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**Гарафонова Ольга Іванівна**  
доктор економічних наук, професор,  
Київський національний економічний університет імені Вадима Гетьмана,  
кафедра менеджменту  
e-mail: ogarafonova@ukr.net  
<https://orcid.org/0000-0002-4740-7057>

**Янковой Роман Васильович**  
ЗВО «Міжнародний науково-технічний університет імені академіка Юрія Бугая»  
Автор  
<https://orcid.org/0000-0001-5307-0991>

**Кузьменко Олена Михайлівна**  
Кандидат економічних наук, доцент,  
доцент кафедри бізнес-економіки та підприємництва, КНЕУ ім. В. Гетьмана,  
<https://orcid.org/0000-0003-4954-2815>

**КВАЛІМЕТРИЧНЕ ТРАКТУВАННЯ ВЗАЄМОДІЇ ЕНТРОПІЇ  
ТА РИЗИКІВ У ПРОЦЕСІ ЗОВНІШНЬОЇ РЕЛОКАЦІЇ УКРАЇНСЬКИХ  
ПІДПРИЄМСТВ У ГЛОБАЛЬНОМУ СЕРЕДОВИЩІ**

**Garafonova Olga**

Doctor of Economic Sciences, Professor,  
Kyiv National Economic University named after Vadym Hetman,  
e-mail: ogarafonova@ukr.net  
<https://orcid.org/0000-0002-4740-7057>

**Yankovoi Roman**

Higher Education Institution «Academician Yuriy Bugay International Scientific and  
Technical University»  
<https://orcid.org/0000-0001-5307-0991>

**Kuzmenko Olena**

Kyiv National Economic University named after V. Hetman  
Department of Business Economics and Entrepreneurship  
<https://orcid.org/0000-0003-4954-2815>

**QUALIMETRIC TREATMENT OF THE INTERACTION OF ENTROPY  
AND RISKS IN THE PROCESS OF EXTERNAL RELOCATION  
OF UKRAINIAN ENTERPRISES IN THE GLOBAL ENVIRONMENT**

**Анотація.** Стаття присвячена дослідженню взаємодії ентропії бізнес-середовища та ризикових детермінант у контексті зовнішньої релокації українських підприємств у глобальному просторі. Обґрунтовано, що повномасштабна війна спричинила різке зростання невизначеності, порушення виробничих процесів та трансформацію ланцюгів доданої вартості, що актуалізувало релокацію як ключовий механізм забезпечення стійкості та адаптивності бізнесу. Запропоновано кваліметричний підхід до кількісного оцінювання релокаційної вразливості, який поєднує аналіз ентропійних характеристик середовища, груп ризиків та адаптивної спроможності підприємства. Релокація підприємств у глобальному вимірі має багатовекторний характер і формується під впливом комплексу ризиків — політичних, економічних, технологічних, логістичних і соціальних, — які виступають детермінантами ухвалення управлінських рішень щодо переміщення виробництва або бізнес-офісів за кордон. На основі факторного та кластерного аналізу ідентифіковано основні інституційні, ринкові, фінансові та соціальні параметри приймаючих країн, що виконують функцію антиентропійних факторів і визначають ступінь передбачуваності та стабільності середовища після переміщення. Побудовано інтегральний показник релокаційної вразливості, який дозволяє оцінити нелінійний ефект взаємодії ентропії та ризиків і визначити ключові детермінанти просторової мобільності підприємств. Показано, що релокація є не лише реакцією на кризові умови, а й стратегічним інструментом формування нових траєкторій розвитку та інтеграції у міжнародні бізнес-екосистеми. Отримані результати формують методичну основу для розроблення державної політики підтримки релокованого бізнесу та оптимізації стратегічних рішень підприємств в умовах глобальної турбулентності.

**Ключові слова:** релокація підприємств; ентропія бізнес-середовища; ризики; кваліметрична оцінка; релокаційна вразливість; адаптивність; глобальне середовище

**Abstract.** The article is devoted to the study of the interaction of business environment entropy and risk determinants in the context of external relocation of Ukrainian enterprises in the global space. It is substantiated that the full-scale war caused a sharp increase in uncertainty, disruption of production processes and transformation of value chains, which

*actualized relocation as a key mechanism for ensuring the stability and adaptability of business. A qualimetric approach to the quantitative assessment of relocation vulnerability is proposed, which combines the analysis of entropic characteristics of the environment, risk groups and adaptive capacity of the enterprise. The relocation of enterprises on a global scale has a multi-vector nature and is formed under the influence of a complex of risks — political, economic, technological, logistical and social — which act as determinants of making management decisions regarding the relocation of production or business offices abroad. Based on factor and cluster analysis, the main institutional, market, financial and social parameters of host countries that perform the function of anti-entropic factors and determine the degree of predictability and stability of the environment after relocation are identified. An integral indicator of relocation vulnerability is constructed, which allows assessing the nonlinear effect of the interaction of entropy and risks and identifying key determinants of spatial mobility of enterprises. It is shown that relocation is not only a reaction to crisis conditions, but also a strategic tool for forming new development trajectories and integration into international business ecosystems. The results obtained form a methodological basis for developing a state policy to support relocated businesses and optimizing strategic decisions of enterprises in conditions of global turbulence.*

**Key words:** *enterprise relocation; business environment entropy; risks; qualimetric assessment; relocation vulnerability; adaptability; global environment*

JEL codes: C51; C52; C53; D81;

**Statement of the problem.** In the current conditions of global economic turbulence, enterprises increasingly face rising levels of business-environment entropy, which manifests itself through greater uncertainty, market instability, geopolitical risks, and structural transformations within global value chains. For Ukrainian enterprises, these challenges have become especially significant due to large-scale external shocks, military aggression against Ukraine, the destruction of production and logistics infrastructure, changes in trade-flow configurations, and the need to maintain continuity of economic activity in a highly volatile environment. This, in turn, has intensified the processes of external business relocation as one of the key strategic mechanisms of adaptation, survival, and development.

Business relocation in the global dimension is multidirectional and shaped by a combination of risks—political, economic, technological, logistical, and social—that act as determinants of managerial decisions regarding the transfer of production facilities or business offices abroad. In this context, understanding how external-environment entropy interacts with risk factors and transforms enterprise behavioral models, forming new trajectories of global business mobility, becomes critically important.

At the same time, the study of relocation processes requires not only theoretical reflection but also quantitative assessment that enables an objective evaluation of the influence of different groups of factors on decisions to relocate a business. In this regard, the application of a qualimetric approach opens up opportunities for developing integrated indices, evaluation scales, and comparative analysis models that allow systematic measurement of entropy levels, aggregate risk, and enterprise relocation potential. Such an approach creates a methodological basis for designing effective strategies of adaptation and reorientation in the global environment.

Therefore, examining the interrelationship between entropic processes, risk factors, and the global relocation of Ukrainian enterprises—combined with qualimetric

measurement—is scientifically and practically relevant. It contributes to forming an analytical toolkit for substantiating managerial decisions, optimizing the international presence of businesses, and ensuring their resilience under multidimensional uncertainty.

**Analysis of research and publications.** The issue of business relocation in Ukraine has gained particular relevance after the outbreak of the full-scale war, which has led to significant transformations in economic, institutional, and managerial dimensions. Studies devoted to this topic propose various theoretical and applied approaches to understanding the causes and mechanisms of enterprise relocation. One of the first areas emerging in the academic discourse concerns the analysis of government policies aimed at supporting relocated companies. Study [1] emphasizes that the effectiveness of relocation largely depends on government actions focused on minimizing risks associated with the movement of enterprises and ensuring conditions for the restoration of their activities in safer regions. The authors highlight key barriers— infrastructural, financial, and logistical — and argue for the necessity of systematic state support.

An important aspect of current research is the use of qualimetric methods for analyzing relocation processes. Study [2] demonstrates that enterprises can enhance their resilience and adaptability by applying multi-criteria assessment tools. The author proposes a model that enables quantitative measurement of business-process efficiency during relocation and adaptation to new conditions. The financial dimension of business relocation is presented in study [3], which examines the sources and instruments of financing required for restarting companies at new locations. The authors emphasize the critical importance of access to concessional lending, grant programs, and local economic-support mechanisms. A similar perspective is developed in study [4], which underlines the role of risk-oriented management models in ensuring the sustainable functioning of relocated enterprises. Digital transformation plays a key role in ensuring business resilience. Article [5] argues that the implementation of digital tools allows minimizing losses during relocation, ensuring operational continuity, and optimizing stakeholder interaction. The study highlights the role of IT solutions in maintaining customer bases, enabling remote management, and adapting business models to hybrid environments. Another block of research focuses on the human factor. In study [6], it is emphasized that the success of relocation depends not only on material resources but also on the level of employee support, their readiness for change, and their ability to adapt to new conditions. The authors stress that an effective motivation policy reduces the risks of staff loss and improves productivity after relocation. An entropic perspective on business relocation is presented in study [7], where relocation is interpreted as a response to increasing entropy in the economic environment. The authors argue that growing uncertainty, instability, and systemic risks stimulate enterprises to engage in spatial mobility to stabilize their production processes. Socio-economic and gender aspects of relocation are examined in article [8], which shows that women-owned businesses relocated to EU countries face specific barriers—legal, linguistic, and social. At the same time, the authors highlight that a favorable institutional environment in Europe creates opportunities for the integration and development of these enterprises. Strategic and managerial aspects of relocation are addressed in study [9]. The article summarizes the experience of enterprises that relocated due to wartime conditions and demonstrates that the key factors of business survival include the flexibility of business models, local partnerships, and effective strategic planning.

Finally, study [10] expands the overall picture by illustrating how state institutions, businesses, and regional communities interact in the process of restoring economic activity. The research concludes that support for relocation must be integrated, comprehensive, and long-term.

**Identification of previously unresolved parts of the overall problem.** Despite the growing number of scientific studies devoted to business relocation under conditions of military threats, economic instability, and global transformations, several important aspects of this issue remain insufficiently explored in the contemporary literature. In particular, a comprehensive, scientifically grounded approach to integrating entropic characteristics of the business environment into managerial decision-making models for relocation has not yet been developed. The interaction between entropy, risk determinants, and enterprises' adaptive behavior is considered only fragmentarily, which complicates understanding the nature of business relocation vulnerability under multidimensional uncertainty.

Furthermore, mechanisms enabling the quantitative assessment of the influence of different groups of risks on decisions to relocate a business are not sufficiently examined, as existing models often overlook the need for multi-criteria analysis and fail to account for the synergistic interaction of internal and external factors. At the same time, systematic approaches to the qualimetric measurement of relocation vulnerability are lacking, which limits the possibilities for practical diagnostics of enterprises' conditions and forecasting their behavior. Another unresolved issue is the development of a typology of relocation strategies that incorporates the global context, including international value chains, cross-border risks, and new requirements for digital and organizational flexibility of businesses. Altogether, these gaps indicate the need for designing a new scientific and methodological approach that integrates entropic, risk-oriented, and qualimetric analysis to thoroughly investigate relocation processes.

**Purpose of the Article.** The purpose of the article is to provide a scientific justification and develop a comprehensive approach to assessing the impact of entropic changes in the business environment and risk factors on the relocation of enterprises in the global context by constructing a qualimetric model that enables a quantitative determination of the level of enterprises' relocation vulnerability and the identification of key determinants of their spatial mobility.

**Research methodology.** The research methodology is based on a systematic combination of theoretical and applied approaches that ensure a comprehensive examination of the impact of entropy and risks on business relocation in the global dimension using qualimetric tools. First, methods of theoretical generalization, system-structural analysis, and content analysis are applied to define the essence of relocation processes, identify entropic changes in the business environment, and develop a list of relocation-related risks. The empirical component is grounded in the collection of primary data through a survey of enterprises, which makes it possible to identify motivational factors, barriers, levels of uncertainty, and the scale of business adaptation after relocation. To process the collected data, factor analysis is used to structure latent groups of risks, regression modelling is applied to assess the influence of risk and entropy parameters on the probability of relocation, and cluster analysis is employed to build a typology of enterprises according to their relocation vulnerability.

A central element of the methodology is the development of a qualimetric model of an integral index of relocation vulnerability, which includes the selection of indicators,

their normalization, the determination of weights using expert or factor methods, and the calculation of a composite measure allowing for a quantitative assessment of the enterprise's propensity for relocation. The reliability of the results is ensured through the use of triangulation, cross-validation, and comparison of outcomes derived from different analytical approaches.

This methodology enables the formation of a holistic understanding of the influence of entropic processes and risk determinants on business relocation decisions and provides a scientifically grounded basis for developing recommendations for enterprises and public policy.

**Presentation of the main material.** The large-scale geopolitical transformations caused by the full-scale aggression against Ukraine have significantly exacerbated the challenges of maintaining economic activity and ensuring the continuity of business operations. Under conditions of sharply increasing entropy, turbulence, and uncertainty within the external environment, the destruction of production facilities, and rising risks faced by employees, external business relocation has become one of the key instruments for sustaining enterprise resilience and adaptability. In such circumstances, entry into foreign markets—previously viewed primarily as a strategy of international scaling or globalization-driven expansion—has acquired the character of a forced anti-crisis measure aimed at preserving operational activity and protecting human capital.

The relocation of Ukrainian enterprises abroad is not a homogeneous process, as it involves various models: from full transfer of production capacities to partial personnel migration, the establishment of temporary offices, or the creation of hybrid business structures. This variability necessitates a comprehensive scientific analysis of the motivations, organizational mechanisms, and economic consequences of relocation, enabling an assessment of its impact at both micro- and macro-levels. Accordingly, relocation serves not only as a direct response to crisis conditions but also as an important factor shaping new development trajectories by providing enterprises with access to export-oriented markets, international partnerships, investment resources, and support programs.

The academic study of the relocation phenomenon has become especially relevant because relocated businesses play an increasingly important role in the recovery of the national economy and in Ukraine's integration into global value chains. The analysis of enterprises that have already transferred their activities abroad makes it possible to identify the most effective adaptation models, determine major systemic barriers, and assess the long-term potential for scaling successful cases. Thus, the issue of relocation extends beyond a situational reaction to security threats and becomes an important subject of scholarly discourse in the context of economic security, sustainable development, and strategic management.

The results of the conducted research showed that many legal entities and sole proprietors were compelled to relocate abroad not only because of the direct impact of hostilities or threats to employee safety. Interviews with business representatives revealed that relocation decisions were often made spontaneously, under extreme time pressure, informational uncertainty, and psychological stress. This is a typical characteristic of business operation in a high-entropy environment, where managerial decisions must be made in the absence of stable reference points and predictable scenarios.

At the same time, the motives for relocation were not limited solely to physical security concerns. Respondents highlighted several additional factors, including:

- the desire to implement a long-standing strategic idea of entering foreign markets;

- assessment of a more favorable institutional, investment, and regulatory environment in the host country;

- the presence of personal or social ties abroad, which reduced adaptation barriers;

- prior experience in international cooperation, including participation in exhibitions, international projects, and collaborations, which fostered readiness for expansion.

The process of external relocation of Ukrainian enterprises takes place under conditions of heightened global economic turbulence, accompanied by increasing entropy of economic systems and the emergence of specific risks associated with adaptation to new jurisdictions. Within the qualimetric approach, the institutional and market opportunities of host countries may be interpreted as factors that reduce enterprise-level entropy, as they contribute to higher predictability of the operating environment and lower uncertainty in managerial decision-making. The research results made it possible to identify a set of institutional and market parameters of the host environment that constitute the foundation for a qualimetric assessment of the interaction between entropy and risk in the context of external business relocation. These parameters may serve as indicators of integrated evaluation of the adaptability and resilience of relocated enterprises.

One of the fundamental institutional factors reducing entropy during external relocation is the availability of systematic inventories of real estate assets and production facilities suitable for business activity. The operation of unified registries of available premises ensures informational certainty, shortens managerial decision-making time, and reduces transaction risks. In qualimetric terms, this parameter can be reflected through indicators of production infrastructure availability, real-estate market transparency, and speed of facility selection. Modernization programs for infrastructure and renovation of industrial facilities also serve as important components of an anti-entropy environment. The upgrading of energy supply systems, water supply, heating, ventilation, and digital networks stabilizes production processes and reduces operational risks.

From a qualimetric perspective, this group of indicators characterizes the level of technical and infrastructural readiness of the relocation environment and may be assessed through measures of energy reliability, digital accessibility, and infrastructure preparedness. Another significant factor reducing entropy is the availability of comprehensive programs supporting market access and expanding marketing opportunities for relocated enterprises. Such programs include public procurement mechanisms, export support schemes, institutional consulting, and analytical guidance. Access to information on the structure and dynamics of local markets reduces information asymmetry and supports more rational strategic decision-making. Within the qualimetric approach, these opportunities can be represented by indicators of market information availability, institutional support, and the level of enterprise integration into local markets.

A separate group of anti-entropy factors includes financial instruments for supporting relocated businesses. These include concessional loan programs,

specialized investment tools, support for innovative projects, and public-private partnership mechanisms. The availability of financial resources reduces liquidity and investment risks, which directly influences the level of economic entropy faced by enterprises. In qualimetric measurement, this block can be reflected through indicators of financial-resource availability, capital cost, and intensity of investment support.

Another dimension of entropy-risk interaction emerges through programs stimulating the return of enterprises to the recovering regions of Ukraine. Security mechanisms, funding for demining, tax incentives, and special economic regimes reduce strategic uncertainty and form long-term expectations regarding the possibility of reintegrating production. From a qualimetric perspective, these parameters may serve as indicators of strategic stability and predictability of enterprise development. Entrepreneurial networks, including associations of Ukrainian businesses abroad, also play an important role in reducing socio-economic entropy. They provide informational support, facilitate partnerships, and lower the risks associated with integration into new business ecosystems. These parameters may be evaluated using indicators of institutional embeddedness and the intensity of network interactions.

In addition to institutional factors, market opportunities in host countries represent important components of qualimetric assessment. Market openness, favorable logistical conditions, and access to international distribution channels reduce sales risks and increase the stability of enterprise cash flows. The geographical positioning of host countries often creates preconditions for the integration of relocated enterprises into global value chains, thereby reducing economic-process entropy.

Another important parameter that reduces entropy in entrepreneurial activity is the level of regulatory certainty in the host environment. Simplified business registration procedures, transparent tax systems, and effective property-rights protection reduce institutional risks and enhance the stability of business operations. In qualimetric terms, this block may be characterized through indicators of regulatory transparency, administrative efficiency, and tax-system stability.

Social factors also influence the level of entropy experienced by relocated enterprises. The entrepreneurial culture of host countries, support from local communities, and the activity of diaspora-based business associations form an environment of trust that reduces social risks and facilitates enterprise integration into local economic systems. Within a qualimetric approach, these characteristics may be presented through indicators of social embeddedness and levels of entrepreneurial support.

An important anti-entropy factor is the availability of labor resources and the ability to rapidly form production teams. The presence of a skilled workforce, developed vocational-education systems, and access to innovation-support programs reduce production risks and support the stabilization of enterprise operations. Qualimetrically, these parameters may be assessed through indicators of labor-resource availability, workforce qualifications, and innovation activity.

Thus, the institutional and market opportunities of host countries may be interpreted as a system of anti-entropy factors that reduce the risks associated with external business relocation. Their qualimetric representation enables the development of an integrated model for assessing the interaction of entropy and risks in the relocation process, forming a methodological basis for determining the level of adaptability, resilience, and development potential of relocated businesses in the global environment.

Therefore, the relocation of Ukrainian enterprises is a complex, multifactorial process that combines economic, security-related, psychological, and social determinants. As a result, diverse decision-making trajectories and behavioral models emerge under conditions of heightened turbulence. This approach allows relocation to be conceptualized as a specific form of entropy and risk management during periods of crisis-driven global transformations, making it an important subject for further applied and theoretical research.

**Discussion.** Under conditions of high entropy—characterized by increasing uncertainty, instability of environmental parameters, turbulence, destruction of production facilities, and continuously rising risks for personnel—external relocation has become one of the key instruments for ensuring the resilience and adaptability of enterprises. Entry into foreign markets, which in earlier periods was primarily interpreted as a strategy of international expansion, scaling, and integration into global economic processes, has in the current environment acquired the form of a forced anti-crisis decision aimed at preserving operational activity, protecting human capital, and developing alternative product-distribution channels.

A qualimetric perspective allows the decision-making process regarding relocation to be conceptualized as a function of the interaction among three interrelated groups of indicators: environmental entropy  $H$ , enterprise risks  $R$ , and the adaptive capacity and resilience of the enterprise  $A$ . This approach makes it possible to formalize relocation processes and transition from descriptive characteristics to quantitative measurement of enterprise relocation vulnerability.

For measurement purposes, an integrated indicator of relocation vulnerability is proposed:

$$IRV = \alpha H + \beta R - \gamma A + \delta(H \times R),$$

where  $\alpha, \beta, \gamma, \delta \geq 0$  are weighting coefficients determined either through expert methods Delphi or based on factor analysis. The positive interaction term  $H \times R$  reflects a nonlinear synergistic effect: under high entropy, even moderate risks sharply increase the probability of relocation, whereas an increase in  $A$  (digital maturity, financial buffer, network ties) reduces IRV and shifts decision-making from a reactive to a proactive mode.

**Conclusions.** The article demonstrates that the external relocation of Ukrainian enterprises is shaped by the complex interaction between entropic processes and risk factors, which determine the level of uncertainty and business resilience during periods of profound geoeconomic transformations. The application of a qualimetric approach made it possible to develop an integrated model for assessing relocation vulnerability that encompasses institutional, market, financial, and social parameters of the host environment. It has been established that anti-entropy factors—such as accessible infrastructure, regulatory certainty, market-support mechanisms, financial instruments, and entrepreneurial networking—significantly reduce risks and enhance the adaptability of relocated businesses. The research shows that relocation functions not only as an anti-crisis measure but also as a strategic resource for long-term development, opening opportunities for integration into global value chains.

The proposed model can be used to forecast enterprise behavior and to support the development of public policies aimed at strengthening business resilience under conditions of uncertainty.

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**Шлапак Алла Василівна**

доктор економічних наук, доцент  
проректор з науково-педагогічної роботи та інноваційного розвитку,  
Київський столичний університет імені Бориса Грінченка, Київ, Україна  
e-mail: av.shlapak@kubg.edu.ua  
ORCID ID: 0000-0001-8697-7039

**Бобер Лариса Петрівна**

старший викладач кафедри міжнародної економіки,  
Київський столичний університет імені Бориса Грінченка,  
Київ, Україна  
e-mail: l.bober@kubg.edu.ua  
ORCID ID 0009-0007-1910-9371

## ПРИЙНЯТТЯ РІШЕНЬ НА ОСНОВІ ДАНИХ У СТРАТЕГІЧНОМУ УПРАВЛІННІ ЕКОНОМІЧНИМ РОЗВИТКОМ МІСЬКИХ АГЛОМЕРАЦІЙ

**Shlapak Alla**

Doctor of Science in Economics, Associate Professor, Vice-Rector for Scientific  
and Pedagogical Work and Innovative Development,  
Borys Grinchenko Kyiv Metropolitan University, Kyiv, Ukraine  
e-mail: av.shlapak@kubg.edu.ua  
ORCID ID: 0000-0001-8697-7039