Ihor V. Kryvovyazyuk[1], Yulija V. Volynchuk[2], Iryna M. Pushkarchuk[3]

METHODOLOGICAL APPROACH TO THE EFFICIENCY EVALUATION OF INNOVATIVE PROCESSES IN LOGISTICAL ACTIVITY OF ENTERPRISES

The paper presents a pioneering approach to assessing the effectiveness of innovation processes in logistics. Indicators and the procedure of evaluating the efficiency of innovation processes in enterprise logistic activity are described. Possibilities of applying this approach are suggested.

Keywords: *efficiency evaluation; logistics; innovation process.*

Ігор В. Кривов'язюк, Юлія В. Волинчук, Ірина М. Пушкарчук

МЕТОДОЛОГІЧНИЙ ПІДХІД ДО ОЦІНЮВАННЯ ЕФЕКТИВНОСТІ ІННОВАЦІЙНИХ ПРОЦЕСІВ В ЛОГІСТИЧНІЙ ДІЯЛЬНОСТІ ПІДПРИЄМСТВ

У статті розкрито новаторський підхід до оцінювання ефективності інноваційних процесів у логістиці. Виділено показники та розкрито порядок оцінювання ефективності інноваційних процесів в логістичній діяльності підприємств. Запропоновано можливості застосування даного підходу.

Ключові слова: *оцінювання ефективності; логістика; інноваційний процес.*
Форм. 15. Рис. 1. Табл. 1. Літ. 11.

Игорь В. Кривовязюк, Юлия В. Волынчук, Ирина Н. Пушкарчук

МЕТОДОЛОГИЧЕСКИЙ ПОДХОД К ОЦЕНКЕ ЭФФЕКТИВНОСТИ ИННОВАЦИОННЫХ ПРОЦЕССОВ В ЛОГИСТИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ ПРЕДПРИЯТИЙ

В статье раскрыт новаторский подход к оценке эффективности инновационных процессов в логистике. Выделены показатели и раскрыт порядок оценки эффективности инновационных процессов в логистической деятельности предприятий. Предложены возможности для применения данного подхода.

Ключевые слова: *оценка эффективности; логистика; инновационный процесс.*

Introduction. Logistics is currently the most widely used instrument of cost optimization at enterprises that under constant exacerbations of economic relations and deepening crisis plays an important role in shaping the opportunities for increasing profitability from economic activity. Innovative activity that has no proper justification and qualified management could become a threat to enterprise stability by disrupting the sustainability of its logistic flows. Hence, the task of maintaining an acceptable level of stability while implementing projects, launching new and modernizing older products in manufacturing, accompanied by the change of material, information and financial flows is actual for any company. Solution of this problem requires using an innovative approach to developing economic and mathematical models for assessment and maintenance of proper efficiency of logistic activity of enterprises during the period of creation and implementation of innovations.

Recent research and publications analysis. Solving the problem of evaluating the effectiveness of innovative processes in enterprise logistics has not yet found necessary

[1] Lutsk National Technical University, Ukraine.
[2] Lutsk National Technical University, Ukraine.
[3] Lutsk National Technical University, Ukraine.

reflection in the works of both Ukrainian and foreign scientists. However, in a number of studies partial solutions to the problem were found, in particular, in (Amit et al., 2012). This study on supply chain strategy depicts how enterprises manage supply chain operations and evaluate the impact of operations on customer perception. C. Gonzalez and A. Carlos (2014) presented the methodology, design and results of the logistics management information system implementation supporting supply chain management decision-making. In (Raja, 2009) the model of integrated decision support system is based on output data of corporate logistics, that produces cement, with multiple distribution channels. Estimation of efficiency has found its solution during the implementation of enterprise's logistic strategies in the works of S. Srivastava (2013) and also I. Krivovyazyuk and Y. Kulik (2013), R. Richey et al. (2013).

Unresolved issues. Significant scatteredness of scientists' views on logistics management, assessing the efficiency of its implementation during the implementation of innovations causes the fundamental need for the formation of a methodical approach to solving the totality of problems accompanying the studied processes.

The research purpose is to present the methodical approach to the efficiency evaluation of innovation processes in enterprise logistics.

The target audience, i.e. users of the proposed methodology may be executives in logistic services and divisions as well as other structural subdivisions in particular, supply, production support, distribution, stock management, transportation, storage. It can also be useful for the highest level of enterprise management while establishing future development targets. At the same time it can be used by consulting organizations while delivering the level of usefulness of the used methods of logistics processes management to potential clients including investors or other stakeholders.

Key research findings. The development of innovation in logistics in the last decade, as international experience shows, characterizes (Little, 2007): gradual transfer of responsibility for innovation from the linear to top managers; change in priorities of optimizing logistic costs during the formation of added value and innovation, aimed to satisfy customers needs; the use of adaptive and flexible logistic systems and supply chains; understanding that clients and other participants of supply chains are the main "customers" encouraging companies to introduce innovations; attraction of clients and participants of supply chains at the early stages of innovation development.

So, the result of innovative processes in logistics is a logistic product, which is characterized by certain properties and constituting usefulness for clients and the enterprise it self.

In our opinion, the integral index of innovations effectiveness (E_{log}) in logistics must cover all functional subsystems of logistics (supply, production support, sales) and crosscutting logistic functions (stock management, transportation, storage etc.).

In turn, partial indicators of innovative processes effectiveness depend on the values of specific indicators that define, characterize and affect the effectiveness of supply, production, distribution, transportation and storage at the enterprise. Their list is presented in Table 1.

Calculation of the generalizing index will be determined by the effectiveness of individual components of logistic activity (using the methodology of (Tkachova, 2011)):

Table 1. **Indicators for evaluating the effectiveness of innovative processes in logistic activity of enterprises,** *developed by the authors*

Functional subsystems and key logistic functions	*Indicators for calculation*
Functional subsystem of supply	- the share of expenses on debt capital to finance the acquisition of material resources/fixed assets for manufacturing of innovative products in the total volume of debt capital; - the share of expenses on setting contracts on the supply of material resources for innovative manufacturing in the total expenses on the storage subsystem; - the coefficient of stocks supply for innovative manufacturing (the ratio of actually received stocks to contractual stocks); - the coefficient of turnover ratio of stocks in innovative production (the cost of sold innovative production/average balance of circulating assets invested in innovative production)
Functional subsystem of production support	- the coefficient of production program's fulfillment in manufacturing of innovative products; - the coefficient of provision with necessary stocks of innovative products manufacturing; - the coefficient of processes automatization in manufacturing of innovative products; - the coefficient of the production capacity of the enterprise in innovative manufacturing; - the share of productive expenses in the value of finished innovative products; - the share of lost/damaged material resources during their reception, accommodation, storage and delivering to manufacturing
Functional subsystem of distribution	- the index of dynamics of innovative products sales (growth); - the coefficient of executed orders for innovative products; - the coefficient of forecasting accuracy on the demand for innovative products; - the level of logistical service during the implementation of innovative products (the ratio of the number of satisfied final and interim consumers to the total number of transactions); - the share of expenses on the delivery of final innovative products in the cost of delivery of the total products of enterprise
Stock management	- the share of returns of low quality innovative production (the ratio of cost volume of low quality innovative product returned to the enterprise to the total sale volume of innovative product); - maneuverability of capital invested in innovative production (the ratio of these stocks to the value of net current assets of the enterprise); - the coefficient of providing stocks with working capital (reverse to maneuverability); - the coefficient of accumulation (or stock structure) – shows the ratio of industrial stocks total and volumes of unfinished production of innovative production to the sum of finished innovative production and goods
Transportation	- the coefficient of supply reliability of innovative production (the ratio of timely and fully fulfilled supplies to their total number); - the quality level of transport documentation during the shipment of innovative production; - the degree of cargo safety (of innovative product) during transportation; - the share of transport costs in innovative production costs
Storage (including cargo-recycling)	- utilization rate of warehouse space for innovative production (the ratio of storage space occupied by innovative production to the total area of warehouses); - the efficiency coefficient of storage system's response to the standard order (the maximum reaction time – 24 hours); - the average speed of vehicle service for incoming/outgoing material flow (the maximum time of loading or unloading – 24 hours); - the share of expenses on warehouse storage of raw materials and materials in the cost of finished innovative production; - the share of volumes of cargo-recycling of innovative production in the total volume of cargo-recycling of cargoes

$$E_{\log} = f(E_{Sup}, E_{\Pr od}, E_{Distr}, E_{SM}, E_{Tr}, E_{Stor}), \tag{1}$$

where E_{log} – the generalizing index of innovative processes effectiveness in enterprise logistics; E_{Sup}, E_{Prod}, E_{Distr}, E_{SM}, E_{Tr}, E_{Stor} – partial indicators of innovative processes efficiency in functional subsystems of supply, production support, distribution and implementation of the functions of stock management, transportation and storage.

The order of innovative processes evaluation in enterprise logistics is schematically summarized below (Figure 1).

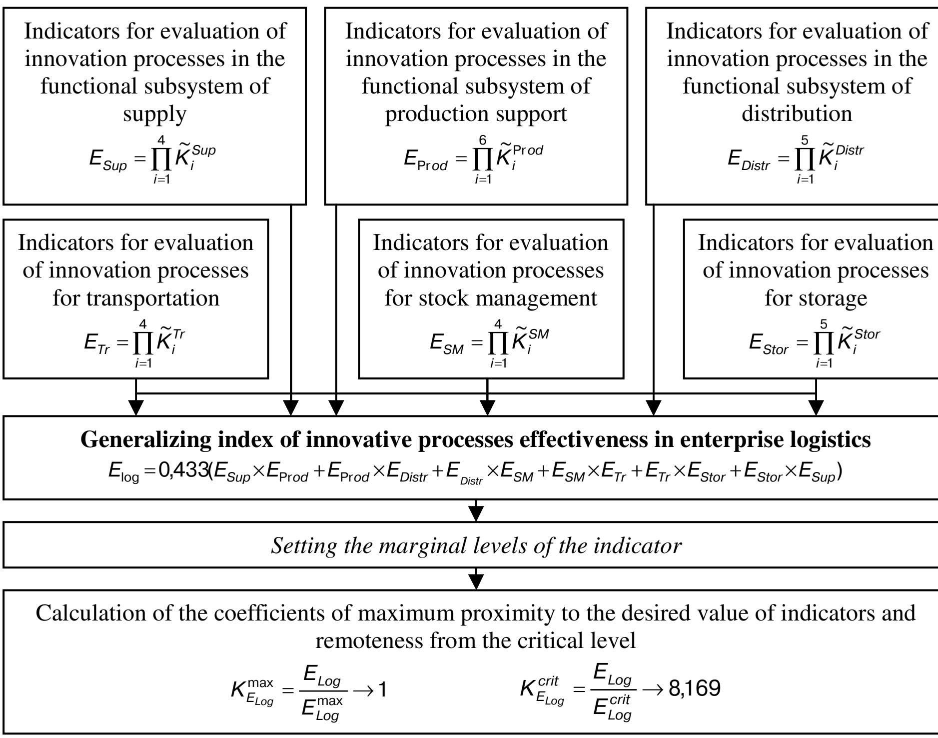

Figure 1. **The order of innovation processes evaluation in enterprise logistics,** *developed by the authors*

Formulas for the calculation of partial indicators of innovative processes efficiency are considered below:

$$E_{Sup} = \prod_{i=1}^{4} \tilde{K}_i^{Sup}; \tag{2}$$

$$E_{\Pr od} = \prod_{i=1}^{6} \tilde{K}_i^{\Pr od}; \tag{3}$$

$$E_{Distr} = \prod_{i=1}^{5} \tilde{K}_i^{Distr}; \tag{4}$$

$$E_{SM} = \prod_{i=1}^{4} \tilde{K}_i^{SM}; \tag{5}$$

$$E_{Tr} = \prod_{i=1}^{4} \tilde{K}_i^{Tr}; \tag{6}$$

$$E_{Stor} = \prod_{i=1}^{5} \tilde{K}_i^{Stor}, \tag{7}$$

where i – the sequence number of individual indicator; $\prod_{i=1}^{4} \tilde{K}_i^{Sup}$, $\prod_{i=1}^{6} \tilde{K}_i^{\Pr od}$, $\prod_{i=1}^{5} \tilde{K}_i^{Distr}$, $\prod_{i=1}^{4} \tilde{K}_i^{SM}$, $\prod_{i=1}^{4} \tilde{K}_i^{Tr}$, $\prod_{i=1}^{5} \tilde{K}_i^{Stor}$ – the normalized (standardized) values of individual indicator performance in the functional subsystems of supply, production support, distribution and during the implementation of the functions of stock management, transportation and storage accordingly, in the range from 0 to 1. At the same time, the maximal value of each indicator equals to 1, if at least one of the coefficients equals to 0, then a partial indicator of innovative processes effectiveness will be 0 too.

It should also be taken into account that qualitative characteristic of the indicators may be positive or negative which means their influence can be either stimulating, or destructive. Accordingly, there are indicators-stimulants and indicators-disstimulants. Therefore, the standardization of indicators should be conducted further, for which the standard statistical method for stimulants (formula 8) and disstimulants (formula 9) was used. In this context, standardized indicators-stimulants can be calculated by the classical formula (the methodology of (Cupalova, 2008)):

$$stX_i^s = \frac{X_i^s}{X_{\max}^s}, \tag{8}$$

where stX_i^s – the standardized value of indicator-stimulator; X_i^s – the actual value of indicator-stimulator; $X_{\max}^s$ – the maximum value of indicator-simulator; $i = 1 \ldots n$ – partial indicators under study.

Indicators-disstimulants are calculated by a modified formula of variations (basing on the methodology by V. Gavura (2011)):

$$stX_{ij}^d = 1 - \frac{x_{ij}^d - x_{\min}^d}{x_{\max}^d}, \tag{9}$$

where stX_{ij}^d – the standardized value of indicator-disstimulants; x_{ij}^d – the actual value of indicator-disstimulants; $x_{\min}^d$ – the minimum value of indicator-disstimulants; $x_{\max}^d$ – the maximum value of indicator-disstimulants; $ij = 1 \ldots n$ – partial indicators under study.

The use of formula (9) allows gain proportional to the indicators partial coefficients and avoid the value of the coefficient equals zero in the case of the highest relevant indicator, accepting the situation where the lowest value is 0.

The formula for combining the generalizing partial indicators of effectiveness for the constituents of logistic activity in the integral indicator has the following form:

$$\begin{aligned} E_{\log} = 0{,}433(&E_{Sup} \times E_{\Pr od} + E_{\Pr od} \times E_{Distr} + E_{Distr} \times E_{SM} + \\ &+ E_{SM} \times E_{Tr} + E_{Tr} \times E_{Stor} + E_{Stor} \times E_{Sup}). \end{aligned} \tag{10}$$

The coefficient 0,433 depends on the number of constituents in logistic activity of an enterprise (n = 6) and was obtained as follows:

$$k = 0{,}5\sin(360^\circ / n) = 0{,}5\sin(360^\circ / 6) = 0{,}5\sin 60^\circ = 0{,}433. \qquad (11)$$

The integral index calculated by the offered method is expedient to compare with marginal levels – maximum and critical. In order to do so, the determination of the coefficients of proximity to the maximum value of efficiency indicators and remoteness from critical level is offered:

$$K_{E_{Log}}^{\max} = \frac{E_{Log}}{E_{Log}^{\max}} \rightarrow 1; \qquad (12)$$

$$K_{E_{Log}}^{crit} = \frac{E_{Log}}{E_{Log}^{crit}} \rightarrow 8{,}169, \qquad (13)$$

where $K_{E_{Log}}^{\max}$ – the coefficient of proximity to the maximum value of generalizing (integrated) indicator of the innovative processes efficiency in enterprise logistics; E_{log} – the actual integrated efficiency of logistics; $K_{E_{Log}}^{crit}$ – the coefficient of remoteness from critical level of E_{log} indicator; $E_{Log}^{\max}$, E_{Log}^{crit} – the maximum and the critical values of generalizing indicator of innovative processes effectiveness in logistics. $E_{Log}^{\max}$ determines the desired level of logistics effectiveness, which an enterprise is trying to achieve, and E_{Log}^{crit} shows the minimum marginal level, decrease to that level indicates the inefficiency of innovation processes in enterprise logistics.

The marginal levels of E_{log} are defined as follows:

1) since the maximum value of efficiency indicators is 1, then:

$$E_{Log}^{\max} = k \times n \times 1 = 0{,}433 \times 6 \times 1 = 2{,}598; \qquad (14)$$

2) the critical level of indicators was the selected value of 0,35, so:

$$E_{Log}^{crit} = k \times n \times 0{,}35^2 = 0{,}433 \times 6 \times 0{,}1225 = 0{,}318. \qquad (15)$$

Thus, the values of $K_{E_{Log}}^{\max}$ are in the range from 0 to 1 and $K_{E_{Log}}^{crit}$ – in the range from 1 to 8,169, since $E_{Log}^{\max} / E_{Log}^{crit} = 8{,}169$. If the calculated coefficient $K_{E_{Log}}^{\max}$ equals to 1, then at the same time the calculated coefficient $K_{E_{Log}}^{crit}$ equals to 8,169. In this case, the generalized efficiency of innovation processes in logistics reaches the maximum level. If the values of such calculated coefficients are minimum, it means the complete remoteness from the desired level.

Conclusions. The proposed methodical approach to the evaluation of innovative processes in enterprise logistics involves calculation of the integral index based on partial indicators that characterize all functional subsystems in logistics (supply, production support, distribution) and crosscutting logistic functions (stock management, transportation, storage). Its application in economic practice will allow determining both the overall level of innovative processes effectiveness and reserves for improvement of investigated constituent elements of enterprise logistics.

Prospects for further research are in determining the influence of carried out innovation processes on the logistic potential of enterprises that would reflect the ability of systematically integrated units of an enterprise for successful implementation of innovation-oriented logistic activity.

References:

Гавура В.О. Інструментарій оцінки конкурентоспроможності регіонів // Економічний форум.– 2011.– №4. – С. 100–108.

Купалова Г.І. Теорія економічного аналізу: Навч. посібник. – К.: Знання, 2008. – 639 с.

Ткачова А.В. Оцінка ефективності логістичної діяльності промислового підприємства: інтегральний підхід // Прометей.– 2011.– №2. – С. 156–161.

Amit Abhijit, D.A.S., Sequeira, A.H., Ramanuja, G.S. (2012). Supply Chain Management & Logistic Strategy at S M Electronics for Reducing Cost & Improving Service, May 1, 2012 // ssrn.com.

Di Paola, N. (2013). Demand Chain Management for Value Creation and Innovation: The Case of Perishable Products. International Journal of Innovation in Business, Forthcoming, August 12, 2013 // ssrn.com.

Gonzalez, C., Carlos, A. (2014). Sistema Para La Gestion Logistica Empresarial (System for Business Logistics Management). SOTAVENTO M.B.A., No. 23, Enero-Junio // ssrn.com.

Krivovyazyuk, I.V., Kulik, Y. (2013). Model of logistics strategies' selection in conditions of crisis state of enterprise. Economist, 11: 57–60.

Little, A.D. (2007). Innovation Excellence in Logistics – Value Creation by Innovation. Brussels, European Logistics Association. 40 p.

Raja, M. (2009). A Model-Based Decision Support to Manage Outbound Logistics. The IUP Journal of Systems Management, 7(4): 45–57.

Richey, R., Roath, A., Whipple, J., Fawcett, S. (2013). Exploring a Governance Theory of Supply Chain Management: Barriers and Facilitators to Integration. Journal of Business Logistics, 31(1): 237–256.

Srivastava, S.K. (2013). Issues and Challenges in Reverse Logistics. In: Supply chains: issues and analysis (chapter 2, pp. 61–82). Editor: Surendra M. Gupta. CRC Press.

Стаття надійшла до редакції 26.06.2015.