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ANALYTICAL-HIERARCHICAL MODEL FOR ASSESSING THE INFLUENCE OF STAKEHOLDERS ON INTERNATIONAL SUPPLY RISKS: CASE STUDY OF UKRAINE

АНАЛІТИЧНО-ІЄРАРХІЧНА МОДЕЛЬ ОЦІНЮВАННЯ ВПЛИВУ ЗАЦІКАВЛЕНИХ СТОРІН НА МІЖНАРОДНІ РИЗИКИ ПОСТАЧАННЯ: ДОСЛІДЖЕННЯ УКРАЇНИ

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Пукаляк М.Р. Аналітично-ієрархічна модель оцінювання впливу зацікавлених сторін на міжнародні ризики постачання: дослідження України. Науково-методична стаття.

У статті досліджено міжнародні ризики постачання та запропоновано підхід до їх оцінювання на основі методу аналізу ієрархій (АНР). Метою є формування ієрархічної моделі для систематизації складових ризиків і визначення їх відносної вагомості у прийнятті управлінських рішень. Виокремлено шість груп ризиків: економічну, організаційно-управлінську, технологічну, логістичну, екологічно-соціальну та зовнішньополітичну. Для кожної групи визначено систему показників комплексного оцінювання. Запропонована тривірнева модель формує методичну основу застосування АНР для оцінювання міжнародних ризиків постачання. Практична цінність підходу полягає у систематизації факторів ризику та підтримці управлінських рішень.

Ключові слова: міжнародні ризики постачання, оцінювання ризиків, метод аналізу ієрархій (АНР), багатокритеріальне прийняття рішень, міжнародна логістика, аналіз зацікавлених сторін, управління ризиками

Pukaliak M.R. Analytical-Hierarchical Model for Assessing the Influence of Stakeholders on International Supply Risks: Case Study of Ukraine. Scientific and methodical article.

The article examines international supply risks and proposes an assessment approach based on the Analytic Hierarchy Process (AHP). The study aims to develop a hierarchical model for systematizing supply risk components and determining their relative importance in managerial decision-making. Six risk groups are identified: economic, organizational and managerial, technological, logistical, environmental and social, and geopolitical. A set of indicators is defined for each group to support comprehensive risk assessment. The proposed three-level model provides a methodological basis for applying AHP to international supply risk assessment. Its practical value lies in systematizing risk factors and supporting managerial decision-making.

Keywords: international supply risks, risk assessment, Analytic Hierarchy Process (AHP), multi-criteria decision-making, international logistics, stakeholder analysis, risk management

Depending on the type of supply, the assessment of supply risks is formed differently, since both the conditions of operations and the factors affecting their reliability change. In turn, stakeholders play a key role in this process, who directly or indirectly influence the emergence, increase or minimization of risks. In this regard, to determine the priority of stakeholders, it is necessary to assess their influence on the formation of international supply risks. Stakeholders are not only a source of risks (for example, due to non-fulfillment of obligations, changes in terms of cooperation or regulatory restrictions), but also an important tool for reducing them through coordination of actions, exchange of information and increased transparency of interaction.

In addition, different groups of stakeholders have different levels of influence on individual aspects of international supply – economic, logistical, political or technological. That is why their identification, ranking, and consideration of interests in the risk assessment process allows for increased validity of management decisions and ensures more effective functioning of the international supply system in conditions of uncertainty, which is relevant in today's conditions.

Analysis of recent publications on the problem

Modern research in the field of supply chain management pays considerable attention to the problems of identification, assessment and minimization of risks arising under the influence of economic, political, technological, logistical and socio-ecological factors. In the works devoted to risk management, it is emphasized that the growing instability of the global environment, the complication of international relations and the strengthening of dependence between the participants of supply chains require a transition from the traditional response to risks to their comprehensive assessment and forecasting.

Abernikhina I. [1] explores approaches to risk management using international standards, in particular: ISO 31000, COSO ERM and FERMA. The author presents the advantages and disadvantages of each of the considered methods and based on them, an organizational and functional model of the risk management system is formed.

The formed model contains key elements that will monitor risks: a risk committee, a risk management center, specialists in risk management of production processes and a digital risk platform. Therefore, if there is an opportunity to plan and identify risks, then any enterprise will bear lower costs. However, the proposed approach is mainly focused on the organizational aspect of risk management and does not take into account a comprehensive quantitative assessment of risk factors in international supply chains.

In the work of Bezditko O. [2], important problems of forming logistics supply chains in Ukraine are presented. In general, the authors focus on reducing trust between partners, disruptions in information systems, imperfect transport infrastructure, losses due to delays in deliveries. Accordingly, the authors provide detailed characteristics of the identified problems, and therefore provide a strategy for the formation and management of logistics supply chains, which contains indicators of efficiency, the use of innovations and safety barriers. The analysis of this article makes it possible to note the need to allocate risk components within supply chains, as this will ensure high-quality and effective functioning of the supply system. However, the issues of determining the relative importance of individual risk groups and their comprehensive quantitative assessment remain insufficiently addressed.

The assessment of supply chain risks in the pharmaceutical industry was carried out in the work of Ilchenko N. [4] and socially responsible risk management of logistics chains for the export of agricultural products was considered in the work of Lyman V. [5]. The author of the work [5] focused on the risk management stage, which includes risk identification and assessment, development of response strategies and implementation of measures, monitoring and control of risks, communication with stakeholders and adaptation and improvement of risks at enterprises. The proposed stages of risk management will contribute to increasing the efficiency of enterprise operations, reducing uncertainty and ensuring the stability of supply chains in a changing external environment. In these works, significant attention is paid to the stages of risk identification, development of response and control strategies, however, the proposed approaches are mainly sector-specific and do not form a universal model for assessing international supply risks.

In the study [8], the authors consider the sustainability of supply chains in e-commerce. In particular, the scientists identified such problems in supply chains as the increase in transportation costs, limited infrastructure, cybersecurity, reverse logistics, etc. In order to ensure the sustainability of supply chains in e-commerce, the authors propose the use of a 3 PL strategy for operators, which will ensure visibility, security and reliability of cooperation. At the same time, a significant part of existing approaches focuses on individual types of risks, while an integrated assessment of their cumulative impact remains a relevant scientific task.

It is relevant to study the scientific works of authors who used the analytical-hierarchical research method. Accordingly, we found works in which the analytical-hierarchical evaluation method was used in other areas of activity, in particular: corporate social responsibility in determining the influence of stakeholders on the formation of CSR [10] and the influence of enterprises of various fields of activity (food, light, energy, machine-building and IT industries) on the formation of CSR [9]; in making decisions regarding corporate social responsibility in peacekeeping processes [14], assessing the level of innovative activity of the regions of Western Ukraine [5] and substantiating the priorities of technological development of the enterprise [13]. Therefore, the issue of assessing international supply risks on the basis of the analytical-hierarchical process, as well as determining the influence of stakeholders on their formation by building an appropriate AHP model, is relevant.

However, the analysis of current research indicates that the application of AHP for assessing international supply risks while simultaneously considering the influence of different stakeholder groups remains insufficiently explored. Most existing models either focus on specific categories of risks or do not take into account the role of actors that shape and influence the level of risk in international supply processes. Thus, the unresolved aspect of the general problem is the lack of a comprehensive methodological approach to assessing international supply risks that would combine the systematization of major risk groups, the determination of their relative importance, and the consideration of the influence of key stakeholders. This highlights the need to develop an AHP-based model for assessing international supply risks, which constitutes the objective of this study.

Identification of previously unresolved parts of the general problem

The purpose of the study is to study the influence of stakeholders on international supply risks. However, before studying the influence on supply risks, it is necessary to form the components of international supply risks. One of the effective methods for determining the influence of stakeholders and assessing their influence on the formation of international supply risks is the use of the analytical hierarchy process (AHP model), with the help of which a complex problem can be structured by components or elements [5, 9-14].

Formulation of research objectives (task setting)

The effectiveness of the proposed model lies in the detailed analysis of each studied element, which in turn leads to the study of all weaknesses and strengths. It is important to note that the AHP model is relevant in the context of globalization challenges, as it easily adapts to the conditions and factors of assessment.

Accordingly, to achieve the set goal, the following tasks must be performed:

- 1) determining the components of assessing international supply risks;
- 2) determining the stakeholders that influence international supply risks;
- 3) building an AHP model to assess the impact of stakeholders on international supply risks;
- 4) providing AHP assessment of the impact of stakeholders on international supply risks

5) analyzing the results of the assessment of the impact of stakeholders on international supply risks and drawing conclusions.

Materials and methods

The assessment of the impact of stakeholders on international supply risks must be carried out using six stages [10]. At the first stage, the components of the assessment of international supply risks are determined. Six main components are taken into account: economic, organizational and managerial, technological, logistical, environmental and social, and foreign policy. Such decomposition allows for a comprehensive coverage of all key aspects that affect the functioning of the international supply system. At the second stage, stakeholders are identified that influence the formation of international supply risks. These include: business representatives, representatives of customs authorities, suppliers, customers, society and local authorities, as well as employees. Each of these groups has a specific impact on individual risk components, forming both potential threats and opportunities for their minimization. The third stage involves building a hierarchical AHP model, in which the goal is at the top level – assessing the impact of stakeholders on international supply risks. The second level places the identified risk components, and the lower level places the relevant stakeholder groups. This provides structuring of the task and the possibility of pairwise comparisons.

At the fourth stage, the impact of stakeholders is directly assessed using the AHP model, which includes the formation of pairwise comparison matrices and the determination of weight coefficients for each group of stakeholders in relation to each risk component. The fifth stage involves the analysis of the results obtained, in particular, the assessment of the consistency of expert judgments and the interpretation of the determined weight coefficients. This allows us to establish the priority of stakeholders in the context of their impact on various types of supply risks. At the final, sixth stage, conclusions and recommendations are formed on the management of international supply risks, taking into account the determined impact of stakeholders. Thus, the proposed model allows us to systematically take into account the multifactorial nature of international supply risks and reasonably determine the role and priority of stakeholders in the process of their assessment and minimization.

The analytical-hierarchical model for assessing the impact of stakeholders on international supply risks is presented in Fig. 1.

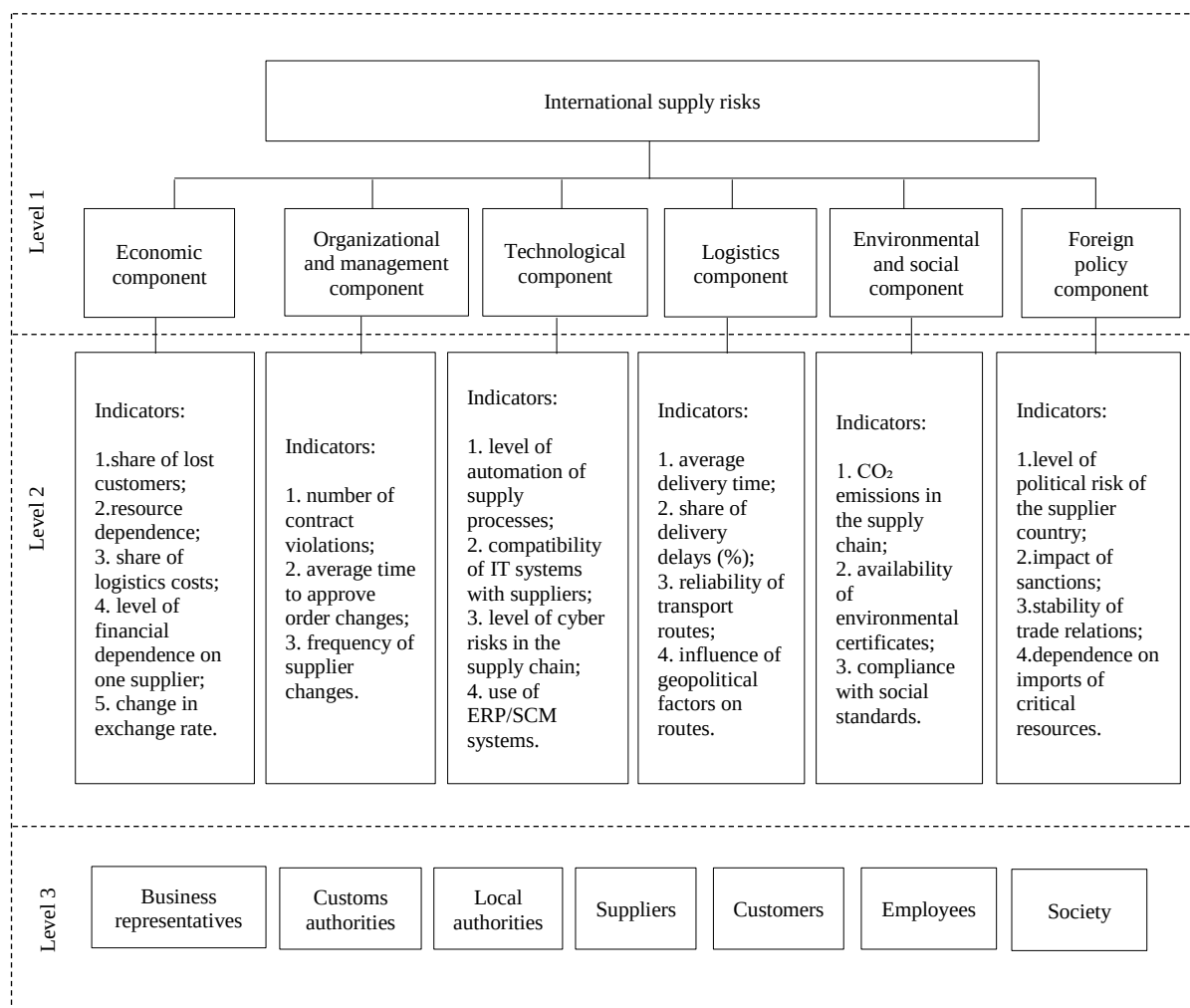


Figure 1. Analytical hierarchy model for assessing the influence of stakeholders on international supply risks

Source: elaborated by the author based on [5, 9-12]

The first level of the analytical-hierarchical model reflects the general goal of the study, which is to assess international supply risks. It is this goal that is an integrating element of the entire hierarchy and determines the direction of further analysis of the presented problem. To achieve it, international risks are structured according to six interrelated components: economic, organizational and managerial, technological, logistical, ecological and social, and foreign policy. Such a division provides comprehensive coverage of all the main areas of activity of the enterprise and the external environment that can affect the effectiveness of international supplies.

The economic component characterizes the financial stability of the international supply chain and determines the degree of its sensitivity to changes in the economic environment. It is assessed by such indicators as the share of lost orders, resource dependence, the share of logistics costs, the level of financial dependence on one supplier and changes in exchange rates for imported supplies. Lost orders reflect the direct economic consequences of the implementation of risks, resource dependence characterizes the degree of diversification of supply sources, financial dependence on a single supplier determines the level of risk concentration, and currency fluctuations directly affect the cost of imported products and the overall economic efficiency of the enterprise's international activities.

The organizational and managerial component reflects the level of effectiveness of coordination of interaction between participants in the international supply chain and the quality of management of partnership relations. It is assessed by the number of violations of contract terms, the average time for agreeing on changes in orders, and the frequency of changing suppliers. An increase in the number of violations of contractual obligations indicates insufficient efficiency of organizational processes or a low level of interaction between counterparties. A significant time for agreeing on changes in orders reduces the flexibility of the international supply chain and complicates the prompt response to changes in the external environment, while a high frequency of changing suppliers may indicate instability of the partner network or an insufficient level of trust between participants in international cooperation.

The technological component characterizes the level of digital maturity of the enterprise and its ability to use modern information technologies to manage international supplies. It includes indicators of the level of automation of supply processes, compatibility of information systems with suppliers, the level of cyber risks in the supply chain and the use of ERP and SCM systems. A high level of automation ensures a reduction in operating costs, an increase in the speed of information processing and a minimization of human errors [7]. At the same time, effective integration of information systems between all participants in the supply chain contributes to increasing the transparency of processes and the quality of management decision-making. Cyber risks are of particular importance, the relevance of which is constantly growing due to the digitalization of international trade and the increase in the number of electronic communications between counterparties.

The logistics component determines the efficiency of physical movement of goods along international transport routes and characterizes the level of reliability of logistics processes. It is assessed by the average delivery time, the proportion of delivery delays, the reliability of transport routes and the influence of geopolitical factors on the functioning of the logistics infrastructure [4]. Reducing delivery time increases the competitiveness of the enterprise, while increasing the number of delays negatively affects the fulfillment of contractual obligations and customer satisfaction [8]. At the same time, the reliability of transport routes increasingly depends on the international political situation, military conflicts, sanctions policy and other factors of global instability.

The ecological and social component reflects the compliance of the international supply chain with modern principles of sustainable development and corporate social responsibility [6]. For its evaluation, indicators of the level of CO₂ emissions in the supply chain, availability of environmental certificates and compliance with social standards are used. In the modern conditions of international business, the environmental responsibility of enterprises becomes an important factor of competitiveness, as more and more international partners pay attention to the compliance of suppliers with the requirements of environmental management, social responsibility and ESG principles [3]. Failure to comply with such requirements can lead not only to reputational losses, but also to the loss of access to certain international markets or participation in global value chains.

The foreign policy component covers various macro-environmental factors that are beyond the direct control of the enterprise, but have a decisive impact on the functioning of international supply chains. It is assessed by the level of political risk of the supplier country, the impact of international sanctions, the stability of trade relations and dependence on imports of critical resources. It is this component that allows us to take into account the impact of geopolitical instability, trade conflicts, international restrictions and government policies on the continuity of international supplies and the long-term sustainability of supply chains.

The second level of the analytical-hierarchical model is represented by a system of indicators that detail each of the specified components of international supply risks. It is these indicators that provide the opportunity to move from a general conceptual assessment to a quantitative measurement of individual aspects of risk. They serve as criteria for conducting expert assessment, forming matrices of pairwise comparisons according to the AHP methodology, determining local and global weighting factors and further calculating the integral indicator of international supply risks. Normalizing indicators to a single scale allows ensuring their comparability regardless of the units of measurement and the nature of the impact on the overall level of risk.

The third level of the analytical-hierarchical model is represented by the main groups of stakeholders that directly or indirectly influence the formation of international supply risks. Such stakeholders include business representatives, customs authorities, local authorities, suppliers, customers, employees and society. Business

representatives form a general risk management strategy, determine the policy of cooperation with international partners and make key management decisions. Customs authorities influence the speed of passage of goods across the state border, the duration of customs clearance and the level of administrative barriers. Local authorities create regulatory and legal conditions for the functioning of enterprises, influence the development of infrastructure and the investment climate of the region. Suppliers determine the stability of resource provision, the level of product quality, the timeliness of contractual obligations and the technological compatibility of production processes. Customers form requirements for product quality, delivery deadlines, service level and environmental responsibility. Employees ensure the direct implementation of operational processes, the implementation of technological procedures and the maintenance of the efficiency of the internal organization of the enterprise. Society exerts an indirect influence through the formation of social expectations, environmental requirements, public control and public assessment of the activities of enterprises.

An important feature of the proposed model is the presence of multiple relationships between the second-level indicators and the third-level stakeholder groups. This indicates that none of the risks is formed under the influence of only one subject. On the contrary, each indicator simultaneously depends on the actions of several stakeholders, and each group of stakeholders affects several components of international supply risks at once. This approach fully corresponds to the modern concept of supply chain management, according to which the effectiveness of the entire system is determined by the level of coordination and interaction of all its participants.

Thus, the proposed analytical-hierarchical model is a comprehensive tool for assessing international supply risks, which integrates systemic, risk-oriented and stakeholder approaches. Its use allows for a structured determination of the influence of different groups of stakeholders on individual risk components, a quantitative assessment of their relative importance using the hierarchy analysis method, a calculation of the integrated level of international supply risks, and a formulation of scientifically sound management decisions to increase the resilience of international supply chains in the face of global uncertainty and dynamic changes in the external environment.

In order to ensure AHP assessment of international supply risks, it is necessary to form a matrix of pairwise comparisons of Saati assessment elements [9, 11, 12]:

$$i \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix}, \quad (1)$$

where a_{ij} – results of expert evaluation regarding the priority of evaluation elements; n – total number of elements being evaluated; i – ordinal numbers of the elements being evaluated.

Presentation of main results and their justification

To determine the specific characteristics of international supply risks, it is necessary to conduct a survey involving the following groups of respondents: business representatives (executives and managers), customs authorities, and external stakeholders (suppliers and customers). The sample size is determined using the following formula [15]:

$$n = \frac{Q \cdot D^2 \cdot I \cdot S}{p^2 \cdot (Q-1) + D^2 \cdot I \cdot S}, \quad (2)$$

where, n – the required sample size; Q – the total number of stakeholders; D – the critical value corresponding to the 95% confidence level (1,96); I – the estimated proportion (set at 0.5); P – the margin of error (ranging from 0.05 to 0.1).

$$S = 1 - I. \quad (3)$$

After performing the necessary calculations, the required number of respondents is obtained.

$$\begin{aligned} n &= \frac{288 \cdot 1,96^2 \cdot 0,5 \cdot 0,5}{0,1^2 \cdot (288-1) + 1,96^2 \cdot 0,5 \cdot 0,5}, \\ n &= \frac{288 \cdot 3,8416 \cdot 0,25}{0,01 \cdot 287 + 3,8416 \cdot 0,25} \\ n &= \frac{276,6}{3,8304} \\ n &= 72,21 \end{aligned}$$

Therefore, the required sample size consists of 72 respondents. The respondents were distributed across the regions of the country and according to the previously defined categories: business representatives (executives and managers), customs authorities, and external stakeholders (suppliers and customers) (Table 1).

Table 1. Distribution of Respondents by Regions of Ukraine

Regions of Ukraine	Respondents			
	Business representatives	Customs authorities	Suppliers	Customers
1. Western (Lviv and Transcarpathian regions)	3	3	3	3
2. Central (Kyiv and Cherkasy regions)	3	3	3	3
3. Northern (Chernihiv and Sumy regions)	3	3	3	3
4. Eastern (Kharkiv and Dnipro regions)	3	3	3	3
5. Southern (Odesa and Mykolaiv regions)	3	3	3	3
6. Podilskyi (Vinnytsia and Khmelnytsk regions)	3	3	3	3
7. Total	18	18	18	18

Source: author's own elaboration

An even distribution of respondents will make it possible to ensure the representativeness of the sample, avoid regional biases in the research results, and increase the objectivity of the conclusions obtained regarding the assessment of supply risks.

A practical example of a matrix of pairwise comparison of components of international supply risks of the first level of the Saati hierarchy is presented in Table 2. The calculation of the components presented in Table 1 is carried out by an expert using the Expert Choice software.

Table 2. Matrix of pairwise comparison of international supply risk components of the first level of the hierarchy

Components of international supply risks	Components of international supply risks						Priority
	1	2	3	4	5	6	
1. Economic	1	3	5	1	7	3	0,26
2. Organizational and management	1/3	1	3	1/3	5	1	0,14
3. Technological	1/5	1/3	1	1/5	3	1/3	0,09
4. Logistics	1	3	5	1	7	3	0,26
5. Environmental and social	1/7	1/5	1/3	1/7	1	1/5	0,07
6. Foreign policy	1/3	1	3	1/3	5	1	0,18

Source: elaborated by the author based on [9, 11, 12]

The assessment is carried out by experts, by assigning points in the range from 1 to 9 and only odd numbers (the points indicate the importance value, where: 1 – equal, 3 – moderate, 5 – significant, 7 – significant, 9 – determining importance). The element that is more important than the element being compared with it receives a higher score [11, 12]. The results of pairwise comparisons of elements of the economic component of the second level of the hierarchy are presented in Table 3.

The results of pairwise comparisons of elements of the logistic component of the second level of the hierarchy are presented in Table 4.

Table 3. Matrix of pairwise comparison of elements of international supply risks
of the economic component of the second level of the hierarchy

Elements of international supply risks	Elements of international supply risks					Priority
	1	2	3	4	5	
1. Share of lost customers	1	1/3	1/3	1	1	0,04
2. Resource dependence	3	1	3	3	3	0,09
3. Share of logistics costs	3	1/3	1	3	3	0,07
4. Level of financial dependence on one supplier	1	1/3	1/3	1	1	0,03
5. Change in exchange rate	1	1/3	1/3	1	1	0,03

Source: elaborated by the author based on [9, 11, 12]

Table 4. Matrix of pairwise comparison of elements of international supply risks
of the logistics component of the second level of the hierarchy

Elements of international supply risks	Elements of international supply risks				Priority
	1	2	3	4	
1. Average delivery time	1	1	1/3	1/3	0,05
2. Share of delivery delays	1	1	1/3	1/3	0,05
3. Reliability of transport routes	3	3	1	1	0,08
4. Influence of geopolitical factors on routes	3	3	1	1	0,08

Source: elaborated by the author based on [9, 11, 12]

The results of the pairwise comparison of stakeholders of international supply risks of the third level of the hierarchy are presented in Table 5.

Table 5. Pairwise comparison matrix of stakeholders of international supply risks of the third level of the hierarchy

Stakeholders	Stakeholders							Priority
	1	2	3	4	5	6	7	
1. Business representatives	1	3	5	1	3	5	3	0,24
2. Customs authorities	1/3	1	3	1/3	1	3	1	0,14
3. Local authorities	1/5	1/3	1	1/5	1/3	1	1/3	0,06
4. Suppliers	1	3	5	1	3	5	3	0,24
5. Customers	1/3	1	3	1/3	1	3	1	0,14
6. Employees	1/5	1/3	1	1/5	1/3	1	1/3	0,06
7. Society	1/3	1	3	1/3	1	3	1	0,12

Source: elaborated by the author based on [9, 11, 12]

The obtained results are confirmed by the indices of accuracy, disagreement of expert opinions and stability [11]. The formulas for calculating the indicated indices are given below.

Formula for calculating the reliability of the obtained results (NR) [11]:

$$NR = \sum_{i=1}^n w_i \left(\sum_{j=1}^n k_{ji} \right), \quad (4)$$

where k_{ji} – j evaluation element of the i column of the formed matrix, n – number of elements that are evaluated against each other, w_i – international supply risk weighting.

Formula for calculating the accuracy of expert opinions (TE) [11]:

$$TE = S_i / E_i, \quad (5)$$

where S_i – stability indicator regarding the impact of international supply risks, E_i – random index.

Formula for calculating the stability of expert assessment (S_i) [11]:

$$S_i = P_{\max}^{-1} / n - 1, \quad (6)$$

where $P_{\max}$ – the highest value of expert assessment; n – total number of components of international supply risk assessment.

The results of pairwise comparison of components and elements of international supply risks for all levels of the hierarchy are presented in Table 6.

Table 6. Results of pairwise comparison of components and elements of international supply risks of all levels of the hierarchy

Hierarchy level	Items that were compared	Value
1	2	3
Level 1	Economic	0.26
	Organizational and management	0.14
	Technological	0.09
	Logistics	0.26
	Environmental and social	0.07
	Foreign policy	0.18
Level 2	Share of lost customers	0.04
	Resource dependence	0.09
	Share of logistics costs	0.07
	Level of financial dependence on one supplier	0.03
	Change in exchange rate	0.03
	Number of contract violations	0.07
	Average time to approve order changes	0.04
	Frequency of supplier changes	0.02
	Level of automation of supply processes	0.02
	Compatibility of IT systems with suppliers	0.01
	Level of cyber risks in the supply chain	0.04
	Use of ERP/SCM systems	0.02

Continuation of Table 6

1	2	3
	Average delivery time	0.05
	Share of delivery delays	0.05
	Reliability of transport routes	0.08
	Influence of geopolitical factors on routes	0.08
	CO ₂ emissions in the supply chain;	0.03
	Availability of environmental certificates	0.02
	Compliance with social standards	0.02
	Level of political risk of the supplier country	0.07
	Impact of sanctions	0.05
	Stability of trade relations	0.03
	Dependence on imports of critical resources	0.03
	Business representatives	0.24
Level 3	Customs authorities	0.14
	Local authorities	0.06
	Suppliers	0.24
	Customers	0.14
	Employees	0.06
	Society	0.12

Source: author' own elaboration

According to the results of the analysis at the first level of the hierarchy, it was found that the economic (0.26) and logistical (0.26) components have the greatest impact on supply risks. This indicates the critical role of financial stability, costs, and the efficiency of transport and logistics processes in the context of international activity. The foreign policy component (0.18) is also significant, reflecting the impact of geopolitical instability, sanctions, and changes in international trade. Organizational and managerial (0.14) and technological (0.09) factors have an average level of influence, while environmental and social risks (0.07) are currently the least significant, although their importance is gradually increasing in the context of global trends in sustainable development. Analysis of the second level of the hierarchy showed that among economic factors, resource dependence (0.09) and the share of logistics costs (0.07) have the greatest importance, which indicates the vulnerability of enterprises to supply constraints and increased transport costs. In the logistics group, the key factors are the reliability of transport routes (0.08) and the influence of geopolitical factors (0.08), which confirms the relevance of risks associated with disruption of supply chains. Among foreign policy factors, the level of political risk of the supplier country (0.07) and the influence of sanctions (0.05) dominate.

Organizational and management factors show that the greatest threat is breach of contract (0.07), while the frequency of supplier changes has the least impact (0.02). In the technology group, the most significant is the level of cyber risks (0.04), which emphasizes the growing role of digital security in supply chains. Environmental and social factors have relatively low values, but the level of CO₂ emissions (0.03) is more significant compared to other indicators in this group.

At the third level of the hierarchy, it is determined that business representatives (0.24) and suppliers (0.24) have the greatest impact, which is logical, since they are the ones who directly shape and implement the supply process. Customs authorities (0.14) and customers (0.14) also play a noticeable role, while the impact of local authorities (0.06) and employees (0.06) is less significant. Society has a moderate impact (0.12), reflecting the growing role of business social responsibility.

Conclusions and prospects for further research

The most critical for the international supply system are economic and logistical risks, which require priority management of these areas. The significant influence of foreign policy factors confirms the need to take into account the geopolitical situation when choosing suppliers and routes. Resource dependence and reliability of logistics are key bottlenecks in the supply system. The role of cyber risks is growing, which requires the implementation of modern IT solutions and data protection. The main subjects of influence are business and suppliers, so effective interaction between them is critically important. Despite their lower weight, environmental and social factors are of strategic importance in the long term.

Thus, the results of the AHP analysis allow us to reasonably determine the priority areas of risk management and form an effective strategy for ensuring the reliability of international supply chains. This, in turn, helps to increase the company's resilience to external and internal threats, optimize costs, minimize supply disruptions and ensure the continuity of operational activities. In addition, the use of this approach creates the basis for making strategic management decisions aimed at increasing the competitiveness of the enterprise in an unstable international environment.

Abstract

The article assesses international supply risks based on the analytical hierarchy process (AHP method). The AHP model provides for three levels of hierarchy, which allows for a comprehensive analysis of the impact of various factors and the subsequent determination of their relative importance. In general, the paper identifies six components of international supply risks: economic, organizational and managerial, technological, logistical, environmental and social, and foreign policy. Each of the formed components contains indicators that can be used to assess international supply risks. The AHP model reflects the relationship between the strategic goal of the study, key risk groups, the system for their quantitative assessment, and the main stakeholders who form or change the level of international supply risks. This model construction corresponds to the modern systemic approach to risk management, according to which international supply risks are considered as the result of the interaction of economic, organizational, technological, logistical, environmental, and foreign policy factors that are formed under the influence of a wide range of stakeholders.

The results obtained allowed us to determine the priority of individual risk groups and establish their impact on the overall level of international supply risks. Based on the calculations performed, the feasibility of using the analytical hierarchy process as an effective tool for supporting management decisions in conditions of uncertainty and multi-criteria was substantiated. The proposed approach provides an increase in the validity of the choice of management alternatives, contributes to the identification of critical risk zones and the formation of adaptive supply chain management strategies.

The practical significance of the results obtained lies in the possibility of using the developed AHP model to assess international supply risks at enterprises of various industries operating in conditions of global instability. This, in turn, contributes to increasing the stability, flexibility and competitiveness of logistics systems in the long term.

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