

How To Measure Changes In The Risk States - Concept Of Definition

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ABSTRACT

Hypothesis, that variability in conditioning of long-term liabilities realization influences changes in risk states of the liabilities' service is verified in the paper. Consequently, a risk is treated as a random vector whose elements are controlled variables, representing the results of financial decisions. Statistical measures, such as probability of taking certain values from the controlled variables' variability intervals, expectation, variance and covariance of the vector's elements were applied to describe the risk states. The dynamics of risk states changes during the period of long-term liabilities repayment was described by the changes of risk measures relatively to a benchmark risk vector. Statistical properties of the latter were estimated on the basis of controlled variables values adopted for the enterprise's development plans.

Keywords: control variables, statistical risk model, risk measurement, risk states, dynamics of risk states

INTRODUCTION

Business organization management processes are based on its development plans. They contain two fundamental sets: a set of conditions determining realization of these plans and a set of objectives intended to make the vision of organization outlined in the plans come real. There are short-term goals inscribed in it – operational goals and strategic goals. To achieve these, continuous financial management needs to be ensured not only as regards the organization's on-going operation, but payment of long-term liabilities resulting from development projects as well.

The finance management relating to liability servicing is performed with numerous conditions accepted in planning and derived from the organization's immediate or more distant environment¹. In the course of realization of plans, differences between features of goals defined in the business organization's development plans and features of the goals that have already been achieved may emerge. This can be caused by the fact that people responsible for management concentrate on achievement of goals that have been planned, without taking into account changes of determinants accepted in the plans. A situation like this, unfavourable to the plans, is defined as operation in a risk environment. Such scenario outline for realization of plans enables one to put forward the main hypothesis of this paper, namely that variability of determinants for realization of long-term financial liabilities is the cause of changes in the liabilities servicing risk status.

Should this hypothesis prove to be true, it will become a matter of essence to answer, how variability of the risk status should be measured, how far these variations can influence the scenario of achieving the goals set in the development plans?

1. BUSINESS ORGANIZATION'S FINANCE MANAGEMENT

Plans of financial decisions assume consistency of financial incomings and liabilities due dates. It is also assumed that the volume of flows will not be lower than the amount of liability on the due date. Thus, financial

¹ Read more about the role of the organization's environmental determinants and their impacts in the conditions of major destabilization of the assumptions in: Zemke J., *Ryzyka zarządzania organizacją gospodarczą*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2009, pp. 36 – 37

management should constitute an ordered set of decisions that will guarantee fulfilment of all liabilities of the period, on the condition that a certain volume of funds is cumulated at certain points of time.

2. THE RISK OF FINANCIAL MANAGEMENT PROCESSES IN THE CONDITIONS OF LONG-TERM LIABILITIES SERVICING

The risk of long-term liabilities exposes the organization to adverse effects that can be caused by:

- a. inadequate financial resources available,
- b. inadequate debt structure,
- c. unfavourable tendency in the market interest rates.

The source of the business organization's financial resources – in both short-term and long-term prospect – can be found in its equity, in a loaned capital and in a combination of both: the equity and loaned capital². Regardless the source to be chosen, the capital is returned in the form of a dividend or paid back as instalments.

The processes of financial management are disturbed by uncertainty as regards the portion of funds cumulated in-between liabilities due dates which is necessary for the organization to finance its operations. This can translate into a temporary deficit of funds for payment of a complete instalment of the long-term liability in due time³.

The structure of debt is a result of the financial strategy. Its basis is formed by the rule of timing assets and liabilities in a manner, where “cash flows generated by assets are sufficient to service and pay back the liabilities at the end of these assets life cycle” [1, p. 305].

Changes of interest rates cause changes in financial costs of servicing both long-term and short-term liabilities. As a rule, financial costs are generated by the level of interest rates, while costs of short-term liabilities are lower than financial costs of liabilities servicing.

3. LONG-TERM LIABILITIES SERVICING RISK MODEL

There are the following significant controlled variables of financial decisions risk: the weighed average cost of capital, the average ROI, the period of return, the level of criterial rate and IRR.⁴

² There is no consent as to whether the capital structure is a significant determinant of the organization's market value. The hypothesis, that this is a neutral factor, indicates assets profitability, which determines the organization's value, but does not identify the streams of profits. Should one accept the alternative hypothesis, the growth of debt level resulting from increasing the loaned capital increases costs of debt servicing, thus reducing taxes. *Analiza ekonomiczna w przedsiębiorstwie*, Jerzemowska M. (ed.) Polskie Wydawnictwo Ekonomiczne Warszawa 2004, p. 155, also Davis E.W., Pointon J., *Finanse i firma*, Polskie Wydawnictwo Ekonomiczne Warszawa 1997, p. 223 and further.

³ Financial decisions will be to estimate the „long-term „base” which can be forecasted with a relative certainty and the changing short-term Leeds”, see: Myddelton D., *Rachunkowość i decyzje finansowe*, Polskie Wydawnictwo Ekonomiczne, Warszawa 1997, p. 381.

⁴ Weighed Average Cost of Capital - $WACC = \frac{K_w}{K_w + K_0} k_e + \frac{K_0}{K_w + K_0} k_d (1 - t_c)$, where: K_w – equity, K_0 – external capital,

k_e – cost of equity, k_d – cost of external capital, t_c – income tax rate; *Analiza ekonomiczna w przedsiębiorstwie*, Polskie Wydawnictwo Ekonomiczne, W – wa 2004, Jerzemowska M. (ed.) *op. cit.* p. 163.

The required ROI for a capital investment Project is defined as a criterial rate or a minimum efficiency rate; its level indicates the minimum required rate of return the organization has to generate within some definite time in order to fulfill its obligations towards institutions providing investment capital, Myddelton D., *Rachunkowość i decyzje inwestycyjne*, Polskie Wydawnictwo Ekonomiczne, Warszawa 1997, p. 306 and further.

Criterial rate – the level of lost opportunities is determined by the rate of discount used by the shareholders to estimate the future dividends (even if the dividend is not paid out); see: Myddelton D. *op. cit.* p. 369.

Let $Z = \{ Z_1, Z_2, Z_3, Z_4 \}$, where: $Z_1 = WACC$, $Z_2 = OZ$, $Z_3 = D$, $Z_4 = W_w$, stands for a set of controlled variables of the process of long-term liabilities servicing, where variable D means the difference between rate $D = S_K - S_{IRR}$, while $W_w = \frac{WS_p}{Z_b}$ is a measure of free cash to liabilities Z_b /long-term + current liabilities in total /, where: OZ - return period, S_K - rate of return, S_{IRR} - internal rate of return, W_{sp} - free cash volume.

The mathematical model of financial decisions' risk in probabilistic space (Ω, F, P) is represented by vector: $\{m(Z_1), m(Z_2), m(Z_3), m(Z_4)\}$, where vector components $m(Z_j)$ are random variables approximating controlled variables of financial desions risk⁵.

3.1 Measures of risk status

Let f stand for probability density function of random vector $X = (X_1, \dots, X_m)$ components. This assumption enables one to define a set of measures of the vector. Elements of this set are basic statistical measures: probability of controlled variables to take values from a certain interval, vector of components expected values, vector of component variances, matrix of risk vector components variances and covariances⁶.

3.2 Changes in risk status

Changes of financial management processes determinants cause changes of risk statistical measures: probability that risk vector components take values from certain intervals of variability $P(Z)$, components of expected values vector $E(Z)$, variances $Var(Z)$ and covariances $Cov(Z_i, Z_j)$ of risk vector components. The picture of changes, which is so essential in its informational aspect, determines the status of risk, making it possible to refer measures updated as a result of the monitoring process to measures of risk vector accepted as a standard⁷. Changes in determinants influence:

1. changes in controlled variables intervals of variability in subsequent points of time $(q, q + 1)$ / $q=1, 2, \dots, z$ /,

⁵ Construction of space and measures on this space elements are presented in [9, chapter.4]. Probabilistic space (Ω, F, P) is an ordered set of three elements: space of elementary events Ω , set F of all subsets of space Ω and measures $P: F \rightarrow R$.

⁶ Probability P that random components $\{X_i\}$, where $i = 1, 2, \dots, m$ of risk vector X take values from interval $[a_i, b_i]$:

$$P(a_1 \leq x_1 \leq b_1, \dots, a_m \leq x_m \leq b_m) = \int_{a_1}^{b_1} \dots \int_{a_m}^{b_m} f(x_1, \dots, x_m) dx_1, \dots, dx_m, \text{ vector of expected values of components } \{X_i\} \text{ of risk}$$

vector X : $E(X) = (E(X_1), \dots, E(X_m))$, where $E(X_i) = \int_{a_1}^{b_1} \dots \int_{a_{i-1}}^{b_{i-1}} \int_{a_{i+1}}^{b_{i+1}} \dots \int_{a_m}^{b_m} x_i f(x_1, \dots, x_m) dx_1, \dots, dx_{i-1} dx_{i+1}, \dots, dx_m,$

vector of components variances $\{X_i\}$: $Var(X) = (Var(X_1), \dots, Var(X_m))$,

$Var(X_i) = \int_{a_1}^{b_1} \dots \int_{a_{i-1}}^{b_{i-1}} \int_{a_{i+1}}^{b_{i+1}} \dots \int_{a_m}^{b_m} [x_i - E(X_i)]^2 f(x_1, \dots, x_m) dx_1, \dots, dx_{i-1} dx_{i+1}, \dots, dx_m,$ matrix of covariances

$Cov = [cov(X_i, X_j)]$, where $cov[X_i, X_j] = \int_{a_1}^{b_1} \dots \int_{a_m}^{b_m} [x_i - E(X_i)][x_j - E(X_j)] f(x_1, \dots, x_m) dx_1, \dots, dx_m.$

⁷ We are talking about the standard management system in the conditions of risk, where updated statistical measures of risk are compared with measures defined as model [9, chapter 9].

2. changes of distances between expected values vector $E(Z)$, vector of component variances $Var(Z)$ of risk vector, in subsequent points of time $(q, q + 1)$ / $q=1,2,\dots,z$ / respectively as referred to the model of vector $E^{(w)}(Z)$, $Var^{(w)}(Z)$ ⁸.

Changes of controlled variables variability intervals cause changes of risk measures. This is a consequence of accepting the assumption providing for the continuous distribution of the probability distribution density function and of the risk measures definitions presented in footnote 6.

Mahalanobis measure enables one to estimate changes of distances of expected values vectors and risk vector variances in relation to the position of these vectors' respective reference standards. This is an important information in the process of financial management in the conditions of risk and in monitoring changes of the risk status. Three situations may occur here:

1. Components of vectors $\{X_i^{(q)}\}$ for each i in the phase of monitoring effects of decisions q , have identical variances equalling 1, and they are not correlated – then matrix C is a unit matrix, points situated at identical distances a certain central point create a hypersphere in the m - dimensional space.
2. Components of vectors $(X_i^{(q)})$ for each q are not correlated, but have different variances σ_i^2 , where $i=1,2,\dots,m$. C is a diagonal matrix with diagonal σ_i^2 , points situated at identical distances from a certain central point create a hyperspherical ellipsoid in m dimensional space, and its axes are parallel to the coordinate system axis.
3. Components of vectors $\{X_i^{(q)}\}$ are correlated and have different variances, C is a matrix of variances and covariances, points situated at identical distances from a certain central point create a hyperspherical ellipsoid in m -dimensional space, which is turned through a certain angle relative to the coordinate system. The angle of rotation is determined by the matrix of own vectors of matrix C , while lengths of the axes of hyperspherical ellipsoid are equal to square roots of its own root.

The three cases presented above incline one toward an obvious conclusion, its contents suggesting that changes of parameters of the hyperspherical ellipsoid reflect changes of the risk status. How should one measure the changes then?

Let $X = (X_1, X_2, X_3)$ and $X^{(w)}$ i $X^{(q)}$ be respectively a risk vector reference standard and a risk vector in phase q of the process of monitoring the effects of risk that has been taken. The picture of risk status changes is determined by the position of vector $X^{(q)}$ in relation to the position of vector $X^{(w)}$.

⁸ Let $X = (X_1, X_2, \dots, X_m)$ and $Y = (Y_1, Y_2, \dots, Y_m)$ are random vectors from probabilistic space (Ω, F, P) and a certain symmetric, positively defined matrix C is given, Ω - a space of elementary events $m(Z_j)$, F - a set of all subsets of space Ω / σ - a field in this space, P - measure taking values from interval $[0, 1]$ /function $f(F) \rightarrow R$ /. The distance in space (Ω, F, P) in the sense of Mahalanobis is defined as: $d_M(X, Y) = \sqrt{(X - Y) C^{-1} (X - Y)^T}$, see: Mahalanobis P.C., *On the generalized distance in statistics. Proceedings at the National Institute of Science of India* 2, 1936, pp. 49 – 55. Model vector / $E^{(w)}, Var^{(w)}$ / is a vector the components of which have been estimated based on variability intervals of controlled variables of financial decisions risk assumed in the plan.

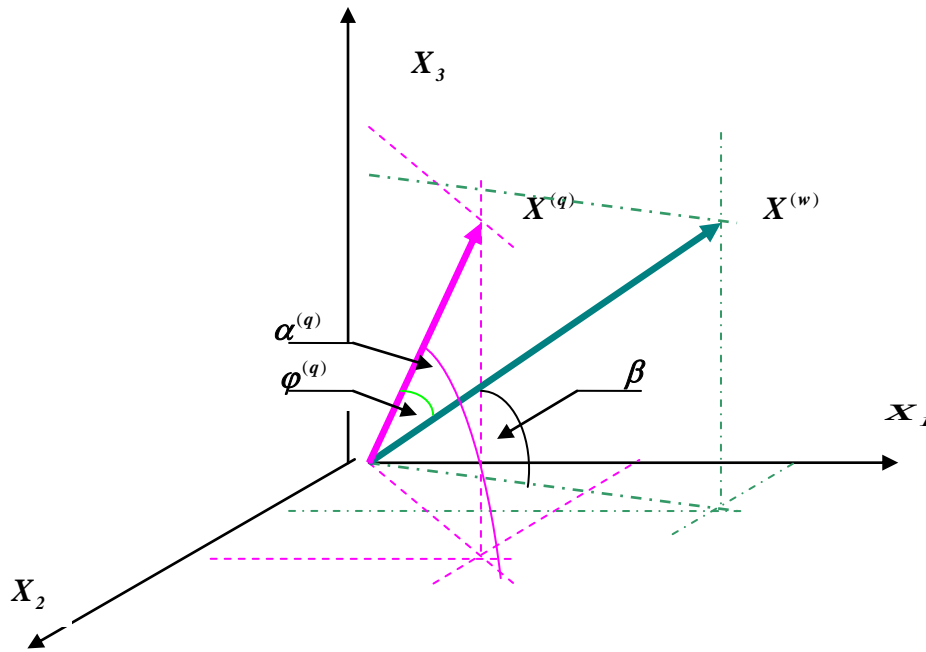


Fig. 1 Position of vectors $X^{(w)}$ and $X^{(q)}$ in the space of risk vectors

Changes of the risk status are measured by deviation of vector $X^{(q)}$ from the reference standard of vector $X^{(w)}$, where angle $\varphi^{(q)}$ is the measure of deviation. The deviation measured with $\varphi^{(q)}$, value is complemented by measures of inclination angles of vectors $X^{(w)}$ and $X^{(q)}$, β i $\alpha^{(q)}$ respectively. The measure of angle β constitutes a base parameter – invariable in all process of monitoring the changes of the risk status. This is a result of assumptions accepted for the business organization’s plans, defining the risk vector reference standard. Changes of the risk status in sequential phases q of the process of monitoring the effects of risk are therefore indicated by the difference of angles $\beta - \alpha^{(q)}$.

Identification of variability measures enables generalizations that are essential for the reasoning here. Let $\mathbf{rz}(X^{(w)})$ and $\mathbf{rz}(X^{(q)})$ stand for projections of vectors $X^{(w)}$ and $X^{(q)}$ respectively into the $m - 1$, -dimensional hyperspace, therefore:

$$\mathbf{rz}(X^{(w)}) = (X_1^{(w)}, \dots, X_{m-1}^{(w)}, \mathbf{0}), \quad \mathbf{rz}(X^{(q)}) = (X_1^{(q)}, \dots, X_{m-1}^{(q)}, \mathbf{0}).$$

If $\|X\| = \sqrt{\sum_{i=1}^m (X_i)^2}$, $\|\mathbf{rz}(X^{(w)})\| = \sqrt{\sum_{i=1}^m (X_i^{(w)})^2}$ and $\|\mathbf{rz}(X^{(q)})\| = \sqrt{\sum_{i=1}^m (X_i^{(q)})^2}$, stand for the module /length/ of vectors X , $\mathbf{rz}(X^{(w)})$ and $\mathbf{rz}(X^{(q)})$ respectively,

where: X_i , $X_i^{(w)}$, $X_i^{(q)}$ are i -th components of vectors X , $\mathbf{rz}(X^{(w)})$ and $\mathbf{rz}(X^{(q)})$, therefore:

$$\varphi = \arccos \left(\frac{\mathbf{X}^{(w)} \circ \mathbf{X}^{(q)}}{\|\mathbf{X}^{(w)}\| \cdot \|\mathbf{X}^{(q)}\|} \right),$$

$$\beta - \alpha^{(q)} = \arccos \left(\frac{\mathbf{X}^{(w)} \circ \mathbf{rz}(\mathbf{X}^{(w)})}{\|\mathbf{X}^{(w)}\| \cdot \|\mathbf{rz}(\mathbf{X}^{(w)})\|} \right) - \arccos \left(\frac{\mathbf{X}^{(q)} \circ \mathbf{rz}(\mathbf{X}^{(q)})}{\|\mathbf{X}^{(q)}\| \cdot \|\mathbf{rz}(\mathbf{X}^{(q)})\|} \right),$$

where: $\mathbf{X}^{(w)} \circ \mathbf{X}^{(q)}$ - scalar product of vectors $\mathbf{X}^{(w)}$ and $\mathbf{X}^{(q)}$.

A deeper picture of changes can be obtained as a result of comparing mutual positions of hyperspherical ellipsoids that are a picture of points of m -dimensional space situated at the same distance from the central point. Axes of ellipsoids are determined by characteristic roots λ_i of the matrix of variance and covariance C of risk components $\{X_i\}$, where $i = 1, 2, \dots, 3$, and precisely $\sqrt{\lambda_i}$. Assuming that components of risk vector X are correlated and their variances σ_i^2 are not identical, one should assume that changes of the risk status in sequential phases q of the risk effects measurement will be reflected by changes of the hyperspherical ellipsoid position. Position changes are related to the ellipsoid rotation relative to the coordinate system. The angle is determined by own vectors of the matrix of variance and covariance of C /the third case /.

Assumptions. Risk model $X = (X_1, X_2, \dots, X_m)$, matrix of variance covariance $C = [\text{cov}(X_i, X_j)]$, where $i, j = 1, 2, \dots, m$. Let $C_w = (W_1, W_2, \dots, W_m)$, be a matrix of own vectors of matrix C . Let us also assume that the condition $\sigma_1^2 = \sigma_2^2 = \dots = \sigma_m^2$ ⁹ does not occur. Besides, let λ_i are characteristic roots of matrix C .

Matrix $I = (I_1, I_2, \dots, I_m)$, is a basis for m -dimensional space, where for any $i = 1, 2, \dots, m$,

$$I_i = \begin{pmatrix} I_1 = 0 \\ \dots \\ I_{i-1} = 0 \\ I_i = 1 \\ I_{i+1} = 0 \\ \dots \\ I_m = 0 \end{pmatrix}.$$

Rotation of a combination of vectors (W_1, W_2, \dots, W_m) relative to the combination of vectors

of basis (I_1, I_2, \dots, I_m) is determined by combination $\Delta = (\Delta_1, \Delta_2, \dots, \Delta_m)$, where $\Delta_i = \arccos \left(\frac{W_i \circ I_i}{\|W_i\| \cdot \|I_i\|} \right)$, and lengths of the axis of hyperspherical ellipsoid equal $\sqrt{|\lambda_i|}$ for any $i = 1, 2, \dots, m$.

⁹ In case when variance of the risk vector components are taking identical values, the hyperspherical ellipsoid is a hyperspherical ball or a hyperspherical ellipsoid with axes parallel to the coordinate system axes.

Important informative contents as regards changes in the status of risk is provided by position changes of the hyperspherical ellipsoid which constitutes a spatial picture described by elements of matrix C relative to position of the hyperspherical ellipsoid related to the risk vector reference standard.

Let $C_w^{(q)} = (W_1^{(q)}, W_2^{(q)}, \dots, W_m^{(q)})$ stand for the own vector of the matrix of variance and covariance of risk vector X in phase q of risk monitoring, while $C_w^{(w)} = (W_1^{(w)}, W_2^{(w)}, \dots, W_m^{(w)})$ for the own vector of the matrix of variance and covariance of risk vector reference standard X . Changes of the status of risk understood as occurrence of effects of decisions differing from those that have been are measuring changes of the position of vectors $C_w^{(q)}$ and $C_w^{(w)}$, and the measure of changes is represented by deviations measured by changes of angles

$$\text{between components of both vectors } \Theta_i = \arccos \left(\frac{C_w^{(w)} \circ C_w^{(q)}}{\|C_w^{(w)}\| \cdot \|C_w^{(q)}\|} \right), \text{ for } i = 1, \dots, m.$$

The problem of the hyperspherical ellipsoid position variability is presented on the example of a three-dimensional space. Let $X^{(w)} = (X_1^{(w)}, X_2^{(w)}, X_3^{(w)})$ stand for a risk vector and $C_w^{(w)} = (C_1^{(w)}, C_2^{(w)}, C_3^{(w)})$ for a matrix of own vectors of the matrix of variance and covariance of the risk vector reference standard $X^{(w)}$, $C_w^{(q)} = (C_1^{(q)}, C_2^{(q)}, C_3^{(q)})$ a matrix of own vectors of the matrix of variance and covariance of vector $X^{(q)}$ in phase q of the risk effects monitoring. Changes of the risk status in phase q are measured by deviations of Θ_i , where $i = 1, 2, 3$.

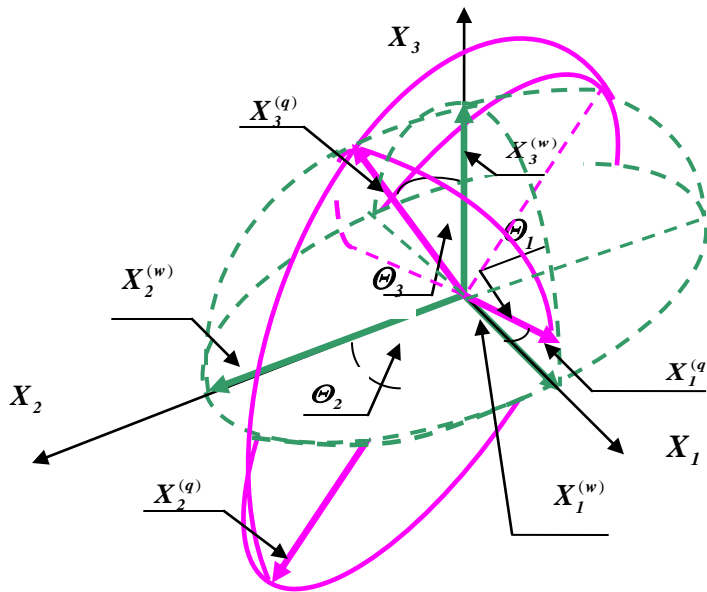


Fig. 2 Mutual position of two hyperspherical ellipsoids in the three-dimensional risk space

Besides rotation of the hyperspherical ellipsoid determined by $C_w^{(q)}$ with reference to the standard of hypersphere $C_w^{(w)}$, change of the ellipsoid axis length is another geometric picture of the changes in the status of

risk. By definition, the ordered sequence $\langle \gamma_1^{(q)}, \gamma_2^{(q)}, \gamma_3^{(q)} \rangle$, where $\gamma_i^{(q)} = \sqrt{|\lambda_i^{(q)}|}$ defines the axis length of hypersphere $C_w^{(q)}$, while sequence $\langle \gamma_1^{(w)}, \gamma_2^{(w)}, \gamma_3^{(w)} \rangle$, where $\gamma_i^{(w)} = \sqrt{|\lambda_i^{(w)}|}$ defines the axis length of hypersphere $C_w^{(w)}$; $i = 1, 2, 3$.

The estimated values of $\gamma_i^{(w)}$ and $\gamma_i^{(q)}$ can be identical for any i , or such $1 \leq i \leq 3$, exist, for which $\gamma_i^{(q)} \neq \gamma_i^{(w)}$. In the first case, hyperspherical ellipsoids defined by matrixes $C_w^{(w)}$ and $C_w^{(q)}$ do not translocate relative to each other, and are identical, i.e. $(C_w^{(w)} - C_w^{(q)}) = \emptyset$. This means that parameters of the risk status in phase q are identical with those accepted in the business organization’s plans. The second case, where differences are observed: $\gamma_i^{(q)} \neq \gamma_i^{(w)}$ /even for one of i values only/ means that there are such points $P(x_1, x_2, x_3)$ of the space of elementary events Ω , that belong to hypersphere $C_w^{(q)}$ and do not belong to hypersphere $C_w^{(w)}$, or points P belong to $C_w^{(w)}$, but do not belong to $C_w^{(q)}$. Thus, three situations are possible: 1. $(C_w^{(q)} - C_w^{(w)}) \neq \emptyset$, 2. $C_w^{(q)} \subset C_w^{(w)}$ and 3. $C_w^{(w)} \subset C_w^{(q)}$. Cases 1 and 2 are warning of undesirable changes in the status of risk in relation to the reference standard in phase q . Case 3 will mean that there is no risk to implementation of decisions as regards long-term liabilities servicing.

The reasoning presented on the example of a three-dimensional space, can be generalized in a natural manner onto any finite dimension of a space of elementary events Ω .

Recapitulation

The structure of the paper has been subordinated to the construction of a sequence of conclusions, so that it can be considered as a correct proof of the hypothesis put forward in the introductory paragraphs. Has this effort been successful?

There can be no doubt left when answering such a straightforward question. What remains therefore, is to prove that the reasoning presented in the study supports the hypothesis, unless this is impossible, which should be substantiated anyway. It may also happen that the result of the analysis neither supports the hypothesis, nor challenges it. So, what is the case here?

The title of the article refers the reader to the principles of financial management in the conditions of long-term liabilities servicing. As a matter of fact, the contents of the paper is omitting the decision-making process proper, focussing on the problem of monitoring changes of the risk status as regards financial decisions being made. Identification of risk status variability resulting from changes of planned conditions occurring in the process of making financial decisions is the focal point of the reasoning. This identification, so important for proving the hypothesis, enables one to build a mathematical model of risk and this is a significant stage of description of the risk status variability. Where does this conclusion come from?

The mathematical model of risk is a vector with random components that are identified with controlled variables of the management process in the area of financial decisions [9, p. 80 and further]. This identification enables one to define statistical measures of vector position changes in the probabilistic space “spread” over the space of elementary events constituting measurements of controlled variables.

Section three of the paper contains constructions of measures of the risk status changes. Changes of controlled variables in time are the foundations of this construction. The idea of construction is a result of the desire to cover the “materialized” attributes of variability: rotation, change of distance, change of risk dimension / vector, parameters of hyperspherical ellipsoids.

Controlled variables do not change for no reason – they are caused by variability of decision-making processes determinants and this proves the hypothesis that has been put forward for this work. It is supported by conclusions from the empirical study presented in the final section of the paper.

AUTHOR INFORMATION

Jerzy Zemke graduated at the Nicolaus Copernicus University in Toruń, Poland where he completed his Master Thesis in Mathematics. He obtained his Ph.D. degree in Economics at University of Gdansk, Poland. He lectures at the Faculty of Management of the University of Gdansk in mathematics, econometrics, operation research, and risk in economic organizations. During the period 2005 – 2008 his research interests focused on enterprises' management under risk and especially on formalization of the risk space definition, the risk itself and risk measurement methods. The results have been published in the monograph 'Risks in economic organization management' (edited by the University of Gdansk, April 2009). Additionally to his academic assignments, he collaborates with financial institutions, banks and insurance companies. He is a licensed insurance and reinsurance broker.

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