make decision if solution D is applicable in microsituation c_2. Measure of similarity S is calculated as a percent of common part $c_1 \cap c_2$ for each of microsituations being compared. But it should be taken into account that solution D is connected with microsituation c_1 and in case $c_1 \cap c_2 \subset c_1$ is also based on missing part – $c_1 \setminus (c_1 \cap c_2)$, which is missing from c_2. This fact decreases applicability level of solution D for searching general solution. $c_1 \cap c_2 \subset c_2$ describes for what part of microsituation c_2 solution D is applicable. In other words, similarity level of different microsituations is measure of their unity. In such way, we can perform more precise accounting of changing characteristics of prototype system during decision taking in emergency situation, which leads us to idea of using situation model for prototype system representation. That ultimately allows us to speak about the relationship of situational simulations with the general theory of artificial intelligence.

In next sections, we published a more detailed review on questions of microsituations usage for risks management in emergent situations of avalanche snowfalls and development of economical crisis an emergency economical situation

8.2 Microsituation as a base part of risks management in risks management of possible snow avalanches

✓ Methods of forecasting avalanche-dangerous situations and flaws of common approaches

Snow avalanches have a special place of natural emergent situations. They cause moving snow masses perform huge destructions in all 6% of earth surface, where avalanche-dangerous regions are located.

As a whole, one of the directions, i.e. the risk of emergent situations management and, in particular, situations initiated by the snow-slip, should be considered constant monitoring and building of interpretation models for prediction of such situations initiation. Hereinafter, such models form the basis for the system of decision–making support; this is favorable to development recommendations on modern performance of maintenance measures directed to natural calamities prevention.

Among the most essential and important problems in the given aspect one should note substantiation of the utility to use the corresponding mathematical apparatus intended both for investigation of the avalanche dangerous situations development dynamics and for development of methods for estimation of the potential avalanche cells, prediction of avalanches volumes and descent frequency. This concerns the fact that every avalanche can be regarded as a unique phenomenon of nature with its specific peculiarities. At the same time despite its uniqueness, it is possible to single out the climatic conditions variations characteristic ranges, which are prerequisites to prediction of the feasible avalanche descent. Eventually, the totality of these two factors defines the presence those approaches to prediction and warning of avalanches descent, at present these approaches are used in geoinformation systems (GIS) which make it possible to accumulate continuously meteorological information, carry out various calculations, reveal regularities and realize spatial tie of the obtained results [Durand,1993] and [Kuzemin and Toroev, 2006].

Considering methods and models of avalanches descent prediction the method images of similarity and regression analysis are singled out the most often [Buser et al, 1987]. At the same time, there is no doubt that the foundation of avalanche dangerous situations initiation prediction consists in the procedure of the preliminary analysis of such events. In this case, as a rule, the solution of the formulated problem is based on the statistical analysis methods. In particular, the approaches of such analysis make it possible to substantiate the most significant system of the facts, which is expedient to use in the avalanche-dangerous situations prediction procedures. Such approaches found their development in the predictions of snow avalanches descent based on application of the nearest neighbors' method or through the application of the regression equations [Buser et al, 1987]. But results of the prediction obtained with such methods are not always applicable and demonstrate a number of shortages: they require significant computational resources; they don't embrace existing variety of causes resulting in avalanches formation. The shortage is also the impossibility to define the degree of the avalanche hazard, number and dimensions of avalanches [Fuhn, 1998].

The data of nomograms, which in a general case extend the interconnection of such indices as temperature, value of snow cover, and precipitations are also used for estimation of the avalanches descent probability. Nevertheless, in spite of this the remaining non-predictive nature of the avalanche dangerous situation does not always allow to prevent negative consequences of emergencies caused by their descent. This is associated with that the available procedures of the avalanche dangerous situation initiation prediction are not sufficiently precise. At the same time, the severity of the problem and variety of the ways to solve it motivate the necessity to search alternative methods, which can give more argued answers.

✓ Representation of avalanche-dangerous and avalanche-safe situations

Analysis of different characteristics of the avalanche climate initiation medium makes generally the foundation of the avalanches descent prediction. Among such characteristics the most abundant ones are: the air temperature, humidity, atmospheric precipitations volume, wind velocity, angle of the slope of surface (descent angle) where the avalanche descent is possible. In general, the variation dynamics of both individual of the above characteristics the avalanche climate initiation and their totality can, with some probability, characterize initiation either avalanche-dangerous or avalanche non-dangerous event. As this takes place, a feasible range of the studied avalanche climate initiation characteristics variations describes a definite region of avalanche-dangerous and avalanche-non-dangerous situation.

Consider we have an avalanche-dangerous situation Ω_L and avalanche-safe situation Ω_N. That situations could be described as set of most statistically important characteristics X_1, X_2, X_3, X_4, X_5, where, for example, X_1 — air temperature; X_2 — air humidity; X_3 — wind speed; X_4 — amount of precipitation; X_5 — angle of hill slope.

By-turn situation Ω could be represented as a set of microsituations $\Omega = \{\omega_i\}, i = 1,...,n$ each corresponding to a definite group of reviewed types of environmental data corresponding avalanche climate and reflecting, from one side, probability of avalanche-dangerous situation and from another – probability of avalanche-safe situation. In other words avalanche-dangerous situation Ω_L could be presented as homogenous unity of different microsituations $\Omega_L = \bigcup_i \Omega_{L_i}$, and avalanche-safe situations represents unity $\Omega_N = \bigcup_i \Omega_{N_i}$. Each such microsituation represents probability of avalanche-dangerous or avalanche-safe situation in general.

In that way, estimation results could be interpreted as a base for forming according systems of microsituations forming data for knowledge base of informational-analytic system of crisis situations management.

In the conceptual plan, the essence of the probabilistic aspect of the avalanche climate initiation analysis can be reduced to the definition of the probability to assign some point as the considered medium current characteristics either to the region of the avalanche initiation or to the initiation of avalanche non-dangerous situation. Otherwise, the given approach can be treated as a correspondence of the current characteristics of the avalanche climate initiation medium; parameters of these characteristics define some region using probabilistic distribution of avalanche dangerous or avalanche non-dangerous situations preceding this. Consequently, it is possible to speak about so-called probable conformity of the researched characteristics of the avalanche-dangerous climate environment to probabilistic distribution of the avalanche-dangerous or avalanche non-dangerous situations.

In particular, procedure of such analysis can be considered proceeding from the pair wise analysis of various characteristics of the avalanche climate initiation. The advisability of such a transition is related to the fact that at the stage of the preliminary analysis it is possible to omit less significant factors of impact on the avalanche dangerous situation initiation. Thus, the base element of the analysis procedure being considered is estimation of the probability of the avalanche climate initiation current parameters to fall within the regions typical and atypical for the avalanche climate initiation. The given regions can be presented in the plane in the form of the rectangle; its metric values correspond to definite parameters of variation of the avalanche- dangerous and avalanche non-dangerous situations initiation medium characteristics (Figure 137) [Kuzemin et al, 2007b].

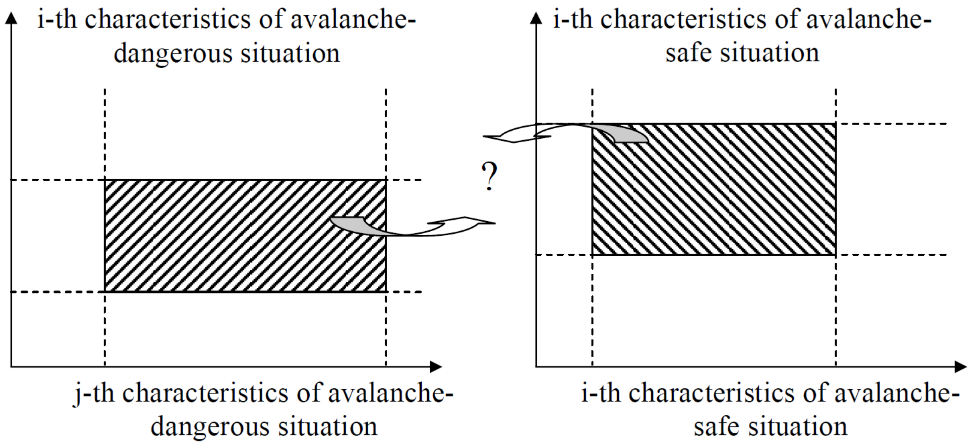


Figure 137. On the explanation of the probabilistic aspect of the avalanche climate initiation medium analysis

In addition, we should note, that reviewed characteristics of environment of avalanche climate, in general follows normal law of distribution. This allows using that low for preliminary calculations. In Table 5 the corresponding probabilities are presented taking into account avalanche-dangerous and avalanche-safe situations.

Table 5. Probabilities of correspondence of the current parameters of avalanche climate initiation medium to the avalanche dangerous and avalanche non-dangerous situations

Characteristics of the avalanche climate initiation medium analysis	Feasibility of correspondence
under condition of considering the avalanche dangerous situation and avalanche dangerous current parameters	
air temperature – wind velocity	0,854
air temperature – wind velocity	0,823
wind velocity – precipitations quantity	0,707
precipitations quantity – descent angle	0,809
under condition of considering the avalanche-dangerous situation and avalanche- non-dangerous current parameters	
air temperature – wind velocity	0,488

air temperature – wind velocity	0,582
wind velocity – precipitations quantity	0,317
precipitations quantity – descent angle	0,341
under condition of considering the avalanche-non-dangerous situation and avalanche- non-dangerous current parameters	
air temperature – wind velocity	0,798
air temperature – wind velocity	0,878
wind velocity – precipitations quantity	0,866
precipitations quantity – descent angle	0,939
under condition of considering the avalanche-non-dangerous situation and avalanche- dangerous current parameters	
air temperature – wind velocity	0,555
air temperature – wind velocity	0,482
wind velocity – precipitations quantity	0,403
precipitations quantity – descent angle	0,591

As can be seen from the data in Table 5 the assumptions made above are reasonably justified i.e. the probability of correspondence of the like situations and parameters is essentially significant. This allows generalizing even for estimation of probable initiation of the avalanche dangerous as a whole. To do this one should consider:

- either generalization of the obtained probabilities reasoning from the significance of different groups of characteristics of the avalanche climate initiation characteristics analysis in the assumption that the probabilities of correspondence can be considered as conditional probabilities of the concrete situations analysis;
- or a separate group of characteristics of the avalanche climate initiation medium analysis based on the greatest/least values of the correspondence probabilities.

✓ Forming of avalanche-dangerous and avalanche-safe microsituations

For demonstrating proposed approach and proving its effectiveness let's analyze probability aspects of several characteristics of avalanche-dangerous climate using real snow avalanches data in Itagar-Chichkan region of Kirgizstan republic during 2001–2006 years. A main idea of such analysis is determination of wrong estimation – amount of avalanche-dangerous situation, which will be classified as avalanche-safe, and vice-versa.

For preliminary data analysis, we perform analysis of environmental statistical characteristics for forming set of data, which describes the probability of avalanches in general:

$$Z = \{X_1, ..., X_n\} \quad (2)$$

where Z – generalized characteristics of avalanche appearance.

$X_1, ..., X_n$ – set of most significant statistical characteristics connected with avalanche fall.

Using set 2 we determine interconnections of characteristics leading to avalanche and avalanche-safe situations and form groups of such characteristics in general (separate microsituations):

$$\{X_1,...,X_n\} \Rightarrow \begin{cases} \beta_1^L,...,\beta_n^L \\ \beta_1^N,...,\beta_n^N \end{cases} \quad (3)$$

where $\beta_1^L,...\beta_n^L$ – set of most valuable interconnections between factors and characteristics of avalanche appearance taking into account probability of avalanche appearance (avalanche-dangerous situations)

$\beta_1^N,...\beta_n^N$ – set of most valuable interconnections between factors and characteristics of avalanche appearance leading to no avalanche happening (avalanche-safe microsituations)

Each microsituation is described by a probability range $((\delta_i^d \div v_i^d)$, where d – separate microsituation, i – separate group of characteristics of avalanche appearance in general. If it is needed it is possible to take into account an overall dynamics of changing characteristics of possible avalanche appearance:

$$\left.\begin{matrix} \beta_1^L,...,\beta_n^L \\ \beta_1^N,...,\beta_n^N \end{matrix}\right\} \Rightarrow \begin{cases} \lambda_1^L,...,\lambda_n^L \\ \lambda_1^N,...,\lambda_n^N \end{cases} \quad (4)$$

where $\lambda_1,...,\lambda_n$ – set of adjustments of most valuable factors with different microsituations characteristics leading to avalanche appearance.

In such manner, we perform a generalization of data groups (situations classes or simply microsituations). Corresponding results for forecasting avalanche-dangerous and avalanche-safe situations are presented in Table 6 [Dyachenko et al, 2007].

Table 6. Results of forecasting of avalanche-dangerous and avalanche-safe situations

Groups of microsituations	Probability of classifying as correct avalanche-dangerous class	Probability of classifying as correct avalanche-safe class
X_1, X_2, X_3, X_4	0,54–0,82	0,51–0,87
X_1, X_2, X_4, X_5	0,50–0,87	0,52–0,77
X_1, X_2, X_3	0,52–0,77	0,51–0,70
X_2, X_3, X_5	0,51–0,69	0,50–0,73
X_2, X_3, X_4, X_5	0,51–0,96	0,50–0,80

Presented in Table 6 range of probabilities of correct classifying to any class of situation could be interpreted as some integral characteristic of corresponding microsituation. In other words each data group of avalanche-dangerous situation (Ω_L) and avalanche-safe situations (Ω_N) are the set of microsituations:

$$\left.\begin{matrix} \Omega_L \\ \Omega_N \end{matrix}\right\} \rightarrow < X_k, Z, R \rightarrow \begin{cases} \delta_i^L \div v_i^L \\ \delta_i^N \div v_i^N \end{cases} \quad (5)$$

where X_k – separate characteristics of avalanche appearance,

Z – generalized characteristic of avalanche appearance,

R – most valuable interconnections of avalanche appearance.

Thus, using this assumption and data presented in Table 6, avalanche-dangerous situation could be presented as a set of separate integral characteristics of such microsituations. As a confirmation of such generalization, we could serve some procedure of microsituations comparison. But, since not all microsituations are following normal distribution law, in order to check comparison hypothesis non-parametric tests are more suitable.

One of the possible tests, which could be used, is Wilcoxon test for connected sets, which answers a question: if any event in analyzed data happens, which leads to significant change in microsituation hierarchy [Prosvetov, 2005]. Wilcoxon test could be presented as such equation:

$$w_{g,j} = \sum_m \left|\lambda_g^m - \lambda_j^m\right|; g, j \in \{i\}; m = 1,...,n; \lambda_g^m, \lambda_j^m \in \{\Omega_L, \Omega_N\} \qquad (6)$$

In other words, distinguishability between different microsituations is a subject of this research. The value of such test could be interpreted as a difference measure of reviewed microsituations.

The more value of Wilcoxon test, the more distinguish reviewed microsituations are.

Results of Wilcoxon test are presented in Table 7 (values 1-5 correspond to avalanche-dangerous situations, 6-10 – avalanche-safe one)

Table 7. Wilcoxon test value

	1	2	3	4	5	6	7	8	9	10
1	–	0,920	2,041	2,705	0,242	1,534	2,463	3,441	2,995	1,413
2	0,920	–	1,689	2,671	0,634	1,778	2,082	2,064	2,225	1,528
3	2,041	1,689	–	0,217	1,968	0,568	0,169	1,618	2,089	0,942
4	2,705	2,671	0,217	–	2,263	1,355	1,087	1,005	1,355	2,136
5	0,242	0,634	1,968	2,263	–	1,044	2,596	2,624	3,087	0,886
6	1,534	1,778	0,568	1,355	1,044	–	0,157	1,868	2,371	1,174
7	2,463	2,082	0,169	1,087	2,596	0,157	–	2,149	2,101	0,266
8	3,441	2,064	1,618	1,005	2,624	1,868	2,149	–	0,198	2,354
9	2,995	2,225	2,089	1,355	3,087	2,371	2,101	0,198	–	3,556
10	1,413	1,528	0,942	2,136	0,886	1,174	0,266	2,354	3,556	–

Data analysis of Table 7 results in a conclusion where obtained values of Wilcoxon test are significant for microsituations, which belong to different classes. This allows generalizing comparison of different microsituations. Let us review an integrated Wilcoxon criteria value (as sum of partial test values) from each microsituation to class of avalanche-dangerous and avalanche-safe situations. Corresponding values are presented in Table 8.

Analysis of Table 8 shows, that for avalanche-dangerous microsituations integral test value with avalanche-dangerous situations is lower than integral test value with avalanche-safe situations and vice-versa. That tells us, that in general avalanche-dangerous and avalanche-safe situatios are presented with homogenous microsituations.

Table 8. Integral Wilcoxon test values

Microsituations	Integral test value with avalanche-dangerous situations	Integral test value with avalanche-safe situations
1	5,908	11,846
2	5,914	9,677
3	5,915	5,386
4	7,856	6,938
5	5,107	10,237
6	6,279	5,570
7	8,397	4,673
8	10,752	6,569
9	11,751	8,226
10	6,905	7,350

Graphical interpretation of Table 8 (Figure 138) allows to establish a definite procedure of microsituations separation and to perform analysis of new microsituations using approach, which would be presented in next section.

✓ Avalanche-dangerous microsituation classes

Therefore, representing a set of factors and current nature environment state as a microsituation allows increasing stability of avalanche-fall forecasts. Every such a microsituation corresponds to a definite combination of factors of the avalanche initiation environment.

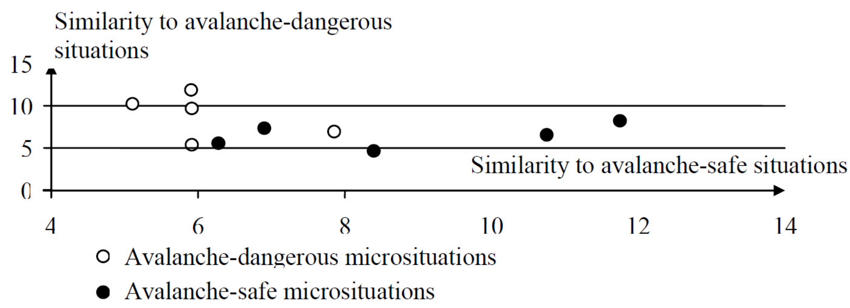


Figure 138. Position of microsituations in situations space

At the same time, such representation makes it possible to break up the whole set of causes affecting the avalanches initiation into two subclasses. One of subclasses characterizes a set of microsituations reflecting the avalanche initiation and the other subclass is typical for non-avalanche situation as a whole. Then the emergency avalanche situations risks management can be presented as a generalized description of the system with the help of a totality of different microsituations. Based on such interpretation the logical rules of the analyzed data set generalization for further their subdivision into classes of avalanche dangerous and non-avalanche dangerous situations:

$$\text{Avalanche dangerous}= \begin{array}{l}(\{F_L^L(X)\}/\{F_N^L(X)\})\cup(\{F_L^L(X)\}/\{F_N^N(X)\})\cup\\ (\{F_N^N(X)\}/\{F_L^L(X)\})\cup(\{F_L^N(X)\}/\{F_N^L(X)\})\cup\\ (\{F_N^L(X)\}/\{F_L^N(X)\})\cup(\{F_L^N(X)\}/\{F_N^N(X)\})\end{array} \quad (7)$$

$$\text{Non avalanche dangerous}= \begin{array}{l}(\{F_N^L(X)\}/\{F_L^L(X)\})\cup(\{F_L^L(X)\}\cap\{F_N^N(X)\})\cup\\ (\{F_L^N(X)\}\cap\{F_N^L(X)\})\cup(\{F_N^N(X)\}/\{F_L^L(X)\})\end{array}$$

where $F_L^L(X)$ ($F_L^N(X)$), $F_N^L(X)$ ($F_N^N(X)$) – probability function of referring avalanche dangerous (non-avalanche dangerous) microsituation to the avalanche dangerous (non-avalanche dangerous) class, respectively, on the set of factors of the avalanche danger initiation X [Kuzemin et al, 2007a].

Model 7 describes following possible choices of warning on possible avalanches:

Choice 1. Avalanche-dangerous set is formed as a subtraction of sets, limited by probability polynomials $\{F_L^L(X)\}/\{F_N^L(X)\}$. Avalanche-safe set — $\{F_N^L(X)\}/\{F_L^L(X)\}$ (Figure 139).

Choice 2. Border of avalanche-dangerous set is corresponding to symmetrical subtraction $(\{F_L^L(X)\}/\{F_N^N(X)\})\cup(\{F_N^N(X)\}/\{F_L^L(X)\})$. Avalanche-safe set is an intersection $(\{F_L^L(X)\}\cap\{F_N^N(X)\})$ (Figure 140).

Choice 3. Border of avalanche-dangerous set is $(\{F_L^N(X)\}/\{F_N^L(X)\})\cup(\{F_N^L(X)\}/\{F_L^N(X)\})$. Avalanche-safe set is an intersection of two sets: $(\{F_N^N(X)\}\cap\{F_L^L(X)\})$ (Figure 141).

Choice 4. Border of avalanche-dangerous set is expressed as subtraction $(\{F_L^N(X)\}/\{F_N^N(X)\})$, avalanche-safe set — $(\{F_N^N(X)\}/\{F_L^L(X)\})$ (Figure 142).

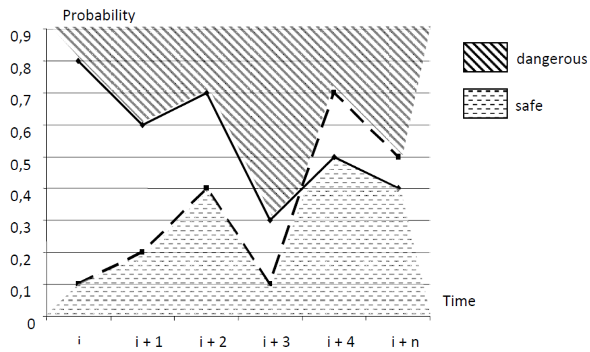


Figure 139. Probability distribution for 1-st version

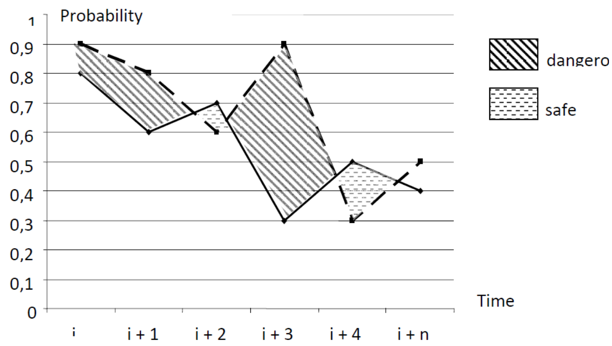


Figure 140. Probability distribution for 2-nd choice

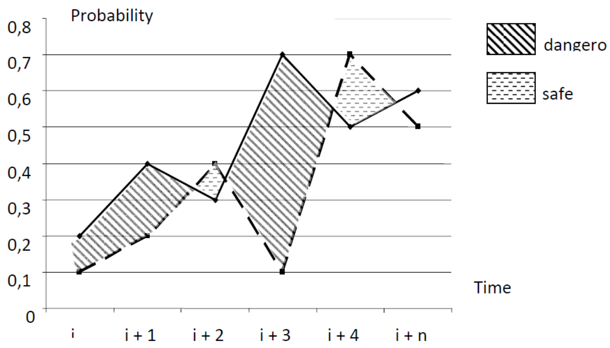


Figure 141. Probability distribution for 3-rd choice

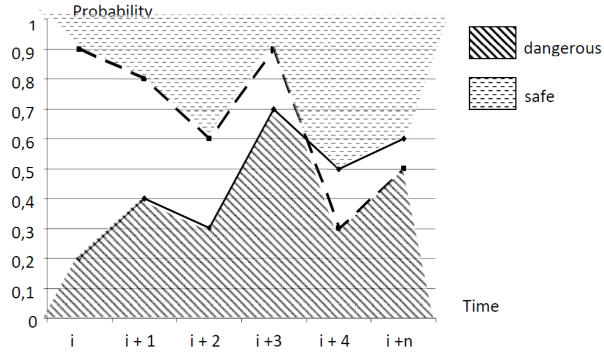


Figure 142. Probability distribution for 4-th choice

So, received probabilities allows us to answer quickly in which class belongs current situation (microsituation) and provides a base to review and analyze sets of avalanche-dangerous situations. Analysis of such sets allows to formalize sets of avalanche-dangerous and avalanche-safe situations and to build procedure of corresponding forecasting actions. At the same time presentation of the avalanche danger factors in the form of the microsituations classes allowed to get an objective correspondence between the probabilistic estimates of the avalanches descent and the avalanche danger scale degrees; eventually this makes it possible to correct time of the prediction system response to the possible avalanche descent. Essence of such estimate consists in construction and analysis based on the theory of fuzzy sets, corresponding functions of prediction time correction $\mu(X)$ (Figure 143) [Kuzemin et al, 2007b].

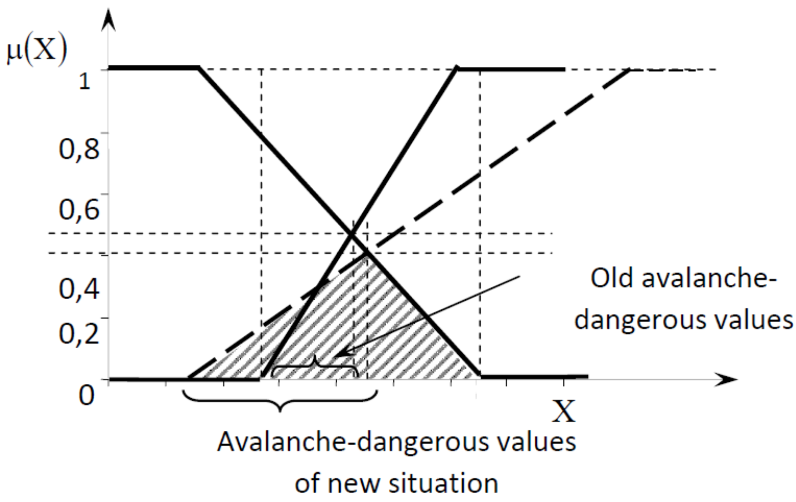


Figure 143. Methods of the fuzzy sets theory as the basis for correction of the prediction system time response to the possible avalanche descent

As a whole, the essence of such description reduces to construction of the fuzzy model for estimating temporal characteristics of the avalanche dangerous situations. Thus, for example, it is possible to suppose that in the case of the avalanche non-dangerous situation analysis the time until the assumed avalanche descent will be the more the greater is the probability of referring current parameters of analysis of the avalanche climate initiation environment to such situation. Respectively, in the case of insufficient probabilities of referring of the avalanche climate initiation environment analysis current parameters to such situation can testify to insignificant reserve of time until the avalanche descent moment. When considering the avalanche dangerous situations the corresponding characteristics are the opposite. This allows introducing into definition the functions of the avalanche descent time fuzzy set; their generalization makes it possible to predict the avalanche descent time.

It is possible to pass to the distribution functions in the estimate of the avalanche descent time based on the corresponding probabilities analysis of the fuzzy set available data separation into avalanche dangerous and avalanche non-dangerous situations.

Thus, the model construction generalized scheme and construction of the procedure for prediction of the avalanche-dangerous situations initiation is reduced to:

- sequential obtaining of the probabilistic characteristics of the avalanche climate initiation medium;
- construction of the corresponding sets of subdivision into avalanche-dangerous and avalanche-nondangerous situations;
- analysis of the avalanche descent initiation time using fuzzy models of its interpretation.

8.3 Microsituation as a base for comparative analysis of financial flows

Variety of emergency economic situations through prism of financial flows generalization. Introduced term "microsituation" could be extended also for performing analysis of financial flows of different economic users. In other words, objective laws of economic development consider constant interference of economic agent with different sides of external environment. The changes in environment results in rebuilding of internal structure of economic agent, cause this process leads to stability of economic agent and overriding economic crisis factors. In the same time effectiveness of financial flows could be increased introducing analysis subsystem. Direction and speed of financial flows movement demonstrates transiency of economic processes and speed of changes in external environment of reviewed economic agent. Thus, for example:

- transiency of economic processes closely connected with unpredictability and errors in forecasts about future economic development;
- globalization influence on overall economic processes all over the world. This could be easily confirmed by visual identity of index EMBI+ (The Emerging Markets Bond Index Plus, Figure 144) of such countries as Poland and Bulgaria, which allows assuming a possibility of same tendencies in financial flows. Nevertheless, for more significant conclusions a quantitative estimations is required, which leads to need of reviewing different levels of affecting of researched processes, which, by-turn brings us to review of separate microsituations;
- possibility of review of unexpected economic crisis as a set of specific situational aspects of management, which influence on effectiveness of taken decision;
- effectiveness of financial flows analysis greatly depends on existing system of their estimation and system of taking decision on those estimations, which directly connected with the process of formalization and analysis of many financial flows characteristics and, by-turn, leads again to microsituation statement in financial sphere. Necessity of such review is connected with limited applicability of traditional models for decision taking in social-economic systems [Voloshin, 2005].

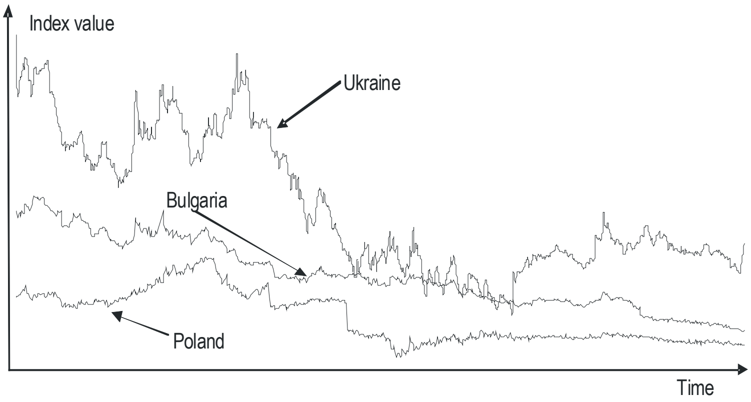
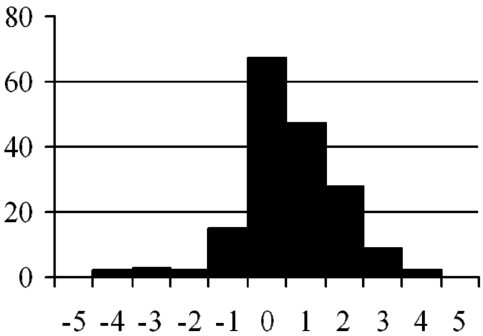
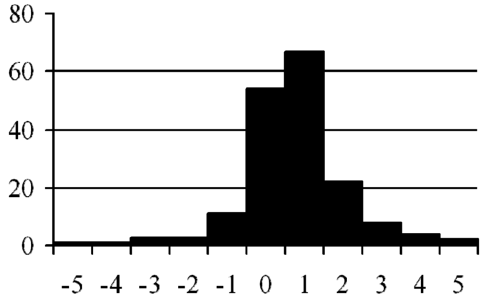


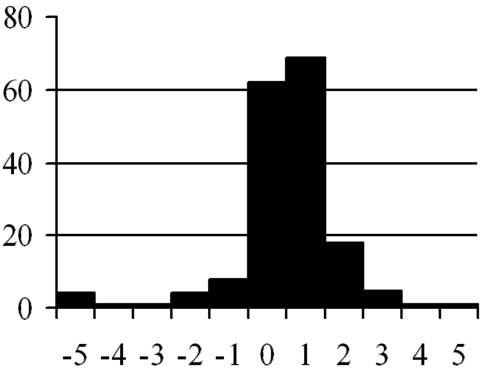
Figure 144. Dynamics of EMBI+ index change for several countries



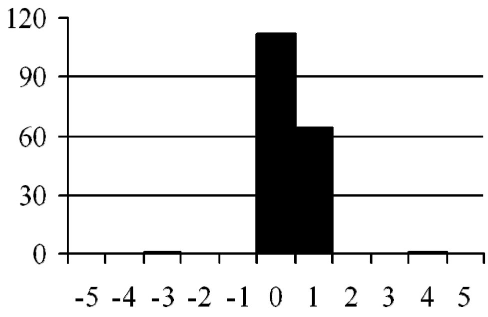
a) KAC-20



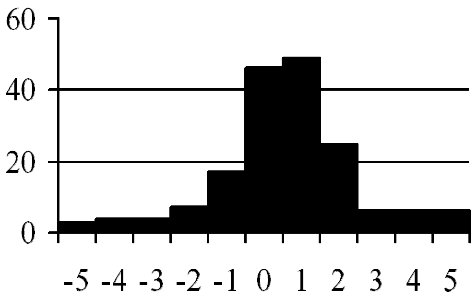
b) SOKRAT



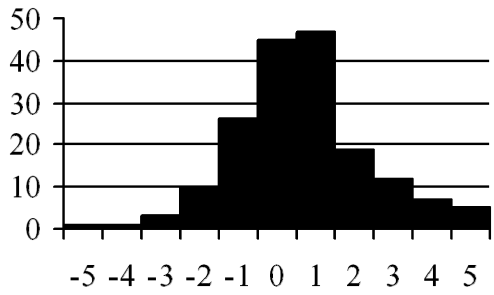
c) Sofia Bondar Priadka Ukraine



d) TEKT-KKOC Price Bonds



e) PFTS



f) KINDEX

Figure 145. Density of profitability distributions of some Ukrainian indexes

In the same time, complexity of solving economic tasks increases with the use of different estimations for the same processes. As an example of such estimation, we could name a set of tasks, connected with tendency estimation in funding market development, which from one side could be hardly forecasted for countries with transition economy, and for another side, is vitally important for taking decision in sphere of economic safety, cause it describes processes of reassignment of free money and financial resources.

Nevertheless, analysis and correct conclusion about processes is complicated because of different statistic characteristics of separate economic factors, describing the same processes (Figure 145) [Kuzemin and Lyashenko, 2006]. In addition, it is vitally important to estimate an interconnection influence of financial flows from different economic agents, which happening both on micro- and macro-levels [Kuzemin et al, 2005].

Therefore, in process of financial flow analysis we need to create a database, which in fact needs to be converted to real knowledge base. If we revive a structure of such process (Figure 146) it can be characterized as a procedure of receiving new informational images, which, in next step are grouped and analyzed in some kind, depending on microsituations in financial sphere.

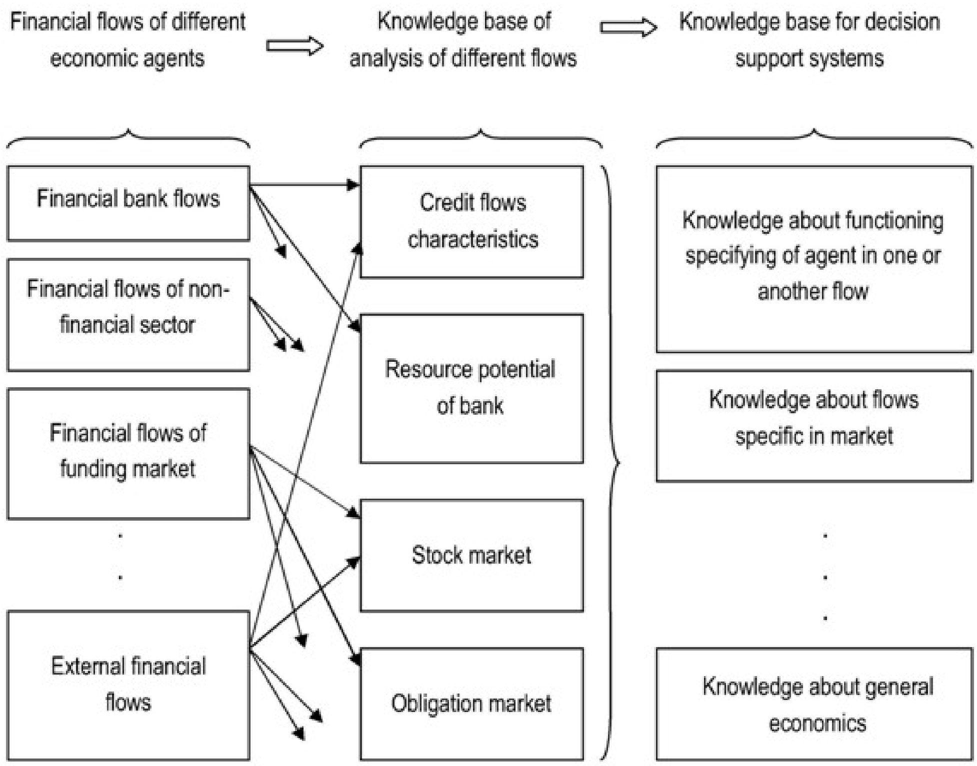


Figure 146. Generalized structure of process forming knowledge base in decision support system based on analysis of different financial flows, characterizing separate microsituations

8.3.1 Classical interpretation of effective bank management task and microsituation as base for performing comparison of bank functioning

One among possible approaches for comparative estimation of bank system or separate banks is comparison of their liquidity and profit-generation levels. Base idea of such comparison is connection between liquidity and profit-generation potential, which means that more risky bank operations could lead to extra income. Thus, when considering the probabilistic interpretation of banking activity management starting from a definite liquidity level one should take into account the fact that the bank tends to support the liquid assets volume at the level sufficient to ensure meeting previously taken commitments. At the same time, the bank defines the probability of the need for loan resources to meet its commitments. Then, for example, the interpretation of the banking system development based on the liquidity analysis can be considered as a probability for a random two-dimensional value to penetrate into some specified field where acceptable and admissible liquidity and profitability levels parameters manifest themselves as boundaries of such a field.

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The classical interpretation of the bank management efficiency can be considered in terms of the fuzzy sets theory. The given approach becomes possible through introduction into consideration of the ownership function of some set of the bank liquidity and profitability indices corresponding to a subset of efficient managing actions of the given indices.

Then, for example, the fuzzy interpretation of the bank management efficiency in the specified phase space is limited to building and estimation of the corresponding ownership functions characterizing the degree of reaching the bank efficient management in the specified variation intervals of the banking activity being analyzed. In this case, it is expedient to choose a fuzzy interpretation of the intended parameters variations in the limits of the admissible values of liquidity and profitability indices presented in the probabilistic model by the corresponding probabilistic curve as a formal description of such functions. The advisability of such a transition is motivated by that the fuzzy formalization of the corresponding probabilistic curve is possible based on the concept of the fuzzy number of L-R type, which in the given case can be regarded as a trapezoidal fuzzy number. Such an interpretation of the ownership function makes it possible not only to describe the processes under investigation formally but also to take into account existing economical aspects in their development.

As be marked before, for conducting of comparative analysis of functioning of banks an important instrument is the use of the finance flows, which makes it possible to give the most complete description of the banking on the basis of multiple presentation of the initial data (separate indices of activity) x_t^γ of their sets of γ at a certain temporal interval t in terms of the finance flows – $\{x_t^\gamma\}$.

This is associated with that the basis of the flow approach comprises the possibility to realize the structuring of data for complex dynamic systems; it is precisely the structuring that opens different directions for carrying out the necessary analysis [Kuzemin and Lyashenko, 2007a].

At the same time, the flow processes involve all spheres of the market economy, this is rather important as far as the banks is concerned as the centers of redistribution of monetary and reallocation of capital. This also allows taking into account the degree of various environment factors action, governing thereby the information saturation of the indices being considered.

It should be noted in this case that the flow approach can serve not only as the set of instruments for the banks functioning and development, but also act as the combining center of various approaches applications for carrying such analysis.

In the given aspect, to perform the comparative analysis of the banks functioning and development based on the flow approach, by the microsituation, variety of the banking description with the help of the corresponding parameters and indices should be meant. In this case the concrete microsituation S^L can be described in the form of a separate finance flow or some set of them being defined with a set of data $\gamma,(\gamma=1,...,m)$, characterizing the banking of some bank $L,(L=1,...,n)$:

$$S^L=(\{x_t^{k1}\})^L, k1\in\gamma \tag{8}$$

$$S^L=(\{x_t^{k1}\},\{x_t^{k2}\},\{x_t^{k3}\})^L, k1,k2,k3\in\gamma \tag{9}$$

Thus, comparing banks between themselves we, first, compare the microsituations, which in the given case describe the state of the banks functioning and development in terms of some parameter or their totality:

$$S^1=\left(\{x_t^{k1}\},\{x_t^{k2}\},\{x_t^{k3}\}\right)^1\approx S^2=\left(\{x_t^{k1}\},\{x_t^{k2}\},\{x_t^{k3}\}\right)^2, 1,2\in L, \tag{10}$$

where S^1 – is the microsituation describing the first of the banks being analyzed,

and S^2 – is the microsituation describing the second of the banks being analyzed.

At the same time it is possible to carry out comparison of the banks development and functioning as a whole fixing parameter t. Then, in the given case, variation of some of the banking parameters being analyzed x_{tp}^{γ} for a fixed date tp in terms of the whole variety of banks – $\{x_{tp}^{\gamma}\}^L, L,(L=\overline{1,n})$ is considered as a finance flow.

In this case, the concrete microsituation can be presented in the following form:

$$S_{tp}^L=\{x_{tp}^{\gamma}\}^L, tp\in t,\gamma,\left(\gamma=\overline{1,m}\right) \tag{11}$$

or

$$S_{tp}^L=\left(\{x_{tp}^{\gamma}\},\{x_{tp}^{\gamma}\},\{x_{tp}^{\gamma}\}\right)^L, tp\in t,\gamma,\left(\gamma=\overline{1,m}\right). \tag{12}$$

Then the comparison consists in performance of the analysis between the microsituations describing the state of the banking system functioning as a whole at some fixed dates of time:

$$S_{tp1}^L=\left(\{x_{tp1}^{\gamma}\},\{x_{tp1}^{\gamma}\},\{x_{tp1}^{\gamma}\}\right)^L\approx S_{tp2}^L=\left(\{x_{tp2}^{\gamma}\},\{x_{tp2}^{\gamma}\},\{x_{tp2}^{\gamma}\}\right)^L, tp1,tp2\in t \tag{13}$$

Ultimately, we receive some set of microsituations $\Omega=\{S^L,S_{tp}^{\gamma}\}$, completely describing functioning and development of the banking system. Since, as mentioned above, not all microsituations can have the normal distribution, then we shall consider nonparametric tests to verify the hypothesis for coincidence of the microsituations being investigated. In the given case, it is expedient to use the test Wilcoxon for bound samplings [Kuzemin et al, 2005], which answers the question: whether some event essentially changing the microstructure hierarchy took place in the analyzed data, which characterize different samplings.

In other words, when carrying out the comparative analysis of banks functioning and development the analyzed microsituations distinguishability is studied. Then the value of the Wilcoxon test can be used as the measure of distinction (agreement) of the microsituations being considered. The greater is the value of the test being considered, the more distinguishable as a whole are the microsituations being considered and vice versa, the less is the value of the test being considered the closer are the microsituations being considered.

8.3.2 The initial data and results of the comparative analysis of banks functioning in Ukraine

The foregoing approach is being considered as an example of the banking in Ukraine in terms of such index as a share of the granted credits in the overall totality of bank assets.

The paramount importance of consideration of such banking values is associated with that just the credits

- on the one hand, constitute a considerable part of bank operations and, respectively, operating profits in total gains of a bank from such operations,
- on the other hand, the granted credits growth results in credit risks and, consequently, in the banks development destabilization.

Thus, the problem associated with the succession of the development dynamics of relation between the granted credits and total volume of banks assets both for the banking system as a whole, and in terms of separate banks functioning is rather significant. The more so the generalized dynamics of the relation between the granted credits and total volume of banks assets as a whole is indicative of the rise in the banks preferred weight with the increased part of the granted credits in their assets volume (Figure 147, generalized using the site www.finance.ua.). Hence the essence of the first question as to carrying out the comparative analysis of the banking activity consists in estimation of the succession in variation of the granted credits preferred weight in their assets volume during each year of the period being investigated. To analyze such a succession is possible because of investigation of the microsituations each of them describes the state of the banking system functioning as a whole for the fixed date of time tp in terms of the banking activity index x_{tp}^{γ} – the credits preferred weight in the banks' assets (see Eq. 8). The results of such investigation obtained within the periods of 2004, 2005, 2006 and 2007 years in section of each month represent a separate microsituation shown in Figure 148 (generalized based on the above approach and data of the site www.finance.ua). In this case, the black circles mark the microsituations the most consistent between themselves, the microsituations less consistent are not shown at all.

The dimension of each circle represents the degree of correspondence (consistency) of microsituations being investigated in section of every month of the years covered. The smaller is the circle, the greater is the consistency between the microsituations.

In other hand, the analysis performed according to the above methods of consistency in development of separate banks is no less interesting in the considered aspect. To perform such an analysis let us consider a group of 12 banks representing those representing and operating in the same region that makes it possible to consider indirectly the action of various factors on their functioning and development. For the microsituations, their comparison will represent consistency of separate banks development, generalization of their finance flows appears, this represents the specific weight of credits in the structure of such banks assets. Further comparison is carried out based on Wilcoxon criterion accordion to Eq.5. Figure 149 shows results of such consistency.

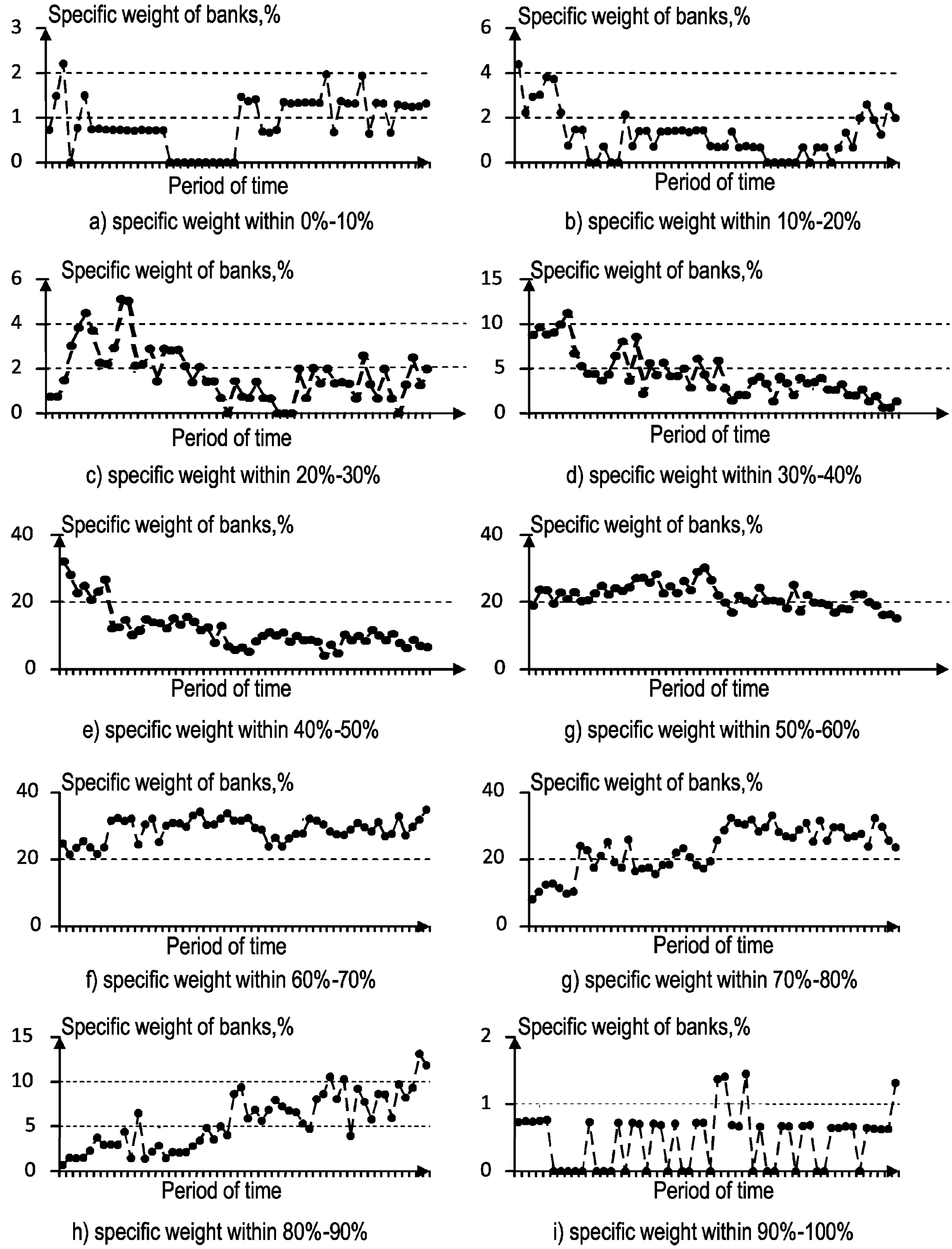

Figure 147. The specific weight dynamics of the granted credits to the total assets volume in the banking system as a whole during the period from 01.01.2004 till 01.05.2008

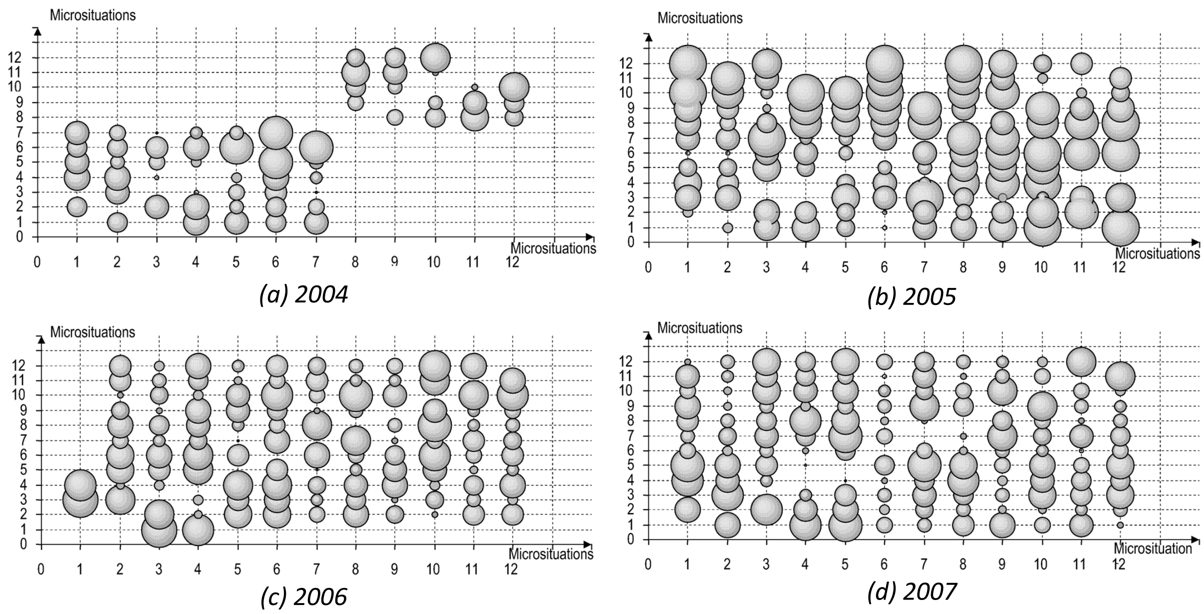

Figure 148. Consistency of microsituations representing variation of the credits specific weight in the banks assets volume according to the results of the banking system work

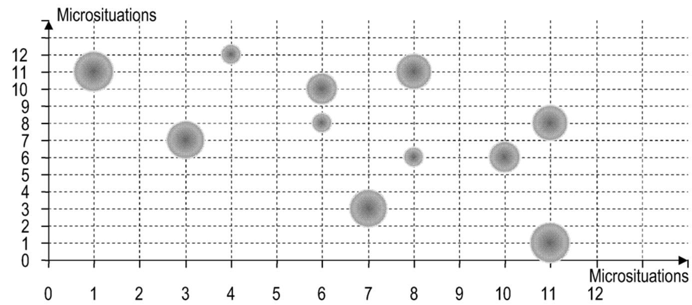

Figure 149. Consistency of microsituations representing variation of the credits specific weight in the banks assets volume according to separate banks of the group being studied by the results of their work within the period from 01.01.2004 till 01.05.2008

As evident from the data in Figure 149 the microsituations consistency in the considered aspect is not observed for the group of banks under study. Thus it may be concluded that each of the banks chooses its own strategy of increase of the credits being granted. Nevertheless, according to the data in Figure 148 such a strategy as a whole is aimed at increasing the credits specific weight in the bank assets structure. Consequently, the problem of the credit risk rise remains an urgent one.

If we speak directly on visualization of results of comparative analysis, we can use representation of such data in some kind of curve, which was described in previous parts of this paper. One suitable approach is taking into account distance between different microsituations according to Figure 148, where such distance is taken using different metric with coordination measure (in those examples we have a size of each circle describing degree of coordination of microsituations). In formalized equation, this could be described as follows:

$$R = M\left(S_n^m, S_{n+1}^{m+1}\right), \tag{14}$$

Where R – is coordination distance between microsituations using some metrics M;

S_n^m – size of the circle, describing micrositution **nm** in previous analysis of micrositutions set;

S_{n+1}^{m+1} – size of the circle, describing micrositution **nm** in next analysis of micrositutions set.

Resulted curve using equation 9 will describe dynamics of coordination change of current bank and could serve as its dynamics profile. In the same time for such dynamics review, it is possible to use methods of nonlinear dynamics, which receive wide appliance for performing comparative analysis in economical researches.

8.3.3 Methods of nonlinear dynamics are in the estimation of development of banks

Methods of nonlinear dynamics are widely used in analysis and forecasting of parameters showing the development of stock exchange market, insurance market, and dynamics of investment handling. Simultaneously analyses of bank segments of finance market based on methods of nonlinear dynamics are not sufficient explored in scientific publications. One of boundaries of such approach to such type of markets is the necessary amount of sample data collected, which may characterize the development of bank sector. Even for such markets, the investigation of discontinuities of economic processes is quite important for taking into account existing dynamics and the possibility of weakening regarding to further development of banks.

Phase portrait of statistical data series is the key term of nonlinear dynamics, characterizing main parameters of bank's processing and their time-induced changes. Such series are e.g.

KI – data series, defining dynamics of bank's loan-investment portfolio;

KR – data series defining dynamics of loans handed over;

MK – data series, defining bank's activity on the markets of interbank loans;

ZP – data series, characterizing dynamics of amount of bank's securities;

D – data series, defining the general amount of resources, acquired as deposits;

DF – data series, generalizing amount of resources acquired as deposits of physical persons;

DY – time series generalizing amount of resources acquired as deposits of legal persons;

In this way, bank's activity may be described as an amount of data series mentioned above, which can be generalized as follows:

Data series, defining dynamics of bank's loan-investment portfolio as:

$$\mathrm{KI}(x_1, x_2, \ldots, x_t) = \mathrm{KR}(y_1, y_2, \ldots, y_t) + \mathrm{MK}(z_1, z_2, \ldots, z_t) + \mathrm{ZP}(d_1, d_2, \ldots, d_t), \quad (15)$$

and data series, defining the overall amount of resources, acquired as deposits:

$$\mathrm{D}(e_1, e_2, \ldots, e_t) = \mathrm{DF}(ef_1, ef_2, \ldots, ef_t) + \mathrm{DY}(ey_1, ey_2, \ldots, ey_t) \quad (16)$$

where $x_t, y_t, z_t, d_t, e_t, ef_t, ey_t$ – values of according series at a fixed time moment t.

Then, in a phase space of dimension 2 using Cartesian coordinates the phase portrait of statistical data series may be defined as a set of points:

$$\Phi(\mathrm{CHR}) = \{r_i, r_{i+1}\}, i = \overline{1, t-1}, \quad (17)$$

where CHR – one of series shown above according to equ. 15 and 16.

r_i, r_{i+1} – are the values of series shown, in defined time intervals.

According to the fundamentals of rating of bank's development with methods of nonlinear dynamics in Figure 150 are shown phase portraits of data series, reflecting dynamics of interbank loans, taking into account the specifics of activities of different Ukrainian banks (values are taken from www.finance.ua).

As seen from Figure 150 generally for banks are characteristic different phase portraits of investigated data series. Simultaneously you may see that the dynamics of phase portraits of "Bazis" and "Grant" banks are most correlated compared with the dynamics of phase portraits of investigated series for "Big Energy" and "Nadra". This fact may be first explained by existing bank's strategy to act on market of interbank loans.

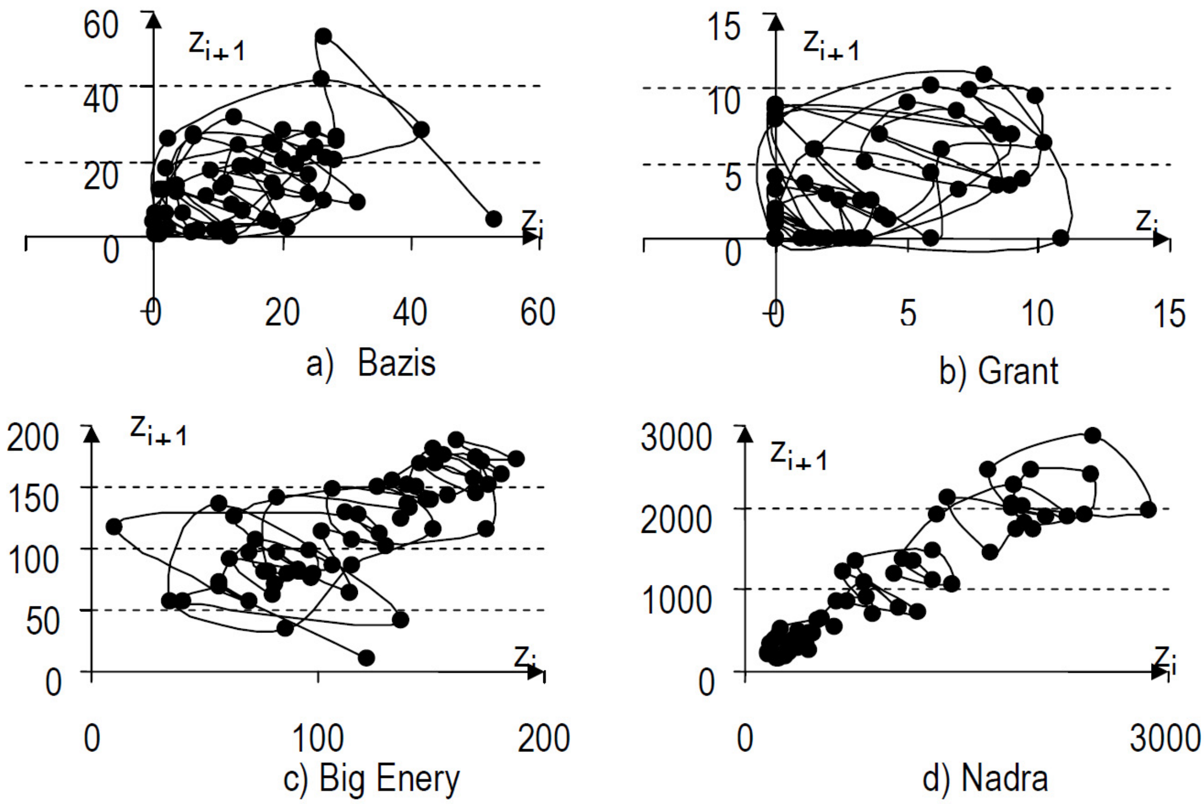

Figure 150. Phase portraits of data series defining bank's activities on the market of interbank loans for 2004-2008 (monthly)

Such strategy, however, will be defined based on existing conditions and factors, influencing bank's activities. This fact is reflected in the phase portraits of investigated data series shown above. So the "Bazis" bank and the "Grant" bank are related to the same group of banks, which are additional administrated by intermediate management. "Big energy" and "Nadra" banks also are administrated by intermediate management (www.bank.gov.ua). Therefore, one may state, that phase portraits of data series, shown above, reflect existing conditions of functioning, belonging to different banks. With other words, methods of nonlinear dynamics may be used on equal rights for investigation and analysis of development processes of complex economic systems, banks belonging to.

In this chapter, a set of most perspective methods, developed during last 4 year by authors for comparative analysis of banks functioning were reviewed. As example of such methods should be mentioned:

- formalization of banks' management effectiveness using connection between liquidity and profit-generation potential based on fuzzy sets theory;
- integral structured representation of reviewed processes spatiotemporal dynamics;
- methods of performing comparative analysis of functioning and development both whole banking industry and one bank based on generalized conception of microsituations set, each describing such activity as a result of determined financial flows, which, in one's turn reflects that o another factors of banks activity. For microsituations comparison non-parametric tests based on Wilcoxon criteria are used;
- performing comparative analysis of banks function using non-linear dynamics, including phase portrait. It is shown a set of cyclic changes in temporal sets of data, which allows to describe a certain characteristics of banks development.

Adequacy and effectiveness of proposed approaches is tested on real data in different aspects of banks activities, which renders it usable for performing extended comparative analysis of separate banks and bank systems.