Enterprise safe management. Quantitative modeling aspects

Valery G. Matveykin, Boris S. Dmitrievsky, Vladimir I. Mednikov

***Abstract*—**Primitive community safety based on some its representatives' strength and endurance. Later during the industrial age manufacturing processes complexity increased and needed not only named human qualities, but wide knowledge. Enterprises' safe management became increasingly important. Their safety was determined by the amount of capital accumulated, relationships with raw materials or other resources providers and market customers. K. Marx created enterprise capital math model in terms of value-added. Later Kobb and Douglas created enterprise math models which included capital and labor for its safety. Never the less enterprises' system has addiction crisis. J.M. Keynes suggested the state model of money flows and its control as a tool of overcoming crisis. In order to reduce uncertainty in enterprise safe management R Kaplan and D. Norton created model of enterprise strategic management system, which based on aggregation of four heterogeneous components such as finance (capital), internal processes, marketing, personnel education and growth. Thus, the capital accumulation remains the only way to form enterprise safety. Unlike predecessors we devised enterprise's math model, i.e. their function, which uses seven complementary resource components and obligatorily comprise enterprise external environment. Based on the model we proved incompletion and inaccuracy of enterprise activity descriptions, which inherent to modern directions of its safety. Our devised models made it possible to create commodity market math models, including crisis, to create math models of environment influence on enterprise resources, including force majeure, and finally determine the enterprise resource protection sufficiency in these interactions. These models describe the other way for enterprises' safety.

***Keywords* —** system of enterprises, force majeure, management, market, protection sufficiency, system's resource.

I. Introduction

THe purpose of any enterprise creature such as household, entrepreneurial, foreign, state is to satisfy external environment in its assignment function *f*. It means not only enterprise resources, which use to carry out its functions, but also its external environment should be composed into management contour. So resources being protected means functions are protected. Modern Russian enterprises achieve safe management by combining their capital [1], and using contemporary protective equipment. Individual economic interests of different scale market[2] participants and difference of participants' activity dynamics ($\frac{p_{max}}{MC}$ and $\frac{p_{min}}{MC}$ on Fig. 1) cause concurrence, i.e. competition, for market consumers, i.e. for capital ("Competition vector" on Fig. 1). Symbol *MC* denotes some manufacturing cycle; during *MC* market participants manufacture or consume product in quantity from p_{max} to p_{min}. Bi-directional "Competition vector" can be interpreted as market participants' individual economic interests. Direction from high to low dynamic participant means fight for low dynamic participant consumes, otherwise - for high dynamic participants.

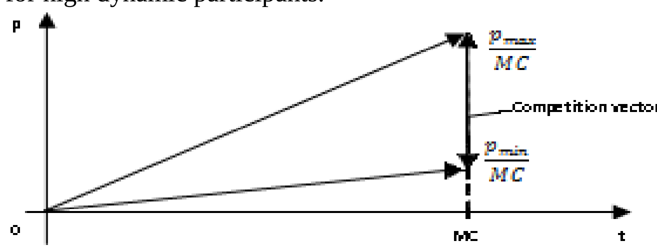

Fig.1 market participants' competition interpretation

The consequence of the concurrence leads to capital concentration (Fig. 2) among members of society (base of statistic). On Fig. 2 denoted: 1 – expected capital, treasure concentration between members in primitive society age; 2 – capital, treasure concentration between members in "wild market" age, based on data [3]; 3 – real capital, treasure concentration [4]; t – time.

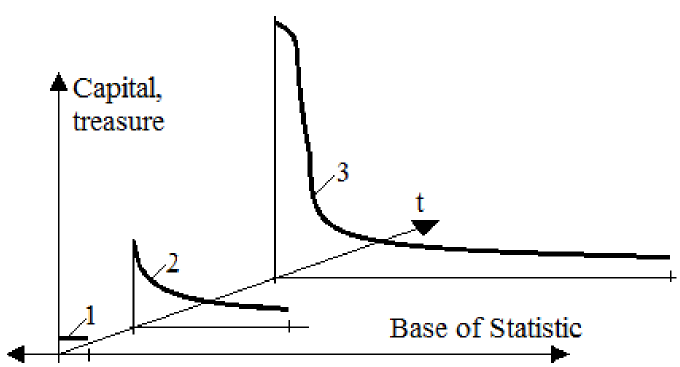

Fig.2 capital, treasure concentrations at different ages

The most dangerous conditions for any enterprise are crisis and force majeure. Nowadays the struggle for capital is the

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only means to achieve enterprises safe management. This long time struggle has led to the system of views “economic interests - a threat to those interests - protection of economic interests”. Over the centuries, this system generates uncertainty and instability in enterprises’ system development.

On our opinion, crisis occurs when system of enterprises exceeds a certain threshold in business development. Besides and more important modern theory and practice are impossible to find the effective instrument to forecast the scale, depth and duration of economic crises [2]. In order to find such instrument and finally to devise enterprise protection theory we created math models of enterprise, its environment and their interactions including force majeure. Based on our modeling practice we assert that any enterprise or any special technical subject being human created have cognitive model showed on Fig.3. Element “Storage” contains information about enterprise behavior, or about special technical subject influence, or about training, teaching processes including those which haven’t been crated so far. Based on this element usage some targeted processes (manufacturing, consuming, influence, others) and pertinent functions *f* were built. Because of force majeure hasn’t this element, it’s impossible to build targeted process and influence and management functions. Hence force majeure and its influences are aimless processes.

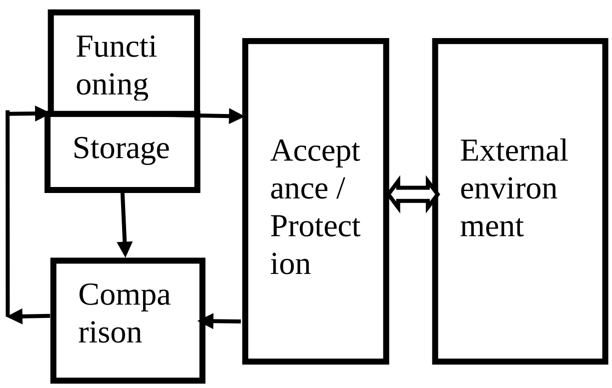

Fig. 3 enterprise’s or special technical subject’s cognitive model

The article describes different ways where system of enterprises can reach safety state in interactions. The base of this state is every participant’s success in markets [2].

We’ve proved inadequate descriptions of the modern enterprise safe activity directions (economic, informational, internal security, and others). Based on devised math models we’ve found the sufficiency of its resources protection from internal environment point of view and from external one.

2. Enterprise and its external environment models.

We are interested in two kinds of interactions between enterprise and its external environment. They are market, including crisis, and the external environment influence on it, including force majeure. The third kind of interaction - the enterprise influence on its external environment - is left out of the article subject.

Term "market" refers to the simultaneous bi-directional authorized resource exchange: money of consumers and products $p\ (t)\ =\ f\ (t)r(t)$ of manufacturers; herewith the direction "from the consumer to the manufacturer" is "demand" [5] and the opposite direction is "offer"[5].

The term "external environment influence on enterprise" means this environment unauthorized, usually negative, manage enterprise resources *r(t)*; herewith this influence performer may be represented remote control special technical subject (sts) or force majeure (fm). We recognized the difference between fm and sts: fm is aimless negative influence on enterprise resources, but sts has such purpose. It means that sts has determined assignment function $f_{sts}(t)$ and fm doesn't.

In order to simplify the understanding the enterprise protection from internal and external environment points of view we found their infological model (Fig. 4) by using decomposition method.

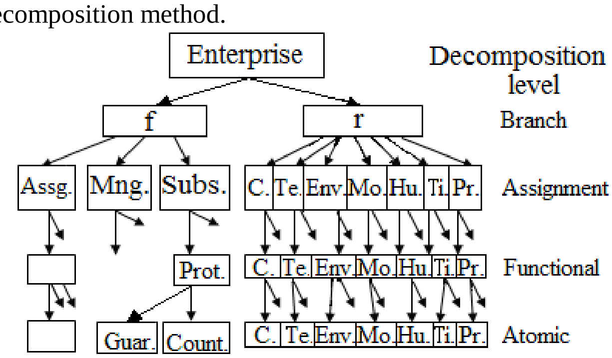

Fig.4 enterprise or special technical subject Infological model

Enterprise’s or sts’s function *f* has such components as assignment “Assg.”, management "Mng.", subsidiary "Subs.", other components represents protection function “Prot.”, resources security function "Guar" and counterwork function “Count” for counterwork negative influence on resource r. Seven complementary components represent the resource *r* of enterprise or sts. These components are C. - communicative, Te – technical, Env - environment, Mo – money, Hu – human or employees, Ti – time, Pr – protection.

Every function *f* has its own set of these complimentary components. We used such resource components as an individual employee of the enterprise, workplace in premises, the money unit on current account and others, which do not require any explanations. So these components represent elementary components on "Atomic" level (Fig. 4). We’ve proved the complementarity of the resource components from point of view manufacturing, financial, and the law. It became the basis for affirmation: infological model on Fig. 4 is adequate to the actual enterprise or sts.

2.1. Enterprise model.

We used system function *f(s)* [2]

$$f(s) = \frac{p_0\ s^0 + p_1 s^1 + \cdots + p_n s^n}{[r_0]s^0 + [r_1]s^1 + \cdots + [r_n]s^n} + \varphi(s), \qquad (2.1)$$

where p_i – amounts of enterprise main indicators, or the facts of output (*p* - production) in terms of elementary intervals Δt as for instance day; $[r_i]$ – the facts of complementary resource utilization for manufacturing p_i (see Fig.5, where t_j designates some moment of time as for instance influence or sampling moment); n - number of Δt in the interval of time $n\Delta t$ as for instance a month.

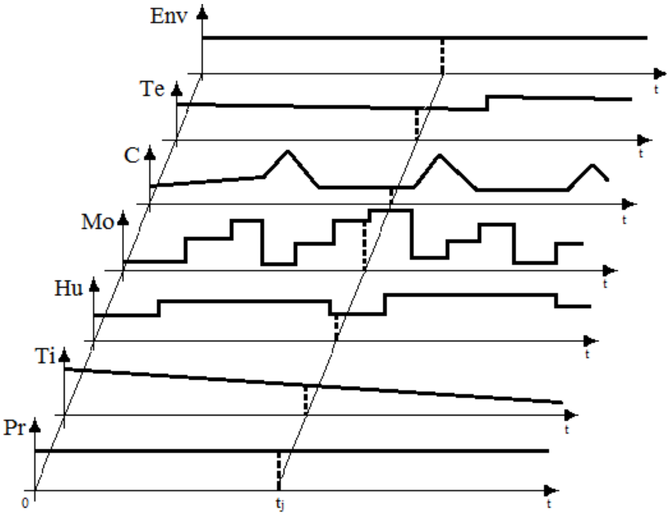

Fig.5 example of complementary resource components behavior in time

We introduced a significant difference in the model (2.1): resource r_i is represented seven complementary components showed on Fig. 4. Every enterprise executable function has these seven components. Thereby the model f(s) (2.1) is multi-variable function. Model (2.1) acquired a significant novelty which the complementary polynomials reflect in the denominator of model (2.2).

$$f(s) = \frac{p_0 \quad + p_1 s^1 \; + \cdots + \quad p_n s^n}{\begin{bmatrix} r_{env\,0} & + r_{env\,1} s^1 + \cdots + & r_{env\,n} s^n \\ r_{te\,0} & + r_{te\,1} s^1 + \cdots + & r_{te\,n} s^n \\ \cdots & & \\ r_{pr\,0} & + r_{pr\,1} s^1 + \cdots + & + r_{pr\,n} s^n \end{bmatrix}} + \varphi(s) \tag{2.2}$$

where φ(s) - initial enterprise activity condition.

The model (2.2) makes the enterprise activity transparent.

We've observed the economic life of different enterprises. These observations' results are as follows:

- different resource components of any executable function has different information attribute K_{inf}. For example the enterprise geographic relief (r_{env}) represents information about submergence its territory in case of force majeure "heavy rain"; different quantitative relationship between every complementary component of any executable function and the result of this function performance, or in other words the value w (weight or the severity of the consequences for the function in case of this components damage); each resource component has individual perviousness PN unauthorized influences on it. Some examples beneath represent estimated K_{inf} and PN of Env., Te., C., Hu, Ti. resource components and pertinent protection;

Env: PN=1, Kinf=[0, 1] Harm in breathing mix. Protection: ventilation;

C: PN=0, Kinf=1 Resistance to malware. Protection: antivirus;

Te: PN=0,5, Kinf=1 Equipment failure. Protection: operators' training, proper operation;

Hu: PN=0, Kinf=1 Working efficiency. Protection: wellness activity;

Ti: PN=0, Kinf=1 Deadline for assignment. Protection: qualification, skills;

- different enterprises have different amounts of resources protection efficiency $E_{prot} = E_{guar}E_{count}$, where E_{guar} is efficiency of organizational means and technical devices of resource component security; E_{count} is efficiency of counterwork unauthorized influence on it; herewith some of means and devices no exist so far. Multiplication $E_{guar}E_{count}$ means that resources security function perform first, and counterwork function bases on result of security function and is performed after security function.

We used these results in model (2.2), so its modification (2.3) obtained additional significant difference

$$f(s) = \frac{1}{\begin{bmatrix} w_{env}(1-K_{inf\,env})(1-PN_{env})\, E_{sguar\,env}E_{count\,env} \\ \cdots \\ \cdots \\ w_{pr}(1-K_{inf\,pr})(1-PN_{pr})E_{guar\,pr}E_{count\,pr} \end{bmatrix}} X$$

$$X \frac{p_0+p_1 s^1+\cdots+p_n s^n}{\begin{bmatrix} r_{env\,0} & + r_{env\,1} s^1+\cdots+ & + r_{env\,n} s^n \\ r_{te\,0} & + r_{te\,1} s^1+\cdots+ & + r_{te\,n} s^n \\ \cdots & & \\ r_{pr\,0} & + r_{pr\,1} s^1+\cdots+ & + r_{pr\,n} s^n \end{bmatrix}} \tag{2.3}$$

where column matrix of type coefficients $w(1 - K_{inf})(1 - PN)E_{guar}E_{count}$" locates before polynomials in denominator of model (2.3).

We apply this column matrix in two ways. Firstly, to characterize enterprise safety from internal environment point of view. In this case external environment doesn't influence on enterprise activity in market and we use E_{guar} and E_{count} for resources protection description during all functions performing. For example, Management guesses resources protection is sufficient if security system registers bullet flight in some part of enterprise space, or if protection system uses high-end equipment. Secondly, to characterize enterprise safety from external point of view, i.e. in case of sts or force majeure influences on enterprise resource components. In this case besides E_{guar} and E_{count} increasing we use resources' parameters K_{inf} and PN which should be reduced, because some sts forms influence process beforehand based on these enterprise parameters study. Enterprise Management guesses resources protection is sufficient, if protection system uses not only newest equipment, but maximum reduced K_{inf} and PN.

Model (2.3) helps us to understand "the care items" of some commercial enterprise safety directions (Fig. 6). For example, the developers of "economic safety" assume that enterprise safety is achieved by the only "basic" resource r_m protection (component Mo. on Fig.4); an "informational safety" - the only resource r_{com} (C. on Fig.4); "physical protection" - the only r_{env} (Env) and r_{staff} (Hu), etc.

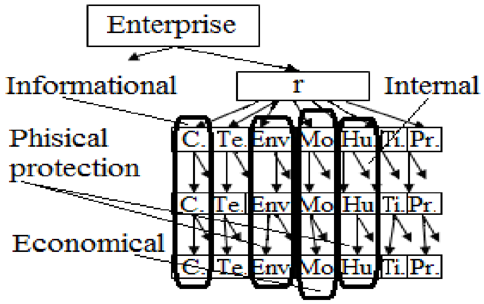

Fig.6 “the care item” of some enterprise safety directions

These examples show the enterprise descriptions given by named and other safety directions inadequate to its real activity. The reason is as follows. These directions neglect plenty paths for negative influences on resource components, as well as neglect many ways for enterprise protection by these components protection. To develop measures for enterprise safe state in interactions with external environment this neglect compels Management to use such evaluations of main indicator $p(t)$ as “average”, “mean-square”, i.e. inaccurate one, and to build enterprise protection "like a neighbor," or to use some foreign solutions.

2.2. Enterprise external environment model.

We observed economic life of enterprises which locate in external environment and established that model (2.3) describes their activity precisely; herewith “our” enterprise has production links with the providers of some resources $p_{outside}(s) = f_{outside}(s)\ r_{outside}(s)$ as for instance electricity. This had led us to assort that enterprise external environment math model is finite set of models (2.3)

$$\{f_{outside}(s)\},\ i \geq 1, \qquad (2.4)$$

We named these providers of set (2.4) as echelon 1. They are number “2”, “3”, “4” in Fig. 7.

Analogously, echelon 2 contains real enterprises “5”, “6”, “7” which provide their products $p(s)$ enterprises “2”, “3”, “4” by using their production links.

Further, some enterprise of echelon 2 uses products from providers “8”, “9”, “10” in echelon 3. In this case the model (2.3) could be used again to describe these providers’ activity. The resulting structure in Fig.7 refers to the type of "star". As the boundary of the structure we had chosen high-performance providers, for example, in the form of mass production. Our criteria selection bases on known examples of these enterprises to obtain recession and then crisis fast.

Here some practical examples. For enterprise “1” of engineering industry high-performance providers (metal, engines, gears, electrical and electronic components, others) locate in echelon 2; for enterprise “1” of building sector similar providers (cement, rebar, additives, others) locate in echelon 1; for enterprise 1 of agro-processing industry similar providers (grain, meat, vegetables, milk, etc.) locate in echelon 1. Hence, accordance with criteria chosen similar providers are benchmark of production links; they are the starting of production chains of enterprise 1. We apply this method to form neural network structure of some administrative territory by compiling “stars” in Fig. 7. After that we created the model of the territory and used neural network unit for modeling some indicators for example territory activity dynamic.

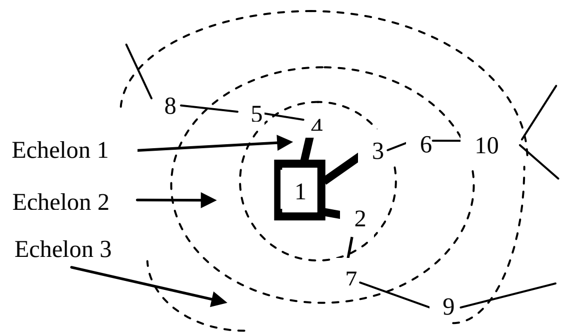

Fig.7 production links between enterprise “1” and providers “2”, “3”, “4” of echelon 1, providers “5”, “6”, “7” of echelon 2, and providers “8”, “9”, “10” of echelon 3

We took into account all enterprises of all echelons in Fig. 7 have individual amount of $E_{pr} < 1$ of their resources. So we put these amounts into the nodes of the graph of production links in Fig. 7 and calculated risk. Give one numerical example. Fig. 8 shows one production link between enterprise 1 and providers “3”, “6” and “10”. Assume these providers have protection effectiveness $E_{pr”3”} = 0,8$; $E_{pr”6”} = 0,7$ and $E_{pr”10”} = 0,6$. The quantitative definition of risk represents the expression $risk = (1 - E_{pr“1”})$. In everyday language the amount of risk quantitatively characterizes “blindness”, imperfection and similar characteristics of modern protective equipment. All contemporary enterprises’ safety directions and protective equipments have this “blindness”. Nevertheless this equipment improvement is continuing, so the *risk* is reduced.

We applied formula for $risk = (1 - E_{pt})$ to calculate the *risk* of production link on Fig. 8. We’ve found $risk_{»1»} = 1 - E_{pr«1»}E_{pr«3»}E_{pr«6»}E_{pr«10»} = 1 - 0,2688 = 0,7311$. Logically clear $risk_{»1»}$ depends on production link length.

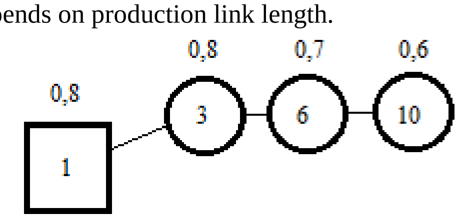

Fig.8 graph of one production link between enterprise 1 and providers “3”, “6” and “10”

Taking in account several variants of possible production links in all echelons, Management prepares pertinent quantity of graphs and esteems its *E* or *risk*. Result is as follows the enterprise safe management is sufficient from external environment point of view, if one or more graphs are satisfied assigned amount of *risk*.

3. Enterprise and its environment interaction math model.

Manufacturers’ as well as consumers’ daily routine consist of carry out their functions in market; herewith any influences on

participant's resources, including force majeure, are occasional events. We found that 1) "protection" is both enterprise's function and resource; 2) enterprise safety characterizes its property, which is either the design parameter or the result of protection function performing during enterprise activity. Owing to what we assert one system implements both enterprise functions - management and resources protection.
It's useful for practice either manufacturer's internal processes or customer's processes as well as their interaction processes have small deviation from the set during long period of time and have large deviations during shirt period of time. Base on it we assert these processes are linear so their interactions are linear too.

We devised math models of different scale successful commodity market: elementary, simple, international monopolistic, complex and real (Fig. 9) [2].
The two equivalent expressions (3.1) and (3.2)

$$P_{manuf}/n\Delta t = P_{consum}/n\Delta t \qquad (3.1)$$

$$[f_{manuf}(n\Delta t) r_{manuf}(n\Delta t)]/n\Delta t = \\ = [f_{consum}(n\Delta t) r_{consum}(n\Delta t)]/n\Delta t \qquad (3.2)$$

represent successful elementary market model, where P_{manuf} is quantity of commodity manufactured; P_{consum} is quantity of commodity consumed; $n\Delta t$ is registry time interval; $f_{manuf}(n\Delta t)$ and $f_{consum}(n\Delta t)$ are manufacturer's and consumer's functions respectively; $r_{manuf}(n\Delta t)$ and $r_{consum}(n\Delta t)$ are manufacturer's and consumer's complementary resources respectively. It is competently to use either terms "equilibrium" [6] or "supply and demand" [5] for all market models devised [2].

For any scale market negative influence on $r_{manuf}(n\Delta t)$ or $r_{consum}(n\Delta t)$ results some thread "$-\Delta r$" in t_j moment of time (see Fig.5). This influence may be performed by some special subject sts, which has influence purpose, or by force majeure fm, which hasn't one. Hence we are entitled to write $r_j - \Delta r$, where $-\Delta r = f_{sts}(t_j) r_{sts}(t_j) = p_{sts}(t_j)$. In this case we may write market models (3.1) and (3.2) for example in form (3.3)

$$f_{manuf} r_{manuf} \neq f_{consum} r_{consun}(1 - f_{sts}\, r_{sts}/r_{consum}), \qquad (3.3)$$

where bracket $(1 - f_{sts} r_{sts}/r_{consum})$ characterizes quantitatively relative amount of thread after sts's influence on market participant resource.
In this case the model (2.3) will be modified in form of (3.4):

$$f(s) = \frac{1}{\begin{bmatrix} w_{env}(1-K_{inf\ env})(1-PN_{env})E_{guar\ env}E_{cout\ env} \\ \cdots \\ \cdots \\ w_{pr}(1-K_{inf\ pr})(1-PN_{pr})E_{guar\ pr}E_{count\ prot} \end{bmatrix}} \times \\ \times \frac{p_0 + p_1 s^1 + \cdots + x_j s^j + \cdots + x_n s^n}{\begin{bmatrix} r_{env0} & + r_{env1} s^1 + \cdots + & + r_{envn} s^n \\ r_{te\ 0} & + r_{te\ 1} s^1 + \cdots + r_{te\ j}\left[1 - f_{sts}\, r_{sts}/r_{te\ j}\right] s^j + \cdots & + r_{te\ n} s^n \\ \cdots & & \\ r_{pr\ 0} & + r_{pr\ 1} s^1 + \cdots + & + r_{pr\ n} s^n \end{bmatrix}} \qquad (3.4)$$

where all denoted elements of model (3.4) were explained in text above; elements of type "$x_k s^k$" describe the main indicator p behavior from j-th to n-th moment of time.

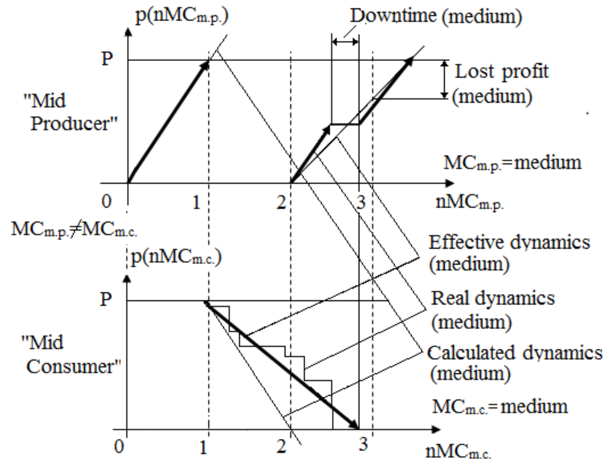

Fig.9 example of mid producer's and mid consumer's dynamics ligament in real market

Our observations show, being aimless processes some fm influences have big amount of "energy" and shirt duration. It means big "energy" concentration in time. On the other hand, we've found similarity of different fm influences: if "energy" concentration exceeds certain threshold, enterprise resource components independence will be broken or mingled coherency will be appeared.

Our modeling shows that perviousness *PN* (see above) plays crucial role in this case. Examples of thresholds: throughput capacity of drainage for fm "heavy rain"; seismic resistance for fm "Earthquake"; historical maximum rise of water in the ocean for fm "hurricane"; etc. Furthermore we assert that nonlinear relations between the concentration and components' independence will be appeared after this exceeding. Because of absence or zero f_{sts} leads a single value of bracket type $[1 - f_{sts} r_{sts}/r_{te\ \ j}]$ in model (3.4) which confirm our assertion. Example for "Earthquake": the more fm energy the more amount of r_{te} , r_{hu} , r_c damage. In case of fm influence on consumer, elementary market math model (3.3) takes the form for example (3.5)

$$f_{manuf} r_{manuf} \neq f_{consum} r_{fm\text{-}consum}\,, \qquad (3.5)$$

where $r_{fm\text{-}consum}$ is joint distribution function of fm as normal random process and behavior of named above enterprise' resource components, for example, r_{hu} as normal random process.

Described method could be used in order to get math model of other scales commodity markets and to get interaction math models for more than two enterprise resource components [7], [8]. Devised math models show plenty real ways for enterprise safe management improvement.

4. Calculation example.

Assume we have normal random processes fm "Earthquake" which influences in j-th moment of time on enterprise resource component r_{hu} which is also normal random process (see Fig. 5). These processes' models are described expressions as follows

$$r_{fm} = \frac{1}{\sqrt{2\pi Dr_{fm}}} exp - [r_{fm} - Mr_{fm}]^2/2Dr_{fm} \quad (4.1)$$

$$r_{hu} = \frac{1}{\sqrt{2\pi Dr_{hu}}} exp - [rhu - Mr_{hu}]^2 / 2Dr_{hu} \quad (4.2)$$

where r_{fm} and r_{hu} present value of fm process and hu process relatively; Mr_{fm} and Mr_{hu} are mean value of named processes respectively; Dr_{fm} and Dr_{hu} are variance of named processes respectively. Using (4.1) and (4.2) we could find joint distribution function of $r_{fm\text{-}hu}$ or their envelope which is also normal random process [7].

$$r_{fm\text{-}hu} = \frac{1}{2\pi\sqrt{\left(1-(\rho_{fm-hu})^2\right)Dr_{fm}Dr_{hu}}} \times$$

$$\times\ exp\{\frac{1}{2(1-(\rho_{fm-hu})^2)}[\frac{(r_{fm}-Mr_{fm})^2}{Dr_{fm}} +$$

$$+ \frac{(r_{hu}-Mr_{fm})^2}{Dr_{hu}} - 2\rho_{fm\text{-}hu}\frac{(r_{fm}-Mr_{fm}(r_{hu}-Mr_{hu})}{\sqrt{Dr_{fm}Dr_{hu}}}]\}, \quad (4.3)$$

where $\rho_{fm\text{-}hu}$ – correlation coefficient between r_{fm} and r_{hu} or their covariance, normalized by their dispersions

$$\rho_{fm\text{-}hu} = \frac{k_{fm-hu}}{Dr_{fm}Dr_{hu}} = \frac{cov[r_{fm}r_{hu}]}{Dr_{fm}Dr_{hu}}, \quad (4.4)$$

where $k_{fm\text{-}hu} = cov\{r_{fm}r_{hu}\}$ – mixed central moment of the second order, or covariance, or moment correlation of normal random processes r_{fm} and r_{hu}:

$$k_{fm\text{-}hu} = cov\{r_{fm}r_{hu}\} = M\{[r_{fm} - Mr_{fm}][r_{hu} - Mr_{hu}]\}. \quad (4.5)$$

The parameter Mr_{hu} characterizes statistically average damage of r_{hu} in case of r_{fm} influences. Obviously, the more r_{fm} the more $cov\{r_{fm}r_{hu}\}$ and different losses.
Believing that the influence result $r_{fm\text{-}hu}$ will appear in j-th moment of time, the model (3.4) could be modified into form of (4.6)

$$f(s) = \frac{1}{\begin{bmatrix} w_{env}(1-K_{inf\ env})(1-PN_{env})E_{guar\ env}E_{count\ env} \\ \vdots \\ \dots \\ w_{pr}(1-K_{inf\ pr})(1-PN_{pr})E_{guar\ pr}E_{count\ pr} \end{bmatrix}} \times$$

$$\times \frac{p_0 \quad + p_1 s^1 + \dots + x_j s^j + \dots \ + x_n s^n}{\begin{bmatrix} r_{env0} & + r_{env1}s^1 + \dots + r_{envj}s^j + \dots & + r_{envn}s^n \\ \dots & & \\ r_{hu\,0} & + r_{hu\,1}s^1 + \dots + r_{fm-hu\,j}s^j + \dots & + r_{fm-hu\,n}s^n \\ \dots & & \\ r_{pr\,0} & + r_{pr\,1}s^1 + \dots + r_{pr\,j}s^j + \dots & + r_{pr\,n}s^n \end{bmatrix}} \quad (4.6)$$

Based on expression (4.3) for $r_{fm\text{-}hu}$ and having $r_{fm} = 1$; $Mr_{fm} = 0{,}0000003171$ ("Earthquake" impact duration is no more 10 seconds; one impact every 5 years); $r_{hu} = 1$; $Mr_{hu} = 0{,}2$, we have the covariance matrix content

$$\begin{bmatrix} cov\{r_{fm}r_{env}\} = 0 \\ cov\{r_{fm}r_{com}\} = 0 \\ cov\{r_{fm}r_{te}\} = 0 \\ cov\{r_{fm}r_{hu}\} = \\ 0{,}4899 \\ cov\{r_{fm}r_{m}\} = 0 \\ cov\{r_{fm}r_{ti}\} = 0 \\ cov\{r_{fm}r_{prot}\} = 0 \end{bmatrix} \quad (4.7)$$

The matrix content could be interpreted this way: because of fm "Earthquake" enterprise resource r_{hu} has damage – $\Delta r_{hu} \approx 49\%$. Our models show we could reduce "$-\Delta r_{hu}$" by changing *PN*.

5. Conclusion.

The article describes safe enterprise activity on unified mathematical basis and terminology; proved that modern commercial enterprise safety directions describe enterprises incomplete and inaccuracy; material above characterizes enterprise protection sufficiency, firstly, as parameter, which increase effectiveness of internal functions performance, and, secondly, as a property of enterprise management system, which include network of resources providers. Enterprise safety is defined analytically from internal environment point of view and from external one; production links structure between enterprise protected and its environment were revealed; enterprise model, its environment math model and their interactions math model type market, including crisis, and external environment influences, including force majeure, were devised; these models form the protected manufacturing environment of any enterprise and reduce uncertainty in enterprise management activity concerning *risks*. Devised models show that one system performs both management and resources protection functions. These models opened ways to increase enterprise management system effectiveness.

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