UDC 658
УДК 658

ESTIMATION OF BUSINESS ACTIVITY RISKS IN THE CONDITIONS OF SYNERGETIC DEVELOPMENT FOR THE ECONOMIC

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ОЦІНКА РИЗИКІВ ПІДПРИЄМНИЦЬКОЇ ДІЯЛЬНОСТІ В УМОВАХ СИНЕРГЕТИЧНОГО ХАРАКТЕРУ РОЗВИТКУ ЕКОНОМІКИ

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ОЦЕНКА РИСКОВ ПРЕДПРИНИМАТЕЛЬСКОЙ ДЕЯТЕЛЬНОСТИ В УСЛОВИЯХ СИНЕРГЕТИЧЕСКОГО ХАРАКТЕРА РАЗВИТИЯ ЭКОНОМИКИ

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Introduction. Due to nonlinear character of economic dynamics, business in the world has to be pursued in constantly growing uncertainty and volatility of market environment. This is reflected in unpredictable course and rate of the financial and economic crises, increasing the volatility of financial markets and rapid transformational changes in market conjuncture [1]. Therefore, the problems of evaluation and managing of business risks in the last two decades have become some of the most critical in the activity of enterprises, financial institutions, etc.

Literature analysis. Currently, the generally accepted methodology of risk evaluation that was developed by financial institutions of western economic system and the regulatory bodies [2,3, etc.] is a Value-at-Risk approach (VaR) [4,5]. However, VaR methodology can only be applicable for stable markets evaluation. This methodology does not adequately reflect the value of risk when markets undergoing rapid and (or) abrupt changes under crisis-considered conditions.

Problem statement. Moreover, the model curves of probability distribution of financial and economic indicators changes used in most existing relevant VaR evaluation methods, are not always appropriately describe the realities of business in modern non-linear economy dynamics. For instance, it is well known [6] that, such distribution curves are asymmetrical and leptokurtic (sharp peaks and fat tail risk curve). However, normal distribution curves (under the Risk Metrics™ method) are symmetrical with zero kurtosis. Pareto-Levy distribution curves (considered under the hypothesis of fractal market [6,7] or in most nonlinear stochastic models GARCH [8] are leptokurtic but they have no asymmetry.

Results and discussion. We proposed the novel method based on VaR methodology to evaluate business risks. This method can be applicable to describe the stable markets, and also to describe nonlinear dynamic economic processes. Such economic processes include fleeting (even abrupt economic changes and crises).

In this paper, computer simulation of the time series of the expected revenue evolution is considered as a result of enterprise business in non-linear stochastic market environment. Calculations were carried out in according with the synergetic Lorenz model [9]:

$$\begin{cases} \dot{I} = I + F + \xi(t) \\ \delta \cdot \dot{F} = -F + I \cdot p + \xi(t) \\ h \cdot \dot{p} = (p_e - p) - I \cdot F + \xi(t) \end{cases} \tag{1}$$

Here I - the revenue of the company at the moment t as the function of the demand Q for goods (services) which offered by enterprise on the market; F – the function of enterprise production which determines the efficiency of conversion costs of various types of resources into the relevant products; p - the conditional price of goods (services), which generally represents a complex function which depends on multiple external and internal factors of nonlinear market environment. Accordingly, $\dot{I}$, $\dot{F}$, $\dot{p}$ – represent the rate of change (time derivatives) and δ, h - system parameters, which depend on the velocity of the changes I, F, p under the effect of deterministic (sudden or permanent) pe and stochastic factors $\xi(t)$ of the nonlinear market environment.

It should be noted that the value of the control parameter pe in system (1) can describe deterministic effect of market factors of any nature, for example, changes in the market opportunities, targeted alterations of financial market by government or other institutions (credit rate, exchange rate, tax system etc.), impact of military operations on the market, sudden force majeure, the introduction of innovative technologies, changes in consumer preferences and standards, etc.

Thus, the parameter $\xi(t)$ in the system (1) describes the effect of stochastic factors of the business environment which represent an additional source of business risks. It was assumed that $\xi(t)$ changes depend on the normal distribution and this parameter affects dynamic variables I, F, p equally. Modeling of corresponding time series was carried out by computer simulation method using MathCAD software taking in account the following initial values of the dynamic variables and parameters of the system (in arbitrary units): I_0 = 0,01, F_0 = 0,01, p_0 = 0,01, δ=5, h=2,5, observation time $t = (0\ldots150)$. We modeled stochastic and deterministic nonlinear effect of market environment on the evolution of the system (1) by simulation of different values of the control parameters, namely the amplitude of Gaussian noise D [10] and pe, accordingly. We selected values pe that corresponded to the transitions of the system (1) from a point of bifurcation to the stationary fixed state and the deterministic chaos state (i.e. economic crisis). We used obtained time trends data to determine the parameters of probability distribution curves of the expected revenue I in according with [5], namely the skewness coefficient β and kurtosis θ. We analyzed probability distribution curves for expected revenue in case of nonlinear deterministic trend of the company activity evolution (i.e. during the transition from a fixed point bifurcation to the equilibrium state (D = 0)) and we found that these curves are characterized by asymmetry $(\beta \neq 0)$ and they have leptokurtosis$(\theta > 0)$. For example, there are positive asymmetry for $pe = 5$ $(\beta > 0)$ and negative asymmetry $(\beta < 0)$ for $pe = 12$ for these curves. Interestingly, we observed disappearance of asymmetry and leptokurtosis on probability distribution curves I when we taken in account the additional effect of stochastic nonlinear market environment factors ($D \neq 0$) on the financial and economic activity of the enterprise. The results of computer simulation of the company evolution at the system (1) transiting from the bifurcation point to the state of chaos (economic crisis, $pe = 37$) show that probability distribution curves for expected revenue are characterized by small values of asymmetry and leptokurtosis.

We used non-financial corporations' example to demonstrate the application of proposed synergistic method for business risks evaluation in a VaR framework. For these corporations, the majority of assets are illiquid, and the main risk relates to changes in operating cash flows. Therefore, a key cost parameter in this case is the Cash-Flow at Risk (C-FaR) [11]. The time horizon of the forecast for calculating C-FaR is usually longer than time window for VaR evaluation for financial institutions, namely, between one and twenty quarters [11]. The basic financial risk factors and non-financial corporation specific factors which affect operating cash flows (i.e. changes in demand for the company products, competitive pricing, innovation and technology) have been often used to calculate the C-FaR.

To generate histograms showing a frequency distribution of expected revenue I we used numerical data obtained in the analysis of time series for system (1) and its elements were taken as follows:

$$x_i = I_{t+1} - I_t \quad , \qquad i = \overline{1, n-1} \,. \tag{2}$$

Density plots of normalized frequency distribution of expected revenue were built using standard functions in MathCAD for different time series (2). These time series were generated by computer simulation of the system evolution (1) taking into account different values of deterministic p_e and stochastic $\xi(t)$ nonlinear factors of the market environment. This normalization was performed per unit at maximum density. To be specific, the number of histogram distribution segments was chosen equal to ten in all cases.

The next step was required to determine the quantitative characteristics of business risk. This value was obtained by plotting of approximate function describing the distribution density of enterprise expected revenue $P(x)$ which fitted the best into these distribution histograms. In general, the distribution curves could be asymmetric. Therefore, the approximate function is proposed as follows:

$$P(x) = a_1^- \cdot e^{-a_2^-\left(\left|x - a_3^-\right|\right)^{a_4^-}} + a_1^+ \cdot e^{-a_2^+\left(\left|x - a_3^+\right|\right)^{a_4^+}} , \tag{3}$$

where a_1^-, a_2^-, a_3^-, a_4^-, a_1^+, a_2^+, a_3^+, a_4^+ - the approximation parameters for the left hand (-) and for the right side (+) of the distribution curves, respectively. We postulate that a_3^- = a_3^+ in (3) and these values are correspond to the enterprise expected revenue with maximum probability. For example, Figure 1 shows density function of the normalized probability distributions of expected earnings as the results of computer simulation time trends of company evolution in system (1). Here histograms - normalized frequency distribution of expected revenue for time series (2), solid line - approximate functions according to (3); points - normal (Gaussian) distributionthe histograms built for $pe = 5$, $D = 0$ (Fig. 1a) and $pe = 5$ i $D = 5$ (Fig. 1b).

This analysis shows that there is a good agreement between the results of numerical approximations and corresponding histograms in all cases. This proves that an approximate function in (3) has been chosen correctly. Moreover, we performed the histogram approximation by classic method using the Pearson distribution [12]. The results obtained with Pearson distribution give markedly worse approximation than the results obtained with the function (3).

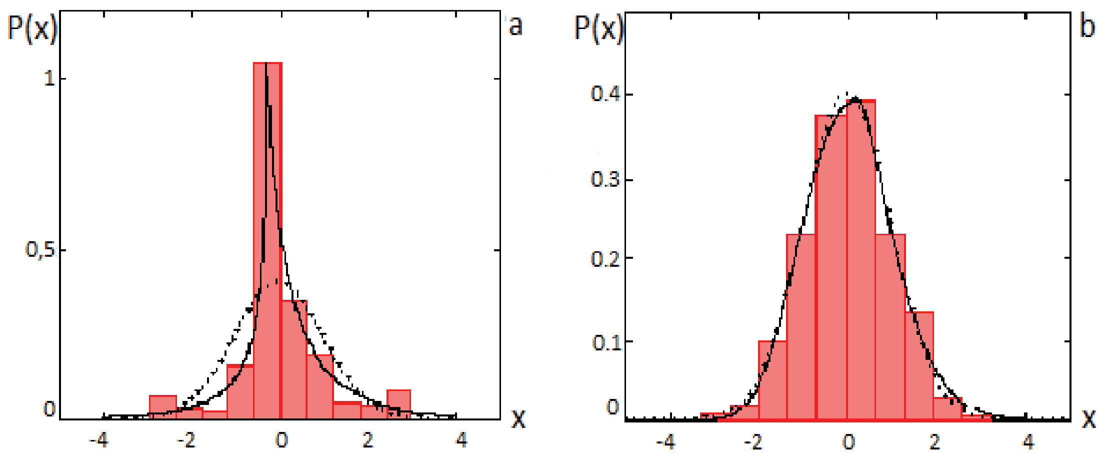

Figure 1 – Density function of the normalized probability distributions of expected earnings as the results of simulation time trends of company evolution in system (1), authoring.

Next, we performed a renormalization of the density function of probability distribution of expected revenue $P(x)$ per unit area under the curve in the form of

$$\widetilde{P}(x)=\frac{P(x)}{\int_a^b P(x)dx} \quad , \tag{4}$$

where a, b – corresponding integration limits, and then we calculated the cumulative function of probability distribution of expected revenue using the following formula:

$$F(x)=\int_a^x \widetilde{P}(x)dx \quad . \tag{5}$$

Fig.2 shows an example of functions $\widetilde{P}(x)$ (solid line) and $F(x)$ (points) for time series trend changes in expected revenue for $pe = 5$ and $D = 0,1$, μ - mode.

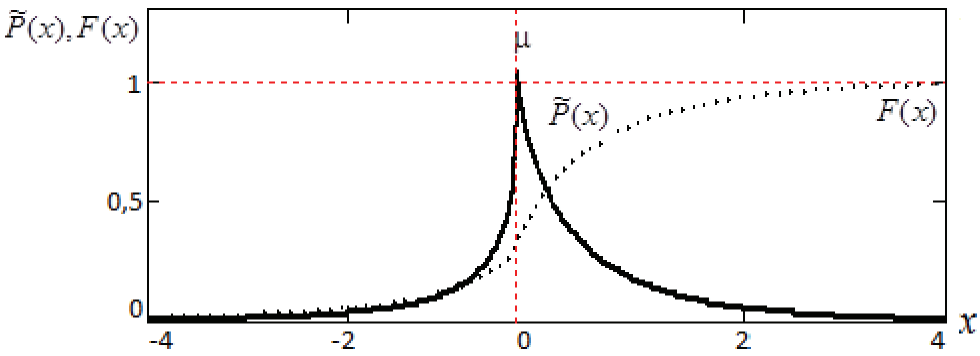

Figure 2 – Probability distribution of enterprise expected revenue I derived from computer simulation of time trends of the company evolution in according with model system (1), normalized per unit area (for $pe = 5$ and D=0,1), authoring.

Thus, the described method allows the adequate estimation of VaR value taking into account the asymmetry and fat tail risk curve in the real time without using historical data. This method based on an analysis of the distribution curve (4) and (5) obtained in simulation studies of time trends in the evolution of system (1), and it allows to perform evaluation of VaR values for potential losses in revenue (VaR_{-}) as well as the possible gain in revenue (VaR_{+}). In addition, in some cases quantitative comparison VaR_{-} and VaR_{+} could generate the additional information for managers to make the most optimal management decisions related to enterprise financial and economic activities.

According to mentioned above, the maximum possible value of expected cash loss with confiding probability level $(1-\alpha)$ at the same time horizon of the forecast $VaR_{-}^{(1-\alpha)}$ (see Fig.2) is defined as follows:

$$VaR_{-}^{(1-\alpha)} = F(\alpha)=\int_a^\alpha \widetilde{P}(x)dx \ , \tag{6}$$

where $F(\alpha)$ - quantile of level α for cumulative function of probability expected revenue according to (5).

Then, the value of the maximum possible expected earnings with confiding probability level $(1-\alpha)$ at the same time horizon of the forecast $VaR_{+}^{(1-\alpha)}$ (see Fig. 2) is equal to quantile of level $(1-\alpha)$ for cumulative function of probability expected revenue $F(1-\alpha)$ according to (5) and was calculated as follows:

$$VaR_{+}^{(1-\alpha)} = F(1-\alpha) = \int_{a}^{1-\alpha} \tilde{p}(x)dx \ . \qquad (7)$$

We also propose to use the semi-variance method [13] and the value of semi-standard deviation from mode (SSV_{-}) and (SSV_{+}) (as the quantitative risk measures possible losses and gain in revenue, accordingly) to evaluate absolute values of the risk of losses and earnings which resulted from the proper financial-economic activity of enterprise.

Table 1 – Parameters of the business risks evaluation by method (1) – (7) in the frameworks VaR methodology (in arbitrary units), authoring..

Deterministic factor p_e	Amplitude of Gaussian stochastic factors, D	Observation time t,	Semi-standard deviation from mode, SSV_+	Semi-standard deviation from mode SSV_-	Confiding probability level $(1-\alpha)$, %					
					99		97.5		95	
					$VaR_+^{(1-\alpha)}$	$/VaR_-^{(1-\alpha)}/$	$VaR_+^{(1-\alpha)}$	$/VaR_-^{(1-\alpha)}/$	$VaR_+^{(1-\alpha)}$	$/VaR_-^{(1-\alpha)}/$
5	0	0…50	1,03	1,08	4,60	4,55	3,30	3,05	2,41	2,04
	0,1	0…50	1,15	0,90	2,75	1,95	2,31	1,51	1,95	1,16
	5	0…50	0,89	1,12	2,80	2,20	2,27	1,89	1,85	1,61
12	0	0…150	0,88	1,19	5,17	6,24	3,70	4,33	2,66	2,92
	0,1	0…150	0,91	1,11	4,81	6,44	3,46	4,51	2,51	3,05
	5	0…150	1,11	0,91	2,17	2,50	1,87	2,08	1,60	1,73
37	0	0…150	1,08	0,93	2,21	1,99	1,90	1,71	1,62	1,46
	5	0…150	1.19	0,83	2,20	2,33	1,89	1,97	1,62	1,65

On the Table1 we can see the results of the business risks evaluation by proposed method (1) – (7) in the frameworks VaR methodology.

Conclusions. In the frameworks of the Value-at-Risk (VaR) methodology the novel method for business risks evaluation is proposed. This method can be applicable for the stable markets analysis as well as for description of nonlinear dynamics in economic processes including crisis-related economical changes. This method is based on computer simulation studies of the business evolution in according to the synergistic model of generalized Lorenz system. This approach allows performing the adequate estimation of VaR value taking into account the asymmetry and fat tail risk curve in the real time without using historical data. We can evaluate the parameters of business risks to predict not only possible losses, but also potential gain in the enterprise revenue with using proposed method.

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ABSTRACT

Danchuk V.D., Kozak L.S., Danchuk M.V. Estimation of business activity risks in the conditions of synergistic development for the economic. Economics and management on transport. – Kyiv. National Transport University. 2015. – Vol. 1.

In this paper is proposed an original method for business risks evaluation within the VaR methodology. This method may be applicable not only to describe stable markets, but also for nonlinear dynamic economic processes and crisis. This approach is based on computer simulation studies of a business evolution by synergetic model of Lorenz system. Presented method allows adequate estimation of VaR-value taking into account an asymmetry and fat tail risk curve in real time mode without using historical information.

KEYWORDS: VALUE-at-RISK METHODOLOGY, BUSINESS RISK, RISK CURVE, LORENZ SYNERGETIC MODEL.

РЕФЕРАТ

Данчук В.Д. Оцінка ризиків підприємницької діяльності в умовах синергетичного характеру розвитку економіки / В.Д. Данчук, Л.С. Козак, М.В. Данчук // Економіка та управління на транспорті. – К.: НТУ, 2015. – Вип. 1.

В рамках методології VaR запропоновано оригінальний метод оцінки параметрів підприємницьких ризиків, який може бути застосовним не тільки для опису стабільних ринків, але й

перебігу нелінійно динамічних (синергетичних) економічних процесів, кризових явищ. Цей метод базується на проведенні чисельних імітаційних досліджень еволюції підприємницької діяльності згідно синергетичної моделі системи Лоренца. Представлений метод дозволяє здійснювати адекватні оцінки величини VaR, семіквадратичних відхилень від моди з урахуванням асиметрії та ступеню “важкості” хвостів кривих ризику в режимі реального часу без використання історичних відомостей.

КЛЮЧОВІ СЛОВА: МЕТОДОЛОГІЯ VALUE-at-RISK, ПІДПРИЄМНИЦЬКИЙ РИЗИК, КРИВА РИЗИКУ, СИНЕРГЕТИЧНА МОДЕЛЬ ЛОРЕНЦА.

РЕФЕРАТ

Данчук В.Д. Оценка рисков предпринимательской деятельности в условиях синергетического характера развития экономики / В.Д. Данчук, Л.С. Козак, М.В. Данчук // Экономика и управление на транспорте. – К.: НТУ, 2015. – Вып. 1.

В рамках методологии VaR предложен оригинальный метод оценки предпринимательских рисков, который может быть применим не только для описания стабильных рынков, но и нелинейно динамических (синергетических) экономических процессов, кризисных явлений. Этот метод базируется на проведении численных имитационных исследований эволюции предпринимательской деятельности согласно синергетической модели системы Лоренца. Представленный метод позволяет осуществлять адекватные оценки величины VaR, семиквадратических отклонений от моды с учетом асимметрии и степени "тяжести" хвостов кривых риска в режиме реального времени без использования исторических сведений.

КЛЮЧЕВЫЕ СЛОВА: МЕТОЛОГИЯ VALUE-at-RISK, ПРЕДПРИНИМАТЕЛЬСКИЙ РИСК, КРИВАЯ РИСКА, СИНЕРГЕТИЧЕСКАЯ МОДЕЛЬ ЛОРЕНЦА.

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