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EFFICIENCY OF THE LOGISTICS CHAIN AS A FACTOR OF ECONOMIC SECURITY OF ENTERPRISES

Abstract. The basis of economic and financial security of the enterprise is effective financial and economic activity, stable financial condition, rational use of financial resources, the ability to counter threats to the internal and external environment. One of the factors of effective financial and economic activity and economic security of enterprises is the formation of effective logistics chains that provide its participants with opportunities to counter threats to the internal and external environment. Formation of effective logistics chains on the basis of taking into account the economic interests of its participants causes changes in the results of their financial and economic activities and creates the basis for their financial independence, socio-economic efficiency and stability.

The purpose of the article is to form approaches to assessing the efficiency of the logistics chain on the basis of economic and financial security of enterprises.

The article investigates scientific approaches to evaluating the efficiency of the logistics chain of enterprises, identifies their strengths and weaknesses, analyzes their methodology. An approach to evaluating the efficiency of the logistics chain of industrial enterprises, the use of which will reconcile the economic interests of the participants in the logistics chain, reduce their financial costs, ensure effective economic activity, form the basis for their financial and economic security.

The scientific novelty of the article is the formation of a modern approach to evaluating the efficiency of the logistics chain, which, in contrast to existing ones, involves the use of an indicator of the efficiency of logistics activities of enterprises, the proposed indicator is the stationarity of ratio of operating results to logistics costs relative to the mean or deterministic trend over time, and identification of potential models of logistics efficiency of enterprises, which would ensure economic and financial security of enterprises. It is proved that efficiency of the logistics chain is achieved under the condition that the financial result from the operating activities of the enterprises united by the logistics chain in relation to their costs for logistics activities will not change for a long time or will naturally change with a reliable forecast and possibility economic forecasting of

further cooperation. The expediency of using this approach was confirmed on the basis of the analysis of the efficiency of logistics chains of selected enterprises. The initial data for the construction of this model were the logistics costs as a component of the company's operating expenses and the financial result from operating activities. The deficiencies in the use of existing accounting standards and regulations that govern the integrated assessment of the enterprise's logistics costs have been established. It is proposed to use the Davis databases, which are formed on the basis of a web-survey of enterprises regarding the value of their logistic costs. It is noted that the actual stability of the logistics chains for each enterprise and the optimal ratio of their results to costs are determined by the current market conditions. An idea of the efficiency of connections in the logistics chain is formulated. It was concluded that the existence of a long-term stable equilibrium in the form of vector co-integration for all subjects of the logistics chain can be considered optimal.

Prospects for further research are the development of a scientific approach to the formation of a logistics cluster as a basis for financial and economic security of enterprises.

***Keywords*:** economic security, financial security, financial costs, financial results, efficiency, the logistics chain, logistics activities.

JEL Classification C22, D22, D61, O30

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ЕФЕКТИВНІСТЬ ЛОГІСТИЧНОГО ЛАНЦЮГА ЯК ЧИННИК ЕКОНОМІЧНОЇ БЕЗПЕКИ ПІДПРИЄМСТВ

Анотація. Основою економічної та фінансової безпеки підприємства є ефективна фінансово-економічна діяльність, стабільний фінансовий стан, раціональне використання фінансових ресурсів. Одним із чинників ефективної фінансово-господарської діяльності та економічної безпеки підприємств є формування ефективних логістичних ланцюгів, що забезпечують його учасникам можливості для протидії загрозам внутрішнього і зовнішнього середовища. Формування ефективних логістичних ланцюгів на засадах урахування економічних інтересів його учасників зумовлює зміни в результатах їхньої фінансово-

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економічної діяльності та створює засади для їхньої фінансової незалежності, соціально-економічної ефективності та стабільності.

Метою статті є формування підходів до оцінювання ефективності логістичного ланцюга на засадах забезпечення економічної і фінансової безпеки підприємств.

Досліджено наукові підходи до оцінювання ефективності логістичного ланцюга підприємств, виявлено їхні переваги і слабкі місця, проаналізовано їх методологію. Запропоновано підхід до оцінювання ефективності логістичного ланцюга промислових підприємств, використання якого дозволить узгодити економічні інтереси учасників логістичного ланцюга, знизити їхні фінансові витрати, забезпечити ефективну економічну діяльність, сформувати засади для їхньої фінансової та економічної безпеки.

Науковою новизною статті є формування сучасного підходу до оцінювання ефективності логістичного ланцюга, який, на відміну від наявних, передбачає використання індикатора ефективності логістичної діяльності підприємств, яким є стаціонарність відношення результатів від операційної діяльності до логістичних витрат відносно середнього значення або детермінованого тренду в часі. На основі цього також запропоновано підхід до формування моделей ефективної логістичної діяльності підприємств. Доведено, що ефективність логістичного ланцюга досягається за умови, коли фінансовий результат від операційної діяльності поєднаних логістичним ланцюгом підприємств щодо їхніх витрат на логістичну діяльність не буде змінюватися протягом тривалого часу або буде закономірно змінюватися з достовірним прогнозом і можливістю економічного прогнозування подальшої співпраці. Доцільність використання цього підходу підтверджено на основі проведеного аналізу ефективності логістичних ланцюгів обраних підприємств. Вихідними даними для побудови даної моделі слугували логістичні витрати як складова операційних витрат підприємства та фінансовий результат від операційної діяльності. Установлено недоліки застосування чинних стандартів бухгалтерського обліку і нормативних актів для комплексного оцінювання логістичних витрат підприємства. Запропоновано використовувати бази даних Девіса, які формуються на підставі веб-опитування підприємств щодо величини їхніх логістичних витрат. Наголошено, що фактична стійкість логістичних ланцюгів для кожного підприємства й оптимальне відношення їхніх результатів до витрат визначає поточна кон'юнктура ринку. Сформульовано уявлення відносно ефективності зв'язків у логістичному ланцюзі. Зроблено висновок, що оптимальною можна вважати наявність довгострокової стійкої рівноваги у формі векторної коінтеграції для всіх суб'єктів логістичного ланцюга.

Установлено, що перспективами подальших досліджень є розроблення наукового підходу до формування логістичного кластера як основи для фінансової та економічної безпеки підприємств.

***Ключові слова*:** економічна безпека, фінансова безпека, фінансові витрати, фінансові результати, ефективність, логістичний ланцюг, логістична діяльність.

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Introduction. Economic security, financial condition and realization of financial interests of enterprises are directly related to the efficiency of their activities. One of the fundamental components of the latter is the efficiency of logistics activities, which can be defined as a characteristic of the quality of performance of the logistics system in general and specifically the logistics chain in respect to the financial costs of logistics to maintain them. The amount of financial resources directed to logistics, on the one hand, determines the economic benefit from the economic activity of the participants in the logistics chain, such as manufacturers and suppliers, and on the other hand, the expenditures of logistics service consumers. Qualitative changes in the logistics chain cause corresponding changes in revenues and expenses of these entities, i.e. positive changes in the efficiency of their logistics and overall financial-economic activity, an improvement of their competitive position in the market compared to other market participants, and an increased level of satisfaction of their needs and interests. Therefore, all participants in logistics relations are

interested in increasing their efficiency, maximizing revenues and minimizing financial costs for logistics, thus forming the basis for economic security of the subjects, ie the protection of financial and economic interests of enterprises from existing and potential risks, as well as ensuring the continuous reproduction of economic and financial interactions. The solution of these problems is especially relevant in the economic crisis. Given the above, it is important to analyse the methods for assessing the efficiency of the logistics system and substantiate the models of improving the efficiency of the logistics chain for ensure economic and financial security of enterprises.

Analysis of research and problem statement. The issues of assessing the efficiency of logistics activities and the development of directions and mechanisms for their improvement as a basis for ensure economic and financial security of enterprises have been the subject of analysis by many economists. This resulted in the formation of various scientific approaches to solving this problem. One of the classic methods for assessing the efficiency of logistics is the method of Christopher M. (2011), according to which the first stage involves identification of the financial and economic processes that would provide an increase in economic performance, reduce the cost of products and the use of financial resources, and lead to an improvement in the quality of service, a decrease in delivery time, etc. [1]. These are the qualitative metrics that form a system of indicators used to assess the efficiency of logistics activities.

Zborovskaja O. (2009), Kuz'min O. (2017), Krauth E. (2005) and Waters D. (2003) propose to assess the efficiency of logistics activities on the basis of the indicators such as the cost of logistics, quality of service for consumers of a logistics product, duration of the logistics process and logistics cycle, level of economic effect from logistics operations, etc. or by using integration and system approaches to these indicators [2—5]. As such, this approach allows the definition of efficiency as a result of interactions between the subjects — participants in logistics relations and as a degree of implementation of the interests of the subjects of logistics activities.

At the same time, according to Lukinskiya V. (2017), this approach to assessing the efficiency of the logistics chain should be supplemented by such an indicator as the time spent on delivery of goods [6]. The researchers propose to analyse this indicator by analysing the feedback from the participants on the conditions of product movement, time lost on technological and transport delays, time spent due to the correspondent (favourable or unfavourable) traffic situation during current deliveries, etc. According to the researchers, this approach allows taking into account the dependence of economic effect and logistics costs on delivery time, assessing the productivity of logistics activities, and, consequently, estimating the benefit from reducing the delivery time for the competitiveness of the enterprise and implementation of economic interests of the participants in the logistics relations.

Tipu A. and Fantazy K. (2014) also link the efficiency of the logistics chain to the economic characteristics, such as logistics strategy of enterprises, flexibility to changes in market conditions, and interrelations between logistics supply chains; the analysis of the above was conducted by the authors on the basis of expert assessment of logistics activities of enterprises. This allowed them to compare the level of efficiency of the logistics chain in developed and underdeveloped countries, and to provide recommendations for improving the efficiency of logistics relations in these countries [7].

At the same time, it should be noted that the above approaches to the efficiency of logistics deal with the financial results and costs of the economic entity, but do not take into account the competitive position of its counterparties that are also direct participants in logistics relationships and business processes; they do not provide an assessment of qualitative changes in the logistics chain and their impact on the integrated index of the efficiency of logistics activities in the dynamics.

The methodology for assessing the efficiency of the logistics chain, which is used by modern scientists, is limited to the use of the classical approach to the calculation of this indicator, i.e. the ratio of results to costs associated with logistics activities. However, this does not enable detecting the existence of a long-term stable equilibrium for all entities in the system «supplier — manufacturer — consumer». Therefore, an important scientific task is the formation of an indicator

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of the efficiency of the logistics chain, which would be based on the principle of stationarity, i.e. the achievement of dynamic stability. In this context, the efficiency of the logistics chain is a lever to meet not only current but also future needs of participants in logistics relations, and, consequently, it is the basis for ensure economic and financial security of enterprises in the long run.

The purpose of the article is to form approaches to assessing the efficiency of the logistics chain on the basis of economic and financial security of enterprises.

Research results. Since, according to our hypothesis, the efficiency of the logistics chain is the basis for the economic and financial security of enterprises in the long run, then, to form an approach to assessing the efficiency of logistics, we will proceed from the principle of stability and consider this indicator in dynamics. In view of this, the formation of the logistics chain will be considered effective if the financial result from operating activities with respect to the costs associated with the logistics activities of enterprises involved in a logistics chain will not change over time, or predictably change with a reliable forecast and the possibility of economic forecasting of further interactions.

The relevancy of using this method will be confirmed by the analysis of logistics chains of three manufacturers. The sample of statistical data is reliable, as it is based on the indicators of financial and economic activity of hypothetical enterprises over a 15-year period. The main connections and interactions between the participants in the logistics chain are presented in *Fig. 1*.

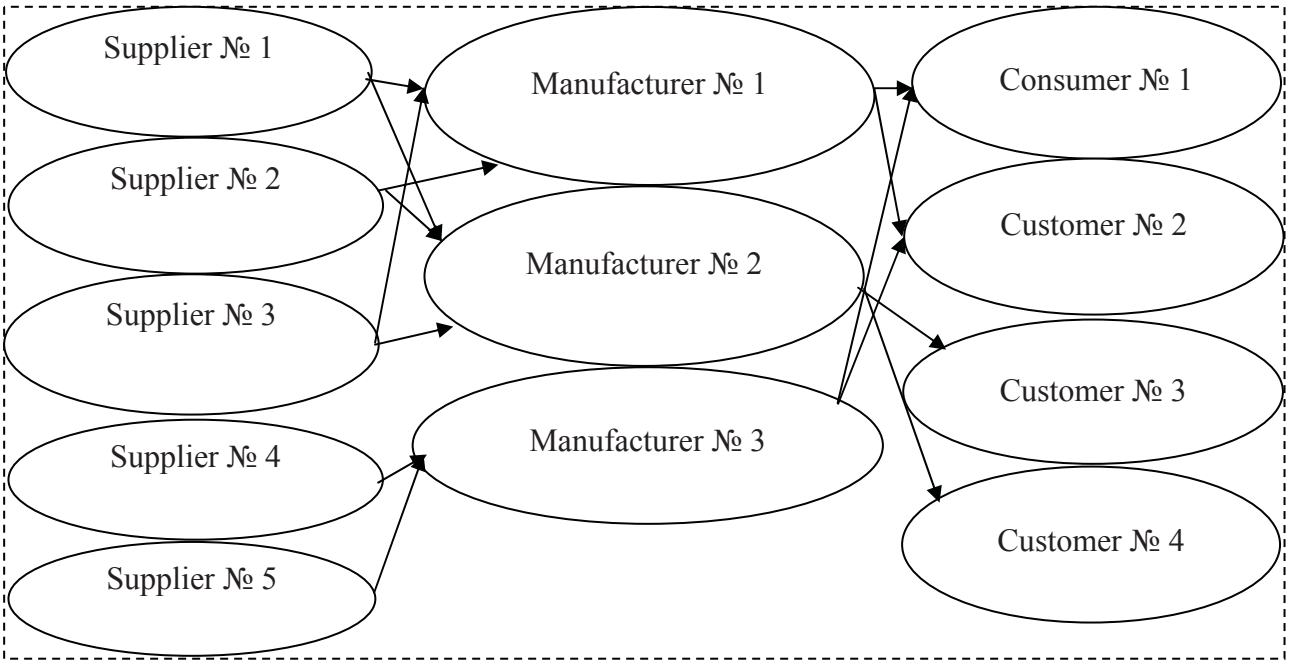

Fig. 1. **Schematic of interactions of manufacturers connected in a logistics chain**

The initial data for the construction of this model are logistics costs as part of operating costs of the enterprise, as well as the financial result from operating activities. Evaluating the logistics costs of industrial enterprises is a problem that needs to be addressed by implementing special recommendations and / or provisions in the accounting system for their identification, evaluation and accounting. Current international accounting and financial accounting standards [8; 9] do not allow for a comprehensive assessment of logistics costs of the enterprise, as these costs are accounted for, on the one hand — as part of operating costs included in the cost of goods sold (material, in-shop, and depreciation costs, etc.), and on the other hand — as part of administrative, marketing and other operating costs.

Therefore, we consider it expedient to open analytical accounts and subaccounts to accounts of the «Operating expenses» class in international accounting standards, which will allow determining the accumulated amount of logistics costs, as well as detailing and analysing their respective components.

We solved the problem of the lack of a clear regulatory mechanism for determining the amount of logistics cost through using the Davis database formed on the basis of a web survey of enterprises on the amount of their logistics costs. A clear structuring of personal data of the manufacturers is carried out on an open web site platform, where they indicate the amount of costs for transportation, inventory, warehousing, customer service (order tracking) and administrative expenses [10]. This method for evaluating logistics costs was introduced in 1974 and has been successfully used by business analysts to determine and forecast the amount of logistics costs. A significant advantage of the Davis database is the possibility of interpreting the data. Accordingly, the level of logistics costs was determined as a percentage of sales, whose dynamics we present in *Fig. 2*.

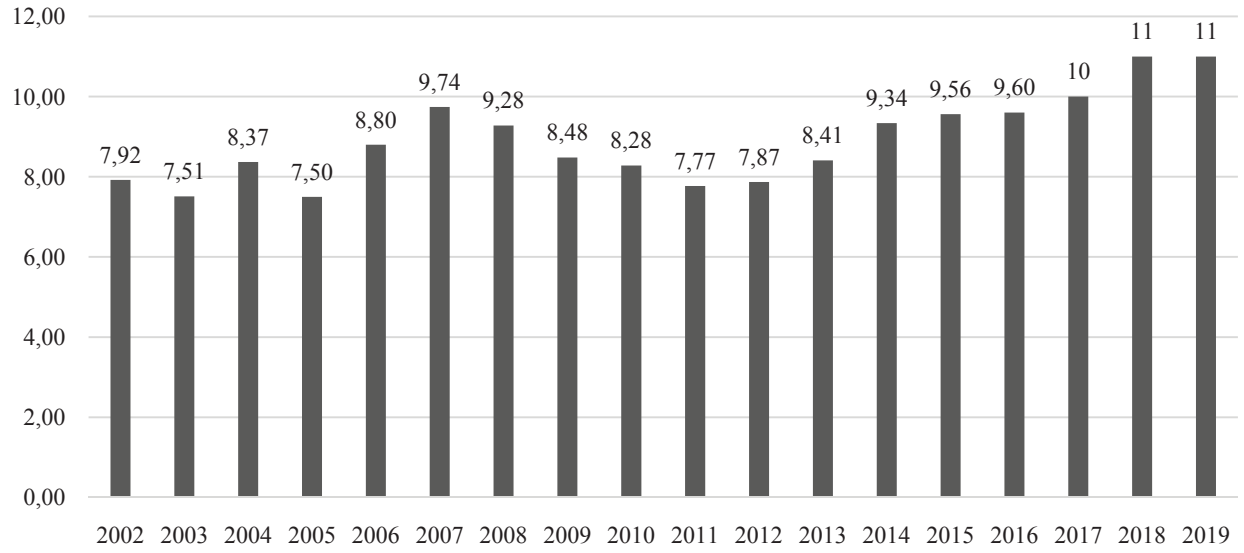

Fig. 2. **Dynamics of the logistics costs of enterprises presented using the Davis database** (in % to sales in 2002—2019)

Source: compiled according to the data [10; 11].

One cannot but agree with Rudkovskij O. (2015) that the strategic purpose of logistics is to optimize the «benefit — cost» interests of all participants in the logistics chain, so the main condition for the sustainability of the logistics chain is equality of the benefit to cost ratio for each enterprise [12]. However, in practice, this ratio may not be realized even for the most successful logistics chains. The declared equality may deviate due to substantial differences in the capacity of enterprises, significant differences in the amount of their expenses and cost of products, due to the integration of the enterprises into other logistics chains, and so on. Given the above, we believe that the actual stability of logistics chains for each enterprise and optimal «result to cost» ratio are determined by the current market situation. That is, the logistics relationship in the chain will be considered effective if the formed «result to cost» ratio either does not change over time, or predictably changes with a reliable forecast and economic interpretation. From a mathematical point of view, this means the occurrence of stationary time series deviations from the mean or deterministic trend, or the existence of a long-term stochastic trend between the connected enterprises.

To confirm this hypothesis, corresponding time series models of the efficiency of the logistics chain formed by real enterprises were built. The criterion for the efficiency of the logistics chain was the ratio of the financial result from operating activities to the logistics costs of the enterprise for a 15-year period.

Empirical Results and Discussions. In the process of modelling, three main stages were identified.

Stage 1 consists in checking the type of stationarity of time series for unit roots, which was carried out using the Dickey-Fuller test (DF) [13]. This test allows checking the values of the

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applied coefficients in the first-order autoregressive equations AR (1) of the Markov process. Three versions of the test are applied sequentially:

1) no constant, no trend:

$$\Delta y_t = b * y_{t-1} + \varepsilon_t ; \quad (1)$$

2) constant, no trend:

$$\Delta y_t = b_0 + b * y_{t-1} + \varepsilon_t ; \quad (2)$$

3) constant and linear trend:

$$\Delta y_t = b_0 + b_1 * t + b * y_{t-1} + \varepsilon_t , \quad (3)$$

where ε_t is «white noise».

This allows identifying, firstly, stationary series I (0), secondly, series with a drift and, thirdly, series that have a linear trend.

Further on, the series that are non-stationary according to the results of these tests, are differentiated and the DF (1) test is also applied to them to estimate the first-order integration I (1) and DS (difference-stationarity) of the series.

In the data array that we have chosen to assess the efficiency of the logistics activities of the studied enterprises, there are no stationary series around a linear trend with TS (trend-stationary) type of stationarity. At the same time, four time series are originally stationary with zero mean efficiency, and one series is stationary with a positive drift (*Table 1*).

Table 1

Types of stationary time series of logistics chain efficiency of enterprises

Enterprises	Level of significance of the DF test	Drift b_0
Manufacturer № 1	**0.0048**	**0.56±0,14**
Supplier № 1	0.227	I(1)
Supplier № 2	0.14	I(1)
Supplier № 3	0.1236	I(1)
Customer № 1	**0.0033**	**0**
Customer № 2	0.446	I(1)
Manufacturer № 2	0.389	I(1)
Customer № 3	0.149	I(1)
Customer № 4	0.0864	I(1)
Manufacturer № 3	**0.0018**	**0**
Supplier № 4	**0.038**	**0**
Supplier № 5	**0.0038**	**0**

Note: 1) stationary series with drift at the significance level of $p < 0.05$ are marked in bold; 2) I (1) — integrated series of order 1.

Testing the time series for cointegration. Stage 2 involves an analysis of pairs of non-stationary DS I (1) time series for the existence of a stationary linear combination or cointegration of time series; the analysis is carried out using the Engle — Granger test [14] based on the model of long-term equilibrium relationship between non-stationary series:

$$y_{t1} = \alpha + \beta * y_{t2} + \varepsilon_t \sim \mathrm{I}(0) . \quad (4)$$

Analysis of the residuals of regression equation (4) allows us to detect the existence of cointegration. The absence of cointegration corresponds to the existence of a unit root in a series of residuals and, correspondingly, is identified by the DF test.

However, if there are stable long-term relationships between the analysed indicators, or equilibria that can be disturbed in a short period of time, then such time series are cointegrated.

The study reliably identified only two pairs of cointegrated enterprises in the logistics chain 1 that purely comprises suppliers and consumers:

1) y_{t1} – **Supplier № 2**, y_{t2} – **Consumer № 2**, $\alpha = -0.092 \pm 0.378$, $\beta = 0.583 \pm 0.24$ with a low coefficient of determination of the model $R^2 = 0.31$;

2) y_{t1} – **Supplier № 3**, y_{t2} – **Supplier № 1**, $\alpha = 0.89 \pm 0.12$, $\beta = -0.597 \pm 0.125$ with an acceptable coefficient of determination $R^2 = 0.64$.

The parameters of the Model 2 with negative cointegration are more reliable. Although the enterprises represented in the pairs do not have direct logistical interactions, they yet have indirect

relationships formed through a common manufacturer — **Manufacturer № 1.** Obviously, an increase in the efficiency of logistics activities by one relative unit in **Supplier № 1** correlates with a decrease in this indicator in **Supplier № 3**. At the same time, a stable equilibrium of logistics efficiency is achieved in the long term, at the level of 0.89 relative units.

Estimation of the cointegrated vector. Stage 3 involves estimating the cointegrated vector, i.e. the stochastic trend of the set DS I (1) time series. To estimate it, we used the Johansen test [15]. This test is an extension of the Engle — Granger test for VAR models and accordingly allows estimating the cointegration vector matrix at a given rank of cointegration using a maximum likelihood estimates (MLE) approach, based on the error correction vector model (5):

$$\Delta y_t = A(B' y_{t-1} + c_0 + d_0 t) + c_1 + \varepsilon_t, \quad (5)$$

where A is correction vector matrix;

B' is cointegration vector matrix;

c_1 is absolute term vector (actually normalized or balanced vector);

c_0 is displacement scalar;

d_0 is the coefficient of proportionality of the linear deterministic trend of stochastic cointegration.

Of the three logistics chains, the long-term stochastic trend of the group of enterprises only exists in the second chain, associated with Manufacturer № 2 (see *Fig. 1*).

Table 2 presents the parameters of the cointegration vector of long-term equilibrium of the system «supplier — manufacturer — consumer».

Table 2

Parameters of cointegration vectors of long-term equilibrium of the system «supplier — producer — consumer»

Enterprises	A: matrix of correction vectors (rate of return to steady state)	B': matrix of cointegration vectors (deviation from equilibrium)	c_1: vector of free members
Manufacturer № 2	-0.4054	0.754	0.0258
Supplier № 1	0.5244	-1.8397	0.0931
Supplier № 2	-0.8809	0.4303	0.0453
Supplier № 3	-0.1654	-3.6548	-0.0125
Customer № 3	0.2853	-0.7184	-0.1017
Customer № 4	-0.4161	0.5137	-0.0685

Source: authoring.

Supplier № 2 deviates least from the equilibrium point $|B|_{\min} = 0.43$. It also has a maximum rate $|A|_{\max} = 0.88$ of return of short-term shocks to a long-term stable state. The efficiency of logistics activities of **Supplier№ 3**, on the contrary, exhibits the most pronounced deviation from the equilibrium and thus stays the longest. The long-term state of equilibrium corresponds to the high efficiency of logistics activities of 4.664 with a very weak negative deterministic linear trend $d_0 = -0.002$.

Conclusions and economic interpretation. Let us consider in more detail three typical models that are subject to economic interpretation.

Model 1: the efficiency of the logistics activities of most enterprises that have formed a logistics chain is characterized by stationary changes in dynamics. Therefore, in the case when the deterministic trend (shift) is characterized by upward dynamics and is positive, we say that the logistics activities of these enterprises are quite efficient.

Model 2: the efficiency of logistics activities of most enterprises that have formed the logistics chain is characterized by non-stationary changes in dynamics. The latter means that these difference-stationary time series do not achieve cointegration equilibrium, which reveals the inefficiency of the existing logistics chain.

Model 3: the efficiency of logistics activities of most enterprises that have formed the logistics chain is characterized by multi-stationary changes in dynamics. Accordingly, there is a connection between the series, i.e. vector cointegration ratios, which leads to a long-term stable

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equilibrium of the logistics system of the enterprises. In this case, the magnitude of a possible positive shift is not as important as the existence of a long-term stochastic trend. Logistics activities in this logistics chain are estimated as super-efficient, as the consequence of the joint impact of all enterprises is their overall sustainability.

It should be noted that innovations in the process of production relations and logistics, abrupt economic fluctuations and shocks, other changes due to the intensive development of market economy, are reflected in the non-stationarity of time series. At the same time, the application of Model 3 provides a possibility of achieving long-term stationary equilibrium of enterprises participating in logistics relations and increasing the efficiency of the latter, and, consequently, increasing the degree of implementation of their economic and financial interests, the ensure economic and financial security of enterprises in dynamics.

Thus, in our opinion, the determining indicator of the efficiency of the logistics chain is the stationarity of the ratio of results from operating activities to logistics costs of enterprises with respect to a deterministic trend over time or the mean, the value of which depends on the market situation. In this case, it can be considered that the optimal model of logistics relationships and interactions is the existence of long-term stable equilibrium in the form of vector cointegration for all subjects in the logistics chain. The above substantiates the economic significance of the proposed approach to assessing the efficiency of the logistics chain in the dynamics as a factor of ensuring economic and financial security of all participants in the logistics relationships.

Prospects for further research are the development of a scientific approach to the formation of a logistics cluster as a basis for financial and economic security of enterprises.

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