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CHOOSING A SCENARIO FOR IMPROVING THE SUSTAINABILITY OF SUPPLY CHAINS IN CONSTRUCTION

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ABSTRACT

Purpose: The aim of this study is to examine acceptable methods for choosing directions for increasing the sustainability of supply chains in construction. The study also determinate the factors affecting the sustainability of supply chains in construction

Theoretical framework: Supply chain integration in many industries is based on integrated enterprise resource and relationship processing systems (ERP), but the construction industry has traditionally lagged behind in these processes. The need to create effective relationships in supply chains and increase the resilience of supply chains in construction has become evident in the context of the pandemic. However, the weak formalization of these processes in construction has led to the need to find acceptable methods for choosing directions for increasing the sustainability of supply chains in this industry.

Methodology: This is a descriptive-based study. Approaches to factors of the supply chain stability were researched and systemized and from this the situations for the increasing stability of the supply chains are determinated. The choice of a model of the increasing stability of the supply chains was determined by the analytic hierarchy process. Hierarchy analysis was used as a method for selecting a scenario for increasing the sustainability of supply chains in construction.

Findings: The results of the research carried out to conduct a multi-criteria choice using the opinions of experts in the construction industry. The choice of scenarios for increasing sustainability is due to the fact that the introduction of adaptive information technologies allows to take into account all groups of selected factors, while ensuring synchronization of production planning, product shipment and inventory management, increasing market feedback, ensuring that production volumes correspond to product demand, as well as reducing logistics costs and the price of products for the end customer.

Research, Practical & Social Implication: The study contributes to a better understanding crucial factors of the sustainability of supply chains in construction. The processes of analyzing and evaluating factors contribute to improving the sustainability of supply chains in construction, by focusing on critical factors, adopting them according to the requirements of the construction.

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Originality/value: Based on the presented results, concluded that the scenario formation of increasing sustainability of the sustainability of supply chains by the introduction of adaptive information technologies allows to take into account all groups of selected factors, while ensuring synchronization of production planning, product shipment and inventory management, increasing market feedback, ensuring that production volumes correspond to product demand, as well as reducing logistics costs and the price of products for the end customer.

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ESCOLHENDO UM CENÁRIO PARA MELHORAR A SUSTENTABILIDADE DAS CADEIAS DE ABASTECIMENTO NA CONSTRUÇÃO

RESUMO

Objetivo: O objetivo deste estudo é examinar métodos aceitáveis para a escolha de direções para aumentar a sustentabilidade das cadeias de abastecimento na construção. O estudo também determina os fatores que afetam a sustentabilidade das cadeias de suprimentos na construção

Estrutura teórica: A integração da cadeia de fornecimento em muitas indústrias é baseada em sistemas integrados de processamento de recursos empresariais e de relacionamento (ERP), mas a indústria da construção tradicionalmente tem ficado para trás nestes processos. A necessidade de criar relações eficazes nas cadeias de abastecimento e aumentar a resiliência das cadeias de abastecimento na construção tornou-se evidente no contexto da pandemia. Entretanto, a fraca formalização destes processos na construção levou à necessidade de encontrar métodos aceitáveis para escolher direções para aumentar a sustentabilidade das cadeias de abastecimento nesta indústria.

Metodologia: Este é um estudo de base descritiva. Foram pesquisadas e sistematizadas abordagens aos fatores de estabilidade da cadeia de abastecimento e a partir delas são determinadas as situações para a crescente estabilidade das cadeias de abastecimento. A escolha de um modelo de estabilidade crescente das cadeias de abastecimento foi determinada pelo processo de hierarquia analítica. A análise hierárquica foi utilizada como método para selecionar um cenário para aumentar a sustentabilidade das cadeias de abastecimento na construção.

Descobertas: Os resultados da pesquisa realizada para conduzir uma escolha multicritério utilizando as opiniões de especialistas da indústria da construção. A escolha de cenários para aumentar a sustentabilidade deve-se ao fato de que a introdução de tecnologias de informação adaptativas permite levar em conta todos os grupos de fatores selecionados, ao mesmo tempo em que garante a sincronização do planejamento da produção, do envio de produtos e da gestão de estoques, aumentando o feedback do mercado, garantindo que os volumes de produção correspondam à demanda do produto, além de reduzir os custos logísticos e o preço dos produtos para o cliente final.

Pesquisa, Implicação prática e social: O estudo contribui para uma melhor compreensão dos fatores cruciais para a sustentabilidade das cadeias de fornecimento na construção. Os processos de análise e avaliação dos fatores contribuem para melhorar a sustentabilidade das cadeias de abastecimento na construção, concentrando-se nos fatores críticos, adotando-os de acordo com as exigências da construção.

Originalidade/valor: Com base nos resultados apresentados, concluiu que a formação de cenários de crescente sustentabilidade da sustentabilidade das cadeias de abastecimento através da introdução de tecnologias de informação adaptativas permite levar em conta todos os grupos de fatores selecionados, ao mesmo tempo em que garante a sincronização do planejamento da produção, do envio de produtos e da gestão de estoques, aumentando o feedback do mercado, garantindo que os volumes de produção correspondam à demanda do produto, bem como reduzindo os custos logísticos e o preço dos produtos para o cliente final.

Palavras-chave: Cadeias de Fornecimento, Sustentabilidade, Construção, Cenário, Métodos.

ELECCIÓN DE UN ESCENARIO PARA MEJORAR LA SOSTENIBILIDAD DE LAS CADENAS DE SUMINISTRO EN LA CONSTRUCCIÓN

RESUMEN

Propósito: El objetivo de este estudio es examinar métodos aceptables para elegir orientaciones para aumentar la sostenibilidad de las cadenas de suministro en la construcción. El estudio también determina los factores que afectan a la sostenibilidad de las cadenas de suministro en la construcción.

Marco teórico: La integración de la cadena de suministro en muchas industrias se basa en sistemas integrados de procesamiento de recursos y relaciones empresariales (ERP), pero la industria de la construcción se ha quedado

tradicionalmente rezagada en estos procesos. La necesidad de crear relaciones eficaces en las cadenas de suministro y de aumentar la resistencia de las cadenas de suministro en la construcción se ha hecho evidente en el contexto de la pandemia. Sin embargo, la escasa formalización de estos procesos en la construcción ha llevado a la necesidad de encontrar métodos aceptables para elegir direcciones que permitan aumentar la sostenibilidad de las cadenas de suministro en esta industria.
Metodología: Se trata de un estudio de base descriptiva. Se investigaron y sistematizaron los enfoques de los factores de la estabilidad de la cadena de suministro y, a partir de ahí, se determinaron las situaciones para aumentar la estabilidad de las cadenas de suministro. La elección de un modelo de estabilidad creciente de las cadenas de suministro se determinó mediante el proceso de jerarquía analítica. El análisis jerárquico se utilizó como método para seleccionar una situación para aumentar la sostenibilidad de las cadenas de suministro en la construcción.
Resultados: Los resultados de la investigación llevada a cabo para realizar una elección multicriterio utilizando las opiniones de expertos en la industria de la construcción. La elección de escenarios para aumentar la sostenibilidad se debe a que la introducción de tecnologías de la información adaptativas permite tener en cuenta todos los grupos de factores seleccionados, al tiempo que garantiza la sincronización de la planificación de la producción, el envío de productos y la gestión de inventarios, aumentando la retroalimentación del mercado, asegurando que los volúmenes de producción se correspondan con la demanda de productos, así como reduciendo los costes logísticos y el precio de los productos para el cliente final.
Investigación e implicaciones prácticas y sociales: El estudio contribuye a una mejor comprensión de los factores cruciales de la sostenibilidad de las cadenas de suministro en la construcción. Los procesos de análisis y evaluación de los factores contribuyen a mejorar la sostenibilidad de las cadenas de suministro en la construcción, al centrarse en los factores críticos, adoptándolos en función de los requisitos de la construcción.
Originalidad/valor: Sobre la base de los resultados presentados, se concluye que la formación de escenarios de aumento de la sostenibilidad de la sostenibilidad de las cadenas de suministro mediante la introducción de tecnologías de la información adaptativas permite tener en cuenta todos los grupos de factores seleccionados, al tiempo que garantiza la sincronización de la planificación de la producción, el envío de productos y la gestión de inventarios, aumentando la retroalimentación del mercado, asegurando que los volúmenes de producción se correspondan con la demanda de productos, así como la reducción de los costes logísticos y el precio de los productos para el cliente final.

Palabras clave: Cadenas de Suministro, Sostenibilidad, Construcción, Escenario, Métodos.

INTRODUCTION

The stability and the supply-chain efficiency have one of the most important function in the modern economy. Since the beginning of the year 2020 majority of the states all over the world closed their borders and in so doing, they created hindrances to the international trade and transportation. Since the beginning of the year 2020 the pandemic touched upon all aspects of the economic action, so there are problems with the important of supply chains in the logistic and transport systems. Change in offer and demand, which followed the world lockdown, showed the sore spots in the production strategies and supply chains of the companies in different branches of economic activity.

The temporary trade restrictions and deficiency in some goods heightened the political and competitive pressure in order to raise the domestic production and also to reduce or even to bridge dependence on the external sources and to give a new meaning to using of lean strategies, which intends minimization of the amount of stock in their supply chains. Companies has a priority task to make their supply chains more stable, in such case without reducing of their competitiveness.

Under such conditions the determining of the extra stock level enters into the foreground and also its form and location in the value chain. Clearly the reserve stock carries a risk of obsolescence and also freezes monetary funds. It contradicts general practice of the timely inventory replenishment.

Economic of such practice must be brought into correlation with all costs of failure including the loss of income and heavy prices of supplies, which are limited. The time and efforts which need for the buying of the supplies should be also paid.

New trajectories of the development of the supply chains should become orienting points for the companies which are intend to maximize the benefit from the integration.

The current conditions place new demands on the supply chain stakeholder because the competitive advantage depends on the management structure which will react to the change in the external medium parameters rapidly. So, the aim of this study is to examine acceptable methods for choosing directions for increasing the sustainability of supply chains in construction. The study also determinate the factors affecting the sustainability of supply chains in construction

LITERATURE REVIEW

The increasing stability of the supply chains in the modern economic environment requires the comprehensive research of the factors which exert influence on the stability. There is much discussion about research of the factors of the supply chains stability in the in the scientific community. But the scientifics have diverse judgements upon the subject.

The first group of the authors researches the problems of supply chain stability from the point of view of the sustainable economic development concept forming the paradigm. – “the sustainable supply chains management” (SSCM). The conception of the sustainable supply chain (SSCM) is based on the increasing of the economic efficiency SCM using the social-ecological aspects not only in the material, information and financial management but also in the cooperation among companies (Carter and Rogers (2008)). As opposed to the conception of the supply chain management (SCM), in which the clients requirement is the main driver, the conception of the sustainable supply chain (SSCM) takes into account neighborhood effects and also requirements of the external to the supply chain related parties (Seuring and Müller (2008)).

Keeping the conception SSCM, Sembiring, Tambunan, Ginting (2020) lays stress on the priority of the ecological standards in the process of the ensuring of sustainability above the economical standarts. In the author's opinion when choosing suppliers, it is necessary to take

into account the ecological regulatory compliance by them, moreover as a top target should be the raising corporate social responsibility in the process of the functioning of the supply chain.

Advocating this theory SSCM Seuring and Müller (2008) conducted content analysis more than 140 sources about supply chai stability and came to the decision that about quarter of all researched articles drilled down either the social factors as the top factors, or the interrelation of the ternion of sustainable development. The authors researched the methods which were used for the determination of the stability factors and made clear that by the analysis within SSCM dominates empirical analysis (123 articles) compared with the theoretical or desk researches (68 articles) (Seuring and Müller (2008), Oelze, Brandenburg, Jansen, Warasth (2018)).

Carter and Easton (2011) researched the influence of the factors of the supply chains stability within the concept of SSCM. In their works they came to the decision, that terms "ecological" and "sustainable" are used in the scientifical literature as intersubstitutable in more than half of the works. In more than quarter of the works the supply chain stability relates with the corporate social responsibility (CSR).

The other group of scientific identifies the factor of information management as the priority factor of the increasing of the supply chain stability. The authors who adhere to this opinion take up the position that the supply chains stability depends on completeness and timeliness of information about market uptake, time of delivery, order volume, price changes and other factors and misrepresentation of information creates unforeseen problems in the supply chains.

Graves (1999), Chen et al. (2000), Lee & Whang (2000) and the other scientifics researched the degree of influence of the quality of information on supply chain stability. So, Graves (1999) explains the influence of a poor-quality prediction on the bullwhip effect or else the effect of "imaginary swings in requirement". Chen et al. (2000) explains the influence of the information about the prediction on the lead-time interval and volume of stocks based on the simulation approach. Lee & Whang (2000) said that the exchange of information brings to bear influence on the determining of order quantity for a supplier from the standpoint of the decreasing inventory levels and their costs. Shaban (2020) carried out research in the modeling of dispersion in the supply chain. In his investigation the author used a simulation model for studying of the influence of the correlated requirement on the coefficient of diversion of the orders, the magnification factor of net holdings and the middle gear of filling in different circumstances.

Park (2020) also carried out research of influence of needful information exchange level on the optimization of the supply chain. He studied the influence of the asymmetrical in-and out meanings of the informational flows on the speed of the filling of orders and total cost of stocks. He also explained that the synchronization of the informational flows guarantees profitability of every level of the supply chain and this fact will increase the stability of the whole supply chain.

Park (2020) found the dependence of the supply chain stability on the completeness and quality of information and he made it clear that it is impotent not only the information about an end-consumer but also the information about every element of the supply chain.

The authors of the third group consider the stock management as a stability factor. In their works Lee and Wu (2006) made it clear that supply stocks play an important role in the supply chain management and effective supply stocks management can increase the customers satisfaction, balance the plans for product release and reduce the supply chain costs.

The process of the stocks management is one of the critical factor of the industrial effectiveness that is why it is necessary to answer the questions: when and how much physical resources it is necessary to order, when must be produced the factory order, what level of reserve stock is needed. Validity of this factor of the increasing of the supply chain stability is described in the works of the following authors: Bowersox, Closs (2006), Andersson, Batten (1988), Mohamed (2014), Ceryno (2013), Gunasekaran (2003). Such methods and models of the stocks management in the supply chains are described in the works of Kot (2011), Wikner (2014).

The fourth group of the authors considers the supplier management as a factor of the stability increasing. The research in the fields of the supplier management as a factor of the stability increasing are focused on the studying of the stability criterion based on the Delphi method. In his article Wang (2019) characterized the choice of the stable suppliers as a main factor of the stability. He suggested the decision procedure for the choice of a supplier based on the normalized heterogeneous matrix construction and ranking of the alternative stable suppliers. In their research Evseeva and Gorshenin (2020) characterized the choice of the most favorable supplier as a factor of the chain reliability and of the cost reduction.

Consequently, one more group of factors of the stability guarantee appeared in the in the scientific community - relational competences. In his research Segu (2020) explains the importance of the relational competences along with the information technologies.

The competence in the relationship is the determinative factor in the supply chain which characterizes and strengthen the partnership. The competence in the relationship can improve

the productiveness of the supply chain and influence on the activity model of the supply chain. According to Wu et al. (2014) the relational competence lets exchange information and it extends relationship among partners. The relational competence lets the supply chain partners concentrate on the general purposes, taking decisions and establishing partnerships (Zacharia et al. (2011), Wittman et al. (2009), Kumara and Rahmanb (2015) also stressed the importance of immersion into the partnerships, belief and personal interaction which are cornerstones of the relational competence and influence on the business partnerships.

Thanks to the relation competence companies expand activities over the whole supply chain and promote the integration of the system and internal and external resources (Segu (2020). Kumara, Rahmanb (2015) demonsrated that the sustainability performance of each partner in the supply chain influence on the stability of the whole supply chain, in such a case, relationships “customer - supplier” play an important role in the stability increasing of the supply chain. On the base of the literature review he made a conclusion that most of the problems which are connected with the sustainable development can be solved through relationship management.

The construction industry has significant features of the organization of the production process and, consequently, supply chains. Research on construction supply chains reveals such features and causes of their instability (Akintoye, McIntosh, Fitzgerald, 2000). The importance of creating integrated supply chains for construction projects is shown in the work of Malik Khalfan and others (2008). The issues of coordination in supply chains in construction (which can significantly increase their sustainability) are considered in Othman, Rahman (2010). The use of various concepts for supply chain integration in the construction industry is presented in McDermotti & Khalfan, (2012). The effect of moving from traditional to partner procurement within construction supply chains is shown in Khalfan, Mcdermott, P., & Cooper, R. (2005).

MATERIAL AND METHODOLOGY

The study of the methodology indicated in the scientific literature allowed us to make a conclusion that the authors use both quantitative and qualitative methods. The content analysis is the prevailing method of the choice of the directions for improving of the supply chains sustainability. So, in his work, Saeed (2017), on the base of the content analysis, made a conclusion that of the 232 articles related to sustainable development, 46% were related to the increasing of the sustainability on the base of environmental factors, 43% were related to social factors and 11% were related to economic factors of increasing of the sustainability.

The scenarios for ensuring of the supply chains stability in the medium term are proposed at the third stage from the point of view of system analysis on the base of the selected factors:

- Implementation of cloud-based technologies for the supply chain planning (A)
- Integrated planning (B)
- Stock provisioning policy (C)
- The supplier network expanding (D)

The strategy of implementing of modern IT technologies based on cloud computing is able to integrate information flows at different levels of the supply chain, as well as provide a relevant level of relationship management, and accordingly include factors such as information, relational competencies, suppliers and inventory.

The implementation of integrated planning will allow to take into account the movement of material and information flows, including environmental and social factors.

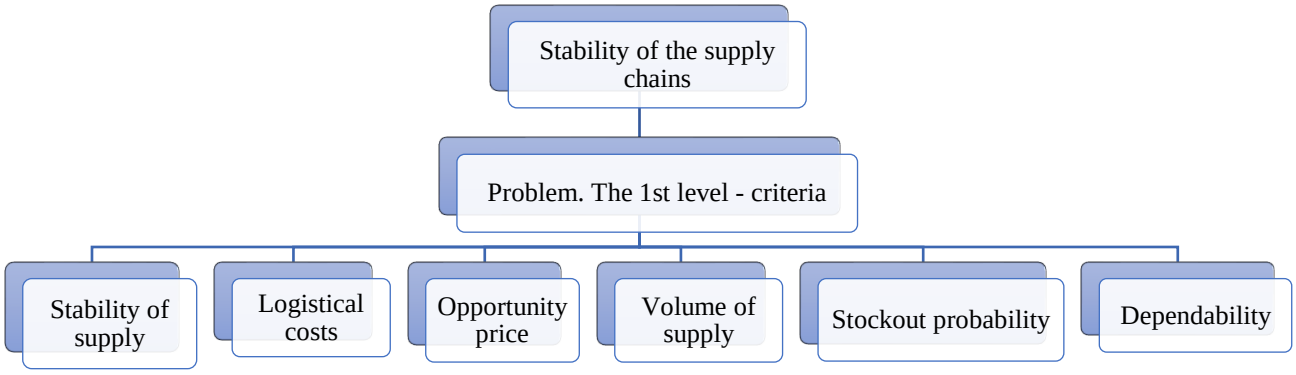
The inventory reservation policy is based on the inventory management system, determining the level of current and insurance stocks at each top of the supply chain on the base on forecasting data.

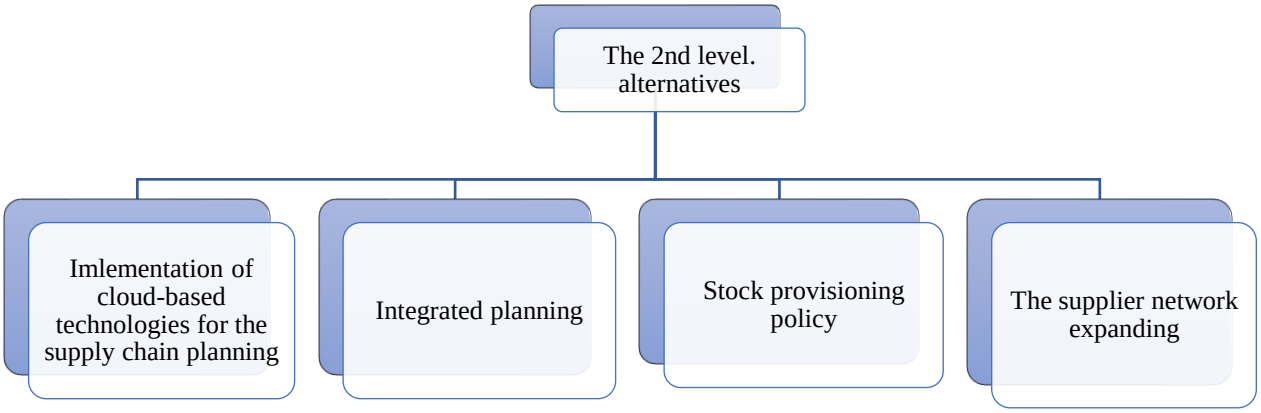
The choice of alternatives to increase of the supply chains stability in the short term is carried out by the method of hierarchy analysis (MHA). The advantage of MHA over most existing methods is a clear expression of the opinions of experts and decision makers, as well as a clear representation of the structure of the problem: the elements and interdependencies.

Let's present our task in a hierarchical form, defining the goal, selection criteria and alternatives.

The general goal (focus) of the problem - improving of the supply chains sustainability is the highest level of the hierarchy. Each of the criteria can be divided into sub-criteria. The level of alternatives follows the sub-criteria the quantity of which can be quite large.

FIGURE 1. Tree of objectives for selecting of scenario for increasing of the supply chain sustainability





Source: Prepared by the authors (2022).

Processing of results in MHA carries out on the base of matrix analysis methods using of special procedures for evaluating preferences based on a special MHA - scale. The importance of the criteria is evaluated by pairwise comparisons of each factor with each other.

RESULTS AND DISCUSSION

Introduce the notation of the compared factors:

A1 – Supply stability;

A2- Logistic costs;

A3 – Price conditions for the use of alternatives;

A4 – Scope of supply;

A5 - stockout probability;

A6 - Dependability;

Compare the criteria with each other in terms of significance. The results of determining the priority vectors are presented in Table 1.

TABLE 1. Pairwise comparison matrix

Factors	A1	A2	A3	A4	A5	A6	∑	Priority vector	ƛ	IC	RI	CR
A1	1	2	3	9	6	4	25	0,389240				
A2	0,5	1	2	5	4	2	14,5	0,225759				
A3	0,33	0,5	1	4	3	2	10,833	0,168671				
A4	0,11	0,2	0,25	1	0,5	0,33	2,3944	0,037281	6,215	0,043	1,24	0,0347
A5	0,17	0,25	0,33	2	1	0,5	4,25	0,066171				
A6	0,25	0,5	0,5	3	2	1	7,25	0,112880				
∑	2,36	4,45	7,08	24	16,5	9,83	64,228	1,000000				

IC - index of conformity
RI - random index of conformity
CR - conformity relation
Source: Prepared by the authors (2022).

The next step is to calculate of the priority vector for this matrix. In mathematical terms, it means the calculation of the main eigenvector, which after normalization becomes the priority vector. The priority vector was determined by summing the elements of each row and normalizing it by dividing each sum by the sum of all elements. Let us define priority vectors. To do this, we will compile special tables - matrices of pairwise comparisons for each criterion, an example of evaluation by criterion A1 is presented in Table 2.

TABLE 2. Pairwise comparison matrix by the criterion A1

	A	**B**	**C**	**D**	**∑**	**Priority vector**	**λ**	**IC**	**RI**	**CR**
A	1	7	3	3	14	0,547730829				
B	0,14	1	0,5	0,5	2,14	0,08372457				
C	0,33	2	1	1	4,33	0,169405321	3,8541	0,0486	0,58	0,0839
D	0,33	2	1	1	4,33	0,169405321				
∑	1,8	12	5,5	5,5	24,8					

Source: Prepared by the authors (2022).

After finding the priority vectors by factors and evaluation criteria, it is necessary to calculate the conformity indicators of the matrix. The CR values by all criteria are less than the established threshold of conformity 0.10 Therefore, the results can be considered acceptable. The final stage of the analysis is the selection of priority by the hierarchy analysis method. The generalized weights or priority of activity options are equal to the sum of the products of the local priorities of each option by each criterion of significance of the criterion.

TABLE 3. Priority selection by MHA

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**Priority by MHA**
Priority vector	0,3892	0,2258	0,1687	0,0373	0,06617	0,1129	
A	0,56	0,38	0,14	0,52	0,39	0,399	0,4176234
B	0,09	0,15	0,07	0,096	0,39	0,106	0,1220615
C	0,17	0,38	0,39	0,189	0,143	0,399	0,27932011
D	0,17	0,09	0,39	0,189	0,074	0,096	0,17506368

Source: Prepared by the authors (2022).

According to table 3, the optimal alternative for improving of the supply chains sustainability in the short and medium term is the scenario «Introduction of cloud-based planning technologies of supply chains».

CONCLUSIONS

Based on the presented results, it can be concluded that the main goal proposed in this study was achieved, since it became possible to identify the factors for improving of the supply

chain sustainability and formulate scenarios for improving sustainability in the short term. To select priority scenarios for increasing of the sustainability, the method of expert assessments was used with the participation of 30 specialists in the logistic field. The choice of scenarios for increasing sustainability is due to the fact that the introduction of adaptive information technologies allows to take into account all groups of selected factors, while ensuring synchronization of production planning, product shipment and inventory management, increasing market feedback, ensuring that production volumes correspond to product demand, as well as reducing logistics costs and the price of products for the end customer.

In the next stage of the study it is important the definition of stability margin and critical values of the supply chains stability and analysis of dynamic properties of supply chains in pre-defined borders of change of structural parameters and output variables.

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