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Financial vectors of spatial development of an enterprise

Abstract. Enterprise development requires the use of additional financial resources that enterprises do not have. The use of traditional financing methods is often unavailable, which requires the search for new available financial vectors for enterprise development, such as venture investment, the stock market, crowdfunding, and crowdinvesting. Therefore, the paper aimed to provide information for choosing the most suitable financial vectors for enterprise development in existing business conditions. The study was carried out using historical and logical methods, system analysis, abstraction, and other methods of scientific research. The legal framework and historical experience of venture financing development in Ukraine and the specifics of the Ukrainian stock market functioning were analysed. It was established that the volume of venture investments was insufficient to ensure the development of medium-sized and large enterprises, while Ukrainian venture funds have been created mainly with the participation of international organisations or within the framework of intergovernmental agreements. The study of the Ukrainian stock market revealed the dominance of over-the-counter securities trading over organised exchange trading, the prevalence of transactions involving government bonds and the secondary market, and instability of the regulatory framework and transformations of market infrastructure elements. The unorganised nature of the Ukrainian stock market functioning was substantiated. The expediency of using crowdfunding as an alternative financial instrument for enterprise development was justified; its advantages and disadvantages were identified, along with the absence of clear legislative procedures for its regulation. It was determined that in Ukraine crowdfunding is predominantly used to finance social projects, while Ukrainian enterprises possess the potential to apply new, flexible, and adaptive financial vectors of development. The results obtained allow enterprises to familiarise themselves with the existing financial vectors for ensuring their development and choose those that are most appropriate for each enterprise

Keywords: venture capital; stock market; shareholder; crowdfunding; crowdinvesting

INTRODUCTION

The combination of dominant global approaches to enterprise development and Ukraine's internal conditions creates a specific environment for spatial enterprise development. The prevalence of globalisation and the adoption of international business practices often limit the creation of tailored development trajectories that optimise resource use and exploit available business opportunities. Inertia in large enterprises and isolated attempts at progressive production are insufficient to ensure comprehensive sectoral or national economic development. Therefore, the prospects for spatial enterprise development lie in the effective use of financial vectors, substantiated by the objective necessity of their application.

Despite the novelty of the above categories, certain developments of researchers in each of the suggested areas can be identified. V.V. Kudriavtseva & V.O. Boryshchak (2025) presented analytical studies of the possibilities of developing venture financing in Ukraine, based on the application of international experience. According to their findings, the development of venture financing should be supported with state support programmes, creation of favourable investment climate, improvement of intellectual property protection and legal regulation. The literature also addressed the use of venture financing for the development of innovative activity. V.O. Terletska (2023) noted the importance of using general methods and models of

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statistical analysis, econometric modelling with special tools for evaluating the results of the venture structure's functioning and forecasting its development in conditions of limited information when studying venture activities.

The Polish experience was analysed by W. Leoński (2022), who examined the application of crowdfunding and crowdinvesting in Poland. The study identified three reward-based platforms and two non-reward platforms, with no equity-based crowdfunding platforms. The popularity of crowdfunding was attributed to its simplicity, which enabled organisers to raise funds while participants received innovative products and engaged in unique projects; the findings also indicated its potential role in supporting the future development of Polish enterprises. Equity crowdfunding was examined by F.J. Mazzocchin & C. Lucarelli (2023), who identified factors influencing its success and failure. The results highlighted the role of hard information (firm, financial, and project characteristics) and soft information (intellectual, human, and social capital, and social media networks), enhanced by digital media that facilitate interaction between entrepreneurs and investors.

Research by C.K. Tiwari *et al.* (2023) argued for the need for government regulation of crowdfunding and crowdinvesting in developing countries. Researchers argued that the growing digital crowdfunding market can create opportunities for financial manipulation and fraud. Firms using this source of financing have been found to have weak capital structures and limited debt capacity. In addition, most investors financing these new businesses had relatively small investments compared to venture capitalists and business angels and have less experience in conducting the necessary due diligence and risk assessment of these investments. Y. Thalassinos (2023) also emphasised the importance of crowdfunding, but argued that in order for crowdfunding to become a respected and widely used financing tool, it is necessary to introduce rules to protect both startup founders and investors. Due to legal support, crowdfunding can act as a significant mean of mobilising private capital, which goes beyond the creative sector and becomes an active source of economic development for enterprises. The study of crowdinvestors by their investment strategies and motivations was conducted by M. Goethner *et al.* (2021) using cluster analysis based on individual investment decisions. Three types of crowdinvestors were identified: casual investors, crowders, and experienced investors, who differ in their response to project quality signals, information related to the project and social impact. It was found that crowdinvestors were by no means a homogeneous group, investors motivated by different factors who respond to different signals when making investment decisions.

The reviewed studies indicated the relevance of new financial vectors of enterprise development for the Ukrainian context. Due to the recent emergence of crowdfunding, crowdinvesting, and venture financing in Ukraine, the number of studies addressing these concepts remains limited. Nevertheless, the literature generally associated their emergence with the development of digitalisation, shifts in economic paradigms, and the transformation of financial intermediation institutions. The purpose of the study was to identify possible financial vectors for the spatial development of enterprises in Ukraine through the prism of their previous use in the existing institutional and economic conditions. The main objectives of the study were: to analyse the regulatory framework for the application of venture financing, the stock market, crowdfunding and crowdinvesting; to investigate the dynamics and features of the application of the specified financial vectors of spatial development of enterprises in Ukraine for the period 1991-2025; to identify the main trends in the development of financial vectors and the prospects for their application by Ukrainian enterprises.

MATERIALS AND METHODS

The object of the study was the financial development vectors of Ukrainian enterprises including venture financing, the stock market, crowdfunding, and crowdinvesting. The study focused on developments between 1991 and 2025, which fall within Ukraine's period of independence. It was based on the use of sources of statistical information (State Statistics Service of Ukraine, 2025), the investigation of the regulatory framework (Draft of Law of Ukraine No. 1082, 2009; Law of Ukraine No. 5080-VI, 2012; Law of Ukraine No. 2465-IX, 2022) and the analysis of the latest Ukrainian and international scientific papers. The selection of sources for this paper was guided by the principles of relevance, scientific reliability, legality, and originality. Relevance was ensured by considering the impact of the 2022 Russian military aggression and digitalisation on the application of financial vectors for spatial enterprise development. Scientific reliability involved the use of peer-reviewed research materials, while legality was maintained through the analysis of laws and regulations. The principle of originality prioritised primary sources containing new scientific results over secondary analyses.

The study employed the historical method, system analysis, abstraction, identification of causal relationships, and other scientific research methods. The historical method facilitated the identification of factors that stimulated or constrained the application of financial vectors for spatial enterprise development, considering the volumes and activity of venture financing, the stock market, crowdfunding, and crowdinvesting in their historical and economic context. System analysis combined quantitative data on these financial instruments with logical reasoning and experience to assess their interrelations and the influence of technical, economic, and socio-psychological factors. The abstraction method ensured clarity in analysing and evaluating the dynamics of financial vector application, with particular attention to prospects for their future use.

The presented study was carried out through the sequential passage of such stages as the formulation of the problem and the definition of the goal, when the relevance of the research question was determined. The second step involved the implementation of theoretical analysis based

on the investigation of scientific studies and research conducted, which resulted in the development of a research programme and the selection of methods for its implementation in the third stage. The next research stage was data processing, in particular, their quantitative and qualitative analysis and the identification of trends and patterns. The final stage of the study involved summarising the results and formulating conclusions. The sequential completion of these stages ensured the objectivity and scientificity of the results obtained, transforming isolated data into substantiated knowledge.

It was noted that the diversity of such vectors as venture financing, stock market development, crowdfunding, and crowdinvesting does not allow them to be reduced to single units of measurement, since venture financing uses such a unit of measurement as an object that may differ in size, the stock market operates with stocks, bonds, and derivatives (futures, options), crowdinvesting and crowdfunding use monetary units (UAH, USD). Each of these vectors had different levels of profitability or its complete absence, therefore, it was inappropriate to compare these vectors. In accordance with the fact that these vectors are only penetrating Ukrainian scientific thought and practice, it was important to analyse such initial trends with the purpose of their further application in the practice of enterprise development.

RESULTS AND DISCUSSION

Enterprise development is a multifaceted concept, which is most often characterised from a financial standpoint. However, despite this scientific development, such traditional methods of financial support for an enterprise as bank lending, leasing, grants, etc., are increasingly being revealed, however, in such conditions the author can emphasise the increasing need to develop financial vectors of enterprise development. Financial vectors of spatial development of an enterprise are ways to attract financial resources necessary for the enterprise and identify the cheapest ways to provide them to activate the main type of activity of the enterprise. Successful use of the possibilities of financial vectors of enterprise development allowed forming an effective capital structure, which leads to an increase in production capabilities. By the end of 2025 in Ukraine there was a significant predominance of small enterprises (State Statistics Service of Ukraine, 2025), for which the use of traditional means of attracting financial resources was extremely difficult due to the lack of a positive credit history and appropriate property security.

Under the conditions of simplification of business establishment and digitalisation, newly created business entities focused on the use of software products, attraction of intellectual resources, etc., do not own property that can be reliably estimated, accordingly, they lose the prospects of lending, while owning a development resource. In such difficult conditions, it is advisable to investigate new financial vectors of enterprise development, for example, venture capital investment, which is almost the only possible source of financing. Maximising the effect of cooperation between an entrepreneur and a venture investor, by definition of the researcher (Kuzmin *et al*., 2020), is possible in conditions necessity to use external experience, namely, a perspective vision, management assistance, and contemporary solutions of a team of venture managers.

Venture financing. For Ukrainian businesses, the use of the venture investment mechanism is relatively new. Despite the developed legislative framework, in particular the Draft of Law of Ukraine No. 1082 (2007), venture investment has not gained significant popularity. The development of venture investment in Ukraine can be characterised by two milestones – as a period of an unorganised market and a period of legally regulated functioning. The first stage of the development of venture business in Ukraine was the arrival of foreign direct investments from highly developed countries in 1992-2001. The second stage was started after the adoption of the Law of Ukraine No. 5080-VI (2012), which marked the beginning of the development of Ukrainian venture funds. Despite state assistance in the form of reduced taxation, which, as expected, was supposed to contribute to the growth of capitalisation, it did not lead to the active development of venture funds (Butko *et al.*, 2017). Despite the creation of establishment of venture direction in Ukraine, researchers emphasise its differences from global trends (Hryhor & Potapenko, 2019). Ukrainian realities suggest that venture funds usually operate with the aim of redistributing financial flows and minimising the tax burden, unlike other countries, where the main task of venture funds is to introduce innovations into production.

The instability of the external environment in combination with the riskiness of venture entrepreneurship itself has created a situation where Ukrainian venture market is mainly interested in enterprises of the second and third stages of the life cycle, namely, start-up and early-stage. However, there is no interest in the initial stages of generating and developing business ideas (Lytvyn & Bulak, 2022). This position of investors is quite correct, since the classic method of generating scientific and technical developments through the functioning of scientific schools at universities and research and development laboratories at enterprises at the current stage of technological development has exhausted itself, despite numerous scientific discussions. Moreover, the unpredictability of the environment keeps the owner of the enterprise from investing in new developments.

Despite the relatively high efficiency of capitalisation of venture funds in the form of 30% of capitalisation each year, the spread of their activities is not active towards newly created innovative enterprises (Onyshchenko, 2014). By the end of 2024, according to the Ukrainian Association of Investment Business (2025), 1,723 venture capital institutions with assets of a total value of UAH 548,551.0 million operated in Ukraine. Venture capital funds in Ukraine make up the largest part of joint investment institutions. The interpretation of this indicator in a time range is presented on Figure 1.

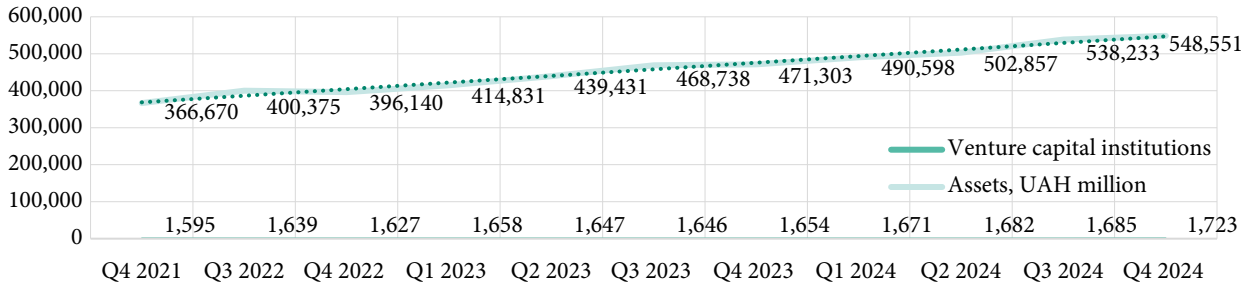

Figure 1. Dynamics of development of venture capital institutions in 2021-2024
Source: compiled by the author based on Ukrainian Association of Investment Business (2025)

The identified stable trends in the growth of the number of venture funds are also completely levelled by researchers (Kuzmin *et al.*, 2020), since a decrease has been detected in both the share of expenditures on scientific research and development and the share of innovative products in the total volume of industrial production in Ukraine. However, this position cannot be accepted, because the effectiveness of venture investment could be levelled both by the methods of forming statistical reporting, and by the fact that venture investments could be made specifically at small business entities which are not required to submit statistical reporting.

The analysis of the development of venture business in Ukraine, conducted by I.V. Lytvyn & Yu.V. Bulak (2022), showed an increase in the number of joint investment institutions per asset management company during the period 2021-2025, including during the full-scale invasion. A unique feature of this phenomenon was the dominance of the technological dominant in military affairs. Exactly the need for rapid technological responses at the front forces venture funds to intensify their activities. Exactly growing demand for innovative products forms the prerequisites for the expansion of venture investment, although until the war, most venture financing agreements were concluded unofficially due to the reluctance of participants to disclose information. Such kind of entry into the investment market of venture funds permits to consolidate their positions as one of the main investors in the post-war recovery in the future.

However, the venture capital market as a tool for spatial development is extremely unstable, it experienced a crisis at the beginning of the war in 2014 with an initial decrease and subsequent recovery of capital flows. However, the unstable economic situation has led to the fact that there are 3 venture capital companies operating in the country – the Direct Investment Fund "Ukraine", Ukrainian Growth Funds (UGF) and Western NIS Enterprise Fund. A feature of their activities is that they all have long-term investment experience, in particular, the Direct Investment Fund "Ukraine" is managed by Claflin Capital Management (Boston, USA) and since the beginning of its activities in Ukraine in 1992 it has invested over USD 22.5 million in 31 Ukrainian enterprises; the UGF, established in 1996, which invested USD 55 million in 75 Ukrainian companies; Western NIS Enterprise Fund is an investment fund with an initial capital of USD 50 million, provided by the US government. All other funds are disproportionate in size and scope of activity (Ryzhakov, 2015). But if researcher analysed the volume of invested venture investments, their low ability to provide conditions for the development of medium and large enterprises becomes clear. Moreover, a feature of their study was financing the increase in production by purchasing part of the shares of enterprises issued within the framework of the secondary issue.

Research showed that the activities of Ukrainian venture organisations are unique, since Ukraine has not a single fund that would work according to Western standards, that is, attract funds from third-party investors (Ryzhakov, 2015). The researcher emphasised that all Ukrainian venture funds were created by international organisations such as the European Bank for Reconstruction and Development or within the framework of intergovernmental agreements. For example, the government of Ukraine, in order to support the development of innovative enterprises, introduced a number of non-repayable grants and measures to promote enterprises in the technological and key sectors of the country. The activities of private capital in the field of venture financing are poorly represented. However, the positive fact is that despite the new round of military aggression in Ukraine in 2022, venture investors continued to finance the enterprise despite the fact that 91% of Ukrainian projects require financial support in war conditions. Accordingly, the prospects for development in the future will only grow and external venture investors are already actively using this, for example, the Google venture fund financed grants for 25 startups to ensure their further development.

Thus, it can be concluded that the demand for venture financing exceeds the supply, which is common for markets that are only developing. The research of D.A. Ryzhakov (2015) stated that there is a number of circumstances that stimulate the development of venture investment in Ukraine, in particular, this is a combination of "mental and historical features of the Ukrainian nation: the spirit of entrepreneurship and "smart adventurism"; a high level of education of the population; the fusion of the features of Asian and European cultures – a combination of individualism with collectivism; the presence of numerous research institutes; an increase in the number of private small and

medium-sized enterprises; an increase in demand for engineering specialists; a high level of qualification of labour resources, especially at existing and former enterprises of the military-industrial complex". The objectivity of this opinion of the researcher should be highlighted, however, a number of independent external circumstances still do not allow venture business to actively influence the processes of spatial development of enterprises.

Despite such well-founded positions in scientific communities, a version is also put forward regarding the restriction of the development of venture financing due to the active functioning of the stock market as an alternative source of capital inflow (Prytuliak, 2013). The analysis also considered the opinion according to which the researcher claimed that one of the reasons for the low spread of venture funds is the ban on pension funds and insurance companies from investing in venture funds (Kovtun, 2009), but this opinion was poorly substantiated, since neither the activities of pension funds nor the activities of insurance companies in Ukraine have acquired such a scale to act as a source capable of financing venture activities.

It is expected that military actions will form a certain structure of demand for technological goods, and post-war reconstruction will also increase the consumption of new technologies and goods, which already actualises the preparation for changes in production processes. Such activation will additionally increase the shortage of qualified personnel, respectively, increase the need to increase the use of automation technologies in all areas without exception (Adamiv & Lysa, 2023). The first steps in this line have already been taken, since venture investment has already penetrated the areas of machine learning and artificial intelligence (AI). Moreover, among the most promising industries are business process automation, agricultural technologies, remote work, education, medical technologies, marketing and sales, environmental technologies, financial services, etc.

Notably, venture investment is primarily a type of business and its ultimate goal is commercialisation. In scientific publication directly states that "the interest of a venture capitalist is not formed by the results of scientific and technological progress or innovation activities in general, but only that what can be commercialised, that is, be in demand among many consumers and, accordingly, provide a high total income to its owner in a relatively short period of time" (Kuzmin *et al.*, 2020). Accordingly, venture investment is a mechanism in which other parties should be interested – enterprise owners, society, local government, etc. Therefore, despite the existence of complete chaos in the issues of financing venture funds, institutionalisation of their activities, and willingness of enterprises to cooperate with them, the opinion of O. Kuzmin *et al.* (2020) can be agreed with. Furthermore, under current circumstances, it is the state that is tasked with regulating the activities of venture business, because the state is the ultimate beneficiary through the ability of venture investors to provide a number of public benefits in the form of increased employment, development of new technologies, creation of value added chains, etc.

Thus, the development of venture investment in Ukraine is at the stage of establishment and is influenced by all possible elements of an unstable economic environment that deter both owners of financial resources and potential recipients from concluding venture agreements. The study of venture financing allowed forming a set of conditions in which the development of venture business operates, in particular: the absence of a strategy for the development of venture business at the state level, which is conditioned by the dualistic nature of Ukrainian business – the development of private initiative on the one hand is accompanied by growing integration trends on the other; low awareness of entrepreneurs with the possibilities of cooperation with venture funds; limited legislative framework for the establishment and functioning of venture investors forms institutional instability of investments; insufficient number of qualified specialists-innovators in venture institutions, and their absence in most small cities; lack of instruments to stimulate venture business; low rates of diffusion of innovations at enterprises and lack of incentives for the introduction of new products. It has been established that, despite the dominance of a number of negative signs of the development of venture financing, the influence of the military factor, as a catalyst for demand for innovation, can act as a driver for the penetration of venture financing, first into the production of military equipment, and later into other areas of production activity.

Stock market. The development of the stock market in Ukraine is regulated by the Law of Ukraine No. 3480-IV (2006), which was adopted in 1991 and marked the establishment of the Ukrainian Stock Exchange. The Ukrainian stock market includes 10 stock exchanges: PFTS Stock Exchange, Kyiv International Stock Exchange (KISE), Ukrainian Stock Exchange (USE), Ukrainian Interbank Currency Exchange (UICE), INNEKS Stock Exchange, Prydniprovsk Stock Exchange (PSE), Ukrainian International Stock Exchange (UISE), Perspektiva Stock Exchange, and East European Stock Exchange (EESE), which are located in the Kyiv, Mykolaiv, and Dnipro (Stebliy *et al.*, 2017). Despite the existence of such a large number of exchanges, researchers suggest that there is a lack of financial instruments with high investment potential, a low level of capitalisation, insufficient transparency, and limited liquidity, while trading activity on the market depends on the presence of foreign speculative capital.

A feature of the Ukrainian stock market is the presence of over-the-counter trading in securities and its excess over the volume of organised exchange sales, as noted by V.O. Shapovalov (2015). The researcher emphasised that in the history of Ukraine in 2014, a phenomenon was observed when the stock market was characterised by a rather low activity of the exchange segment, although its share gradually increased. Other features of the Ukrainian stock market, which the researcher identified, are: the predominance of government bond transactions in the total

number of transactions (88.07%); the existence of trade hidden from the market, in particular, the share of stock trading on all stock exchanges of Ukraine was only 6.26% of the total volume of stock trading; the predominance of the secondary market, the share of which is 96.88%.

For quite a long time, before the adoption of the Law of Ukraine "On Joint Stock Companies" in 2022, the overwhelming share of securities of Ukrainian enterprises had a documentary form of issue, which complicated their circulation and increased transaction costs (Stebliy *et al.*, 2017). In Ukraine, the non-documentary form of shares has been the main and mandatory form since 2011. Significant transformation processes in the stock market led to cardinal changes in the field of implementing technological changes in the market – the world experience of online trading of shares of Ukrainian enterprises was introduced, and the technical possibility was provided for Ukrainians to purchase shares of foreign companies in Ukrainian currency in 2020 (Nieizviestna & Tryhubchenko, 2023).

In addition, the variability of the regulatory framework for the functioning of the stock market, changes in the depository and registrar systems, institutions of financial intermediation and protection of property rights, which led to the fact that investment processes in the joint-stock sector of Ukraine remain at a rather low level, according to V.O. Shapovalov (2015). The consequence of such dysfunction is that enterprises established in the form of joint-stock companies do not fully use the advantages of their organisational and legal form as a way to ensure development. The development of these trends creates the prerequisites for a decrease in the openness of the stock market, a decrease in its liquidity, and a limitation of investment efficiency.

The lack of an institutional framework and experience in organised financial markets leads to various manipulations and abuses in the capital market. More experienced players skilfully use situational opportunities, which threatens the activities of small participants in the placement of shares. This feature deters many entrepreneurs from working in the financial market despite the fact that the the National Securities and Stock Market Commission (NSSMC) is actively fighting price manipulation by stopping the circulation of issuers' securities due to the detection of signs of fictitiousness, stopping trading in issuers' securities, cancelling securities issues, and revoking licenses for professional activities in the stock market based on the results of considering cases of violations. Thus, it can be argued that the Ukrainian stock market, despite the assertions of researchers about its unformed institutional basis, has a solid regulator, the NSSMC.

As stated by O.V. Nieizviestna & Ye.H. Tryhubchenko (2023), Ukraine also introduced "the concept and mechanism of using corporate agreements in the activities of business companies and brought the activities of independent members and committees of the supervisory board of joint-stock companies into line with the requirements of EU legislation. Moreover, at the legislative level, a method of disclosing information on the securities market using the services of authorised persons providing information services on the securities market has been put into effect, and the obligation to publish this information in printed publications has been abolished". Therefore, the institutional basis for the development of the stock market is gradually being crystallised in Ukraine through the development of the regulator's activities, the adoption of a legislative framework, the introduction of principles and mechanisms of work, which has already led to a reduction in the cost of meeting the requirements for enterprises to enter the market and the number of reports to the NSSMC, and elimination of certain methods of previously used raiding. However, researchers noted that the institutional environment of the stock market in Ukraine only externally and in formal terms corresponds to the characteristics that are inherent to developed countries of the world, however, the application of the declared provisions is low due to the low level of accumulation of share capital and the underdevelopment of securities circulation.

A negative circumstance that still hinders the development of the stock market in Ukraine is the unsuccessful experience of privatisation, which led to the non-transparent transfer of state-owned enterprises into the hands of cunning businessmen. The lack of proper institutional support led to dishonest "primary accumulation of capital and society witnessed the predatory (semi-wild) methods by which the redistribution of social wealth and the development of national private capital began. Against the background of privatisation and the subsequent post-privatisation redistribution of property rights, the current joint-stock sector of the economy was formed in its essence" (Sirko, 2016).

The only characteristic that most researchers support is the definition of the Ukrainian stock market as an unorganised structure. In particular, according to the definition of A. Sirko (2016), both an organised and an unorganised securities market operate in Ukraine, while it is emphasised that the share of the organised market is 6-10%. This situation indicates a closed asset management policy at enterprises, the lack of incentives to attract external capital, and the fear of owners to lose control over capital. The researcher also noted the low quality (irrelevance) of information about enterprises (the results of their activities, ownership structure, investment projects, etc.). The lack of civilised access to securities trading leads to distortion of the pricing procedures for securities, and there is oppression of the interests of minority shareholders, which discourages the purchase of shares by external investors.

The combination of these shortcomings has led to the self-isolation of the joint-stock sector from the stock market, which makes it impossible for capital inflows to develop enterprises. Enterprises are wary of their assets from entering the stock market due to the lack of transparency in the protection of private property rights, the monopolisation of capital markets, the usual practice of raiding with the use of corruption in the judiciary, etc. In the conditions of an unformed institutional environment, enterprises are cautious about the stock market due to fears of losing

corporate control over the enterprise. In addition, entering the stock market limits the enterprise's "opportunities to obtain quasi-rents through the use of various "grey" schemes for minimising tax and customs payments, lobbying for government orders, and manipulating prices when concluding agreements, especially with state and municipal enterprises, artificially maintaining the cheapness of the national labour force and delays in paying wages" (Andrushkiv & Hrushko, 2020).

An important characteristic of the Ukrainian stock market is the lack of motivation of foreign investors to enter or return after exiting due to a number of macroeconomic crises, war, etc. This situation reduces the number of purchase and sale transactions on the market, which limits the ability of enterprises to attract resources for their development. Moreover, in addition to this trend, an understandable negative aspect is also the absence of a large number of issuers and an extremely low number of enterprises willing to put their shares up for sale. Another important feature of the Ukrainian stock market is the complexity of portfolio investment (Kostyrko, 2017).

The most evident shortcomings of the Ukrainian stock market are: accumulation of controlling stakes in the hands of small owners who are not interested in additional issues; dominance of large shareholder structures and their potential ignoring of the rights of small shareholders; similar of market transactions; deformed system of pricing for securities, which was formed by the absence of concentrated capital in the market; small number of institutional investors and their insufficient activity; total distrust of the population in financial intermediation operations due to its high risk and negative experience of privatisation processes in the past; weak awareness of society about the possibilities of financial investment (Shapovalov, 2015); the joint-stock companies operate in a closed form, which implies the possibility of using exclusively the capital of existing shareholders for their development. However, these shareholders have the preferential right to purchase shares, which complicates the arrival of external shareholders. There is even an approach that proposes the general expediency of abandoning the institution of private joint-stock companies (Shapovalov, 2015).

The lack of interest of enterprises in entering the stock market is also explained by the need to ensure financial transparency of its work, and such actions, according to the owners and management, can make business entities vulnerable to regulatory authorities and law enforcement agencies. The negative experience of raiding in Ukraine has a number of cases when not only minority, but also majority shareholders lost their enterprises due to corrupt court decisions (Dovhan & Malyk, 2013). Although in order to protect the interests of shareholders, the Principles of Corporate Governance were approved and the Decree of the President of Ukraine "On Measures for the Development of Corporate Governance in Joint-Stock Companies" was adopted, these documents did not bring significant consequences.

The identified shortage of financial resources, along with the complexity of the procedures for other methods of attracting capital in the domestic financial market, creates the need for enterprises to attract financial resources from the external market. One of the ways to attract external resources in this case may be the initial public offering of shares, as a certain mechanism for revitalising the stock market (Kostyrko, 2017). The objective necessity of using the stock market as a stimulant for the development of an enterprise is that by using it, enterprises have access to stock market capital, support a positive image of the enterprise, which, in turn, also additionally contributes to the opportunities to obtain bank loans on attractive terms.

The use of the stock market as a way to attract additional financing by the end of 2025 is extremely difficult, which is determined by the dualistic nature of the Ukrainian entrepreneur – on the one hand, the business needs additional financial resources, on the other hand, this business is not ready to enter the market and sell securities due to the instability of the institutional environment. The Ukrainian stock market is a unique combination of issuers who want to attract additional financing, and issuers who own liquid securities who do not want to enter the open market and either sell assets to existing shareholders or engage in sporadic trading, thereby protecting themselves from the arrival of an external shareholder, and accordingly, a source of influence. In turn, enterprises that are ready for an external owner who can bring not only financial assets, but also fresh management ideas, do not arouse interest among owners of financial resources. Such a situation in the financial market requires the construction of new standards for securities trading and real effective legislative regulation.

Crowdfunding. The current stage of enterprise development is characterised by the total use of digital technologies, blockchain, the Internet of Things, mobile transactions, AI, which have already become familiar attributes of many enterprises. However, the involvement of information technologies in the inflow of capital is insufficient and is not used to its full extent, in particular crowdfunding. Conventional approaches to financing the spatial development of enterprises in Ukraine have not shown their effectiveness, despite the direction of capital in effective sectors of the economy, they have not become driving forces for the development of other related sectors of the economy, therefore, there was a need to develop and implement a new tool – crowdfunding.

Some steps in this area have been taken from the perspective of the development of the theory of the network economy. The use of business models for creating goods, which involve the combination of different players (parties, stakeholders) to a higher degree, compared to the conventionally established methods of interaction between the seller and the buyer, is already quite widespread in Ukraine. The advantages of using the joint financing method are also traced in another study by L. Bodenchuk, & I. Liganenko (2021), which noted that under such conditions, network cooperation business models allow the

accumulation of relatively small assets, while ensuring their high profitability. Moreover, conditions arise when cooperation between direct competitors in certain areas of activity becomes productive, which has already been called cooperative competition. Thus, a situation arises when the spread of information technologies completely changes the structure of industry markets, reduces barriers to entry into business, borders disappear, and simultaneously the "plug and play" principle emerges in business, which creates opportunities for attracting various types of resources at different stages of enterprise development. Under such circumstances, enterprises can ensure rapid, agile spatial development, increase the volume of activity, increase the efficiency of investments, and create goods with new value indicators. Such mobility allows forming new markets and operating in them to ensure further development opportunities.

Studies of Ukrainian Institute of the Future (n.d.) prove the unalternative path of digital development, which can already form the prerequisites for the growth of the national economy by 10-12% per year based on the use of creative data, the application of the Internet of Things, the digital transformation of both individual businesses and entire sectors, the spread of the sharing economy, the virtualisation of physical infrastructure IT systems; using AI and digital platforms, which are the main elements of crowdfunding as a way to finance the spatial development of enterprises. It was observed that monetary capital is gradually transitioning into a virtual form, while acquiring digital, abstract, but capable of ensuring the coordinated organisation and management of many processes in the economic life of the state. However, along with this, "no other form of capital is currently able to compete with monetary capital in comprehensiveness, pervasiveness, globality of influence on each country in particular and humanity as a whole" (Bodenchuk & Liganenko, 2021). That is, the movement of capital cannot be controlled centrally, it flows to where it can be most effectively placed. Crowdfunding, based on a combination of capital generated from various mutually independent sources, makes financial dictates impossible, the use of bonuses in favour of individual investors, etc.

Under the current economic conditions, it is clear that the use of digital platforms in business changes the traditional principles of doing business. Due to the development of information technologies, the patterns of functioning of industry markets are changing, the essence and speed of economic relations are being transformed. Therefore, the emergence of new areas of activity, sets of combinations of resource use, modification of management approaches is a permanent phenomenon that develops in unforeseen directions. In the environment of rapid dissemination of information about projects, and accordingly, rapid collection of capital for their financing, additional opportunities arise for the development of the so-called "creative" environment and "creative" market. The digitalised economic environment is characterised by the creation, distribution, and preservation of content in different languages and in different formats, which makes enterprise development projects accessible for understanding by capital owners from different countries (Samoilenko, 2023).

The use of information technologies has already taken place at all stages of social reproduction (production, distribution, exchange, consumption), which opens up countless new opportunities for economic development. However, given the dominance of the need for financial resources, it is extremely important to use information technologies as a way of accumulating capital by building connections between different economic entities, regardless of their size, main profile of activity, level of competence, location, and coordination of actions between them. In such conditions, money is in the form of flows, and it is under the conditions of informatisation that it most fully embodied the qualities of capital, since it allowed its owners to steadily receive significant profits with minimal effort, despite cyclical problems in non-financial sectors of the economy (Andrushkiv & Hrushko, 2020). Given the simplicity of transactions on the one hand and the need to finance enterprise development projects on the other, as well as the lack of target investors, there is an objective need to use a crowdfunding tool that can ensure the interests of all three mentioned parties.

A feature of the application of crowdfunding is the use of digital platforms that have the same characteristics and provide easy entry and exit opportunities for the owner of capital, which creates equal opportunities for investing in new projects, both for individuals and for large corporations or medium-sized enterprises. As noted by O. Vatamaniuk (2022), participation in financing on a crowdfunding platform "does not require certification or quality verification of the goods offered for sale, but instead relies on reputation and feedback mechanisms". Without a doubt, such a position is quite unreliable, however, crowdfunding is based on a reputational component, based on which the interests of both recipients of capital and its contributors can be coordinated. Additionally, crowdfunding is favoured by the possibility of making a contribution "here and now", without concluding long-term agreements, defining the obligations of the parties and employment relationships. That is, the need for "legal" agreements is eliminated, the time for completing transactions is reduced, and the dynamics of capital accumulation on the platform is tracked, which allows investors to understand the potential opportunities for project implementation.

Since the potential owner of capital has a number of ways to invest it, it can be noted that the specific feature of crowdfunding is the lack of clear legislative procedures for its regulation, which on the one hand introduces some uncertainty, and, on the other hand, protects against total changes, as is the case, for example, in the stock market or in the banking sector. Thus, a certain liberalisation of capital flows is ensured, which will obviously be implemented in the future in the form of incorporation of the capital movement norm and the Economic Code of Ukraine. The development of such a financial vector is necessary for the

regulation of currency relations, as noted by T.S. Hudima & Ye.O. Skubak (2015).

The development of crowdfunding in Ukraine is still at an early stage. Researchers identified both positive and negative aspects; one of the main factors restraining its development is the predominant use of crowdfunding for financing social projects, while profit-oriented projects remain largely neglected (Otlyvanska, 2017). A similar positive opinion regarding the prospects for the development of crowdfunding was also held in another research, conducted by V.O. Ohorodnyk (2014), who claimed that traditional instruments of financing the development of enterprises have already exhausted themselves and other ways need to be sought. In particular, the researcher suggested the opening of a "state crowdfunding platform for the modernisation of the national financial and investment system and the renovation of the Ukrainian economy". The base of the resource provision of this platform should be state funding. Agreeing with another research by V.V. Riznyk & N.A. Riznyk (2018), it is worth emphasising the possibilities of crowdfunding to accumulate financial resources using the media, because it is the dissemination of high-quality information that allows centrally collecting funds for projects that do not meet established investment efficiency indicators based on consumer loyalty, the achieved image of the enterprise, the high riskiness of the project, etc. Therefore, it is necessary to support the opinion of the researcher regarding the great future in the use of crowdfunding platforms as one of the instruments for financing investment activities.

The spread of crowdfunding platforms in the world is a logical consequence of the long-term dominance of the banking sector as an apologist for ensuring its own profitability. Accumulating the resources of large industrial giants, they are not flexible in meeting the growing consumer demand for financial resources from the population. However, there is an active growth of fintech companies. Therefore, banks are forced to compete with platforms that create a closed circle of consumption: from choosing a product to paying for it or obtaining a loan to pay for it. It is an objective fact that the number of e-commerce transactions based on platforms is actively developing. However, such development takes place in a low-organised space, where the interests of consumers are not protected, and the instruments of influence are absent, which creates opportunities for manipulation of consumers (Kornivska, 2020).

The basic principles of introducing crowdfunding into the economic activities of enterprises in Ukraine are the level of incomes of the population, the experience of consumption and savings, the level of diversification of objects, forms, instruments of money accumulation, the possibility of investing capital, etc. The fundamental factor in the development of crowdfunding is the presence of "social capital of collective financing, the core of which is the trust of potential investors in the creators of projects that are financed" (Marchenko, 2014). That is, the research claims that the spread of crowdfunding can occur only if social and economic conditions are combined.

It is worth noting that Ukrainians already have significant experience in online banking and have been able to fully verify the effectiveness of digital banking services due to the large number of possible transactions, developed banking infrastructure, reliable protection of personal data, etc., so this fact will contribute to the accelerated implementation of crowdfunding in the work of enterprises. The development of crowdfunding marked the beginning of a new type of financial support for business development that does not require legislative regulation and is not determined by certain financial frameworks. For the first time, financial resources freely overcome the borders and laws of the economy. Crowdfunding involves any person or business entity ready to invest their own resources in business development, while the main driver of the development of the crowdfunding idea is the institution of trust and reputation.

Crowdinvesting. In line with the idea of comprehensive penetration of information processes into all areas of enterprise operations, digitalisation is observed to influence institutional changes, accelerating them in accordance with the evolution of behavioural patterns and adjustments in the modern value system. The demand for products is determined by these factors, because a new method of communication has appeared – social networks. The use of blogging opportunities, the work of influencers, wide information availability, and organisational building opportunities create conditions for the rapid and flexible development of enterprises. However, the influence of social networks is also defined as a way of commercial attraction of funds for the implementation of projects – crowdinvesting.

Existing opportunities for the development of crowdinvesting in Ukraine are extremely favourable, since enterprises have all the necessary network capabilities for this: enterprises can independently develop certain strategies for their development and concentrate in their hands all channels for disseminating information about these projects; the use of remote work and remote interactions is increasingly popular, which also contributes to remote investing; the emergence of blogging institutions has crystallised the emergence of new agents of influence who convey ideas, content, and form the correct interpretation of projects; observing the experience of other people forms a broad outlook in Ukrainians regarding the development of both a person (investor) and enterprises, which serves as an incentive for finding new ways to effectively invest funds. These polyphonic conditions for the spatial development of enterprises contribute not only to the development of crowdinvesting, but also push manufacturers to develop new goods and services, transform enterprise management systems, and create new industries.

Despite the fact that crowdinvesting is a relatively new tool for spatial development of enterprises, it still remains not very widespread and most business managers are sceptical about it due to their opinion about the inability of crowdinvesting to provide large investments and,

moreover, to establish them on a permanent basis. However, the restraint of crowdinvesting is objective given the set of real circumstances related to the professionalisation of management: the lack of a legislative framework for the application of crowdinvesting limits the possibilities of both investors and recipients – there are no rights and obligations of the parties and liability for actions; uncertainty of tax administration procedures; negative experience of the use of collectively collected funds by state structures deters potential investors from financing; the high concentration of monopolies among large enterprises creates conditions under which crowdinvesting is uninteresting for them given their own high opportunities to ensure development, and small business entities cannot take advantage of crowdinvesting due to the lack of information about them among investors and, accordingly, distrust; the significant proportion of non-public and shadow transactions within crowdinvesting, which cannot be traced in any way from the legal side; traditional knowledge of financial management among most managers prevents them from searching for new ways of spatial development of enterprises.

Contemporary network conditions for doing business have become an additional factor in the spread of new business models that integrate a significant number of product groups on single platforms and allow increasing the profits of all entities, connecting buyers and producers, accelerating trade, creating new markets and expanding business. In the world economy, as a result of global transformations, the volume of economic transactions implemented based on new business technologies and innovative forms of business, in particular, outsourcing, outstaffing, freelance, consulting, has significantly increased (Honcharenko & Ostapenko, 2022).

The development of crowdinvesting in Ukraine is being restrained due to the following shortcomings in the development of digital business: the spread of digital information eliminates the need for trade intermediaries; the prerequisites for global competition are being formed as opposed to the previously existing local one; there is an inability of the institutional environment to respond in a timely manner to changes in business, which creates conditions for the emergence of economic disputes. The difficult economic conditions that were formed by non-systemic reforms and the war led to the fact that crowdinvesting is only in its infancy and mainly concerns military needs. This situation is formed by the following circumstances: the low incomes of the majority of citizens are mainly directed to consumption and do not have investment value; spending income on current consumption is dictated primarily by a low investment culture, uncertainty in preserving current savings; the instability of banking institutions warns depositors against cooperation; rewards in the field of crowdinvesting are not high and constant, which repels professional investors; crowdinvesting does not allow "laundering income", which does not contribute to the "inflow" of dirty, albeit potentially effective money; Ukrainian society has not yet been imbued with the idea of voluntary commercial financing of the development of individual enterprises; since the Ukrainian investor's trust exists only in specific entrepreneurs at specific enterprises and the willingness to finance "imaginary" projects is absent among most citizens.

Given the availability of information about markets and enterprises, according to V. Kornivska (2020), the main advantage in attracting an investor in the context of the wide presence of financial platforms, banking instruments, and a number of e-commerce operators is a deep marketing strategy for attracting capital, specially developed for each project, in order to further retain the client. The researcher claimed that the investor will bring their funds and remain in the crowdinvesting project "only under the condition of the lack of alternative interaction between the client and the operator: the creation of such conditions under which free entry into the system is associated with the difficulties and disadvantage of exiting it due to the strict rules of the ecosystem established by providers". An important argument in favour of the further development of crowdinvesting is the rapid development of enterprise communications through the use of social networks and its own websites, which allows for the fastest and most complete dissemination of information about future projects and ensuring a virtual dialogue with potential investors. The Internet communications perform a number of social tasks in wartime, but after it ends, the time will come to activate the economic function of crowdinvesting.

Research on crowdinvesting has shown that the main incentive for its development is the rapid collective financial approval by a large number of investors of the need for the production of a certain product. Crowdinvesting is a way to attract resources to projects that do not provide traditional indicators of economic efficiency or such indicators cannot be reliably determined. The use of crowdinvesting minimises time and expands the geography of potential investors. Emphasising the importance and prospects of these vectors of spatial development of enterprises, the main trends in their application in Ukraine were outlined (Table 1).

Table 1. Trends in the application of financial vectors of enterprise development in Ukraine

Financial vector	Emergence in Ukraine	Distribution conditions	Key obstacles	Prospects for application in Ukrainian conditions
Venture financing	2017	• Presence of a large number of innovative products that require additional financing. • Need for cooperation with asset management companies.	• Insufficient venture capital investors. • Poor awareness of enterprise management about such financing opportunities. • Difficult form of interaction through asset management companies.	• Concerns highly profitable areas of production of high-tech products. • Venture financing can ensure the chain development of industries related to high-tech production.

Table 1. Continued

Financial vector	Emergence in Ukraine	Distribution conditions	Key obstacles	Prospects for application in Ukrainian conditions
Stock market	1991	• Internal sale of shares between shareholders of the same company prevails. • Operates in a changing legal field. • State's attention is focused on the government bond market, ignoring the possibility of buying and selling shares and bonds of the private sector.	• Presence of experience in raider seizures deters owners of shares from selling them. • Weak attention of the state and development of instruments to stimulate the development of the stock market.	• Determined by the development of the legal field. • Can be ensured through cooperation with business partners.
Crowdfunding	2020	• Experience in collective financing of cultural, charitable and military needs. • Development of digital awareness of the population.	• Lack of experience in online investing. • Concerns of resource owners about asset protection. • Cannot be applied to all industries and projects. • Projects may not be considered as promising.	• Ensures the development of high-tech production, which cannot be confirmed by economic efficiency indicators. • Increases the interest of the resource owner in investments through the vision of the project where the resources are invested.
Crowdinvesting	2020	• Readiness of the enterprise to develop and offer to the market goods and services that are seen by the population as promising for financing. • Presence of public trust in enterprises offering financing projects. • Presence of free funds among the population.	Businesses do not see crowdfunding as a tool for providing long-term financing for projects that require significant investments.	Actively used through the donation mechanism for the needs of the army, and after the end of war, will become a well-known method of profitable allocation of the population's funds.

Source: developed by the author

The set of studied financial vectors of spatial development of enterprises demonstrates certain trends in the possible attraction of financial resources by enterprises. Undoubtedly, each enterprise has the opportunity to use conventional financing schemes, however, the long previous experience of using such instruments as lending, foreign direct investment, state investment, grant aid, etc., did not ensure the development of Ukrainian enterprises despite the growing volumes of such investments officially published by statistical bodies. Throughout the entire studied period of 1991-2025, the main source of financial support for the development of Ukrainian enterprises was their own funds generated by effective production activities. However, the suspension of profitable work prevents the active development of business and traditional sources of its financing, therefore the use of the studied financial vector of spatial development of enterprises is appropriate for application.

CONCLUSIONS

The development of financial vectors of spatial development of enterprises in Ukraine is somewhat limited due to the significant predominance of familiar and traditional methods of financing businesses such as bank lending, leasing or receiving grants in financing enterprises, however, the global experience has developed new ways of financing businesses, which can be interpreted as financial vectors of spatial development of enterprises. Such financial vectors of spatial development of enterprises include venture financing, stock market development, crowdfunding and crowdinvesting. Research on the development of venture financing has established that its application in the state significantly differs from theoretical canons, in particular, in Ukraine venture funds usually operate with the aim of redistributing financial flows and minimising the tax burden, while in other countries of the world venture funds contribute to the introduction of innovations into production. The development of the Ukrainian stock market is also characterised by certain unique features based on the previous unsuccessful experience of privatisation, the variability of the regulatory framework for the functioning of the stock market, changes in the depository and registrar systems, institutions of financial intermediation and protection of property rights, etc. In addition, the presence of over-the-counter trading in securities and its excess over the volumes of organised exchange sales has been established. Acting as new financial vectors for the development of enterprises, crowdfunding and crowdinvesting are poorly regulated vectors by law, which creates a certain uncertainty for business in the appropriateness of their application, and therefore, these vectors are used mainly in financing social projects, although they have entrepreneurial potential. Thus, Ukrainian management practice has a number of conventional and new financial vectors of spatial development of enterprises that are flexible and adaptive to different circumstances and types of business, helping to ensure the development of enterprises. Future research should be devoted to finding new vectors for obtaining financial resources to activate the development of enterprises through the formation of parity or agreed conditions for investing funds between private, collective, and public capital in conditions where

each of the participants may be unable to fulfil the obligations assumed.

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Фінансові вектори просторового розвитку підприємства

Анотація. Розвиток підприємств вимагає використання додаткових фінансових ресурсів, якими підприємства не володіють. Використання традиційних способів фінансування досить часто є недоступним, що вимагає пошуку нових доступних фінансових векторів розвитку підприємств таких як венчурне інвестування, фондовий ринок, краудфандинг та краудінвестінг. Стаття мала на меті надати інформацію для вибору найбільш підходящих фінансових векторів розвитку підприємств в існуючих умовах господарювання. Дослідження здійснювалося з використанням історичного та логічного методів, системного аналізу, абстрагування та інших методів наукових досліджень. Проаналізовано правові підстави та історичний досвід розвитку венчурного фінансування в Україні, а також особливості функціонування українського фондового ринку. Встановлено, що обсяги венчурних інвестицій є недостатніми для забезпечення розвитку середніх і великих підприємств, а внутрішні венчурні фонди створювалися переважно за участю міжнародних організацій або в межах міжурядових угод. Дослідження фондового ринку України засвідчило домінування позабіржової торгівлі цінними паперами над організованим біржовим ринком, переважання операцій з державними облігаціями, вторинного ринку, а також нестабільність нормативно-правового регулювання та трансформацію інфраструктурних елементів ринку. Доведено неорганізований характер функціонування українського фондового ринку. Обґрунтовано доцільність використання краудфандингу як альтернативного фінансового інструменту розвитку підприємств, визначено його переваги та недоліки, а також встановлено відсутність чітких законодавчих процедур його регламентації. Виявлено, що в Україні краудфандинг переважно застосовується для фінансування соціальних проєктів, водночас українські підприємства мають потенціал використання нових, гнучких і адаптивних фінансових векторів розвитку. Отримані результати дозволяють підприємствам ознайомитися з існуючими фінансовими векторами забезпечення свого розвитку та обрати ті, які є найбільш доцільними для кожного підприємства

Ключові слова: венчурне фінансування; фондовий ринок; акціонер; краудфандинг; краудінвестінг

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Research on the Warsaw real estate market under conditions of post-pandemic recovery and migration processes

Abstract. The transformation of the Warsaw real estate market under the influence of global macroeconomic instability, pandemic-related restrictions, and large-scale migration waves necessitates a scientific analysis of structural changes and adaptive mechanisms within the housing sector. The aim of the study was to conduct a comprehensive analysis of the Warsaw real estate market conditions during 2021-2025, to assess the level of its market concentration, and to identify the determinants of demand transformation in the context of post-crisis recovery. The methodological framework of the study was based on a systems approach, incorporating statistical analysis of time series data, comparative methods, SWOT analysis, and mathematical tools for assessing market concentration, including the Herfindahl-Hirschman Index, the Linda Index, and the Gini coefficient. The results indicated that price dynamics in both the primary and secondary housing markets in Warsaw over the period 2021-2025 demonstrated an upward trend, with peak growth recorded in 2024, driven by inflationary pressures and supply shortages. It has been established that the spatial distribution of housing prices across the districts of the capital reflects a high level of differentiation, with central locations maintaining their status as the most stable investment assets. A significant shift in the structure of demand has been identified, marked by an increase in the share of foreign buyers, particularly Ukrainian citizens, whose contribution to market indicators has become strategically important since 2022. Based on calculations of the Herfindahl-Hirschman Index for 2021-2024, a trend towards market deconcentration has been substantiated, alongside a transition from a moderate to a low level of market power among dominant players. It is projected that further stabilisation of the sector will occur through the intensification of suburbanisation processes and the adaptation of supply to new socio-demographic needs of migrants. The practical significance of the study lies in the potential application of its findings by investment analysts to minimise risks, as well as by public authorities in the formulation of strategies for the spatial development of urban agglomerations in the post-crisis period

Keywords: housing prices; developers; market concentration; Herfindahl-Hirschman Index; Linda Index; Gini coefficient

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INTRODUCTION

The Warsaw real estate market is a key segment of Poland's national economy, as it reflects not only the condition of the construction industry and housing sector but also the overall level of societal development. The construction sector plays a particularly important role in the capital, as it is here that the country's main political, economic, and cultural institutions are concentrated. Warsaw is significantly influenced by intensive migration processes, changes in the macroeconomic environment, global geopolitical trends, and specific local factors. It is one of the most dynamic European cities in terms of urbanisation and growing housing demand. The majority of Eastern European offices of large international companies are located in Warsaw.

The relevance of the study for the period 2021-2025 is determined by several factors. Firstly, the Warsaw real estate market is recovering from the coronavirus pandemic in terms of rising demand for housing and rental properties. The works of M. Tomal & M. Helbich (2022) and M. Bryx *et al.* (2023) analysed the consequences of the COVID-19 pandemic and its impact on demand. An important methodological contribution is provided by N. Pfeifer & M. Steurer (2022), who identified early indicators of real estate market behaviour during the pandemic crisis. Secondly, migration processes in 2022-2025 have had a noticeable impact on demand structure, particularly those triggered by the full-scale invasion of Ukraine by Russia in 2022. In their study, M. Głuszak & R. Trojanek (2024) substantiated mechanisms of asymmetric housing price adjustment, while in their subsequent work M. Głuszak & R. Trojanek (2025) they demonstrated that population growth due to the inflow of refugees directly leads to increased rental rates. Thirdly, rising material costs and changes in banks' credit policies affect housing affordability, as noted by J. Jaroszewicz & H. Horynek (2024) and O. Jeż & J. Žukovskis (2025). Additionally, S. Kuźmar *et al.* (2026) examined the impact of remote working on urbanisation processes, while R. Cellmer (2023) identified the role of infrastructure in price fluctuations. An important area of research is the integration of Ukrainian refugees, analysed by K. Kochaniak & A. Huterska (2023), as well as the transformation of investment behaviour described by A. Chmielewska *et al.* (2022), where real estate is considered a safe asset. The transformation of Warsaw's housing sector correlates with global trends in property ownership in major cities. As noted by N. Gallent *et al.* (2022), increasing investment demand and the spread of second-home ownership practices often reduce market accessibility for local households, becoming a critical factor during periods of economic instability.

As the Warsaw real estate market is an important indicator of the economic stability of both the city and the country, identifying the factors influencing it is a relevant task for determining future development prospects. The aim of the study was to analyse the current state of the Warsaw real estate market and to assess the supply of residential and commercial properties, taking into account pricing policy, developer activity, and transformations in housing demand. The objectives of the study were:

- to analyse the spatial and dynamic characteristics of the Warsaw real estate market by examining the structure of residential and commercial construction across city districts and identifying pricing trends in the primary and secondary markets during 2021-2025;
- to assess the level of market concentration and the competitive environment among leading developers in the primary real estate market of the capital using index-based evaluation methods;
- to substantiate strategic directions for adapting the Warsaw real estate market to contemporary economic and migration challenges based on the conducted SWOT analysis, identifying key vectors for its further development.

MATERIALS AND METHODS

The study applied a systems approach, which made it possible to consider the dynamics of the Warsaw real estate market development in the period 2021-2025 as a complex system, taking into account the interaction of economic, social, and demographic factors. Dialectical logic was used to identify contradictions between rising prices and the real purchasing power of the population, while the methods of induction and deduction enabled a transition from the analysis of individual districts (local markets) to the formation of city-wide development trends. Comparative statistical analysis was carried out by comparing the growth rates of housing prices in the primary and secondary markets over the period 2021-2025, which made it possible to identify moments of market shocks. The index method was applied as a mathematical tool for calculating the Herfindahl-Hirschman Index (HHI), Linda Index (LI), and Gini coefficient (GI) indicators, allowing for a quantitative assessment of the level of monopolisation and the inequality of share distribution among the 20 largest developers in the city.

To ensure an objective assessment of the level of spatial price differentiation in the Warsaw real estate market and to avoid subjectivity in the interpretation of indicators, methods of descriptive statistics were employed. The coefficient of variation (V) was selected as a key indicator of market heterogeneity, as it made it possible to assess the relative degree of price dispersion in relation to their average level. The calculation was carried out using the following formulae:

$$V = (\sigma/\bar{x}) \times 100\%, \quad (1)$$

where $\bar{x}$ – the arithmetic mean price per 1 m^2 of housing across all administrative districts of the city; the following formula was used for its calculation:

$$\bar{x} = (\Sigma x_i)/n, \quad (2)$$

where σ – the standard deviation, which measures the average extent to which prices in each district deviate from the overall city-wide mean value:

$$\sigma = (\Sigma(x_i - \bar{x})^2/n)^{0.5}. \quad (3)$$

To interpret the results, the following statistical criteria were applied: $V \leq 33\%$ – the dataset is considered homogeneous, and the level of differentiation is moderate; $V > 33\%$ – the dataset is considered heterogeneous, which mathematically confirms a high level of price differentiation and deep market segmentation. The research methodology was based on classical approaches to measuring market power. The assessment of structural parameters was carried out by comparing the shares of individual real estate market participants with overall market indicators, which ensured a high level of accuracy in identifying market transformations. The market share of an individual housing developer (Ci) was determined using the following formula:

$$\mathrm{Ci} = \frac{D\mathrm{i}}{\mathrm{M}}, \quad (4)$$

where i – the developer, *D*i – the number of residential units commissioned by that developer, and M is the total number of residential units commissioned by all developers in the Warsaw real estate market.

Assessing the market share of an individual developer based on the parameter "number of commissioned residential units" made it possible to identify the level of housing demand satisfaction. Among the examined top twenty leading developers, the following were selected: Dom Development, Develia, Robyg, J.W. Construction, Ronson, Atal, Marvipol, Yareakn, Skanska, Echo Investment, Lokum, Euro Styl, Mid-size group, Panattoni Development Europe, Warsaw Urban Development, Mazovia Residential Group, Capital Housing Investments, Vistula Home Development, and Nova Praga Development. As the twenty largest developers in Warsaw account for approximately 98% of the market share, this sample is considered representative for analysing overall industry trends. Given the negligible combined share of other market participants (around 2%), their impact on overall concentration indicators was deemed statistically insignificant, which allowed the study to focus on the activities of leading developers.

HHI was used to quantitatively assess the overall level of concentration in the primary real estate market in Warsaw and to determine the degree of market monopolisation. This indicator makes it possible to evaluate the level of competition among developers and to identify the risks of market power being concentrated in the hands of a limited number of companies. The HHI was calculated using the following formula:

$$HHI = \sum_{i=1}^{N} D_i^2, \quad (5)$$

where D_i – the market share of developer (i) expressed as a percentage, and N is the total number of developers. HHI < 1,000 indicates low market concentration; 1,000-1,800 indicates moderate concentration; above 1,800 indicates high concentration.

To identify the boundaries of the oligopolistic core of the market and to determine the exact number of firms holding a dominant position, the LI was calculated. Unlike the HHI, this indicator makes it possible to detect the potential formation of monopolistic structures by analysing "breaks in continuity" in the distribution of market shares among leading firms. If the index value exceeds the established threshold ($\Delta > 200\%$), this signals excessive concentration of market power in the hands of specific dominant entities, providing grounds for the application of antitrust regulation. The LI was calculated using the following formula:

$$\mathrm{LI} = \frac{1}{\mathrm{k}-1} \times \sum_{\mathrm{m}=1}^{\mathrm{k}-1} \mathrm{l_m}; \quad (6)$$

$$\mathrm{lm} = \frac{\frac{1}{\mathrm{m}}\sum_{\mathrm{m}=1}^{\mathrm{m}} \mathrm{q_i}}{\frac{1}{\mathrm{k}-\mathrm{m}}\sum_{\mathrm{m}+1}^{\mathrm{k}-\mathrm{m}} \mathrm{q_i}}, \quad (7)$$

where k – the number of the largest enterprises in the real estate market (from 2 to N); m is the number of the largest enterprises within the group of k major firms; lm is the ratio of the average share of the m largest firms (out of the k largest) to the average share of the remaining (k - m) firms.

The index is calculated up to the point where $Lm + 1 > Lm$, which is referred to as a "break in the continuity of the L indicator", i.e. until a firm with a relatively small market share appears in the calculation. Such a break indicates the presence of a significant gap in market power between the leading group and the remaining participants in the real estate market. When $Lm + 1$ becomes greater than Lm, this signals that the next firm in the ranking has too small a share compared to the preceding ones, and its inclusion in the analysis "dilutes" the structure of the market core. Thus, this point serves as a mathematical criterion for determining the optimal number of firms that shape the competitive landscape and should be included in the calculation.

To assess the degree of inequality in the distribution of market shares among development entities, GI was applied. In the context of this study, this indicator makes it possible to quantitatively determine the level of market monopolisation by analysing the deviation of the actual distribution of commissioned housing volumes from the line of absolute equality. The value of the coefficient ranges from 0 (perfect equality, where each developer has an equal share) to 1 (absolute concentration of market power in the hands of a single entity). The GI was calculated using the following formula:

$$\mathrm{GI} = 1 - 2\Sigma(x_i \times Sum(y_i)) + \Sigma(x_i \times y_i), \quad (8)$$

where the variable x_i represents the cumulative share of developers (ordered by increasing volumes of commissioned residential units), and y_i represents the cumulative share of residential units commissioned by the respective developers within the total construction volume.

The study employed a SWOT analysis, which made it possible to identify the internal strengths and weaknesses of the Warsaw real estate market, as well as the external opportunities and threats to its development under conditions of macroeconomic instability. The empirical basis of the research consisted of official data from the Statistical Office in Warsaw (2025), analytical reports of the National Bank of Poland (2025a; 2025b), as well as statistical monitoring from APM Development (2025), Warsaw Business Journal (2025), Investropa (2026), and RynekPierwotny (2025a; 2025b). The use of these sources ensured the verification of data on price dynamics and the transformation of demand in both residential and commercial real estate markets. The limitations of the study are related to the availability of statistical information. Some of the indicators used were, at the time of analysis, published only up to 2024. Thus, the empirical calculations presented from Table 4 onwards are based on the most recent available data.

RESULTS AND DISCUSSION

The analysis of the residential real estate market in Warsaw for 2021-2025 indicates a significant territorial differentiation in housing prices, shaped by the level of infrastructure provision, the prestige of locations, and the investment attractiveness of individual administrative districts of the city. In the central parts of the capital, characterised by a high concentration of business activity and well-developed transport infrastructure, price levels are considerably higher compared to peripheral districts. A detailed distribution of the price per square metre of housing in the primary market by administrative districts of Warsaw is presented in Table 1.

Table 1. Price levels in the primary housing market in Warsaw by district (2025)

District	Primary market prices, zł / м^2
Wola	25,691
Śródmieście	25,383
Żoliborz	23,784
Wilanów	19,641
Ochota	18,767
Bielany	18,686
Mokotów	18,672
Praga Północ	18,347
Praga Południe	18,273
Ursynów	17,901
Bemowo	17,629
Włochy	16,720
Targówek	15,177
Ursus	15,063
Białołęka	13,839
Wawer	13,823
Wesoła	13,586
Rembertów	12,746
Mean ($\bar{x}$)	17,520
Standard deviation (σ)	6,100
Coefficient of variation (V)	34.8%

Source: compiled on the basis of Statistical Office in Warsaw (2025), Tabelaofert (2025), RynekPierwotny (2025b)

It has been established that the Warsaw real estate market is characterised by a high level of variation in housing prices depending on the district. In the central parts of the city, forming the core districts (Śródmieście, Wola), prices exceed 25,000 zł per m^2. At the same time, the Mokotów district demonstrates a level of 18,672 zł per m^2, reflecting its specificity as a prestigious location with a substantial volume of supply across different price segments. In contrast, in districts bordering the suburbs (Białołęka, Rembertów), prices start from 12.7-13 thousand zł per m^2. This confirms a high degree of price differentiation based on geographical factors and the sustained popularity of central locations in the capital, as reflected in recent monitoring reports by the Statistical Office in Warsaw (2025), Tabelaofert (2025), and RynekPierwotny (2025b). Such territorial disparity serves as a key indicator for developers when planning new investment projects for 2025-2026.

The high price differentiation across Warsaw districts is driven not only by geographical location but also by the capitalisation of local advantages. Research by R. Cellmer (2023) confirmed that the development of transport infrastructure and accessibility to recreational areas are decisive factors influencing property values. To assess such complex relationships, it is appropriate to apply hedonic pricing methods, the scientific justification of which is provided by J. Jaroszewicz & H. Horynek (2024), who emphasised the quality of the residential environment as a key indicator for planning new investment projects in 2025-2026. At the same time, it should be noted that the fundamental aspects of pricing and spatial development in Warsaw,

which underpin modern models, were established in earlier works by M. Widłak *et al.* (2015) and K. Olszewski *et al.* (2017). However, the high level of price variation is only an external manifestation of spatial heterogeneity. As noted by J. Jura (2021), this heterogeneity has intensified as a result of post-pandemic demand transformation and active suburbanisation. For a deeper understanding of the internal structure of the Warsaw real estate market, the level of concentration across its main segments was analysed. The results of the relevant calculations were presented in Table 2.

Table 2. Comparison of average rental prices in Warsaw by property type as of 2025, zł

Property type	Average monthly rent	Rent per м²
Studio	2,500-3,000	100-120
One-bedroom	2,900-3,500	80-110
Two-bedroom	3,500-4,300	70-130
Three-bedroom	4,500-6,000	65-100

Source: compiled on the basis of Tabelaofert (2025), Investropa (2026)

Housing prices in the secondary market and rental levels demonstrated a clear dependence on the quantitative characteristics of the property, particularly the number of rooms and total floor area. As shown in Table 2, an inverse relationship is observed between the size of the dwelling and the price per square metre. In particular, the highest unit prices are recorded for small-sized apartments (studios), where the rental rate amounts to 2,500-3,000 zł and the price per 1 m^2 is the highest. In three-bedroom apartments, the total rent increases to 4,500-6,000 zł; however, the average price per square metre is significantly lower compared to compact housing. This trend confirms the high demand for small-sized properties, which are the most liquid among young people and migrants. Within the analysed sample, it has been confirmed that the key pricing factor in this segment is precisely the functionality and size of the property, which results in a higher market valuation per square metre in compact apartments compared to multi-room dwellings.

The identified trend of increasing unit rental costs for compact housing is directly correlated with the socio-economic challenges faced by new residents of the capital. As studios and one-bedroom apartments are the most in demand among migrants, the high rental rates for such properties (2,500-3,000 zł) create significant financial barriers to market entry. P.-P. Verhaeghe & D. De Coninck (2022) highlighted the issue of inequality in the rental market, which intensifies during periods of large-scale migration inflows, when demand for budget housing segments exceeds supply. Similar structural challenges in Central European real estate markets under post-pandemic recovery conditions were analysed by J.K. Kazak *et al.* (2023), emphasising the need to adapt housing policy to new social realities. An additional factor is the "economies of scale" effect in pricing: as the number of rooms and total area increase, the growth rate of total rent slows relative to the increase in space. This leads to a situation where renting multi-room apartments, when shared among several occupants, may be more financially advantageous per person than renting an individual studio. However, for migrants and young professionals who prioritise autonomy, compact housing remains the preferred option, which sustains the unusually high price per square metre in this segment.

Thus, the data on the high cost of small housing confirms the hypothesis of increasing financial pressure on the most vulnerable categories of tenants in Warsaw. The identified patterns indicate the need for more in-depth monitoring of housing affordability under conditions of demographic change. However, to fully understand market trends, it is not sufficient to analyse only the current price structure; it is also important to trace their evolution over recent years. The dynamics of average prices in the primary and secondary housing markets in Warsaw for the period 2021-2025 were systematised and presented in Table 3.

Table 3. Dynamics of average prices in the primary and secondary housing markets in Warsaw for 2021-2025

Year	Price per m^2 in the primary market, zł	Change compared to the previous year in the primary market, %	Price per m^2 in the secondary market, zł	Change compared to the previous year in the secondary market, %
2021	11,362	-	12,463	-
2022	12,895	+13.5	14,076	+12.9
2023	13,713	+6.4	14,277	+1.4
2024	16,512	+20.4	18,677	+30.9
2025	17,293	+4.7	18,385	-1.6

Source: compiled on the basis of National Bank of Poland (2025b), RynekPierwotny (2025a)

The analysis of the dynamics of average prices in the primary housing market of Warsaw demonstrates a steady upward trend: prices increased from 11,362 zł/m^2 in 2021 to 17,293 zł/m^2 in 2025, representing a total growth of +52%. In contrast, the secondary housing market is characterised by less stable dynamics, manifested in significant fluctuations in annual growth rates compared to the relatively predictable primary segment. According to O. Jeż & J. Žukovskis (2025), such pressure on prices is largely driven by changes in banks' credit policies and

reduced mortgage accessibility. In particular, while growth in the primary market occurred gradually, the secondary segment experienced a sharp intensification of price pressure, with the most significant surge recorded in 2024 (+30.9%). In this context, J.V. Duca & A. Murphy (2021) analysed post-pandemic asset overvaluation, while K.A. Kholodilin *et al.* (2024) highlighted the role of monetary policy in the formation of price bubbles, explaining the nature of the Warsaw price surge. This uneven pattern of change reflects trends identified in reports by RynekPierwotny (2025a) and analytics by Tabelaofert (2025), which noted that the secondary market responded more sharply to changes in mortgage programmes and migration shocks.

The structure of housing buyers in Warsaw demonstrates a clear transformation under the influence of socio-economic changes, as evidenced by data from the Statistical Office in Warsaw (2025) and Investropa (2026). A key aspect is the integration of Ukrainian refugees, studied by K. Kochaniak & A. Huterska (2023), which has become a significant factor shaping demand. An upward trend was observed during 2022-2024, driven by post-pandemic recovery, inflationary pressures, increased migration flows, rising construction material costs, and government mortgage support programmes. Moreover, real estate is increasingly perceived as a safe asset, as confirmed by A. Chmielewska *et al.* (2022) in their study on the transformation of investment behaviour. Thus, during 2021-2025, a gradual increase in average housing prices was observed, reaching a peak in 2024, after which the growth rate began to slow. This may indicate partial market saturation and the adaptation of demand to new economic conditions.

The sharp rise in housing prices in 2024 has intensified concerns about the risk of "price bubbles". According to K.A. Kholodilin *et al.* (2024), expansionary monetary policy often leads to market overheating, which aligns with the analysis by J.V. Duca & A. Murphy (2021) regarding global asset overvaluation. At the same time, K.A. Kholodilin (2025) emphasised in subsequent research that effective government regulation can serve as a tool for stabilising market indicators and minimising speculative volatility. The structural changes in the composition of housing buyers in Warsaw during 2021-2024 are systematised and presented in Table 4.

Table 4. Structure of housing buyers in Warsaw for 2021-2024, %

Buyer categories	Years				
	2021	2022	2023	2024	2024/2021
Polish households (for owner-occupation)	68	60	58	55	-13
Polish investors (purchase for rental/capital)	20	18	20	22	2
Foreign investors (EU, USA)	5	6	7	8	3
Ukrainian citizens	<1	5	8	9	8
Citizens of other countries	7	11	7	6	-1

Source: compiled on the basis of K. Kochaniak & A. Huterska (2023), RynekPierwotny (2025a), Statistical Office in Warsaw (2025)

Thus, the profile of homebuyers in Warsaw reflects a clear transformation of the primary real estate market under the influence of socio-economic changes between 2021 and 2024. The decline in the share of Polish households in favour of investors and foreign buyers indicates the growing role of the primary real estate market as an investment vehicle. At the same time, the active migration of Ukrainian citizens since early 2022 has become a key factor driving up demand, particularly in the affordable housing segment in Warsaw.

As the growth in demand is accompanied by increased competition among the main market players, it is necessary to analyse the degree of supply concentration among the city's largest developers. This will allow to determine how monopolised the market is and how capacity is distributed among the leading companies under current market conditions. The market shares of the primary real estate market among Warsaw's top 20 developers and the results of the HHI assessment were presented in Table 5.

Table 5. Market share of leading developers in the primary real estate market of Warsaw for 2022-2024, and their contribution to the HHI based on the number of commissioned residential units

No.	Developer	2021			2022			2023			2024			2024/2021
		Units	Share, %	HHI	Units	Share, %	HHI	Units	Share,%	HHI	Units	Share,%	HHI	
1	Dom Development	1,500	14.15	200.2	1,600	13.92	193.8	1,700	13.46	181.4	1,791	13.20	174.2	1.19
2	Murapol	2,200	20.75	430.6	2,300	20.02	400.8	2,350	18.61	346.2	2,297	16.93	286.9	1.04
3	Develia	1,400	13.20	174.2	1,500	13.06	170.7	1,600	12.67	160.6	1,654	12.19	148.7	1.18
4	Robyg	900	8.49	72.1	1,000	8.70	75.7	1,150	9.11	83.0	1,225	9.02	81.4	1.36
5	J.W. Construction	700	6.60	43.6	750	6.52	42.5	800	6.34	40.3	868	6.40	41.0	1.24
6	Ronson	300	2.83	8.0	320	2.78	7.7	350	2.77	7.7	384	2.83	8.0	1.28
7	Atal	200	1.89	3.6	220	1.91	3.6	200	1.58	2.5	168	1.24	1.5	0.86
8	Marvipol	400	3.77	14.2	450	3.91	15.3	550	4.36	19.0	613	4.52	20.4	1.53
9	Yareakn	350	3.30	10.9	420	3.65	13.3	500	3.96	15.7	562	4.14	17.1	1.61

Table 5. Continued

No.	Developer	2021			2022			2023			2024			2024/ 2021
		Units	Share, %	HHI	Units	Share, %	HHI	Units	Share,%	HHI	Units	Share,%	HHI	
10	Skanska	500	4.71	22.2	550	4.79	22.9	650	5.15	26.5	735	5.42	29.4	1.47
11	Echo Investment	300	2.83	8	320	2.78	7.7	380	3.01	9.0	439	3.23	10.4	1.46
12	Lokum	200	1.89	3.6	220	1.91	3.6	250	1.98	3.9	286	2.11	4.4	1.43
13	Euro Styl	180	1.70	2.9	200	1.74	3.0	250	1.98	3.9	306	2.25	5.1	1.70
14	Mid-size group	250	2.36	5.6	270	2.35	5.5	290	2.30	5.3	306	2.25	5.1	1.22
15	Panattoni Development Europe	800	7.55	57	900	7.83	61.3	1,100	8.71	75.9	1,358	10.01	100.2	1.70
16	Warsaw Urban Development	120	1.13	1.3	130	1.13	1.3	140	1.11	1.2	153	1.13	1.3	1.28
17	Mazovia Residential Group	100	0.94	0.9	110	0.96	0.9	120	0.95	0.9	133	0.98	1.0	1.33
18	Capital Housing Investments	90	0.85	0.7	95	0.83	0.7	100	0.79	0.6	112	0.83	0.7	1.24
19	Vistula Home Development	60	0.57	0.3	70	0.61	0.4	80	0.63	0.4	92	0.68	0.5	1.53
20	Nova Praga Development	55	0.52	0.3	65	0.57	0.3	70	0.55	0.3	82	0.60	0.4	1.49
	Top 20 in total	10,605	100	1,059.6	11,490	100	1,031.3	12,630	100	983.7	13,568	100	937.4	1.28
							Change in HHI							122.2%

Source: compiled on the basis of Statistical Office in Warsaw (2025), RynekPierwotny (2025a)

The market leader remains Dom Development, which consistently increases its sales volumes and maintains a leading share in the housing market. Companies such as Murapol, Develia, and Robyg demonstrate moderate growth in their market shares, while the share of small and medium-sized companies is also gradually increasing, contributing to stronger competition. The HHI for the top 20 companies decreased from 1,059.6 in 2021 to 937.4 in 2024, reflecting a decline in the level of concentration in the primary real estate market over time and a transition from moderate to low concentration from an antitrust perspective (as HHI < 1,000), alongside a gradual intensification of competition among developers. This trend indicates that although large players retain leading positions, the primary real estate market is becoming more balanced due to the growing activity of medium-sized and smaller companies. The increase in sales volumes and the stable presence of market leaders, combined with a moderate strengthening of competition, create conditions for price stabilisation in the primary market and the expansion of housing supply, particularly in the central districts of Warsaw.

The conducted analysis of the market power of leading players made it possible to identify an important structural transformation. As the market power of the top 20 developers becomes less concentrated in the hands of a few leaders and company shares are distributed more evenly, this confirms the absence of signs of oligopolisation in the primary housing segment, despite significant volumes of commissioned developments. The calculated indicators based on formulae (4) and (5) demonstrate that even leading market players are compelled to adapt their strategies to conditions of intensified competition. This creates strategically favourable conditions for investors, as deconcentration typically encourages developers to improve the quality of their projects and to offer more flexible pricing conditions in order to maintain their market positions. The results of the LI calculations for leading developers in the primary real estate market in Warsaw for 2021-2024 were presented in Table 6.

Table 6. Analysis of the LI for leading developers in Warsaw for 2021-2024

No.	Developer	L_{2021}	L_{2022}	L_{2023}	L_{2024}	L_{2024}/L_{2021}, %
For two developers, LI 2	Murapol Dom Development	146.643	143.822	138.336	127.293	-19.35
For three developers, LI 3	Murapol, Dom Development, Develia	141.967	139.172	134.558	128.416	-13.55
For four developers, LI 4	Murapol, Dom Development, Develia, Robyg	174.481	168.127	156.515	140.167	-34.314
For five developers, LI 5	Murapol, Dom Development, Develia, Robyg, Panattoni Development Europe	162.025	145.333	130.889	119.83	-42.195

Source: compiled on the basis of the data in Table 5, Statistical Office in Warsaw (2025), RynekPierwotny (2025a)

The calculation of the LI for the market core confirms these conclusions: the absence of significant jumps in the LI indicator suggests that the gap between the leaders (Dom Development, Murapol) and other participants is gradually narrowing. This reduces the risks of the emergence of a rigid oligopoly and indicates that market power is becoming more evenly distributed among medium-sized players. According to the results presented in Table 6, the LI values for all analysed groups of developers show a downward trend over the period 2021-2024. In particular, the most significant decrease is observed for the group of five leaders (LI 5), indicating the erosion of the monopolistic core and increasing competitive pressure from medium-sized market participants. The absence of increases exceeding 200% indicates the lack of acute antitrust risks during the analysed period. In summary, it should be noted that the further development of the urban agglomeration will be influenced by new labour standards. The implementation of remote and hybrid working models, as emphasised by S. Kuźmar *et al.* (2026), intensifies suburbanisation processes, as buyers increasingly prefer larger housing units in more remote areas, which will reshape the demand structure in the long term.

The analysis of the stability of the top three leaders within the market core (Murapol, Dom Development, Develia) over 2021-2024 shows the smallest decline in the aggregated LI 3 indicator (-13.55 percentage points). This indicates the high resilience of the market core formed by these three leading developers. Their combined position and influence, although declining, do so more slowly than in other groups. The inclusion of additional players (top 4 and top 5) into the market core – namely Robyg (top 4) and Panattoni Development Europe (top 5) – leads to a significantly greater decline in the aggregated LI indicator: LI 4 decreased by 34.314% and LI 5 by 42.195%. This may suggest that the activity volumes of the fourth and fifth developers within the market core are more volatile and more sensitive to external economic factors compared to the top three leaders. For the top five developers, the LI shows the largest decline over the period (-42.195 percentage points), indicating that smaller local players within the market core are losing their positions more rapidly over time. This reinforces the dominance of the absolute leaders (top 3), despite their own moderate decline.

The overall downward trend of the aggregated LI indicator across all groups in 2021-2024 indicates a reduction in the collective weight or dominance of leading groups in the real estate market, which is consistent with the decline in HHI from 1,059.6 to 937.4 during the same period. However, this decrease is less pronounced for the top three firms within the market core, confirming moderate concentration and increasing competition, particularly from medium-sized and smaller companies that are not part of the top five (as their market shares, as shown in Table 1, are growing – for example, Panattoni Development Europe from 7.55% to 10.01%).

The top three leaders within the market core remain the most stable in maintaining their combined position (showing the smallest decline in the LI indicator). This confirms their continued dominance despite the overall deconcentration of the market, as reflected in the decline of the HHI. Thus, an analysis of LI trends for aggregated groups confirms that the real estate market is becoming less concentrated (HHI is decreasing), but the dominance of the top three players remains stable, as their combined LI 3 position is declining the least. The next indicator of the level of concentration in the real estate market is the GI. This index made it possible to assess the level of uneven distribution of enterprises, expressed in terms of their share in the total number of residential units completed in Warsaw (Table 7).

Table 7. Results of GI calculations for the Warsaw real estate market valuation framework for 2021-2024

Year	2021	2022	2023	2024	2024/2021, %
GI	0.2778	0.2770	0.2763	0.2739	-0.0039

Source: the results are based on the financial statements of companies operating in the primary real estate market

The results of the GI calculations in assessing the Warsaw real estate market indicate a slight decrease in inequality (from 0.2778 in 2021 to 0.2739 in 2024). This suggests that the distribution of contributions to commissioned residential units has become more even over time. This trend is consistent with the findings of the HHI and LI, which point to a gradual deconcentration of the real estate market. Despite the fact that leading developers – Murapol, Dom Development, and Develia – retain key positions, a gradual increase in the share of medium-sized and small enterprises can be observed. This situation reflects the stability of the primary real estate market, characterised by a relative balance between large corporations and smaller developers, which is a positive indicator for the long-term development of the sector. The generalisation of the obtained results regarding the economic conditions and the level of market concentration in the Warsaw real estate market provided the basis for conducting a SWOT analysis of the strategic directions of its development. Based on these findings, a SWOT matrix for the development of the Warsaw real estate market was constructed, as presented in Table 8.

Table 8. SWOT matrix of the Warsaw real estate market

	Opportunities (O)	Threats (T)
	a. Increased demand due to the integration of Ukrainian migrants into Polish society. b. The development of suburbs and suburbanisation driven by remote working. c. Investment in energy-efficient housing and "green construction". d. The arrival of new international developers and an expansion of the housing supply. e. The use of European grants and funds for housing infrastructure.	a. Macroeconomic influences such as persistent instability, inflationary risks, and exchange rate volatility. b. Rising unemployment or stagnation of household incomes. c. Oversupply of rental housing in the event of a decline in migration flows. d. Potential tightening of government regulation of the real estate market and increased tax burden. e. Geopolitical tensions in the region that may affect investment sentiment.
Strengths (S)	**SO-strategies**	**ST-strategies**
a. A resilient Polish economy and growth in real household incomes. b. Stable demand for housing from both domestic and international migrants. c. Well-developed infrastructure and high attractiveness of the city for investors. d. Active participation of large developers shaping a competitive environment. e. Government programmes supporting mortgages and young homebuyers.	1-A. Leveraging Poland's stable economic conditions and government mortgage programmes to stimulate housing purchases among young families and migrants. 2-B. Intensifying investment in residential projects in the suburban areas of Warsaw (Wilanów, Ursynów, Wesoła) based on the suburbanisation trend. 3-C. Development of energy-efficient construction and "green" residential complexes with the participation of leading developers (Dom Development, Skanska). 4-D. Supporting cooperation between the state and major developers to expand supply in the primary housing market.	1-D. Maintaining a high level of competition among the top 20 developers in the housing market to prevent monopolisation of the sector. 2-C. Utilising the financial stability of the banking sector to mitigate the impact of inflationary fluctuations on lending. 3-B. Orienting developers towards long-term rental models (build-to-rent) to reduce the risk of market volatility. 4-A. Attracting foreign investors as a compensatory mechanism in the event of a slowdown in domestic demand.
Weaknesses (W)	**WO- strategies**	**WT- strategies**
a. High housing costs in central districts of Warsaw, limiting affordability. b. Lengthy bureaucratic procedures for obtaining construction permits. c. Shortage of affordable housing for tenants with middle incomes. d. Dependence on the cost of construction materials and energy resources. e. Rising interest rates in 2022-2023, which temporarily reduced demand.	1-A. Reducing bureaucratic barriers through the digitalisation of construction permitting procedures. 2-C. Stimulating the development of affordable rental housing through public-private partnerships. 3-B. Utilising European recovery funds to modernise the existing housing stock and reduce energy consumption. 4-D. Introducing tax incentives for developers investing in social housing.	1-D. Diversifying the developer structure through support for small and medium-sized development companies. 2-C. Implementing market monitoring based on the National Bank of Poland and the Statistical Office in Warsaw to forecast crisis trends. 3-B. Developing a long-term government programme to support rental housing in cooperation with the Warsaw municipality. 4-A. Strengthening control over construction quality and environmental standards to prevent social risks.

Source: compiled by the authors

The results of the SWOT analysis indicate that the Warsaw real estate market remains one of the most stable and, at the same time, dynamic in Central Europe. Its strengths include sustained economic growth of the city, a high level of urbanisation, well-developed infrastructure, and the presence of strong development companies that account for a significant share of new housing construction. Warsaw attracts investors both from Poland and abroad, creating conditions for a stable inflow of capital into the sector. An additional advantage is the active support of government lending programmes aimed at young families and first-time homebuyers. At the same time, the market has a number of vulnerabilities, including high construction costs, lengthy administrative procedures, and a limited availability of land plots in central districts. This leads to an increase in the price per square metre and reduces housing affordability for younger generations. Significant threats also include price volatility, inflationary pressure, and the risk of saturation in the investment segment, which may slow further growth. Despite these risks, the Warsaw real estate market offers broad opportunities for further development. Increasing demand from Ukrainian citizens, foreign investors, and representatives of the IT sector creates potential for the expansion of the rental housing segment and more efficient utilisation of the existing housing stock. In the medium term, a high pace of construction activity is expected to persist, particularly in districts such as Wola, Mokotów, and Wilanów, alongside growing developer activity in suburban areas. Thus, the Warsaw real estate market is currently undergoing a phase of structural stabilisation and modernisation, which ensures its attractiveness for both domestic and international investors. The successful combination of regulatory reforms, technological innovations, and socially oriented housing policies may become the foundation for its sustainable development in the post-pandemic period and under conditions of prolonged migration mobility.

The analysis of price dynamics and the impact of market shocks on the Warsaw real estate market confirms the conclusions of O. Jeż & J. Žukovskis (2025) regarding the faster growth rates of prices in the primary market compared to the secondary market. A more in-depth analysis conducted in this study identified a peak increase of +20.4% in 2024 in the primary real estate market in Warsaw. While M. Głuszak & R. Trojanek (2024; 2025) suggested the presence of "price bubbles", the results obtained for 2025 (a slowdown in growth to +4.7%) indicate not a bursting "bubble" but rather a stabilising adjustment. This suggests that in 2025 the Warsaw real estate market is moving out of a phase of heightened demand and entering a stage of market equilibrium at a higher price level.

The results of the study also support the thesis of M. Bryx *et al.* (2023) regarding the impact of the pandemic, while highlighting a critically important point: the post-pandemic recovery of the Warsaw real estate market, reinforced by the effects of war, has created a cumulative convergence of factors (including migration), generating a cost escalation effect for developers. The aftermath of the pandemic led to pent-up demand for real estate in Warsaw and disrupted established supply chains for construction materials and energy-intensive resources. The war caused a sharp demographic pressure and an energy crisis, increasing the cost of building materials production. The combination of these processes created a synergistic effect that the real estate market would not have generated under the influence of only one of these factors. These conclusions are consistent with the findings of O. Shandrivska & I. Balinska (2024) regarding the impact of migration processes and the socio-economic conditions of temporarily displaced Ukrainians on the Polish economy.

The provided assessment of migration dynamics and the transformation of housing demand in Warsaw quantitatively confirms the hypothesis of M. Głuszak & R. Trojanek (2024) regarding the impact of Ukrainian refugees on the rental market in Poland. The results demonstrate that Ukrainians have become full-fledged participants in the property purchase and sale market, increasing their share from more than 1% to 9% over the period 2021-2024. This finding correlates with the work of K. Kochaniak & A. Huterska (2023) on refugee integration. From the perspective of economic theory, this signifies a transition of capital from the category of "temporary residence" to "long-term investment in human capital and assets", thereby creating a foundation for further strengthening the stability of housing demand in Warsaw.

The results of market concentration assessment, as discussed by A. Yelowitz *et al.* (2012) and T. Kvålseth (2018), generally align with the notion of market monopolisation by large developers in the capital. However, the findings of this study indicate a decline in the HHI from 1,059.6 to 937.4, signalling the deconcentration of the Warsaw real estate market. This represents a positive development for the economy and reduces barriers to entry into the capital's real estate market. The identification of the stability of the market core – represented by the three leading developers (Murapol, Dom Development, Develia) – alongside the volatility of the fourth and fifth market positions further complements theoretical foundations of market cyclicality. This demonstrates that the largest real estate market players possess greater financial resilience to macroeconomic shocks.

The results of the spatial differentiation assessment, which clearly indicate the dependence of housing prices on proximity to the business centre, reveal a price gap between the Wola district (25.7 thousand zł) and the Białołęka district (13.8 thousand zł), consistent with the findings of R. Cellmer (2023) regarding the importance of points of interest (POI). It has been established that price differentiation in districts such as Śródmieście and Wola has reached its maximum (with prices exceeding 25,000 zł/m^2), indicating a clear formation of zones of capital concentration and offices of international companies. In contrast, districts such as Białołęka, Rembertów, and Wawer remain peripheral, with price levels in the range of 12-13 thousand zł/m^2. This confirms the theory of differential rent, according to which location is the primary determinant of added value.

The spatial differentiation presented in this study makes it possible to identify the specific characteristics of housing across administrative districts: investment housing, concentrated in areas with a high POI index as discussed by R. Cellmer (2023). This type of housing is represented by small flats in central locations intended for short-term rental needs; and socio-migration housing, which has acquired distinct features due to rising prices and intensified migration flows during the Russian-Ukrainian war. These factors have influenced the transformation of housing demand towards "second-tier" districts (for example, Targówek and Ursus), where housing is more affordable. This has led to the emergence of new local centres of activity in Warsaw.

The assessment of the spatial concentration of developer activity made it possible to differentiate territorial developers as follows: leading developers (Dom Development, Murapol, Develia) maintain diversified portfolios; however, their presence in prestigious districts positions these areas as "low-risk zones". Conversely, smaller companies are compelled to develop in more remote districts or the suburbs of Warsaw, confirming the arguments of J. Jura (2021) regarding suburbanisation. This supports the conclusion that spatial price differentiation in Warsaw has intensified: the effects of the pandemic and the active phase of the war have not equalised price levels but, on the contrary, have reinforced differentiation. As a result, prices in prestigious districts have increased further, particularly due to their perceived security as assets, while housing in peripheral districts has become more accessible to mass consumers and migrants.

The study by A. Chmielewska *et al.* (2022), which highlighted that investor motivation has shifted towards assets with high liquidity and adaptability, aligns with the findings of this research regarding the rapid increase in prices in central business districts of Warsaw (particularly Wola), where investment attractiveness remains consistently high

regardless of external factors. It is important to note the need for further academic discussion. J. Jura (2021) and S. Kuźmar *et al.* (2026) emphasised processes of deurbanisation and growing demand for suburban housing driven by the effects of the pandemic and the expansion of remote working. However, the results of this study on housing demand under the influence of the Russian-Ukrainian war in 2025 – reflected, among other indicators, in property prices in districts such as Śródmieście and Wola – demonstrate that centripetal forces remain dominant. High property prices in central districts indicate that physical accessibility to office and social infrastructure is valued more highly than the "green zones" of suburban areas.

Thus, the identified divergence between theoretical assumptions of deurbanisation and the actual price dynamics in Warsaw in 2025 reflects a complex transformation of consumer priorities. While the pandemic period stimulated interest in suburban real estate as a means of adapting to isolation, new geopolitical and economic challenges have redirected demand towards central districts, which serve as guarantors of security, stability, and immediate access to critical infrastructure. This leads to the conclusion that, despite the spread of remote working practices, centralisation processes in Warsaw remain a fundamental driver of the real estate market. Accordingly, the observed price resilience of central locations confirms their role as "safe assets" during periods of market shocks, necessitating a reassessment of existing suburbanisation models in favour of a concept of reinforced urban concentration under crisis conditions.

CONCLUSIONS

The study conducted suggests that the the Warsaw real estate market in the period 2021-2025 underwent a phase of fundamental transformation driven by the synergistic effects of pandemic-related changes, geopolitical shocks, and unprecedented migration waves. The research demonstrated that, despite an intensive academic debate on de-urbanisation and the potential outflow of population to suburban areas, the actual dynamics of prices and construction volumes in Warsaw indicate the persistent dominance of centripetal forces. It has been established that the strategic advantage of central districts such as Śródmieście and Wola lies not only in the concentration of office infrastructure but also in a high level of social security and rapid access to essential services. This reflects a shift in consumer priorities: whereas in 2021 the key demand was for space and isolation ("green zones"), by 2025 liquidity and infrastructural stability had come to the forefront. Within the analysis of the competitive environment, it was found that the primary real estate market of the capital exhibits a gradual trend towards decreasing concentration and the erosion of a monopolistic core. The application of the HHI to the activities of the top 20 developers confirmed a transition from a moderately concentrated market (HHI > 1,000) in 2021 to a low-concentration market (HHI < 1,000) in 2024. Although leading developers still control around 98% of market supply, the calculation of the LI indicated the absence of acute antitrust risks and an increase in competitive pressure from medium-sized market players.

Such a level of market power enables large developers to effectively offset price risks associated with rising costs of construction materials and energy resources; however, it simultaneously creates significant barriers to entry for new participants. This explains the relative rigidity of prices in terms of downward adjustment, even during periods of declining purchasing power among the population. The importance of the obtained results lies in confirming the status of housing in Warsaw's urban core as a "safe asset" under conditions of regional instability. The findings have practical implications for investors and urban planners, as they highlight the need to revise housing development strategies towards increasing building density in areas with established social infrastructure, rather than further expanding urban boundaries. It should be noted that the results of this study may have been influenced by specific exogenous factors, particularly the intensity of government demand-stimulation programmes (for example, subsidised mortgage loans), which contributed to increased price volatility in the primary market. In addition, this study primarily focused on price and quantitative indicators, while qualitative characteristics of housing, particularly compliance with environmental standards (EU ESG directives), were beyond the scope of the analysis and may serve as a subject for further research. Accordingly, future research perspectives lie in focusing on the analysis of "green certification" of buildings as a factor in asset capitalisation in the post-crisis period.

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Дослідження ринку нерухомості Варшави в умовах пост-пандемічного відновлення та міграційних процесів

Анотація. Трансформація ринку нерухомості Варшави під впливом глобальної макроекономічної нестабільності, пандемічних обмежень і масштабних міграційних хвиль зумовлює потребу в науковому аналізі структурних змін та адаптаційних механізмів житлового сектору. Метою дослідження було проведення комплексного аналізу кон'юнктури ринку нерухомості Варшави впродовж 2021-2025 років, оцінювання рівня його ринкової концентрації та ідентифікація детермінант трансформації попиту в умовах посткризового відновлення. Методологічну основу роботи становив системний підхід із застосуванням статистичного аналізу динамічних рядів, методів порівняння, SWOT-аналізу, а також математичного інструментарію оцінки ринкової концентрації в частині застосувань індексів Херфіндаля-Хіршмана, Лінда та Джині. У результаті дослідження встановлено, що динаміка цін на первинному та вторинному ринках Варшави у період 2021-2025 років демонструвала висхідний тренд із піковими показниками зростання у 2024 році, що було спричинено інфляційним тиском та дефіцитом пропозиції. Доведено, що просторовий розподіл вартості житла у розрізі районів столиці відображає високу диференціацію, де центральні локації зберігають статус найбільш стійких інвестиційних активів. Виявлено суттєву зміну структури суб'єктів попиту: зафіксовано зростання частки іноземних покупців, зокрема громадян України, чий внесок у формування ринкових показників став стратегічно значущим після 2022 року. На основі розрахунку індексу Херфіндаля-Хіршмана за 2021-2024 роки обґрунтовано тенденцію до деконцентрації ринку нерухомості та перехід від середнього до низького рівня ринкової влади домінуючих гравців. Прогнозується, що подальша стабілізація галузі відбуватиметься шляхом інтенсифікації субурбанізаційних процесів та адаптації пропозиції до нових соціально-демографічних потреб мігрантів. Практичне значення дослідження полягає у можливості імплементації отриманих висновків інвестиційними аналітиками для мінімізації ризиків, а також суб'єктами державного управління при формуванні стратегій просторового розвитку міських агломерацій у посткризовий період

Ключові слова: ціни на житло; девелопери; концентрація ринку; індекс Херфіндаля-Хіршмана; індекс Лінда; індекс Джині

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Adaptation strategies and resilience models for Ukrainian enterprises in times of crisis and martial law

Abstract. In the context of Russian full-scale armed aggression against Ukraine – unprecedented since the country's independence – traditional management approaches have proved ineffective, creating an urgent need to explore new mechanisms for business survival. The transformation of enterprises under the influence of extreme uncertainty is becoming a decisive factor not only for preserving the country's economic potential but also for its future recovery. The study aimed to conduct a comprehensive analysis of the adaptation tools used by Ukrainian companies during the period of martial law, which has been in force since 2022, and to develop a scientifically grounded model for enhancing their viability. The research was based on the application of a systematic approach, classification methods and a comparative analysis of the evolution of scientific views on economic stability within the framework of the "conflict continuum" concept. The study identified key vectors of business transformation, covering the operational, financial and technological spheres. The study demonstrated that adaptive capacity acts as a fundamental mediator that directly shapes the overall resilience of an organisation. It has been established that cost optimisation has become a strategic imperative, compelling management to implement flexible budgeting, energy autonomy and lean manufacturing methods. Asset relocation has been identified as a key component of resilience; with the support of government programmes, it can be used for production cycle to be maintained in safe regions. Digital transformation, which ensures cyber resilience and business continuity in hybrid environments, has been given particular attention. The role of alternative funding sources, such as grants and risk-sharing, in supporting business solvency has been highlighted. The authors proposed a generalised model that integrates strategic flexibility, decentralised decision-making and scenario planning as the basis for crisis management. The recommendations and developed models can be used by business leaders to adjust their crisis management plans, as well as by government authorities when developing programmes to support and stimulate investment in the post-war period

Keywords: entrepreneurial resilience; relocation; cost optimisation; digitalisation; cyber resilience; alternative financing; risk sharing

INTRODUCTION

The full-scale military aggression launched by Russia against Ukraine in February 2022 has caused the greatest geopolitical disruption to the global economy of the 21st century. S.V. Korobka (2023), based on an analysis of the destructive impact of the war on macroeconomic indicators, demonstrated that the cumulative losses led to a reduction in the country's gross domestic product by more than a third. The author highlighted the correlation

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between the destruction of production capacity and the sharp decline in economic activity for further analysis of the scale of the real losses suffered by the Ukrainian economy. As noted by A.S. Alshebami (2025), in this context, the study of organisational adaptation and entrepreneurial resilience in Ukrainian business takes on paramount scientific and practical relevance.

Traditional business management models, designed for peacetime and economic stability, have proved ineffective in the context of unprecedented challenges such as military aggression. Enterprises have faced not only physical destruction and loss of resources, but also extreme uncertainty, requiring a shift towards qualitatively new, flexible anti-crisis management strategies. The range of responses by Ukrainian enterprises to wartime challenges varies from passive resource conservation to active innovative transformation. V. Korolkov *et al.* (2025) noted that different models of adaptive behaviour are determined by the level of risk, sector-specific characteristics, geographical location and available resources. According to I.O. Bobyliev & N.M. Chupryna (2025), the analysis of adaptive strategies in wartime is relevant as it can be used for formulation of recommendations that enterprises can utilise in critical situations, whilst also contributing to the overall development of resilience theory in conditions of instability. E. Berthelsen (2025) noted that contemporary scientific approaches to the study of conflict are increasingly moving away from the dualistic opposition of "peace versus war" in favour of the concept of a conflict continuum. Organisations operate in an environment of constant strategic competition and hybrid threats; therefore, adaptation is not a one-off crisis response but a continuous process of organisational change aimed at gaining or maintaining competitive advantages. The core concepts in adaptation research are adaptive capacity (AC) and entrepreneurial resilience (ER). Study by by A.S. Alshebami (2025) on micro and small enterprises in times of crisis confirmed that AC acts as a mediator that has a positive and significant impact on ER. Factors that enhance AC include crisis management preparedness and customer-centric adaptation.

The constant pressure of military and economic challenges is transforming the process of adaptation into a powerful driver of innovation and structural change. Rather than being a reaction to disruption, adaptation is driving the implementation of effective cost management and innovative technological and organisational solutions. This, according to D. Sarwar & S. Rye (2025), leads to permanent changes in the configuration of global supply chains and trade relations, which are expected to persist even after the conflict has ended. Thus, as argued by O. Karintseva *et al.* (2025), successful adaptation strategies require a combination of rapid tactical response and long-term strategic planning. The study aimed to conduct a comprehensive analysis of the adaptation strategies of Ukrainian enterprises during the period of martial law, to identify factors of resilience, and to develop scientifically grounded approaches to strengthening business resilience in the context of wartime and post-war transformations.

The study goals included:

- to systematise theoretical and methodological approaches to the adaptation of Ukrainian enterprises in times of crisis and war, and to clarify the role of resilience and digital transformation models in ensuring their sustainability;
- to analyse the adaptation strategies of Ukrainian enterprises and assess the impact of government programmes, grant support, international financial organisations and risk-sharing instruments on their financial stability and viability;
- to develop and justify a generalised model of adaptation strategies, identifying priority areas for their optimisation to strengthen business resilience.

LITERATURE REVIEW

There is growing interest in the academic literature in researching economic resilience in the context of hybrid conflicts, which combine traditional military threats with cyberattacks, disruptions to supply chains and the need for institutional adaptation. Indeed, modern armed conflicts pose unique economic challenges, and Russian full-scale aggression against Ukraine has provided a case study for analysing the mechanisms of survival and recovery of economic systems under conditions of uncertainty.

Regional conflicts are no longer isolated issues; instead, they have a rapid and negative global impact, forcing organisations to review their risk management strategies. L. Bednarski *et al.* (2023) and D. Sarwar & S. Rye (2025) highlighted that geopolitical conflicts create systemic vulnerabilities and cause large-scale disruptions in critical supply chains, which immediately affect the global economy. E. Berthelsen (2025) argued that modern conflict requires businesses to adopt so-called "hybrid times", where strategies of war and peace must be applied simultaneously, forcing organisations to review their fundamental processes.

Research into the impact of war on the economy has undergone a significant evolution. Macroeconomic studies from 2018 to 2020 focused primarily on the overall impact of conflicts, analysing the dependence of growth on imports (Bonfatti & O'Rourke, 2018) and the long-term effects of war on economic development (Thies & Baum, 2020). These studies laid the foundation for analysis of macroeconomic vulnerability. However, after 2022, the focus shifted significantly from diagnosing macroeconomic factors to practical planning for resilience at the micro level. Work since 2022 has centred on operational survival tactics, such as relocation (Korobka, 2023), and the latest management models specifically adapted to conditions in Ukraine (Varakin *et al.*, 2024). This shift from the analysis of passive variables (dependence, growth) to active management variables (adaptive leadership, relocation) indicates a paradigm shift: academic attention has moved from vulnerability assessment to the study of AC (Zelisko, 2023; Alshebami, 2025). This transformation reflects the

evolution of crisis management, aimed not only at survival but also at sustainable functioning under conditions of constant threat. This trend is consistent with the findings of I. Pokromovic *et al.* (2022), showing that business resilience is formed through a combination of organisational, strategic and financial components.

Strategic management in highly turbulent environments is given significant attention in the literature. For instance, I.O. Bobyliev & N.M. Chupryna (2025) addressed strategic management models that can be used by enterprises to navigate an extremely volatile environment, emphasising the need for hybrid approaches. I. Pokromovica (2025) emphasised that changes in global and national economic indicators, in particular gross domestic product, inflation, unemployment and production volumes, correlate with indicators of enterprise resilience. This indicates that, in the context of significant fluctuations in these economic indicators caused by crisis phenomena, corresponding changes in the level of enterprise resilience occur. In this regard, according to the authors, to accurately assess corporate resilience, it is advisable to cover specific characteristics of the Ukrainian economy, the extent of its integration into the global economic space, as well as the nature and intensity of external shocks.

A substantial element of management in crises is the role of leadership. M.K. Sott & M.S. Bender (2025) provided a conceptual framework for adaptive leadership in times of crisis. Research findings emphasise that leaders must not only respond to external shocks but also actively manage internal organisational changes. An organisation's ability to rapidly change its structure and processes is a prerequisite for successful survival. Furthermore, in a study by M. Fedyk (2024), resilience achieved during conflict is regarded as a prerequisite for effective post-war recovery. The interaction between the public and private sectors is particularly noteworthy. F. Graf *et al.* (2023) demonstrated that the institutionalisation of a crisis regime in public administration creates a more stable environment for economic activity. This is consistent with the research by D. Varakin *et al.* (2024), demonstrating that adaptive business strategies are more effective when supported by flexible state mechanisms.

In response to direct military risks and financial shocks, businesses have developed a range of operational and financial adaptation mechanisms, ranging from the physical relocation of assets to strict financial discipline and the search for non-traditional sources of capital. Research by N. Smochko & T. Luzhanska (2022), H. Zelisko (2023) and S.V. Korobka (2023) emphasised that relocation is the primary tool for maintaining the economic activity of enterprises. Another approach, according to K. Kekola (2022) and K. Itiola (2023), is the diversification of activities, which helps mitigate risks and increase profitability, though it requires systematic risk assessment in wartime conditions. The issue of financial stability was actively examined by O. Karintseva *et al.* (2025), emphasising the significance of rigorous cost optimisation and the review of contractual obligations.

The issue of contract management is becoming increasingly relevant in a climate of legal and regulatory uncertainty. Despite the need for businesses to possess strong negotiating skills, F.D. Domingos *et al.* (2025) have highlighted the difficulty of revising public contracts due to strict regulations. According to K. Alekseieva *et al.* (2023), government and international support programmes are substantial in ensuring sustainability. T. Batrakova & E. Semibratova (2023) argued that grants, international aid and crowdfunding serve as alternative sources of funding. The latter, as shown by K. Efrat *et al.* (2023) and S. Adala *et al.* (2025), is based on mechanisms of emotional interaction between donors and businesses and operates according to the "compassion economy" model, which makes it an effective but unstable instrument of long-term financing.

At the same time, researchers view digitalisation not merely as a means of survival during a crisis, but as a fundamental driver of post-war modernisation and the socio-economic development of regions (CSIS, 2021). For instance, V. Tyshchenko *et al.* (2024) demonstrated that digital transformation forms the basis for innovative development, which is of strategic rather than merely tactical significance. In the context of economic recovery, I. Nechayeva & I. Shylovets (2024) viewed digital technologies as a factor that will help the country and its individual regions to recover and modernise. Automation, which is part of digital transformation, influences the future of production processes, results and economic structures (European Parliament, 2021).

The war in Ukraine has accelerated the revision of global cyber strategies. G. Austin & N. Khaniejo (2023) and G.B. Mueller *et al.* (2023) demonstrated that cyber operations have become an integral component of modern armed conflict. Therefore, NATO and international institutions regard digital transformation as a key element of security (NATO ACT, 2023). Cyber resilience is becoming a strategic economic asset, and the digitalisation of business, according to V. Tyshchenko *et al.* (2024), must be combined with physical security measures, in particular relocation. Thus, an analysis of academic sources indicates growing attention from researchers to the issue of business adaptation in crisis and wartime conditions. At the same time, existing studies predominantly examine individual aspects of resilience, which necessitates a comprehensive analysis of Ukrainian businesses' adaptation strategies under martial law.

MATERIALS AND METHODS

The study drew on academic literature and empirical case studies illustrating the strategies adopted by Ukrainian enterprises during the period of Russia's full-scale aggression, which has been ongoing since 2022. The criteria for selecting sources were their thematic relevance, particularly in areas such as macroeconomic vulnerability; operational survival tactics, such as relocation; the latest management models adapted to the conditions of martial law; financial stability and cost optimisation; digital transformation and cyber resilience. The empirical basis of the study also

included secondary statistical and analytical sources regulatory and analytical documents from the European Parliament (2021), research findings from Diia. Business (2023), sectoral analytics from the IT Ukraine Association (2023), analytical materials from Deloitte (2023), as well as open data and analytical reports from Opendatabot (2025a; 2025b). The study also included an analysis of the effectiveness of state support programmes such as "Affordable loans 5-7-9%" and grants ("YeRobota") (Ministry of Economy of Ukraine, 2025a; 2025b), as well as mechanisms for attracting financing from international financial organisations (IFOs), in particular risk-sharing instruments such as "Ukrainian Guarantees" (European Investment Bank, n.d.; European Bank for Reconstruction and Development, n.d.). The focus was on strategies reflecting a shift from the analysis of macroeconomic vulnerability factors to the examination of management decisions at the enterprise level. The focus was on models that increase ER. To achieve this objective, the study was conducted in three main stages using appropriate methods.

The first stage involved a theoretical framework and an assessment of the initial conditions, using historical and comparative analysis to trace the evolution of academic approaches – from a focus on the general impact of conflicts and macroeconomic vulnerability in 2018-2020 to a focus on operational survival tactics and AC (post-2022). The concept of the conflict continuum and "hybrid times" was also applied to determine how organisations function in conditions where strategies of war and peace are applied simultaneously. The second stage involved the analysis and systematisation of adaptive mechanisms (a systemic approach). Methods of analysis, classification and systematisation were used to identify and structure the various strategies implemented by Ukrainian businesses, enabling a move beyond simple anti-crisis measures. Classification was applied to structure cost-optimisation methods by area of implementation (financial, organisational, technological, strategic). Systematisation was used to identify the key elements of strategic reorientation, including crisis management, decentralisation of decision-making and scenario planning. Correlation analysis (based on secondary data) was applied to confirm that AC is the main mediator positively influencing ER.

The third stage involved synthesis, effectiveness assessment and the formulation of recommendations (synthetic and conceptual analysis). The synthesis identified key components of resilience models that integrate financial discipline, strategic flexibility and technological innovation. Effectiveness assessment was used to compare the advantages and limitations (risks) of key adaptive strategies (operational, financial, technological and external financial support strategies) against criteria of economic stability, management flexibility and long-term adaptability of enterprises. Conceptual analysis was used to identify critical gaps in the scientific literature, such as the need to transition from "survival mode" to "growth mode" and the assessment of the long-term social costs of adaptation. Based on the results obtained and the gaps identified, long-term recommendations were formulated for business and the state regarding the enhancement of the resilience of Ukrainian enterprises in the context of wartime and post-war transformations. The methodology is based on the transparent use of secondary sources, a clear classification of adaptation strategies (financial stability, strategic flexibility, digitalisation, securing funding), as well as the application of standardised analytical methods (analysis, synthesis, risk assessment). This can be used to replicate the research stages, verify the classifications, and assess the effectiveness of the strategies using the provided sources and defined analytical approaches.

RESULTS

According to data from Diia.Business (2023), Ukrainian businesses have gradually adapted to the conditions of war, as reflected in their management decisions: 33.4% already had an action plan in place, whilst 50.5% were in the process of deliberation and intuitive management. The analysis identified main trends and directions of Ukrainian enterprises' adaptation to the conditions of martial law. These directions are summarised in Figure 1.

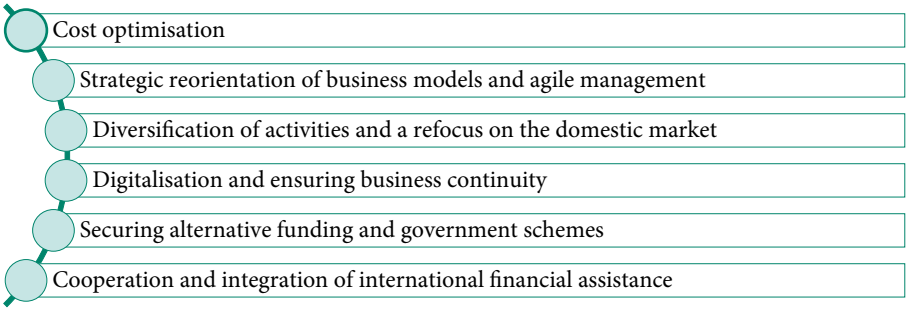

Figure 1. Ways in which Ukrainian businesses are adapting to the conditions of martial law
Source: compiled by the authors

Cost optimisation as a key element of financial stability. O. Karintseva *et al.* (2025) and I.O. Bobyliev & N.M. Chupryna (2025) established that, in the context of full-scale war, economic instability and dynamic shifts in consumer demand, cost optimisation has become a strategic imperative for Ukrainian businesses. This tool is

crucial for ensuring financial stability, maintaining profitability and competitiveness. The challenges of martial law have radically altered the structure of enterprises' operating costs: in particular, indirect or non-productive costs associated with physical security and ensuring business continuity have risen significantly. These additional items include costs for security, ensuring energy self-sufficiency (purchasing generators, uninterruptible power supply systems, and implementing alternative energy sources) and, in the event of relocation, costs for moving staff and equipment. The introduction of alternative energy sources increases initial investment costs, but at the same time ensures that businesses are resilient to systemic disruptions in the electricity supply. Furthermore, this helps reduce long-term operating costs.

In conditions of extreme uncertainty, where traditional static budgeting models have become obsolete, as noted by O. Karintseva *et al.* (2025), flexible budgeting has become the primary approach to financial management, in particular, methods such as rolling forecasting and zero-based budgeting (ZBB). These methods can be used to quickly adjust financial plans based on up-to-date data and new scenarios, thereby increasing adaptability. To support these flexible approaches, it is necessary to implement real-time cost control systems. The ability to promptly obtain and analyse up-to-date data on expenditure can be used for rapid decisions, minimising the loss of resources and time, which is particularly important in rapidly changing conditions. As part of optimising personnel costs and increasing flexibility, O. Karintseva *et al.* (2025) argued that the use of outsourcing and outstaffing is relevant. Organisational adaptation also involves training staff to perform multiple functions (multifunctionality) and implementing lean manufacturing principles. These measures help eliminate unproductive wastage of resources and time, ensuring maximum efficiency within existing constraints. Paradoxically, the rise in costs associated with ensuring energy self-sufficiency and physical security (as an initial response to risk) has acted as a catalyst for the adoption of cost-effective production practices and innovative cost management. This demonstrated that adapting to military challenges serves as a driver for improving overall business operational efficiency.

To reduce infrastructure costs, including logistics costs such as warehouse and transport maintenance, the study by I.O. Bobyliev & N.M. Chupryna (2025) demonstrated that businesses are actively seeking to collaborate with other companies. Sharing resources helps minimise downtime and improves the efficiency of logistics routes, which are also optimised using modern digital technologies. Furthermore, companies are forced to focus on producing or selling only the most profitable products, which can be used to rationalise resources and reduce unproductive stock. A substantial component of optimisation is the renegotiation of supply contracts. Although negotiations to amend terms during a crisis are legally complex, they are essential for survival. Scientific approaches to negotiations in crises emphasise the importance of reframing the problem and showing empathy towards the counterparty ("Feel the other side's pain"). Successful contract restructuring requires not only legal analysis but also psychological readiness to adjust initial expectations to minimise potential losses for both parties. Optimisation methods can be classified according to the areas in which they are implemented (Table 1).

Table 1. Methods for optimising costs in Ukrainian enterprises during martial law

Area of optimisation	Specific methods (examples)
Financial	Flexible budgeting (Rolling forecast, ZBB), real-time cost control
Organisational (HR)	Outsourcing, outstaffing, cross-functional training, decentralisation of decision-making
Technological (operational)	CRM/ERP implementation, process automation, infrastructure sharing (collaboration)
Strategic (security)	Emphasis on the most profitable products, the introduction of alternative energy sources, and the optimisation of logistics routes

Source: compiled by the authors based on O. Karintseva *et al.* (2025), I.O. Bobyliev & N.M. Chupryna (2025)

Strategic reorientation of business models and agile management. I.O. Bobyliev & N.M. Chupryna (2025) demonstrated that martial law forced companies to abandon rigid hierarchical structures and adopt more flexible organisational structures. As M. Fedyk (2024) argued, in conditions of armed conflict, the companies that survive are those capable of ensuring maximum flexibility, innovation and responsiveness. Effective strategic management in conditions of military instability, according to I.O. Bobyliev & N.M. Chupryna (2025), requires a comprehensive rethinking of traditional approaches, including: crisis management as a priority for risk management and ensuring business continuity; decentralisation of decision-making, in the form of granting greater autonomy to regional or functional units for faster response to local challenges and changing circumstances; scenario planning for the development of multi-variant strategic scenarios that can be used to prepare for various levels of escalation or destabilisation. The managerial implications of crisis conditions, as emphasised by M.K. Sott & M.S. Bender (2025), highlight the need to cultivate adaptive leadership and ensure the flexibility of the organisational structure for the effective allocation of resources. Such an approach creates a cycle of continuous growth, even when the organisation operates under conditions of high uncertainty.

The analysis presented by H. Zelisko (2023) demonstrated that business relocation is one of the most

significant and radical instruments of economic security implemented in response to the challenges of war. Relocation, which N. Smochko & T. Luzhanska (2022) defined as the movement of businesses (within the country or abroad) from zones of active hostilities, aims not only to protect existing facilities from destruction, but also to preserve employment, establish the production of critically needed goods and services, and replenish local, regional and state budgets. The practical implementation of these theoretical approaches is confirmed by the scale of this process in Ukraine. In particular, the dynamics of business relocation demonstrate the high adaptability of Ukrainian businesses: for instance, during 2025, Ukrainian businesses conducted internal relocation 8,345 times (Fig. 2).

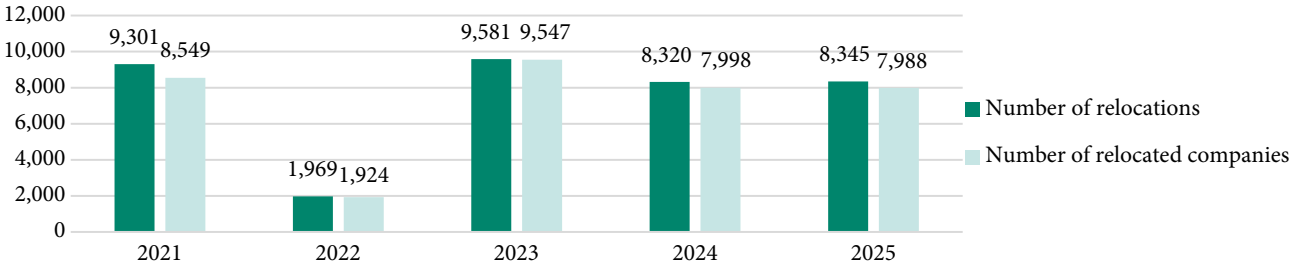

Figure 2. Number of relocations and relocated companies, 2021-2025, units
Source: compiled by the authors based on Opendatabot (2025a)

The data presented in Figure 2 indicated a certain shift in the dynamics of business relocation over the period under review. Whilst the figures up to 2022 reflected natural market mobility, the sharp drop in the number of relocations in 2022 (to 1,969) can be attributed to a state of 'shock-induced paralysis' and critical uncertainty. During this period, most enterprises focused on physical survival and the preservation of assets and staff in the context of imminent danger. The recovery and subsequent rapid growth in figures in 2023-2025 (over 8-9 thousand relocations annually) indicate that the shock phase has been overcome and that relocation has been transformed into a conscious tool of an adaptive competitive strategy. The high intensity of relocations from 2023 onwards indicates that businesses have moved from passive waiting to actively seeking safer and more economically viable locations to resume operations. The scale of this internal migration of capital and production capacity points to the emergence of a new economic geography in Ukraine, where security considerations are becoming a decisive factor in the strategic planning of business operations.

As noted by N. Smochko & T. Luzhanska (2022), the Ukrainian government, in conjunction with the Ministry of Economy, is implementing a state relocation programme aimed at supporting businesses located in areas of active hostilities. State support, which includes logistical assistance and financial incentives, is critical, as the relocation process is costly and complex from both a legal and technical perspective. Relocation is of particular importance for small and medium-sized enterprises (SMEs), which form a key component of the Ukrainian economy. According to S.V. Korobka (2023), the creation of favourable conditions for SME development in safe regions is one of the main ways for the state to emerge from the economic crisis. Enterprises relocating within the country can take advantage of preferential financing programmes, such as the state programme "Affordable loans 5-7-9%" (Ministry of Economy of Ukraine, 2025a).

Whilst domestic relocation is primarily a tactical move to ensure physical security, relocating businesses abroad requires a fundamental review of the entire business strategy. A study by H. Zelisko (2023) demonstrated that for successful international relocation, companies must thoroughly examine the specifics of doing business in the chosen country, assess the associated financial costs, and adapt their operational models to the new regulatory and market environment. Given Ukraine's European integration trajectory and the availability of preferential conditions for access to the single market, the European region has become the primary focus for such strategic expansion. Data presented in the study by T. Shepel (2025) confirmed this priority: 62% of companies that decided to relocate internationally chose EU countries (Fig. 3).

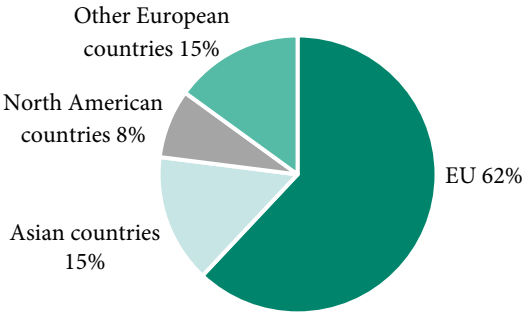

Figure 3. The geographical distribution of Ukrainian companies' relocations worldwide (breakdown by region)
Source: compiled by the authors based on T. Shepel (2025)

According to the study, the EU countries to which the largest number of companies have relocated are Poland (47%) and Germany (19%). Other EU countries included Bulgaria (12%), Belgium (10%), Estonia (8%) and Romania (3%). The physical relocation of a business is merely

the initial, reactive phase of adaptation, but its successful completion depends directly on the implementation of the subsequent, strategic phase, which involves flexible management and decentralisation. The high military risk that triggered the relocation leads to a change in the operational environment. For a company to function effectively in its new location and respond swiftly to local challenges (such as issues with logistics, staff or contractors), it must implement decentralised management structures, which, according to I.O. Bobyliev & N.M. Chupryna (2025) increases the overall resilience of the business and its ability to adapt rapidly to dynamic market changes.

Diversification of activities and a refocus on the domestic market. A study by K. Itiola (2023) demonstrated that business diversification, which involves the development of new products or services, is one of the fundamental strategies for minimising financial and operational risks in times of crisis. Under martial law, diversification is critical for managing risks associated with geographical instability and sharp fluctuations in demand, helping to maintain profitability. For enterprises, particularly small and medium-sized businesses, which typically have limited financial and human resources, concentric diversification has proven to be the most viable. This strategy involves creating new products or services that logically complement the existing portfolio. The advantage of concentric diversification lies in the fact that it can be used with existing infrastructure, equipment and expertise, minimising the need for risky investments. Although a significant proportion of Ukrainian businesses focus on maintaining their product range, almost a quarter of companies opt to produce new types of products (or services) whilst retaining their core range (Fig. 4).

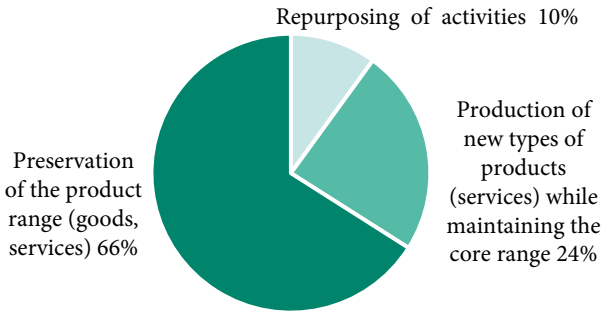

Figure 4. Percentage breakdown of the strategies preferred by relocated businesses when resuming operations
Source: compiled by the authors based on L. Yakymova (2025)

An analysis of the data presented in Figure 4 showed the distribution of recovery strategies among relocated enterprises, expressed as a percentage. Thus, most relocated entities (66%) focus on the strategy of "maintaining the product range", which is logical at the initial stage of relocation. At the same time, the choice of the strategies of "business reorientation" and "product portfolio diversification" indicates that these approaches are adopted by only a limited number of enterprises and serve as additional options for adapting to the new market.

The war caused significant, asymmetric disruptions to global supply chains, leading, as established in the study by D. Sarwar & S. Rye (2025), to shortages of critical materials, volatility in energy markets and serious transport problems. These events, according to L. Bednarski *et al.* (2023), forced many firms to completely rethink the configuration of their global logistics networks. The adaptation strategies documented in D. Sarwar & S. Rye (2025) are aimed at enhancing the resilience of supply chains. Such strategies include diversifying supply sources and reducing dependence on a single supplier or geographical region, developing strategic reserves and stockpiling critical materials to ensure production continuity, accelerated digitalisation, and the use of technologies to optimise logistics and track shipments. This highlights permanent changes in supply chain configurations, which will persist even after the conflict has ended.

In the context of external instability and the blockage of export routes (particularly maritime ones), refocusing on the domestic market has become an essential strategy for survival and stabilisation. According to Diia. Business (2023), most businesses continue to orient their development towards the domestic market: 50.9% of businesses in the western regions, 51.8% of enterprises in the northern regions, 67% of companies in the central part of the country, 62.7% of businesses in the eastern regions, and 67.8% of enterprises in the south. War significantly reduces revenues from foreign and domestic trade, but, according to C.F. Thies & C.F. Baum (2020), emphasising domestic demand, particularly for critical goods, provides businesses with relatively stable effective demand. Military operations often lead to a reallocation of resources within a country. R. Bonfatti & K.H. O'Rourke (2018) argued that domestic raw materials can be redirected from traditional exports to meet the needs of the military sector or critical civilian production.

The shift towards exports by a significant proportion of businesses previously dependent on the domestic market is having a positive impact on the Ukrainian market; among other things, it is improving the quality of products and services, boosting demand for innovation, enhancing management culture, raising wages for skilled workers, and facilitating the return of refugees. A significant proportion of enterprises planning an export reorientation are businesses that already had experience of export activity in the pre-war period. The results of the Diia.Business survey (2023) shows that 43% of SMEs plan to develop their exports. By region, 48.2% of businesses in the western regions, 47.8% in the northern regions, 33% in the centre of the country, 36.2% in the eastern regions, and 30% in the southern part of the country have made this decision.

A study by K. Kekola (2022) demonstrated that diversified companies with multiple business segments exhibit greater resilience thanks to the so-called internal capital

markets mechanism. This mechanism ensures efficient reallocation of financial and production resources from segments that have been severely affected by war or logistical constraints to those segments that demonstrate better growth opportunities (for example, in the domestic market or in the defence procurement sector).

The role of digitalisation in ensuring business continuity. Digital transformation, as the foundation of resilience, has proved to be not merely a trend but also a catalyst and cornerstone for ensuring business continuity for Ukrainian enterprises. The successful experience of major players in the logistics sector (such as Nova Poshta and Ukrposhta), examined in a Deloitte analytical study (2023), has demonstrated that the use of digital technologies maintains vital operations even during active hostilities and systemic infrastructure disruptions. The introduction of remote working and learning has become the primary mechanism for retaining human capital and ensuring operational flexibility. Digital services, which were already being developed in Ukraine before the war, ensure business and even resolve financial matters (such as applying for loans or grants) from anywhere. According to I. Nechayeva & I. Shylovets (2024), this sector has the potential to be decisive in post-war reconstruction, transforming the workforce, infrastructure and business processes as a whole. The effectiveness of implementing such digital solutions and the resilience of the Ukrainian technology sector are directly reflected in foreign trade indicators, the trends of which are shown in Figure 5.

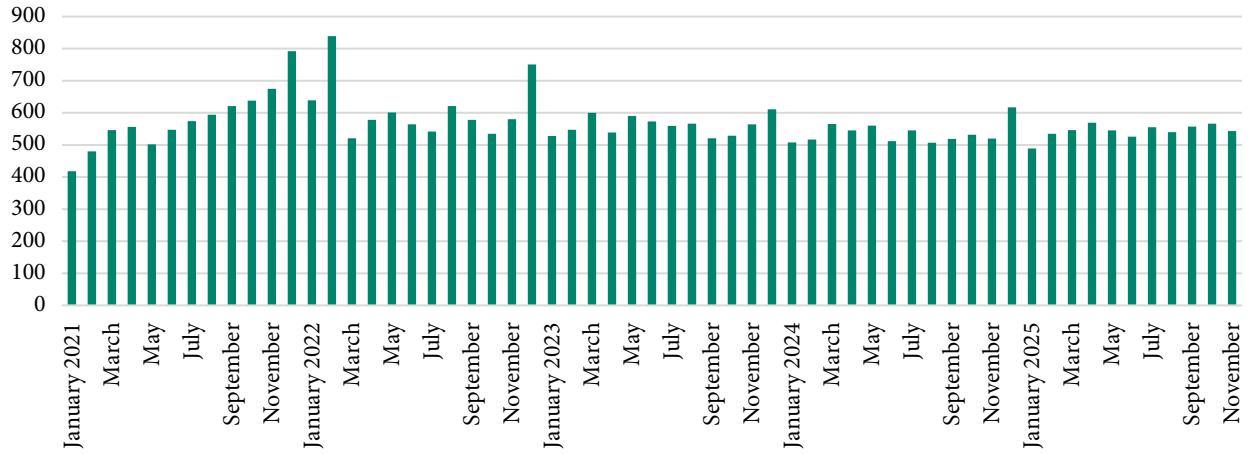

Figure 5. Trends in Ukrainian IT services exports, million USD
Source: compiled by the authors based on Opendatabot (2025b)

The trend shown in Figure 5 indicates that, before the full-scale invasion, there was a marked upward trend, reaching an all-time high just before the invasion began, in February 2022 (over 800 million USD). Despite the conditions of war, the sector demonstrated a high degree of adaptability. Although export volumes declined slightly, they remained stable at around 500-600 million USD per month. In 2024-2025, a certain stagnation in export figures is observed: revenue volumes fluctuate around the $550 million mark, which may be a consequence of both a global slowdown in the IT market and the exhaustion of domestic resources for extensive growth amid prolonged military risks. This industry remains a key component of the economic base, and its development and the promotion of exports, according to Opendatabot (2025b), IT accounts for 12% of Ukraine's total exports, which are a priority for stabilising the economy. Digitalisation in the context of the Russia-Ukraine war is characterised by specific dynamics driven by the circumstances of the conflict. Although global economic theories may suggest that economic stagnation often leads to a decline in investment in new technologies and productive capacity (Manche & Carbonell, 2022), in Ukraine, investment in digital solutions (such as ERP, remote infrastructure and cybersecurity) is proceeding at a rapid pace. M. Fedyk (2024) explained this by noting that technology is not so much a tool for economic growth as a critical tool for survival and ensuring continuity, which is a prerequisite for adaptation in wartime conditions. However, the active implementation of technology simultaneously increases vulnerability to cyberattacks, a fact that became particularly evident during Russian military aggression.

The military aggression against Ukraine became the field for the most extensive and sustained use of hostile cyber operations in world history. Technologies that provide new opportunities also bring new threats that directly influence the nature of military operations. As noted by G. Austin & N. Khaniejo (2023), this has created new challenges for businesses, such as the need to integrate cyber defence into their operational activities. According to the IT Ukraine Association (2023), cybersecurity expenditure as a proportion of the total annual budget for large companies (more than 250 employees) averages 10-15%, whilst small companies (with up to 50 employees) serving many clients with critical data spend an average of >20%. For a medium-sized enterprise, total expenditure on cybersecurity amounts to approximately 98,000 USD (Table 2).

Table 2. Cybersecurity costs for a company in Ukraine in 2023 (based on a company with 200 employees)

Costs	Total expenditure (USD)
Cost of monitoring staff behaviour	3,000
Simulation of a cyberattack on computer systems to test their security	35,000
Simulation of a real attack on the system	60,000
Total	98,000
Per employee	~500

Source: compiled by the authors based on IT Ukraine Association (2023)

The high proportion of expenditure on attack simulations and testing (totalling $95,000) demonstrates the maturity of Ukrainian companies' approach to cybersecurity. Instead of building static barriers, businesses are investing in dynamic system testing, which is a logical extension of the strategy of digitalisation and risk minimisation in turbulent conditions. Ukrainian cybersecurity, which is fundamental to economic resilience, according to G. Austin & N. Khaniejo (2023), requires continuous cyber defence, thereby blurring the line between cyber competition, crisis and war, which demands constant readiness; "defence in depth" as a proactive and multi-layered protection strategy, rather than merely a reaction to existing threats; and consistent budgetary allocations – cybersecurity must be among the highest priorities, requiring continuous funding to sustain core capabilities. A substantial element for enhancing cyber resilience, according to G.B. Mueller *et al.* (2023), is an effective partnership between the government and the private sector. This cooperation is vital for preventing a state of strategic digital parity and for sharing information on threats. Based on Ukraine's experience, cybersecurity is becoming an integral part of a survival strategy, transforming business competitive advantages into a long-term perspective.

Securing alternative funding and government schemes. In a climate where traditional sources of funding (bank lending, private investment) are becoming limited due to increased risk and uncertainty, businesses are forced to turn to alternative mechanisms. Crowdfunding is substantial among these, serving as a modern tool that raises funds from a wide range of investors via online platforms. According to data from Statista (n.d.), the global crowdfunding market was valued at 1.05 billion USD in 2025. The average annual growth rate in the crowdfunding market is expected to be 20.5% between 2024 and 2029.

The functional purpose of crowdfunding has also undergone a transformation. Whereas previously it mainly supported ambitious new projects, under the conditions of martial law established by L. Didenko *et al.* (2025), it has become a "financial lifeline" for existing but struggling businesses. This thesis was confirmed by S. Adala *et al.* (2025): in their view, the growing number of crowdfunding campaigns is aimed not at realising new ideas, but at covering urgent needs, such as operating costs, rent or staff wages. The success of these rescue campaigns, despite the high level of uncertainty, is partly explained not only by economic expediency but also by socio-psychological factors. Research showed that the willingness of crowdfunding participants to support small businesses during a crisis may be driven by a sense of social solidarity they derive from this support (Efrat *et al.*, 2023). One of the main crowdfunding platforms in Ukraine is Biggggidea, which actively promotes the implementation of socially significant initiatives and the raising of funds for projects through collective contributions (Table 3).

Table 3. Key figures on the funding of social initiatives via the Biggggidea platform in Ukraine, 2025

Indicator	For 2025
Number of benefactors (individuals)	110,412
Number of opportunities (projects) over the entire period (units)	13,995
Total amount invested (UAH)	58,443,914

Source: compiled by the authors based on Bigidea (n.d.)

Data in Table 3 indicate the emergence of a support system for socially significant initiatives. Donors demonstrate a high level of trust in digital fundraising platforms, highlighting the shift in philanthropy from large one-off donations towards a mass movement of small contributions. The number of implemented opportunities indicates that the Biggggidea platform is an effective tool for scaling up local initiatives in the fields of culture, education and social protection. The average donation amount (the ratio of the total sum to the number of donors) is approximately 529 UAH, which demonstrates the accessibility of social investment for the average citizen, a key indicator of the democratisation of financial support for social change. On average, each initiative receives around 4,176 UAH, indicating that the platform is primarily focused on supporting micro-projects or the initial stages of implementing big ideas.

State support is crucial for reviving businesses and preventing them from going bankrupt (Alekseieva *et al.*, 2023). The Ukrainian government has introduced or adapted a range of anti-crisis measures and preferential financing programmes. The "Affordable loans 5-7-9%" programme: Implemented by the Entrepreneurship Development Fund (EDF). Research conducted by H. Zelisko (2023) indicated

that this programme offers preferential interest rates (5%, 7% or 9% per annum) depending on the business's revenue and commitments to create jobs. According to data from the Ministry of Economy of Ukraine (2025a), during the period of martial law, entrepreneurs received 99,700 loans totalling 370.4 billion UAH. In 2025, under the programme, businesses secured 30,100 loans totalling nearly 94 billion UAH (Fig. 6).

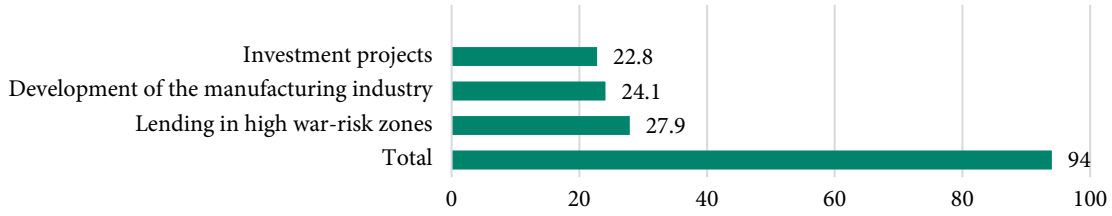

Figure 6. Total value of loans under the "Affordable Loans 5-7-9%" scheme in 2025, in billions of UAH
Source: compiled by the authors based on the Ministry of Economy of Ukraine (2025a)

An analysis of the data presented in Figure 6 shows that by 2025, the "5-7-9%" programme had evolved into an effective tool for the structural restructuring of the economy. The allocation of resources reveals a shift in the programme's focus from supporting current liquidity to strategic areas of economic recovery and resilience. The total volume of lending across the three strategic areas amounts to approximately 74.8 billion UAH, underscoring the government's priority on security challenges and industrial development. The high proportion of loans in high-risk areas also attests to the effectiveness of state portfolio guarantee mechanisms, which ensures mitigation of some of the war-related risks. The largest volumes of lending have been taken up by businesses in the agricultural sector, the processing industry, and the wholesale and retail trade. On the "Diia" government services portal, via the "YeRobota" tab (YeRobota, n.d.), entrepreneurs can apply for grants, which serve as an alternative source of non-repayable funding for relocation, business recovery and diversification. In particular, the state has invested 12 billion UAH in the development of small and medium-sized businesses through the YeRobota grant programmes (Ministry of Economy of Ukraine, 2025b). Almost 25,000 entrepreneurs have received financial support to start or develop their businesses. Grant recipients have already returned 75% of the invested funds in the form of taxes and duties paid to the budget. The main areas of grant support and the figures characterising them are presented in Table 4.

Table 4. Level of government investment in the development of SMEs through grant programmes

Areas of grant support	Number of grants, units	Total investment, UAH
"Vlasna Sprava" (microgrants)	22,488	5.3 billion
Processing plants	926	4.6 billion
Horticulture and the development of greenhouse farming	268	1.3 billion
To war veterans and their families	1,122	525 million

Source: compiled by the authors based on the Ministry of Economy of Ukraine (2025b)

In terms of the number of grants, the "Vlasna Sprava" programme is the undisputed leader in terms of reach. By contrast, the "Processing Enterprises" sector has the highest average grant value (approximately 5 million UAH). The total volume of investment through the YeRobota programme demonstrates the state's transition from a model of social payments to a model of investing in citizens' economic agency. The areas of use for grant funds include the purchase of equipment, the restoration of production facilities (with the possibility of resubmission), and investments in energy resilience (solar panels, generators).

An analysis of the data presented confirms the strategic role of public investment; however, the authors agree with the view expressed by K. Alekseiev *et al.* (2023) regarding the need to improve the mechanisms for allocating these resources. Although state aid is necessary, a substantial task for improving effectiveness is to establish clear criteria for selecting viable business entities. It is necessary to identify and support those companies that have the potential for recovery and growth, whilst simultaneously removing so-called "zombie enterprises". Thus, state support must evolve from simple liquidity financing to strategic investment in sustainability.

Cooperation and integration of international financial assistance. Under martial law, the state undertakes to create all the necessary conditions for the functioning and recovery of businesses. This includes the systematisation of state aid, for example, in sectors such as agribusiness, which has a direct impact on food security. The government must also implement regulatory and legal measures aimed at stimulating business activity and minimising risks. D. Varakin *et al.* (2024) noted that effective management of economic security during military operations requires the development of adaptive risk management strategies that combine external support with the internal flexibility of enterprises.

T. Batrakova & E. Semibratova (2023) argued that external financial assistance plays a decisive role in sustaining the functioning of the public sector of the economy, stabilising the country's monetary and financial situation, and safeguarding the national currency's exchange rate. However, mechanisms that reduce investment risks are of critical importance to the private sector. IFOs, such as the European Investment Bank or the European Bank for Reconstruction and Development, actively use risk-sharing instruments, in particular "Ukrainian Guarantees". These guarantees serve as a mechanism to cover financial risks for various transactions in the public and private sectors (loans, counter-guarantees). The main effect of introducing guarantees is a reduction in collateral requirements for companies receiving financing, which significantly broadens the range of enterprises that can access the necessary funds. A striking example is the creation of the Ukraine Sub-Fund by EFSE (European Fund for Southeast Europe), which was implemented with the support of the German and EU governments (EU NEIGHBOURS east, 2024). This fund aims to support the recovery and resilience of war-affected businesses by working with local financial institutions.

During wartime, it is necessary to implement digital monitoring tools for international aid, as they ensure transparency and oversight of project implementation, the prompt identification of problems and minimisation of risks, alignment with EU standards, the effective allocation of resources and coordination among participants, simplified reporting for recipients, and timely assessment of the impact of aid on business resilience and economic stability. Long-term economic recovery is impossible without attracting significant volumes of foreign direct investment (FDI). This is a key element for economic transformation and the transition to a "new economy", as FDI fulfils not only a financial but also a structural and technological function in economic development. Attracting FDI requires the state not merely to adopt an "open-door policy", but to develop comprehensive, long-term public policies and tailored incentives. Effective strategies for attracting FDI include: the development of sectoral clusters; reducing the tax burden; strengthening educational and research programmes; and providing venture capital and investment incentives.

The process of international cooperation involves a transition from initial assistance to investment partnerships. Initial financial assistance (grants, concessional loans) is aimed at ensuring survival and liquidity. However, to ensure long-term economic transformation and attract FDI, it is necessary for the state, in conjunction with IFIs, to effectively absorb and minimise investment risks through guarantees. According to T. Batrakova & E. Semibratova (2023), mitigating these risks through risk-sharing mechanisms is a factor that stimulates private sector lending and forms the basis for sustainable recovery. The alternative financing and international support instruments that were actively used during the period 2022-2024 are presented in Table 5.

Table 5. Alternative financing instruments and international support

Source of funding	Tool	Purpose	Effect
State	Preferential loans (5-7-9%), Grants ("YeRobota")	Relocation, regeneration, job creation	Supporting liquidity and safeguarding SME production
Community/Private sector	Crowdfunding (rescue campaigns)	Covering operating costs (rent, staff)	Financial lifeline, made possible by social solidarity
IFIs	Ukrainian Guarantees (risk-sharing), Specialised sub-funds (EFSE)	Private/public sector financing, energy efficiency	Reduction of financial risks, expansion of access to credit

Source: compiled by the authors

Financial support for Ukrainian businesses is a multi-tiered structure that has emerged in response to the extreme challenges of wartime. The public sector (the Financial Support Programme) serves as the foundation for liquidity. Programmes such as "5-7-9%" and "YeRobota" serve as a "first aid" measure for businesses. Their role is critical not only for creating new jobs but also for the physical preservation of production capacity through relocation mechanisms. The community and the private sector are viewed as emotional capital. Crowdfunding serves as a unique instrument of social solidarity. Unlike, for example, bank lending, it covers the most "vulnerable" operating costs (rent, wages), enabling small businesses to survive during periods of zero profit, which makes MFIs a guarantor of stability. The use of risk-sharing instruments is essential for attracting capital to a country with high military risks, enabling Ukrainian banks to lend to the real sector whilst having potential losses partially covered by international donors.

Thus, resilience in wartime is a multidimensional construct: it requires a combination of operational changes (relocation, diversification), financial discipline (cost optimisation) and adaptive leadership. A critical factor for survival, particularly for SMEs, is access to non-traditional sources of funding (grants, crowdfunding), which, according to V. Korolkov *et al.* (2025), fill the gaps created by dysfunctional traditional markets. A summary of the key findings shows that each strategy has significant advantages, but is also accompanied by risks that must be addressed when developing, inter alia, national economic policy (Table 6).

Table 6. A synthesis of the effectiveness of adaptive strategies

Strategy	Adaptation mechanism	Benefits	Limitations and risks
Operational adaptation	Relocation and diversification	Reducing direct military risks; maintaining production capacity and flexibility.	High logistics costs; risk of losing skilled staff; regional imbalances.
Financial adjustment	Cost optimisation	Maintaining liquidity and financial viability in the context of reduced demand.	Risk of a decline in the quality of products/ services; strained relations with counterparties when renegotiating contracts.
Technological adaptation	Digital transformation	Continuity of processes; foundation for rapid post-war modernisation and regional development.	Requires significant investment; high risk of cyberattacks; a shortage of skilled IT staff.
Financial support	Grants and crowdfunding	Fast and affordable non-bank financing to help SMEs survive in the short term.	Lack of long-term reliability; dependence on emotional "economy of compassion"; limited scope.
Strategic management	Adaptive leadership	Speed of decision-making; an organisation's capacity for structural transformation.	Reliance on the skills of a limited number of leaders; potential burnout among management teams.

Source: compiled by the authors

Analysis of the adaptive strategies presented indicates that they are geared towards business survival and transformation in conditions of extreme uncertainty, where each adaptation model strikes a balance between the immediate preservation of assets and long-term structural risks. Operational and financial adaptation ensures basic viability through relocation and the maintenance of liquidity, yet poses risks of human capital loss and a decline in product quality. At the same time, technological digitalisation and adaptive leadership act as catalysts for modernisation, although they are critically dependent on scarce skills and high investment. Overall, the effectiveness of these strategies is twofold: they ensure a flexible response to wartime challenges, but simultaneously make them vulnerable to "economy of compassion", cyber threats and managerial burnout, necessitating a shift from piecemeal measures to an integrated resilience system.

Thus, the adaptation of Ukrainian enterprises to the challenges posed by martial law is a multi-faceted process that exceeds the scope of simple anti-crisis measures. Research shows that successful enterprises use comprehensive adaptation models that integrate financial discipline, strategic flexibility and technological innovation. At the same time, the digitalisation of processes acts as an integrator of all adaptation strategies; not only ensuring management flexibility (through remote working) and reducing operational costs (through business software systems such as ERP and CRM), but also strengthening the resilience of supply chains (through accelerated digitalisation of logistics). This accelerated technological modernisation, driven by security challenges and the need for continuity, is transforming the business environment for the long term. Furthermore, decentralised management and scenario planning supported swift response for relocated and affected enterprises to local changes, turning physical relocation into a strategic advantage. Lastly, financial stability is ensured not only by internal optimisation (ZBB, Lean), but also by external support, which utilises risk-sharing instruments (IFO guarantees) to overcome the limitations of the traditional financial market.

DISCUSSION

The analysis confirms a shift in the scientific paradigm from static vulnerability analysis to a dynamic study of AC, which is consistent with the findings of A.S. Alshebami (2025). A common feature of the results is the recognition of AC as a critical mediator that directly shapes ER. However, in contrast to the study by A.S. Alshebami (2025), which focuses primarily on small enterprises in more stable crisis conditions, the current study emphasises that, in wartime conditions, this link is reinforced by the need to simultaneously apply survival and development strategies.

A substantial aspect of the discussion is the concept of the "conflict continuum" and the "hybrid era", proposed by E. Berthelsen (2025). The findings of this study are fully consistent with the author's argument that modern business can no longer distinguish between periods of "war" and "peace". A common conclusion is the need to integrate security strategies into day-to-day operational activities. At the same time, this study complements this concept with practical tools, in particular through the model of digitalisation as a means of ensuring cyber resilience, which is considered in less detail in the study by E. Berthelsen (2025).

The issues of strategic management in conditions of extreme turbulence, as explored by I.O. Bobyliev & N.M. Chupryna (2025) are corroborated in the present study regarding the importance of decentralisation and scenario planning. The authors share the view of I.O. Bobyliev & N.M. Chupryna (2025) stated that rigid hierarchical structures are losing their effectiveness. However, this study further categorises cost optimisation methods into four areas (financial, organisational, technological, strategic), providing practitioners with a more structured roadmap for action compared to general recommendations on flexibility. The study by M.K. Sott & M.S. Bender (2025), dedicated to adaptive leadership, emphasises the role of internal organisational changes in ensuring business resilience. The findings are consistent with this position, particularly regarding the need to develop staff multifunctionality. At the same time, the difference in approach lies in the focus on external support factors: it is argued that even with adaptive leadership

in place, a business critically needs access to government programmes and risk-sharing instruments to remain viable.

The issue of business relocation, which has been thoroughly examined by N. Smochko & T. Luzhanska (2022) and H. Zelisko (2023), is a recurring theme in this study as well. The data on the number of relocations in 2025 (8,345 cases) in this study confirm arguments of H. Zelisko (2023) regarding relocation as a radical security tool. However, this study expands on this discourse, highlighting that relocation abroad (in particular, 62% to the EU) requires not merely a physical move, but a complete transformation of the business model to meet the demands of new markets, which is a more complex challenge than domestic relocation. The financial aspect of resilience through cost optimisation is examined in detail by O. Karintseva *et al.* (2025). The conclusions drawn in this study concur regarding the importance of strict financial discipline; however, a paradox was identified that was not emphasised in O. Karintseva *et al.* (2025): rising costs related to security and energy independence (generators, alternative energy) often serve as a catalyst for the implementation of Lean technologies, which improve long-term efficiency of the enterprise.

The role of digital transformation as a driver of recovery was highlighted by V. Tyshchenko *et al.* (2024); the authors of this paper share the author's view that digitalisation has strategic, rather than merely tactical, significance. In addition to the conclusions of V. Tyshchenko *et al.* (2024), the authors justify the need for digital monitoring of international aid as a factor of transparency, which is critical for attracting foreign investment in the post-war period. Lastly, alternative financing mechanisms, in particular crowdfunding, were examined by K. Efrat *et al.* (2023), highlighting the "economy of compassion" as the basis for such capital. The authors of this paper agree with this, but emphasise the instability of this instrument, proposing instead enhanced cooperation with IFIs through EU risk-sharing sub-funds as a more reliable strategy. Thus, this study integrates existing theoretical work on resilience with the unique empirical experience of Ukrainian business, proposing a comprehensive model that considers both internal managerial transformations and the need for institutional support.

CONCLUSIONS

The study summarised key adaptation strategies employed by Ukrainian enterprises during the period of martial law and assessed their impact on building business resilience in the context of hybrid threats. The results of the analysis indicated that the integration of financial discipline, strategic flexibility and digital transformation is becoming the foundation for ensuring the sustainability and recovery of enterprises in a situation of prolonged uncertainty. The study determined that financial stability is achieved through flexible budgeting, real-time cost control, optimisation of logistics and contractual operations, as well as the introduction of alternative energy sources. The strategic reorientation of business models – through crisis management, decentralised decision-making and scenario planning – ensures that businesses can adapt to rapid changes. Relocation, diversification of activities and a shift towards the domestic market play a significant role in minimising geographical and operational risks. Digital transformation, automation and the development of cyber resilience are key prerequisites for maintaining business continuity and competitiveness. Government and international financial support is also crucial, including grant programmes, crowdfunding, risk-sharing instruments and guarantee mechanisms provided by international financial institutions.

Based on the findings of the study, recommendations have been formulated aimed at strengthening the adaptive capacity of businesses and improving public policy under martial law. Business representatives must implement flexible management models, through scenario planning, rolling forecasting and the decentralisation of decision-making processes. Operational resilience should be enhanced by diversifying the product portfolio and entering new markets, which must be accompanied by the development of digital infrastructure, process automation and the strengthening of cyber security systems. Financial sustainability should be given particular attention through the mobilisation of alternative sources, such as grants, crowdfunding and participation in guarantee schemes. At the same time, it is necessary to ensure workforce flexibility by training staff in cross-functional skills and developing managerial competencies. At the level of public policy, the priority must be to strengthen institutional mechanisms to support relocation and encourage the resumption of business operations. It is necessary to expand risk-sharing programmes for the SME sector in close cooperation with international financial institutions. At the same time, it is necessary to improve mechanisms for providing grant aid based on clear criteria for business viability, to develop transparent digital monitoring of the use of international support, and to implement targeted government programmes to enhance the cyber resilience of the private sector.

The study results highlighted an area requiring further academic exploration: further theoretical and methodological research into the processes of building business resilience and adaptive management models in the context of prolonged crises and uncertainty. A promising area is the development of a system of indicators to assess enterprises' readiness for investment, scaling up and participation in post-war recovery programmes. It is also necessary to analyse the impact of the crisis environment on behavioural aspects of management, organisational culture, the emotional resilience of staff and the development of innovative potential, considering management strategies that combine military and peacetime development scenarios.

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Адаптаційні стратегії та моделі стійкості українських підприємств в умовах кризи та воєнного стану

Анотація. В умовах безпрецедентної за часи незалежності повномасштабної збройної агресії росії проти України, традиційні управлінські підходи виявилися малоефективними, що зумовлює гостру потребу в дослідженні нових механізмів виживання бізнесу. Трансформація підприємств під впливом екстремальної невизначеності стає визначальним фактором не лише збереження економічного потенціалу країни, а також її майбутнього відновлення. Метою даної роботи було здійснення всебічного аналізу адаптаційних інструментів українських компаній у період воєнного стану, що триває з 2022 року, та розробка науково обґрунтованої моделі підвищення їхньої життєздатності. Дослідження базувалося на застосуванні системного підходу, методів класифікації та порівняльного аналізу еволюції наукових поглядів на економічну стійкість у межах концепції «конфліктного континууму». У роботі ідентифіковано ключові вектори трансформації бізнесу, що охоплюють операційну, фінансову та технологічну сфери. Доведено, що адаптивна спроможність виступає фундаментальним медіатором, який безпосередньо формує загальну резилієнтність організації. Встановлено, що оптимізація витрат перетворилася на стратегічний імператив, змушуючи менеджмент впроваджувати гнучке бюджетування, енергетичну автономію та методи ощадливого виробництва. Важливим складником стійкості визначено релокацію активів, яка за підтримки державних програм дозволяє зберегти виробничий цикл у безпечних регіонах. Особливу увагу приділено цифровій трансформації, що забезпечує кіберрезильєнтність та безперервність процесів у гібридних умовах. Виявлено роль альтернативних фінансових джерел, таких як гранти та ризик-шерінг, у підтримці платоспроможності бізнесу. Авторами запропоновано узагальнену модель, яка інтегрує стратегічну гнучкість, децентралізацію рішень та сценарне планування як основу антикризового управління. Сформовані у роботі рекомендації та моделі можуть бути використані керівниками підприємств для коригування антикризових планів, а також органами державної влади при розробці програм підтримки та стимулювання інвестицій у післявоєнний період

Ключові слова: підприємницька резилієнтність; релокація; оптимізація витрат; цифровізація; кіберрезильєнтність; альтернативне фінансування; ризик-шерінг

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Comprehensive motivation system as a basis for the development of organisational innovation activity

Abstract. In the context of global competition and technological change, innovation is key to sustainable organisational development, yet its potential often remains unrealised due to imperfect motivation systems, highlighting the need for a comprehensive motivational mechanism. The purpose of this study was to theoretically substantiate the impact of an integrated motivation system on the development of organisational innovation and to identify key approaches to its formation. To achieve this, the research applied a systems approach, analysis and synthesis, comparative analysis, and logical generalisation. The findings emphasised the role of motivation as a catalyst for innovation processes, outline the structural components of a comprehensive motivation system designed to stimulate employees' innovative activity, and propose a multi-component approach that combines material, non-material, and procedural incentives. Particular attention was given to shaping an organisational environment that is tolerant of risk, supportive of experimentation, and encouraging of employee initiative. It was identified critical contemporary challenges-wartime conditions, digitalisation, and resource constraints-and demonstrates their impact on the effectiveness of motivational systems in the innovation domain. It concluded that effective innovation development is impossible without a targeted motivational system that integrates the satisfaction of economic needs with the pursuit of self-realisation, recognition, and creativity. It has been shown that the integration of a comprehensive motivation system into the organisation's development strategy ensures its adaptability to external challenges and creates conditions for innovative activity. The practical value of the study lies in using the Integrated Motivation Model to unlock innovation potential and enhance organisational competitiveness

Keywords: work motivation; innovation development; non-material incentives; organisational justice; innovation potential; human resource management

INTRODUCTION

In the current context of economic turbulence and structural transformation, labour motivation is acquiring a decisive role in ensuring the innovative development and resilience of enterprises. Transitional economies face particular challenges, as organisations must adapt to institutional instability, resource scarcity, and uncertainty while stimulating employee engagement and creativity. Traditional systems based mainly on financial incentives no longer capture the complex, multidimensional nature of motivation. Therefore, it is critical to develop approaches that align employee motivation with innovation-driven competitiveness and sustainable growth.

M. Pasko & V. Samoilenko (2023) underlined that recognition, professional training, and career development opportunities act as long-term drivers of employee engagement. Their findings highlighted that non-material incentives create sustainable employee loyalty and stimulate continuous organisational development, which traditional wage-based approaches cannot guarantee. This perspective confirms that intangible motivators should be regarded as strategic assets in building innovative capacity.

A similar conclusion was reached by A.C. Edmondson & D.P. Bransby (2023), who demonstrated that psychological safety supported by trust and individual autonomy

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exerts a stronger and more sustainable impact on innovative behaviour than monetary incentives, emphasising that innovation depends on an environment of confidence and openness rather than financial mechanisms alone. A similar relationship was identified by S. Wen (2020), who found that organisational and team identification mediate the connection between perceived organisational support and innovative behaviour. The study demonstrated that non-material incentives such as recognition, trust, and participation become considerably more effective when employees strongly identify with their organisation, indicating that corporate culture functions not only as a motivational context but also as a multiplier of achieved outcomes.

The modernisation of incentive systems is addressed by D. Roumpi (2023), who argued that a balanced combination of material and non-material motivators is essential for building organisational resilience. Her research demonstrated that traditional remuneration policies, though necessary, are insufficient to sustain long-term innovative activity. Instead, organisations must rethink strategic Human Resource Management (HRM) practices by incorporating procedural fairness, recognition, and opportunities for professional growth. This argument is particularly relevant for economies undergoing transformation, where limited resources often restrict the effectiveness of financial incentives. Crisis conditions create additional complexity in shaping motivation, as shown by H. Zacher & C.W. Rudolph (2021). Their study revealed that during times of instability, employees prioritise stability, fairness, and organisational support over temporary financial adjustments. These findings illustrate a structural shift in motivational needs: employees are more motivated by security and fairness than by short-term material benefits. Such results have strong implications for organisations in transitional and crisis-prone economies, where resilience depends on the ability to design adaptive motivational systems.

A Ukrainian perspective was provided by N. Podolchak *et al.* (2025), who studied the motivation of civil servants during wartime. Their findings showed that solidarity, institutional trust, and moral support outweigh economic incentives, which lose significance under extreme conditions. This research highlighted the necessity of designing HR systems that respond not only to economic but also to socio-psychological needs. It also demonstrated that motivation becomes a critical instrument of resilience in national governance structures.

Taken together, these studies showed notable progress in understanding different aspects of motivation-non-material factors, organisational culture, crisis adaptation, and sustainability. However, they also reveal several limitations. Most studies examine isolated factors rather than providing an integrated framework. Many focus on specific industries or national contexts, which limits the generalisability of results. Moreover, the predominance of cross-sectional data restricts understanding of how motivational systems evolve over time. Finally, although researchers acknowledge the importance of intangible incentives, few propose concrete models for systematically integrating them with financial and procedural mechanisms. The reviewed studies demonstrated that while progress has been made in highlighting fairness, adaptability, and integrated HR systems, a holistic motivational framework is still missing.

The purpose of this article was to substantiate the conceptual foundations of the Integrated Motivation Model (IMM) and demonstrate its applicability for diagnosing, monitoring, and improving the motivational climate of enterprises under conditions of crisis and post-crisis transformation.

MATERIALS AND METHODS

This study employed a comprehensive set of general scientific and specialised research methods, including a systems approach, analysis and synthesis, comparative analysis, and logical generalisation. The research logic followed a stepwise trajectory. First, a systematic review of existing literature on motivation and innovation was conducted, which revealed key conceptual contradictions and highlighted the fragmentation between material, non-material, and procedural approaches. Second, GAP analysis was applied to compare Ukrainian HR practices with European benchmarks, thereby identifying structural asymmetries in motivational systems. Finally, these insights provided the basis for the development of the IMM as an interpretive framework, consolidating diverse motivational dimensions into a single conceptual system.

The selection of international data sources was deliberate. Reports by Organisation for Economic Cooperation and Development (OECD), World Bank, and Eurofound were chosen due to their methodological rigor and longitudinal scope. OECD (2021) surveys provided macro-level indicators of human capital and innovation policy that made it possible to situate Ukraine in a global context. The Human Capital Index (World Bank, 2021) and regional development assessments were employed because they systematically evaluate resilience and adaptability of labour resources, which is crucial in transitional economies. Eurofound (2021; n.d.) surveys offered representative data on working conditions, employee well-being, and organisational practices across the European Union (EU). Together, these sources ensured comparability of Ukraine's motivational practices with both European and international standards, while maintaining relevance to the Ukrainian socio-economic environment.

The classification of motivational gaps was based on qualitative categorisation principles. To assess the levels of discrepancies in motivational practices, a qualitative categorisation (Medium, High, Very High) was applied. Medium indicated noticeable but non-critical differences requiring partial improvement; High reflected systemic discrepancies significantly affecting motivational effectiveness and demanding comprehensive adjustments; Very High denoted critical mismatches that hinder the formation of an effective motivational environment and require

urgent reform. The classification was based on expert interpretation, drawing on a comparative analysis of Ukrainian HR practices and international benchmarks presented in Eurofound (2021; n.d.), World Bank (2021), as well as in academic studies (Akram *et al.*, 2020; Choi *et al.*, 2022; Mubashar *et al.*, 2022). Accordingly, the assigned levels reflect the relative magnitude of differences identified in these sources rather than the results of direct statistical measurement. To diagnose the motivational environment, GAP analysis was applied, allowing the identification of asymmetries between declared HR policies and actual practices. For assessing organisational innovation potential, the IMM was employed. IMM comprises four interrelated components-material, intangible, procedural, and adaptive stimuli – that jointly provide a holistic interpretation of motivational dynamics. It is explicitly emphasised that the IMM has not been empirically tested as an independent model within this study. Instead, it was employed as a conceptual and diagnostic instrument to interpret the results of the GAP analysis and to frame motivational deficits in a systemic way.

The empirical foundation relied primarily on secondary data from the above-mentioned institutional sources, complemented by analytical reports and documented corporate practices in HR management. The triangulation of OECD, World Bank, and Eurofound data allowed for the verification of patterns across multiple datasets and reduced the risk of relying on a single institutional perspective. While no original primary dataset was generated, secondary analysis allowed for meaningful benchmarking and provided the basis for conceptual generalisations. Nevertheless, several limitations were recognised. First, the reliance on secondary data reduces the scope for context-specific generalisations, since institutional differences may distort applicability to the Ukrainian environment. Second, the absence of original survey data implies that employee-level perceptions could only be approximated through reported aggregates. Third, the categorisation of motivational gaps may depend on the operational definitions adopted by international institutions, which are not always fully tailored to the Ukrainian socio-economic context. These constraints highlight the exploratory nature of the findings.

RESULTS AND DISCUSSION

The analysis of motivational practices in innovation-oriented organisations cannot be divorced from their classical theoretical foundations. A.H. Maslow (1954) proposed the hierarchy of needs, establishing a framework that linked employee performance to the progressive satisfaction of physiological, social, and self-actualisation needs. His theory remains relevant for innovation contexts, where higher-order needs such as creativity and autonomy often determine engagement. F. Herzberg (1971) advanced the two-factor theory, distinguishing between hygiene factors and motivators. His insights clarified why salary adjustments may prevent dissatisfaction but fail to generate genuine commitment or creativity. This distinction is critical in interpreting motivational gaps identified in the survey data. V. Vroom (1964) contributed expectancy theory, which emphasised that effort, performance, and reward are cognitively evaluated by employees. In innovation settings, this theory underscores the necessity of transparent links between contribution and recognition, a gap evident in transitional economies.

D.C. McClelland (1961) highlighted three key needs – achievement, affiliation, and power-arguing that individual differences shape motivational outcomes. In road construction and similar industries, the balance between achievement orientation and affiliation is especially relevant for fostering teamwork alongside innovation. J.S. Adams (1965) formulated equity theory, which linked perceptions of fairness in input-output exchange to motivational strength. This theory resonates with the findings that procedural transparency strongly influences employees' willingness to share ideas. E.A. Locke (1968) developed goal-setting theory, which established that specific, challenging goals enhance motivation more than vague targets. Innovation requires precisely such clarity, especially when employees must invest energy in uncertain projects. T.M. Amabile (1996) emphasised creativity and intrinsic motivation as pivotal for innovative performance. Her work shifted attention from material incentives toward non-material enablers, including autonomy and recognition, both of which appear underrepresented in Ukrainian enterprises. E.L. Deci & R.M. Ryan (1985) elaborated self-determination theory, highlighting autonomy, competence, and relatedness as critical intrinsic motivators. This theoretical lens validates the evidence that employees' lack of autonomy correlates with disengagement, regardless of wage levels. A.B. Bakker & E. Demerouti (2007) validated the Job Demands-Resources model, showing that organisational resources mitigate stress and increase innovative productivity. Their framework justifies the IMM's incorporation of procedural and adaptive elements. J. Barney (1991) introduced the resource-based view, conceptualising motivation as a strategic resource. D.J. Teece *et al.* (1997) extended this through dynamic capabilities, linking organisational adaptability to the restructuring of motivational systems. Both perspectives justify considering motivation not merely as an HR practice but as a strategic asset.

R.V. Krejcie & D.W. Morgan (1970) provided methodological standards for sample size determination and reliability, which remain widely cited in HR research. Their criteria informed the representativeness of the survey and enabled comparative benchmarking. Finally, J.A. Colquitt *et al.* (2006) highlighted the micro-level mechanisms through which perceptions of justice and emotional support influence engagement. Their findings demonstrate that social exchange processes are as important as material incentives in shaping innovative behaviour. Taken together, these foundational theories provide the conceptual scaffolding for the IMM, justifying its multidimensional structure that incorporates material, intangible, procedural, and

adaptive elements. To systematise these contributions and clarify their relevance for the study, Table 1 summarises the main theoretical approaches and their implications for innovation-oriented motivation.

Table 1. Evolution of motivation approaches: From classical theories to the IMM

Stage / paradigm	Key characteristics	Representative theories / concepts
Classical stage	Focus on material incentives; linear understanding of employee needs and behaviour	A.H. Maslow (1954), D.C. McClelland (1961), V. Vroom (1964), F. Herzberg (1971)
Psychological & behavioural stage	Emphasis on intrinsic motivation, job satisfaction, fairness, and equity	J.S. Adams (1965), E.A. Locke (1968), E.L. Deci & R.M. Ryan (1985), T.M. Amabile (1996)
Organisational & cultural stage	Importance of procedural justice, psychological safety, and participative leadership	T. Akram *et al.* (2020), E.A. Saether (2020), S.-B. Choi *et al.* (2022), T. Mubashar *et al.* (2022), T.W.H. Ng *et al.* (2024)
Strategic & adaptive stage	Integration of HRM with innovation, digital transformation, and Environmental, Social, and Governance (ESG); recognition of HR as a strategic asset	J. Barney (1991), D.J. Teece *et al.* (1997, A.B. Bakker & E. Demerouti (2007), J.B. Carnevale & I. Hatak (2020), A. Ahmić & M. Ćosić (2025)
Integrated stage IMM	Combination of material, intangible, procedural, and adaptive incentives within a flexible, multilevel framework	Author's conceptual contribution; synthesis of all previous stages

Source: compiled by the author

Table 1 presents a synthesised framework outlining the historical evolution of motivation approaches-from classical economic theories to the development of the IMM. Each stage reflects a progressive expansion of conceptual depth, leading to a multidimensional and diagnostically robust framework for motivating innovation-oriented human capital. Modern research increasingly highlights the multidimensional nature of motivation in crisis-prone economies. S.-B. Choi *et al.* (2022) demonstrated that organisational justice significantly enhances innovative work behaviour, primarily through the mediating effects of trust and psychological safety, emphasising that fair treatment and transparent communication create the psychological conditions necessary for creativity and innovation. This aligns with the findings indicating that weak fairness perceptions are central to disengagement in Ukrainian enterprises.

T.W.H. Ng *et al.* (2024) revealed that while remuneration remains important, long-term engagement is primarily driven by recognition trust and opportunities for growth Employees often report stagnation where intangible motivators and developmental support are absent. In a field study, T. Akram *et al.* (2020) report that perceived organisational justice, including distributive, procedural, and interactional fairness, positively predicts employees' innovative work behaviour, partly through knowledge sharing. Complementarily, perceived organisational justice is positively associated with employee engagement, a condition that typically enables greater creative and innovative contributions at work T. Mubashar *et al.* (2022). Recent evidence indicates that organisational justice and non-material ("emotional") incentives are positively associated with happiness at work – a close proxy for job satisfaction – underscoring that fairness in motivational practices matters beyond pay levels (Ravina-Ripoll *et al.,* (2024). Taken together with evidence that justice predicts innovative work behaviour and is positively related to employee engagement, this literature aligns with the IMM's emphasis on fairness and non-material incentives. M. Colić *et al.* (2022) cautioned that excessive reliance on financial incentives may undermine motivation and engagement when employees' intrinsic and developmental needs are neglected. This aligns with broader evidence that undervaluing creativity and autonomy increases turnover intentions and weakens commitment. J.B. Carnevale & I. Hatak (2020) showed that HR practices focused on employee adjustment and well-being strengthen organisational resilience by fostering flexibility and sustaining motivation during periods of uncertainty. Complementing this view, A. Ahmić & M. Ćosić (2025) demonstrated that digital HRM systems enhance resilience by developing anticipation, coping, and adaptation capabilities, thereby ensuring continuity of innovation and long-term workforce engagement. The data similarly show that Ukrainian firms lacking adaptive HR practices experienced sharper motivational declines during crises. Eurofound (2021; n.d.) emphasised that work environment quality, procedural transparency, and the balance between material and intangible incentives shape readiness for innovation. This directly parallels the findings of motivational gaps across Ukrainian enterprises. The World Bank (2021) reaffirmed that human capital, rather than infrastructure, is the primary driver of resilience in transitional economies. This supports the evidence that disengagement erodes not just productivity but also organisational competitiveness.

S. Strohmeier (2020) stressed the importance of intuitive, user-friendly digital HR systems, warning that administrative rigidity and overly bureaucratic designs undermine employee motivation and trust. The results confirm this observation: employees in Ukrainian firms often describe HR systems as cumbersome and unresponsive. Evidence from M. Nguyen *et al.* (2024) further underlines the role of collective engagement and participatory decision-making in sustaining innovation during turbulence. These studies reinforce the IMM's inclusion of adaptive and collective motivators. Taken together, these contemporary studies

highlight the same gaps revealed in the data: limited use of non-material incentives, weak fairness, and insufficient adaptability. Building on these contemporary findings, Table 2 summarises the discrepancies revealed through GAP analysis, contrasting motivational practices in Ukraine with those observed in EU and global benchmarks.

Table 2. GAP analysis of motivational practices: Ukraine vs EU/global benchmarks

Motivational component	Ukraine (current state)	EU/Global best practices	GAP (discrepancy level)
Material incentives	Focus on base salary; bonuses not linked to innovation (Shalimova & Magopets, 2019; Herasymenko & Herasymenko, 2019; Kalinin, 2025).	KPI-based bonuses, stock options, profit sharing (Herzberg, 1971; Amabile, 1996; Teece *et al.*, 1997; Noe *et al.*, 2014).	High
Intangible incentives	Limited recognition; weak mentoring and training programs (Herasymenko & Herasymenko, 2019; Leskova, 2022; Kalinin, 2025).	Structured training systems, mentoring, internal corporate academies (Akram *et al.,* 2020; Colić *et al.,* 2022).	Medium
Procedures and culture	Low transparency in decision-making; dominance of administrative control (Shalimova & Magopets, 2019; Kovryha, 2020; Kalinin, 2025).	Transparent procedures, participatory management, trust-based culture (Deci & Ryan, 1985; Choi *et al.,* 2022).	High
Adaptiveness (ESG, Digital HR)	Minimal HR digitalisation; initial ESG integration (Shalimova & Magopets, 2019; Lositska *et al.*, 2021; Kalinin, 2025; Senyshyn & Hirniak, 2025).	Use of AI/HR analytics, ESG-integrated HRM, resilience-building programs (Carnevale & Hatak, 2020; World Bank, 2021; OECD, 2021; Ahmić & Ćosić, 2025).	Very High

Source: compiled by the author

Table 2 presents the GAP analysis of motivational practices in Ukraine compared with EU and global benchmarks, highlighting discrepancies across four motivational dimensions. The synthesis of classical foundations and contemporary evidence underscores the fragmented nature of existing motivational practices. Classical theories provide enduring insights into the roles of fairness, autonomy, recognition, and goal clarity, while modern studies confirm their continued relevance under conditions of volatility. The GAP analysis, summarised in Table 2, demonstrates that Ukrainian enterprises overemphasise material incentives while underutilising non-material, procedural, and adaptive elements. This imbalance results in disengagement, reduced creativity, and weakened innovation capacity.

The IMM directly addresses these gaps by consolidating four dimensions-material, intangible, procedural, and adaptive – into a coherent system. The IMM's diagnostic capacity allows organisations to identify motivational deficits, compare them across contexts, and design interventions aligned with international best practices. By situating the IMM at the intersection of classical theory and contemporary empirical evidence, the present study provides both a theoretical contribution to HRM literature and a practical tool for organisations navigating crises and transitions. The current study highlights the urgent need for integrated motivational systems in transitional economies, where innovation capacity is undermined by fragmented incentive structures, inconsistent fairness practices, and insufficient adaptability. Having outlined both classical and modern foundations, the study further interprets the findings in the context of contemporary research (2019-2025) and institutional evidence, which highlights the theoretical and practical contributions of the IMM.

Organisational justice and psychological safety. The analysis demonstrates that fairness and transparent reward allocation remain central determinants of motivation in innovation-oriented organisations. This observation is consistent with S.-B. Choi *et al.* (2022), who demonstrated that organisational justice significantly enhances innovative work behaviour through the mediating effects of trust and psychological safety, underscoring that fair treatment and transparent organisational processes foster the psychological conditions necessary for creativity and innovation. Consistent with this, fairness perceptions are strongly related to employee creative and innovative behaviour, as evidenced by the justice-innovation linkage reported by T. Akram *et al.* (2020). Fair treatment is likewise strongly related to employee engagement T. Mubashar *et al.* (2022), thereby providing the motivational and relational resources that underpin organisational adaptability.

These findings resonate with the evidence that motivational gaps in Ukrainian enterprises are closely linked to weak justice perceptions, particularly in reward distribution and participatory decision-making. A. Newman *et al.* (2023) further emphasised that justice-oriented HR systems act as a resilience mechanism during crises, ensuring stability in employee commitment. Taken together, these studies validate the IMM's emphasis on procedural fairness as a distinct dimension that requires systematic monitoring.

Balancing material and non-material incentives. The empirical evidence also confirms that financial compensation alone is insufficient to sustain innovation performance. E.A. Saether (2020) demonstrated that creativity and long-term innovation depend on intrinsic motivation, perceived fairness, and procedural justice rather than monetary rewards. Similarly, T.W.H. Ng *et al.* (2024) found that

while remuneration satisfies immediate needs**,** sustainable engagement is primarily driven by recognition, trust, and opportunities for professional growth.

M. Colić *et al.* (2022) found that while financial incentives are used, the application of non-financial incentives was stronger and more consistently linked to motivation in small, medium and large companies. Their findings imply that reliance on financial incentives alone risks under-serving employees' intangible needs and may thus undermine engagement when those needs remain unmet. The findings parallel these observations: Ukrainian HR practices overemphasise salary adjustments while underutilising non-material motivators such as autonomy, recognition, and creativity platforms (Leskova, 2022). R. Ravina-Ripoll *et al.* (2024) provide additional evidence that fair non-material (emotional) incentives and organisational justice are positively associated with happiness at work, which serves as a close proxy for job satisfaction, indicating that fairness in motivational practices matters beyond pay levels. These insights validate the IMM's inclusion of intangible stimuli as a core component of sustainable motivation.

Adaptation in crisis-prone environments. One of the most striking insights of this study is that motivational systems must be inherently adaptive to remain effective under conditions of volatility. J.B. Carnevale & I. Hatak (2020) showed that HR practices promoting employee adjustment and well-being strengthen organisational commitment and resilience through flexibility and sustained motivation. In parallel, A. Ahmić & M. Ćosić (2025) found that digital HRM systems reinforce these effects by enabling adaptive learning, innovation continuity, and effective coping mechanisms under turbulent conditions.

Likewise, Eurofound (n.d.) highlighted that employee readiness for innovation depends on the balance between material security and intangible recognition, especially under crisis conditions. The World Bank (2021) emphasised that human capital, rather than physical infrastructure, remains the key driver of resilience in transitional economies. Similar integration logic can also be observed beyond HRM: Y. Cherenko *et al.* (2025) demonstrated that Enterprise Resource Planning – Business Process Management Systems (ERP-BPMS) integration reduces operational risks in critical infrastructure. This parallel underlines that fragmented systems are inherently vulnerable, while integrated frameworks – whether in infrastructure management or in HRM – are crucial for ensuring resilience and adaptability. The results confirm these trends – motivational systems that fail to adapt to external shocks risk deepening disengagement and losing critical talent. By explicitly incorporating adaptive incentives, the IMM addresses this systemic vulnerability.

Learning, skills development, and digital transformation. Continuous development emerged as a decisive factor for motivation in – 21st-century workplace. R.A. Noe *et al.* (2014) already anticipated this shift, and recent research reaffirms its importance. Eurofound (2021) stressed that organisations providing structured opportunities for reskilling and digital learning reported higher employee satisfaction and innovation readiness. More recently, S. Strohmeier (2020) argued that digital HR systems must remain intuitive, non-burdensome, and technologically user-friendly to maximise employee engagement and trust, emphasising that complex or overly formalised designs can diminish motivation and limit adaptive potential. The evidence supports these claims, revealing that the absence of accessible digital HR platforms in Ukrainian enterprises hampers transparency and reduces employees' perceived fairness. This validates the IMM's integration of digital HR solutions within the adaptive dimension.

Resilience and innovation culture. The relationship between motivation and innovation culture is reinforced by contemporary studies. S. Suhandiah *et al.* (2023) highlighted that autonomy fosters psychological resilience, which in turn sustains innovative work behaviour. Complementarily, S.-H. Kwon & J.-S. Kim (2025) emphasised that participatory decision-making enhances cognitive flexibility and creativity, thereby reinforcing innovation performance. C. Burlina *et al.* (2025) similarly showed that organisations in transitional economies benefit from embedding collective engagement into motivational frameworks, particularly when facing turbulence. These perspectives confirm that resilience is not solely a psychological construct but is actively shaped by organisational HRM strategies. The results demonstrate that companies neglecting collective motivators – such as team recognition and participatory innovation platforms-experience lower levels of organisational creativity. The IMM addresses this by embedding collective engagement within its intangible and adaptive dimensions.

Synthesis and contribution of IMM. When viewed collectively, contemporary research underscores three critical themes: 1) procedural fairness and justice are indispensable for fostering trust and innovation; 2) a balance between material and non-material incentives is essential for sustained engagement; and 3) adaptability, learning, and resilience must be systematically integrated into HRM frameworks. The IMM consolidates these dimensions into a unified diagnostic tool that enables organisations to assess motivational gaps quantitatively and qualitatively. Unlike existing models, which treat incentives in isolation, the IMM provides a multidimensional perspective linking fairness, creativity, adaptability, and recognition into a coherent framework. This systemic approach not only reflects the fragmented insights of prior studies but also translates them into a practical model that organisations can operationalise under conditions of crisis and transformation.

Theoretically, the IMM extends current HRM and innovation literature by synthesising diverse motivational constructs into a single framework applicable across crisis-prone economies. Practically, it provides managers with a tool for diagnosing weaknesses, designing balanced incentive systems, and benchmarking against international best practices. In the Ukrainian context, where organisational justice and adaptive incentives remain underdeveloped, the IMM offers a roadmap for aligning HRM strategies with global standards while accounting for local

constraints. Furthermore, by emphasising measurable indicators such as fairness perception, autonomy levels, and adaptability indices, the model supports evidence-based HR policy-making.

CONCLUSIONS

In conclusion, the development and application of IMM open new avenues for creating modern motivational systems capable of fulfilling strategic, diagnostic, and forecasting functions. It is essential that such a model remains user-friendly, intuitive, and not overly time-consuming in its implementation. This paves the way not only for supporting innovation-driven organisational growth but also for establishing resilient HR solutions in complex and resource-constrained environments. The study confirms that successful innovation depends on a balanced motivational environment. Financial incentives alone are insufficient; employees show greater readiness for innovation when systems also provide fairness, trust, managerial support, and tolerance of risk. The IMM enables organisations to integrate material, intangible, procedural, and adaptive stimuli into a single structure, reducing motivational gaps and stimulating creativity.

A key contribution of the IMM is its emphasis on measurability. By operationalising indicators such as satisfaction with motivation, dissatisfaction index, perceptions of organisational justice, and readiness for innovation, the model functions as a diagnostic tool. This allows organisations to identify imbalances, compare different professional groups, and benchmark practices against international standards. Such an approach supports evidence-based adaptation of HR systems to specific sectoral or national contexts. The findings also highlight that determinant of innovative behaviour include fairness, managerial support, and the presence of an innovation-oriented culture. Motivation thus emerges not as a narrow HR function but as an integral element of strategic development. The IMM demonstrates flexibility, as it can be applied at enterprise, industry, or national levels. Future research should focus on empirical validation of the IMM across sectors, particularly in high-turbulence environments.

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Комплексна система мотивації як основа розвитку інноваційної діяльності організації

Анотація. В умовах глобальної конкуренції та технологічних змін інновації стають ключем до стійкого розвитку організацій, проте їхній потенціал часто не реалізується через недосконаліть систем стимулювання, що зумовлює потребу у комплексному мотиваційному механізмі. Мета дослідження полягала у теоретичному обґрунтуванні впливу комплексної системи мотивації на розвиток інноваційної діяльності організації та визначення ключових підходів до її формування. Для досягнення поставленої мети застосовано системний підхід, аналіз і синтез, порівняльний аналіз та логічне узагальнення. У результаті визначено роль мотивації як каталізатора інноваційних процесів, окреслено структурні складові комплексної системи мотивації, спрямованої на стимулювання інноваційної активності персоналу, та запропоновано багатокомпонентний підхід, що поєднує матеріальні, нематеріальні й процедурні стимули. Особлива увага приділялась формуванню організаційного середовища, яке є толерантним до ризику, сприяє експериментам і підтримує ініціативність працівників. Виявлено ключові виклики сучасності – воєнний стан, цифровізацію та ресурсні обмеження – і показано їхній вплив на ефективність мотиваційних систем у сфері інновацій. Зроблено висновок, що ефективний розвиток інноваційної діяльності неможливий без цілеспрямованої системи мотивації, яка поєднує задоволення економічних потреб із прагненням до самореалізації, визнання та творчості. Показано, що інтеграція комплексної системи мотивації у стратегію розвитку організації забезпечує її адаптивність до зовнішніх викликів і створює умови для інноваційної активності. Практична цінність дослідження полягає у використанні Integrated Motivation Model для розкриття інноваційного потенціалу та підвищення конкурентоспроможності організацій

Ключові слова: мотивація праці; інноваційний розвиток; нематеріальні стимули; організаційна справедливість; інноваційний потенціал; управління персоналом

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Development of a criteria scale for assessing the effectiveness of green marketing strategies in agricultural enterprises

Abstract. In the current conditions of increasing environmental awareness of society and stricter requirements for sustainable development, there was a need to transform the marketing strategies of agricultural enterprises. The aim of the study was to develop a comprehensive criteria scale for evaluating the effectiveness of green marketing strategies in the agricultural sector. The methodological basis of the study was formed by methods of system analysis, generalisation and classification. As a result of the study, an expanded multi-level criteria system was formed, combining economic, environmental and social parameters into a single integrated assessment model. A detailed list of indicators was proposed, covering resource efficiency, energy consumption, pollution levels, waste management, impact on soil and water quality, enterprise participation in social initiatives, interaction with communities and the level of environmental transparency. Traditional assessment systems, including Return on Investment, Triple Bottom Line and Balanced Scorecard, have been adapted to the context of sustainable agricultural production, making it possible to integrate quantitative and qualitative parameters into a common methodological platform. A step-by-step algorithm for the practical application of the criteria scale has been developed: identification of relevant indicators, their normalisation, determination of weighting coefficients, construction of an integral index and further interpretation of the results. The proposed scale makes it possible to identify structural imbalances between economic performance indicators and environmental or social impacts, form predictive assessments, and determine directions for optimising green marketing strategies. The practical significance lies in the possibility of using the developed scale to improve management decisions and increase the effectiveness of green marketing approaches of agricultural enterprises

Keywords: environmental orientation; corporate responsibility; resource conservation; innovative approaches; performance indicators; environmental management; conservation initiatives

INTRODUCTION

The growing public interest in environmental issues and the increasing focus on sustainable development principles necessitate a rethinking of approaches to the formation of marketing strategies for enterprises, particularly in the field of agricultural production. Green marketing strategies are seen as a tool for environmentally conscious business practices that can influence the competitiveness and image of agricultural enterprises. Currently, there is no unified approach to evaluating the effectiveness of such strategies, which limits the possibilities for systematic analysis of results and comparison of the effectiveness of different measures.

The issue of green marketing has been studied in the works of Ukrainian and foreign scientists, who have developed various conceptual approaches to the integration of environmental principles into the activities of enterprises. In the work of O. Havrylets *et al.* (2022), the concept of green marketing is presented as a multifaceted tool for market positioning, combining management decisions, communication strategies and adaptive

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mechanisms aimed at increasing the competitiveness of an enterprise in the face of environmental challenges. The authors conducted an in-depth analysis of how environmental guidelines can reformat marketing approaches and proved that environmental advantages can become a significant element of value proposition.

N.M. Kraus *et al.* (2022) examined the green transformation of business in relation to economic, social and technological changes. The researchers provide a structured description of the factors that encourage companies to implement environmental solutions and emphasise the relationship between the level of environmental integration and the strategic sustainability of companies. Particular attention was paid to the mechanisms for implementing green policies in corporate governance. Thus, in the works of L. Plakhotnikova & T. Bulakh (2019), an in-depth analysis of the relationship between environmental marketing and corporate social responsibility was carried out. The authors demonstrated that environmental communications influence not only consumer behaviour but also internal corporate culture, determining the priority of ethical standards and environmental values in the activities of an enterprise.

T. Kotsko & O. Kovalchuk (2020) considered environmental marketing as the basis for the long-term development of an enterprise. In their research, they proposed models for implementing environmental principles in strategic planning and outlined tools that enable the stable functioning of an enterprise in conditions of increasing environmental restrictions and regulatory requirements. Research by scientists from other countries, in particular the works of P.O. Osiako *et al.* (2022), presented a systematic review of approaches to the implementation of green marketing in global practice. The authors analysed empirical models used in environmentally oriented companies, compared the results of studies on the effectiveness of green strategies in various industries, and emphasised the importance of environmental innovations in increasing the competitiveness of businesses at the global level. In the study by C.J. Gelderman *et al.* (2021), green marketing is considered as a component of environmentally oriented business practice that directly influences consumer satisfaction and loyalty. The authors argue that the systematic implementation of environmental marketing tools not only improves the image of the company, but also creates long-term competitive advantages, especially in manufacturing sectors that are sensitive to environmental challenges, particularly in the agricultural sector.

Existing studies mainly focus on general aspects of green marketing, while methods for assessing the effectiveness of implementing such strategies in the agricultural sector have not been sufficiently developed. The lack of clear criteria limits the possibilities for systematic assessment of the economic, environmental and social results of green initiatives and complicates comparisons of the effectiveness of measures in different enterprises in the industry. The approach to formalising the assessment system and its integration into the management processes of agricultural enterprises is considered as a direction for further research. The issues of formalising the system for assessing the effectiveness of green marketing strategies in agricultural enterprises remain insufficiently researched, in particular with regard to the integration of economic, environmental and social indicators. The lack of a coordinated criteria scale limits the possibilities for a comprehensive assessment of the results of implementing such strategies, complicates the comparison of the effectiveness of measures between enterprises and periods, and reduces the accuracy of determining areas for improvement. As a result, there is a need to develop methodological tools that would ensure a systematic assessment and allow for objective conclusions to be drawn about the impact of green strategies on the financial indicators of the enterprise, the environmental safety of production, and the social responsibility of the business. In view of this, the aim of the article was to develop a criteria scale that will make it possible to assess the effectiveness of green marketing strategies in agricultural enterprises and ensure a comprehensive approach to measuring the effectiveness of environmentally oriented management decisions.

MATERIALS AND METHODS

The research materials and methods focused on developing a reproducible methodology that provides a sound basis for developing a criteria-based scale for assessing the effectiveness of green marketing strategies in agricultural enterprises. The research was theoretical and methodological in nature and was based on a systematic approach, which made it possible to consider green marketing activities as a set of interrelated elements that form an integral result. The methodological basis was constructed in such a way as to ensure a structured definition of criteria, their interrelationships, and their further integration into a single assessment scale.

System analysis was used in the research process to identify the structural components of green marketing strategies and determine their impact on the overall environmental and competitive performance of the enterprise. Within the framework of system analysis, the green marketing activities of an agricultural enterprise were considered as an integral system, which is a set of interrelated marketing practices aimed at achieving economic, environmental and social goals. The elements of this system analysed were the enterprise's product policy (environmental characteristics of products, certification, packaging), production processes (resource consumption, energy efficiency, use of environmental technologies), marketing communications (eco-branding, labelling, consumer information), the reputation component (environmental image, level of trust in the brand) and the system of supply and interaction with stakeholders (environmental requirements for suppliers, cooperation with communities and partners). Analysis of the interrelationships between these elements made it possible to determine their cumulative impact on the effectiveness of green marketing strategies and to justify the selection of criteria for constructing an assessment scale.

The generalisation method was used to process scientific approaches and practical models presented in Ukrainian and international sources, which allows typical characteristics to be identified and combined into a logically coherent system of criteria. The classification was used to group the selected indicators into content blocks corresponding to the environmental, economic and reputational aspects of agricultural enterprises' activities. The indicators were classified according to the following criteria: the content focus of the impact (economic, environmental or social and reputational performance), level of effect (internal processes of the enterprise or external results of interaction with stakeholders), nature of indicators (quantitative and qualitative) and time orientation of results (short-term and long-term effects). This made it possible to group the indicators into corresponding blocks in a structured manner and to provide a comprehensive reflection of the effectiveness of green marketing strategies.

The comparative analysis made it possible to compare approaches to measuring the effectiveness of environmental marketing strategies in different scientific schools and to adapt them to the conditions of the agricultural sector. The comparative analysis consisted of comparing scientific and methodological approaches to assessing the environmentally oriented activities of enterprises represented in various research and regulatory schools. In particular, international environmental management standards (ISO 14001:2015, 2015), sustainable development and environmental transformation indicators used within the European Green Deal (European Commission, 2024), as well as a system of industry-specific key performance indicators for agricultural enterprises in the EU, the US and Ukraine. The comparison was made based on the criteria of indicator structure, level of formalisation of assessment, possibility of quantitative measurement and adaptability to the specifics of agricultural production, which made it possible to select relevant indicators and adapt them to the conditions of agricultural enterprises.

The logic behind the development of the scale involved the sequential selection of criteria, analysis of their content, and determination of integral characteristics for further transformation into a structured assessment model. Initially, data was collected from scientific publications, analytical reports, regulatory documents, and strategic recommendations highlighting green marketing practices. The selection of sources was based on the following criteria: relevance to the topics of green marketing and sustainable development; availability of methodological approaches or systems of indicators for assessing environmental, economic or social performance; focus on practical application in the agricultural sector; scientific and institutional authority of the source. The source base included scientific articles from peer-reviewed international and Ukrainian publications, analytical reports from international organisations, and regulatory and methodological documents in the field of environmental management. The sample covered scientific and analytical sources published between 2019 and 2024.

Next, a qualitative assessment of each indicator was carried out, determining their relevance to the specifics of agricultural production and the possibility of their application in quantitative or qualitative terms. After that, the criteria were harmonised according to the logic of their impact and grouped into blocks, which made it possible to form the initial structure of the scale. The final stage was the development of an integrated scheme that reflects the sequence of assessment and ensures the practical reproducibility of the approach. The qualitative assessment of indicators was carried out using content analysis and expert coding methods, which involved interpreting the indicators according to their functional purpose and impact on the effectiveness of green marketing strategies. The indicators were coded according to the following criteria: type of effect (economic, environmental or social), level of impact (internal processes of the enterprise or external results of interaction with stakeholders), form of manifestation (direct or indirect impact) and the possibility of quantitative measurement. Content analysis made it possible to exclude duplicate or methodologically incorrect indicators and ensure that the selected criteria corresponded to the specifics of agricultural production.

The criteria were coordinated and grouped according to the logic of cause-and-effect, reflecting the sequence of the formation of the effectiveness of green marketing strategies: from resource and technological support, through production processes and marketing communications, to the economic, environmental and social-reputational results of the enterprise's activities. This approach made it possible to form substantively homogeneous blocks of criteria and ensure the internal consistency of the scale. The formation of an integrated assessment scheme involved combining the selected criteria into a single model, adhering to the principles of consistency, minimisation of duplication and comparability of indicators. Weighting coefficients can be determined using an expert method or by evenly distributing weights between groups of criteria depending on the assessment objectives. The integrated scheme provides for the aggregation of normalised indicators into a general performance index, which increases the analytical value of the scale and ensures the practical reproducibility of the proposed approach.

RESULTS AND DISCUSSION

Green marketing began to take shape in the late 1980s and in the 21st century is considered one of the areas of strategic business management focused on integrating environmental aspects into production and commercial activities. Consumers are increasingly taking into account the environmental characteristics of products when making purchasing decisions, which necessitates the inclusion of environmental factors in marketing strategies. The implementation of green marketing involves adapting production processes, product promotion and communication policies to the requirements of sustainable development, ensuring the consistency of economic, environmental and

social outcomes. Analysis of practical cases allows to identify the main mechanisms for implementation and the key components of effective "green" strategies.

The introduction of green strategies allows agricultural enterprises to reduce costs through energy and resource savings, increase consumer loyalty to the brand, strengthen the image of a socially responsible business, improve access to investments and international grants, and ensure compliance with environmental legislation and EU standards.

The principles of environmental marketing form the conceptual basis for building strategies focused on combining economic performance and environmental responsibility of the enterprise. As noted by O.M. Sorokolit (2024), it is these principles that determine the key guidelines for the greening of business processes and ensure the consistency of management decisions with the principles of sustainable development. In order to systematise their content and structure, a generalised diagram is presented in Figure 1.

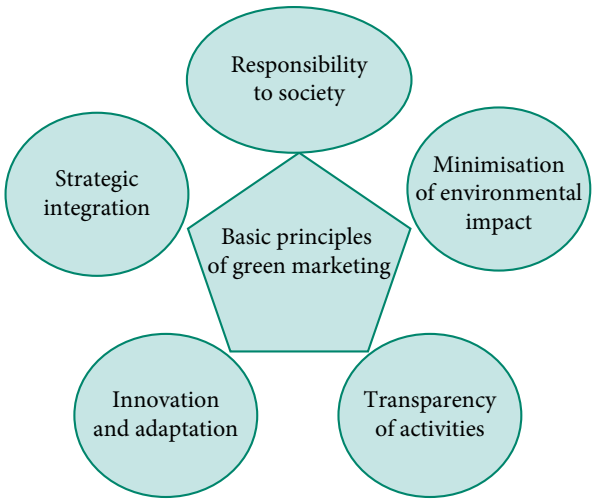

Figure 1. Basic principles of green marketing
Source: developed by the author

Strategic integration emphasises the need to include environmental priorities in long-term business planning. Social responsibility focuses on the ethical dimension of business interactions with stakeholders. Minimising environmental impact reflects the desire to reduce resource consumption and negative environmental consequences. Innovation and adaptation characterise a company's ability to implement modern environmental solutions and respond to changes in the external environment. Transparency ensures consumer confidence through openness of environmental information and integrity of communications (Romanenko & Nifatova, 2025). Together, these principles form a comprehensive methodological framework for building effective green marketing strategies. Green strategies in the agricultural sector may include: the use of organic technologies (rejection of pesticides and chemicals); environmentally friendly packaging (biodegradable, compostable materials); energy-efficient processes (use of solar energy, reduction of fuel consumption); open environmental communication with consumers (labelling, eco-branding).

An example of the application of green marketing strategies is organic farming, which uses biological fertilisers and natural plant protection methods in the production process, avoiding the use of chemicals. The products are sold through specialised eco-markets or online platforms that provide confirmation of environmental quality through certification labelling on the packaging. This practice allows the company to integrate the principles of sustainable development into its production and commercial activities and ensures interaction with consumers who are focused on environmentally friendly products and a healthy lifestyle. The use of organic technologies creates the conditions for optimising energy costs and reducing the negative impact of production on the environment. The systematic use of such strategies also makes it possible to analyse the effectiveness of measures in terms of economic, environmental and social indicators.

It is important for managers not only to implement a green strategy, but also to measure its effectiveness. Without appropriate assessment tools, it becomes difficult to evaluate the feasibility of investments, identify effective/ineffective areas and make comparisons between periods or companies. Assessing the effectiveness of green strategies involves identifying the target audience, communication channels and developing appropriate indicators for analysis. Integrating marketing communications into the assessment system allows for the systematisation of collected data, including information on consumer perceptions of environmental initiatives, awareness levels and customer engagement in "green" programmes. The use of such approaches provides a synthesis of economic, environmental, and social indicators, which is necessary for a comprehensive assessment of the effectiveness of green marketing strategies. The approach allows identifying priority areas for strategy improvement and performing a comparative analysis of results between different companies or periods (Kaur *et al.*, 2022).

Contemporary scientific and practical literature highlights a wide range of approaches to evaluating the effectiveness of marketing strategies. For the most part, they are financially and economically oriented and focus on indicators such as profit, profitability, return on investment, sales volume, etc. However, for green strategies, it is advisable to use combined models that include not only financial but also environmental and social results of strategy implementation. Traditional evaluation methods include: ROI (Return on Investment) – shows how much profit is generated for each hryvnia invested in marketing; ROMI (Return on Marketing Investment) – allows to evaluate the effectiveness of marketing expenses; CPA (Cost Per Acquisition) – the cost of attracting one customer; CLV (Customer Lifetime Value) – assesses the long-term value of a customer to the company; Indicators of growth in sales volume, market share, volume of new contracts, etc. (Shabbir *et al.*, 2020). However, the

use of these methods alone is insufficient in the case of green marketing strategies, as they: ignore non-financial effects such as environmental safety, environmental impact, and emission reduction; do not take into account social resonance, in particular changes in public opinion, increased brand trust, and consumer awareness; are focused on short-term benefits, while green strategies have predominantly long-term goals.

In response to the limitations of traditional financially-oriented performance measurement methods, which do not take into account environmental and social aspects, an approach to comprehensive assessment is being developed that integrates financial, environmental and social indicators. This approach involves the simultaneous analysis of the economic performance of an enterprise, the impact of its operations on the environment, and the social consequences of its interactions with consumers and stakeholders (Szabo & Webster, 2021). As a result, a more complete picture of the effectiveness of green marketing strategies is provided, and it becomes possible to identify priority areas for the enterprise's development in the context of sustainable development: Balanced Scorecard (BSC) – includes financial, customer, internal and innovation perspectives; Triple Bottom Line (TBL) – an approach that assesses effectiveness in three areas: economy, ecology, and society; Sustainable Performance Indicators (SPIs) – a set of indicators that reflect the sustainability of an enterprise's activities, particularly in the agricultural sector.

In the practical activities of agricultural enterprises, the use of comprehensive models for evaluating the effectiveness of green marketing strategies is still limited. This situation is due to the lack of methodological recommendations and regulatory mechanisms, insufficient training of management personnel, and the complexity of collecting and processing environmental statistics at enterprises. Assessing the effectiveness of green strategies requires a multidimensional approach that integrates economic, environmental and social indicators, as traditional financially-oriented criteria do not reflect the specifics of environmentally-oriented measures and the enterprise's interaction with the environment. This approach allows for the formation of a comprehensive system for monitoring and analysing the results of the implementation of green marketing practices in agricultural enterprises.

As a result of the study, a scientifically based criteria scale for evaluating the effectiveness of green marketing strategies in agricultural enterprises was developed. The proposed scale is based on the integration of economic, environmental and social-reputational criteria and reflects the structural components of green marketing activities and the interrelationships between them. The results of the study are presented in the form of a structured model that combines quantitative and qualitative indicators and provides a comprehensive assessment of the effectiveness of implementing green marketing strategies in the activities of agricultural enterprises. To build a system for evaluating the effectiveness of green marketing strategies, a classification of criteria was applied, which was formed on the basis of a systematic generalisation of common approaches to evaluating the effectiveness of marketing and environmental measures, which were made by B.I. Dar *et al.* (2024). This classification is presented in Table 1.

Table 1. Criteria scale for assessing the effectiveness of green marketing strategies of agricultural enterprises

Group of criteria	Indicators	Units of measurement	Data sources / collection methods
Economic	Growth in sales volume of products in the green segment	% or UAH	Sales statistics, accounting reports
	Return on investment in green marketing	%	Financial reports, internal audit
	Cost reduction through the introduction of resource-saving technologies	UAH / %	Production costs, energy balances
	Share of environmentally oriented customers	%	CRM system, consumer surveys
Environmental	Reduction in harmful emissions	t/year	Internal environmental monitoring, reports
	Reduction in energy, water and chemical fertiliser consumption	% or units of resources	Production data, technical records
	Waste reuse or recycling rate	%	Reports on disposal and recycling
	Introduction of environmental certification	presence / absence	Certificates, audit
Social	Level of environmental awareness among consumers	% of respondents	Surveys, sociological research
	Level of employee satisfaction with environmental working conditions	% or scale-based score	Questionnaires, internal HR monitoring
	Expansion of partnerships with communities and environmental organisations	number of partnerships	Reports on social projects
	Brand reputation assessment	point-based score or rating	Consumer surveys, marketing research

Source: developed by the author based on B.I. Dar *et al.* (2024)

The author's criteria scale for assessing the effectiveness of green marketing strategies of agricultural enterprises is based on a combination of economic, environmental and social criteria, which provides a comprehensive assessment

of the implementation of green strategies at the enterprise level. The classification includes three main areas: economic, environmental and social. Economic criteria reflect the financial results of strategy implementation, in particular the volume of sales of environmentally friendly products, the profitability of environmentally friendly marketing activities, the effectiveness of resource-saving technologies and the share of consumers with environmental preferences. Environmental criteria characterise the impact of activities on the environment, in particular the volume of harmful emissions, energy, water and fertiliser consumption, the level of waste reuse or recycling, and the availability of certification documentation on the environmental safety of production and products. Social criteria reflect the company's interaction with internal and external stakeholders, the level of consumer awareness of environmental initiatives, staff participation in green programmes, partnerships with communities and environmental organisations, and brand reputation indicators. All criteria for evaluating the effectiveness of green marketing strategies must be quantified, provide units of measurement, and enable dynamic analysis, including comparisons of indicators over time and between different companies in the industry. To this end, it is advisable to use index or rating systems in which each criterion is assigned a weighting coefficient according to its significance for the purposes of evaluation.

The proposed criteria scale is consistent with international approaches to environmental management and sustainable development policies, in particular with the requirements of ISO 14001:2015 (2015) and the strategic guidelines of the EU Green Deal (European Commission, 2024). The environmental criteria of the scale related to reducing resource consumption, waste management, environmental certification and monitoring of environmental impact are consistent with the logic of systematic environmental management laid down in ISO 14001. At the same time, the integration of economic, environmental and social indicators into a single assessment model correlates with the comprehensive approach to sustainable development that underpins the EU Green Deal. The practical use of the criteria scale requires adherence to a specific algorithm that ensures the consistency and systematic nature of the assessment process. This approach allows for the integration of heterogeneous indicators, standardises data collection and processing, and ensures the comparability of results both over time and between individual enterprises implementing green marketing strategies.

The author's criteria scale for assessing the effectiveness of green marketing strategies was developed as an integrated model that combines the economic, environmental and social dimensions of agricultural enterprises' activities. The purpose of the scale was to provide a comprehensive and systematic approach to evaluating the effectiveness of implemented green strategies: it allows not only financial results to be taken into account, but also the environmental impact and social aspects of an enterprise's activities to be assessed, forming a single integrated performance indicator. The author's model provides for a multi-stage evaluation algorithm, which includes the collection of primary data from enterprises, their normalisation, the determination of weighting coefficients depending on the significance of each criterion, and the integration of the results into a single comprehensive indicator.

The economic criteria of the scale cover the assessment of the profitability of green initiatives, the impact on reducing resource costs and long-term financial stability. Environmental criteria allow measuring the level of emission reduction, the efficiency of natural resource use, and the company's compliance with international and national environmental standards. Social criteria take into account the impact on local communities, the improvement of environmental awareness among staff, and the development of corporate social responsibility. The use of such an integrated system allows for the harmonisation of quantitative and qualitative indicators, expressed in relative and absolute units of measurement, based on financial, statistical, sociological, and monitoring data.

To ensure the practical reproducibility of the proposed criteria scale, a step-by-step algorithm for its application was developed, which allows systematising the process of evaluating the effectiveness of green marketing strategies in agricultural enterprises. The algorithm reflects a logical sequence of actions – from the formation of a list of indicators to the interpretation of an integral efficiency indicator, which ensures the comparability of results over time and between different enterprises. The main stages of the algorithm for applying the criteria scale are presented in Table 2.

Table 2. Algorithm for applying the criteria scale for evaluating the effectiveness of green marketing strategies

Stages of the algorithm for applying the scale	Description of actions
1. Formation of a list of indicators	Defining specific criteria for evaluating the effectiveness of green marketing strategies.
2. Collection of actual data for each criterion	Collecting the necessary information and statistical data corresponding to each defined criterion.
3. Data normalisation	Converting the collected indicators to a single scale for comparison (e.g., from 0 to 1 or from 0 to 100).
4. Application of weighting coefficients	Assigning a weight to each criterion according to its importance to the company or the overall assessment objective.

Table 2. Continued

Stages of the algorithm for applying the scale	Description of actions
5. Calculation of the integral performance indicator	Summing the normalised and weighted values to obtain an overall strategy effectiveness index.
6. Interpretation of results	Analysing the resulting integral indicator to determine the level of effectiveness (e.g. high, medium, low)

Source: developed by the author based on B.I. Dar *et al.* (2024)

The algorithm for evaluating the effectiveness of green marketing strategies provides a systematic and transparent procedure for collecting, processing and analysing data. The use of the algorithm allows standardising the assessment methodology, ensuring the comparability of results between different periods and companies, and identifying areas for further improvement of strategies, results, determining weighting coefficients and calculating an integral performance indicator. Integrating the assessment process into the enterprise's strategic planning system ensures that the results of green initiatives are used in management decision-making. Regular monitoring of performance indicators creates conditions for systematic control and timely correction of marketing activities. Assessment data can be used for internal auditing, environmental reporting and communications with investors and partners, as well as to ensure transparency of the enterprise's environmental responsibility activities.

BSC has a strategic orientation but does not include specialised criteria for assessing the environmental aspects of agricultural production and resource conservation, while the author's scale takes into account the impact of technological decisions on environmental stability, resource consumption levels and the social obligations of enterprises. This design allows for quantitative assessment of strategy implementation, comparison of the effectiveness of different scenarios, prediction of their impact on the long-term sustainability of the enterprise, and support for informed management decisions. The proposed model demonstrates methodological novelty and practical value, combining traditional approaches with adapted criteria for evaluating green marketing strategies in the agricultural sector.

M. Ahmad *et al.* (2024) investigated the impact of financial technologies and natural resource management on the ecological footprint in EU countries using empirical macroeconomic indicators. The approach allows for the assessment of the overall effect of the transition to green practices, but does not take into account the internal operational processes of enterprises and social aspects. The presented scale compensates for these limitations by including detailed criteria for internal processes, corporate culture, and interaction with local communities. S.S. Alharbi *et al.* (2023) analysed global practices of green financing and renewable energy implementation using statistical methods, which allows assessing the impact of investments on environmental outcomes. However, their approach does not offer a structured methodological tool for assessing the overall effectiveness of strategies at the level of an agricultural enterprise. The authors' scale integrates these financial aspects while taking into account environmental and social criteria, and allows for the calculation of an integrated performance indicator.

S. Bhatnagar & D. Sharma (2022) conducted a bibliometric analysis of the development of green finance and its drivers, demonstrating historical and scientific trends in the development of green marketing, but did not offer a practical model for assessing the effectiveness of a strategy at the enterprise level. In turn, the authors' scale is a practical tool for managers, as it allows to evaluate specific actions of the company and predict the impact on economic and environmental indicators. C. Utomo *et al.* (2023) reviewed green finance methods for "green construction", highlighting key tools for evaluating investment projects. Their methodology is well suited for project analysis, but is not adapted to the agricultural sector and does not cover the social interactions of the enterprise. The author's scale takes these aspects into account, providing the opportunity to assess social responsibility, the effectiveness of interaction with staff and the local community.

A. Tariq & A. Hassan (2023) examined the role of green finance, environmental regulations, and economic development in the transition to a sustainable economy, focusing on government mechanisms and macroeconomic effects. However, their approach does not provide tools for directly assessing the effectiveness of specific strategies in enterprises. The authors' scale allows these macroeconomic indicators to be combined with micro-level criteria of operational and social effectiveness. A. Mamun *et al.* (2022) assessed the impact of green finance on the decarbonisation of the global economy, while M. Hua *et al.* (2024) assessed its impact on the transformation of the real economy. Both approaches are macro-level and use sector-level statistics, which limits the ability to compare enterprises within the agricultural sector. The author's scale is unique in that it combines quantitative and qualitative indicators at the level of individual enterprises, which allows for a more detailed assessment of strategy effectiveness.

L.L.B. Lazaro *et al.* (2023) analysed the definitions of green finance in Brazil's biofuel policy, which allows for the clarification of the conceptual framework and the standardisation of criteria for practical application. However, their approaches do not directly form a tool for assessing the effectiveness of enterprises. The author's scale is based on clear criteria that integrate economic, environmental and social aspects, includes the determination of weighting coefficients and the calculation of an integral indicator, which provides a reliable tool for comparing companies and making management decisions. A comparison with

these approaches shows that the author's scale is distinguished by its comprehensiveness, methodological novelty and practical value. It allows assessing the effectiveness of green marketing strategies at the enterprise level, takes into account internal processes, social responsibility and economic results, which makes it a universal tool for increasing the competitiveness and reputational capital of agricultural companies.

CONCLUSIONS

The article proposes an author's criteria scale for assessing the effectiveness of green marketing strategies of agricultural enterprises. The scale integrates three groups of criteria: economic, environmental and social. Specific indicators, units of measurement and data sources are defined for each group. An algorithm for the practical application of the scale has been developed, which includes the stages of data collection, normalisation, determination of weighting coefficients and calculation of the integral efficiency indicator. The proposed approach allows for a comprehensive assessment of the implementation of green strategies and comparison of results between different enterprises and periods. A theoretical analysis of the formation of a criteria scale for evaluating the effectiveness of green marketing strategies in agricultural enterprises has been carried out. The developed scale based on a systematic approach includes three interrelated groups of criteria: economic, environmental, and social. Economic criteria reflect the impact of strategies on financial results and profitability, environmental criteria reflect the impact on the environment and resource consumption, and social criteria reflect the impact on interaction with customers, employees and communities. This structure provides a comprehensive assessment of the effectiveness of "green" strategies and allows for the integration of various aspects of an enterprise's activities into a single analytical system. The algorithm for applying the scale involves the following sequential steps: defining evaluation criteria, collecting and normalising data, assigning weighting coefficients, calculating the integral indicator and its analytical interpretation.

Systematising the assessment process ensures the comparability of results over time and between different companies, and also allows the assessment of the effectiveness of green initiatives to be included in strategic planning and internal management processes. The integration of economic, environmental and social criteria into a single scale allows for the analysis of the interrelationships between financial results, environmental impact and social activity of the enterprise, which contributes to a comprehensive assessment of the effectiveness of green marketing strategies. Prospects for further research include testing the proposed scale in real agricultural enterprises, improving it to take into account the specifics of different sub-sectors, and developing software to automate the assessment process.

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Розробка критеріальної шкали оцінювання ефективності зелених маркетингових стратегій на аграрних підприємствах

Анотація. У сучасних умовах підвищення екологічної свідомості суспільства та посилення вимог до сталого розвитку виникає потреба трансформації маркетингових стратегій аграрних підприємств. Метою дослідження була розробка комплексної критеріальної шкали для оцінювання ефективності зелених маркетингових стратегій аграрного сектору. Методологічну основу дослідження становили методи системного аналізу, узагальнення та класифікації. У результаті дослідження сформовано розширену багаторівневу критеріальну систему, що поєднує економічні, екологічні та соціальні параметри в єдину інтегровану модель оцінювання. Запропоновано деталізований перелік індикаторів, який охоплює ефективність використання ресурсів, енергоспоживання, рівень забруднення, управління відходами, вплив на якість ґрунтів і водних ресурсів, участь підприємства у соціальних ініціативах, взаємодію з громадами та рівень екологічної прозорості. Проведено адаптацію традиційних систем оцінювання, включно з Return on Investment, Triple Bottom Line та Balanced Scorecard, до контексту сталого аграрного виробництва, що дало змогу інтегрувати кількісні та якісні параметри у спільну методичну платформу. Розроблено поетапний алгоритм практичного застосування критеріальної шкали: ідентифікація релевантних показників, їх нормалізація, визначення вагових коефіцієнтів, побудова інтегрального індексу та подальша інтерпретація результатів. Запропонована шкала дає змогу виявляти структурні дисбаланси між економічними показниками діяльності та екологічними чи соціальними наслідками, формувати прогностичні оцінки та визначати напрями оптимізації зелених маркетингових стратегій. Практичне значення полягає у можливості використання розробленої шкали для удосконалення управлінських рішень і підвищення результативності екологізованих маркетингових підходів аграрних підприємств

Ключові слова: екологічна орієнтація; корпоративна відповідальність; ресурсна економія; інноваційні підходи; показники результативності; екологічний менеджмент; природоохоронні ініціативи

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University business incubator services and students' entrepreneurial mindset in Algeria

Abstract. The growing institutional emphasis on the entrepreneurial university has placed university business incubators at the centre of contemporary debates on student entrepreneurship and entrepreneurial capability development. Against this backdrop, the aim of this study was to examine the effect of university business incubator services on the entrepreneurial mindset of university students in an Algerian university context. The study adopted a quantitative descriptive-analytical design and drew on primary data collected through an electronic questionnaire administered to 390 students. The measurement instrument demonstrated strong internal consistency, and the data were analysed using descriptive statistics and multiple linear regression. The findings provided clear empirical evidence that university business incubator services exert a positive and statistically significant effect on students' entrepreneurial mindset. However, this effect is differentiated across service dimensions. Shared services and facilities emerged as the strongest predictor, followed by performance evaluation and technical support, whereas marketing and financial services showed the weakest, though still significant, effect. These results indicated that the current contribution of university incubators is strongest in providing an enabling environment, practical support, and structured guidance, while their external market and financial functions remain comparatively underdeveloped. The practical significance of the study lies in substantiating the need to review the development priorities of university business incubators, in particular, strengthening marketing and financial support, which can be used by university administrations and political and managerial structures to increase the effectiveness of incubation programs and stimulate student entrepreneurship

Keywords: student entrepreneurship; higher education; entrepreneurial support; entrepreneurial education; ecosystem connectivity

INTRODUCTION

Entrepreneurship has become a major priority in higher education worldwide, as universities are increasingly expected not only to deliver disciplinary knowledge but also to foster entrepreneurial mindset, initiative, and venture creation capacity among students. Within this transformation, university business incubators have attracted growing attention as institutional mechanisms designed to support entrepreneurial development through training, mentoring, networking, and access to entrepreneurial resources. The existing research confirms the importance of such support structures. For instance, N. Shiri *et al.* (2025) demonstrated that entrepreneurial environmental support, entrepreneurial education, and entrepreneurial inspiration have been shown to play a significant role in shaping university students' entrepreneurial mindset. Similarly, A.L. Makai & T. Dőry (2023) found that perceived university support and the broader institutional environment have been found to influence entrepreneurial intention and perceived behavioural control among students participating in university-based startup programmes. In the same vein, T. Anjum *et al.* (2024) identified business incubation centres have been identified as relevant contributors to entrepreneurial intention when combined with entrepreneurship education and cognitive-motivational factors.

Recent scholarship also suggests that entrepreneurial development in higher education depends on a combination

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of educational, institutional, and ecosystem-related conditions. As demonstrated by J. Lyu *et al.* (2023), university entrepreneurial offerings have been shown to facilitate the transition from entrepreneurial intention to nascent entrepreneurial activity. Similarly, G. Mele *et al.* (2022) showed that university business idea incubators accelerate student entrepreneurship by exposing students to practice-oriented environments that support idea development and entrepreneurial experimentation. M.P. Brito Ochoa *et al.* (2024) reported that entrepreneurship centres and business incubators have also been reported to contribute to the wider entrepreneurial ecosystem by enhancing institutional support for entrepreneurial engagement. In addition, T. Ratkovic *et al.* (2025) highlighted the importance of student diversity, social background, and contextual factors in shaping entrepreneurial support outcomes, while Y. Liang *et al.* (2025) demonstrated that entrepreneurship education, creativity, and digital literacy also influence entrepreneurial intention in higher education contexts. Finally, J.A. Sisu *et al.* (2024) indicated that entrepreneurial intention is enabled by a combination of causal configurations rather than by a single determinant, which confirms the multidimensional nature of entrepreneurial development among students.

Despite these advances, an important research gap remains. First, much of the recent literature has focused primarily on entrepreneurial intention, whereas fewer studies have examined entrepreneurial mindset as a broader cognitive and behavioural construct. Second, many studies address university support, entrepreneurship education, or incubation in general terms, without isolating the specific contribution of business incubator service dimensions. Third, international empirical evidence has been generated mainly in contexts outside Algeria, which limits the contextual relevance of current conclusions for Algerian universities. Consequently, there is insufficient evidence on how distinct dimensions of university business incubator services-namely shared services and facilities, marketing and financial services, and performance evaluation and technical support-affect the entrepreneurial mindset of university students in the Algerian higher education context.

The relevance of the present study is therefore both theoretical and practical. Theoretically, it contributes to current research by extending the analytical focus from entrepreneurial intention to entrepreneurial mindset and by disaggregating incubator support into specific service dimensions rather than treating it as a single undifferentiated construct. Practically, it provides evidence that may help universities improve the design, prioritisation, and strategic orientation of their incubator services in ways that better support student entrepreneurship. In this respect, the study responds to the need for more context-sensitive research on university entrepreneurship support in underexplored national settings.

Accordingly, the purpose of this study was to examine the effect of university business incubator services on the entrepreneurial mindset of university students in an Algerian university context. To achieve this purpose, the study pursued the following objectives: first, to assess students' perceptions of university business incubator services; second, to evaluate the level of entrepreneurial mindset among the surveyed students; and third, to test the effect of overall incubator services and their three dimensions on entrepreneurial mindset. The novelty of the study lies in three principal aspects: it focuses on entrepreneurial mindset rather than entrepreneurial intention; it analyses incubator support through differentiated service dimensions; and it provides empirical evidence from an Algerian university context that remains underrepresented in the recent international literature.

In light of these considerations, the study examined the extent to which university business incubator services affect the entrepreneurial mindset of university students. More specifically, it asked whether overall incubator services and their dimensions – shared services and facilities, marketing and financial services, and performance evaluation and technical support – exert a statistically significant effect on entrepreneurial mindset. On this basis, the study tested the following hypotheses:

H1: university business incubator services have a positive and statistically significant effect on entrepreneurial mindset;

H2: shared services and facilities have a positive and statistically significant effect on entrepreneurial mindset;

H3: marketing and financial services have a positive and statistically significant effect on entrepreneurial mindset;

H4: performance evaluation and technical support have a positive and statistically significant effect on entrepreneurial mindset.

MATERIALS AND METHODS

This study adopted a quantitative descriptive-analytical design to examine the effect of university business incubator services on the entrepreneurial mindset of university students. The empirical investigation was conducted at the University Centre of Aflou, Algeria. Data were collected from January to March 2026. This period was selected because the targeted students had completed the university incubator training courses, which enabled them to provide informed evaluations of the incubator services and their perceived contribution to entrepreneurial mindset development.

A convenience sampling technique was employed. This approach was considered appropriate because the study targeted students who were accessible through the official communication channel of the university business incubator and who had prior awareness of, or direct engagement with, its activities. The electronic questionnaire was distributed through the official WhatsApp group of the university business incubator at the University Centre of Aflou. Participants were eligible for inclusion if they were officially enrolled at the University Centre of Aflou and had prior knowledge of, or direct participation in, the incubator's training activities or services. Students from other institutions, respondents with no knowledge of the incubator, incomplete questionnaires, and unengaged responses were

excluded. After screening the collected responses and removing incomplete or invalid questionnaires, a final sample of 390 valid responses was retained for statistical analysis.

Primary data were collected using a structured electronic questionnaire prepared in Arabic, as it was the language most familiar to the target respondents. The questionnaire consisted of two main sections. The first section covered demographic characteristics, including gender, age, academic level, and faculty affiliation. The second section measured the study variables. University business incubator services were assessed using 15 items grouped into three dimensions: shared services and facilities, marketing and financial services, and performance evaluation and technical support. Entrepreneurial mindset was measured using 10 items. All items were evaluated on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

The questionnaire items were developed and adapted from previous studies and recognised frameworks in the fields of business incubation and entrepreneurial mindset. The dimensions of university business incubator services were informed by incubation literature identifying shared facilities, entrepreneurship training, business planning assistance, legal advice, marketing support, financial support, networking, technical assistance, ICT support, mentoring, monitoring, and performance evaluation as core incubator services (Ayad *et al*., 2022; Sohail *et al*., 2023). Accordingly, the incubator services scale was structured around three dimensions: shared services and facilities, marketing and financial services, and performance evaluation and technical support.

The entrepreneurial mindset items were developed with reference to studies on entrepreneurial orientation and entrepreneurial traits among students. These studies commonly emphasise risk-taking, innovativeness, autonomy, proactiveness, competitiveness, need for achievement, tolerance for ambiguity, responsibility, and experimentation as key components of entrepreneurial behaviour and mindset (Clark *et al*., 2025). To ensure content validity, the initial Arabic version of the questionnaire was reviewed by a panel of academic experts and trainers affiliated with the university business incubator and the Entrepreneurship Development Centre. These reviewers were selected because of their direct knowledge of the university incubator training programme in Algeria. Their comments were used to refine item clarity, improve contextual relevance, and ensure conceptual alignment with the services provided by Algerian university incubators.

A pilot study was conducted with 30 students who were not included in the final sample. The pilot study aimed to assess the clarity of the Arabic questionnaire, the comprehensibility of the items, and the preliminary reliability of the measurement scales. The pilot results indicated that the questionnaire was understandable to respondents, and only minor wording adjustments were made before launching the final data collection. Construct validity was assessed using Exploratory Factor Analysis (EFA). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.894, and Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), confirming the suitability of the data for factor analysis. The EFA results explained 68.4% of the total variance, with factor loadings ranging from 0.625 to 0.881. These results support the construct validity of the research instrument.

The collected data were coded and analysed using IBM SPSS Statistics 27. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to describe the sample characteristics and summarise respondents' perceptions. Internal consistency was assessed using Cronbach's alpha. The reliability coefficients were 0.930 for university business incubator services, 0.878 for entrepreneurial mindset, and 0.929 for the overall questionnaire, indicating highly satisfactory reliability.

The study hypotheses were tested using multiple linear regression. Entrepreneurial mindset was specified as the dependent variable, while the three dimensions of university business incubator services were entered as independent variables. Model significance was assessed using the F-test, whereas the significance of individual predictors was examined through standardised beta coefficients, t-values, and p-values. The explanatory power of the model was evaluated using R^2 and adjusted R^2 at a significance level of 0.05. To verify the adequacy of the regression model, post-estimation diagnostic tests were conducted for multicollinearity, independence of errors, and the normality, linearity, and homoscedasticity of residuals. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (1964). Participation was voluntary, and respondents were informed about the purpose of the study before completing the questionnaire. Anonymity and confidentiality were assured, and the collected data were used exclusively for academic research purposes.

Despite its contribution, this study has several limitations. First, the use of convenience sampling limits the generalisability of the findings to all Algerian university students. Second, the study relied on self-reported questionnaire data, which may be affected by response bias. Third, the research was conducted in the context of a single Algerian higher education institution, which may limit the applicability of the findings to other universities or incubator settings. Finally, the cross-sectional design captures students' perceptions at one point in time and does not allow for examining changes in entrepreneurial mindset over time.

RESULTS AND DISCUSSION

The demographic profile of the respondents is presented in Table 1. The sample was relatively balanced by gender, with a slight predominance of male respondents (51.3%), while female respondents accounted for 48.7%. In terms of age, the majority of respondents were aged between 22 and 30 years (69.2%), followed by those aged 30 years and above (20.5%), whereas only 10.3% were under 22 years of age. With regard to academic level, Master's students constituted the largest group (64.1%), followed by Bachelor's students (30.8%) and PhD students (5.1%). As for faculty

affiliation, over half of the respondents (51.3%) were from the Faculty of Economics, Commerce, and Management Sciences, followed by the Faculty of Technology (20.5%). This distribution suggests that the business incubator attracted stronger participation from disciplines more closely related to entrepreneurship and business development.

Table 1. Demographic profile of the respondents

Variable	Category	Frequency	Percentage (%)
Gender	Male	200	51.3
	Female	190	48.7
Age	<22 years	40	10.3
	22-30 years	270	69.2
	>30 years	80	20.5
Academic level	Bachelor's degree	120	30.8
	Master's degree	250	64.1
	PhD	20	5.1
Faculty	Economics, Commerce, and Management Sciences	200	51.3
	Technology	80	20.5
	Humanities and Social Sciences	50	12.8
	Sciences	30	7.7
	Foreign Languages and Arts	30	7.7

Source: author's elaboration based on survey data using SPSS

Descriptive statistics were calculated to assess respondents' perceptions of university business incubator services and entrepreneurial mindset. As shown in Table 2, the overall mean score for university business incubator services was high (M = 3.54, SD = 0.75), indicating a generally positive evaluation of the support provided. Among the three dimensions, Shared Services and Facilities recorded the highest mean (M = 3.68, SD = 0.76), followed by Performance Evaluation and Technical Support (M = 3.50, SD = 0.76). By contrast, Marketing and Financial Services received only a moderate evaluation (M = 3.33, SD = 1.00). The dependent variable, Entrepreneurial Mindset, also recorded a high mean score (M = 3.88, SD = 0.72). Overall, these findings indicate that students viewed the incubator positively, although its contribution appeared stronger in terms of infrastructure and technical support than in market and financial facilitation. To examine the individual effect of each dimension of university business incubator services on entrepreneurial mindset, three simple linear regression analyses were conducted. The results are reported in Table 3. All three dimensions had a positive and statistically significant effect on entrepreneurial mindset. Shared Services and Facilities produced the strongest individual effect ($R = 0.482$, $R^2 = 0.233$, $F = 117.81$, $B = 0.461$, $p < 0.001$), indicating that this dimension alone explained 23.3% of the variance in entrepreneurial mindset. Marketing and Financial Services also had a significant, though weaker, effect ($R = 0.384$, $R^2 = 0.148$, $F = 67.32$, $B = 0.279$, $p < 0.001$), accounting for 14.8% of the variance. Likewise, Performance Evaluation and Technical Support had a significant positive effect ($R = 0.415$, $R^2 = 0.172$, $F = 80.84$, $B = 0.396$, $p < 0.001$), explaining 17.2% of the variance in the dependent variable. These findings support all three sub-hypotheses and indicate that each service dimension contributes significantly to fostering students' entrepreneurial mindset.

Table 2. Descriptive statistics of the study variables

Variable	Mean	Standard deviation	Interpretation
Shared services and facilities	3.68	0.76	High
Marketing and financial services	3.33	1.00	Moderate
Performance evaluation and technical support	3.50	0.76	High
University business incubator services (overall)	3.54	0.75	High
Entrepreneurial mindset	3.88	0.72	High

Source: author's elaboration based on survey data using SPSS

Table 3. Simple linear regression results

Independent variable	R	R^2	F-value	p-value	Unstandardised coefficient (B)	Decision
Shared services and facilities	0.482	0.233	117.81	<0.001	0.461	Supported
Marketing and financial services	0.384	0.148	67.32	<0.001	0.279	Supported
Performance evaluation and technical support	0.415	0.172	80.84	<0.001	0.396	Supported

Note: dependent variable: entrepreneurial mindset. * $p < 0.05$, ** $p < 0.01$
Source: author's elaboration based on survey data using SPSS

To assess the simultaneous predictive power of the three dimensions of university business incubator services, a multiple linear regression analysis was performed. Prior to interpreting the model, the main regression assumptions were examined (Table 4). The Tolerance values ranged from 0.531 to 0.692, and the VIF values ranged from 1.445 to 1.882, indicating that multicollinearity was not a concern. The Durbin-Watson statistic was 1.94, suggesting no evidence of first-order autocorrelation. In addition, inspection of the normal probability plot and residual scatterplots indicated that the assumptions of residual normality and homoscedasticity were adequately satisfied. The overall model was statistically significant ($F = 66.52$, $p < 0.001$) and explained 34.1% of the variance in entrepreneurial mindset ($R^2 = 0.341$; Adjusted $R^2 = 0.336$). Among the predictors, Shared Services and Facilities emerged as the strongest predictor ($\beta = 0.305$, $t = 6.662$, $p < 0.001$), followed by Performance Evaluation and Technical Support ($\beta = 0.242$, $t = 4.874$, $p < 0.001$). Marketing and Financial Services also retained a positive and statistically significant effect ($\beta = 0.168$, $t = 3.571$, $p = 0.001$). Taken together, these findings indicate that university business incubator services play a meaningful role in shaping students' entrepreneurial mindset, with shared facilities and technical support exerting the greatest influence.

Table 4. Multiple linear regression results and collinearity diagnostics

Independent variable	Tolerance	VIF	Standardised beta (β)	t-value	p-value	Decision
Shared services and facilities	0.617	1.621	0.305	6.662	<0.001	Supported
Marketing and financial services	0.692	1.445	0.168	3.571	0.001	Supported
Performance evaluation and technical support	0.531	1.882	0.242	4.874	<0.001	Supported

Note: dependent variable: entrepreneurial mindset. Model summary: $R^2 = 0.341$, Adjusted $R^2 = 0.336$, $F = 66.52$, $p < 0.001$, Durbin-Watson = 1.94
Source: author's elaboration based on survey data using SPSS

The findings of the present study indicate that university business incubator services make a statistically significant contribution to the development of students' entrepreneurial mindset in the Algerian university context. This result suggests that incubator support within higher education extends beyond organisational assistance and contributes to the formation of entrepreneurial confidence, initiative, and readiness for action. This interpretation is consistent with recent evidence. A.L. Makai & T. Dőry (2023) showed that entrepreneurial environmental support and entrepreneurial inspiration positively shape students' entrepreneurial mindset, while N. Shiri *et al.* (2025) demonstrated that perceived university support enhances entrepreneurial intention and behavioural control in university-based entrepreneurial settings. It also accords with work by M. Uddin *et al.* (2025), emphasising that effective entrepreneurship education in emerging economies depends on support systems capable of linking academic learning to entrepreneurial practice.

A particularly important finding is that shared services and facilities emerged as the strongest predictor of entrepreneurial mindset. This suggests that the practical and structural elements of incubation may exert a more immediate effect on students than other forms of support because they provide visible, accessible, and experience-based forms of engagement. In this respect, the incubator's physical and social infrastructure may reduce entry barriers and strengthen students' confidence in their entrepreneurial capacity. This interpretation is consistent with prior work. J. Lyu *et al.* (2023) showed that university entrepreneurial offerings facilitate the transition from entrepreneurial intention to more concrete entrepreneurial engagement. It also aligns with evidence provided by G. Mele *et al.* (2022), indicating that university business idea incubators accelerate student entrepreneurship by exposing students to practical entrepreneurial environments and venture-oriented learning processes. More broadly, K.G. Aka & C.A. Enagogo (2025) suggested that entrepreneurial development in higher education is strengthened when institutional support is translated into tangible learning opportunities and operational resources.

The positive and significant effect of technical support and performance evaluation also deserves emphasis. This result indicates that structured feedback, technical mentoring, and continuous follow-up are not secondary features of incubation, but important developmental mechanisms through which students strengthen entrepreneurial capabilities. In contexts characterised by uncertainty and limited entrepreneurial experience, such support may reduce ambiguity and make entrepreneurial tasks more manageable. This interpretation is supported by V.A. Assenova (2020), who provided evidence that incubation and mentoring improve entrepreneurial learning, scaling, and venture development. It is also consistent with N. Thawesaengskulthai *et al.* (2025), who showed that innovation-driven enterprise support models are most effective when coaching and guided development are combined with structured support mechanisms. In a similar vein, C. Walsh *et al.* (2025) suggested that emotional and relational dynamics within student startup incubators may help sustain persistence during the fragile early stages of entrepreneurial engagement.

By contrast, marketing and financial services displayed the weakest predictive effect and the lowest perceived strength. This pattern suggests that the incubator under study is currently more effective in internal preparation than in external market linkage. In other words, students appear to derive substantial value from training,

guidance, and facilities, yet perceive more limited support in financing, commercialisation, and engagement with actors outside the university. This interpretation is consistent with recent research. M.A. Shongwe *et al.* (2026) showed thatuniversity-led incubators often face structural challenges in translating internal support into broader labour-market and ecosystem outcomes. It also aligns with evidence provided by Y. Chang & Q. Cheng (2024), who found that entrepreneurial mentoring, financial support, and commercialisation mechanisms in incubator settings are often unevenly developed and depend on wider institutional and market arrangements. Similarly, B. El Afqih & A. Messaoudi (2025) highlighted that, in the North African context, external innovation support remains a critical area for improvement in university incubator systems.

The explanatory power of the model should therefore be regarded as substantial rather than exhaustive. Although incubator services explained a meaningful share of the variance in entrepreneurial mindset, the literature suggests that entrepreneurial development is influenced by a broader set of personal and contextual factors. M.J. Malebana & S.T. Mahlaole (2023), as well as M.Y. Haddoud *et al.* (2024), showed that prior entrepreneurial exposure and career-related experience, for example, have been shown to strengthen entrepreneurial intention and readiness among university students. Likewise, Z. Zhang *et al.* (2025) suggested that family-related resources and critical-thinking capacities may shape how students interpret and utilise entrepreneurial support structures. Other recent studies also indicate that entrepreneurial support outcomes vary according to student diversity and contextual configurations. In this regard, J.A. Sisu *et al.* (2024) and T. Ratkovic *et al.* (2025) confirmed that entrepreneurial mindset cannot be reduced to a single institutional determinant.

From a practical perspective, these findings suggest that Algerian university incubators should be viewed not only as educational units, but as institutional actors that must progressively connect students to the wider entrepreneurial ecosystem. While the current strength of shared facilities and technical guidance should be maintained, greater attention needs to be directed towards strengthening external mentoring, finance-related support, and market connectivity. This is consistent with evidence showing that entrepreneurial support systems must be adaptive and context-sensitive rather than standardised across student populations and institutional settings (Bordean *et al.*, 2025). It also accords with recent research emphasising that entrepreneurship support in universities should combine educational, institutional, and ecosystem dimensions if it is to generate stronger entrepreneurial outcomes (Anjum *et al.*, 2024; Brito Ochoa *et al.*, 2024). In this respect, the present findings reinforce the argument that incubation is most effective when internal support functions are complemented by wider external linkages.

CONCLUSIONS

This study set out to examine the effect of university business incubator services on the entrepreneurial mindset of university students. The findings provided clear empirical evidence that incubator services constitute a significant explanatory factor in the development of students' entrepreneurial mindset. The results showed that the effect is not uniform across service dimensions. Shared services and facilities exerted the strongest influence, followed by performance evaluation and technical support, whereas marketing and financial services displayed a comparatively weaker effect. These results indicated that the developmental value of university incubation lies primarily in its capacity to provide students with an operationally supportive and technically guided environment conducive to entrepreneurial formation.

The study contributes to the entrepreneurship and higher education literature by demonstrating that university incubators should not be approached merely as organisational support structures, but as formative institutional mechanisms that shape entrepreneurial dispositions among students. At the same time, the results showed that incubator services explain only part of the variance in entrepreneurial mindset, which confirms that this construct is more complex than a single institutional determinant. Accordingly, the findings point to the need for a broader analytical approach that incorporates psychological, social, and contextual factors alongside incubation support. In practical terms, the study suggests that improving the effectiveness of university incubators requires not only maintaining strong internal support functions, but also strengthening their external connectivity with funding channels, market actors, and entrepreneurial networks. Future research should therefore test the model across multiple universities and national contexts, adopt longitudinal designs, and integrate additional explanatory variables such as self-efficacy, prior entrepreneurial exposure, and entrepreneurial behaviour in order to develop a more comprehensive account of how entrepreneurial mindset is formed and translated into entrepreneurial action.

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Послуги університетських бізнес-інкубаторів та підприємницьке мислення студентів в Алжирі

Анотація. Зростаючий інституційний акцент на підприємницькому університеті поставив університетські бізнес-інкубатори в центр сучасних дискусій щодо студентського підприємництва та розвитку підприємницьких компетентностей. У цьому контексті метою дослідження було розглянути вплив послуг університетських бізнес-інкубаторів на підприємницьке мислення студентів в умовах алжирського університету. У дослідженні було використано кількісний описово-аналітичний дизайн, а також первинні дані, зібрані за допомогою електронного опитувальника, проведеного серед 390 студентів. Інструмент вимірювання продемонстрував високу внутрішню узгодженість, а дані були проаналізовані за допомогою описової статистики та множинної лінійної регресії. Отримані результати надали чіткі емпіричні докази того, що послуги університетських бізнес-інкубаторів мають позитивний і статистично значущий вплив на підприємницьке мислення студентів. Водночас цей вплив відрізняється залежно від окремих складових послуг. Спільні сервіси та інфраструктура виявилися найсильнішим предиктором, далі йдуть оцінювання результативності та технічна підтримка, тоді як маркетингові та фінансові послуги продемонстрували найслабший, хоча й статистично значущий, ефект. Ці результати свідчили про те, що нинішній внесок університетських інкубаторів є найвагомішим у створенні сприятливого середовища, наданні практичної підтримки та структурованого супроводу, тоді як їхні зовнішні ринкові та фінансові функції залишаються порівняно недостатньо розвиненими. Практичне значення дослідження полягає в обґрунтуванні необхідності перегляду пріоритетів розвитку університетських бізнес-інкубаторів, зокрема посилення маркетингової та фінансової підтримки, що може бути використано адміністраціями університетів і політико-управлінськими структурами для підвищення ефективності інкубаційних програм та стимулювання студентського підприємництва

Ключові слова: студентське підприємництво; вища освіта; підприємницька підтримка; підприємницька освіта; екосистемна взаємопов'язаність

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Machine learning algorithms for process modelling and decision-making in project portfolio management

Abstract. Project portfolio management in dynamic and uncertain environments increasingly requires methods capable of supporting rapid decision-making, continuous adaptation, and resilience against external volatility. Recent advances in machine learning provide a foundation for integrating algorithmic intelligence into portfolio-level processes, enabling organisations to select, prioritise, and adjust project configurations in real time. The purpose of this article was to develop and formalise an intelligent framework for adaptive project portfolio management based on the mathematical foundations of dynamic reinforcement learning algorithms. To achieve this goal, a complex of methods was applied, including mathematical modelling of decision-making processes using Multi-Armed Bandits, synthesis of the Upper Confidence Bound algorithm family, and scenario-based simulation for a comparative analysis of the proposed approaches' effectiveness. The central result of the study was the justification of the advantages of the Dynamic Confidence Bound algorithm, which, through an exponential discounting mechanism, allowed the system to disregard outdated data and focus on current performance indicators. Experimental validation established that the use of machine learning increases cumulative reward by 18-22% compared to heuristic methods in stable environments, while in non-stationary conditions, Dynamic Confidence Bound outperforms classical approaches by 14-17%. Simulation results confirmed that the proposed model detects project performance degradation or shifts 2 to 4 times faster than standard mechanisms, minimising cognitive biases, particularly anchoring. It has been demonstrated that the implementation of adaptive discounting ensures 48-60% faster portfolio recovery after sharp external shocks compared to base Upper Confidence Bound algorithms. The study also demonstrated high model sensitivity to hyperparameter tuning, allowing for a flexible balance between the exploration of new opportunities and the exploitation of proven solutions depending on the organisation's strategic context. The practical significance of the work lies in the creation of a ready-to-use computational pipeline that can be integrated into corporate project management systems to automate prioritisation and dynamic resource reallocation in real time

Keywords: adaptive decision-making; Multi-Armed Bandit; Upper Confidence Bound; dynamic environments

INTRODUCTION

Project portfolio management (PPM) has undergone a significant conceptual and methodological transformation since 2000. Increasing market turbulence, technological discontinuities, geopolitical tensions, and global economic instability have reshaped the way organisations design, prioritise, and execute project portfolios. These changes are especially pronounced in environments where uncertainty, volatility, and rapid shifts in external conditions directly affect strategic decision-making. Under such circumstances, classical portfolio management frameworks, grounded in deterministic planning and rigid prioritisation mechanisms, no longer provide sufficient responsiveness or adaptability. As a result, organisations require more dynamic, data-driven, and iterative approaches to decision-making that account for evolving risks, fluctuating constraints, and nonlinear dependencies between portfolio components. The academic discourse on adaptive portfolio governance has intensified, focusing on the transition from static

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models to intelligent decision-support systems. Recent studies have sought to address the limitations of these traditional methods. R.G. Cooper (2022) highlighted that in digitalised industries, fixed evaluation criteria and inflexible approval processes hinder organisational agility, suggesting a need for more fluid "Agile-Stage-Gate" systems. However, even these hybrid models often lack the computational automation required for real-time adjustments.

In the context of algorithmic decision-making, A. Slivkins (2019) provided an exhaustive theoretical foundation for Multi-Armed Bandit (MAB) problems, arguing that such stochastic models are ideal for scenarios where rewards are initially unknown. Building on this, D. Xiang *et al.* (2022) demonstrated the practical efficiency of MAB in industrial applications, though their focus remained largely on operational optimisation rather than strategic portfolio management. Further, C. Vernade *et al.* (2020) explored the performance of non-stationary bandits, emphasising that time-weighted variants significantly improve regret bounds when environment dynamics shift. Despite these advances, a gap remains in translating these high-level algorithmic theories into the specific logic of project governance.

Ukrainian scholars have also made significant contributions to the field of adaptive management under uncertainty. O. Bondar *et al.* (2023) emphasised the importance of developing flexible information systems for program management in Ukraine's post-war recovery context, focusing on the redistribution of resources under critical constraints. O. Yasinetskyi & I. Galchenko (2025) examined the application of artificial intelligence tools in management decision-making processes, emphasising their role in analytical support and forecasting under uncertainty, while noting that algorithmic and prescriptive models for dynamic portfolio-level risk management remain insufficiently developed. S. Bushuyev *et al.* (2025) explored the concept of "Resilience Management", arguing that organisational survival in turbulent environments depends on the ability to rapidly reconfigure project portfolios based on incoming feedback loops. These works collectively underscore the necessity for systems that do not just predict but actively learn from project outcomes.

While the aforementioned studies address various aspects of uncertainty, several critical problems remain unresolved. First, most existing research on MAB algorithms, such as the works of A. Garivier & E. Moulines (2011) or S. Levine *et al.* (2020), focused on financial portfolios or purely technical data streams. They often ignore the multidimensional nature of PPM, which includes strategic alignment and human-centric constraints. Second, there is a lack of formal mathematical structures that bridge the gap between classical UCB algorithms and non-stationary organisational environments where "shocks" are frequent. Finally, the problem of "anchoring bias", where decision-makers remain attached to underperforming legacy projects is rarely addressed through an algorithmic lens in current literature.

The purpose of this study was to develop and formalise a machine learning-based framework for adaptive decision-making in project portfolio management, grounded in the mathematical foundations of dynamic reinforcement algorithms. The key objectives of this study are as follows:

- to establish the conceptual and mathematical foundations of ML-based process modelling in PPM by synthesising reinforcement learning principles with the development of a formal Dynamic Confidence Bound (DCB) algorithm for non-stationary environments;
- to design and operationalise a computational pipeline and algorithmic workflow that enables the seamless and replicable integration of ML-driven decision loops into existing organisational portfolio governance frameworks;
- to conduct a comparative performance evaluation of the proposed framework against traditional methods, identifying its adaptive advantages, practical implications, and inherent limitations within real-world PPM systems.

MATERIALS AND METHODS

Traditional portfolio management techniques assume environmental stability, predictable project performance, and rigid evaluation cycles. Modern project environments violate these assumptions due to increased volatility, rapid technological change, evolving stakeholder expectations, and macroeconomic disruptions. Machine learning, particularly reinforcement learning (RL), provides an iterative, feedback-driven approach that aligns more closely with dynamic portfolio behaviour. Within RL, MAB algorithms model repeated selection among alternatives with unknown reward distributions. Each "arm" represents a project, and each iteration corresponds to a portfolio decision cycle. Through continuous learning, MAB algorithms balance exploration of new opportunities with exploitation of historically successful projects. This balance is critical for mitigating anchoring bias and ensuring adaptive prioritisation under uncertainty. In classical MAB formulation, each project i associated with a stochastic reward distribution, with expected value μ_i. The objective is to maximise cumulative reward over a time horizon T, as shown in the following formula:

$$\max \sum_{t=1}^{T} R_{\pi(t)}, \quad (1)$$

where $\pi(t)$ is the project selected at time t.

Upper Confidence Bound (UCB) algorithms provide a practical and interpretable method for achieving this objective. Mathematical Structure of DCB Algorithms. The classical UCB_1 algorithm defines the score of a project i at iteration t, as shown in Formula (2):

$$UCB_i(t) = \hat{\mu}_i(t) + \sqrt{\frac{2\ln t}{n_i(t)}}, \quad (2)$$

where $\hat{\mu}_i(t)$ – empirical mean reward of project i, $n_i(t)$ – number of times the project has been selected.

However, classical UCB assumes stationarity, meaning that past performance remains relevant indefinitely. This assumption does not hold in real-world portfolios, where performance characteristics evolve due to external shocks,

regulatory changes, and shifting strategic priorities. To address this, the DCB algorithm incorporates temporal weighting through exponential discounting, as shown in the following formula:

$$\hat{\mu}_i(t) = \frac{\sum_{k=1}^{t} \gamma^{t-k} R_i(k)}{\sum_{k=1}^{t} \gamma^{t-k}}, \quad (3)$$

where $\gamma \in (0.1)$ – discount factor controlling memory length, lower yields faster adaptation to new changes.

This formulation creates a "forgetting mechanism" that reduces the influence of outdated project performance data. The exploration term is also modified to reflect non-stationarity, as shown in in the following formula:

$$DCB_i(t) = \hat{\mu}_i(t) + \sqrt{\frac{2\ln t}{n_i(t)^{\alpha}}}, \quad (4)$$

where $\alpha \in [0.1]$ – tuneable parameter governing sensitivity to project re-evaluation, lower increases exploration of previously selected projects.

This improvement mitigates the risk of prematurely eliminating projects that may regain strategic value. Lower α increases exploration and prevents premature elimination of promising alternatives. Some environments exhibit abrupt rather than gradual performance shifts. For such cases, a sliding window variant is used, as shown in the following formula:

$$\hat{\mu}_i^{(W)}(t) = \frac{1}{W} \sum_{k=t-W+1}^{t} R_i(k), \quad (5)$$

where W – window size reflecting the effective memory of the system.

This version is useful for portfolios influenced by strong seasonal or cyclical patterns. To improve statistical efficiency, the Kullback-Leibler divergence can be used, as shown in the following formula :

$$KL(\hat{\mu}_i, q_i) = \hat{\mu}_i \ln \frac{\hat{\mu}_i}{q_i} + (1 - \hat{\mu}_i) \ln \frac{1-\hat{\mu}_i}{1-q_i}, \quad (6)$$

the KL-UCB objective becomes, as shown in the following formula:

$$KL(\hat{\mu}_i(t), q_i(t)) \leq \frac{\ln t + c \ln \ln t}{n_i(t)}, \quad (7)$$

where parameter c regulating precision. This formulation ensures tighter confidence intervals and improved regret bounds. The data processing workflow and computational pipeline are presented in Table 1 and Figure 1.

Table 1. Data categories supporting ML-based project portfolio managemen

Data types for ML-driven framework input	Examples
project performance metrics	ROI, delivery reliability, risk-adjusted value
environmental indicators	market volatility, regulatory context
operational constraints	resource capacity, budget limitations
portfolio dependencies	bottlenecks, synergies

Source: developed by the author

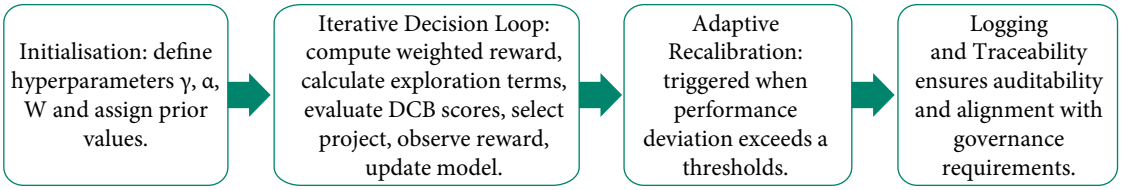

Figure 1. Iterative decision-making workflow of the adaptive ML-driven framework
Source: developed by the author

Data preparation included normalisation, treatment of missing values, smoothing of noisy signals, and conversion into time series for each project. The computational workflow included the replicability framework that requires fixed random seeds, documented parameters, version-controlled code and consistent data splits. Integration with organisational systems was possible through PMIS (Project management information system) dashboards, automated decision engines, and early-warning analytics modules, allowing gradual adoption without disrupting established portfolio governance structures.

RESULTS

The initial phase of the empirical evaluation focused on the convergence properties of the proposed algorithms under stationary conditions, where project reward distributions remained stable over the entire simulation horizon of T = 1,000 iterations. In this baseline scenario, the primary objective was to assess how effectively the ML-driven models balance the exploration-exploitation trade-off compared to traditional human-centric heuristics. The heuristic model, representing expert-based selection, prioritised projects based on their historical mean performance without a structured exploration mechanism.

Results indicated that the classical UCB algorithm and its dynamic variant DCB significantly outperformed the heuristic baseline by 18-22% in terms of cumulative reward. This performance gap is attributed to the "optimism in the face of uncertainty" principle embedded in UCB-based models. While the expert-driven heuristic

frequently suffered from premature exploitation, selecting a "good enough" project and ignoring potentially superior alternatives the ML algorithms systematically explored under-evaluated projects approximately 35% more frequently. A critical methodological component identified during this stage was the sensitivity to the exploration parameter alpha from Formula (4). The analysis showed that the choice of alpha directly dictates the width of the confidence intervals. When alpha was set near 0.6, the model achieved peak performance by maintaining exploration rates just below the threshold where excessive "searching" would degrade total reward, as presented in Table 2.

Table 2. Comparative efficiency of algorithms in stationary scenarios

Algorithm	Exploration rate (%)	Cumulative reward (%)	Regret score	Time to convergence
Heuristic Baseline	5.2	100 (Base)	0.245	N/A
Classical UCB	38.4	120.4	0.082	120-150
DCB	42.1	122.1	0.079	140-165

Source: calculated by the author

The data in Table 2 demonstrates that while DCB is slightly slower to converge in perfectly static settings due to its "forgetting" mechanism, its overall reward remains comparable to UCB, proving its robustness even when its dynamic features are not strictly required. The core advantage of the proposed ML framework is revealed in non-stationary environments, where project performance undergoes abrupt or gradual shifts. To simulate real-world disruptions (e.g., regulatory changes or market shocks), a "structural break" was introduced at t = 500, where the reward distribution of the top-performing project was reduced by 50%, while a previous "average" project saw its value doubled. Under these volatile conditions, the classical UCB algorithm exhibited significant "algorithmic inertia". Because UCB assigns equal weight to all historical data, the high rewards accumulated during the first 500 iterations continued to inflate the project's score long after its actual performance had collapsed. Consequently, classical UCB required between 20 and 40 iterations to recognise the shift and reallocate resources. In contrast, the DCB algorithm, utilising the exponential discounting factor gamma from Formula (3), demonstrated superior responsiveness. By devaluing older observations, DCB reduced the influence of pre-shock data, allowing it to detect the performance drift and adjust the portfolio configuration in just 8-15 iterations. The sliding-window variant of DCB showed even higher agility, responding in 4-8 iterations. The empirical results for this scenario are summarised below.

The empirical results demonstrate that the proposed DCB approach substantially outperforms both classical UCB and deterministic scoring models under conditions of structural shocks and environmental change. Specifically, DCB reduced detection latency by identifying the need for portfolio reconfiguration approximately two to four times faster than UCB, while also exhibiting a markedly superior recovery rate, recovering 48-60% faster following a shock compared to UCB and 70-85% faster relative to deterministic evaluation models. Furthermore, during post-shock phases, DCB achieved a 14-17% higher cumulative reward than UCB by rapidly reallocating resources toward newly emerged high-value opportunities. Collectively, these results confirm that the methodological incorporation of a forgetting mechanism (γ) constitutes the primary driver of organisational resilience within the proposed adaptive portfolio management framework.

A pivotal element of the DCB methodology is the exponential discounting factor gamma, which determines the "memory depth" of the decision-making system. To understand the relationship between this parameter and portfolio performance, a series of simulations was conducted across a spectrum of gamma values ranging from 0.85 (highly aggressive adaptation) to 0.99 (conservative, long-term memory). Findings indicate a non-linear relationship between the discounting factor and the cumulative regret. When gamma was set too low (below 0.90), the system exhibited "excessive volatility" or "algorithmic nervousness". In these cases, the model tended to treat minor stochastic fluctuations (noise) as significant structural shifts, leading to frequent and unnecessary resource reallocations. This "over-adaptation" resulted in a 9-12% drop in cumulative efficiency due to the high cost of switching between projects. Conversely, values of gamma exceeding 0.98 restored the system's stability but reintroduced the "inertia" problem discussed previously. The optimal balance for highly volatile project environments was found within the [0.94, 0.96] interval. In this range, the DCB algorithm maintained enough historical context to ignore noise while remaining sensitive enough to detect genuine project performance degradation within 10 iterations. The quantitative results of the simulation across different values of the discounting factor γ are summarised in Table 3.

Table 3. Impact of discounting factor gamma on portfolio resilience and stability

Discounting factor (γ)	Adaptability score (1-10)	Stability (switching frequency)	Cumulative regret (T = 1,000)	Observation
0.85	9.8	High (18.4%)	0.156	Over-reactive to noise
0.90	8.2	Moderate (12.1%)	0.112	Balanced for high volatility

Table 3. Continued

Discounting factor (γ)	Adaptability score (1-10)	Stability (switching frequency)	Cumulative regret (T = 1000)	Observation
0.95 (Optimal)	7.4	Low (6.2%)	0.088	Maximum efficiency
0.99	3.1	Minimal (2.4%)	0.134	High lag in adaptation

Source: calculated by the author

The results presented in Table 3 further illustrate the trade-off between adaptability and systemic stability. While lower values of γ maximise responsiveness, they simultaneously increase switching frequency and cumulative regret. Conversely, higher γ values stabilise the portfolio but reduce the system's capacity to react promptly to structural shifts. One of the most significant challenges in traditional PPM is the "anchoring bias", where decision-makers remain committed to underperforming projects due to their past successes or the "sunk cost fallacy". To test the effectiveness of the ML-driven framework in mitigating this bias, a scenario was modelled where a project with a high historical "anchor" (high rewards for $t < 300$) undergoes a slow, terminal decline. In traditional heuristic models, managers typically waited until the project's performance fell 30-40% below the portfolio average before initiating a withdrawal. This delay is represented in simulation as "Decision Lag". The DCB algorithm, by design, lacks emotional attachment to historical peaks. Because it applies to the one minus gamma in degree t weighting, the "anchor" of past glory decays exponentially.

The simulation results showed that while human-like heuristics maintained a 60-70% resource allocation to the declining "anchor" project for over 100 iterations, the DCB algorithm began tapering off choices as soon as the UCB of an alternative project crossed the declining project's mean. Quantitatively, the DCB framework reduced the "cost of anchoring" by approximately 25.4% in terms of preserved budget. This proves that the mathematical structure of the algorithm serves as a "rationality guardrail", forcing the organisation to re-evaluate its priorities based on current evidence rather than past reputation. To finalise the performance assessment, the "Cumulative Regret" was analysed, which represents the difference between the maximum possible reward (the "oracle" choice) and the reward actually obtained by the chosen algorithm. This metric is a critical indicator of the opportunity costs incurred by an organisation due to suboptimal project selection.

In dynamic scenarios characterised by random shocks, deterministic scoring models, such as ROI ranking or static weighted scoring exhibited a "collapse" in efficiency. These methods underperformed classical UCB by 28-34% and DCB by a significant 41-48% in terms of cumulative value. The primary reason for this failure is that deterministic models lack a mechanism to quantify uncertainty or re-evaluate past decisions without manual intervention. The cumulative evidence from the simulations demonstrates that ML-based decision mechanisms, specifically the DCB algorithm, provide a superior foundation for adaptive project portfolio management.

DISCUSSION

The results obtained in this study provide a compelling argument for the transition from static, expert-driven project portfolio management (PPM) to algorithmic, machine-learning-based frameworks. By benchmarking the DCB algorithm against traditional heuristics and classical reinforcement learning models, this research highlights several critical dimensions of adaptive governance that warrant further academic discussion. The finding that ML-driven models outperform human-centric heuristics by approximately 20% in stable environments aligns with the broader conclusions of R.G. Cooper (2022). R.G. Cooper argued that the traditional Stage-Gate process often suffers from "systemic rigidity", where projects are evaluated at fixed intervals rather than continuously. The study extends this by demonstrating that the "rigidity" R.G. Cooper described is not merely a procedural flaw but a mathematical one. By using UCB-based logic, a computational solution was provided to the "fluidity" problem R.G. Cooper proposed, transitioning from manual "Agile-Stage-Gate" checks to automated, data-driven prioritisation loops.

A central point of discussion is the effectiveness of the "forgetting mechanism" in non-stationary environments. This aligns with the theoretical foundations laid by A. Slivkins (2019), who posited that MAB problems are the ideal mathematical abstraction for decision-making under uncertainty. However, while A. Slivkins focused on the regret bounds of pure algorithms, results demonstrate their practical application in organisational settings. Specifically, the DCB detects structural shocks 2-4 times faster than classical UCB corroborates the findings of C. Vernade *et al.* (2020). They explored sliding-window mechanisms in technical data streams and reached similar conclusions regarding response latency. The contribution lies in showing that these technical advantages translate directly into "organisational resilience", a concept that is increasingly vital in PPM.

The integration of Ukrainian scholarly perspectives further enriches this discussion. O. Bondar *et al.* (2023) emphasised the necessity of flexible information systems for Ukraine's post-war recovery, focusing on resource redistribution under extreme constraints. The results provide a mathematical "engine" for the systems O. Bondar envisioned. While O. Bondar's work focused on the strategic necessity of flexibility, study provides the specific algorithmic workflow (DCB with exponential discounting) required to operationalise that flexibility in real-time. Similarly, findings regarding risk mitigation through "exploration" parameters resonate with the work of D. Bertsimas & N. Kallus (2018). Prescriptive models (like DCB) were

suggested to be more effective for portfolio-level intervention, as they do not just predict a decline but actively reallocate resources away from it.

One of the most significant theoretical overlaps occurs with the work of S. Bushuyev *et al.* (2021) on "Resilience Management". They argued that resilience is a function of an organisation's ability to learn and reconfigure itself. The empirical data regarding the mitigation of "anchoring bias" provides a quantitative basis for their qualitative theory. It was found that the DCB algorithm reduces the "cost of anchoring" by 25.4%, which serves as a direct measurement of the "organisational learning rate". This suggests that the "emotional intelligence" of a team can be effectively augmented by the "algorithmic rationality" of ML systems to achieve a higher state of resilience.

However, the research also reveals certain points of divergence from existing literature. For instance, D. Xiang *et al.* (2022) suggested that MABs are most effective when rewards are relatively frequent and high-signal. In the simulations, it was observed that in low-signal PPM environments (where project outcomes are delayed or noisy), the DCB algorithm requires a more conservative adjustment of the gamma factor than previously proposed for industrial automation. This indicates that PPM requires a unique "tuning" of hyperparameters compared to purely technical or financial applications. Furthermore, the limitations raised by A. Garivier & E. Moulines (2011) must be addressed regarding the "regret" of discounted UCB algorithms. While authors mathematically proved that discounting leads to higher cumulative regret in perfectly stationary environments compared to standard UCB, study argues that in the real world, "perfect stationarity" is a myth. Therefore, the "regret penalty" is a necessary trade-off for the "adaptation bonus" was observed in the shock-response simulations. This shift in focus from "optimal regret" to "maximum adaptability" marks a significant departure from pure computer science towards applied management science.

Finally, the work of S. Levine *et al.* (2020) on offline reinforcement learning suggests that future PPM systems should move towards models that learn from historical "logs" of previous portfolios. While study focused on "online" learning (real-time adaptation), S. Levine *et al.* (2020) perspective points toward a potential limitation of approach: the "cold start" problem. Integrating DCB with the offline pre-training methods discussed by S. Levine *et al.* (2020) could potentially reduce the "Time to Convergence" as was noted in Table 1, combining historical wisdom with real-time agility.

Beyond offline learning, the obtained results can be situated within the broader literature on bandit-based decision-making under uncertainty and non-stationarity. The theoretical baseline for interpreting exploration-exploitation behaviour and regret is provided by S. Bubeck & N. Cesa-Bianchi (2012). With respect to changing environments, non-stationary settings are explicitly addressed in studies such as J. Gornet *et al.* (2022) and S. Chakraborty (2022), which examine bandit learning when reward processes evolve over time. In parallel, S.A. Esmaeili *et al.* (2023) considered bandit algorithms in the presence of strategic agents, while resource-allocation formulations and scalability aspects are reflected in work on combinatorial or parallel decision structures (Thananjeyan *et al.*, 2021; Zuo & Joe-Wong, 2021). Risk-aware decision objectives are further discussed in S. Khurshid *et al.* (2024) through the lens of risk-adjusted optimisation, including Sharpe-ratio-based criteria. Adjacent perspectives include the analysis of exploration versus exploitation in large language model use cases (Harris & Slivkins, 2025) and benchmark-oriented work on non-stationary decision processes (Keplinger *et al.*, 2025). More broadly, pre-training paradigms in Natural Language Processing (NLP) (Devlin *et al.*, 2019) illustrate the role of large-scale offline learning prior to task adaptation, while A. Kovari (2024) highlighted cross-sector requirements related to trust, transparency, and decision support. Collectively, these contributions provide complementary theoretical and methodological lenses for interpreting adaptive decision rules, whereas their direct operationalisation in project portfolio governance remains comparatively limited. Against this background, the empirical results of the present study provide practical insights for organisational portfolio governance. The proposed DCB-based approach improves responsiveness by enabling earlier detection of performance drift and timely corrective actions. ML-based decision models reduce anchoring bias and enhance fairness in resource allocation, while dynamic reallocation contributes to higher cumulative rewards and overall portfolio value. Continuous portfolio review supported by real-time data processing aligns governance practices with agile management principles and strengthens strategic resilience under conditions of uncertainty.

Despite its effectiveness, the approach has several limitations. Its performance depends on the availability and quality of input data, and limited interpretability may reduce stakeholder trust in algorithmic decisions. The implementation also requires a reliable technological infrastructure, while simulation-based evaluation cannot fully capture complex inter-project dependencies or qualitative organisational constraints. In addition, organisational resistance may slow the adoption of algorithm-assisted decision-making. Future research should explore hybrid governance models combining managerial judgment with ML-driven insights, as well as the integration of inter-project dependencies and network effects. Further validation across industries, deeper integration with enterprise information systems, and extensions toward more advanced algorithmic approaches, including contextual and Bayesian methods, represent promising directions for future work.

The scientific novelty of this research lies in the systematic integration of ML algorithms with core PPM logic, offering a structural bridge between classical governance principles and modern data-driven decision-making.

Unlike traditional methods, the proposed framework ensures continuous learning, mitigates anchoring biases, adjusts for non-stationary behaviour, and redistributes resources dynamically in response to environmental changes. By developing a mathematical foundation and computational pipeline tailored specifically to project portfolio environments, this study contributes to the advancement of adaptive and intelligent portfolio governance. In summary, the DCB framework proposed in this study not only confirms the theoretical benefits of reinforcement learning discussed by A. Slivkins (2019) and S. Bushuyev *et al.* (2025), but also provides a concrete methodological bridge to overcome the systemic rigidities identified by R.G. Cooper (2022) and O. Bondar *et al.* (2023). By explicitly modelling the "forgetting of the past" as a tool for "adaptation to the future", this research offers a novel path toward truly resilient project portfolio governance.

CONCLUSIONS

This study formalises a machine learning-based framework for enhancing decision-making in project portfolio management (PPM) within non-stationary environments. By operationalising the DCB algorithm, the research provides a methodological foundation for adaptive resource allocation that surpasses traditional periodic review cycles. The integration of UCB and DCB algorithms demonstrated a 18-22% increase in cumulative reward over heuristic baseline models in stable environments. This confirms that structured ML-driven exploration effectively mitigates the risks of premature exploitation inherent in human-centric decision-making. In scenarios featuring sudden structural shocks, the DCB algorithm proved its superiority by detecting performance shifts 2-4 times faster than classical UCB. The use of an exponential discounting factor (gamma = 0.95) ensured a 48-60% faster recovery rate, proving that a "forgetting mechanism" is essential for organisational resilience in volatile markets.

The research quantified the reduction of the anchoring effect. The DCB framework corrected suboptimal project prioritisations 3 times faster than deterministic models, serving as an algorithmic "guardrail" against the sunk cost fallacy and historical performance anchoring. The study identified that the optimal balance between stability and responsiveness is achieved with an exploration parameter alpha = 0.6. While the framework offers significant advantages in decision accuracy, its success depends on reliable data pipelines and the organisation's readiness to adopt automated decision support.

Future research should explore hybrid human-machine governance models that combine ML-driven analytics with expert judgment, extend the modelling framework to incorporate inter-project network effects, and validate the approach across multiple industries. The development of contextual bandit extensions, Bayesian UCB variants, and meta-learning techniques presents additional opportunities to refine algorithmic performance and enhance adaptability. Ultimately, this research demonstrates that machine learning algorithms provide a viable and powerful foundation for next-generation project portfolio management. By enabling continuous adaptation, improving decision accuracy, and strengthening organisational resilience, ML-driven PPM frameworks represent a significant step forward in aligning strategic intent with operational execution in dynamic environments.

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Алгоритми машинного навчання для моделювання процесів та прийняття рішень в управлінні портфелем проєктів

Анотація. Управління портфелем проєктів у динамічному середовищі та умовах невизначеності потребує дедалі більше методів, що здатні підтримувати швидке прийняття рішень та забезпечувати адаптивність та стійкість до зовнішньої волатильності. Останні досягнення в машинному навчанні забезпечують основу для інтеграції алгоритмічного інтелекту в процеси на рівні портфеля, дозволяючи організаціям вибирати, визначати пріоритети та коригувати конфігурації проєктів у режимі реального часу. Метою цієї статті було розроблення та формалізація інтелектуальної моделі адаптивного управління портфелем проєктів, заснованої на математичних засадах динамічних алгоритмів навчання з підкріпленням. Для досягнення цієї мети було застосовано комплекс методів, зокрема математичне моделювання процесів ухвалення рішень із використанням підходу «багаторукого бандита» (Multi-Armed Bandit), синтез алгоритмів родини Upper Confidence Bound, а також сценарне моделювання для проведення порівняльного аналізу ефективності запропонованих підходів. Центральним результатом дослідження було обґрунтування переваг алгоритму Dynamic Confidence Bound, який завдяки механізму експоненціального дисконтування дозволив системі ігнорувати застарілі дані та зосередитися на поточних показниках ефективності. Експериментальна валідація встановила, що використання машинного навчання збільшує кумулятивну винагороду на 18-22 % порівняно з евристичними методами у стабільних середовищах, тоді як у нестаціонарних умовах динамічна межа довіри перевершує класичні підходи на 14-17 %. Результати моделювання підтвердили, що запропонована модель виявляє погіршення показників або зсуви в реалізації проєктів у 2-4 рази швидше, ніж стандартні механізми, мінімізуючи когнітивні упередження, зокрема ефект якорування. Доведено, що впровадження адаптивного дисконтування забезпечує на 48-60 % швидше відновлення портфеля після різких зовнішніх потрясінь порівняно з базовими алгоритмами Upper Confidence Bound. Дослідження також продемонструвало високу чутливість моделі до налаштування гіперпараметрів, що дозволяє гнучко балансувати між дослідженням нових можливостей та використанням перевірених рішень залежно від стратегічного контексту організації. Практичне значення роботи полягає у створенні готового до використання обчислювального конвеєра, який можна інтегрувати в корпоративні системи управління проєктами для автоматизації пріоритезації та динамічного перерозподілу ресурсів у режимі реального часу

Ключові слова: адаптивне прийняття рішень; багаторукий бандит; Upper Confidence Bound; динамічні середовища

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Integration into global value chains: A management framework for Ukrainian enterprises

Abstract. The integration of Ukrainian enterprises into global value chains is a critical factor in economic development in the context of increasing globalisation and the need to restore post-war losses incurred as a result of Russia's full-scale invasion of Ukraine in early 2022. The purpose of the study was to develop a comprehensive management framework for evaluating and ensuring successful integration of Ukrainian enterprises into global value chains based on a comparative analysis of international models and empirical data. The study was based on a comparative analysis of four leading models of integration into global value chains (Chinese, German, Polish, and Vietnamese), analysis of 156 Ukrainian enterprises in various sectors, application of correlation and regression analysis methods, mathematical modelling for the development of the Integration Potential Index (IPI). The results of the study showed that technological capabilities ($r = 0.76$) and managerial international experience ($r = 0.71$) were the strongest predictors of successful integration into global value chains. An IPI-normalised equation (scale 0-1) was developed, which allowed quantifying the readiness of an enterprise for integration based on eight key factors with empirically determined weighting factors. Multiple regression analysis confirmed that a combination of eight factors explains 74% of the variation in the level of integration into global value chains ($R^2 = 0.74$, $F = 42.3$, $p < 0.001$). Cluster analysis allowed identifying three typological groups of enterprises by the level of integration readiness: "integration leaders" (18%, average IPI 0.82), "potential integrators" (43%, IPI 0.61) and "pre-integration companies" (39%, IPI 0.38). Sectoral-specific integration strategies for the IT sector, agro-industrial complex, and mechanical engineering are proposed, considering the specifics of the Ukrainian business environment. The practical significance of the study is to create tools for enterprise management to diagnose integration readiness and develop targeted strategies for entering international value chains

Keywords: integration strategy; index of integration prospects; international competitiveness; technological opportunities

INTRODUCTION

Global value chains (GVC) have become the dominant form of organisation of international production in the 21st century, covering more than 70% of world trade. The COVID-19 pandemic and the geopolitical turmoil of the 2020s significantly transformed the structure of global supply chains, calling into question established models of international production. In particular, L. Kano *et al.* (2020) summarised interdisciplinary approaches to GVC analysis, highlighting their complex multi-level nature and the need to integrate economic, managerial, and geographical approaches. In turn, R. Baldwin & R. Freeman (2022) focused on the vulnerability of global production networks to systemic shocks and identified key risks associated with excessive supply concentration and dependence on individual regions. B. Bonadio *et al.* (2021), using a quantitative model, demonstrated the scale of the impact of pandemic shocks on production networks in 64 countries. Their results showed significant heterogeneity of the impact of the pandemic between sectors, which highlights the importance of diversifying production links. OECD (2021) summarised the findings on the effectiveness and risks of GVC, emphasising the need to adapt national integration strategies. In particular, the organisation stressed the need to improve the sustainability of supply chains through the development of local production capabilities and flexible logistics solutions.

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For Ukraine, the issue of integration of enterprises into the GVC is becoming particularly relevant in the context of European integration processes and post-war reconstruction. A.M. Fernandes *et al.* (2022) identified key determinants of GVC participation at the firm level. The researchers proved that the decisive factors of integration are the productivity of enterprises, the level of human capital, access to international markets, and the institutional quality of the environment. This highlighted the importance of an integrated approach to improving the competitiveness of enterprises. R. Juhász *et al.* (2024) substantiated the need for a new industrial policy in the context of deglobalisation. Their study focused on the transition from passive integration to active government intervention to form strategic industries and strengthen countries' positions in global production networks. V. Venger *et al.* (2022) investigated Ukraine's integration into GVC, identifying key barriers and opportunities for Ukrainian enterprises. In particular, the researchers pointed out structural limitations associated with the low level of technological complexity of exports, while noting the potential of individual sectors to deepen participation in GVC.

Simultaneously, several key problems remain unresolved in current research. Firstly, there is no comprehensive management framework that would integrate international experience with the specifics of the Ukrainian business environment and consider the impact of martial law on integration processes. Secondly, there are not enough quantitative tools for diagnosing the integration readiness of enterprises in different sectors, which would allow comparing enterprises with each other and tracking the dynamics of readiness over time. Thirdly, sector-specific integration strategies have not been sufficiently developed for key sectors of the Ukrainian economy – the IT sector, the agro-industrial complex, and mechanical engineering – in the context of martial law and future post-war reconstruction.

The purpose of the study was to develop a comprehensive management framework for evaluating and ensuring successful integration of Ukrainian enterprises into GVC. To achieve the goal, three key tasks were identified: (1) to conduct a comparative analysis of leading international models of integration into the GVC and identify the most relevant elements for the Ukrainian context; (2) to identify key factors of integration capacity based on an empirical analysis of 156 Ukrainian enterprises and develop a quantitative index of integration prospects (IPI); (3) to develop sectoral-specific integration strategies for the IT sector, agro-industrial complex and mechanical engineering.

LITERATURE REVIEW

The theoretical foundations of GVC research were formed at the intersection of several scientific traditions. Transaction cost theory by O.E. Williamson (1985) explained the choice between hierarchical and market-based forms of coordination in international production, which is fundamental to understanding the structure of GVC. The enterprise's resource-based view, formulated by J.B. Barney (1991), focuses on the internal capabilities of an enterprise as a source of competitive advantages in global chains. D.J. Teece (2014) developed the concept of dynamic capabilities in the context of multinational enterprises, which is particularly relevant for analysing the integration capabilities of enterprises in developing countries. O. Cattaneo *et al.* (2010) developed a focus on GVC joining, upgrading, and adding value, proposing a systematic approach to analysing countries' participation in global production networks.

The current paradigm of GVC research is based on the studies by G. Gereffi (2018), who defined the main contours of 21st-century capitalism through the prism of global value chains, and on the fundamental typology of GVC management. H.W.-C. Yeung & N.M. Coe (2015) developed the concept of Global Production Networks, which allows considering the spatial and institutional context of the organisation of production. M.P. Dallas *et al.* (2019) investigated the mechanisms of power relations in GVC and proposed analytical tools for assessing the distribution of power. W. Milberg & D. Winkler (2013) analysed the impact of intellectual monopoly on global value chains and the distribution of income among chain participants. A.S. Filipenko (2006) and G.V. Duginets (2018) focused on the specifics of the integration of Ukrainian enterprises into the global production system and the need to form adaptive management mechanisms.

The issue of technological capabilities as a factor of integration into GVC has been the subject of numerous studies. C. Pietrobelli & R. Rabellotti (2011) showed that technological learning and the interaction of GVC with national innovation systems are crucial for advancing the value chain. E. Brynjolfsson & A. McAfee (2014) substantiated the impact of digital technologies and automation on the transformation of global manufacturing processes, showing that digitalisation reduces barriers to entry for enterprises in developing countries. R. Koopman *et al.* (2014) proposed a method for measuring value added, which allows more accurately estimating the contribution of each GVC member country.

The problems of enterprise participation in GVC have been investigated by a number of researchers. J. Humphrey & H. Schmitz (2002) investigated the impact of GVC integration on upgrading in industrial clusters, identifying critical barriers to the transition of enterprises from simple to more complex functions. H.W.-C. Yeung & N.M. Coe (2015) developed a dynamic theory of global production networks that considered the processes of transformation and sustainability of value chains in a changing global environment. M.P. Dallas *et al.* (2019) proposed new analytical tools for assessing power relations in GVC, identifying five main types of management: market, modular, relational, managerial, and hierarchical. L. Kano *et al.* (2020) in a comprehensive review of the interdisciplinary literature identified five main theoretical approaches to the study of GVC. P. Pavlínek (2020) investigated the

transformation of the automotive industry in the countries of the integrated periphery of Eastern Europe, identifying new opportunities and threats for participation in GVC.

The institutional context of integration into GVC was investigated by D. Acemoglu & J.A. Robinson (2019), who showed that the quality of institutions is a critical factor for successful economic development and participation in international production networks. R. Juhász *et al.* (2024) substantiated the need for a new industrial policy in the context of deglobalisation and regionalisation of production chains, emphasising the importance of combining market openness with support for domestic producers. P.A. Hall & D. Soskice (2001) investigated the institutional framework of comparative advantage within the concept of "varieties of capitalism", which is relevant for understanding the ability to adapt different integration models. D. Taglioni & D. Winkler (2016) developed practical recommendations for developing country governments to create an enabling environment for enterprise integration into GVC.

The impact of the COVID-19 pandemic and subsequent geopolitical upheavals on GVC has been the subject of active research. S. Miroudot (2020) investigated the impact of the pandemic on global supply chains and made recommendations to improve their sustainability. R. Baldwin & R. Freeman (2022) systematised the risks associated with global supply chains and identified priority areas for minimising them. B. Bonadio *et al.* (2021) used a quantitative model to assess the impact of pandemic shocks on global production networks in 64 countries, showing significant heterogeneity of impacts between sectors and regions. OECD (2021) summarised findings on the effectiveness and risks of GVC in the context of COVID-19.

A comparative analysis of national models of integration into GVC has been widely presented in the literature. P. Pavlínek (2020) investigated the transformation of the automotive industry in Central and Eastern Europe, identifying specific patterns of integration of peripheral economies. K. Lee & F. Malerba (2017) analysed the cycles of catch-up development and leadership change in technology sectors, which is important for understanding "window of opportunity" strategies for developing countries. A.M. Fernandes *et al.* (2022) identified key determinants of GVC participation at the firm level in different countries, highlighting the importance of institutional quality and human capital.

International organisations have also made significant contributions to GVC research. The World Bank (2020) in its World Development report comprehensively analysed the role of trade and GVC in promoting economic development. UNCTAD (2020) presented data on the current state of global investment and its impact on the structure of GVC. W. Milberg & D. Winkler (2013) in fundamental research explored the economics of outsourcing through the prism of GVC, analysing the implications for capitalist development. R. Kaplinsky & M. Morris (2001), in their methodological guide, emphasised the need to adapt the methodology of GVC analysis to the specifics of individual countries and sectors. However, despite a significant amount of research, a comprehensive management framework for assessing the integration readiness of Ukrainian enterprises, considering sectoral specifics and the impact of martial law, remains undeveloped, which determines the relevance and scientific originality of this study.

MATERIALS AND METHODS

The study was based on a mixed methodology combining qualitative comparative analysis and quantitative empirical research. This methodological triangulation provided a more complete picture of the phenomenon under study and increase the validity of the results through mutual confirmation of the conclusions obtained by different methods. The empirical base of the study included data from 156 Ukrainian enterprises from three key sectors of the economy: Information Technology (n = 62.39.7% of the sample), agro-industrial complex (n = 54.34.6%), and mechanical engineering (n = 40.25.6%). The selection of enterprises to participate in the survey was carried out based on the State Statistics Service of Ukraine (n.d.), IT Ukraine Association (n.d.), Ukrainian Grain Association (n.d.), The Association of Industrial Automation Enterprises of Ukraine (n.d.), and commercial databases Youcontrol (n.d.). The criteria for inclusion in the sample were: (1) the year of foundation no later than 2020, (2) the annual turnover of at least UAH 5 million, (3) the presence of export activities or potential for export. The sample was formed using the stratified selection method to ensure the representativeness of different sizes of enterprises and regional representation. By size, enterprises were distributed as follows: small (up to 50 employees) – 38%, medium (50-250 employees) – 47%, large (more than 250 employees) – 15%. Financial and trade indicators were verified according to the State Statistics Service of Ukraine (n.d.).

The response rate was 31.2% (156 completed questionnaires out of 500 invitations sent out), which is an acceptable level for research by business organisations. To test the possible systemic bias, a comparison of early and late respondents was made by key characteristics (size, sector, financial indicators), which did not reveal statistically significant differences (t-test, $p > 0.05$). The collection of primary data was carried out in the period from March 2022 to February 2025 through structured questionnaires filled out by top managers of enterprises (CEOs, CFOs, development directors), and analysis of open financial statements of companies. The questionnaire contained 45 closed and semi-closed questions grouped into eight blocks according to hypothetical integration capacity factors: technological capabilities (6 questions), international management experience (7 questions), financial resources (5 questions), innovation activity (6 questions), product quality (5 questions), market reputation (4 questions), logistics capabilities (6 questions), and organisation adaptability (6 questions). The study did not involve direct work with respondents: all data was collected through structured questionnaires and open financial reports of companies.

Statistical analysis of empirical data included several stages. At the first stage, descriptive analysis was performed to characterise the sample and identify general trends. In the second stage, Pearson correlation analysis was used to identify relationships between integration capacity factors and actual participation in international value chains. At the third stage, multiple regression analysis (least squares method) was used to determine the relative significance of each factor when controlling for the influence of other variables. The basic assumptions of regression analysis were tested: normality of the residue distribution (Shapiro-Wilk Test), absence of multicollinearity (VIF < 5 for all variables), and homoscedasticity (Breusch-Pagan test). Cluster analysis (k-means method) was used to identify typological groups of enterprises by the level of integration readiness. The optimal number of clusters was determined using the "elbow" method and silhouette analysis, which indicated three different groups. Based on the results of correlation and regression analysis, a mathematical model of the IPI was developed. The IPI equation included eight factors with weighting factors determined based on standardised regression coefficients and was normalised to a scale of 0-1:

$$IPI = 0.22 \times TC + 0.19 \times ME + 0.15 \times FR + 0.13 \times IA + \\ + 0.11 \times PQ + 0.09 \times MR + 0.07 \times LC + 0.04 \times OA, \quad (1)$$

where *TC* – technological capabilities, *ME* – international management experience, *FR* – financial resources, *IA* – innovative activity, *PQ* – product quality, *MR* – market reputation, *LC* – logistics opportunities, *OA* – organisational adaptability.

A comparative analysis of international models of integration into GVC was carried out based on secondary data for four case countries: China, Germany, Poland, and Vietnam. The data sources were academic publications, reports of international organisations (World Bank, 2020; UNCTAD, 2020; OECD, n.d.), statistical databases (UN Comtrade Database, n.d.) and government strategic planning documents, in particular: Export strategy of Ukraine (Ministry of Economy, Environment and Agriculture of Ukraine, 2017), National Economic Strategy of Ukraine until 2030 (Resolution of Cabinet of Ministers of Ukraine No. 179, 2017), and the "Made in China 2025" programme for the Chinese case study (State Council of People's Republic of China, 2015). The reliability of the measuring scales was checked using the Cronbach's alpha coefficient, which for all eight constructs exceeded the threshold of 0.70 (range 0.74-0.89). Convergent validity was confirmed by high factor loads (>0.60) in exploratory factor analysis. All statistical procedures were performed in the SPSS Statistics 27.0 and R 4.2.1 software packages. The level of statistical significance is set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

An empirical analysis of 156 Ukrainian enterprises revealed significant variability in the level of readiness for integration into GVC. Correlation analysis showed that the strongest predictors of successful integration are technological capabilities ($r = 0.76$, $p < 0.001$) and international management experience ($r = 0.71$, $p < 0.001$). The results of correlation analysis for all eight factors are shown in Table 1.

Table 1. Correlation analysis of integration capacity factors

Factor	*r*	*p*	Interpretation
TC	0.76	<0.001	Strong
ME	0.71	<0.001	Strong
IA	0.64	<0.001	Moderate-strong
FR	0.58	<0.001	Moderate
PQ	0.53	<0.01	Moderate
MR	0.47	<0.01	Moderate
LC	0.38	<0.05	Weak-moderate
OA	0.29	<0.05	Weak

Source: calculated by the author based on empirical data (n = 156)

Technological capabilities included the availability of state-of-the-art equipment, the use of advanced manufacturing technologies, the digitalisation of business processes, and the ability to adapt technologies to the specific requirements of international partners. International management experience covered previous cooperation with foreign companies, knowledge of international quality standards (ISO 9001, ISO 14001), knowledge of foreign languages by top management, and understanding of the specifics of doing business in foreign markets. The results showed that enterprises where at least 30% of top management had international experience showed a 45% higher probability of successful integration compared to companies without such experience.

Financial resources showed a moderate correlation ($r = 0.58$, $p < 0.001$), indicating that access to capital was a necessary but insufficient condition for integration. Innovation activity showed a correlation of $r = 0.64$ ($p < 0.001$), which highlighted the importance of continuous improvement of products and processes to maintain positions in GVC. Product quality ($r = 0.53$, $p < 0.01$) and market reputation ($r = 0.47$, $p < 0.01$) were less critical factors in the sample dominated by B2B segment companies. Logistics capabilities ($r = 0.38$, $p < 0.05$) and organisational adaptability ($r = 0.29$, $p < 0.05$) showed relatively weak but statistically significant correlations, which indicated their auxiliary role in the integration process.

Multiple regression analysis ($R^2 = 0.74$, $F = 42.3$, $p < 0.001$) confirmed that a combination of eight factors explains 74% of the variation in the level of integration with GVC, which indicates the reliability of the developed model and its high predictive power. The developed IPI helped to classify enterprises into four categories with clear characteristics and recommendations for each group. Validation of the IPI in the test sub-sample (20% of the sample, n = 31) showed a high correlation with the actual participation of enterprises in international value chains ($r = 0.83$, $p < 0.001$), which confirmed the practical significance of the proposed index for the diagnosis of integration readiness. Sectoral analysis revealed significant differences in integration readiness between the three sectors of the economy studied. The main results of the sectoral analysis are shown in Table 2.

Table 2. Sectoral analysis of integration readiness of Ukrainian enterprises

Indicator	IT sector	Agro-industrial complex	Mechanical engineering
Average IPI	0.72	0.58	0.49
Number of enterprises	62 (39.7%)	54 (34.6%)	40 (25.6%)
TC	High	Low	Low
ME	High	Average	Low
Recommended strategy	Technological upgrade	Qualitative differentiation	Niche specialisation
IPI dynamics (2022-2025)	0.68 → 0.72 ↑	Heterogeneous	0.52 → 0.49 ↓

Source: calculated by the author based on empirical data (n = 156)

The IT sector showed the highest average IPI (0.72), which is explained by high technological capabilities, significant international management experience and low barriers to remote cooperation. The geography of IT services exports included the United States (42%), Western Europe (38%), Israel (12%), and other regions (8%). The level of English proficiency among specialists exceeded 85%, and most companies used Agile and DevOps methodologies. For the IT sector, the strategy of "technological upgrade" was recommended, which provided for the transition from outsourcing simple services to developing complex products and platform solutions. A critical factor in implementing this strategy is investing in R&D at the level of 15-20% of revenue and developing long-term partnerships with global technology companies.

The agro-industrial complex showed an average IPI of 0.58, with high product quality indicators, but limited technological capabilities and innovative activity. The main problem was that Ukrainian enterprises mainly exported raw materials and minimally processed products, receiving only 15-20% of the final cost of the product in the chain. For the agro-industrial complex, a strategy of "qualitative differentiation" was proposed, which was based on the development of organic production, certification according to European Food Safety Standards, investment in processing infrastructure and logistics modernisation.

Mechanical engineering was characterised by the lowest average IPI (0.49), reflecting outdated technologies (the average age of equipment is more than 20 years), insufficient international experience, and limited financial resources for modernisation. For mechanical engineering, a strategy of "niche specialisation" was proposed, which provided for focusing on specific components or processes where Ukrainian enterprises had unique technological competencies or access to resources. The implementation of this strategy required technological modernisation with an investment of 3-7% of revenue over 5 years, professional development of the workforce and the involvement of foreign consultants for knowledge transfer. Cluster analysis allowed identifying three types of enterprises by the level of integration readiness. The characteristics of each group are shown in Table 3.

Table 3. Characteristics of enterprise clusters by level of integration readiness

Indicator	Integration leaders	Potential integrators	Pre-integration processes
Sample share	18%	43%	39%
Average IPI	0.82	0.61	0.38
ME	6.5 years	2.3 years	0.4 years
International certification	92%	41%	12%
Internal market orientation	28%	56%	92%
Investing in training	3-5% PF	1-2% PF	<0.5% PF

Note: PF – payroll fund
Source: calculated by the author based on Cluster analysis (n = 156)

"Integration leaders" (18% of the sample, average IPI 0.82) – companies with high integration potential that have already actively participated in international value chains. These enterprises had formalised procedures for cooperation with foreign partners, ISO quality management systems, international certifications, and used PMI/PRINCE2

project management methodologies. The top management of integration leaders had considerable international experience (an average of 6.5 years per manager), and the companies themselves actively invested in staff development, allocating 3-5% of the salary fund for training.

The group of "potential integrators" (43% of the sample, average IPI 0.61) was characterised by the presence of basic technological capabilities and some experience in international cooperation, but faced barriers to deepening integration. The most common obstacles for this group were: insufficient understanding of the requirements of international quality standards (74% of respondents), weak marketing competencies (62%), inflexibility of the organisational structure (55%), and limited financial resources for certification and modernisation (68%). Overcoming these barriers required targeted investment in the development of competencies and institutional support from the state and industry associations. "Pre-integration companies" (39% of the sample, average IPI 0.38) needed fundamental transformations before joining the GVC. The majority of enterprises in this group were focused exclusively on the domestic market (92%), had no experience of international cooperation (87%), and used outdated technologies (78% did not have international certification). For this group, the first stage of integration should focus on basic modernisation: updating the technological base, teaching management the basics of international business, and gradually entering foreign markets through intermediaries or trade missions. A comparative analysis of international models of integration into GVC revealed four distinctive patterns, each of which was characterised by specific institutional mechanisms and strategic priorities. The main results of the comparative analysis are shown in Table 4.

Table 4. Comparative analysis of international models of integration into GVC

Characteristics	China	Germany	Poland	Vietnam
Key mechanism	State planning, SEZ	Technological excellence, Mittelstand	Geographical proximity, EU membership	Attracting FDI, export zones
Main sectors	Electronics, Mechanical Engineering	Cars, chemicals, equipment	Cars, electronics, BPO	Textiles, electronics, shoes
Role of the state	Dominant	Supporting	Institutional	Liberalising
Investment in R&D, % of GDP	2.4	3.1	1.4	0.5
Relevance for Ukraine	Limited	IT, mechanical engineering	High	Average

Note: SEZ – special economic zone, FDI – foreign direct investment, BPO – business process outsourcing
Source: compiled by the author based on P.A. Hall & D. Soskice (2001), O. Cattaneo *et al.* (2010), D. Taglioni & D. Winkler (2016), G. Gereffi (2018), P. Pavlínek (2020)

The Chinese model demonstrated the key role of government planning and large-scale investment in industrial infrastructure. The creation of special economic zones, targeted support for strategic sectors and large-scale technological transfer through attracting foreign investment have become the basis of the Chinese strategy for integration into the GVC. However, the Chinese model has limited applicability for Ukraine due to differences in the scale of the economy and political systems. The German model was based on technological excellence and long-term relationships in supply chains, which is consistent with the concept of a coordinated market economy (Hall & Soskice, 2001). The Mittelstand system (small and medium-sized enterprises), the dual education system, and the focus on Industry 4.0 created an institutional environment that promoted deep integration of enterprises into European and global value chains. The experience of supporting innovative SMEs and developing technical education is relevant for Ukraine.

The Polish model illustrated the importance of geographical proximity to developed markets and institutional integration through EU membership. Similar to the conclusions of P. Pavlínek (2020) for Central Europe, after joining the EU in 2004, Poland has rapidly integrated into European production networks, especially in the automotive, electronics, and food sectors. This experience is most relevant for Ukraine, given its geographical proximity and common historical context. The Vietnamese model showed the possibilities of rapid integration through attracting foreign direct investment and creating export zones. Participation in trade agreements (CPTPP, EVFTA) has significantly accelerated the integration of Vietnamese businesses into global chains, especially in the electronics and textile industries. For the Ukrainian context, the most relevant elements were the Polish model (focusing on European value chains, using geographical proximity, institutional harmonisation with the EU), and the Vietnamese model (attracting FDI for technological transfer, creating specialised industrial zones). Comparative analysis also revealed the critical role of the institutional environment in shaping successful integration models (Acemoglu & Robinson, 2019). R. Juhász *et al.* (2024) emphasised that new industrial policies should combine market incentives with targeted support for strategic sectors.

Analysis of the dynamics of integration capacity of enterprises during the study period (2022-2025) revealed several important trends related to martial law. The IT sector showed a steady increase in integration readiness (an increase in the average IPI from 0.68 to 0.72). Many

IT companies were able to quickly adapt to new conditions, refocusing on completely remote work and diversifying the geography of customers (the share of the United States increased from 38% to 42%, new markets appeared in Australia and Latin America). The agro-industrial sector showed heterogeneous dynamics: enterprises of the western regions actively increased exports to the EU (an increase of 35% in 2022-2023), taking advantage of new opportunities created by the abolition of duties on Ukrainian products, while companies of the southern and eastern regions faced significant difficulties due to military operations and logistics restrictions. Mechanical engineering was going through the most difficult period (the decline in the average IPI from 0.52 to 0.49), but some enterprises that reoriented themselves to the production of defence products showed improvements in financial and technological indicators.

A study of the dynamics of integration processes by individual clusters showed that the "integration leaders" showed the highest resistance to external shocks: their average IPI decreased by only 3% in the first months of a full-scale invasion and fully recovered within a year. "Potential integrators" suffered large losses (-12% of the IPI), with the recovery occurring unevenly depending on the sector and region. "Pre-integration companies" were the most vulnerable: 23% of enterprises in this group completely stopped or significantly reduced their activities. These results were consistent with the findings of K. Lee & F. Malerba (2017) that crisis periods create "windows of opportunity" for some businesses and threaten the existence of others.

The role of public policy in promoting the integration of Ukrainian enterprises into the GVC is critical (OECD, 2021). The results of the study indicated the need for an integrated approach that combines tools for financial support, infrastructure development, and institutional reforms. In particular, it is considered appropriate to create a specialised export support fund (capitalisation of USD 500 million), support of industry clusters based on the Triple Helix model (association of enterprises, research institutions, and educational institutions), harmonisation of technical regulations with European directives (currently only 65% of the regulatory base is harmonised), and development of transport and logistics infrastructure (Taglioni & Winkler, 2016; Bonadio *et al*., 2021).

Digitalisation proved to be a key factor in increasing the competitiveness of Ukrainian enterprises in GVC: companies with a higher level of digital maturity showed 35% better integration results. The educational policy should be consistent with the needs of integration into GVC: 68% of enterprises experienced a shortage of managers with international experience, 54% – specialists with knowledge of foreign languages at the C1-C2 level. It is recommended to develop training programmes for international business managers at leading universities, internships for students at European enterprises (200-300 people, 3-6 months), twinning programmes, and technical assistance from the EU.

Comparison of the results obtained with international studies showed both general and specific patterns for Ukraine. Similar to the conclusions of J. Humphrey & H. Schmitz (2002), the study confirmed the critical role of technological capabilities for successful GVC upgrades. In contrast to the research by P. Pavlínek (2020) in relation to Central Europe, where large multinational corporations played a key role, medium-sized technology-oriented enterprises (50-500 employees) showed greater potential in the Ukrainian context, which could flexibly adapt to the requirements of international partners. The results are also consistent with the findings of UNCTAD (2020) on the growing role of digital technologies in shaping new models of GVC participation. A.M. Fernandes *et al*. (2022) identified key determinants of GVC participation at the firm level, highlighting the importance of institutional quality, access to finance, and human capital, as confirmed by the results of this study.

An important conclusion of the study was the identification of the "paradox of institutional inefficiency". Despite the formal introduction of market institutions, real institutional support for integration into GVC remained insufficient due to the practice of institutional mimicry, when formal institutions were created without filling them with real content and implementation mechanisms (Acemoglu & Robinson, 2019). Overcoming this paradox requires not only legislative changes, but also a transformation of the management culture and strengthening control and reporting mechanisms.

CONCLUSIONS

The study developed a comprehensive management framework for assessing and ensuring the integration of Ukrainian enterprises into global value chains, based on a comparative analysis of international models and an empirical study of 156 Ukrainian companies from three key sectors of the economy. The key result was the identification of technological capabilities and managerial international experience as the dominant factors of integration success, explaining the 74% variation in the level of enterprise participation in international value chains. The developed index of integration prospects provides management with a practical tool for systematic self-assessment of readiness to join the GVC and priority areas of development. Cluster analysis allowed identifying three typological groups of enterprises: "integration leaders" (18%), "potential integrators" (43%) and "pre-integration companies" (39%). Differentiated approaches to the development of integration capacity are proposed for these groups.

Sector-specific strategies for IT, agriculture, and mechanical engineering are summarised in a short form: technological upgrade, qualitative differentiation, and niche positioning, respectively. A comparative analysis of international models revealed that the most relevant for Ukraine is the combination of elements of the Polish experience of European integration and the Vietnamese strategy for attracting foreign direct investment, adapted to the specifics of the Ukrainian institutional environment and geopolitical situation. The results of the study also revealed

the "paradox of institutional inefficiency", overcoming which is a necessary prerequisite for successful integration. The practical significance of the study lies in the creation of evidence-based tools for management decisions on integration into GVC at the level of individual enterprises, industry associations, and public authorities. The IPI index can be used as a diagnostic and benchmarking tool, and to monitor the progress of integration efforts.

At the level of state policy, the results of the study substantiate the need to create a specialised export support fund, develop the Triple Helix cluster model, harmonise technical regulations with European directives, modernise the transport and logistics infrastructure, and reform the training system for international business. Prospects for further research include a longitudinal analysis of the dynamics of integration capacity of Ukrainian enterprises for 5-7 years, a study of the impact of artificial intelligence and automation on the transformation of models of participation in GVC, an analysis of the effectiveness of various tools of state support for integration processes, and a comparative study of the integration experience of Ukraine with other countries-candidates for EU membership (Moldova, Georgia, Serbia, Montenegro). A separate study requires the impact of digitalisation and the development of e-commerce on the models of participation of Ukrainian enterprises in global value chains.

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CONFLICT OF INTEREST

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Інтеграція до глобальних ланцюгів вартості: управлінська рамка для українських підприємств

Анотація. Інтеграція українських підприємств до глобальних ланцюгів вартості є критичним фактором економічного розвитку в умовах посилення глобалізації та необхідності відновлення післявоєнних втрат, понесених внаслідок повномасштабного вторгнення росії на територію України на початку 2022 року. Метою дослідження було розроблення комплексної управлінської рамки для оцінки та забезпечення успішної інтеграції українських підприємств до глобальних ланцюгів вартості на основі порівняльного аналізу міжнародних моделей та емпіричних даних. Дослідження базувалося на порівняльному аналізі чотирьох провідних моделей інтеграції до глобальних ланцюгів вартості (китайської, німецької, польської та в'єтнамської), аналізі 156 українських підприємств різних секторів, застосуванні методів кореляційного та регресійного аналізу, математичного моделювання для розробки Індексу інтеграційної перспективності (IPI). Результати дослідження виявили, що технологічні можливості (r = 0,76) та управлінський міжнародний досвід (r = 0,71) є найсильнішими предикторами успішної інтеграції до глобальних ланцюгів вартості. Було розроблено нормалізовану IPI формулу (шкала 0-1), яка дозволяє кількісно оцінити готовність підприємства до інтеграції на основі восьми ключових факторів із емпірично визначеними ваговими коефіцієнтами. Множинний регресійний аналіз підтвердив, що комбінація восьми факторів пояснює 74 % варіації в рівні інтеграції до глобальних ланцюгів вартості ($R^2 = 0,74$, $F = 42,3$, $p < 0,001$). Кластерний аналіз дозволив виділити три типологічні групи підприємств за рівнем інтеграційної готовності: «інтеграційні лідери» (18 %, середній IPI 0,82), «потенційні інтегратори» (43 %, IPI 0,61) та «перед-інтеграційні компанії» (39 %, IPI 0,38). Запропоновано секторально-специфічні стратегії інтеграції для IT-сектору, агропромислового комплексу та машинобудування з урахуванням особливостей українського бізнес-середовища. Практична цінність дослідження полягає у створенні інструментарію для менеджменту підприємств щодо діагностики інтеграційної готовності та розробки цільових стратегій входження до міжнародних ланцюгів створення вартості

Ключові слова: інтеграційна стратегія; індекс інтеграційної перспективності; міжнародна конкурентоспроможність; технологічні можливості

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