Electronic scientific and practical journal

INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

#13 (2022)
June '22

WWW.SMART-SCM.ORG
ISSN 2708-3195
DOI.ORG/10.46783/SMART-SCM/2022-13

ISSN 2708-3195
9 772708 319005

Electronic scientific and practical collection
INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Electronic scientific and practical publication in economic sciences

ISSN 2708-3195
DOI: https://doi.org/10.46783/smart-scm/2022-13

Released 6 times a year

№ 13 (2022)
June 2022

Kyiv - 2022

Founder: Viold Limited Liability Company

The electronic scientific and practical journal is registered in international scientometric data bases, repositories and search engines. The main characteristic of the edition is the index of scientometric data bases, which reflects the importance and effectiveness of scientific publications using indicators such as quotation index, h-index and factor impact (the number of quotations within two years after publishing).

In 2020, the International Center for Periodicals (ISSN International Center, Paris) included the Electronic Scientific and Practical Edition "Intellectualization of Supply Chain Management" in the international register of periodicals and provided it with a numerical code of international identification: ISSN 2708-3195 (Online).

Recommended for dissemination on the Internet by the Academic Council of the Department of Logistics NAU (No. 7 of February 26, 2020). Released 6 times a year. Editions references are required. The view of the editorial board does not always coincide with that of the authors.

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DOI: https://doi.org/10.46783/smart-scm/2022-13
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UDC 658.7: 656:502.1
DOI: https://doi.org/10.46783/smart-scm/2022-13-3
JEL Classification: C51, F64, L92, O44, R11.
Received: 14 May 2022

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MATHEMATICAL METHOD OF ASSESSING THE POTENTIAL USE OF LOGISTICS INFRASTRUCTURE

Mariya Hryhorak, Lesia Kostiuchenko, Oleh Harmash. «Mathematical method of assessing the potential use of logistics infrastructure». *The article reveals the content of the interpretation of the potential of logistics infrastructure concept. The main approaches to determining the logistics potential are described, on the basis of which a methodology for assessing its use is proposed. The purpose of the article is to research the components of the potential of logistics infrastructure objects and develop a mathematical model for its assessment. The author's understanding of the logistics potential of the logistics infrastructure is based on an integrated vision of the potential. Such integration has the form of a three-dimensional model with a "resources-abilities-competencies" coordinate system. The resource plane of such a model reveals the phenomenon of transformation of opportunities into abilities. In turn, abilities through their disclosure, consolidation and renewal with the help of training are transformed into competences.*

The proposed mathematical model of assessing the integral potential of the logistics infrastructure of the enterprise is performed taking into account its life cycle. This approach ensures the objectivity of the assessment of the integral potential. This can provide an assessment of the potential in view of three components that provide directions for the formation and use of logistics infrastructure facilities: resourceful (assessment of material or energy intensity), organizational (efficiency of management, coordination, etc.) and functional (functional infrastructure components, blocks, etc.). Each of these components is characterized by a set of parameters, the assessment of which reflects their compliance with a certain stage of the life cycle of the object under study. The correct selection of a group of parameters is important. In particular, such a group of

parameters can be: compliance as a complete set of necessary functions, operations, properties, etc.; excellence as a level of innovative development, informatization, digitization, etc.; usefulness as a level of specialization or versatility (capacity); relevance as a level of expediency, need for use, etc.; relevance as the possibility or suitability of being replaced by a similar means or resource. In this way, the integration of the potentials of individual elements of each direction of formation forms the overall potential of the logistics infrastructure object.

***Keywords**:* logistics infrastructure, logistics infrastructure potential, potential application assessment method, potential assessment model, integrated logistics infrastructure potential.

Марія Григорак, Леся Костюченко, Олег Гармаш. «Математичний метод оцінки використання потенціалу логістичної інфраструктури». *У статті досліджено трактування поняття потенціалу логістичної інфраструктури. Описано головні підходи до визначення логістичного потенціалу на основі якого запропоновано методику оцінки його використання. Метою статті є дослідження складових потенціалу об'єктів логістичної інфраструктури та розробка математичної моделі його оцінки. Авторське розуміння логістичного потенціалу логістичної інфраструктури ґрунтується на інтегрованому баченні потенціалу. Таке інтегрування має форму тривимірної моделі з системою координат «ресурси-здатності-компетенції». Ресурсна площина такої моделі розкриває феномен перетворення можливостей в здатності. У свою чергу здатності через їх розкриття, закріплення й оновлення за допомогою навчання трансформуються у компетенції.*

Запропонована математична модель оцінки інтегрального потенціалу логістичної інфраструктури підприємства виконане з урахуванням його життєвого циклу. Такий підхід забезпечує об'єктивність оцінки інтегрального потенціалу. Це може забезпечити оцінку потенціалу з огляду на три складові, які забезпечують напрями формування і використання об'єктів логістичної інфраструктури: ресурсну (оцінка матеріало- чи енергоємності), організаційну (ефективність управління, злагодження тощо) та функціональну (функціональних інфраструктурних складових, блоків тощо). Кожна з цих складових характеризується сукупністю параметрів, оцінка яких відображає їх відповідність певній стадії життєвого циклу досліджуваного об'єкта. Важливим є правильний підбір групи параметрів. Зокрема, такою групою параметрів можуть бути: відповідність як повний набір необхідних функцій, операцій, властивостей тощо; досконалість як рівень інноваційного розвитку, інформатизації, цифровізації тощо; корисність як рівень спеціалізації/універсальності (дієздатності); актуальність як рівень доцільності, потреби у використанні тощо; значущість як можливість або придатність до заміни аналогічним засобом або ресурсом. Таким чином інтегрування потенціалів окремих елементів кожного напрямку формування утворює сукупний потенціал логістичного інфраструктурного об'єкту.

Ключові слова: логістична інфраструктура, потенціал логістичної інфраструктури, методика оцінки використання потенціалу, модель оцінки потенціалу, інтегральний потенціал логістичної інфраструктури.

Мария Григорак, Леся Костюченко, Олег Гармаш. «Математическая модель оценки реализации потенциала логистической инфраструктуры». *В статье исследовано видение понятия потенциала логистической инфраструктуры. Описаны основные подходы к определению логистического потенциала, на основании которого предложена методика оценки его использования. Целью статьи является исследование составляющих потенциала использования объектов логистической инфраструктуры, а также разработка математической модели его оценки. Авторское видение логистического потенциала логистической инфраструктуры основывается на интегрированном видении потенциала. Такая интеграция имеет форму*

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трехмерной модели с системой координат «ресурсы-способности-компетенции». Ресурсная плоскость такой модели раскрывает феномен превращения возможностей в способности. В свою очередь способности средством их раскрытия, укрепления и обновления, а также обучения трансформируются в компетенции.

Предложенная математическая модель оценки интегрального потенциала логистической инфраструктуры предприятия составлена с учетом его жизненного цикла. Такой подход обеспечивает объективность оценки интегрального потенциала. Это может обеспечить оценку потенциала с учётом трех составляющих, обеспечивающих направление формирования и использования объектов логистической инфраструктуры: ресурсная (оценка материало- или энергоемкости), организационная (эффективность управления, сплоченности и т.п.), функциональная (функциональных инфраструктурных составляющих, блоков и т.д.). Каждая из этих составляющих характеризуется совокупностью параметров, оценка которых отображает их соответствие определенной стадии жизненного цикла исследуемого объекта. Важным является правильный выбор группы параметров. В частности, такой группой параметров могут быть: соответствие в качестве полного набора необходимых функций, операций, свойств и т.п.; совершенство как уровень инновационного развития, информатизации, цифровизации и т.д.; полезность как уровень специализации/универсальности (дееспособности); актуальность как уровень целесообразности, потребности в использовании и т.п.; значимость как возможность или способность к замещению аналоговым средством или ресурсом. таким образом, интегрирование потенциалов отдельных элементов каждого направления образует совокупный потенциал логистического инфраструктурного объекта.

Ключевые слова: логистическая инфраструктура, потенциал логистической инфраструктуры, методика оценки использования потенциала, модель оценки потенциала, интегральный потенциал логистической инфраструктуры.

Introduction. The current stage of the development of economic relations in Ukraine is characterized by the emergence and development of new relations, the basis of which is the cooperation of producers, suppliers, users for the purpose of integrated management of business processes throughout the entire life cycle of products. Non-production factors have a greater impact on the economy of enterprises: sales, supply, service, the effective implementation of which is ensured by the maximum use of the logistics infrastructure potential. Therefore, today the research and development of methodology for assessing the potential of logistics infrastructure are gaining relevance.

Analysis of recent research and publications. The problems of managing the logistics infrastructure and directly defining the logistics potential were investigated in their works by such scientists as Hrytsenko S.I., Krykavskyi E.V. [4], Kovalev K.Yu., Levkovets R.P., Pashchenko Yu.E., Sokolova O.E. [5], Smerichevska S.V. etc. On the basis of their scientific developments, a range of issues regarding approaches to assessing the potential of logistics infrastructure facilities are also resolved. A fairly thorough analysis of the definition of the term "logistics potential" is presented in the publication [2]. Based on the results of the terminological analysis, the author identified different approaches to determining the logistics potential (see Table 1).

The purpose and objectives of the study. The purpose of the article is to research the components of the potential of logistics infrastructure objects and develop a mathematical model for its assessment.

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Table 1 – Generalization of approaches to determining logistics potential

Approaches	Definition of logistics potential
Resourceful	the possibility of using resources for logistics operations and functions
Effective	the ability to ensure the achievement of the set goals of logistics activities
Effective and resourceful	symbiosis of resource and effective approaches

Source: developed by the authors on the basis of [3, p.281 – 284]

Basic material and results. In general logistics infrastructure is a set of elements that perform important logistics tasks and ensure the implementation of logistics processes [1; 2]. In other words, it is an integrated set of warehouse, transport, handling, packaging, information and financial infrastructure of the enterprise, which in the complex provide effective logistic service of the material flow according to the principle "from door to door" with minimal costs in accordance with the requirements of consumers. The given definition indicates the need for effective use of logistics infrastructure in the process of coordination and maintenance of supply chains, which also reinforces the relevance of the study of assessment parameters of this component of logistics.

The author's understanding of the logistics potential of the logistics infrastructure is based on an integrated vision of the potential. Such integration has the form of a three-dimensional model with a "resources-abilities-competencies" coordinate system. The resource plane of such a model reveals the phenomenon of transformation of opportunities into abilities. In turn, abilities through their disclosure, consolidation and renewal with the help of training are transformed into competences [2, c. 285]. The implementation of a complex of such opportunities takes place under the conditions of the implementation of business processes and self-organization processes and contributes to the creation of value for stakeholders. Based on such a position, it is possible to define the logistics potential as the ability of the logistics system to achieve its strategic goals in the most effective way in terms of time, quality and costs, taking into account the influence of factors of its internal and external environment.

Let's summarize the mentioned theoretical positions of various scientists regarding the definition of the economic essence and the conceptual model of logistics potential. Therefore, we offer an integrated vision in the form of a four-dimensional model with a "resources-capabilities-management system-competencies" coordinate system. In such a coordinate system, the resource plane reveals the phenomenon of the transformation of opportunities into abilities, and abilities through their disclosure, consolidation and renewal through training are transformed into competences. The realization of the specified opportunities complex takes place under the conditions of the implementation of business processes and self-organization processes and contributes to the creation of value for interested parties (stakeholders). The degree of satisfaction of the requests of various stakeholders from the result of the transformation of resources and the success of the logistics system functioning in general depend not only on the availability of resources, but also on the knowledge and skills to combine them into single technological and management processes, that is, on intellectual and human potential.

On the other hand, modern scientific developments of specialists in economics in general and logistics in particular pay little attention to the assessment of the use of potential capabilities of logistics infrastructure objects as a component of the logistics system in general. At the same time, there are often works devoted to the assessment of the investment or competitive potential of enterprises. The majority of

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authors are inclined to the opinion of the expediency of using integral potential, taking into account the life cycle of a certain enterprise or logistics system.

The formation of the mathematical model for assessing the integral potential of the logistics infrastructure of the enterprise is carried out taking into account the life cycle of its objects. This approach ensures the objectivity of the integral potential assessment approach. This can provide an assessment of the potential in view of three components that provide directions for the formation and use of logistics infrastructure facilities: resourceful (assessment of material or energy intensity) – ***R***, organizational (efficiency of management, coordination, etc.) – ***O*** and functional (functional infrastructure components, blocks, etc.) – ***F***. Each component is characterized by a set of parameters, the assessment of which reflects their compliance with a certain stage of the life cycle of the object under study. The correct selection of a parameters group is important. In particular, such a group of parameters can be (see Table 2):

– compliance (full set of necessary functions, operations, properties, etc.) – ***C***;

– excellence (level of innovative development, informatization, etc.) – ***E;***

– usefulness – level of specialization or universality (functionality) – ***U***;

– relevance (level of feasibility, need for use, etc.) – ***Re***;

– significance (possibility or suitability for replacement by a similar means or resource) – ***S***.

Table 2 - The structure of the parameters of the assessment of the elements of the logistics infrastructure potential formation

Directions of formation		Evaluation parameters				
Component	Element	Compliance	Excellence	Usefulness	Relevance	Significance
Resourceful	$\forall r \in R$	C_r	E_r	U_r	Re_r	S_r
Organizational	$\forall o \in O$	C_o	E_o	U_o	Re_o	S_o
Functional	$\forall f \in F$	C_f	E_f	U_f	Re_f	S_f

Source: developed by the authors on the basis of [1]

Then, at a certain life cycle stage of the logistics infrastructure object, each potential element is a function of the corresponding evaluation parameters according to the following formulas:

$$\left.\begin{aligned} \forall o \in O : e_o = f_o(\mathrm{C}_o E_o U_o \mathrm{Re}_o \mathrm{S}_o); \\ \forall r \in R : e_r = f_r(\mathrm{C}_r \mathrm{E}_r \mathrm{U}_r \mathrm{Re}_r \mathrm{S}_r); \\ \forall f \in F : e_f = f_f(\mathrm{C}_f \mathrm{E}_f \mathrm{U}_f \mathrm{Re}_f \mathrm{S}_f). \end{aligned}\right\} \quad (1)$$

It is important to take into account that each of the above-described elements of the logistics infrastructure potential, in turn, is influenced by other elements. Thus, logistics infrastructure objects are characterized by dependence not only on the corresponding parameter estimates, but also on other adjacent elements of the logistics system and external conditions (see Table 3).

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Table 3 - The structure of parameters influencing the level of elements potential

Directions of formation		Factor parameters		
Component	Element potential	Resource element	Organizational element	Functional element
Resourceful	$\forall r \in R$ p_r	$\forall r \in R$ e_r	$\forall o \in O$ e_o	$\forall f \in F$ e_f
Organizational	$\forall o \in O$ p_s	$\forall r \in R$ e_r	$\forall o \in O$ e_o	$\forall f \in F$ e_f
Functional	$\forall f \in F$ p_f	$\forall r \in R$ e_r	$\forall o \in O$ e_o	$\forall f \in F$ e_f

Conclusions. The structure of the parameters of influence on the level of potential by detailing the elements given in Table 2 produces the following conclusion. At a certain stage of the life cycle of a logistics infrastructure object, the level of potential of each individual element may have a different value. Since the directions of potential formation of individual evaluation parameters of its elements are related to the rest of the elements, and are influenced to varying degrees by external conditions. Mathematically, this dependence is a function of the corresponding parameters of other elements:

$$\left.\begin{aligned} &\forall f \in F : p_f = f_{p_f}(e_r, e_o, e_f), \forall r \in R, \forall o \in O; \\ &\forall o \in S : p_o = f_{p_s}(e_r, e_o, e_f), \forall r \in R, \forall f \in F; \\ &\forall r \in R : p_r = f_{p_f}(e_r, e_o, e_f), \forall o \in O, \forall f \in F. \end{aligned}\right\} \quad (2)$$

In this way, the integration of the individual elements potentials of each direction of formation forms the overall potential of the logistics infrastructure object. Thus, there is structure of formation potential factors in the table 4.

Table 4 – The structure of formation potential factors

Directions of formation		Factor parameters		
Component	Formation potential	Resource element potential	Organizational element potential	Functional element potential
Resourceful	P_R	$\forall r \in R$ p_r		
Organizational	P_O		$\forall o \in O$ p_o	
Functional	P_F			$\forall f \in F$ p_f

Then, at a certain stage of the logistics infrastructure object's life cycle, the overall potential of the logistics infrastructure object will correspond to the function of the corresponding parameters of the potentials of its elements:

$$\left.\begin{aligned} P_R &= f_P(p_1, p_2, \ldots, p_r, \ldots, p_R); \\ P_O &= f_P(p_1, p_2, \ldots, p_o, \ldots, p_O); \\ P_F &= f_P(p_1, p_2, \ldots, p_f, \ldots, p_F). \end{aligned}\right\} \quad (3)$$

Therefore, the integrated set of potentials of individual formations forms the integral potential of the logistics infrastructure object. Within the defined stage of the life cycle, the integral potential of a logistics infrastructure object is a function of the corresponding parameters of the potential factors of its formation and has the following mathematical expression:

$$P_I = f_{P_I}(P_R, P_O, P_F) \quad \text{або} \quad P_I = \sqrt[n]{\prod P_n}, \quad (4)$$

де $P_1 = P_R$; $P_2 = P_O$; $P_3 = P_F$.

Logistics infrastructure management in modern economic conditions is characterized by the presence of a large number of specific features and problems, the main ones of which are analyzed above. The given method of assessing the potential of the logistics infrastructure reflects a synergistic effect that significantly affects the final results of the performance of logistics functions. The proposed approach requires more detailed research, deeper analysis and the development of new models for evaluating the indicators of the use of infrastructure facilities suitable for practical use.

It should be added that for a qualitative assessment of factors affecting the realization of logistics potential at the macro level, it is advisable to take into account indirect effects. For example, such indirect effects are obstacles in the development of the logistics system within the limits of its market functioning. The main such obstacles include the imperfection or lack of state policy and state strategy, which affects the conditions of conducting logistics business and the possibility of realizing the logistics potential of the country. Therefore, an important subject of further research is the study of the methodology for assessing the logistics potential of the logistics services market, which is an important element of the national logistics system.

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