Viktoria Kharchuk, Mychajlo Yastrubskyj

Estimating innovation risk based on forecasting of its level

Annales Universitatis Mariae Curie-Skłodowska. Sectio H, Oeconomia 46/4, 319-330

2012

A N N A L E S
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. XLVI, 4 SECTIO H 2012

Department of Accounting and Analysis, Lvov Polytechnic National University
Department of Management and International Entrepreneurship, Lvov Polytechnic National University

VIKTORIA KHARCHUK, MYCHAJLO YASTRUBSKYJ

Estimating innovation risk based on forecasting of its level

Szacowanie ryzyka prowadzenia działalności innowacyjnej
na podstawie jego prognozowanego poziomu

Keywords: innovation risk, indicators-activators, forecast, alternative scenario

Słowa kluczowe: ryzyko innowacji, wskaźniki–aktywatory, prognozy, scenariusz alternatywny

Introduction

In modern economic theory and practical experience there are many approaches to understanding estimating risks connected with innovation activity.

The term risk broadly refers to situations where outcomes are uncertain. Risk often refers specifically to variability in outcomes around the expected value. In other cases, it refers to the expected value (e.g., the expected value of loses). Regardless of the specific notion of risk being used, risk could be costly[1]. The risk, that occurs in innovation activity on a machine-building enterprise has a specific characteristics requiring special analysis.

The main advantage of article is the development of formalized approach to making managerial decisions basing on the comparison of dynamic levels of innovation risk evaluation and managerial possible consequences.

As a result of consideration of scientific opinion regarding the interpretation of risk, distinguishing its basic properties, we offer proper treatment categories, namely as "the risk of innovation" – a notion of economic, which is a consequence of the

[1] S. E. Harrington, G. R. Niehaus, *Risk Management and Insurance*, McGraw-Hill/Irwin, 2004.

onset of unpredictable events and which results in deviation from the target. Such risk incurs additional costs or more opportunities in the design of innovation and its commercialization.

Innovative risk influences the process of development of science-intensive products. Therefore, in our opinion, is the logical implementation of the classification of risk for life-cycle stages of innovations, including: marketing risk – the risk of unwarranted targeting the development of innovations, the risk of the target segment, information risk, suppliers, risks basic research – the risk of inconsistency research delivered purposes, the risk of failure studies, the risk of human resources, risk of applied research – risk of changes in project objectives innovation, risk of selection, risk of non-compliance; R&D risks – technological risk, the risk of failure of agreements, the risk of delays the development of innovation, the risk of consumer, environmental risk.

Currently there is a wide range of methods for risk assessment[2] [st. 247]. Thus, in the Ukrainian scientific literature dealing with the problem of risk assessment there is a great variet of authors. They are Vitlinskyy V.V. Granaturov V.M., Kaminski A., Nakonechny S.I., S.M. Illyashenko[3] and others. The foreign researchers include I.T Balabanov, G. Kleiner, F.N Fomychev, E.A Utkin[4] and others. However, existing methods do not always focus on features such as type of business innovation and do not give specific practical recommendations for risk assessment.

Literature review

An analysis of scientific literature for the purpose of display and presentation of assessment results, allows the following generalization:

1) the numerical values for risk assessment are only informative when compared with selected range or recommended values. However, such results are inherent considerable subjectivity and complexity reflected in the values of the most essential factors forming and tracking relationships between them;
2) presenting the results of risk assessment through the use of its quality assessment or verbal expression (e.g., “high”, “medium”, “low”, “permissible”, “critical”, etc.) has a surface character and complicates adoption of timely and

[2] V. Lukyanov, T.V. Golovach, *Economic risk*: [Tutorial], K.: Akademvydav, 2007, 460 pp.

[3] V.V. Vitlinskyy, P. Vercheno, *Analysis, modeling and management of economic risk*: [Manual for self-study courses], MBK K, 2000, 299 pp. V. Granaturov, *The analysis of business risks: the problem definition, classification and quantification* [Monograph], Institute of Market Problems and Economic-Ecological Research of Ukraine, Odessa 2003, 164 pp. S.N. Ylyashenko, *Hozyaystvenыy risk and methods of measurement ego*: [Training manual], MSA: Dream-1, 1996, 102 pp.

[4] I.T. Balabanov, *Risk Management*: [Textbook. benefits. for universities], [in:] I.T. Balabanov, *Finances and Statistics*, Moscow 1996, 192 pp. G.B. Kleiner, *Enterprises in an unstable economic environment: risk, strategy, security*, [in:] R.M. Katchalov, V.L. Tambovtsev, *Economics*, Moscow 1997, 288 pp. E. Utkin, *Enterprise Risk Management*: [ucheb.-practical. allowance.], [in:] E. Utkin, D. Frolov, TEIS, Moscow 2003, 400 pp.

adequate management decisions. This is due to the lack of clear identification and definition of the root causes of the risk situation and the need for additional time to find causal relations between factors and, in fact, risk;
3) risk can only be calculated after the occurrence of risk events, which makes it harder to prevent or avoid the negative consequences of it;
4) determining the level of risk is justified when used for a calculation of an entity and at some point. This, however, makes it impossible to develop a unified method which is suitable for analyzing a large number of businesses and ensures an immediate reflection of changes of the primary sources of risk.

Therefore, solving this issue is subject to more thorough research focusing on the problem of integrated risk assessment of innovations based on consideration of broad variety of characteristics of the object of research.

As a result of investigations[5] of risk assessment of mechanical engineering innovations the defining characteristics of the studied kinds at risk were proposed. To ensure cross-cutting and integrated risk mapping innovations primary task is to review the most essential risky factors.

Methodology of evaluating innovation risk

In our view, a comprehensive evaluation metric involves the formation of risk of innovations, which is developing a method of measurement and scale formation. The latter will carry out evaluation of the object and its possible incorporation projected.

Thus, there is an objective necessity in the development of this method of risk assessment innovations, which provides a number of requirements, namely, [58.68]:

1) taking into account the nature of the object, i.e. the representation of risk dynamic phenomenon, which has a number of diverse characteristics;
2) showing not only the obvious relationship between the object of study and input parameters, but also identifying the impact of hidden (latent) factors;
3) reduction of the dimension of space with preservation while allowing the reflection of all the essential properties of the risk of innovation;
4) creating of a reliable information base for developing a set of measures to prevent the risk of arbitrary signs of innovation and respond to them.

The purpose of the proposed method[6] of risk assessment is to identify the innovation principal components (latent factors), that is, the aggregate risk characteristics determining innovation, and determination of the objective list of relevant (most sig-

[5] V.Y. Kharchuk, *Methodological approach to a comprehensive assessment of overall risk innovations, logistics*, Bulletin of the National University "Lviv Polytechnic", Lviv: Publishing Self "LP", No. 633, 2009, pp. 750–756.

[6] V.Y. Kharchuk, *Assessment of risk of innovations in the mechanical engineering*, [in:] O.Ye. Kuzmin, V.Y. Kharchuk, *Problems of Science*, No. 11, 2009, pp. 34–41. (A personal contribution by: the method of risk assessment).

nificant) indicators representing stimulators risk innovations. The developed method for assessment of innovation risk consists of seven stages (Fig. 1).

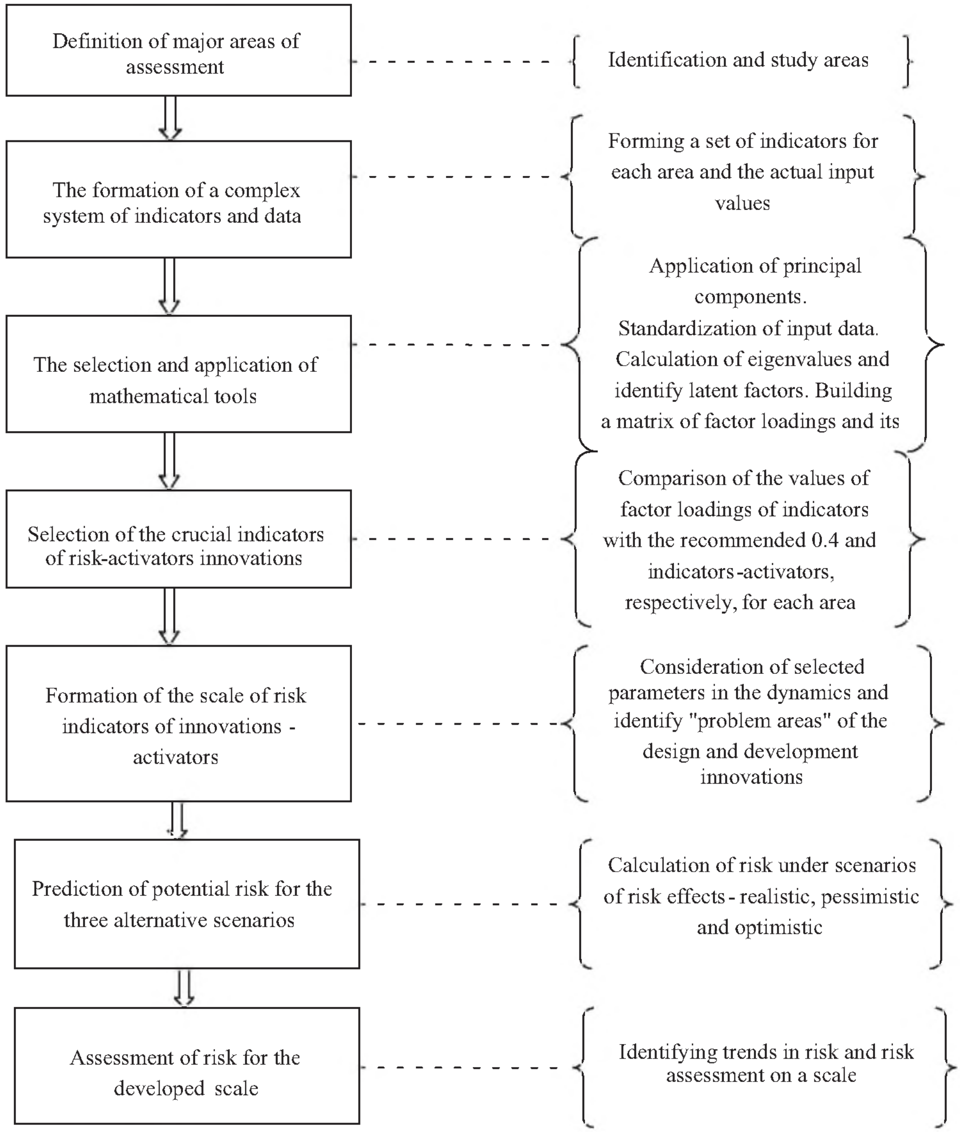

Fig. 1. The sequence of innovation risk assessment

Source: Own study.

The detailed description of stages is presented below.

The first stage is identifying key areas of evaluation. The risk is a multifaceted economic phenomenon that is caused by several factors and has a number of characteristics.

Foreign scholars often say: "what you get measured get done"[7].

Area of enterprise activity is a hypothetical category that aggregates properties of the phenomenon under research. Since the object of study is the risk of innovation, the enterprise sector covers a large set of factors caused not only by the influence of internal and external environments of the enterprise, but also specific features of the development process innovations. Due to the large set of input variables and a large number of complex relationships between them, singled out areas are the latent factors that indirectly affect the object of study. The latent factor is the area of enterprise which not only outlines sources of risk innovations, but also forms a picture of the development of risk events and helps release the most essential characteristics of risk innovations.

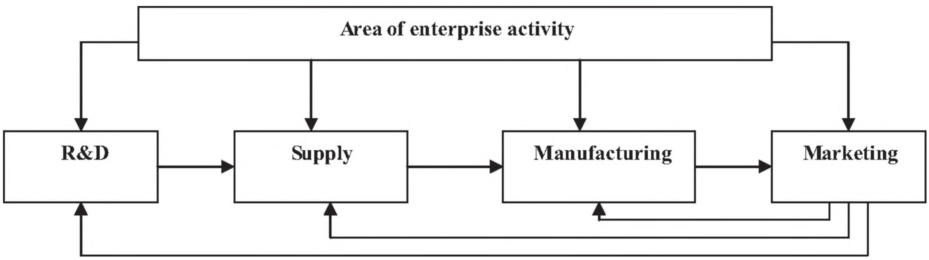

Fig. 2. The relations between areas of innovation and enterprise engineering

Source: Own study.

The second step includes the development of a comprehensive system of indicators of risk and innovation and forming an array of input data. This stage presents a summary of the essential characteristics and risks of innovation in a single system of absolute and relative indicators that simultaneously serve the basic elements of the assessment.

Thus, under a system of indicators of risk assessment innovations one should understand the complex absolute and relative characteristics that describe the qualitative and quantitative changes of the defining characteristics of this type of risk and point to the "trouble spots" of development and design innovation.

The third step is the selection and application of mathematical tools for risk assessment innovations.

The main problems for risk assessment of innovation engineering company are:

1) the difficulty to establish an adequate and sufficient risk assessment scorecard;

---

[7] *Enterprise Risk Management System: Beyond the Balanced Scorecard*, The Conference Board, Inc. NY 2005.

2) the complexity of selecting the most significant parameters and their definition of acceptable standards;
3) the complexity of the display ambiguous relationships (direct and latent) between indicators of risk.

The result of the previous stage is to present the defining characteristics of the risk of innovation as a complex system of indicators. In our case study and evaluation we suggested 56 indicators, while the situation is complicated by the presence of the output characteristics of different dimensions and orientations. The necessity of space dimensionality reduction emerges. Solving the problem of reducing the dimensionality of space and determining the selection of parameters could be achieved through application of principal component analysis.

The fourth stage of risk assessment innovation is the choice of activators of risk innovations. Activators are indicators, symptoms that reflect the most essential characteristics of the phenomenon and growth of which inevitably leads to risky events.

Each of the selected principal components is explained by a set of specific indicators. Therefore, the primary task is to select the most significant variables. For this purpose, the matrix of factor loadings, we chose the values of the parameters that exceed 0.4[8].

The fifth stage of the proposed method involves the formation of scale from a set of performance-activators, which represents the most essential characteristics for which it is expedient to analyze the studied risk. At this stage the review and analysis of the mentioned parameters in the dynamics and the formation of generalizations of set of trends and the development of the object in general are carried out.

Thus, the result of the conducted phase is the formation of complex metrics risk innovations, represented as a scale with a set of variables indicating the decomposition of the defining characteristics of the studied kinds at risk.

The sixth step is the definition of a key indicator for each of extracted areas. It should be noted that each of the five areas presented a set of defining parameters-activators studied type of risk, each of which has a different direction and trend of development. This feature greatly complicates the possibility of using formal forecasting methods, which involve extrapolation of past trends in terms of present and forming a single opinion on the subject of risk events for the whole sector in general. Solving this problem is to identify key indicator of each of the areas that makes the most significant impact on the overall trend of risk for each specific area. The key indicator should be determined by an expert in order to reflect the uniqueness of each case and to analyze the specifics of the particular company. However, this stage involves the formation of a set of predictive values of innovation risk activators in three sets.

[8] M. F. Sheier, *Assessing Coping Strategies: A Theoretically Based Approach*, "Journal of Personality and Social Psychology", 1989, Vol. 56, No. 2, 267–283.

N.K. Malhotra, *Marketing Research. Practical Guidance* [3rd ed.: Lane with the English], by Publishing House "Williams", Moscow 2002, pp. 960.

An important condition for ensuring the effectiveness and reliability of prediction is to determine the optimal time horizon, which is forecast. Given the peculiarity of the phenomenon and considerable variability environment functioning entities, prediction values of innovation risk activator should be made for three months. Hence, it is expedient to use several approaches to the prediction of levels of performance-activators risk innovations.

The first approach is to initially support the implementation of forecasting performance based on the trend of time series. Prediction of the key indicator is based on the forecasted values of supporting indicators into multifactor regression.

The study of the mentioned trends, anticipation of their future development and better management decisions should be based on three models with constant volatility environment, which provides consistency and reliability of conclusions.

Initial data for forecasting the values of auxiliary parameters-activators risk innovations are the data time series analyzed for twenty quarters. Calculation of predictive values is carried out by calculating the parameters of trend time series[9] and using of the software package Microsoft Excel:

$$y_t = b_0 + b_{1t}, \tag{1}$$

where t = 1, 2, 3 ... n – the time variable, b_0, b_1 – regression coefficients. Based on this calculation is the alignment of the dynamic range and predicting future development of the phenomenon.

As a result, data validation models for F-Fisher criterion can show that these equations are adequate.

For values of key parameters-activators for the next quarter there should be calculated predicted values to substitute in the equation of multifactor regression[10]:

$$Y = b_0 + b_1 k_1 + b_2 k_2 + b_3 k_3 ... + ... b_n k_{nt} + e_t, \tag{2}$$

where b – intercept, $b_1 – b_n$ – regression coefficients which indicate the partial weight of evidence a certain level, k_1, k_n – an independent variable, e – unobserved random variable.

---

[9] R.V. Feschur, A.F. Barvinsky, V.P. Kichor, *Statistics. The Theoretical Basis and Practical Sspects* [Teach. manual.], "Intelligence-West", Lviv 2001, pp. 276.

[10] R.V. Feschur, A.F. Barvinsky, V.P. Kichor, *Statistics. The theoretical basis and practical aspects* [Teach. manual.], "Intelligence-West", Lviv 2001, pp. 276.

Results: Forecasting of level performance-activators innovation risk and outlined problem areas for enterprise Public JSC "Drogobych truck crane plant"

In the context of our study k are performance indicators activating risk innovations that have been selected by the method of principal components, where k_2 is the share of defects, k_6 – score feasibility aging, k_{19} – rate of resource dependence, k_{20} – rate of energy dependence, k_{26} – the share of inactive equipment, k_{29} – rate of technical dependence, k_{32} – rate of production inefficiency, k_{34} – accident rate, k_{36} – rate of under-utilization of the results of research work, k_{38} – rate of season made commitments, k_{40} – rate of technology transfer, k_{43} – rate of lost customers, k_{46} – rate of financial failure of R&D, k_{47} – deviation from budget revenues on R&D, k_{51} – score extensive use of time, k_{55} – rate of infringement.

For Public JSC "Drogobych truck crane plant" model trend time series to support performance-activators and multifactor regression model according to all extracted areas are listed in Table 1.

Table 1. Model prediction of performance-activators risk of innovation for enterprise Public JSC "Drogobych truck crane plant"

№ п/п	Areas of enterprise	Trend models to predict the performance of auxiliary-activators and correlation coefficients	Multiple regression models to predict key performance indicators-activators and correlation coefficients
1	R&D area	$k_2 = 12.5 + 0.1t^*$, $R = 0.979$, $k_6 = 61.37 - 0.23\ t$, $R = 0.611$,	$k_3 = 5.1 + 0.82k_2 - 0.19k_6$, $R = 0.883$,
2	Area of supply	$k_{19} = 83.24 - 0.30t$, $R = 0.941$, $k_{20} = 34.29 - 0.77t$, $R = 0.913$,	$k_{21} = 55.83 - 0.232k_{19} + 0.25k_{20}$, $R = 0.583$,
3	Area of production	$k_{26} = 14.35 + 1.11t$, $R = 0.928$, $k_{29} = 26.06 - 0.58t$, $R = 0.660$, $k_{32} = 49.45 - 0.49t$, $R = 0.935$, $k_{34} = 14.8 - 0.07t$, $R = 0.824$,	$k_{25} = -4018.8 - 14.4k_{26} - 73.96k_{29} + 59.6k_{32} + 499.28k_{34}$, $R = 0.660$,
4	Area of marketing	$k_{36} = 21.22 - 0.33t$, $R = 0.940$, $k_{38} = 24.17 - 0.37t$, $R = 0.967$, $k_{40} = 25.19 - 0.54t$, $R = 0.887$, $k_{43} = 16.29 - 0.56t$, $R = 0.939$,	$k_{44} = -8.98 + 0.21k_{36} + 0.52k_{38} - 0.04k_{40} + 0.43k_{43}$, $R = 0.934$,
5	Socio-economic area	$k_{46} = 0.15 + 0.002t$, $R = 0.935$, $k_{47} = 573.87 - 7.51t$, $R = 0.415$, $k_{51} = 26.82 + 0.49t$, $R = 0.970$, $y_{21}(k_{55}) = 0.11 + 0.02t$, $R = 0.961$.	$k_{52} = 54.72 + 24.20k_{46} - 0.02k_{47} - 0.03k_{51} + 6.34k_{55}$, $R = 0.961$.

Notes: t – the time factor.

Calculated by authors from data reported in Public JSC "Drogobych truck crane plant".

The second approach involves the use of naïve-forecast[11]. This method is often used for short-term forecasting. It means that the predicted values are the same as in the last reporting period. Note that naïve-forecast is usually used in combination with other alternative methods for versatile picture of events. Estimated values of activators are given in Table 2.

The third approach in predicting the key and supporting indicators based on the assumption that the trend that existed in the last year analyzed, will be stored and will operate for the next period[12]. To determine the desired forecasted levels calculated average value of key indicators and auxiliary activator-risk innovation during the last year was analyzed. The data are substituted in multifactor regression model for each of the extracted areas (2). As a result, we obtain predicted values, reflecting the trend of recent periods. Estimated values obtained by this approach are presented in Table 2.

Table 2. Matrix-predictive values of activators for Public JSC "Drogobych truck crane plant"

Areas of enterprise	**Estimated value performance-activators**		
	Estimated value for a 1-t approach	Estimated values for 2-d approach	Estimated value for a 3-m approach
1	*2*	3	4
R&D area:			
1. *A key indicator* – share of innovations that have inadequate properties (k_{2}).	6.36	5	4.6
2. Share defects (k_{7}).	14.6	11	12.25
3. Index feasibility aging (k_{16}).	56.57	55	56.25
Area of supply:			
1. *A key indicator* – indicator of resource dependence (k_{21}).	60.42	45	43.2
2. Value of resource dependence (k_{19}).	76.96	75.2	76.50
3. Value of energy dependence (k_{20}).	18.16	20	20.25
Area of production:			
1. *A key indicator* – rate of disposal of fixed assets (k_{25}).	3465.74	3200	3383.374
2. The share of inactive equipment (k_{28}).	37.65	52	46.38
3. The technical dependence (k_{29}).	13.73	15	16.38
4. Value of production inefficiencies (k_{32}).	39.25	40	41.38
5. Rate of accident (k_{34}).	13.43	13.6	13.65

[11] S. Makridakis, 1976, *A Survey of Time Series*, "International Statistical Review", Vol. 44, No. 1, pp. 29–70. M.F. Sheier, *Assessing Coping Strategies: A Theoretically Based Approach*, "Journal of Personality and Social Psychology" 1989, Vol. 56, No. 2, pp. 267–283.

[12] N.K. Malhotra, *Marketing Research. Practical Guidance.* [3rd ed.: lane with English], by Publishing House "Williams", Moscow 2002, pp. 960.

Areas of enterprise	**Estimated value performance-activators**		
	Estimated value for a 1-t approach	Estimated values for 2-d approach	Estimated value for a 3-m approach
1	2	3	4
Area of marketing:			
1. *A key indicator* – share of returns processed results of intellectual activity (industrial designs, etc.) (k_{44}).	3.94	7.88	6.09
2. Under-utilization rate of scientific and research work (k_{37}).	14.26	15	15.4
3. Value of time commitments made (k_{38}).	16.33	22	18.25
4. Indicator of technology transfer (k_{40}).	13.79	15	15.63
5. Value of lost customers (k_{42}).	4.49	7	6.75
Socio-economic area:			
1. *A key indicator* – rate of aging of key personnel (k_{52}).	47	52.2	52.15
2. Indicator of financial failure of R&D (k_{46}).	0.21	0.2	0.2
3. Factor bias "plan – a fact" for the budget revenues on R&D (k_{47}).	731.67	450	447.7
4. Rate of extensive use of time (k_{51}).	37.11	50	43.25
5. Index of frequency of patent (k_{55}).	0.60	0.5	0.55

Note: Calculated from data reported by the authors of Public JSC "Drogobych truck crane plant".

It should be noted that the use of the above approaches to predict performance-activators risk innovations provides:

- incorporation of features of the company that was observed during the analyzed period (twenty quarters);
- display of specific last analyzed period;
- consideration of features of the machine-building enterprise in the last year analyzed;
- reflecting the influence of several parameters simultaneously.

As a result of this phase the matrix of forecasted values of key and supporting indicators under each of extracted areas of activities was formed (Table 2).

Combining selected statistical methods of forecasting and scenario approach has the following advantages:

- gives the possibility of predicting the situation in the future;
- develops of alternative risk events;
- provides for the general idea of the consequences that result from the onset of a script;
- increases reliability and accuracy of forecasting.

The seventh stage is designed for risk assessment scale development. At this stage, we obtained the risk of innovation, which is represented as a set of defining parameters-activators, representing each of extracted areas. Note that this set of parameters includes not only current but also predicted value. Thus, we obtain a dynamic evaluation, since it is possible to outline not only the current "problem sites" in the enterprise, and perspective – through the quarter.

Conclusions

As a result of the research the following conclusions can be drawn:
1) the proposed method provides reduction of dimensional space;
2) the method contributes to the full information content of input variables, while retaining all the properties and characteristics of the phenomenon;
3) the proposed method provides a determination of risk-activators, which represent the most significant of its characteristics;
4) the method is a reliable foundation for comprehensive risk assessment of innovation not only at a particular time, but also for its tracking in dynamic, so you can observe the development of the phenomenon;
5) the method is a reliable basis for the formation of adequate measures to prevent and respond to risk innovation.

Next steps: Research aimed at developing measures to prevent and respond to innovation risk.

Bibliography

1. Balabanov I.T. *Risk Management*, Finances and Statistics, Moscow 1996.
2. *Enterprise Risk Management System: Beyond the Balanced Scorecard*, The Conference Board, Inc. NY 2005.
3. Feschur R.V., Barvinsky A.F., Kichor V.P., *Statistics. The theoretical basis and practical*, "Intelligence-West", Lviv 2001.
4. Granaturov V., *The analysis of business risks: the problem definition, classification and quantification*, Institute of Market Problems and Economic-Ecological Research of Ukraine, Odessa 2003.
5. Harrington S.E., Niehaus G.R., *Risk management and insurance*, McGraw-Hill/Irwin, 2004.
6. Kharchuk V.Y., *Methodological approach to a comprehensive assessment of overall risk innovations, logistics*, Bulletin of the National University "Lviv Polytechnic", Publishing Self "LP", No. 633, Lviv 2009.
7. Kharchuk V.Y., Kuzmin O.Y., *Assessment of risk of innovations in the mechanical engineering*, Problems of Science, No. 11, 2009.
8. Kleiner G.B., Tambovtsev V.L., Katchalov R.M., *Enterprises in an Unstable Economic Environment: Risk, Strategy, Security*, Economics, Moscow 1997.
9. Lukyanov V., Golovach T.V., *Economic Risk: [Tutorial]*, K.: Akademvydav, 2007.
10. Makridakis S., *A Survey of Time Series*, "International Statistical Review", 1976, Vol. 44, No. 1, M.F. Sheier, *Assessing Coping Strategies: A Theoretically Based Approach*, "Journal of Personality and Social Psychology" 1989, Vol. 56, No. 2.

11. Malhotra N.K., *Marketing Research. Practical Guidance*, by Publishing House "Williams", Moscow 2002.
12. Sheier M.F., *Assessing Coping Strategies: A Theoretically Based Approach*, "Journal of Personality and Social Psychology" 1989, Vol. 56, No. 2.
13. Utkin E., Frolov D., *Enterprise Risk Management: [ucheb.-practical. allowance.]*, TEIS, Moscow 2003.
14. Vitlinskyy V.V., Vercheno P., *Analysis, Modeling and Management of Economic Risk: [manual for self-study courses]*, MBK. K., 2000.
15. Ylyashenko S.N., *Hozyaystvenыy risk and Methods of Measurement ego*, MSA: Dream-1, 1996.

Estimating innovation risk based on forecasting of its level

The article considers the issues of the necessity of the methodical tool kit formation that would provide objective preconditions for estimating innovation risk according to its possible future levels. Methods of estimating innovation risk are developed and presented using the study case of a machine-building enterprise

Szacowanie ryzyka prowadzenia działalności innowacyjnej na podstawie jego prognozowanego poziomu

W artykule rozważono problemy związane z koniecznością zastosowania metod, które zapewniłyby obiektywne warunki konieczne do oszacowania ryzyka prowadzenia działalności innowacyjnej na podstawie jego prognozowanego poziomu. Metody oceny tego ryzyka zostały przedstawione na przykładzie przedsiębiorstwa produkującego maszyny.