**Vadyba**
**Journal of Management**
**2017, № 1 (30)**
**ISSN 1648-7974**

# INNOVATIVE PROCESSES IN THE SHIPBUILDING AND SHIP REPAIR INDUSTRY IN LATVIA

**Balajar Aliev[1], Yuri Kochetkov[1, 2], Konstantin Nedelev[1]**
*[1]Baltic International Academy, Riga, [2]Liepaya University, Liepaya*

**Annotation**
Leading enterprises of the shipbuilding and ship repair industry in Latvia, for example, Riga and Liepaja shipyards tend to occupy a leading position in their niches in the European and world markets. This means first and foremost commissioning and practical application of innovations and scientific achievements, i.e., innovation. The objective of the research is to determine the characteristics of innovative processes of enterprises in the shipbuilding and ship repair industry in Latvia. The novelty of the research lies in the fact that for the first time the overall system analysis of innovation processes has been performed, taking into account the existing risks in the Latvian shipbuilding industry. The object of research is innovation processes in the shipbuilding and ship repair industry in Latvia. The goal of the research is to investigate the influence and relationships of the main factors of innovative processes in the shipbuilding and ship repair industry at the system level. Methods of research comprise the mathematical modelling of the system and the analysis of the interaction of factors on the basis of graph theory; balance sheet analysis as well as pulse analysis in the system. For the shipbuilding and ship repair industry in Latvia, the research proposes an interactive model of innovations taking into account risks. The model of the innovation process has mathematically been considered as a signed weighted digraph. The main groups of risks are distinguished as separate vertices of the digraph since they play an important role in the system of operative factors: risks and negative relations violate the balance of the system. In general, the weighted digraph analysed in the research is unbalanced. Therefore, any innovation process is not sufficiently stable mainly due to the effect of risks. This reflects the need for continuous risk identification and management at all stages of innovation. The results have demonstrated that the system of factors in the model of innovation process is absolutely and pulse unstable. This reflects the need for continuous strict control of the innovation process, in particular of existing and potential risks.
KEY WORDS: shipbuilding branch; mathematical modelling; innovation, graph theory.

## Introduction

To fulfil the mission related to an increase in the income and welfare of employees and shareholders, companies of the shipbuilding and ship repair industry in Latvia should develop a specific investment policy and formulate strategic objectives of performance (Kochetkov et al. 2016). First, it is necessary to identify and analyse the major factors of internal and external environment of enterprises that may have an impact on the nature of the investment policy. The main factors of the internal environment of enterprises are labour resources, availability of funds, organisational structure and marketing systems. Environmental factors include political, economic, market, social, etc. Then, connections and interaction are established between the parameters of internal environment of enterprises and the external positive and negative operating factors. This allows determining the most important directions of investment activity of enterprises and formulating strategic goals of enterprises consistent with their mission. Thus, the investment strategy of the industry is formed as a set of long-term areas of their development leading to the achievement of strategic goals.

Leading enterprises of the shipbuilding and ship repair industry in Latvia, for example, Riga and Liepaja shipyards tend to occupy a leading position in their niches in the European and world markets. This will enable enterprises to more effectively carry out their mission. To achieve such an ambitious strategic goal, industry enterprises should move to a higher level of economic growth based on knowledge, latest achievements of science and technology. This means first and foremost commissioning and practical application of innovations and scientific achievements, i.e., innovation. It is known that in the advanced industrialised countries up to 80–85 % GDP growth occurs through innovation.

The main added value in the new context of globalisation is now ensured by intellectual capital. The concept of innovation was introduced by Joseph Schumpeter in the 1930s. New methods, discoveries, inventions, i.e., the results of scientific and applied research and development are considered to be novelties. When novelties are transformed into new products sold on the market, they become innovations. Innovations establish real relationships between scientific and technological progress and business (Янсен 2002). Innovation is considered to be implemented if it has the scientific and technical novelty introduced in the production process, and the goods are sold on the market.

**Subject and relevance.** The development of the productive forces in modern conditions is manifested as the creation, development and use of new science-based technologies. Technology is the basic foundation of innovation. It is believed that scientific and technological progress is the process of introducing innovations and dissemination of advanced technologies and new products. According to the "new growth theory", the society development process is based on scientific discovery and innovation, while technology is the way of the implementation of innovations (Romer 1990). At the beginning of the 21st century, in the advanced economies the fifth technological wave is the dominant one, which is based on computerisation, electronic devices and biotechnologies. Technological stratification is a characteristic feature of the shipbuilding and ship repair industry in Latvia. The outdated technologies of the third and fourth waves – the use of electricity, automation, use of chemicals (often with large amounts of manual labour) – are combined with progressive technologies of the fifth wave. This leads to distortions in the production process and reduces the competitiveness of enterprises. Therefore, the area for innovation in the enterprises of the shipbuilding industry is quite extensive.

*The objective of the research* is to determine the characteristics of innovative processes of enterprises in the shipbuilding and ship repair industry in Latvia. *The novelty of the research* lies in the fact that for the first time the overall system analysis of innovation processes has been performed, taking into account the existing risks in the Latvian shipbuilding industry. *The object of research* is innovation processes in the shipbuilding and ship repair industry in Latvia. *The goal of the research* is to investigate the influence and relationships of the main factors (stages) of innovative processes in the shipbuilding and ship repair industry at the system level; to analyse the possible situations in innovation processes. *Methods of research* comprise the mathematical modelling of the system and the analysis of the interaction of factors on the basis of graph theory; balance sheet analysis as well as pulse analysis in the system.

## Analysis and computations

The innovation process can be represented as "the arena of innovations", where changes occur following certain trajectories (Янсен 2002) This process is subject to certain laws of development, which is an objective prerequisite for making strategic management decisions for the development of a particular enterprise. The main laws of innovative development are cyclical nature, lack of uniformity and certain stages of development, balance of component factors, etc. Innovation can be represented as a complex stochastic process of creation and dissemination of innovations. On the other hand, innovation can be considered to be an event, the occurrence of something new, as well as the process in which one innovation generates the other. Thus, technology improvement leads to the appearance of a new product that may require changes in business, the formation of new markets, etc. (Фостер 1987).

Innovation processes involve the complex of scientific, technological, financial, organisational and other activities. Until recently, a linear model of innovation was used, which consisted of a series of sequential stages:

- research and development;
- applied research;
- technological and development activities;
- development of innovations in production;
- industrial mass production;
- marketing and production distribution.

This model prevailed in many countries in the mid-20th century. The disadvantage of this model is a simple linear relationship between the constituent factors: the greater the volume of scientific and applied research, the more innovations in production. In practice, however, this model does not account for the influence of the market and the complexity of the relationship between science and industry. Therefore, now we use a more complex interactive non-linear model of the innovation process. For the shipbuilding and ship repair industry in Latvia, the research proposes an interactive model of innovations taking into account risks (Aliev et al. 2016) (Fig.1).

Characteristic features and advantages of the proposed model are as follows. Since the model is interactive, there are "loops" of feedback among the individual stages of the innovation process. The impact of the external environment is also taken into account. Implementation of various stages of the innovation process can take place in parallel, i.e., simultaneously, which allows for significant time saving and estimation of the effect of both internal business processes and external factors. An important advantage is the control of non-linear model. Managers, responsible for the innovation process, can make decisions at different stages of the innovation process, in response to changing consumer requirements. The results of the first stage of innovation (scientific and technological research) can successfully be considered and implemented at all stages of the process. When any useful innovations appear in the world's practice of shipbuilding and ship repair, in addition to the ones already being implemented, they can also be introduced in the innovation process.

The interactive model of the innovation process (Fig. 1), in terms of its analysis, is an open "soft" system consisting of several interconnected elements (Gigch 2010). The system has a certain structure and relations among the elements. It is known that a complex system often reacts to external and internal influences not as people expect (Форрестер 2003). For the analysis of the model of innovations as a complex system, a systematic cognitive approach has been used within the framework of the research. The soft system can adapt to changing conditions, and there an important role is played by a subjective factor – people (researchers, managers, technicians, etc.) (Checland 1988). The model of innovation process as a system demonstrated in Fig. 1 can be mathematically viewed as a signed directed weighted graph. In the research, the graph theory has been used, allowing one to perform an in-depth analysis of causal relationships in complex systems (Roberts 1986).

All elements of the system marked by numbers in Fig. 1 and the risks are the vertices of the signed directed weighted graph under analysis. The main risks are highlighted separately, as they play an important role in the balance of the system. There are a total of 11 vertices in the graph: $\mathbf{u}_1, \mathbf{u}_2, \ldots \mathbf{u}_{11}$, interconnected by arcs (arrows) in the system. The designations of vertices ($\mathbf{u}_i$) of the graph are demonstrated in brackets, Fig. 1. In the directed graph under consideration, four arcs are negative, the remaining ones are positive. The sign "**+**" is assigned to the arc ($\mathbf{u}_i$, $\mathbf{u}_j$) if an increase in $\mathbf{u}_i$ leads to an increase (strengthening) of $\mathbf{u}_j$, and a decrease in $\mathbf{u}_i$ leads to a decrease in $\mathbf{u}_j$. The sign "**-**" is assigned if an increase in $\mathbf{u}_i$ leads to a decrease in $\mathbf{u}_j$ and a decrease in $\mathbf{u}_i$ leads to an increase in $\mathbf{u}_j$. The sign "**+**" indicates a positive causal relationship, and the sign "**-**" indicates a negative relationship. Any graph is a pair (**U, A**), where **U** – a set of vertices, and **A** – set of arcs connecting vertices. In this directed graph (digraph), there are both contours (closed chains of the arcs of one direction) and semi-contours (a chain of arcs of different directions).

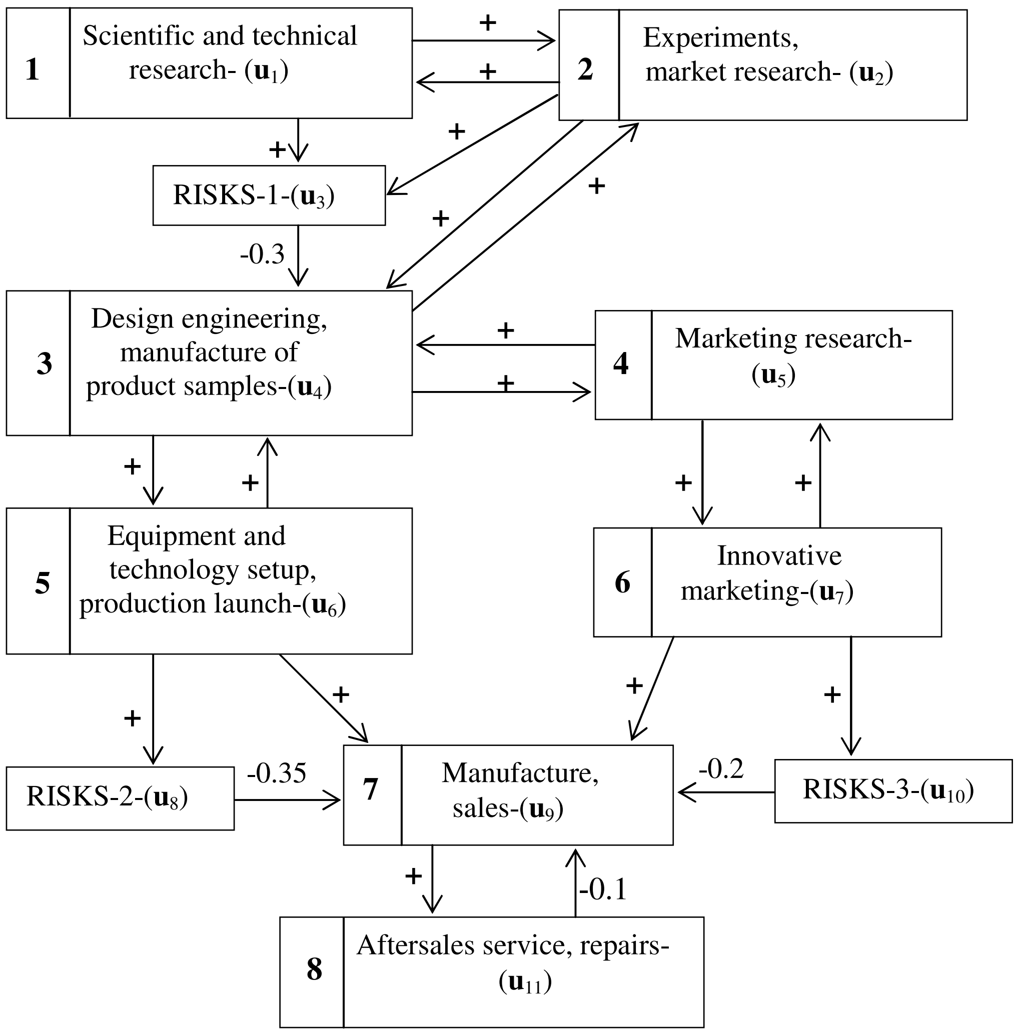


**Fig. 1.** Nonlinear interactive model of the innovation process in the shipbuilding and ship repair industry in Latvia.

Loops of feedback are contours. All of them, except one, are balanced – have positive feedback, and there are no negative arcs. For example, the contour $\mathbf{u}_4 - \mathbf{u}_5 - \mathbf{u}_4$: designing and manufacturing samples of the goods it is necessary to conduct simultaneously the relevant market research, identify consumer needs, evaluate the possible volume of sales. This naturally affects design engineering, as it is necessary to take into account the requirements of market. There is negative arc of feedback (-0.1) only between two vertices ($\mathbf{u}_9$ and $\mathbf{u}_{11}$). With a small probability (10 %), the vertex $\mathbf{u}_{11}$ can exert a negative impact on the process of production and sales ($\mathbf{u}_9$) due to detection, for example, of the hidden defect that should be removed, etc.

Risks (vertices $\mathbf{u}_3$, $\mathbf{u}_8$ and $\mathbf{u}_{10}$) can occur at different stages of the innovation process, and with a certain probability have a negative effect on the subsequent stages of innovations. Since negative arcs emanate from vertices of risks, the corresponding semi-contours will be unbalanced. Risks and negative relations play a negative role and upset the balance in the system. The greatest danger to the innovation process is demonstrated by RISKS-2 (vertex $\mathbf{u}_8$), which occur at an important stage of innovation in the process of adjustment of equipment, technologies and product launch (vertex $\mathbf{u}_6$). In the opinion of experts, these risks with a fairly high probability (0.35) can adversely affect the production and sales of products. The causes of RISKS-2 can be very different: technology errors, poor quality tools and supplies, lack of qualified workers, etc. If RISKS-2 are detected in the process of adjustment of equipment and technologies, they can be eliminated at once at the very same stage ($\mathbf{u}_6$). However, this is not always the case; negative consequences of risks can be identified in the production process, and even during the sales of products, which is undesirable. This requires changes in the production technology or equipment replacement.

Sufficiently large risks arise at the first two initial stages of the innovation process (vertices $\mathbf{u}_1$, $\mathbf{u}_2$). These risks with a probability of 0.3 can adversely affect the subsequent third stage of innovations – the vertex $\mathbf{u}_4$, when the design and manufacturing of samples of goods take place. Therefore, the contour $\mathbf{u}_1 - \mathbf{u}_3 - \mathbf{u}_4 - \mathbf{u}_2 - \mathbf{u}_1$ is unbalanced and contains one negative arc $\mathbf{u}_3 - \mathbf{u}_4$. The presence of unbalanced cycles in the system of signed digraph (contours and semi-contours) demonstrates that the weighted digraph is unbalanced. The imbalance of a digraph indicates that there are hidden problems in the system, which are mainly caused by the effects of various kinds of risks. Therefore, the system will not be stable enough, and various malfunctions can appear. It is virtually impossible to eliminate the causes of imbalance (risks) completely, but they need to be identified and controlled as far as possible.

In the stable functioning of the innovation process, an important role is played by marketing (vertices $\mathbf{u}_5$, $\mathbf{u}_7$). Conducting market research, search for potential buyers of new products already at the stage of designing and manufacturing of samples of goods ($\mathbf{u}_4$) are the key to business success in the context of fierce competition. Here, the presence of the feedback from the vertex $\mathbf{u}_5$ to the vertex $\mathbf{u}_4$ is of importance. At the designing stage, this allows taking into account the individual needs of customers, thereby improving the competitiveness of products on the markets. The introduction of novelties and innovations often requires the search for new customers and expanding sales markets. The process of innovative marketing can give rise to certain risks, the vertex $\mathbf{u}_{10}$. The risks are mainly associated with the modern features of the world economy and politics. Changes in the economic and political conditions in different regions of the world can lead to unpredictable situations, adversely affecting the sales of products. According to industry experts, the probability of the negative impact of these risks on the vertex $\mathbf{u}_9$ (production and sales of products) accounts for 20 %. These can be, for example, unforeseeable changes in the requirements for the characteristics of products, repudiation of the planned contracts, changes in the political situation in the country of the customer, etc.

The weighted digraph considered in the research has been tested for absolute and pulse stability. The lack of stability of the digraph means that the system described by it (innovation process) may exhibit and amplify the negative impact of any factor which, for example, may restrain innovations. To test the stability, the adjacency matrix of the weighted digraph has been analysed (see Fig. 2). Since the digraph is weighted, its adjacency matrix shows the negative probabilities of operating risks. The adjacency matrix takes the following form: A = ($\alpha_{ij}$), where

$$(\alpha_{ij}) = \begin{cases} +1, & \text{if the edge (i, j) is positive,} \\ -1, & \text{if the edge (i, j) is negative,} \\ 0, & \text{if the edge (i, j) is absent.} \end{cases}$$

$$A := \begin{pmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -0.3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.35 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.1 & 0 & 0 \end{pmatrix}$$

**Fig. 2.** The adjacency matrix of the weighted signed digraph corresponding to the model of the innovation process in the Latvian shipbuilding industry.

The characteristic polynomial of the adjacency matrix of the digraph A has the following form:

$$C_A(\lambda) = \det(A - \lambda E) = \alpha_{10} \cdot \lambda^{10} + \alpha_9 \cdot \lambda^9 + ... + \alpha_1 \cdot \lambda^1 + \alpha_0 \cdot \lambda^0,$$

where det – the determinant of the matrix;
E – the corresponding unit square matrix;
$\alpha_i$ – the coefficients of the characteristic polynomial at roots $\lambda_i$.

Parameters $\lambda_i$ are the roots and the eigenvalues of the matrix A only if they satisfy the equation:

$$C_A(\lambda) = \det(A - \lambda \cdot E) = 0.$$

Performing calculations, the following roots of characteristic polynomial that are the eigenvalues of the matrix A have been obtained:

-1.953; -1; -0.554; 1.861; 1; 0.646; 0; 0; -0.316i; 0.316i; 0.

It has been found out that there are eigenvalues of the adjacency matrix that exceed 1 in modulus. In this case, the signed digraph and the corresponding system of factors of the innovation process will be both absolutely (by value) and pulse unstable (Roberts 1986). Introduction of pulse into any vertex of the digraph (changing its value) in the future may cause the increasing pulses in other vertices and lead to negative consequences for the introduction of innovations, as well as innovation process may slow down or stop completely. The main reasons are risks and their negative effect resulting in the imbalance of the system as a whole. For example, in the market study (vertex $\mathbf{u}_2$) one may find that the new products will not have sufficient demand. The occurring risks ($\mathbf{u}_3$) can then lead to the rejection of further stages of this process and the given innovation as a whole.

To solve the problem of prediction of pulse propagation (any external influences) in a weighted digraph system, the theorems on the autonomous pulse processes in signed digraphs have been used in the research (Roberts 1986). Knowing the initial pulse being introduced to some vertex of the weighted digraph and its adjacency matrix A, it is possible to calculate the values of the pulses in other vertices at any time **t**. The time interval ($\mathbf{t_{i+1}}$ **-** $\mathbf{t_i}$) may be different, for example, one or two months, depending on different conditions at different enterprises. The pulse process, in which the i-th component of the vector **P**(0) defining an external pulse is equal to "1" and all other components are equal to zero, is called a simple pulse process with the initial vertex $\mathbf{u_i}$. Initial unit pulse introduced into the vertex $\mathbf{u_i}$ then propagates throughout the system over certain amount of time. For the stand-alone pulse process, the following formula is used in the weighted digraph:

$$\mathbf{P}(\mathbf{t}) = \mathbf{P}(0)*A^{\mathbf{t}},$$

where **P** (0)=(0,0, ... 1,0, ... 0) with "1" at the i-th place;
**P** (**t**) – the vector of pulses at time **t**.

To calculate the propagation of the pulse process in the weighted digraph with initial vertex $\mathbf{u_i}$, the following formulas are used:

$$V_j(t) = V_j(\text{ref.}) + \left\{\text{element } i,j \text{ in matrix } E + A + A^2 + A^3 + \ldots + A^t\right\},$$

where Vj(t) – the value of vertex $\mathbf{u_j}$ of the digraph at discrete points in time t = 0, 1, 2, ...,
E – the identity matrix.

The adjacency matrix A of the weighted digraph (Fig. 2) has been used as a reference. The predictive values of the vertices of the digraph are shown in Table 1 for different points in time, ranging from t = 1 to t = 7. Introducing a unit pulse to the vertex $\mathbf{u_1}$ (e.g., obtaining a positive result of scientific and technical research suitable for practical use), pulses gradually spread across the digraph system. As a result, at t = 4 pulses reach the vertex $\mathbf{u_9}$, and the processes of industrial production and distribution of new products are initiated. At t = 5, pulses reach the vertices $\mathbf{u_{10}}$, $\mathbf{u_{11}}$ and there may be a negative effect of the risks of the third stage, as well as requests for service and warranty repairs from customers of new products.

**Table 1.** Forecast values of digraph vertices in the standalone pulse process for different points in time. t = 1, 2, ... 7 – points in time.

| t | The vertices of the signed digraph | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\mathbf{u_1}$ | $\mathbf{u_2}$ | $\mathbf{u_3}$ | $\mathbf{u_4}$ | $\mathbf{u_5}$ | $\mathbf{u_6}$ | $\mathbf{u_7}$ | $\mathbf{u_8}$ | $\mathbf{u_9}$ | $\mathbf{u_{10}}$ | $\mathbf{u_{11}}$ |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 2 | 1 | 2 | 0.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 2 | 2.7 | 3 | 0.4 | 0.7 | 0.7 | 0 | 0 | 0 | 0 | 0 |
| 4 | 3.7 | 2.4 | 4.7 | 3.2 | 0.4 | 0.4 | 0.7 | 0.7 | 0.7 | 0 | 0 |
| 5 | 3.4 | 6.9 | 6.1 | 1.79 | 3.9 | 3.2 | 0.4 | 0.4 | 0.86 | 0.7 | 0.7 |
| 6 | 7.9 | 5.19 | 10.3 | 12.17 | 2.19 | 1.79 | 3.9 | 3.2 | 3.25 | 0.4 | 0.855 |
| 7 | 6.19 | 20.07 | 13.09 | 6.08 | 16.07 | 12.17 | 2.19 | 1.79 | 4.404 | 3.9 | 3.25 |

I
n different vertices of the digraph, a rise (increase) in pulses occurs differently. At t = 7, the highest value is achieved by pulses at vertices $\mathbf{u_2}$ and $\mathbf{u_5}$: when tests of new product samples are performed, the research of possible markets immediately begins and market research for future product sales is initiated. This increases the risk of the first stage of the innovation process, the vertex $\mathbf{u_3}$. At the same time, the preparatory process for the production of new products may begin, technology is developed, and devices, tools, etc. are designed (the vertex $\mathbf{u_6}$). Scientific and technical research also continues; the pulses grow at the vertex $\mathbf{u_1}$. When the production and distribution of new products are implemented (the vertex $\mathbf{u_9}$), it is also required to carry out maintenance of sold products and, if necessary, correct defects and faults ($\mathbf{u_{11}}$). Risks of the second ($\mathbf{u_8}$) and third ($\mathbf{u_{10}}$) stages are also increasing and may adversely affect the final stages of the innovation process. Apart from the main risks taken into account in the model, other risks may appear and pose an adverse effect virtually at any stage of innovation. Therefore, the system of continuous identification, evaluation, monitoring and control of risks should be developed. Final decisions on risk management and mitigation should be made by senior management of enterprises.

## Conclusions

To achieve a leading position in the global markets, companies of shipbuilding and repair industry in Latvia should move to a higher level of economic growth corresponding to the fifth technological wave, which is based on intellectual capital and innovation. Innovations can be considered as a complex stochastic process of creation and diffusion of innovations. The research proposes a non-linear interactive model of the innovation process in the Latvian shipbuilding and ship repair industry, taking into account the adverse impact of risks. This model adequately takes into account the impact of all major factors and their interaction in the innovation process.

For the analysis of the model of innovation process as a complex system, a cognitive systems approach has been used. The model of the innovation process has mathematically been considered as a signed weighted digraph. The main groups of risks are distinguished as separate vertices of the digraph since they play an important role in the system of operative factors: risks and negative relations violate the balance of the system. The greatest negative impact on the innovation process can be posed by risks related to launching of new products into production. In general, the weighted digraph analysed in the research is unbalanced. Therefore, any innovation process is not sufficiently stable mainly due to the effect of risks. This reflects the need for continuous risk identification and management at all stages of innovation. An important role in the stability of the innovation process belongs to marketing, timely search for new sales markets.

To test for absolute and pulse stability of the model of innovation process, the analysis of the adjacency matrix of the corresponding signed weighted digraph has been performed. The results have demonstrated that the system of factors in the model of innovation process is absolutely and pulse unstable. Due to the risks in the system, the innovation process can be slowed down or even stopped. In general, the process of pulse propagation in the innovation model is quite uneven and unstable: values of pulses in the digraph vertices at subsequent time periods can be reduced. This reflects the need for continuous strict control of the innovation process, in particular of existing and potential risks.

## References

Aliev, B., Kochetkov, Yu. (2016). Risks in the shipbuilding and ship repair industry in Latvia. *Journal of Management*, vol. 28(1), 9 – 13.

Checland, P.B. (1988). Soft systems methodology: an overview. *Journal of Applied System Analysis*, vol. 15.

Gigch, J. P. (2010). *Applied General Systems Theory,* 439p. California State University. Harper Collins Publishers, USA.

Kochetkov, Yu., Aliev, B. (2016). Evaluating the strategic directions of innovative development of the shipbuilding industry in Latvia. *Computer Modelling and New Technologies*, vol. 20(1), 27 – 32.

Roberts, F.S. (1986). *Discrete Mathematical Models, with Application to Social, Biological and Environmental Problems,* 496p. Prentice-Hall, USA. Russian translation, Nauka, Moscow.

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy*, University of Chicago Press, vol. 98(5), 71 – 102.

Форрестер, Д. (2003). *Мировая динамика,* 384с. Издательство «Terra F.». Москва. [in Russian].

Фостер, Р. (1987). *Обновление производства: атакующие выигрывают.* Издательство «Прогресс». Москва. [in Russian].

Янсен, Ф. (2002). *Эпоха инноваций.* Издательство «ИНФРА-М». Москва. [in Russian].

**RECEIVED: 16 January 2017** **ACCEPTED: 10 May 2017**

**Balajar Aliev** is Master of Business Administration (MBA), Doctoral student in Baltic International Academy (Latvia). University study: Baltic International Academy (2011-2013), MBA. Balajar Aliev is President of Administration of Shipbuilding company in Liepaya (Latvia). Publications: several. Scientific interests are regional economy and development, competitiveness and innovation issue, analysis of systems. Address: 4 Lomonosova St., LV-1019, Riga, Latvia. Phone: +37129623317, Fax: +37163480858, e-mail: boris@albjs.lv

**Yuri A. Kochetkov** is Dr.sc.ing., Professor. University study: Riga Polytechnic Institute (1966 – 1971), mechanical engineer. Post-graduation: Moscow Institute of Instrumental Equipment (1977 – 1981), Candidate of technical sciences (1982). 1993 – Dr. sc. ing. ( Latvia). Yuri Kochetkov is Professor of Econometric in Baltic International Academy (Latvia). Also he is scientist in Institute of Mathematical Sciences and Information Technologies of Liepaya University. Publications: 76 scientific papers and 3 patents, teaching aids and synopses – 6. Current research interests: social economical statistics, mathematical modelling and analysis of systems. Yuri Kochetkov is a member of Latvian Association of Statistics. Address: 4 Lomonosova St., LV-1019, Riga, Latvia. Phone: +37163480858, Fax: +37163480858, e-mail: Jurijs.Kocetkovs@rtu.lv

**Konstantin Nedelev** is Professional Bachelorhood of Business Administration (2016), Master degree student. Scientific interests are regional economy, competitiveness and innovations in the conditions of globalization. Address: 4 Lomonosova St., LV-1019, Riga, Latvia. Phone: +37129595920, Fax: +37163480858, e-mail: elektrika88@gmail.com