ISSN 2786-5940
e-ISSN 2786-5959

Vinnytsia National Technical University

INNOVATION AND SUSTAINABILITY

Scientific Journal

Founded in 2021
Frequency: Quarterly

Volume 5, No. 1

Vinnytsia – 2025

Founder:
Vinnytsia National Technical University

Year of foundation: 2021

Recommended for printing and distribution
via the Internet by the Academic Council
Vinnytsia National Technical University
(Minutes No. 10 of March 27, 2025)

State Registration:
Media identifier R30-01505.
Decision of the National Council of Television
and Radio Broadcasting of Ukraine No. 1234,
Minutes No. 25 dated 31.10.2023

The journal is included in category "B"
of the List of scientific professional publications of Ukraine.
Specialties: 0311 Economics; 0413 Management and administration;
0414 Marketing and advertising; 0416 Wholesale and retail sales
(Order of the Ministry of Education and Science of Ukraine No. 530 dated 06.06.2022).

The journal ispresented in the following
international scientometric databases, repositories and scientific systems:
Google Scholar; Vernadsky National Library of Ukraine; Crossref; UCSB Library;
Dimensions; Worldcat; Litmaps; University of Oslo Library; University of Hull Library;
Open Ukrainian Citation Index (OUCI)

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https://inns.com.ua/en

ISSN 2786-5940
e-ISSN 2786-5959

Вінницький національний технічний університет

INNOVATION AND SUSTAINABILITY

Науковий журнал

Рік заснування: 2021
Періодичність випуску: 4 рази на рік

Том 5, № 1

Вінниця – 2025

Засновник видання:
Вінницький національний технічний університет

Рік заснування: 2021

Рекомендовано до друку та поширення
через мережу Інтернет Вченою радою
Вінницького національного технічного університету
(протокол № 10 від 27 березня 2025 р.)

Державна реєстрація:
Ідентифікатор медіа R30-01505.
Рішення Національної ради України
з питань телебачення і радіомовлення № 1234,
протокол № 25 від 31 жовтня 2023 року

Журнал входить до категорії «Б» Переліку наукових фахових видань України
Спеціальності: 051 Економіка; 073 Менеджмент; 075 Маркетинг;
076 Підприємництво, торгівля та біржова діяльність
(Наказ Міністерства освіти і науки України № 530 від 06 червня 2022 р.).

Журнал представлено в таких міжнародних
наукометричних базах даних, репозитаріях та пошукових системах:
Google Академія; Національна бібліотека України імені В.І. Вернадського; Crossref;
UCSB Library; Dimensions; Worldcat; Litmaps; University of Oslo Library;
University of Hull Library; Open Ukrainian Citation Index (OUCI)

Адреса редакції:
Вінницький національний технічний університет
21021, вул. Хмельницьке шосе, 95, м. Вінниця, Україна
E-mail: info@inns.com.ua
https://inns.com.ua/uk

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INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 11.11.2024; Revised: 19.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.08

UDC 332.1; 338.2; 339.13

Reserves for enhancing the effectiveness of neuromarketing research into consumer behaviour in brand development by enterprises

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Abstract. Improving the effectiveness of innovations in consumer behaviour research, including the scientific exploration of new phenomena influencing buyer choices through marketing stimuli based on objective data from neurobiological experiments, is gaining considerable importance – particularly in digital environments and with the use of artific al intelligence technologies. Th s article aimed to provide a critical analysis of the methodological foundations and potential applications of neurobiological tools in the practical marketing activities of food industry enterprises. Based on this analysis, the article offered proposals for improving neuromarketing research projects and enhancing their effectiveness. The study presented the results of integrated marketing research combining physiological process measurements with consumers' self-assessed decision-making data during product selection tasks. These tasks were designed to assess consumer perception and the commercial potential of alternative packaging design concepts for a specific tea brand. An eye-tracking system was employed, with objectively recorded patterns compared against the results of a participant survey evaluating the packaging design concepts. The generalised fi dings indicated that categorical differences enabling effective differentiation of the unique value propositions of a brand – or, in their absence, price – were more influential in purchasing decisions than packaging design or informational content. The study identifi d opportunities for cost reduction and added value in the outcomes of neurobiological experiments by anticipating traditional pre-testing of hypotheses and draft materials, thereby improving research design and marketing decisions aimed at consumers. Promising directions for future research were identifi d and proposed, aimed at refini g the methodology and design of neurobiological experiments in marketing. It is hoped that the study's results will support both researchers and practitioners in identifying and realising reserves for enhancing marketing effectiveness, brand development, and business growth

Keywords: marketing; consumers; purchasing goods; brands; packaging; experiments

Suggest Citation:
Shafalyuk, O., Tashchenko, A., & Shafalyuk, O. (2025). Reserves for enhancing the effectiveness of neuromarketing research into consumer behaviour in brand development by enterprises. *Innovation and Sustainability*, 5(1), 8-17. doi: 10.63341/vis/1.2025.08.

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Introduction

The value of neurobiological research is increasingly recognised globally, with commissioning budgets consistently rising and the findings becoming a significant component in the development of companies' marketing strategies. The methodological basis of neuromarketing and related innovative concepts and practices, along with the correctness of its application in the design and interpretation of experimental results, requires additional attention and scholarly examination. The formation of scientifically unfounded expectations among clients by specialists regarding the potential for objective explanations and predictions of irrational consumer behaviour driven by emotions, memories, etc., as well as breaches of scientific and professional ethics, contradict the requirements of marketing and business effectiveness and social responsibility. These issues impede progress and diminish the effectiveness of applied neurophysiological research in marketing.

Research data from G. Ahluwalia *et al.* (2024) demonstrated the dependence of consumer rationality levels on subjective information processing characteristics, the influence of marketing stimuli, and so forth, particularly in the era of Marketing 6.0. Studies by T.Y. Copaja Arocutipa *et al.* (2025) revealed significant shifts in buyer preferences under the influence of brand names and product pricing parameters, confirming the results of numerous other experiments. The conclusions of J.L.P. López & C.R. Monroy (2023) argued that only neuromarketing-related brain activity studies possess the potential for objective explanation and scientific examination of the "hidden psychological traps" inherent in consumer decision-making and product selection processes. P. Mikalef *et al.* (2023) underscored that information crucial for specialists regarding consumer purchasing decisions, traditionally acquired through questionnaires and similar formats of marketing research, needs to be more effectively supplemented with objective physiological data, including through tracking buyers' gaze during product selection. Their research, based on advancements in theories of dynamic attention (forecasting algorithms utilising ensemble machine learning models) and examining the priority and influence of elements of product offerings in consumer choice from available alternatives, provided valuable insights into critically significant information signals that are not subjectively consciously perceived or are ignored by buyers during surveys. It was argued that the study of physiological data, particularly saccades and other eye movement patterns, can aid in determining the attractiveness of goods to consumers and the effectiveness of buyer interactions with various elements and formats of perceived information. Furthermore, it can help understand the patterns and assess the dynamics of changes in these characteristics of purchasing decision-making over time. However, the accurate interpretation and prediction of cognitive process parameters in decision-making solely based on eye movements and pupil characteristics in the perception of visual and other stimuli remain problematic and require additional scientific validation.

Among the results of research by scholars on neuromarketing issues relevant to the subject area of this article, the conclusions of A.A. Mansor & S. Mohd Isa (2020) are noteworthy within the discourse contrasting traditional and contemporary marketing research methods and technologies. They demonstrated the expediency of a systematic re-evaluation of the prerequisites for applying and the effectiveness of both classic and innovative marketing methods, taking into account the enhancing and unique ideas of the latter. The research by J.M. Penrod (2023) on the development of cognitive neuroscience technologies and psychological theories of human decision-making since the latter half of the 20th century also highlighted the priority of convergence as a trend and explanatory basis for the current progress in neuromarketing. F.R. Mashrur *et al.* (2022) viewed neuromarketing as a domain of innovative synergy between cognitive neuroscience tools and marketing, which is significantly influenced by the advancement of artificial intelligence technologies. This includes the identification of new phenomenology in consumer perception of stimuli and decision-making, necessitating further research and deep scientific understanding. Based on the conclusions of L. Alvino *et al.* (2020), who identified seven neurobiology tools for studying consumer behaviour to enhance the effectiveness of advertising, branding, customer experience, pricing, product development, etc., the integrated use of iMotions and GRAIL platforms for experiment results is advisable. Consolidating and systematising researchers' recorded brain activity and other physiological responses on a common platform will reduce time and costs for experimenters and facilitate the identification of important interconnections between cognitive and emotional reactions and neurophysiological processes.

The findings of P.B. Puprediwar & T. Tapas (2024) demonstrated that for the effective development of neuromarketing and to enhance its significance for businesses, it is essential to address current issues concerning ethics and the high cost of experiments, limitations in participant sample size, and the reliance on laboratory settings. Furthermore, it is necessary to form effective combinations with traditional research methods to augment the explanatory potential of accumulated data. R. Hadi *et al.* (2023) explored the prospects of marketing research and the changing landscape of socio-economic interactions and consumer behaviour with the progression of the Metaverse, highlighting aspects of responsibility for academics and practitioners that are traditionally relevant to the domain of experiments involving human biology and consciousness, and neuromarketing. S. Hemker *et al.* (2021) emphasised in their conclusions the necessity of fully ensuring ethical standards in marketing research and consumer data confidentiality, given the increasing scale of offering customisation and interaction personalisation in marketing. The demand for corporate social responsibility is growing, becoming a guarantor of consumer trust and loyalty, and consequently, the long-term effectiveness of companies. Y.P. Mada (2024)

underscored the importance of balancing the advantages, disadvantages, and limitations of neuromarketing, particularly concerning the prevention of consumer manipulation, which is as critical as issues of research ethics and ensuring the protection of confide tial consumer information. Research by S. Chatterjee *et al.* (2023) demonstrated that neuromarketing holds signifi ant potential for enhancing customer loyalty and improving other marketing outcomes for fi ms, thereby increasing their business value. Increasing the effectiveness and popularisation of neuroscience experiments in marketing will secure the necessary support from business leaders for further progress.

Identifying promising opportunities for methodological improvement and addressing current challenges and solutions to enhance the effectiveness of neuromarketing experiments within companies' brand management systems requires additional research. The article aimed to explore the possibilities of increasing the effectiveness of neuromarketing research in brand promotion and development through in-depth pre-testing and marketing audits of experimentation projects, including reducing ethical confli ts related to influencing participants' physiology.

Materials and Methods

Consumer testing of new packaging design concepts for various tea products of a specific brand was conducted at the request of retail companies interested in enhancing the competitiveness and effectiveness of their private label offerings. Th s involved employing neuromarketing research methods and simulating a retail shelf environment. The research utilised integrated Varjo headsets and software, which allowed for the demonstration of the retail environment to experiment participants with high resolution (approximately 35 pixels per degree of visual angle / 4K rendering per eye) and a high level of immersion, as well as providing accurate eye-tracking data.

The authors, specialists with relevant training and experience in academic and practical work, and members of the Ukrainian Marketing Association, were involved in the preparation and execution of the research project. The ICC/ESOMAR International Code on Market, Opinion and Social Research and Data Analytics (2016) was adhered to throughout the research process. Adherence to this code guarantees that respondents will not be harmed in any way during their participation in the research procedures. The specialists were briefed on the marketing information provided by the retail chains interested in the experimental data. All procedures stipulated by the project were conducted on the premises of the Marketing Institute at Kyiv National Economic University named after Vadym Hetman and the Agency of Industrial Marketing.

Men and women aged 30-60, with average and below-average incomes, who were regular consumers of inexpensive classic tea, were recruited to participate in the testing. The sample size and design stipulated the involvement of 300 participants in the testing and interviews, with 150 participants testing each of the two lines of packaging concept designs, each consisting of 3 product varieties. After participants were familiarised with the product display in the category, they were asked questions evaluating their purchasing experience, specifi ally the following:

Q15. Which tea brands did you notice on the shelf?

Q17. Which variants of the Svoia Liniia brand tea do you recall seeing on the shelf?

Q21. Which type of tea from the shelf did you feel inclined to purchase?

Q25. Please rate the packaging design of the Svoia Liniia tea variants using a 5-Wpoint scale according to the following criteria:

- Overall appeal;
- Ease of fi ding the necessary information;
- Uniqueness;
- Likelihood of purchase.

Q27. To what extent do you agree with the following statements about the Svoia Liniia tea variants? Please respond using a 5-point scale:

- Classic;
- A confide t choice;
- High-quality tea;
- A brand I trust for its quality;
- Good value for money;
- Suitable for family tea time;
- Ideal for everyday and any occasion.

To mitigate potential bias and inaccuracy in consumer responses, and to facilitate better interpretation and analytical processing of the research results, subjective evaluations were compared with biosensor data. Th s approach reduced the extent to which the quality of retrospectively obtained information from participants' responses was dependent on their memory, perception of questions, and the precision of their verbal formulations.

Tracking eye movements while participants examined the product display on the shelf provided objective data regarding consumers' purchasing experience for subsequent quantitative analysis in conjunction with the results of interviews with the neuromarketing experiment participants. The sequence and duration of viewing the product arrangement on the shelf, both overall and for specifi items and areas of focus, were taken into account. The use of other biosensors in the testing was not planned, as there is a lack of objective evidence supporting the validity of conclusions drawn from electroencephalography data regarding participants' levels of motivation, engagement, cognitive processing, and other characteristics important for evaluating product displays in marketing experiments. Specialists trust in such conclusions, and the demand for them is low. The duration of focus and level of attention on a particular product variant, design concept, or packaging element can be attributed to their importance or attractiveness in consumer choice, as well as the difficulty or complexity of their perception, among other factors. The visibility of different Design Concept variants of the brand's products on the shelf was assessed based on consumers' spontaneous and prompted recall. Purchase intent was gauged by consumers'

stated desire to buy specific product offerings from the shelf, both without and with price display, respectively.

Detailed evaluation of the designs involved consumers articulating the strengths and weaknesses they identifi d in specific packaging variants, as well as the elements and concepts overall that appealed to the testing participants. Consumers elaborated on their evaluations using criteria such as the difficulty or ease of fi ding necessary information on the packaging, the perceived price-quality ratio, the uniqueness of its appearance and design solutions, confidence in their choice, and the likelihood of purchasing the products. Brand image characteristics, based on the subjective perception of the different Design Concept variants of the brand's products on the shelf, were evaluated using criteria related to consumers' perceived trust in the brand's quality, the suitability of the specific brand of tea for family tea time, and everyday consumption and any situation. Based on the neuromarketing experiments, the methodology was reviewed, and the stages and elements of the research project that could be improved to enhance the effectiveness of execution, the accuracy of evaluations, and the quality of conclusions were identifi d.

Results and Discussion

With the evolution of consumer choice and the increase in its variability, alongside the simplifi ation of subjectively acceptable purchasing behaviour algorithms, the proportion and signifi ance of impulse and rapid routine purchases are increasing. Approximately half of the products displayed on shelves remain unnoticed by consumers, and the average time it takes for food items to be placed in a retail shopper's basket is 20 seconds (Blyznyuk, 2023). Factors related to product packaging design account for around 70% of all impulse purchases and determine the effectiveness of marketing communications with target audiences throughout the cycle of product selection, purchase, and use (Product packaging testing…, n.d.). Neuromarketing research simulating purchasing situations and using biosensors to record consumer states during purchase decision-making signifi antly reduces the risks of decreased effectiveness in brand development and companies' marketing activities.

The results of the conducted neuromarketing research into Ukrainian consumers' perception of different tea packaging designs (Fig. 1) using iMotions and GRAIL platforms showed that when brand differentiation based on product quality and characteristics is limited, design gains influence in the perception and price expectations regarding companies' offerings to target audiences in the market.

Figure 1. Tea packaging design concepts tested
Source: compiled by the authors

The testing results revealed that consumers did not differentiate between various product varieties within the brand's offerings and did not perceive or understand their intended uniqueness and value (Fig. 2). Similarly, the brand umbrella effect did not materialise, as the study found a signifi ant difference in the parameters of product perception under the influence of price.

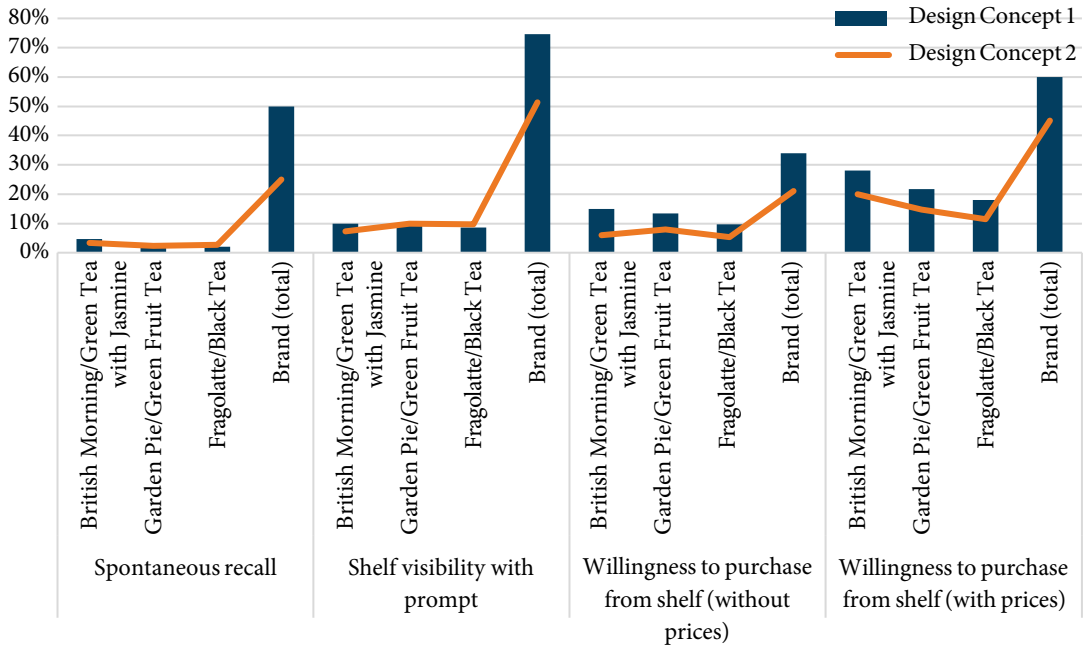

Figure 2. Parameters of perception of packaging design concepts on the shelf
Source: developed by the authors

Preliminary identifi ation of consumer perception/attitude parameters towards the brand, which preceded the detailed testing of design concepts, showed that only about 34% of participants considered purchasing the brand's products under variant 1, and 21% for variant 2. After the experiment, participants viewed the shelves with prices, 60% of them (in the respective group) expressed a desire to buy products of Design Concept 1 and 45% for Design Concept 2.

In the researchers' conclusions, a higher correlation between price and the brand value demonstrated by packaging design is noted. Although experiments by S. Kaheh *et al.* (2021), which investigated the influence of price factors on choice between competing product offerings, including well-known brands, also showed that buyers often preferred to purchase a lower-priced product for a similar item, even if the participant had previously favoured a well-known brand option. Th s is further supported by the results of testing Design Concepts 1 and 2, which did not reveal opportunities for implementing premium pricing effects for the brand. The relationship between spontaneous brand recall and the desire to purchase products from its line at the proposed prices was also observed and is indicative here. A scenario contrary to that anticipated for branded goods is evident in tea selection – an emphasis on the option with an attractive price, with the fi al purchase decision being made based on the acceptability (absence of objections, rejection, negative experience) of certain brands or characteristics of a specific product variety. Price itself is not directly a value for consumers, and the excessively applied dumping pricing in Ukraine contrasts with the development of effective long-term relationships with consumers based on strengthening their perceived uniqueness of brand offerings and increasing target audience loyalty.

The fi dings presented in this article corroborate the conclusions of D. Jukić (2023), which suggest that brand success is dependent on both the perceived value of products by consumers and the specific characteristics of well-known brand identifi ation. Consumer loyalty to brands is signifi antly influenced by their emotional engagement during the process of selecting purchasing options, as well as the preservation and accurate communication of the identity of a well-known brand to target audiences. However, emotions cannot be reduced to mere knowledge or simple sensory perception of brand elements; they are linked to certain subjectively imagined and more complex images associated with them. It is advisable and recommended for companies to utilise the potential of neuromarketing research to identify and constructively address elements of these images in enhancing branding effectiveness. Supporting the efficacy of these recommendations and providing specific ty to the methodological emphases of experimentation projects are the conclusions of Z. Xu *et al.* (2023). Their research aimed to explain the discrepancies between the results of physiological response measurements and surveys (regarding self-assessment of product selection processes) among experiment participants, as well as the phenomenon of consumers favouring brands whose individuality does not align with their personal characteristics. Their research highlighted the necessity for continued research based on the neuroscience concepts of "emotion/feeling" and testing the relevance of the "similarity-attraction" hypothesis when building brand concepts and defi ing target marketing audiences.

The conclusions of the study by C. Paladino *et al.* (2024) proved useful in shaping the design of the marketing experiments and tests presented in this article. Their study indicated that even valuable and promising neuromarketing research fi dings can have limited practical application in brand management due to methodological issues in conducting experiments and challenges in the accurate and universal interpretation of conclusions. A signifi ant contributing factor is the frequent use of reverse inference by researchers, which distorts the interpretation of neuroimaging results and other data.

Design Concept 1 was more noticeable and stood out to consumers during their review of the shelf. The identifi ation of eye movement trajectories and fix tion points using the iMotions and GRAIL platforms supports the validity of this assertion. According to self-report data, 50% of experiment participants spontaneously recalled the brand with Design Concept 1 on the category shelf display, whereas only 25% of shoppers spontaneously noticed Design Concept 2. In total, 75% of participants unequivocally noticed the brand's products on the shelf, while only 51% of consumers noticed Design Concept 2, which signifi antly reduces its potential for impulse purchase (Fig. 2). On the one hand, the aforementioned results of this study collectively support the conclusions of A.S. Koyluoglu (2024) regarding the "eyes-mind" hypothesis, including concerning changes in consumer perception characteristics in the world that are difficult to assess and predict without the application of combined marketing research and analytical tools. On the other hand, and similarly, they necessitate acknowledging the problems concerning the relevance of conclusions about consumer thoughts and attention based on statistical and graphical analysis of visual patterns and eye movement sequences or other physiological characteristics of research participants.

The authors concur with the conclusions of V. Thakur & A. Shaikh (2024), who asserted that all key tools for fi ding and justifying solutions in modern marketing (such as neural networks, fuzzy logic, and genetic algorithms) are associated with processing large and complex datasets. These datasets integrate subtle consumer preferences in the continuous optimisation of marketing strategies within iterative cycles of systemic feedback. In this context, the conclusions of P. Mikalef *et al.* (2023) are entirely pertinent to this experimentation project and others, indicating that despite the growth in data from scientific and marketing research, specialists still possess limited awareness regarding the influence of various types and formats of information/signals on the buyer's decision-making process during product selection. The understanding of which information

signals are most crucial at different stages of consumer decision-making remains limited, hindering accurate and effective predictive generalisations and evaluations. Researchers often rely on specific aspects of choice and machine learning algorithms that can provide the necessary accuracy for experimental success (such as sensory perception and the structuring of product packaging elements, display layouts, etc.). It is acknowledged and taken into account, including in recommendations to companies, that the results of such studies, with limitations, can be used to optimise parameters of marketing interaction with consumers and gain a better understanding of their choices and experiences. In research projects, businesses and specialised agencies are advised to avoid simply testing declarative hypotheses that are not in doubt. R.N. Khushaba *et al.* (2013) did not consider expensive projects monitoring the physiological processes accompanying consumer product choice, using commercial EEG devices and eye-tracking systems, to be effective, as their results indicate the importance of cracker taste and filling compared to their shape.

Similarly, the results of the research presented in this article were not limited to merely reconfi ming already known and proven patterns in the organisation of marketing stimulus perception and product choice decision-making. The projects and conclusions of neurobiological experiments with the noted limitations in effectiveness were critically evaluated. In virtual reality retail store shopping experiments, F. Saff ri *et al.* (2023) found, through analysis of electroencephalogram data (frontal asymmetry), a difference between planned and unplanned purchase decisions, as well as distinctions between periods of purchase consideration and periods without decision-making. Predictably and quite naturally, but using near-infrared functional spectroscopy devices with a brain-computer interface, S. Bak *et al.* (2022) detected a higher level of impulse purchasing of goods in online duty-free stores during consumers' international trips compared to regular online stores.

Indicative of the limitations in effectiveness, which companies and specialised agencies are advised to avoid, are the studies by D. Mendoza Ocasal *et al.* (2025). These focused on examining the fragmented and comprehensive influence of branding elements on purchase decision-making. The researchers found an increase in the strength of influence on brain activity and consumer choice with the transition from presenting experiment participants with brand images to photographs of well-known brands featuring a broader representation of their brand concept elements, as well as promotional videos. It is well-known that images "work" better in the human consciousness than text, and video is more effective than images (Spytska, 2024). Researchers need to consider the individual experience of experiment participants (e.g., a pet dog, being bitten by a dog in childhood, a dog as an allergen – brain activity will differ signifi antly when shown the same image, including among others intended to evoke related associations), consumption situations, and the specifics and positioning of brands (both subjectively and typically). Synchronised interaction, rather than the fragmented operation of brain "areas", as well as the influential uniqueness of personal experience and the emotional colouring of the associations formed by experiment participants, requires particularly careful consideration by specialists. Th s is recommended to be normatively included in neuromarketing research projects.

A preliminary audit and refi ement of the research project materials used for testing the proposed design concepts by the trading companies was not planned, but could have contributed to more effective results. The clear advantages of Concept 1 over the other could be distinctly predicted, considering well-established principles of perception. If the brand is not a determining factor in choice, as established above, then the characteristics of the specific product variant among the alternatives become signifi ant. These characteristics in Concept 1 are highlighted within a particular colour fi ld, which simplifies their identifi ation. The block of colour separating the brand name and tea characteristics creates a certain rhythm for consumers' perception of the packaging information. Bright collages demonstrating the specific flavour profiles of the tea create a cohesive background image in the upper part of the packaging. In Concept 2, the brand name is poorly identifi d. Th s is not critically important when its perception is undifferentiated, but it conceals the advantageous pricing of the private label. Signifi ant characteristics of the product variants are presented using fonts and inscription colours that are difficult to read, which disrupts their holistic perception.

Among the advantages of Design Concept 1, testing participants noted the large and expressive font, which highlights the name and characteristics of different product varieties, and the design was perceived as more modern. 37% of participants in the corresponding group spontaneously recalled and positively evaluated the presence of the "Leaf Tea" mark on the packaging of Concept 1. Consumers highlighted its presence as a favourably noticeable packaging element (compared to the "premium grade" mark on the packaging of the Design Concept 2). Conversely, its absence on some product packaging variants was noticed by consumers and noted as a drawback. For both tea packaging design concepts, experiment participants noted a lack of categorical differences for effective differentiation of the brand's product offerings (Fig. 3). Th s was evident in buyers' evaluations at the level of both product characteristics and the consumption situations for the tested brand of tea.

The integrated and critical drawback of Design Concept 2 identifi d by consumers was its unmodern/outdated, stereotypical design. The black tea packaging variant received particularly negative evaluations, being perceived as non-unique and inexpressive (Fig. 4). A necessary prerequisite for high brand value is the uniqueness of its offerings. Th s includes moving beyond stereotypical associations linked to the product category or dominant brands within it, such as "harmony with oneself and the world", "peace and tranquillity" for tea. Securing a brand's own positioning "territory" that does not confli t with the millennium-old history of tea drinking but progressively

develops it through marketing concepts and design solutions is a complex task requiring non-trivial creative approaches. Among other points, and in full agreement here, it is advisable for companies and specialised agencies to consider the results of neurobiological studies using methods such as those by A. Fici *et al.* (2024). Their article demonstrated differing levels of cognitive and emotional engagement in consumer behaviour across competing retail platforms, impacting customer experience outcomes and business effectiveness. Accordingly, investment in developing retail platforms of a specific format should be preceded by their careful design and optimisation based on research into users' cognitive and emotional responses and their customer experience.

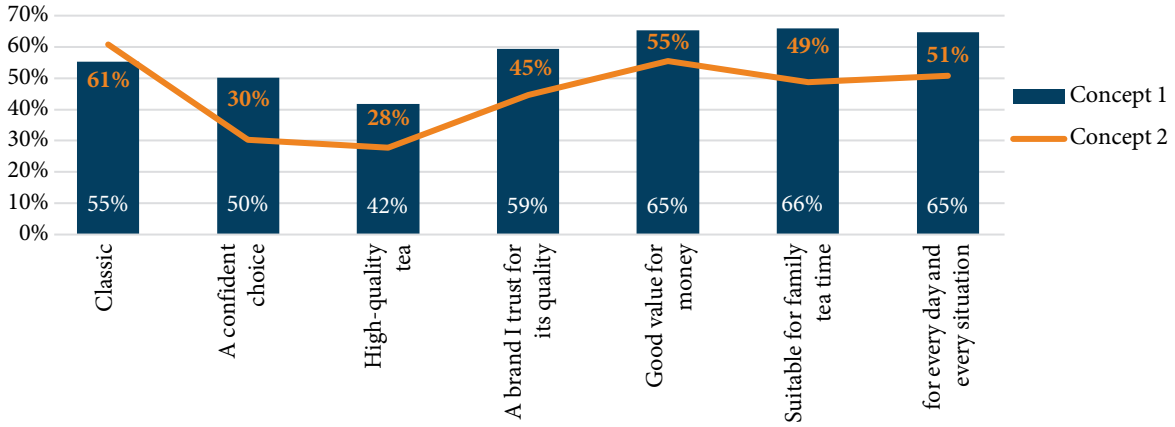

Figure 3. Brand image characteristics of tea packaging design concepts
Source: developed by the authors

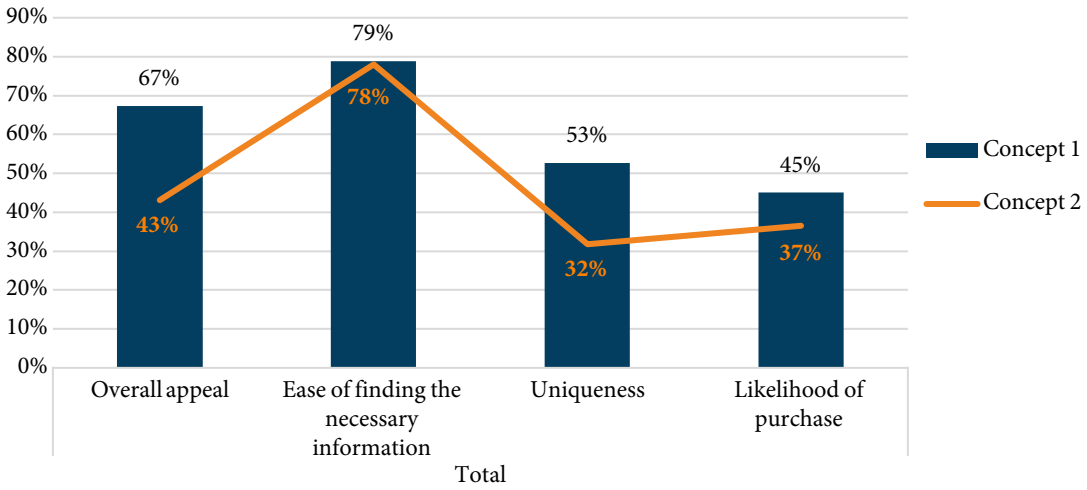

Figure 4. Evaluations of tea packaging during the purchase decision-making process
Source: developed by the authors

In applying the concept of neuromarketing, businesses and specialised research agencies unequivocally require specialists to possess a deep understanding of the patterns and characteristics of consumer perception of all positioning elements within a product category, as well as the development of its cultural codes, to achieve effective differentiation of marketing offerings. The latter allows for the innovative supplementation of stereotypical associations, for instance, by utilising the elements and harmonies of contradictions prevalent in popular Eastern philosophy and culture, including the calming or invigorating effects of tea consumption, as well as derivative traditions/rituals and local norms/images ("English breakfast" (British, aristocratic style), "warm atmosphere", "alpine freshness", healthy/ecological/organic products, etc.). In this context, the packaging's design message becomes the brand concept's calling card, forming the basis for developing characteristics crucial for the successful development and effective promotion of brands: uniqueness, positive image, recognition/awareness, and so forth. Th s study highlights important methodological issues and solutions that defi e the potential for increasing the effectiveness of neuromarketing research in brand development for companies. It also testifies to the potential for further investigation, accumulation, and systematisation of harmonised objective data regarding consumers' cognitive, emotional, and

behavioural responses. The horizons and possibilities of these studies are signifi antly expanded with the intensifi ation of the development and influence of neural networks, the digital environment, and the use of new generations of biosensors in scientific nd practical experiments.

Conclusions

The results of the study made it possible to achieve the stated aim of identifying ways to enhance the effectiveness and ethical standards of neuromarketing experiments in order to support the profitability and development of companies' marketing activities and brands. The generalisations and conclusions in the article demonstrate that utilising neurobiological methods and tools in marketing research enhances the understanding of consumers' cognitive and emotional responses during purchase decision-making processes. However, it was established that the results of neuromarketing experiments and the elements of specialised methodology require signifi ant rethinking and systematisation. The reasons for product choice and the processes of purchase decision-making are often not fully consciously perceived by consumers, being determined by a complex spectrum of sensations, socio-psychological attitudes and stereotypes, emotions, etc., the influence of which is challenging to identify and assess solely through self-reports and interviews with experiment participants. Based on a critical evaluation of available scientific fi dings, including their practical application, it was revealed that the application of neuroscience methods and tools can provide a more objective measurement of a wide range of consumer reactions when observing their purchasing behaviour. Following the identifi ation of reserves and the formulation of recommendations for businesses and specialised agencies, it is noted that neuromarketing methodology requires systemic improvements and correct implementation in research practice. Furthermore, traditional marketing knowledge can be effectively applied to account for the vectors of influence on buyer reactions stemming from situational and object-of-choice specific ties, the impact of customer experience patterns and attitudes, and so forth.

Drawing upon the experience of processing the perception of branded product offerings in food and beverage displays in scientific and practical research, this publication proposes effective approaches and case studies for integrating traditional and neurophysiological research tools, refini g specific stages of experimental work, and evaluating the correlation/signifi ance of components, including the direct parameters of choice variant perception, consumption experience, and brand concept influence factors, as well as the possibilities and challenges of their harmonisation – all of which are useful for enhancing the marketing effectiveness of businesses. The results demonstrate that the level of consumer differentiation between various product varieties within brand lines, as well as the perception/understanding of their unique value as intended by companies, can and should be effectively identifi d through pre-tests on a minimal sample, with subsequent adjustments to research projects. Th s will signifi antly increase the cost-effectiveness of neuromarketing experiments. It is shown that using iMotions technological solutions in neuromarketing research allows for strengthening their evidence base, systematising integrated measurement results from different researchers, regardless of their experimental hardware, and optimising research projects to improve their economic effici cy. Continued experiments using a new generation of hardware that allows for the recording of emotional responses and their changes, in parallel with monitoring buyers' eye movements, as well as for studying consumer behaviour patterns in the digital environment, are of interest for future research in the fi ld of food neuromarketing.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Резерви підвищення ефективності нейромаркетингових досліджень поведінки споживачів у розвитку брендів підприємствами

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Анотація. Підвищення ефективності інновацій у сфері маркетингових досліджень поведінки споживачів, наукове опрацювання нових феноменів впливу на вибір покупців маркетингових стимулів на основі об'єктивних даних нейробіологічних експериментів, а також у цифровому середовищі та з використанням технологій штучного інтелекту, набувають великої актуальності. Метою цієї статті був критичний аналіз методологічних передумов та перспектив застосування інструментів нейробіології у практичній маркетинговій діяльності підприємств харчової індустрії, а також формування на цій основі пропозицій щодо удосконалення дослідницьких проєктів нейромаркетингу, підвищення їхньої ефективності. У статті представлено результати інтегрованих маркетингових досліджень фізіологічних процесів і даних самооцінювання прийняття рішень споживачів, за виконання ними завдань вибору товарів, розроблених для оцінювання сприйняття і комерційних перспектив альтернативних варіантів дизайн-концепцій упаковки чаю конкретного бренду. Було використано систему відстежування руху зіниць очей, виявлені на основі об'єктивних даних патерни співставлялися з результатами опитування учасників тестування дизайн-концепцій упаковки. Узагальнення результатів досліджень показали, що категоріальні відмінності для ефективної диференціації цінності унікальних товарних пропонувань бренду, а за їх браку, ціни, були важливішими факторами впливу на закупівельні рішення, ніж чинники дизайну та інформативності упаковки. Встановлено можливості економії витрат та підвищення цінності результатів нейробіологічних експериментів шляхом передбачення традиційного претесту гіпотез і робочих матеріалів для удосконалення проєкту досліджень і маркетингових рішень для споживачів. Обґрунтовано і запропоновано перспективні для подальших досліджень напрямки удосконалення методології і проєктів нейробіологічних експериментів у маркетингу. Автори публікації сподіваються, що результати дослідження допоможуть науковцям і практикам у виявленні та реалізації резервів підвищення ефективності маркетингу, розвитку брендів і бізнесу

Ключові слова: маркетинг; покупці; купівля товарів; торгівельні марки; упаковка; експерименти

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 08.11.2024; Revised: 25.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.18

UDC 330.3:338:005.5

Waste management in the circular economy: Status and challenges in Ukraine

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Abstract. During the study, the goal was achieved, namely, to assess the current state of the waste management system in Ukraine and to develop recommendations for its improvement based on the principles of a circular economy. Methods of analysis and synthesis were employed to examine the problem, enabling the evaluation of the theoretical foundations of the circular economy and the principles of waste management. The method of statistical analysis was used to collect and analyse empirical data, while the modelling method was employed to predict possible scenarios for the development of waste management by 2025. The results of the study demonstrated that Ukraine's economy remains largely dependent on a linear model, characterised by the creation of products without consideration for further processing. Th s is confi med by the increase in the waste intensity of gross domestic product (GDP), which indicates the absence of signifi ant changes in the adoption of resource-effici t technologies. The stable share of recycled and incinerated waste (20%-25%) against the background of an increase in the total volume of generated waste indicates a lack of changes in waste management technologies and policies, as well as an underdeveloped recycling infrastructure. The growth in the volume of generated waste per unit of GDP demonstrates a tendency towards reduced resource effici cy in the economy, while the number of waste management infrastructure facilities has concurrently declined. The methodological approach described in the research ensures transparency of the research process, thereby allowing it to be replicated using similar methods and data sources

Keywords: circularity; closed loop; resources; reuse; waste disposal; waste management

Introduction

The relevance of this study arises from the need to analyse the current state of waste management in Ukraine within the context of a circular economy (CE), and to identify the main challenges and prospects for implementing innovative approaches. Waste management in the context of a CE is one of the key topics in modern environmental research. The CE, or closed-loop economy, involves the recovery, reuse, and rational consumption of resources, which creates additional value through new services and intelligent solutions. At the global level, the problem of waste management remains pressing. According to research, about 2.12 billion tonnes of waste are generated annually worldwide, with 99% of purchased goods being disposed of within six months. Despite the growing attention to the concept of a CE, its actual implementation has decreased: only 7.2% of the global economy is circular, which is 21% lower than five years ago (Cherry, 2024). In Ukraine, the situation regarding waste management is also a cause for concern. In 2017, the government approved the National Waste Management Strategy until 2030, which envisages the implementation of a systemic approach to waste management at the national and regional levels, reducing waste generation by increasing recycling and reuse (Cabinet of Ministers of Ukraine, 2017). According to the Ministry of Environmental Protection and Natural Resources of Ukraine, the waste management system requires improvement to comply with

Suggest Citation:
Mazur, N. (2025). Waste management in the circular economy: Status and challenges in Ukraine. *Innovation and Sustainability*, 5(1), 18-30. doi: 10.63341/vis/1.2025.30.

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EU standards and integrate into the European waste management system (Ministry of Environmental Protection and Natural Resources of Ukraine, 2022).

Research by scientists and practitioners highlighted the modernisation of approaches to the waste management system within the circular economy. M.T. Munir *et al.* (2023) explored the key components of effective solid waste management, various available machine learning tools, their strengths and weaknesses, and how they can be utilised to create effective waste management systems. In addition, the authors examined the challenges associated with using machine learning for skilled solid waste management and detailed the current and future trends in this fi ld. According to the researchers, the ability of machine learning algorithms to process large amounts of data and detect patterns and trends can be highly valuable for various tasks, such as forecasting, anomaly detection, and optimisation. R.E.V. Sesay & F. Ping (2025) examined AI-driven sorting technologies in municipal waste management as a transformative foundation for sustainable municipal solid waste management (MSWM), focusing on waste reduction, resource recovery, and the development of closed-loop systems. According to these researchers, the application of advanced technologies such as artific al intelligence (AI), machine learning, and big data analytics offers transformative opportunities for enhancing CE frameworks in MSWM. AI-driven solutions can optimise waste collection routes, predict waste generation patterns, and improve sorting effici cy at recycling facilities. Machine learning algorithms can identify trends in waste composition and inform adaptive management strategies, while big data analytics provide comprehensive insights into resource fl ws and system ineffici cies. These technologies can synergistically enhance decision-making, minimise waste generation, and maximise resource recovery.

According to K. Das *et al.* (2025), the application of Internet of Thi gs (IoT) technologies and big data analytics for the real-time management of agri-food waste is a major challenge in the agri-food sector. The authors highlighted the positive impact of IoT and big data in combating agri-food waste; at the same time, they provide practical suggestions for key players across the supply chain. A. Bratovcic (2024) identifi d microplastics as a persistent anthropogenic pollutant that has become a global problem due to their widespread distribution and unknown threat to the environment and living organisms. Th s research focused on the removal of plastic fragments through photocatalytic reactions using recently developed photocatalytic composites, as well as the mechanism of photocatalytic degradation of microplastics. The study by S. Sultana *et al.* (2021) aimed to assess awareness and practices regarding solid waste management among people living in the community. Solid waste management represents a serious public health problem and is closely related to the daily lives of individuals. According to the authors, members of the community can play a key role in solid waste management. According to D. Chester *et al.* (2021), the principal barrier to acquiring and deploying viable waste-to-energy (WTE) technologies in remote or deployed expeditionary sites is the high capital, operating, and maintenance costs. The authors' calculated economic impacts confi m that open burning of waste is not only hazardous to humans and the environment, but also not economically viable. Considering the economic impacts and the mitigation of human and environmental health risks, WTE technologies could be a viable waste management strategy for the future. Th s study aimed to analyse the current state of the waste management system in Ukraine and to develop recommendations for its improvement based on the principles of the CE.

Materials and Methods

The research process employed a systematic approach that allowed for a comprehensive assessment of the current state of waste management in Ukraine in the context of a circular economy. The research methodology included several stages aimed at achieving the stated goal and obtaining new scientific results. Methods of analysis and synthesis were used to analyse the problem, enabling an assessment of the theoretical foundations of the circular economy and the principles of waste management. A critical review of scientific and theoretical sources was conducted, including recent publications in leading international journals over the past three to five years, as well as regulatory and legal documents of Ukraine in the fi ld of waste management (Munir *et al.*, 2023; Horbal & Slipachyk, 2023; Sesay & Ping, 2025). Th s provided a solid basis for determining the relevance of the problem and identifying existing scientific approaches. Specifi ally, the study by S. Sultana *et al.* (2021) aimed to assess awareness and practices regarding solid waste management among people living in the Mugda community of Dhaka, using a descriptive correlational research design.

The method of statistical analysis was used to collect and analyse empirical data. The data sources included official reports of the State Statistics Service of Ukraine (Goal 12…, n.d.), the Ministry of Environmental Protection and Natural Resources of Ukraine (Waste management, n.d.), as well as analytical reports of international organisations (Waste generation in Europe, n.d.). To study and analyse trends in the waste management system, estimated indicators such as GDP waste intensity, the share of incinerated and recycled waste in the total volume of generated waste, the volume of generated waste per unit of GDP (kg per 1,000 USD), the number of waste treatment plants, their capacity by type of plant, and the number and volume of landfills for waste disposal (storage) were used. In the fi ld of waste management, the dynamics of fi ancing, both capital and current, were also analysed.

The processing of these materials enabled the assessment of changes in the fi ld of waste management and the identifi ation of major development trends. The modelling method was used to predict possible scenarios for the development of waste management until 2025. Average rates of change in the number of facilities and their capacity, as

well as the level of reduction in the residual volume of landfills for household waste disposal, were taken into account. Th s approach enabled the assessment of the potential impact of the implementation of a circular economy on the environmental and economic situation in the country. The methodological approach described in this study ensures transparency of the research process, allowing it to be replicated using similar methods and data sources. In addition, it enabled the production of scientifi ally sound results that can inform the development of recommendations for the implementation of a circular economy at the regional level.

Results and Discussion

Despite the fact that Ukraine ranks confide tly among the top ten countries in the world in terms of the volume of accumulated waste, the country recycles, according to various sources, only between four and eight per cent, taking into account sorting and incineration (Garbage recycling, 2024). With the signing of the Association Agreement between Ukraine and the EU, Ukraine entered a new stage of waste management, and Directive 2008/98/EC of the European Parliament and of the Council (2008), which formed the basis of the National Waste Management Strategy, also became an obligation for Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 820-p, 2017). The EU Waste Management Directive (Directive 2008/98/EC of the European Parliament and of the Council, 2008) defi es five key levels of the waste hierarchy, with priority given to the fi st three stages. Waste prevention is the most effective approach in the context of a circular economy, as it reduces the negative impact on the environment at the production and consumption stages. Minimising resource use, eco-design, and extending the life cycle of products help reduce waste before it is generated. Preparing for reuse involves repairing, refurbishing, and repurposing products, preventing them from becoming waste. Th s helps to reduce the consumption of primary resources, save energy, and lower greenhouse gas emissions. Recycling or reusing waste aims to transform it into secondary raw materials that can be reused in production processes. Th s approach reduces the need for the extraction of natural resources and helps to reduce environmental pollution.

The fi st three levels of the waste management hierarchy are consistent with the principles of sustainable development and the circular economy, as they minimise the impact on the environment and human health, reduce waste management costs, preserve natural resources, and contribute to the creation of new business models, jobs, and economic growth. The remaining levels of the hierarchy are considered lower priorities. Alternative recycling, particularly energy recovery, involves incinerating waste to produce energy. Although this process allows for the extraction of energy value, it is accompanied by emissions of harmful substances and the loss of material resources. Final disposal of waste by landfill represents the worst management option, as landfills occupy large areas, pose risks to soil, water, and air pollution, and contribute to the formation of greenhouse gases. Consequently, the EU and most countries worldwide have directed their environmental policies towards prioritising the fi st three approaches, thereby promoting the rational use of resources and reducing negative impacts on nature (Dovgal *et al.*, 2024).

Waste can be prevented through conscious consumption by purchasing only necessary items in suffici t quantities. A mandatory component of the remaining tasks is the provision of high-quality equipment for the collection, transportation, storage, and recycling system. Since the Industrial Revolution, products have been consumed in largely the same way: companies extract or harvest resources to create a product that consumers then buy, use, and ultimately discard. Th s model is known as the linear model of mass consumption. However, this model has contributed to changes in the climate that, if left unaddressed, threaten to make life signifi antly more difficult in the coming decades. Every year, about 2.6 trillion USD worth of materials in fast-moving consumer goods – representing 80 per cent of the material value – are thrown away and never recovered (Gatzer *et al.*, 2022). An alternative to the linear model is the CE. In a closed-loop economy, resources can be used repeatedly, often for the same or similar purposes.

The CE is governed by three main principles:

1. Preserving and enhancing natural capital (the world's stock of natural assets) by controlling fin te resources and balancing the fl w of renewable resources.

2. Optimising resource output by ensuring that products, components, and materials are recycled at the highest possible level at all times.

3. Increasing system effici cy and eliminating unintended negative impacts, such as air and water pollution.

A CE is a worthy goal in itself, but it also offers organisations a competitive advantage. One McKinsey study estimates that the CE could generate over 1 trillion USD in revenue in Europe alone by 2050 (Bouton *et al.*, 2016). Another McKinsey analysis suggests that transitioning to closed-loop business models could help European consumer goods companies access up to 500 billion EUR in value by 2030 (Gatzer *et al.*, 2022). Companies, especially consumer goods fi ms, that commit to environmental, social, and governance (ESG) metrics are likely to become the leaders of the future.

At the national level, productivity can mean the difference between a good standard of living and a poor one. For a company, productivity can determine whether it can afford to raise employees' wages, or even whether it can continue operating. Stagnant or declining productivity can signal serious trouble ahead for individuals, organisations, and nations alike. To reduce the enormous volume of waste currently produced by societies, emissions-intensive production activities must be dramatically slowed. In the past, the idea of slowing productivity growth might have been shocking to governments and consumer goods companies alike. The question now is how consumer goods companies can survive in a world where shoppers are purchasing fewer new items. The clear business potential of

closed-loop consumer goods models offers an answer to this question. Consumer goods companies should regard circularity as an opportunity, not a threat; closed-loop business models can forge a valuable connection between business logic and sustainability. Growing consumer demand for environmentally friendly products is arguably the greatest driver of circularity, but other factors will also play a role. These include regulation, technological progress, infrastructure, supply-side activities, and the macroeconomic environment.

It is worth beginning with regulation. Some governments are already promoting circularity. As part of the European Green Deal, the European Union has adopted the Circular Economy Action Plan (CEAP), which commits billions of euros towards achieving net-zero emissions by 2032. Several European countries have also introduced extended producer responsibility schemes, providing significant fi ancial incentives for companies that aim to transition to closed-loop business models (Freundt *et al.*, 2024). However, regulation, as well as companies' efforts to move towards more sustainable business models, can be significantly influenced by the macroeconomic environment. An economic downturn, inflation, or geopolitical instability can make organisations more reluctant to invest in closed-loop business models. Similarly, a recession can drive consumers towards secondary markets for recycled products. As evidenced by analyses of trends in global society, particularly in Europe, there is a signifi ant opportunity for consumer goods organisations across different sectors to adapt their business models to exploit the profitable opportunities of the circular economy (Frey *et al.*, 2023).

Circularity refers to practices that optimise resource use and minimise waste throughout the entire production and consumption cycle, emphasising sustainability and cost-effectiveness (Bouton *et al.*, 2016). The only way to create these two realities – reducing the carbon footprint and generating profit – is to establish a closed-loop economy. For the past 200 years, the economy has operated built linearly: material is extracted, transformed, produced into goods, sold, consumed, and ultimately discarded as waste. Society has dealt poorly with waste and has largely ignored the consequences (McKinsey Center for Business and Environment, 2015). In the CE system, waste is not considered a fi al product, but a resource that can be reintegrated into the production and economic cycle. The CE seeks to reduce waste generation, maximise its utilisation, and transform it into resources that generate added value. The role of waste in the circular economy is illustrated in Figure 1.

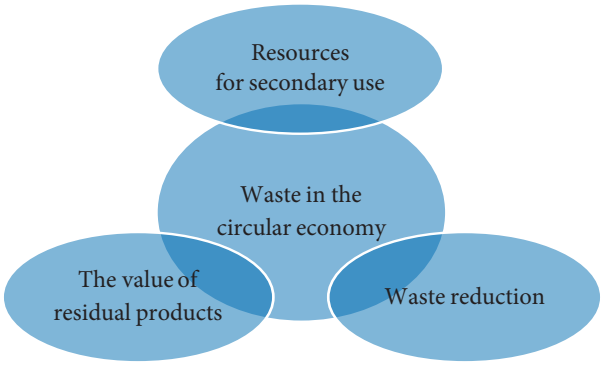

Figure 1. The role of waste in a circular economy

Source: created by the author

In a circular economy, waste is transformed into a valuable resource for secondary use, becoming raw material for new products. For example, plastic is processed into pellets, which are then used in the production of new goods, and organic waste is utilised to produce compost or biogas. Waste reduction is achieved through eco-design, multi-level recycling, and product reuse. Instead of landfilling waste, energy or materials can be recovered from it; for example, construction waste is employed in road construction. It is important to clearly defi e and implement the stages of waste management on a sustainable basis, thereby contributing to the effici t use of resources and reducing the negative impact on the environment.

Priority for reuse involves extending the life cycle of products by repairing, upgrading, recycling, or reusing materials. For instance, in the textile industry, companies such as Patagonia actively employ the concept of reuse, offering customers the opportunity to repair old clothing and purchase second-hand items (Product Repair, n.d.). In the automotive sector, Renault is implementing the Refactory programme, aimed at repairing and reusing car parts, thereby reducing the need for new materials (The Refactory…, n.d.). An important aspect is the development of effective infrastructure for the collection and sorting of waste, which ensures the possibility of its reuse in production. For example, TerraCycle specialises in recycling waste that is traditionally non-recyclable (e.g., toothbrushes, cosmetic packaging, etc.) (The TerraCycle Difference, n.d.). In the plastics sector, Loop Industries (n.d.) is developing technologies for recycling plastic waste, transforming it into high-quality material for new products.

Residual waste that cannot be recycled can be used for energy production. For example, the Swedish company Fortum uses the incineration of municipal waste to

generate electricity and heat, thereby providing heating for cities (Circular economy, n.d.). As the fi al stage in the circular economy system, the safe disposal of waste involves minimising environmental impact. For instance, Veolia is developing innovative methods for the safe disposal of toxic waste, including the use of isolated landfills and chemical stabilisation of hazardous substances (We are committed to…, n.d.).

The integration of waste into the circular economy system offers several advantages. Firstly, there are economic benefits, such as reducing the cost of purchasing primary materials, the development of new business models such as leasing and remanufacturing, and the creation of additional market opportunities. Secondly, environmental sustainability is promoted by reducing CO_2 emissions through decreased waste incineration and extraction of natural resources, alongside reducing environmental pollution, for example, diminishing the quantity of plastic waste in the world's oceans. Thi dly, there are social benefits, including the creation of new jobs in recycling and eco-design sectors, as well as enhancing public awareness of the responsible use of resources.

To ensure the functioning of the waste management system, following European legislation, the activities of specialised enterprises covering the various stages of waste management are necessary. Such enterprises may have different work profiles depending on the type of waste and its treatment methods. A separate group consists of enterprises that collect mixed waste, deliver it to landfills, and subsequently sort it. Organic waste can be used to produce biogas or compost, whilst inorganic waste is pressed, crushed, and sent to processing plants for the manufacture of various equipment and consumer goods. In Ukraine, such enterprises have been created based on solid waste landfills near Lviv, Kropyvnytskyi, and Kharkiv, and there is also a waste recycling line in the Chernivtsi Region. In addition, two plants operate in the Zakarpattia Region, two in Vinnytsia, and one each in Kharkiv and Cherkasy (Garbage recycling…, 2024). Some enterprises accept pre-sorted secondary raw materials by individual categories. They operate through reception points or through agreements with building owners who install specially marked containers for sorting. Such points operate in every city and a significant number of villages, contributing to the expansion of the practice of secondary material use.

Another type of enterprise is engaged exclusively in waste sorting, selecting equipment according to its capabilities. The sorted raw materials are sold to processing plants for further use in production processes. There are approximately 30 such sorting stations in Ukraine (Garbage recycling…, 2024). In addition, a separate category consists of enterprises that directly process secondary raw materials. In Ukraine, about 20 plants specialise in the processing of waste paper, about 30 specialise in glass containers, and about 40 specialise in plastics. Often, the same enterprises that previously operated as reception and sorting points also engage in recycling (Garbage recycling…, 2024). Thus, effective waste management and its integration into the circular economy system not only minimises the negative impact on the environment but also contributes to economic development and the promotion of social responsibility.

Recycling companies purchase waste paper, plastic, and cullet from outside Ukraine due to the low percentage of domestic sorting, whilst some European countries achieve over 90% waste recycling rates (Dolzhenkova, 2023). The experience of European and other countries in the fi ld of waste management can be utilised to organise waste-free production and signifi antly reduce waste at the national level. Even before the full-scale invasion, 51 MW of biogas capacity had been created in different regions of Ukraine based on landfills and agricultural waste – more than 30 installations. The fi st stage of the world's largest biogas plant has been opened in the Vinnytsia Region. However, this does not solve the problem of waste accumulation in general – waste volumes are not decreasing, and it is not economically viable to incinerate it all. Instead, the processing of sorted waste, which becomes secondary raw material, is highly effective (Garbage recycling…, 2024). The gross domestic product (GDP) waste intensity indicator illustrates the share of waste in the creation of GDP. As shown in Figure 2, waste intensity increased gradually from 2015 (approximately 100%) to 2024 (approximately 141%).

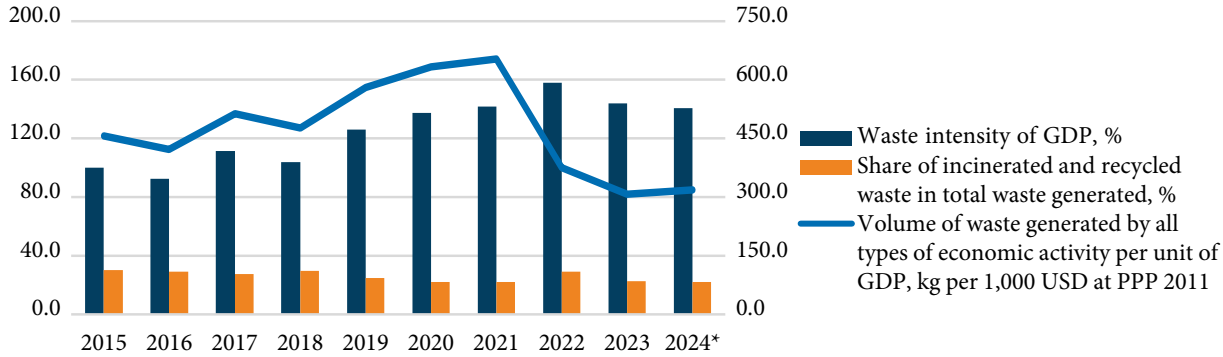

Figure 2. Main parameters of waste generation and disposal in Ukraine, 2015-2024

Note: * – preliminary data

Source: calculated by the author based on data from I. Werner (2024), Goal 12: Responsible consumption and production (n.d.)

In 2022, the waste intensity of GDP reached its highest value (158.2%), indicating an increase in waste generation relative to economic growth. In 2023, the figu e decreased to 143.7%, and the forecast for 2024 is 140.9%. Th s may indicate a stabilisation of the situation and the implementation of certain measures to optimise waste management. The main reasons for the increase can be identifi d as:

a) an increase in the volume of economic activity, which is accompanied by greater waste generation;

b) a possible rise in the share of sectors of the economy with high waste intensity, such as industry or construction.

The data indicate a signifi ant waste intensity within the Ukrainian economy, which has fluctuated in recent years but shows a tendency to gradually decrease. Th s may be a consequence of changes in the structure of production caused by military operations in Ukraine. The growth of this indicator suggests that the country's economy remains largely dependent on a linear model – the creation of products without consideration for recycling. Th s presents a challenge for the transition to a CE.

The indicator of the share of incinerated and recycled waste in the total volume of waste generated demonstrates the effici cy of waste recycling and disposal processes. The data in Figure 2 shows that the share has remained almost stable at 20%-25% throughout the years. Among the main factors causing such "stability" are the lack of signifi ant changes in waste management policies or technologies, and possibly insuffici t motivation for enterprises or an underdeveloped recycling infrastructure. With the growth of the total volume of waste, this stable share implies that the absolute amount of non-recycled waste is also increasing. Th s situation highlights the need to introduce innovative waste recycling and disposal technologies.

Another analysed indicator – the volume of waste generated per unit of GDP (kg per 1,000 USD) – refl cts how much waste is generated in creating a certain volume of GDP, that is, it serves as an indicator of resource effici cy. As the analysis data (Fig. 2) shows, the indicator increased from 2015 (approximately 450 kg) to 2021 (approximately 650 kg). Among the main reasons for this growth are the decline (or absence) of resource-effici t technologies, as well as a decrease in the share of high-tech, less resource-intensive industries. The economy is gradually losing its resource effici cy, which once again underlines the relevance of transitioning towards the principles of sustainable development. The growth of specific waste volumes indicates a decline in the potential for integrating the principles of a circular economy, creating an additional burden on both the environment and the economic system.

One of the key signals of this process is the increase in the waste intensity of GDP, which demonstrates growing environmental pressure. To reduce this indicator, it is necessary to implement measures aimed at transitioning to cleaner technologies, encouraging enterprises to use secondary resources, and developing eco-design and more effici t production processes. However, without a comprehensive state policy and investments in relevant innovations, it will be difficult to change the situation. An additional problem remains the low share of recycled waste, which currently amounts to only about 20%. Th s situation requires active investment in the development of waste recycling infrastructure, the introduction of effective mechanisms to support companies engaged in the secondary use of materials, as well as the strengthening of state regulation in the fi ld of waste management. The lack of appropriate policies and fi ancing threatens further waste accumulation and an increased negative impact on ecosystems.

The negative trend in the growth of waste per unit of GDP indicates a gradual deterioration of production processes, which poses a threat to future economic development. Th s indicator should be used as one of the key criteria for assessing the impact of the circular economy and the effectiveness of environmental initiatives. Its monitoring and analysis will enable a timely response to problems and the adjustment of sustainable development strategies aimed at optimising resource use and minimising waste. In order to confi m the relevance and necessity of implementing the principles and elements of the CE, it is necessary to analyse several other important indicators, namely: the number of waste processing plants, their capacity by type of plant, and the number and volume of landfills for waste disposal (storage) – Table 1.

Table 1. Number of waste treatment facilities and landfills for waste disposal (as at the end of the year)

	Number, units				Installed capacity, thousand tonnes				Residual capacity, million m³			
	2021	2022	2023	2024*	2021	2022	2023	2024*	2021	2022	2023	2024*
Total number of waste treatment facilities	546	546	413	388	20,015.2	9,079.6	6,384.2	4,841.7	–	–	–	–
for waste incineration to produce energy or material products	304	264	239	221	1,186.1	1,106.0	1,321.8	1,278.1	–	–	–	–
for waste incineration for the purpose of heat treatment of waste	88	71	59	53	112.8	72.8	82.9	81.0	–	–	–	–
for waste recovery	251	191	110	95	12,779.6	7,885.7	4,977.8	4,107.5	–	–	–	–

Continued Table 1

	Number, units				Installed capacity, thousand tonnes				Residual capacity, million m³			
	2021	2022	2023	2024*	2021	2022	2023	2024*	2021	2022	2023	2024*
other waste treatment facilities for permanent storage and disposal of waste	20	20	5	3	15.1	15.1	1.7	1.0	–	–	–	–
Landfills for waste disposal, total	1,688	1,453	1,331	1,217	–	–	–	–	3,809.0	4,083.6	3,895.9	3,359.7
of which, household waste	778	794	791	787	–	–	–	–	160.3	147.2	156.4	154.3

Note: data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol, and parts of the temporarily occupied territories in the Donetsk and Luhansk regions; * – preliminary data

Source: calculated by the author based on I. Werner (2024), Goal 12: Responsible consumption and production (n.d.)

The number of waste treatment plants decreased by 28.9% over the period 2021-2024. The largest decrease occurred among waste recovery plants (-62%). There is a decline in plants for the incineration of waste for energy use (-27%) and for incineration without energy production (-40%). The number of other plants for the permanent storage and disposal of waste has decreased particularly signifi antly (-85%). The total installed capacity of waste treatment plants decreased (-75.8%). The largest drop in capacity occurred at waste recovery plants (-67.8%). At the same time, the capacity of waste incineration plants increased in 2023, but decreased again in 2024. The total number of landfills is gradually decreasing (-28%). Despite this, the residual volume of landfills does not show a stable decrease. It fi st increased in 2022 and then decreased in 2024. The number of landfills for household waste has hardly changed, and their residual volume remains high.

The analysis revealed a general negative trend in the reduction of waste treatment facilities, which contradicts the principles of the circular economy. The decline in waste recovery is particularly noticeable, which may indicate insuffici t funding, technological lag, or weak state policy supporting the recycling industry. At the same time, the number of landfills for waste disposal is gradually decreasing, but their residual volume does not show a sustainable reduction. Th s may mean that a signifi ant proportion of waste continues to accumulate in existing landfills rather than being effectively recycled or disposed of.

A positive aspect is the effort to increase the effici cy of waste incineration, particularly for energy production, but the total capacity of such facilities fluctuates, which may indicate unstable operation or limited resources. It is important to accelerate the modernisation of processing facilities and introduce technologies that reduce dependence on landfills. Special attention should be paid to the use of automated sorting systems based on artific al intelligence, as well as the creation of incentives for businesses engaged in the recycling and reuse of materials. It is important to consider the fact that military operations are being conducted on the territory of Ukraine, and that the data provided excludes the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol, and parts of the temporarily occupied territories in the Donetsk and Luhansk regions. Thus, the analysis of the above indicators allows the following conclusions to be drawn:

1. The reduction in the number of waste treatment facilities and landfills may indicate optimisation of the waste management system, as well as transitions to other forms of utilisation or a reduction in waste generation.

2. The largest reduction concerns waste recovery facilities, which is a negative signal, as this is a key component of the CE.

3. A slight increase in the residual volume of landfills in 2022 may be associated with the reconfigur tion of landfills or more effici t waste management.

Based on the trends described in Table 1, quantitative forecasts can be made regarding changes by 2025 (Table 2). To do this, the average rates of change in the number of facilities and capacity, as well as the reduction in the residual volume of landfills, will be taken into account.

Table 2. Forecast of key indicators for 2025 (summarised)

Indicator	2023	2024 (forecast)	2025 (forecast)
Number of treatment plants	413	330	260
Capacity of plants (thousand tonnes)	6,384.2	4,788	3,590
Number of landfills for disposal	1,331	1,130	960
Residual volume of landfills (million m³)	3,895.9	3,820	3,740
Number of municipal waste landfills	791	690	600
Residual volume of municipal waste	156.4	150	145

Source: author's calculations

The calculations show that there is a trend towards infrastructure reduction: the number of facilities and landfills is decreasing, which may lead to an increase in the burden on residual facilities or the need to introduce new technologies. Capacity decline: If waste treatment capacity continues to decline at this rate, it may cause problems with processing signifi ant volumes of waste, especially in densely populated regions. Need for modernisation: Investments are needed in modern waste recovery facilities, as they show the greatest reduction in both volume and capacity. The main recommendations for effective waste management and the development of a circular economy are to introduce new recycling technologies, improve the effici cy of existing facilities, and encourage the reuse of materials. One of the key areas is the development of waste disposal technologies that will reduce dependence on landfills. Th s requires supporting scientific research in the fi ld of materials recycling, introducing new mechanical and chemical methods of waste treatment, and encouraging businesses to invest in innovative approaches.

An important aspect is the modernisation of existing recycling plants and the expansion of their capacity. The use of automated sorting systems based on artific al intelligence and machine learning technologies can signifi antly increase the effici cy of this process. For example, sorting robots are used in Sweden and the Netherlands that use computer vision to recognise and separate materials in the waste stream. Such technologies increase the accuracy and speed of sorting, reducing the amount of residual waste and improving the quality of secondary raw materials.

Encouraging recycling and the reuse of materials also plays an important role in reducing waste. Effective tools may include tax incentives for companies that implement environmentally friendly production cycles or subsidies for small businesses that use secondary raw materials. In Germany and Austria, a system of "green certifi ates" is in place, which encourages enterprises to use secondary materials, contributing to the formation of an environmentally responsible business environment. In addition, it is necessary to conduct an analysis of the environmental effici cy of landfills and gradually reduce their number, replacing them with modern waste processing and disposal complexes. The experience of Singapore and South Korea demonstrates that the creation of centralised processing complexes that combine mechanical sorting, chemical recovery, and energy production can signifi antly reduce the amount of waste entering landfills. Thus, the development of innovative technologies, the application of artific al intelligence in sorting and recycling, as well as support for businesses in implementing environmentally responsible approaches, can signifi antly increase the effici cy of waste management and contribute to the development of a circular economy.

As the results of the analysis shown in Table 3 indicate, during the period 2010-2024, the volume of capital investments in the waste management sector increased by 7.2 times. However, it is necessary to note the uneven dynamics, with sharp fluctuations. The share of capital investments in total investments in environmental protection changed unevenly, with peaks in 2019 and 2022. There was an average increase in the share for 2010-2024, which indicates a gradual reorientation of capital investments specifi ally towards waste management. Current expenses during the period 2010-2024 increased by 4.6 times. The dynamics are relatively stable, with an average annual increase of approximately 6%-8%. In 2022, there was a decrease due to martial law in Ukraine; however, in 2023, expenses returned to the level of 2021. The share of current expenditures in total environmental protection expenditures increased by 12.1% over the period 2010-2024. Between 2015 and 2024, the share stabilised at 36%-40%, indicating a continued focus on current waste management expenditures.

Table 3. Dynamics of expenses in the fi ld of "waste management" in Ukraine

Indicator name	Years									Rate of change, %
	2010	2015	2018	2019	2020	2021	2022	2023	2024*	
Capital investments, at current prices, million UAH	475.6	737.5	1,182.1	5,754.3	2,899.8	3,719.6	2,795.9	3,204.6	3,428.1	7.2 times
Share in the total amount of capital investments in environmental protection, %	17.2	9.6	11.7	35.4	21.9	26.4	43.4	38.7	33.5	+16.3
Current expenses, at current prices, million UAH	2,599.6	6,801.9	8,830.2	10,227.1	11,197.2	11,501.1	8,963.5	11,310.0	12,028.5	4.6 times
Share in the total amount of current expenses for environmental protection, %	25.1	40.2	36.3	37.2	40.0	37.5	37.2	38.6	37.2	+12.1

Note: * – preliminary data

Source: calculated by the author based on data from I. Werner (2024), Goal 12: Responsible consumption and production (n.d.)

Based on the average rate of change in recent years (2020-2024: +10% annually), it is possible to forecast the volume of capital investments in 2025 to be approximately 3,876 million UAH. However, taking into account external factors (martial law, limited funding), growth may slow down. The share of capital investments in total investments in environmental protection, assuming the upward trend continues (albeit with possible fluctuations), will be approximately 42%-45% in 2025. The forecast for the volume of current expenses (assuming stable growth with an average annual increase of 6%-8%) can be outlined within the following limits for 2025: about 13,150 million UAH. At the same time, the share of current expenditures in total environmental protection expenditures is expected to stabilise at 38%40%, unless there are drastic changes in state policy.

The results of the analysis allow the following conclusions to be drawn:

1. In the fi ld of waste management, there is a positive dynamic in the increase in funding, both capital and current, which indicates an increase in attention to environmental issues.

2. The largest increase in capital investments occurred in 2019; however, there has since been stable, moderate growth.

3. Current expenditures have remained stable, even under wartime conditions, which indicates their importance for supporting the main processes in the fi ld of waste management.

4. In 2025-2026, an increase in funding can be expected, although external factors (war, economic situation) may slow the pace.

It should be noted that, as a result of military operations in Ukraine, a signifi ant amount of demolition waste has been generated. As of April 2024, according to the Ministry of Community, Territorial and Infrastructure Development of Ukraine, the volume of such waste exceeded 223 thousand tonnes. In particular, more than 189 thousand tonnes were recorded in Kyiv Region, more than 6 thousand tonnes in Mykolaiv Region, and about 1.9 thousand tons in Odesa Region (Consequences of the war…, 2024). In April 2024, the Ministry of Environmental Protection and Natural Resources of Ukraine reported that the total volume of demolition waste across the country exceeded 670 thousand tonnes (Since the beginning…, 2023). It is worth noting that offi al statistics may not account for some waste remaining at the sites of its generation and not subject to formal recording. In addition, due to martial law, the State Statistics Service of Ukraine has limited the publication of detailed data on waste generation and treatment (Churikanova, 2020). Given the limited availability of official information, accurate data on the volume of waste related to military operations may be incomplete. However, the available figu es indicate the scale of the problem and the need for effective management of such waste to minimise its negative impact on the environment and public health.

Studies highlighting the importance of implementing innovative approaches to waste management support the hypothesis that new technologies are needed in this process. As noted by N. Cherry (2024), the use of artific al intelligence to optimise business models and improve infrastructure is an important factor in the transition to a circular economy. Th se results are consistent with this conclusion, as the implementation of automated sorting and recycling systems increases the effici cy of waste management and reduces waste volume. S.A. Bandh *et al.* (2025) argued that waste management and the circular economy are two of the most important concepts contributing to sustainable approaches to environmental protection. The adoption of these principles contributes to the creation of a more sustainable future for current and future generations. According to H. Richter (2024), projects aimed at cleaning polluted water bodies using fl ating systems made of recycled materials have demonstrated effectiveness in reducing pollution and reusing resources. It is appropriate to agree with this approach, as it is consistent with the principles of a circular economy; however, research showed that the implementation of such technologies requires signifi ant investment and government support.

It fully supported the idea that the CE paradigm can also be extended by using the waste management sector to transform waste into resources. In comparison with previous studies, M. Arena *et al.* (2021) attempt to outline how a waste collection and recycling system can contribute to overcoming some of the cultural, technological, regulatory, and market barriers that affect the demand and supply of recycled material. K. Kotyal (2023) also explored the main challenges and opportunities in the context of sustainable waste management, identifying key areas for improvement and innovation to facilitate the transition to a circular economy. A.S. Rosokhata & M.G. Minchenko (2023) analysed in detail the main tools of the circular economy and their application in Ukraine. The authors compared the dynamics of waste management in Ukraine and EU countries, which is consistent with the conclusions about the need to adapt European practices to improve the national waste management system. The idea proposed by A.S. Rosokhata & M.G. Minchenko (2023) on the importance of extended producer responsibility (EPR) as a key mechanism for waste minimisation deserves support. The analysis of the formation of the circular thinking paradigm during wartime conditions in Ukraine, conducted by N.I. Horbal & S.V. Slipachyk (2023) is particularly relevant in the context of this study. It is reasonable to agree with N.I. Horbal *et al.* (2021) stated that the adaptation of EU methodologies and the use of international experience can accelerate the transition to a circular economy. However, the results indicated that Ukraine needs to take into account specific economic and social features for the effective implementation of these methods.

The study by V.V. Roleders *et al.* (2024) on the conceptual foundations of the circular economy and logistics resource management models is an important addition to this analysis. The authors emphasised the importance of closed logistics chains for achieving environmental and

economic benefits. Th s view is supported by the assumption that integrating logistics principles into the circular economy will contribute to the creation of effective business solutions. M. Varfolomieiev & O. Churikanova (2020) considered the problems of implementing the circular economy in the global context and the possible obstacles to its implementation in Ukraine. Their study confi med the conclusions regarding the need to form a state policy to support circular business models. The authors also emphasise the importance of involving the private sector and the public in the process of economic transformation.

The research of Ye. Mishenin & M. Vysochanska (2023) on reforming solid waste management policy in Ukraine was consistent with the conclusions regarding the need to update national legislation by European standards. In addition, the study by M.V. Ruda *et al.* (2021) showed a significant lag of Ukraine behind developed countries in the fi ld of the circular economy, which is confi med by the results obtained. The authors' recommendations on the need for a comprehensive approach to the implementation of the circular economy at the state level are supported. Considering traditional linear supply chains and their transformation into circular models is important for companies, consumers, and the environment (Fahrni *et al.*, 2024). The fi dings confi med that the use of circular chains creates strategic advantages for businesses, reducing costs and increasing resource effici cy. Similar results were obtained in the study by T. Freundt *et al.* (2024), which demonstrated the importance of "green" marketing strategies for attracting consumers. Agreement with these fi dings is expressed, and it is believed that further research can help to develop effective mechanisms for stimulating the circular economy at the enterprise level. The analysis of scientific sources demonstrated a signifi ant correlation between the results of other researchers and the fi dings of this study. Most studies confi med that the implementation of a circular economy requires a comprehensive approach, involving the public and private sectors, developing innovative technologies, and adapting international experience. At the same time, the specific conditions of Ukraine require the development of individual strategies that take into account the economic, environmental, and social aspects of this process.

Conclusions

The study achieved its goal – an analysis of the challenges and prospects for implementing a circular economy in waste management in Ukraine was undertaken. The study showed that the main obstacles on this path are insufficient infrastructure for waste collection and processing, the economic ineffici cy of certain processing technologies, and the lack of incentives for businesses to transition to a circular model. In particular, the share of incinerated and recycled waste in the total volume of waste generated remained almost stable at 20%-25% during 2015-2024, which demonstrates the absence of signifi ant changes in waste management policies or technologies, as well as possible insuffici t motivation for enterprises or the absence of a developed recycling infrastructure. The existing waste management system in Ukraine does not yet meet the principles of a circular economy, as a signifi ant part of resources is not returned to economic circulation but ends up in landfills, which has a negative impact on the environment.

The results of the study confi med that waste in the circular economy is of strategic importance as a source of secondary raw materials. Effective management of waste contributes to environmental sustainability, economic growth, and the reduction of the impact of human activity on the environment. To achieve these goals, it is necessary to develop a modern infrastructure for the collection, sorting, and processing of waste, introduce effective incentives for businesses, promote environmental awareness among the population, and improve the legislative framework to support the circular economy. Prospects for further research in this area may be aimed at developing mechanisms to stimulate businesses to implement circular models, conducting a detailed analysis of the economic effici cy of modern waste processing technologies at the regional level, as well as studying the best practices of European countries in integrating the principles of the circular economy into national strategies. Finding ways to adapt these solutions to the realities of Ukraine, taking into account economic, social, and environmental factors, is especially important.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Управління відходами у циркулярній економіці: стан та виклики в Україні

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Анотація. Під час проведення дослідження досягнуто мети, що полягала в оцінці поточного стану системи управління відходами в Україні та розробці рекомендацій щодо її вдосконалення на основі принципів циркулярної економіки. Для аналізу проблеми використовувалися методи аналізу та синтезу, що дозволило оцінити теоретичні засади циркулярної економіки та принципи управління відходами. Для збору та аналізу емпіричних даних було використано метод статистичного аналізу, для прогнозування можливих сценаріїв розвитку управління відходами до 2025 року – метод моделювання. Результати дослідження засвідчили, що економіка України значною мірою залишається залежною від лінійної моделі, що характеризується створенням продукції без урахування подальшої переробки. Це підтверджується зростанням відходоємності внутрішнього валового продукту (ВВП), яка свідчить про відсутність суттєвих змін у впровадженні ресурсоефективних технологій. Стабільна частка утилізованих та спалених відходів (20-25 %) на фоні зростання загального обсягу утворених відходів вказує на недостатність змін у технологіях та політиці поводження з відходами, а також брак розвиненої інфраструктури переробки. Це призводить до збільшення кількості неутилізованих відходів, що вимагає запровадження інноваційних технологій та підвищення мотивації для підприємств. Збільшення обсягу утворених відходів на одиницю ВВП демонструє тенденцію до зниження ресурсоефективності економіки, одночасно спостерігається скорочення кількості об'єктів інфраструктури для поводження з відходами. Позитивним аспектом є збільшення фінансування у сфері поводження з відходами, зокрема капітальних інвестицій. Попри виклики, поточні витрати залишаються стабільними навіть в умовах війни, що свідчить про розуміння важливості підтримки екологічних ініціатив. Методологічний підхід, описаний у роботі, забезпечує прозорість процесу дослідження, що дозволяє повторити його з використанням аналогічних методів і джерел даних

Ключові слова: циркулярність; замкнений цикл; ресурси; повторне використання; утилізація відходів; поводження з відходами

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 31.10.2024; Revised: 12.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.31

UDC 336.71:338.465.4(477)

Driving financial innovations: The role of digitisation, transparency, and social responsibility in banking systems

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Abstract. The study of fi ancial innovations in banking systems is highly relevant within the current context of global digitalisation, increasing demands for transparency, and the growing importance of corporate social responsibility. These aspects are crucial for strengthening consumer trust, improving the effici cy of banking operations, and ensuring the resilience of the banking system in Ukraine. The study aimed to examine fi ancial innovations in banking systems, focusing on the interplay between digitalisation, transparency, and social responsibility. Quantitative and qualitative methods were employed, including the analysis of banks' fi ancial statements, regulatory documents, and reports from the National Bank of Ukraine for the period 2019-2023. Econometric modelling identifi d key factors affecting banking performance indicators, such as return on assets, customer perception, and fi ancial stability. The results demonstrated that digitalisation facilitates the automation of banking processes, reduces customer service costs, enhances the accessibility of fi ancial services, and allows banks to adapt more quickly to changes in customer behaviour. It was found that transparency measures, particularly the implementation of reporting standards, improve customer trust and loyalty. The study showed that corporate social responsibility initiatives positively impact banks' reputations and ensure compliance with regulatory requirements, collectively enhancing their competitiveness. The fi dings can be utilised by bank managers, policymakers, and regulators to develop strategies for improving operational effici cy, advancing digital services, strengthening customer trust, and ensuring the sustainable development of Ukraine's banking system

Keywords: fi ancial transformation; digital banking; governance effici cy; client trust; economic resilience; sustainable practices

Introduction

The domain of fi ancial innovations transforming banking systems is undergoing a rapid and continuous transformation within the global fi ancial system. However, the innovations leading to these developments have emerged as critical drivers of effici cy, transparency, and sustainability. Despite these signifi ant potentials, many challenges remain unsolved, such as the uneven development of digital technologies, the need for better transparency frameworks, and the alignment of banking practices with social responsibility. These issues must be addressed to build a strong, inclusive, and adaptable banking ecosystem capable of responding to the requirements of modern

Suggest Citation:
Koldovskiy, A., & Rekunenko, I. (2025). Driving fi ancial innovations: The role of digitisation, transparency, and social responsibility in banking systems. *Innovation and Sustainability*, 5(1), 31-43. doi: 10.63341/vis/1.2025.31.

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economies. As fi ancial systems have become more complex, the need for transparency and corporate responsibility has increased, and this study is motivated by the intersection of rapid technological development and these requirements. The Ukrainian banking sector provides a useful venue for this analysis, as signifi ant transformation has occurred to refl ct digitalisation initiatives and reforms in the banking regulatory system. The author aimed to understand how these forces interact and affect important outcomes such as operational effici cy, consumer trust, and institutional accountability.

Global banking practices and their implications for operational effici cy, compliance, transparency, and economic inclusivity are being transformed by fi ancial innovations, whose roles are evolving. Digitalisation was celebrated by Y. Zhu & J. Shanyue (2023) as an enabler of operational optimisation in banking while simultaneously incorporating environmental, social, and governance (ESG) targets. Their study highlighted how digital technologies increase resource allocation in banking and align banking activities with global sustainability goals. M.O. Al-Smadi (2023) examined the role of digital fi ance in enhancing access to banking services in MENA countries. His fi dings demonstrated that digital platforms play a critical role in closing the fi ancial inclusion gap and bringing cheaper, more user-friendly options to underserved populations and regions, thus creating opportunities for broader economic participation. Y. Chen *et al.* (2022) showed how digital fi ancial inclusion increases corporate economic productivity by improving both cash fl w management and investment strategies. These results are consistent with the Ukrainian banking trend, as evidenced by the active integration of digital tools to enhance competitiveness and economic effici cy. Another important aspect of building trust and equality in fi ancial systems is transparency. Transparent banking practices help reduce income gaps by equalising opportunities for access to fi ancial resources and strengthening stakeholder confide ce in the prospects of fair economic growth (Chia *et al.*, 2022). J.W. Goodell *et al.* (2020) emphasised that mechanisms of organisational transparency create trust and reduce the risks of bad decisions in volatile environments, thus fostering fi ancial stability. V. Gullo & P. Montalbano (2022) showed that measures to enhance transparency can improve investment decisions by increasing investor confide ce and attracting greater funding. Transparency is no longer merely a regulatory necessity but also a strategic advantage for institutions seeking sustainable growth. P. Hui *et al.* (2023) also demonstrated the role of fi ancial innovation in regional innovation capacities through the impact of digital fi ance on inclusiveness and technological advancement. The research showed how digital fi ancial solutions can empower small and medium-sized enterprises (SMEs) and enhance economic resilience in dynamic fi ancial ecosystems.

These studies provided a more complete picture of how fi ancial innovations, transparency, and digitalisation merge to redefi e the core structures of banking. These insights have signifi ant value for the Ukrainian banking sector, which must utilise these advances to build customer loyalty, fulfil regulatory requirements, and advance sustainable development in a progressively digitised monetary environment. Th s study synthesised these perspectives and positions the Ukrainian banking sector within the wider international discussion on digitisation, transparency, and social responsibility. It provided a nuanced assessment of how these configur tions interlock to enhance or obstruct fi ancial performance and stakeholder outcomes in a fast-moving economic environment.

Materials and Methods

Th s study employed an integrated approach that combined qualitative and quantitative methods to analyse the relationships between digitisation, transparency, and social responsibility in Ukrainian banking systems. To establish a theoretical framework, an extensive review of scholarly literature was conducted. Th s included international studies from databases such as Scopus and Web of Science, as well as research by Ukrainian researchers published in specialised economic journals. Key references included Y. Zhu & J. Shanyue (2023), who examined the impact of digital technologies on banking operational effici cy; P.S. Chia *et al.* (2022), who explored the importance of transparency for economic growth; and J.W. Goodell *et al.* (2020), who highlighted the role of fi ancial transparency in building customer trust. The data collection process relied on offic al statistical resources, including reports from the National Bank of Ukraine (Financial sector statistics, 2024; Monetary and fi ancial statistics, 2024), annual fi ancial statements of individual banks, regulatory documents, and industry-specific reports. Publications from leading international organisations, such as the International Monetary Fund (Global fi ancial stability report update, 2021) and the World Bank (World Bank's fall 2023..., 2023), were utilised to provide a comprehensive perspective. Th s approach aligns with comprehensive fi ancial analysis methods developed by A. Rybalko & O. Zaitsev (2020).

Data analysis was conducted using econometric methods, with a regression model developed to evaluate the effects of independent variables – digitisation, transparency, and social responsibility – on the dependent variable, return on assets (ROA). The model incorporated control variables, such as bank size, market concentration, and macroeconomic conditions. The model construction considered insights from previous studies and employed advanced techniques such as panel data analysis and time-series evaluation. Statistical software, such as Stata, was used to ensure the reliability and validity of the fi dings. The robustness of conclusions was tested using criteria including correlation coeffici ts, t-statistics, and p-values. To ensure representativeness, the study selected data from five banks representing different segments of Ukraine's banking market: state-owned, commercial, and international banks. The sample included PrivatBank, Oschadbank, Ukreximbank, Raiffeisen Bank Aval, and

OTP Bank. A key component of the methodology was the econometric model, designed to capture the multifaceted relationships between the studied variables. Th s model provided a systematic understanding of how digitisation, transparency, and social responsibility influence banking performance while excluding detailed results, which are presented in the Results section. Th s comprehensive methodology ensured a rigorous and detailed exploration of the dynamics shaping the Ukrainian banking sector, particularly in the context of modern challenges and opportunities. Data from fi ancial statements, annual reports, and regulatory filings of individual banks were utilised to ensure the accuracy and completeness of the dataset.

The study covered a period of five years, from 2019 to 2023, to capture recent developments and trends in the Ukrainian banking sector. Th s timeframe allowed for an analysis of the impact of digitisation, transparency measures, and social responsibility initiatives on the fi ancial performance and consumer perceptions of Ukrainian banks over time. Example of Ukrainian banks:

1. PrivatBank (as one of the largest banks in Ukraine, PrivatBank offers a wide range of banking services and has a signifi ant market share in the country's banking sector).

2. Ukreximbank (a state-owned bank specialising in export-import operations, Ukreximbank plays a pivotal role in facilitating international trade and fi ancing in Ukraine).

3. Raiffeisen Bank Aval (a subsidiary of Raiffeisen Bank International, Raiffeisen Bank Aval is a leading commercial bank in Ukraine, known for its innovative banking products and services).

4. Oschadbank (as the largest state-owned bank in Ukraine, Oschadbank serves as a key provider of retail and corporate banking services, with a wide network of branches across the country).

5. OTP Bank (a subsidiary of OTP Group, OTP Bank Ukraine offers a diverse range of banking products and services to individuals and businesses, with a focus on digital banking solutions).

These banks represent a diverse mix of state-owned, private, and foreign-owned institutions operating in Ukraine's banking sector, providing insights into the varying strategies and performance outcomes associated with digitisation, transparency, and social responsibility initiatives.

Results and Discussion

Digitalisation deals with the transition of banking procedures, services, and products into an online format, which gives rise to revenues from the area of information technology (Zhu & Shanyue, 2023). Th s transformative shift is referred to by terms such as online banking, mobile applications, digital payments, blockchain technology, and artific al intelligence (Polishchuk *et al.*, 2019). With digitisation, banking services have undergone a revolutionary transformation in how they are offered and consumed, featuring greater convenience, accessibility, and effici cy for customers. With the aid of digital technologies, the banking industry can automate repetitive tasks, simplify operations, and operations the overall quality of customer service. The digitalisation of banks generates a wide range of data, enabling managers to make data-driven decisions, personalise offerings, and design innovative solutions that align with clients' evolving interests.

The concept of banking transparency involves making public all key data concerning a bank's activities and operational performance for its stakeholders, namely its customers, investors, offi als, and society. Operating transparently fosters trust, accountability, and confide ce, leading to a thriving and stable banking ecosystem. Transparency encompasses multiple dimensions, including fi ancial reporting, risk disclosure, fee structures, terms and conditions, corporate governance, and more (Prokopenko *et al.*, 2022). By displaying their operations transparently, banks can build stronger relationships with the customers, instil confide ce in investors, ensure compliance with regulatory requirements, and mitigate reputational risks. Consequently, transparent banking operations contribute to effici t, stable, and trustworthy markets by reducing information asymmetry, preventing fraud or misconduct, and enabling stakeholders to make informed decisions.

Besides standard business ethics and sustainable practices, socially responsible banking must encompass a set of goals that transcend profit-making; therefore, maximising profit is not all that matters (Chia *et al.*, 2022). Banking in an era of escalating social and environmental challenges requires lenders to intentionally integrate social and environmental issues into their operations, business strategies, and decision-making processes. A socially responsible asset base includes a wide range of initiatives, such as improving environmental sustainability, increasing accessibility of fi ancial services for economically marginalised individuals, community development, philanthropy, and ethical investments (Goodell *et al.*, 2020). Social responsibility provides an invaluable pathway for banks to establish a strong reputation, attract and retain customers, mitigate risks, and make a positive social and environmental impact. What makes this even more important is the shift in customer preferences, emerging regulatory expectations, and evolving global sustainability goals, which position banks as ideal candidates to assume the role of socially responsible corporations and drivers of positive change in the community.

The fi ancial sector is constantly evolving due to the influence of digitalisation, transparency, and social responsibility, all of which are evident in contemporary banking practices (Myronchuk *et al.*, 2023). The adoption of digital technologies, championing transparency, and promoting social accountability can ensure competitiveness, sustainability, and resilience for banks in the challenging and complex global marketplace (Sapiński, 2023). Recognising the signifi ance of these elements is a critical responsibility for bank directors, regulators, policymakers, and other stakeholders. Th s recognition is crucial in the current era of digitalisation, where it is necessary to identify both

opportunities and challenges to build a secure, transparent, and sustainable banking ecosystem. For banking systems to anticipate the future development of digitalisation, transparency, and sustainability (Hui *et al*., 2023), it is essential to understand the dynamics of these factors. Together they support innovation, foster trust, and establish the long-term viability of the fi ance industry.

The digital age is characterised by rapid technological advancement, new consumer perspectives, and increased regulatory scrutiny. Th s period highlights the interconnection between digitisation, transparency, and social responsibility as key factors transforming banking systems worldwide (Leonov *et al*., 2024). By examining these factors in depth, stakeholders can gain a clear understanding of the challenges and opportunities that await them amidst the evolving fi ancial landscape, which comprises an interconnected, digital, and socially aware ecosystem requiring thorough analysis (Verbivska *et al*., 2023). Digitisation is reshaping traditional banking features and equipping institutions to enhance performance effici cy, expand market reach, and deliver innovative goods and services that align with the needs of modern customers (Matyushenko *et al*., 2022). Understanding the role of digitalisation in banking is vital, as it aids in identifying existing and emerging trends, spotting signifi ant market opportunities, and implementing preventive measures against the risks posed by disruptive technologies.

Transparency plays a critical role, encompassing openness towards customers and clarity in investment and regulatory matters. Consequently, trust and accountability arise as customers, investors, and regulators gain confide ce in banks (Liu *et al*., 2021). Financial institutions must foster consistency, transparency, and integrity in their operations to build stronger relationships with investors, address reputational risks, and adapt to evolving regulatory requirements. Recognising the importance of transparency is essential for creating an open environment, improving market effici cy, and ensuring system stability within the interconnected fi ancial world. Additionally, the concept of social impact has become a defi - ing attribute of modern banking, serving as a key driver of long-term economic development while adhering to ethical and sustainable business principles. Social awareness in the banking sector involves addressing societal challenges, promoting fi ancial inclusion, and ultimately contributing to sustainable social and environmental conditions. It is essential to recognise that social mobility is one of the most important factors in banking systems, as it helps to meet not only the diverse beliefs of consumers but also to attract socially conscious investors while adhering to regulatory requirements aimed at promoting sustainable development and responsible fi ance (Lucey *et al*., 2023). In this era of integrating digitalisation, transparency, and the prioritisation of social responsibility, banking systems face signifi ant challenges in how they function, interact, and evolve (Nair *et al*., 2019). By thoroughly understanding these factors, stakeholders can capitalise on innovative ideas, build robust and sustainable business models, and develop banks that are transparent, inclusive, and socially responsible – serving everyone from adults to children.

The banking industry is undergoing dynamic digitalisation, driven by advancements in technology, evolving laws and regulations, and shifting consumer demands, all of which influence the sector's transformation. In this fast-changing environment, managers need a comprehensive understanding of the factors influencing banking performance, given the complexity of the industry. By examining the interplay of these elements, the authors aim to identify the driving forces and critical factors that contribute to fi ancial innovation and sustainability in banking systems. Digital banking platforms, mobile applications, and online payment systems have entered the market alongside traditional banks. As a result, automated customer service, fast and convenient banking solutions, and universally accessible fi ancial services should be key priorities for any modern fi ancial institution. While digitisation in banking has the potential to impact performance, its broader implications remain an area of active research. By exploring transparency measures such as disclosure policies and regulatory compliance scores, the authors seek to evaluate their impact on return on assets (ROA) and gain insights into the relationship between transparency and fi ancial performance. Transparency is a pivotal factor that influences banking performance, enhancing trust, accountability, and compliance with fi ancial regulations. The complete transparency of fi ancial disclosures, including governance processes and risk management practices, is a key requirement to foster positive relationships with stakeholders and ensure the stability of banking systems. By examining transparency measures such as disclosure policies and regulatory compliance grades, the authors aim to determine how these efforts affect an organisation's profitability and the role transparency plays in its fi ancial health.

Corporate social responsibility (CSR) has gradually evolved into a signifi ant driver of sustainable banking, primarily through initiatives addressing societal and environmental issues. Banking institutions that invest in CSR projects, such as fi ancial inclusion programmes, community development initiatives, and environmental sustainability efforts, are likely to be perceived positively by socially conscious customers, thereby reducing risks related to brand image. Th s study aimed to investigate the impact of CSR budgets and sustainability actions on ROA, providing insights into the economic implications of socially responsible banking practices. A simplifi d and visually appealing study model (Fig. 1) illustrates the interdependence among the independent variables (digitalisation, transparency, corporate social responsibility), the intervening factors (customer satisfaction, market dynamics, corporate governance), and the dependent variables (banking performance, consumer trust, brand reputation, regulatory compliance).

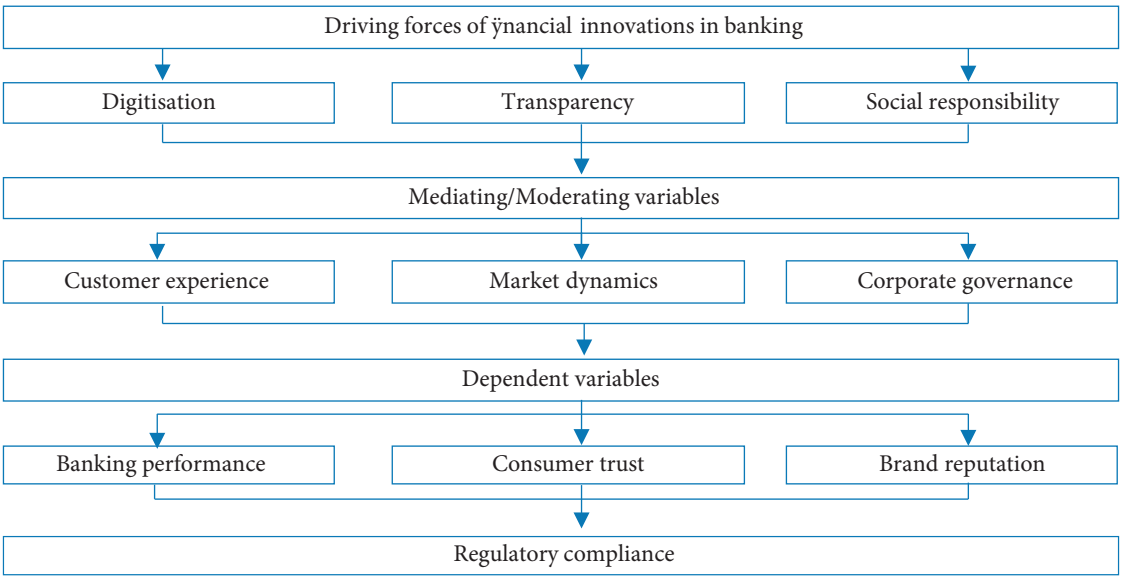

Figure 1. Depiction of the study model

Source: authors' development

Developing an econometric model involves specifying a mathematical framework that captures the relationships among key variables in the context of the research question. Model specifi ation:

$$ROA_i = \beta_0 + \beta_1 \times Digitisation_i + \beta_2 \times Transparency_i + \beta_3 \times \times SocialResponsibility_i + \beta_4 \times Size_i + \beta_5 \times \times MarketConcentration_i + \beta_6 \times EconomicConditions_i + \epsilon_i, \quad (1)$$

where ROA_i is the return on assets for bank *i*; $Digitisation_i$, $Transparency_i$, and $SocialResponsibility_i$ are the respective independent variables for bank *i*; $Size_i$, $MarketConcentration_i$, and $EconomicConditions_i$ are control variables; β_0 is the intercept term; β_1, β_2, β_3, β_4, β_5, β_6 are the coeffici ts to be estimated; and ϵ_i is the error term.

The econometric model, which is qualitative in nature, was developed to provide a clear understanding of the multifaceted factors responsible for banking productivity, with the aim of determining how digitisation, transparency, and social responsibility contribute to performance levels. The model's complexity is mitigated by focusing on ROA, as this indicator is widely regarded as refl cting both profitability and overall bank performance. ROA is calculated as net income divided by total assets. It is considered one of the most widely used and respected measures of fi ancial performance in the credit union sector (Table 1).

Table 1. Structure of the model

No.	Variable	Title	Description
1.	Dependent variable	ROA	A measure of profitability, calculated as net income divided by total assets
2.	Independent variables	a) digitisation	Digital banking adoption rate (proportion of customers using digital banking services)
			Investment in technological infrastructure (capital expenditure on digitisation initiatives)
		b) transparency	Transparency index (a composite measure of the transparency level of banking institutions)
			Regulatory compliance score (the degree to which banks adhere to regulatory reporting standards)
		c) social responsibility	CSR expenditure (investment in corporate social responsibility initiatives)
			Sustainability index (a measure of environmental and social sustainability practices)
3.	Control variables	Size of the bank	Total assets of the bank
		Market concentration	Market share of the bank within its operating region
		Economic conditions	GDP growth rate or other macroeconomic indicators

Source: authors' development

Th s model includes independent, as well as control variables, to account for the presence of other factors while explaining banking performance and their influence on such performance. Market size, bank concentration, and economic conditions act as control parameters explaining, changes in the banking environment and providing a general economic overview. A bank's size quantifies its total assets, which explains differences among banking institutions

in terms of operational scale. The market concentration coefficient is measured by quantifying the market share of the bank in its locality, allowing an analysis of competition levels in the market. Economic indicators, including GDP growth rate, inflation, and prevailing interest rates, reflect how the banking system's macroeconomic purpose interacts with broader economic factors. The model is expressed as a multiple regression equation consisting of an unobserved constant, observable independent variables (digitisation, transparency, social responsibility), and control variables (e.g., country, size, etc.), with a dependent variable (ROA). Sophisticated econometric techniques, such as instrumental variable regression, panel data analysis, and time series analysis, are used to address issues of endogeneity, unobserved heterogeneity, and dynamic effects.

The econometric model studied supports financial innovations (analysed in depth) and the impact of these innovations on banking systems. The sample for this econometric model comprises a crosssectional dataset of Ukrainian banks operating in the country's banking sector. The selection criteria include publicly listed banks with comprehensive financial data available and a diverse range of sizes and business models within the Ukrainian banking industry. The primary data source for this study is the National Bank of Ukraine, which provides comprehensive financial data on banks operating in the country. The regression model enhances transparency and serves as a foundation for evaluating the influence of digitalisation, transparency, and social responsibility on ROA (Fig. 2). These studies have significant implications for banks operating within the Ukrainian financial environment. They anticipate risks as new technological solutions emerge, while also highlighting opportunities arising from the evolution of banking services.

	Robust				
ROA	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval
Digitization	0.0324**	0.0113	2.88	0.005	0.0102 0.0547
Transparency	0.016	0.0088	1.82	0.073	-0.0015 0.0335
Social Responsibility	0.020**	0.006	3.36	0.001	0.0082 0.0321
Size	0.012**	0.0028	4.39	0.000	0.0068 0.0179
Market Concentration	0.009**	0.0032	2.78	0.007	0.0025 0.0150
Economic Conditions	0.006**	0.0024	2.32	0.023	0.0008 0.0105
Constant	0.073	0.044	1.65	0.102	-0.0148 0.1606

Heteroskedasticity Tests:
Breusch-Pagan / Cook-Weisberg chi2(1) = 10.05, p = 0.0015
White's test chi2(1) = 8.92, p = 0.0028

Serial Correlation Tests:
Breusch-Pagan / Cook-Weisberg LM test chi2(1) = 3.79, p = 0.0516
ARCH LM test chi2(1) = 2.61, p = 0.1060

Figure 2. Results and diagnostics of the model in the Stata program
Source: authors' calculations based on Financial sector statistics (2024), Monetary and financial statistics (2024)

The coefficient for digitisation (digital banking adoption rate) is statistically significant ($t = 2.88$, $p < 0.01$), indicating that an increase in digital banking adoption positively influences ROA among banks in Ukraine. For example, for every 1% increase in the digital banking adoption rate, there is a corresponding increase in ROA of approximately 0.0324 units. This suggests that banks in Ukraine can improve their profitability by expanding their digital banking offerings and enhancing their technological infrastructure to meet the growing demand for digital financial services among consumers. Although the coefficient for transparency (transparency index) is positive, it is not statistically significant at the conventional level ($t = 1.82$, $p = 0.073$). While the results suggest a positive relationship between transparency and ROA, further improvements in transparency practices, such as enhancing financial reporting standards and disclosure policies, may be necessary to yield significant impacts on banking performance. The coefficient for social responsibility (CSR expenditure) is statistically significant ($t = 3.36$, $p < 0.01$), indicating that higher investment in corporate social responsibility initiatives positively affects ROA for banks in Ukraine. For instance, for every unit increase in CSR expenditure, there is a corresponding increase in ROA of approximately 0.0201 units. This underscores the importance of integrating social and environmental considerations into banking operations to enhance brand reputation, attract socially conscious customers, and drive sustainable financial performance. The coefficients for control variables, such as bank size, market concentration, and economic conditions, are all statistically significant ($p < 0.05$), indicating their influence on banking performance. Increased market concentration is associated with higher ROA, suggesting that banks with larger market shares may enjoy pricing power and customer loyalty. Favourable economic conditions, such as higher gross domestic product (GDP) growth rates, are positively correlated with ROA, reflecting the overall health of the economy and its impact on banking profitability. Diagnostic tests reveal evidence of heteroscedasticity in the residuals, as indicated by the Breusch-Pagan / Cook-Weisberg test (chi2(1) = 10.05, $p = 0.0015$) and White's test (chi2(1) = 8.92, $p = 0.0028$). Additionally, there is marginal evidence of

serial correlation in the residuals, as suggested by the Breusch-Pagan / CookWeisberg LM test (chi2(1) = 3.79, $p = 0.0516$) and ARCH LM test (chi2(1) = 2.61, $p = 0.1060$). Regression analysis demonstrates that digitalisation, transparency, and social responsibility are critical factors influencing the performance of the banking system in Ukraine. Digital innovation, when combined with transparency practices and effective social responsibility initiatives, allows banks to gain a competitive edge and build stakeholder trust, thereby ensuring fi ancial sustainability.

Findings from the empirical study unveil several key insights into the dynamics of banking performance within the studied context. The analysis highlights a statistically signifi ant positive relationship between digitisation and banking performance, indicating that banks adopting digital banking channels tend to experience higher profitability. Th s underscores the pivotal role of digitisation in enhancing operational effici cy, expanding customer reach, and ultimately driving fi ancial performance in the banking sector. While transparency measures are found to have a positive association with banking performance, the relationship lacks statistical signifi ance, suggesting that other factors may exert a more substantial influence in this regard. The study reveals a signifi ant positive impact of social responsibility on banking performance, with banks allocating resources to corporate social responsibility initiatives achieving higher profitability. Control variables, such as bank size, market concentration, and economic conditions, exhibit signifi ant associations with banking performance, highlighting the complex interplay of factors shaping profi ability.

Diagnostic tests reveal evidence of heteroscedasticity and marginal evidence of serial correlation in the regression residuals, highlighting the need to address these issues to ensure the reliability and validity of the empirical fi dings. The empirical study provides valuable insights into the multifaceted factors influencing banking performance, offering actionable recommendations for banks to enhance their competitive position and achieve sustainable growth in the studied context. Table 2 comprehensively illustrates, with a high level of detail, the influence of digitisation on operational processes, customer behaviour, and fi ancial inclusion. It underscores the transformative power of digitisation to simplify processes, accelerate customer interactions, and boost fi ancial inclusion and empowerment across diverse market segments. Highly digitised banking has become a reality, with signifi ant impacts on operational effici cy, customer behaviour, and fi ancial inclusion. Th ough the adaptation of digital services, banks can expedite service delivery, strengthen customer engagement, and enhance fi ancial inclusion, thereby fostering economic empowerment and inclusive growth.

Table 2. The impact of digitisation on banking operations, customer behaviour, and fi ancial inclusion

No.	Aspect	Description
1. Banking operations		
1.1	Streamlined processes	Digitisation has profoundly transformed traditional banking operations by automating processes such as account opening, transaction processing, and loan approvals. Technologies such as Robotic Process Automation (RPA) streamline workfl ws, minimise errors, reduce costs, and improve effici cy. Real-time data analytics and predictive modelling further enhance decision-making and risk management strategies
1.2	Enhanced customer service	Digital channels provide customers with convenient access to banking services, enabling transactions, account inquiries, and assistance anytime and anywhere. AI and chatbots deliver personalised recommendations and address a wide range of queries, offering roundthe-clock support. Th s improves customer satisfaction, reduces processing times, and fosters meaningful engagement
1.3	Cybersecurity measures	With the rise of digital banking, robust cybersecurity measures are critical to protecting customer accounts and sensitive information. Banks are implementing advanced encryption techniques, biometric authentication, and fraud detection systems to mitigate risks associated with digital transactions. Proactive monitoring, threat intelligence sharing, and employee training form key elements of cybersecurity strategies, enabling banks to address evolving threats in the digital space
2. Customer behaviour		
2.1	Shift in hannel preference	Digital banking channels have expanded rapidly, driving a shift in ustomer behaviour towards online and mobile banking services. Customers' desire for convenience and timesaving opportunities offered by digital platforms, which enable them to perform various activities without visiting a physical branch, suggests that this is their preferred mode of banking. These changes necessitate banks providing user-friendly interfaces, seamless omnichannel experiences, and superior personalised services to enhance customer satisfaction and loyalty
2.2	Data-driven personalisation	Digitalisation enables banks to leverage data and analytics to align offerings with customer needs and preferences, allowing for enhanced personalisation and targeted services. By employing state-of-the-art analytics and machine learning techniques, banks can not only understand client behaviour but also identify transaction trends and preferences. Th s data can be used to develop more appealing product recommendations, campaigns, or pricing strategies. Such tailored approaches foster customer engagement and form the foundation of successful customer relationships
2.3	Adoption of fi ancial management tools	Digital banking services empower customers by providing tools such as banking apps, expense trackers, budgeting applications, and fi ancial planning calculators. These tools enable customers to take greater control of their fi ances, acting as self-managers by setting savings, investment, or budgeting goals. By promoting fi ancial literacy and customer empowerment, banks can play a pivotal role in fostering fi ancial resilience, which strengthens customer loyalty and long-term engagement

Continued Table 2

No.	Aspect	Description
3. Financial inclusion		
3.1	Access to underserved markets	Digitalisation is essential for extending fi ancial services to unbanked and underbanked communities, making fi ancial services more inclusive and expansive. Mobile banking and agent banking networks provide a cost-effective and scalable opportunity to reach areas lacking conventional banking infrastructure, such as remote and rural regions. Access to banking services, including savings accounts, remittance facilities, and microloans, offers marginalised groups greater opportunities for economic and social inclusion, fostering fairness and stimulating activity
3.2	Digital identity and KYC solutions	Digital identity solutions, particularly biometric authentication and electronic KYC procedures, enable banks to onboard customers remotely, eliminating the need for physical visits to branches. These options ensure an effici t application process, reduce administrative burdens, and provide greater convenience for individuals with transportation challenges or limited documentation. Digital KYC solutions also help meet regulatory requirements while safeguarding customers' personal data against potential misuse.
3.3	Financial education and literacy	Digitisation creates a platform for delivering fi ancial education and literacy programmes to underserved communities through digital media. Banks can leverage online resources such as learning platforms, interactive modules, and mobile applications to teach individuals about fi ancial principles, smart budgeting, responsible saving, and borrowing. Active fi ancial literacy campaigns can promote informed fi ancial decisions, encourage saving habits, and facilitate access to formal fi ancial services, ultimately contributing to economic empowerment and long-term fi ancial stability

Source: authors' development

Experimental results confi m the model, highlighting the connection between digital transformation, transparency, social responsibility, and banking performance. The positive correlation between the progress of digitisation in banking operations and the performance metrics of banks underscores the pivotal role of technology in driving business effici cy, customer satisfaction, and fi ancial outcomes. By embracing digital transformation, banks can streamline operations, better meet customers' needs, and seize new business opportunities, as the theoretical framework suggests. Similarly, the empirical methodology underscores the role of transparency procedures in fostering trust and accountability within banking organisations. Banks that prioritise transparency through regulatory disclosure policies and robust reporting procedures are better equipped to mitigate information asymmetry, attract investments, and achieve sustained growth. Th s consistency with the theoretical framework indicates that transparency reduces investors' risks, enhances market sentiment, and consequently improves banks' fi ancial performance. Empirical evidence further supports the notion that CSR has a direct positive relationship with consumer trust and brand reputation. Additionally, CSR initiatives help banks comply with regulatory requirements while creating value for both the institutions and their stakeholders.

The empirical results have important implications for the performance of banking organisations, regulators, and stakeholder groups collectively, calling for strategic action across multiple areas. Recommendations emphasise the importance of banking institutions staying ahead in banking technology by allocating suffici t resources to business advancement. Th s includes developing a datarich technological infrastructure, enhancing data analytics capabilities, and strengthening cybersecurity measures. It is also important to foster a culture of innovation, flex bility, and continuous improvement to address market uncertainties and evolving customer preferences. There is an increasing need for greater transparency in banking institutions, focusing on accountability at all levels, establishing clear disclosure and reporting frameworks, and strengthening governance to gain a competitive edge and rebuild investor trust. Th s also requires creating platforms for open dialogue and transparency with stakeholders on topics such as fi ancial performance, risk management, and regulatory issues. Another priority is to enhance social responsibility, with banks being encouraged to integrate social and environmental considerations into their products and strategies and to strengthen relationships with the communities they serve. As shown in the study, initiatives such as ethical lending, community development projects, and sustainability programmes can signifi antly enhance societal well-being, brand reputation, and stakeholder trust.

The fi dings are also signifi ant for policymakers, who should develop regulatory frameworks that promote transparency, customer orientation, and ethical banking. Financial institutions should be encouraged to integrate social and environmental parameters into their operations and comply with reporting standards through appropriate legislation. Another critical area is fi ancial inclusion, with policymakers encouraged to design programmes that extend fi ancial services to underserved populations, particularly in remote areas. The paper further recommends creating incentive systems for banks that innovate to meet the needs of diverse customer segments and fostering partnerships between governmental, fi ancial, and non-governmental organisations to improve fi ancial literacy. At the same time, strengthening regulatory oversight is equally critical and should ensure compliance with transparency standards, consumer rights, and ethical lending practices. To ensure fi ancial system stability, policymakers should proactively monitor market dynamics, emerging risks, and technological advancements to extend and adapt legislative frameworks. The sharing of best practices with international organisations and industry stakeholders is crucial for maintaining global fi ancial stability.

For stakeholders, their aim is to support the call for transparency and sustainable banking practices. Th s involves backing banks that prioritise integrity, accountability, and ethics, while consistently demanding the disclosure of information to ensure accountability in executive decision-making. Stakeholders should advocate for sustainable investment approaches, responsible lending, and impact investment, which balance economic, social, and environmental benefits. By engaging in shareholder activism and supporting advocacy campaigns, stakeholders can influence banks to adopt better corporate practices. Financial education and the promotion of literacy are also crucial. Stakeholders can encourage banks, schools, and community-based organisations to collaborate in creating customised fi ancial services that address the needs of various societal groups. They can also work with banks to implement programmes that enhance individuals' fi ancial skills and decision-making capabilities. Combined, these measures aim to improve the resilience, inclusivity, and ethical orientation of the banking sector. Th ough a multifaceted approach, sustainability is integrated into core corporate strategies, enhancing transparency, fostering innovation, engaging stakeholders, improving fi ancial literacy, applying social responsibility in supply chain management, and measuring progress effectively.

The integration of sustainability into a bank's corporate strategy must be prioritised. Th s involves embedding sustainability into the organisation's core objectives, with clearly defi ed goals, key performance indicators (KPIs), and alignment with Environmental, Social, and Governance (ESG) responsibilities. The successful implementation of these initiatives, including the incorporation of sustainability considerations into decision-making processes at all organisational levels (Prokopenko *et al*., 2024), requires strong leadership commitment. Transparency and disclosure are critical in this context. Establishing best practices for fi ancial reporting, including comprehensive disclosures of ESG performance, climate risks, and social impact metrics, is essential. The adoption of international standards, such as the Global Reporting Initiative (GRI) and the Task Force on Climate Related- Financial Disclosures (TCFD), would improve comparability and enable stakeholders to make more informed decisions. Increased transparency arrangements are a means to strengthen trust, accountability, and stakeholder involvement. An additional key recommendation is to invest in responsible digital innovation. Technologies such as blockchain, AI, and big data must be leveraged by banks to create innovative solutions that address social challenges, expand fi ancial access, and protect the environment. Th s presents opportunities for collaboration with fi tech innovators, researchers, and civil society organisations to design responsible digital strategies that promote social well-being. Sustainable banking requires active engagement with stakeholders and communities. Th s includes fostering interaction with customers, employees, regulators, and local communities to identify their expectations and concerns regarding sustainability. By prioritising dialogue, incorporating feedback, and involving stakeholders in decision-making, banks can build trust and create a socially conscious, transparent environment. The successful establishment of sustainable banking frameworks with positive social, economic, and environmental impacts would necessitate strategic partnerships with key stakeholders.

Financial literacy and inclusion are equally important. Th s involves teaching fi ancial education classes, implementing digital literacy projects, and hosting community outreach events to enhance fi ancial awareness, improve saving habits, and support responsible lending. These initiatives can be expanded to increase fi ancial access in underserved markets through collaborations with educational institutions, non-profit organisations, and government agencies. Suppliers face corporate sustainability responsibilities that extend beyond internal operations, embedding sustainability in supply chain management. Banks involved in supply chain lending should identify and address ESG risks in their supply chains, prioritise ethical sourcing, and incorporate sustainability criteria into procurement processes. Banks that reward greener decisions and assist suppliers in meeting ethical standards enable organisations to achieve environmental objectives and better sustainability outcomes throughout the supply chain. Accountability requires robust systems for measuring, monitoring, and reporting progress. Systems for rigorous tracking of sustainability targets and identifying opportunities for improvement should be established. Measuring comprehensive ESG performance and providing transparent reporting to stakeholders, along with regular audits, are essential. Th s will not only enhance the credibility of sustainability reports but also enable their continuous improvement. These strategies, implemented by banks, can help improve their sustainability practices, build stakeholder trust, and contribute positively to social, environmental, and economic development. Th s comparison underscores the multifaceted nature of driving fi ancial innovations within banking systems and highlights the importance of addressing corruption, enhancing lending practices, leveraging digital fi ance for sustainable development, and promoting fi ancial inclusion and stability. The fi dings of the study complement and reinforce many insights provided by previous researchers, emphasising the importance of digitisation, transparency, and social responsibility in fostering fi ancial innovations within banking systems.

Promoting fi ancial literacy and inclusion is vital for empowering individuals and communities to make informed fi ancial decisions and access formal fi ancial services. Banks should prioritise investments in fi ancial education programmes, digital literacy initiatives, and community outreach efforts to enhance fi ancial awareness, cultivate saving habits, and encourage responsible borrowing practices. Collaboration with educational institutions, non-profit organisations, and government agencies can amplify the impact of fi ancial literacy initiatives and drive positive social change. Bank services should

extend their commitment to social responsibility beyond internal operations, embedding these principles within supply chain practices. Responsible procurement involves the identifi ation and management of ESG risks along the supply chain, the encouragement of ethical and sustainable sourcing, and the provision of support to suppliers who meet sustainability requirements. Incorporating sustainability standards into procurement processes for vendors and supplier contracts enhances sustainable manufacturing practices and aligns organisational activities with overarching sustainability goals. Finally, establishing robust monitoring and reporting metrics is crucial for tracking progress toward sustainability-related targets, identifying areas for improvement, and demonstrating accountability to stakeholders. Banking institutions should focus on improving the performance of ESGcompliant supply chains, conducting regular audits, assessing and reporting sustainability data with accuracy and transparency. Ensuring the participation of external stakeholders, such as sustainability rating agencies and industry standards bodies, will enhance product credibility and ensure compliance with third-party evaluations. These measures will support banks in enhancing the effici cy of their approaches to sustainable fi ancing practices and advancing their triple bottom line encompassing social, economic, and environmental objectives. Incorporating sustainable development as a core value and an integral component of a bank's business strategy helps safeguard against reputational risks, improves customer receptivity, and uncovers new opportunities for innovation, growth, and the generation of longterm value.

The authors compared the study's fi dings with the literature, emphasising the alignment, differences, and broader implications of digital transformation efforts in Ukrainian banks. Y. Zhu & J. Shanyue (2023) highlighted the signifi ant positive impact of digitisation on operational effici cy and ESG performance. Their fi dings align with this study, which also observed increased operational effici cy and improved customer satisfaction in Ukrainian banks following digitisation. Th s correlation underscores the universal benefits of digitisation efforts across various banking systems. M.O. Al-Smadi (2023) emphasised digital fi ance's potential to enhance fi ancial inclusion. While this study did not directly address fi ancial inclusion, it identifi d increased customer trust and satisfaction in Ukrainian banks, indirectly facilitating broader fi ancial accessibility. Both studies converge on the notion that enhanced trust and satisfaction are critical components of inclusive fi ancial ecosystems. Y. Chen *et al.* (2022) focused on the economic implications of digital fi ancial inclusion, noting improved banking performance and consumer trust as drivers of economic growth. Similarly, this study found that digitisation in Ukrainian banks has bolstered operational effici cy and consumer trust, aligning with broader economic benefits suggested by Y. Chen *et al.* (2022). Th s connection illustrates the potential of digital initiatives to contribute to economic recovery and growth. P.S. Chia *et al.* (2022) underscored the importance of transparency in fostering equitable economic development. The fi dings of this study complement their observations by demonstrating a positive correlation between transparency measures and consumer trust in Ukrainian banks. Th s shared emphasis highlights transparency as a cornerstone for equitable and sustainable economic frameworks. J.W. Goodell *et al.* (2020) investigated transparency practices in fi ancial institutions, concluding that transparency enhances stakeholder trust. Although their study examined a broader range of institutions, the results align with this research, which identifies transparency as a critical factor in fostering trust within Ukrainian banks. Both studies reinforce the role of transparency as a motivator for stakeholder engagement and confide ce.

V. Gullo & P. Montalbano (2022) explored how fi ancial transparency influences investment decisions, suggesting that transparency fosters trust and attracts investments. Th s study supports their conclusion, demonstrating that transparency measures in Ukrainian banks enhance consumer trust, which may lead to increased investment fl ws. These fi dings collectively affirm transparency's dual role in building trust and stimulating economic activity. P. Hui *et al.* (2023) investigated the role of digitisation in revitalising banking operations and enhancing customer experiences. Their observations are consistent with this study's fi dings, which indicate that digitisation efforts in Ukrainian banks have improved operational effici cy and customer satisfaction. Both studies underscore digitisation as a catalyst for innovation and customer-centric transformations in the banking sector. T.U. Kame Babilla (2023) examined digital innovation's role in enhancing fi ancial access for SMEs. While this study did not focus exclusively on SMEs, the improvements in customer trust and banking operations observed may indirectly benefit these enterprises. Th s alignment highlights the indirect but signifi ant impact of digitalisation on supporting SME growth and resilience. Liu *et al.* (2022) discussed the role of digital finance in post-COVID-19 economic recovery, highlighting its contribution to stimulating economic growth through improved banking operations and trust. The fi dings of this study align with their conclusions, demonstrating that digitisation in Ukrainian banks has positively influenced banking performance and trust, contributing to broader economic recovery efforts. P. Janský *et al.* (2023) assessed global progress towards fi ancial transparency, emphasising its role in fostering trust and stability. Th s study complements their analysis by demonstrating how transparency measures in Ukrainian banks enhance stakeholder trust, aligning with global discussions on fi ancial accountability and stability. The fi dings of this study resonate with contemporary research, emphasising the transformative potential of digitisation and transparency in banking. Key areas of alignment include the enhancement of operational effici cy, consumer trust, and fi ancial inclusion. By integrating these insights, Ukrainian banks can further leverage digital and transparent practices to foster economic growth and resilience while addressing broader ESG objectives.

Conclusions

Th s study explored the impact of digitisation, transparency, and social responsibility on fostering fi ancial innovation in the banking industry, with a particular focus on the Ukrainian banking sector. A comprehensive methodological approach was employed, combining qualitative and quantitative data analysis, supported by econometric modelling. The analysis utilised data from reports of the National Bank of Ukraine, fi ancial statements, and regulatory filings of key Ukrainian banks, providing a robust foundation for the study's fi dings.

The research revealed that digitisation signifi antly enhances operational effici cy, streamlines internal processes, and improves customer experience by offering more convenient and accessible banking services. Transparency measures were shown to play a critical role in fostering consumer trust, ensuring accountability, and improving fi ancial performance. Banks that embraced higher transparency levels were found to attract investment and manage risks more effectively. Corporate social responsibility initiatives positively impacted the reputation of fi ancial institutions, reinforced regulatory compliance, and contributed to customer loyalty by aligning bank operations with societal values. One of the study's key outcomes was the development of an econometric model that analysed the relationships between key variables, such as digitisation, transparency, and social responsibility, and their influence on bank performance metrics like ROA. The analysis identifi d clear correlations, offering valuable insights for strategic decision-making in the banking sector. The study also provided recommendations tailored to Ukrainian banks, emphasising the importance of integrating digital solutions, promoting transparency, and leveraging social responsibility to enhance resilience and competitiveness. Future research could focus on the role of emerging technologies, such as artific al intelligence, blockchain, and digital currencies, in reshaping fi ancial systems. Assessing the effectiveness of regulatory frameworks in driving innovation and fostering fi ancial stability presents an important avenue for further exploration. Th s study contributes to the understanding of how digitisation, transparency, and social responsibility collectively shape the development of banking systems. By addressing these dimensions, banks can better navigate changing market dynamics and regulatory environments, establishing more robust, inclusive, and sustainable institutions capable of meeting society's growing expectations.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Стимулювання фінансових інновацій: роль цифровізації, прозорості та соціальної відповідальності в банківських системах

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Анотація. Дослідження фінансових інновацій у банківських системах є надзвичайно актуальним у сучасних умовах глобальної цифровізації, зростання вимог до прозорості та посилення значення корпоративної соціальної відповідальності. Ці аспекти є визначальними для зміцнення довіри споживачів, підвищення ефективності банківських операцій та забезпечення стійкості банківської системи в Україні. Метою дослідження було вивчення фінансових інновацій у банківських системах з акцентом на взаємозв'язку цифровізації, прозорості та соціальної відповідальності. Для проведення дослідження використовувалися кількісні та якісні методи, включаючи аналіз фінансової звітності банків, нормативних документів і звітів Національного банку України за період 2019-2023 років. Економетричне моделювання дозволило визначити ключові фактори, що впливають на показники ефективності банківських операцій, такі як рентабельність активів, сприйняття клієнтами та рівень фінансової стійкості. Результати дослідження засвідчили, що цифровізація сприяє автоматизації банківських процесів, зменшенню витрат на обслуговування клієнтів, підвищує доступність фінансових послуг і дозволяє банкам швидше адаптуватися до змін у поведінці клієнтів. Було з'ясовано, що заходи з прозорості, зокрема впровадження стандартів звітності, підвищують довіру клієнтів і рівень їхньої лояльності. Досліджено, що ініціативи корпоративної соціальної відповідальності позитивно впливають на репутацію банків і забезпечують відповідність регуляторним вимогам, що в сукупності підсилює їх конкурентоспроможність. Отримані результати можуть бути використані керівниками банків, політиками та регуляторами для впровадження стратегій покращення операційної ефективності, розвитку цифрових послуг і зміцнення довіри клієнтів

Ключові слова: фінансова трансформація; цифровий банкінг; ефективність управління; довіра клієнтів; економічна стійкість; стійкі практики

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 19.11.2024; Revised: 20.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.44

UDC 658.5:004

Challenges and obstacles to the digitalisation of logistics at the local level

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Abstract. The article examined the challenges and barriers arising from the rapid development of digitalisation, which is signifi antly transforming the business environment and creating new obstacles for enterprises at the local level. In the contemporary context, addressing these challenges is essential for the effective implementation of digital technologies to enhance enterprise competitiveness and mitigate potential risks. The study aimed to systematise and analyse the key challenges and obstacles to the digitalisation of logistics at the local level and to develop strategies for overcoming them. Th s research was based on an analysis of academic publications and statistical data. Methods of comparative analysis, systematisation, and generalisation were applied. The main challenges and obstacles were categorised into five key groups – economic, technological, organisational, legal, and social – which hinder the adoption of digital solutions. Economic challenges are associated with limited fi ancial resources and the high cost of technology. Technological aspects include inadequate infrastructure and information security issues. Organisational challenges stem from resistance to change and a lack of strategic vision, while legal challenges arise from inconsistencies in legislation and the ambiguous conceptual framework of the digital economy. Social challenges are linked to the need for workforce retraining and staff shortages. A strategy has been proposed to address each group of challenges, including the development of government programmes, improved access to digital technologies, and the introduction of educational initiatives. The practical value of the study lies in the potential application of the proposed strategies by enterprises and organisations to enhance logistics processes within the context of digital transformation. The fi dings may serve as a basis for developing a strategy for the digitalisation of logistics processes, taking regional specific ties into account

Keywords: digital transformation; logistics processes; logistics automation; business models; digital tools; overcoming strategies; region

Introduction

Digitalisation has emerged as a dominant trend since the 2020s, showing no signs of slowing down. Technology companies are set to be the primary investors in the continued advancement of digitalisation, permeating all aspects of life, particularly the business environment. These companies are setting the standards and conditions which businesses must acknowledge to remain competitive and profitable amidst rapid informational changes. Logistics is a particularly popular area for improving the implementation and integration of digital technologies. Companies are actively working to increase the speed of material fl w deliveries, reduce information fl w processing times, and enhance end-user service to maintain their economic position and boost profitability. In doing so, they are deploying

Suggest Citation:
Nebava, M., & Alieksieiev, M. (2025). Challenges and obstacles to the digitalisation of logistics at the local level. *Innovation and Sustainability*, 5(1), 44-51. doi: 10.63341/vis/1.2025.44.

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a wide range of digital technologies and solutions. The convergence of digital technologies and tools has led to changes in traditional business model formation. These shifts require analysis to understand the capabilities of these models and the next steps for their adaptation and sustainable development, including identifying and addressing challenges and obstacles. Cloud technologies and artific al intelligence are becoming integral to business operations, and companies must recognise these changes to ensure the accuracy and effectiveness of these integrations.

The process of adapting business models to the digital economy and the correct selection of implementation strategies encounters challenges and obstacles that have also changed and transformed, refl cting the pace of digitalisation. Since 2010, there has been a surge in research dedicated to adapting business models to the needs of the digital economy and the associated complexities. C.E. Fernandez Rea (2023), in examining digital technologies in agricultural enterprises, identifi d limitations such as high integration costs, the need for specialised knowledge and skills, and the potential for technology failure. M.H. Khaustova (2023) explored and highlighted risks and negative elements in the ongoing process of digitalisation, noting unauthorised access to information, cybersecurity threats, and digital inequality. Researchers O.V. Ptashchenko & O.M. Sokhatska (2022) argued that digital transformation signifi antly impacts not only technology but also work and consumption culture. They emphasised that high implementation costs for new technologies, the need for specialised knowledge, and the necessity for changes in internal company structures are major challenges faced by businesses in the context of digitalisation. According to M. Cichosz *et al.* (2020), key barriers to digital transformation in the logistics sector include the complexity of managing logistics networks, resource limitations, resistance to change, cybersecurity issues, and difficulties in adapting to new technologies. These researchers indicated that overcoming these obstacles requires strong leadership, organisational support, engagement of personnel and partners, as well as process standardisation and data integration.

Researcher D. Bodnar (2022) concluded in their study that digital logistics plays a key role in economic transformation, enhancing business competitiveness through the optimisation of logistical processes, automation of activities, and implementation of electronic documents such as e-CMR and e-AWB. They emphasised that developing digital platforms for interaction among logistics chain participants is crucial, but the level of logistics digitalisation in Ukraine remains low. To improve this, it is necessary to adapt innovative technologies to European Union (EU) standards, conduct in-depth process analysis, and automate processes. L.O. Kustrich (2023) noted that the digitalisation of logistics management creates signifi ant management challenges, particularly due to the need to integrate technologies like the Internet of Thi gs (IoT), blockchain, and automation. She also highlighted that a major obstacle is the lack of unifi d standards for digital systems, which complicates process integration and reduces management effici cy. According to T. Nakonechna & N. Hryniv (2021), one of the most signifi ant challenges in implementing cutting-edge technologies like IoT is the need to mitigate risks caused by human factors, specifi ally errors stemming from insuffici t knowledge or experience. While these technologies can minimise reliance on human intervention, the process of adapting staff to work with them remains a substantial obstacle.

Despite the existing scholarly research, approaches, and summaries in the academic literature, there is a need to analyse and systematise the general challenges and obstacles that arise during the digitalisation of logistics at the local level. Regional aspects of implementing digital technologies, which account for the specifics of local infrastructure, economic environments, and social factors, are under-researched. There is a lack of in-depth analysis of effective strategies to overcome these challenges and obstacles, which would enable businesses to adapt successfully to the conditions of digital transformation. Th s article aimed to identify, systematise, and analyse the existing challenges and obstacles to the digitalisation of logistics at a local level.

Materials and Methods

Th s study employed a comprehensive set of methods to provide a thorough analysis of the challenges of logistics digitalisation at the local level, with a specific focus on the Vinnytsia Region. The use of diverse methodologies allowed for an in-depth exploration of the aspects of digital transformation, the identifi ation of key challenges and obstacles, and the proposal of potential solutions. The method of analysis was applied to examine available academic publications, offi al reports, statistical data, and other sources directly related to the digitalisation of logistics. Th s included a detailed analysis of publications concerning the implementation of digital technologies in the logistics sector, such as the study of M. Cichosz *et al.* (2020), which highlights the barriers to digital transformation. Th s analysis allowed for the identifi ation of the main problems in implementing digital technologies in logistics. Data was also gathered from information resources such as Ukrinform (31 investment projects…, 2023), which provided current information on the state of digitalisation in Ukraine, and the Lviv Chamber of Commerce and Industry (Grants from the…, n.d.), which outlines trends in the implementation of advanced technologies.

The method of systematisation was used to organise the data obtained, allowing for the classifi ation of challenges and obstacles to logistics digitalisation into several key groups: economic, technological, social, organisational, and legal. Th s approach provided a clear understanding of the diverse problems faced by businesses during digital transformation. For example, economic barriers include the high costs of technology implementation, while social barriers include the insuffici t level of digital skills among staff. The method of synthesis was used to integrate heterogeneous data from various sources. Th s allowed for the

formation of a comprehensive understanding of the situation in the region, combining information on the impact of digitalisation on logistics with an analysis of its local specific ties. The synthesis method was particularly important for identifying potential strategies to overcome challenges, as it facilitated the integration of data from various sectors and sources.

One crucial aspect of this research was the examination of the investment climate in the Vinnytsia Region. Th s line of inquiry focused on assessing the regions potential for implementing digital technologies, which is critical for the effective digitalisation of logistics. The analysis of the investment climate included an evaluation of infrastructure availability for the digital transformation of logistics and the study of investment levels in the logistics sector. Th s allowed for an assessment of the regions capacity to adapt to digital challenges and an analysis of measures implemented by regional authorities to stimulate digitalisation, including government support programmes for businesses focused on implementing innovative solutions. To obtain statistical data, specialised resources were used, including data on the number of internet providers in the region (Internet providers – Vinnytsia, n.d.) and a comprehensive study of the IT industry (IT VN Research, 2021). Th s information allowed for an evaluation of the current state of digital infrastructure development and its ability to support the implementation of modern technologies in logistics. The comprehensive approach to selecting methods and incorporating diverse data sources ensured a deep and thorough understanding of the challenges and obstacles to logistics digitalisation at the local level.

Results and Discussion

Digital transformation has led to the emergence of the concept of "digital logistics", which is an integral part of the digital economy. Digital logistics is an innovative form of logistics that signifi antly reduces costs associated with logistical processes, such as order processing, and accelerates their execution (Shostak, 2020). Digital technologies enable the development of new logistical solutions, optimise production, warehousing, transportation, and other processes, and accelerate asset turnover, assigning digital logistics a leading role in the digital economy. Digital technologies encompass all aspects of the logistics process, from electronic waybills, used to reduce document processing time and costs and simplify communication between different links in the logistics chain, to artific al intelligence, which is used for demand forecasting and automating routine processes. Th s leads to the emergence of key features of logistical activities in the context of digitalisation, including increased data processing speed and quality, the development of ecommerce and expansion of distribution channels, and the advancement of autonomous logistics technologies (Minakova & Grigori, 2023). Among the diverse range of digital technologies, blockchain and digital platforms stand out for their use in logistics process management. Blockchain technology is a decentralised database that operates across multiple computers and is updated using cryptographic methods. The advantages of using blockchain in the logistics sector include reduced risk of errors, enhanced data security, and improved transparency and openness.

Logistics process management systems allow for the monitoring of cargo movement and control of warehouse and delivery management processes. The logistics platform Trans.eu (3 steps a…, 2020) connects freight forwarders, shippers, and carriers, providing real-time cargo location monitoring, simplifi d application processing and filing, reduced transportation costs, and optimised fi ancial expenses for the company. The digitalisation of logistics at the local level encounters specific features and characteristics of this local level, namely, large variability in available resources, technological infrastructure, and staff qualifi ations, which are due to regional differences. It is necessary to identify groups by which the systematisation of challenges and obstacles will be conducted, primarily economic, technological, organisational, legal, and social groups (Table 1).

Table 1. Challenges and obstacles to logistics digitalisation

Group Name	Challenge Description
Economic	Limited fi ancial resources for implementing new technologies
	Lack of investment in digital infrastructure at the local level
	High cost of implementing new digital solutions
	Absence of government support or programmes to stimulate digitalisation
	Restrictions on the purchase of foreign equipment and software in the absence of Ukrainian analogues
Technological	Insuffici t development of digital infrastructure
	Low level of technical training of personnel to work with digital tools
	Compatibility problems of new digital solutions with existing logistics systems
	Limited access to high-speed internet and digital platforms
	Lack of modern digital tools at the local level
	Low level of information security
Organisational	Lack of a strategic vision for digitalisation at the local level
	Low level of management readiness for digital changes
	Resistance to change among employees and problems adapting to new technologies
	Lack of motivation from company leadership to implement digital technologies

Continued Table 1

Group Name	Challenge Description
Legal	Inconsistency of current legislation with the needs of the new technological order
	Data protection problems in logistics processes, especially when using digital platforms
	The problem of identifying and determining the legal status of involved digital market entities
	Absence or ambiguity of the conceptual apparatus of the digital economy
Social	Increased unemployment due to automation
	Shortage of qualifi d personnel and specialists and the constant need for retraining
	Increased socio-economic inequality due to uneven informatisation of society

Source: compiled by the author based on K. Verhal (2020), E. Khusainova *et al.* (2021)

Having identifi d the main risk categories, it is important to note that derivative risks will also emerge, such as environmental risks (stemming from increased electricity consumption and greenhouse gas emissions) and educational risks (lack of programmes for staff retraining and upskilling). These challenges affect businesses embarking on the path of logistics digitalisation and business in general. In response to these challenges, it is necessary to consider the opportunities and strategies for overcoming these obstacles to successfully implement logistics digitalisation. The identifi d groups of challenges are difficult to prioritise, given that they appear at every stage of the logistical chains digital transformation. Therefore, they should be analysed in the order previously outlined.

When considering ways to overcome economic challenges, it is crucial to analyse the regions investment climate to gain a clear understanding of the situation at the local level. Looking at the investment climate in the Vinnytsia Region can be interpreted as favourable due to the implementation of government policies aimed at supporting Ukrainian businesses. Thanks to this climate, 31 investment projects were successfully implemented in 2023 (31 investment projects…, 2023), with a total value of nearly 1.44 billion UAH. Th s encourages the continued attraction of investments through investment appeal. The second approach to overcoming this barrier is to utilise government programmes or grants. The Digital Europe programme (Grants from the…, n.d.), introduced by the EU, aims to create a unifi d European digital market and includes six areas, four of which are accessible to Ukraine: high-performance computing, artific al intelligence, information technologies in the economy and society, and digital skills. These strategies focus on attracting funds to cover automation costs. Investments can also address and resolve technological challenges, but fi st, it is necessary to assess the technological state at the local level.

Internet coverage in the city of Vinnytsia is provided by a large number of internet service providers (over 250), offering various tariff plans (Internet providers – Vinnytsia, n.d.) with the option to use rented equipment. Providers have accommodated periodic power outages by ensuring uninterrupted internet access. Collaboration with IT companies to develop specialised digital solutions is an effective strategy for overcoming technological challenges, but the state of the IT sector varies from region to region and requires initial assessment. According to the IT VN Research (2021) results, the Vinnytsia Region ranks 7th among all regions of Ukraine and has 5,880 IT individual entrepreneurs and 475 legal entities operating in IT-related economic activities. Such development of the IT sector signifi antly simplifies the implementation of digital solutions, which helps overcome technological challenges, including system compatibility issues, access to modern tools, and improves information security at the local level. After analysing strategies to overcome technological challenges, it is possible to consider the next category of challenges, namely organisational challenges.

Strategies to overcome organisational challenges are difficult to analyse at the local level due to the limited transparency of logistics companies regarding management and organisation. Therefore, these strategies will be more general and advisory in nature. Developing a long-term digitalisation strategy and establishing a digital council will create a clear plan for implementing digital technologies that take into account local specifics and resources. Th s plan will be coordinated by a dedicated body responsible for planning, monitoring, and controlling the implementation of digital solutions. Training and upskilling senior and middle management will promote understanding and mastery of digital tools, enabling effective process management and informed decision-making. Engaging external experts will provide logistics management with a better interpretation of the challenges and opportunities of digitalisation and the ability to develop a long-term strategy for implementing digital technologies. Training and retraining programmes, along with internal communication and staff engagement, will ensure employees are qualifi d in this area and reduce their resistance to change by making them aware of the advantages, disadvantages, and essence of automation. Integrating digital Key Performance Indicators (KPIs) and fi ancial and reputational incentives can enhance the motivation of company leadership to implement digital technologies. Key performance indicators may include the number of implemented digital solutions, cost reductions due to automation, and others. As for overcoming social challenges, this process should involve the following steps: developing modern and digital training and retraining programmes for employees. Platforms like Prometheus and Udemy (We have selected…, 2023) offer opportunities to improve related professional skills or delve into the basics of another fi ld and receive a certifi ate confi ming acquired skills and knowledge. Establishing

partnerships with educational institutions will enable the development of programmes that meet the demands of the digital economy. Ensuring equal access to digital technologies and increasing the transparency of digitalisation processes are also crucial. The strategies mentioned above will help mitigate negative consequences and overcome obstacles, thereby enhancing the ultimate success of digitalisation for enterprises and businesses.

The issue of digital transformation across various social development phenomena and processes is widely discussed in academic literature. According to O.Y. Davydova & V.D. Kolesnikova (2022), the uneven development of digital infrastructure is one of the main challenges of digitalisation. They noted that some regions experience a lag in the development of network infrastructure, which complicates the integration of digital technologies into business processes. Their conclusions align with the results of this study, which confi m the importance of modern digital infrastructure for successful business transformation. It is noted that the problem of uneven access to digital solutions is signifi antly exacerbated in rural and remote areas. M.S. Shtelmashuk (2024) highlighted that one of the key problems of digitalising logistics processes is the compatibility of new technologies with existing infrastructure solutions, especially in small and medium-sized businesses. The author stated that many companies attempting to integrate digital tools face difficulties due to outdated management systems that do not support innovative solutions such as IoT, blockchain, and SCM systems. Th s necessitates significant additional investments in modernisation, which often poses an insurmountable fi ancial burden for small enterprises. The fi dings of this study also confi med that data format compatibility and integration between different digital platforms are critical challenges for logistics companies. An important aspect is that modern information systems across different enterprises often have varying data exchange standards, which complicates their interaction and requires the implementation of specialised software solutions or additional integration gateways. K. Verhal (2020) highlighted the social challenges of digitalisation, drawing attention to the increase in unemployment due to automation and the polarisation of the workforce based on digital skills. Th s study also noted that human factors, including inadequate employee training, are signifi ant barriers to implementing digital technologies. The authors viewed on the critical importance of investing in digital education is entirely justifi d. Th s assertion can be expanded by emphasising the need for government support programmes for employee retraining.

Ye. Borodin *et al.* (2021) identifi d digital inequality as a key barrier to digitalisation. They noted that the lack of access to high-speed internet and the low level of digital literacy among the population signifi antly complicate the implementation of digital solutions. Developing regional infrastructure and promoting digital education are crucial steps to overcoming digital inequality. Furthermore, the fi dings of this study corroborate their arguments but add that digital inequality also affects the accessibility of solutions for small enterprises. I.V. Kryvovyaziuk & I.S. Sydorchuk (2022) emphasised the low level of technological readiness of enterprises, which slows down the digitalisation process. The authors focused on the partial implementation of solutions, such as cloud computing or big data analytics, which limits competitiveness. Th s research confi ms similar fi dings, highlighting the particular relevance of this barrier for small and medium-sized businesses with limited resources.

L.M. Achkasova (2024) highlighted the legal and regulatory challenges of digitalising transport and logistics systems, emphasising the difficulties associated with the absence of a unifi d legislative framework and clear regulatory requirements for digital platforms. The author noted that these factors signifi antly complicate the implementation of innovative technologies and slow down the digital transformation process in the logistics sector. The lack of standardised data exchange mechanisms and clearly defi ed rules for electronic document management deters companies from actively implementing digital solutions. Th s argument can be expanded by emphasising the importance of international harmonisation of digital standards, creating legal mechanisms for the use of smart contracts in logistics, and strengthening government support for enterprises in implementing cybersecurity technologies. I.K. Pishenin (2021) and A.H. Lisna & O.V. Posilkina (2022) highlighted the cybersecurity problems that accompany digitalisation. They drew attention to the risk of unauthorised access to data and the need to develop effective solutions for its protection. The issue of cybersecurity, as noted by the authors, requires not only technical but also organisational measures, including raising security awareness among employees. M. Hryhorak *et al.* (2021) pointed to organisational barriers associated with the lack of digitalisation strategies. They emphasised that inadequate planning slows down the implementation of digital solutions. Th s idea is valid, as confi med by the data obtained, with the addition that an effective digitalisation strategy should cover both technical and human resource aspects. According to S. Koliadenko *et al.* (2024), a high threshold of education and qualifi ations is a signifi ant obstacle to implementing digital technologies in the agricultural sector. The authors emphasised that adapting educational programmes and training personnel to work with innovative solutions, such as IoT and drones, is crucial for overcoming this barrier. Th s conclusion aligns with the results obtained, which also highlight the importance of investing in digital education for employees. Furthermore, it is noted that developing regional retraining programmes could effectively contribute to mitigating this problem. O.M. Lukjanova (2023) highlighted institutional challenges in digitalisation, focusing on the low involvement of government bodies and the absence of a coordinated legislative framework. The author stated that insuffici t government support signifi antly hinders the implementation of digital transformation strategies. The results obtained

confi m this argument, further emphasising that institutional barriers are exacerbated by the lack of government programmes to stimulate digitalisation, which negatively affects the competitiveness of small and medium-sized enterprises in the digital economy. The analysis conducted allowed for the identifi ation and grouping of the main challenges and obstacles to logistics digitalisation at the local level and the development of strategies to overcome these challenges and obstacles.

Conclusions

The digitalisation of logistics at the local level encounters numerous challenges and obstacles that signifi antly slow down and complicate the implementation process. Economic challenges include the high cost of technological solutions and the need for substantial fi ancial investments to acquire and maintain digital platforms and infrastructure. Social challenges encompass the problem of low digital literacy among employees, the increased risk of unemployment due to the automation of routine processes, and the polarisation of the workforce based on skill levels. Organisational challenges include insuffici t strategic planning, the absence of clearly defi ed digitalisation goals, and low levels of interaction among market participants. Technological challenges are related to outdated infrastructure, the lack of access to modern solutions in some regions, and difficulties in integrating new technologies into existing business processes. Legal challenges arise from an inadequate regulatory framework and the uncertainty of data protection and cybersecurity standards.

The results of this study have shown that the successful digitalisation of logistics requires a comprehensive approach to addressing economic, technological, social, organisational, and legal challenges. Th s includes active support from the state, particularly in providing fi ancial grants and establishing retraining programmes. It is essential to develop strategic digitalisation plans at the enterprise level, which take into account the specifics of each region. It was found that in regions with developed infrastructure, digitalisation contributes to the optimisation of logistics processes, reduction of costs, and improvement of customer service. At the regional level, coordination between local authorities, businesses, and educational institutions is crucial for developing human resources and implementing innovations. Th s article has examined and systematised the key challenges of logistics digitalisation at the local level and developed practical recommendations for effectively overcoming these challenges, considering the specifics of the regional business environment. Further research could focus on studying and generalising the existing experience of implementing logistics strategies in Ukrainian enterprises.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Виклики та перешкоди цифровізації логістики на локальному рівні

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Анотація. У статті висвітлено виклики та перешкоди, що обумовлені стрімким розвитком цифровізації, яка суттєво змінює бізнес-середовище, створює нові виклики для підприємств на локальному рівні. У сучасних умовах постає питання необхідності подолання цих викликів для ефективного впровадження цифрових технологій з метою підвищення конкурентоспроможності підприємств та зменшення потенційних ризиків. Метою дослідження були систематизація та аналіз ключових викликів і перешкод цифровізації логістики на локальному рівні та формування стратегії їх подолання. Дане дослідження базувалося на аналізі наукових публікацій та статистичних даних. У роботі застосовано методи порівняльного аналізу, систематизації та узагальнення. Проаналізовано основні виклики та перешкоди, які виділені в п'ять основних груп: економічні, технологічні, організаційні, юридичні та соціальні, що уповільнюють впровадження цифрових рішень. Економічні виклики пов'язані з обмеженістю фінансових ресурсів та високою вартістю технологій. Технологічні аспекти включають недостатній рівень інфраструктури та проблеми інформаційної безпеки. Організаційні виклики пов'язані з опором змінам та відсутністю стратегічного бачення, юридичні – з невідповідністю законодавства та неоднозначністю понятійного апарату цифрової економіки, а соціальні – з потребою перекваліфікації кадрів та їх нестачею. Запропоновано стратегію для подолання кожної групи викликів, серед яких створення державних програм, покращення доступу до цифрових технологій та розробка освітніх ініціатив. Практична цінність дослідження полягає у можливості використання запропонованих результативних стратегій подолання викликів та перешкод підприємствами та організаціями для вдосконалення логістичних процесів у контексті цифрової трансформації. Отримані результати можуть бути використані для розробки стратегій цифровізації логістичних процесів з урахуванням регіональних особливостей

Ключові слова: цифрова трансформація; логістичні процеси; автоматизація логістики; бізнес-моделі; цифрові інструменти; стратегії подолання; регіон

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 06.11.2024; Revised: 05.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.52

UDC 334.012.63;658.589

Marketing tools in shaping the competitiveness of small enterprises in the economy and agricultural sector

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Abstract. The development of competitive small enterprises under institutionally unstable conditions primarily depends on the effectiveness and functionality of marketing tools for product distribution. The issue of product marketing remains highly relevant due to signifi ant artific al constraints on sales opportunities caused by the impact of war, which disruptively regulates the competitiveness of business entities in Ukraine. Th s article aimed to determine the trajectory of structural changes in the entrepreneurial system and to characterise the role of marketing tools in shaping the competitiveness of small enterprises. The study used economic-statistical and comparative analysis methods, as well as a systematic approach, to assess the dynamics of small businesses and the impact of war on their competitiveness. The research framework included an analysis of innovative marketing tools such as market segmentation, digital technologies, partnership initiatives, and eco-oriented strategies. Organisational and economic assessments of institutionalisation trends in small enterprises within Ukraine's economy have been conducted, with particular emphasis on developments in the agricultural and rural sectors. The capacity of enterprises to operate effici tly has been substantiated through the implementation of innovative marketing tools aimed at reducing transaction costs in exchanges. Key areas of focus included market segmentation based on consumers' environmental preferences, the adoption of digital marketing

Suggest Citation:
Shelenko, D., Shpykuliak, O., Matsola, M., Kolesnyk, T., & Savchyn, A. (2025). Marketing tools in shaping the competitiveness of small enterprises in the economy and agricultural sector. *Innovation and Sustainability*, 5(1), 52-62. doi: 10.63341/vis/1.2025.52.

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tools, the development of partnership initiatives with eco-oriented companies, securing funding for eco-projects, and the introduction of loyalty systems to stimulate demand. The practical signifi ance of this study lies in its potential application by entrepreneurs, marketing specialists, and economic analysts in developing effective strategies for enhancing the competitiveness of small enterprises. Th s can be achieved through the integration of innovative marketing tools, adaptation to environmental requirements, and optimisation of business processes in wartime conditions

Keywords: entrepreneurship; structure; sustainable development; Green Deal; ecosystems; food security

Introduction

The economic resilience of enterprises, and their ability to function effectively in volatile market environments, depends on the effici cy of management in achieving the necessary balance of benefits and costs. In Ukraine, due to the emergence of destructive barriers during wartime, additional problems have arisen for entrepreneurs related to the institutional instability of the market transaction organisation system. To adapt to these conditions, through strategies ensuring the achievement of the main entrepreneurial goal – profit generation – the priority of developing and implementing effective management decisions becomes crucial. In this context, small enterprises are highlighted as a distinct segment of the business ecosystem, the competitiveness of which is determined by the specific institutional capabilities of this type of business entity. In the context of addressing the existing problems of small enterprise operations in ensuring their access to product distribution channels, particularly in the agri-food sector, it is important to develop and implement effective marketing tools. Th s problem is relevant, as the ability of enterprises to compete effectively depends on marketing tools. The conceptualisation and expansion of marketing knowledge are linked to the need for continuous improvements in the mechanisms of implementing market strategies to achieve profitability in business operations. Th s issue has become particularly signifi ant for small-scale businesses.

The development of theoretical marketing concepts and their implementation signifies a constructive ideology for building the competitiveness of small businesses in Ukraine, as small entrepreneurship plays a key role in establishing an economic foundation that ensures employment, the production of goods and services, and contributes to the recovery of territories by enhancing their economic stability and self-suffici cy. The effective development of small businesses depends on access to funding, the use of marketing tools, intellectual resources, and flex ble management. Despite the signifi ant contribution of the agricultural sector to increasing competitiveness and creating jobs, the integration of marketing tools for various subgroups of agricultural enterprises is insufficie tly addressed in the analysed research papers. It is important to focus efforts on developing strategies that consider local production characteristics, fi ancial capabilities, and the needs of agricultural enterprises. Such an approach will enable the creation of a more inclusive marketing model that will contribute to strengthening the market positions of small businesses.

The issue of small business development is being explored by researchers in various vectors of functional manifestation of activity and signifi ance for the economy and society. M. Bahorka & I. Abramovych (2024) emphasised that a modern comprehensive competitive strategy should unite and harmonise goals and objectives at different levels and also create conditions for involving small businesses in the organised market. M. Kyzym *et al.* (2019) argued that considering three key indicators of small and medium-sized enterprise activity – the volume of sold products, the number of employees, and the number of enterprises – allows for the calculation of intermediate relative indicators, such as the volume of sold products per enterprise, the number of employees per enterprise, and the volume of sold products per employee. I. Gontareva *et al.* (2023) identifi d three stages of enterprise strategy formation: situational analysis of the external and internal environment of the enterprise to assess opportunities and threats; the development of marketing strategies to reach the target market, including segmentation and differentiation; the development of instrumental strategies for effective positioning, considering product, price, distribution channels, and promotion methods.

Considering the need to implement functional strategies in the context of cost management and competitiveness, as noted by I. Yatsiv & S. Yatsiv (2024), allows agricultural enterprises not only to optimise operational costs but also to ensure sustainable development through innovation and effective unit management. Particular attention is paid to the connection between functional strategies and cost management, which is key to increasing the competitiveness of agricultural enterprises. Th s is an important aspect for ensuring long-term competitive advantages in the market. M. Bahorka & I. Abramovych (2024) identifi d three stages of enterprise strategy formation: the fi st stage involves a situational analysis of the external and internal environment of the enterprise to assess opportunities and threats, the second stage focuses on developing marketing strategies to reach the target market, including segmentation and differentiation, and the third stage involves developing instrumental strategies for effective positioning, considering product, price, distribution channels, and promotion methods.

I. Burtnyak *et al.* (2024) highlighted that the application of peak pricing stimulates competition among small businesses, helping them adapt to uneven customer fl ws and improve service. Additionally, through the use of seasonal analysis and model modifi ations, small businesses

can more effectively regulate purchase intensity, which contributes to the stabilisation of their operations and enhances their competitiveness. D. Wenyang *et al*. (2024) emphasised that the development of e-commerce stimulates competition among market participants, encouraging them to improve business models and offer higher-quality services. At the same time, through the attraction of foreign investment and the strengthening of the economy, entrepreneurship gains new opportunities for innovation, particularly in the areas of trade, fi ance, and information technology. K. Yereshko *et al*. (2024) demonstrated the importance of using digital technologies through three key aspects: technological, institutional, and infrastructural, as the implementation of modern information systems, compliance with international requirements, and ensuring effective data exchange are critical elements for increasing the competitiveness of small businesses in the economy, including the agricultural sector. The competitiveness of small businesses and the development of e-commerce demonstrate the interdependence between business adaptation to market changes and the improvement of innovative approaches. In the context of economic challenges related to the war, the implementation of such strategies becomes more complex due to signifi ant infrastructural and fi ancial constraints. Th s necessitated the conduct of this research, the purpose of which was to develop approaches to forming an effective strategy for the development of small agribusiness, taking into account competitiveness, the implementation of marketing tools, and ensuring sustainable development.

Materials and Methods

The data used in this study were obtained from national statistical sources, such as the State Statistics Service of Ukraine (Economic statistics…, n.d.) to acquire statistical data on the number of registered enterprises, as well as data on the dynamics of the Ukrainian individual entrepreneur economy during the war (Every third FOP…, 2024), and data from correspondent.net (The number of…, 2023) regarding the number of businesses opened in Ukraine. The study covered the period from 2018 to 2023 and focused on analysing the dynamics of small business development in Ukraine, including the impact of global crises, such as the COVID-19 pandemic, and local challenges caused by the full-scale war.

The research was based on economic-statistical and comparative methods of analysis. In particular, the economic-statistical method was used to assess quantitative changes in the dynamics of small business development by activity volumes, while the comparative method facilitated the identifi ation of specific changes in the structure of small businesses, considering the impact of macroeconomic factors. Comparative analysis was used to identify changes between groups of economic entities (by enterprise size and types of activity) over time, which facilitated the analysis of changes and the comparison of indicators across years, enterprise categories, and types of activity. The application of a systems approach allowed for the structuring of data by categories (large, medium, small, micro) and the study of interrelationships between general trends and the specifics of changes in agriculture. Th s approach made it possible to identify key trends in the structure of economic entities for the period 2018-2022, in particular, the impact of external factors (e.g., war) on the dynamics of business development in the agricultural sector and the economy as a whole. The analysis of marketing tools was also conducted using a systems approach. The main focus was on the use of modern tools such as search engine optimisation (SEO) marketing, customer relationship management (CRM) systems, Big Data, content marketing, and social media marketing (SMM). Based on the collected data, tables were created to demonstrate the dynamics of small business development, its adaptation to crisis conditions, and the effectiveness of marketing tool applications.

The following sources were used for the analysis: scientific publications to study current research on the topic (Ruban, 2023; Karpenko & Matviichuk, 2024; Mykhailenko, 2024) and data from the IMD World Competitiveness Ranking (WCR) to assess the ability of countries to create a favourable environment for business and promote prosperity (Rankings out…, 2024). The assessment of this ranking was based on criteria such as economic performance, government effici cy, business effici cy, and infrastructure, which allowed for the evaluation of how countries adapt to changes in the global market and measure their competitiveness over time. The analysis of scientific publications to form the theoretical and methodological basis of the study allowed for the examination of the studies of Ukrainian and foreign scientists, particularly on the development of small businesses, innovative marketing strategies, and sustainable development. The analysis revealed gaps in existing scientific sources, particularly insuffici t attention to the adaptation of innovative marketing strategies for small agricultural enterprises in wartime conditions. The use of a multi-component methodological approach ensured the acquisition of comprehensive results, which allowed not only for the analysis of the current state of small businesses but also for the formulation of practical recommendations to enhance their competitiveness.

Results and Discussion

A clear understanding of the stages of enterprise strategy formation and effective cost management is key to ensuring its competitiveness. However, the current economic difficulties caused by the war create additional challenges for the implementation of these strategies, complicating the operation of enterprises and affecting their fi ancial capabilities. The war has led to the destruction of enterprise infrastructure, a signifi ant reduction in production, disruption of supply chains, increased unemployment and inflation, reduced tax revenues, low solvency of the population, and much more. The National Bank of Ukraine reports that in wartime conditions, the economy loses 50% of "unreceived" gross domestic product (GDP). In 2022, the Ukrainian economy experienced the most signifi ant decline in

history, with a real GDP contraction of 29.1%, which led to a return of the economic level to the early 2000s, while the need for recovery and reconstruction after a year of war are estimated at 411 billion US dollars (Poharska, 2023).

The occupation of parts of eastern and southern Ukraine and the destruction of infrastructure have led to signifi ant losses for both large and small enterprises. These regions were historically important industrial and economic centres of the country, concentrating a signifi ant number of factories, plants, agricultural enterprises, and small businesses. According to data from Ye. Ruban (2023), the Donetsk Region lost 8.2 thousand entrepreneurs, Kharkiv – 7.1 thousand, Kherson – 4.5 thousand, Luhansk – 3.7 thousand, and Zaporizhzhia – over 2 thousand. In contrast, during this period, more new individual entrepreneurs (IEs) opened in other regions than closed. The largest increase was recorded in Kyiv – plus 12.9 thousand, followed by the Lviv Region, where the number of IEs increased by 12.3 thousand, and the Dnipro Region, which completes the trio of regions with an increase in entrepreneurs – plus 8.6 thousand (The number of…, 2023). The largest losses are concentrated in enterprises in sectors such as metallurgy, the chemical industry, machine building, and agriculture (Andriienko *et al*., 2024). Many companies have lost production capacities, access to resources, workers, and sales markets, and the destruction of transport and energy infrastructure has further complicated the restoration of production in these regions.

Small businesses are the most common element of a market economy. Small entrepreneurship creates a signifi ant number of jobs, fills the market with necessary products and services, satisfies customer demand, and stimulates economic development. In times of crisis, it contributes to the stability of the country's economy. Small enterprises are usually classifi d into several key categories. The main criteria are: the number of employees, annual revenue, asset volume, and industry (The Commercial Code of Ukraine, 2003). In most cases, small enterprises are considered to be those with up to 50 employees and an annual revenue that does not exceed the threshold established by law (for example, in Ukraine – up to 10 million EUR). Small businesses can be classifi d by level of innovation, scalability, environmental focus, or level of digital technology use. In the agricultural sector, enterprises that focus on the green course, traditional production, or export-oriented models are separately identifi d. Th s classifi ation allows for a more accurate assessment of the needs of enterprises, their contribution to the economy, and the identifi ation of support areas from the state or investors. The implementation of "green" economy principles opens up new perspectives for small enterprises, necessitating the integration of environmental approaches into their operations. Global economic processes are increasingly oriented towards sustainable development, posing new challenges for small businesses. The implementation of "green course" provisions in enterprise competitiveness formation strategies requires the use of effective marketing tools that consider a range of key aspects. Marketing platforms are also used to attract green investments, such as bonds directed towards eco-projects. Th s includes an emphasis on "green" fi ancial instruments, such as green bonds, and the promotion of such initiatives through digital and social channels. At the same time, small businesses need to develop partnerships to fi ance environmental initiatives. A differentiated approach to marketing for various business structures allows for the creation of personalised offers that meet their needs.

The rational use of resources and the reduction of environmental impact are key elements of modern marketing strategies. Th s involves creating products and services that adhere to the principles of sustainable consumption and informing consumers about environmental benefits. Integrating waste management into marketing contributes to the formation of a positive brand, for example, through the use of recycled materials or the organisation of recycling. Furthermore, promoting environmentally friendly goods and services that support natural ecosystems helps companies build a strong image. The use of social media to disseminate information about environmental innovations and sustainable development increases brand trust, especially through transparency in environmental reporting. Transparency and regular reports on reducing environmental impact contribute to building trust among customers. Table 1 presents the main marketing tools that can be used to build the competitiveness of small businesses, particularly in the agricultural sector, as well as in other sectors of the economy.

Table 1. Marketing tools in building the competitiveness of small businesses

Tool	Characteristic	Application	Applicable to enterprises in which industries and sectors
SEO marketing	Search engine optimisation to improve website visibility in search engines	Increasing brand awareness, attracting customers online	All industries, including agriculture
Product innovation	Development and implementation of new products that meet modern market needs	Creating competitive products	Agricultural enterprises (e.g., seeds, fertilisers)
Technology innovation	Use of modern IT technologies to optimise processes	Automation and effici t management	Mainly the agricultural sector (fi ld management)
Service innovation	Introduction of consulting or other additional services	Expanding the range of offerings	All industries, with a focus on agriculture
Innovations in marketing for agricultural enterprises	Implementation of modern marketing solutions (targeting, CRM) for the agricultural sector	Increasing sales and customer reach	Only for the agricultural sector

Continued Table 1

Tool	Characteristic	Application	Applicable to enterprises in which industries and sectors
High-quality content marketing	Creation of informative and entertaining content for the audience	Building brand trust	All industries
SMM marketing	Use of social media to promote products and communicate with customers	Brand promotion through platforms	All industries, including agriculture
Big Data technologies	Analysis of large data volumes for personalised marketing	Creating targeted offers for customers	All industries
CRM systems	Organisation and management of customer relationships	Increasing customer loyalty	All industries

Source: compiled and supplemented based on I. Golysheva (2021), O. Karpenko & Y. Matviichuk (2024)

The proposed marketing tools, categorised by their application in the agricultural sector and general small enterprises, highlight the importance of adapting modern technologies, such as SEO, SMM, Big Data, and CRM, for both agricultural and other small businesses to enhance their competitiveness. Analysing the main aspects of small business development, D. Mykhailenko (2024) revealed (business climate, technological innovation, fi ancing, export and digitalisation). The analysis of these aspects allowed for the identifi ation of several key areas of small business development. Firstly, a favourable business climate, which is a determining factor, includes legal stability, transparency of market processes, and support from regulatory bodies. Such a business climate not only facilitates the operation of small enterprises but also stimulates investment, which positively impacts the economy. Another important area is the implementation of cutting-edge technologies, as the use of innovation allows enterprises to remain competitive, improve the quality of their products and services, and optimise production processes. Th s opens up new opportunities for growth and market expansion. At the same time, access to fi ancing remains a challenge for small businesses. High interest rates and complex credit procedures are signifi ant obstacles. In this context, state support in the form of developing fi ancial infrastructure and affordable lending programmes is an important condition for enterprise growth. Access to foreign markets enables small businesses to diversify risks and increase sales volumes. The simplifi ation of customs procedures, export consultations, and free trade agreements contribute to expanding opportunities for exporters. Separately, the importance of digitalisation should be noted, as the use of digital technologies allows for increasing the effici cy of business operations, reducing costs, and strengthening their competitive positions. State support in this area can include access to technology, training programmes for entrepreneurs, and the development of digital infrastructure.

The successful implementation of small business development aspects largely depends on state support, particularly in the form of simplifi d administrative procedures and tax incentives. The state can signifi antly improve the business climate by creating favourable conditions for small businesses, thereby stimulating entrepreneurship development and attracting investment. The state has begun to actively support small businesses through tax breaks, grants, and business recovery programmes. In July 2022, it invested 10 billion UAH in the development of small and mediumsized businesses through grants, as reported by the Ministry of Economy of Ukraine (Ambartsumian, 2024). Receiving this type of funding helps businesses maintain jobs and continue their operations even in the face of economic instability caused by external factors such as war or crises. International organisations, institutions, and individual countries also provide signifi ant resources to assist Ukrainian entrepreneurs. The main areas of this support include funding, consulting assistance, training, and assistance with entering international markets. Data from the State Statistics Service of Ukraine on the number of active business entities by their activity volumes in 2018-2022 (Economic statistics…, n.d.) allow for tracking the dynamics of small business development in changing economic environments (Table 2).

Table 2. Number of operating business entities by activity volumes in 2018-2022

Category	Years					Deviation (+; -) 2022/2018
	2018	2019	2020	2021	2022	
Large enterprises, units						
All of Ukraine	446	518	512	610	494	48
Including agriculture, hunting, and related services	23	34	36	49	39	16
Medium enterprises, units						
All of Ukraine	16,476	18,129	17,946	17,811	15,037	-1,439
of which, individual entrepreneurs	419	378	344	309	254	-165
Including agriculture, hunting, and related services	1,988	1,966	1,830	1,793	1,483	-505
of which, individual entrepreneurs	5	2	3	3	3	-2

Continued Table 2

Category	Years					Deviation (+; -) 2022/2018
	2018	2019	2020	2021	2022	
Small enterprises, units						
All of Ukraine	1,822,671	1,922,978	1,955,119	1,937,827	1,716,977	-105,694
of which, individual entrepreneurs	1,483,297	1,560,650	1,599,411	1,585,105	1,470,330	-12,967
Including agriculture, hunting, and related services	67,585	66,675	65,255	63,118	46,856	-20,729
of which, individual entrepreneurs	20,938	20,348	19,366	18,887	16,635	-4,303
Of which, micro-entrepreneurs, units						
All of Ukraine	1,764,737	1,864,013	1,898,902	1,880,858	1,671,558	-93,179
of which, individual entrepreneurs	1,471,965	1,550,633	1,591,031	1,576,208	1,465,345	-6,620
Including agriculture, hunting, and related services	62,505	61,570	60,163	57,863	42,212	-20,293
of which, individual entrepreneurs	20,851	20,257	19,278	18,819	16,585	-4,266

Source: compiled based on data from the Economic statistics / Economic activity / Agriculture, forestry and fisheries (n.d.)

The analysis of this table can serve as a basis for identifying key trends, such as the increase or decrease in the number of small businesses, their adaptation to crisis conditions, and the impact of external factors on business structure, which will be important for formulating policies to support small entrepreneurship in Ukraine. In 2024, more new businesses were registered than in the corresponding period before the start of the full-scale war, when 186,144 cases were opened. After a sharp decline at the start of the invasion, the number of registrations levelled off and has remained stable for the second year in a row (Every third FOP…, 2024). Despite the hostilities and power outages, businesses have adapted to these challenging conditions and continue their operations and even continue to develop. Looking at Table 3, the real statistics of new individual entrepreneurs IEs over the last four years are evident.

The full-scale invasion and the past global problem, which caused signifi ant problems in the economy not only in Ukraine – COVID-19 – pushed many entrepreneurs towards digitalisation. Businesses that face problems operating offl e are actively moving into the online space. Small businesses that provide services (consulting, education) have completely switched to remote work, which has allowed them to continue operations even in combat conditions. Small agricultural enterprises play a key role in ensuring employment and food security, which is relevant in the face of current economic challenges.

Table 3. Number of new IEs 2021-2024

Number of new IEs			
January-August 2021	January-August 2022	January-August 2023	January-August 2024
186,144	132,666	193,521	193,192

Source: compiled based on the Every third FOP closes in the fi st year of operation (2024)

Table 4 presents an analysis of the factors that hinder agricultural entrepreneurship in Ukraine, which is a key source for analysing the main obstacles to the development of the agricultural sector. The agricultural sector, which is of strategic importance to the Ukrainian economy, faces the need to implement modern approaches to enhance sustainability and competitiveness. One of the key areas is the integration of environmental practices into entrepreneurial activity, which would include: conducting an audit of activities to assess the current state of environmental friendliness of processes; developing an environmental strategy for the enterprise, focused on optimising resource use and waste recycling; certifying products according to international quality and environmental standards; actively communicating achievements through digital platforms, which will allow for the formation of a positive image among consumers.

Table 4. Factors restricting agricultural entrepreneurial activity in Ukraine for 2018-2024

Impact factor	Years						
	2018	2019	2020	2021	2022	2023	2024*
Agriculture (%, enterprises)							
Insuffici t demand	9	11	9	8	16	21	24
Weather conditions	28	26	29	28	25	24	18
Lack of labour	4	4	3	3	3	5	10
Lack of materials and equipment	3	2	3	2	5	3	2
Financial constraints	26	23	24	21	25	24	23
Other factors	23	23	28	24	43	45	44
No barriers	36	37	35	40	25	24	23

Continued Table 4

Impact factor	Years						
	2018	2019	2020	2021	2022	2023	2024*
Crop production (%, enterprises)							
Insuffici t demand	7	9	7	6	13	20	23
Weather conditions	30	30	34	32	27	27	22
Lack of labour	2	3	2	2	3	5	8
Lack of materials and equipment	2	2	1	1	5	3	2
Financial constraints	23	20	20	16	21	19	20
Other factors	22	22	26	24	45	46	47
No barriers	39	39	37	42	28	26	23
Animal husbandry (%, enterprises)							
Insuffici t demand	15	17	17	15	24	24	26
Weather conditions	17	15	18	18	21	17	10
Lack of labour	7	6	6	3	3	7	15
Lack of materials and equipment	4	2	6	4	7	5	1
Financial constraints	36	28	32	32	38	36	30
Other factors	26	26	32	27	44	46	36
No barriers	28	33	30	35	20	18	23

Note: * – data is presented for the fi st quarter of the current year

Source: calculated by the author based on data from the Economic statistics / Economic activity / Agriculture, forestry and fisheries (n.d.)

Alongside this, the application of effective marketing tools is important: market segmentation, the use of digital marketing, the expansion of partnerships, and the attraction of funding for ecoinitiatives. Th s will create a solid foundation for the adaptation of small agricultural enterprises to modern challenges and enhance their competitiveness. Ukrainian enterprises are actively seeking new opportunities in foreign markets. To achieve this, a strategy for applying marketing tools in the context of sustainable development should be developed, focusing on the following areas: segmenting the market based on consumers' ecological preferences and targeting marketing campaigns at eco-conscious audiences; using digital marketing tools, such as content marketing, SEO, and targeted advertising, to promote organic products among international and local audiences; developing partnerships with other eco-oriented businesses and participating in sustainable development initiatives to increase market visibility; attracting funding through grant programmes and loans for eco-projects, enabling the introduction of innovations and advanced technologies in production; implementing loyalty systems for eco-conscious customers, including bonuses or discounts for choosing environmentally friendly products, thus stimulating sustained demand. The outlined actions help small businesses adapt to market challenges, identify the directions of the "green" course in the strategy of forming enterprise competitiveness, and increase competitiveness in the long term. In many cases, this is a forced step due to the decrease in purchasing power in the domestic market. Export expansion is supported by state and international programmes, which help entrepreneurs enter European and other markets.

Small businesses actively use marketing tools to remain competitive in a rapidly changing environment, indicating the integration of technological advancements, market knowledge, and the effective use of fi ancial resources, as this allows them to create innovative products, services, and business models (Branzova, 2024). These types of enterprises, focusing on the economic potential of new cultures, are able to meet the needs of emerging markets. Th s approach, according to T. Kuzmin *et al.* (2024), not only ensures their stability but also opens up new opportunities for scaling. The topic of the chosen study correlates with the results of the study by T. Kuzmin *et al.* (2024), as marketing tools contribute to the adaptation of small businesses to new markets and the expansion of their opportunities, but the difference lies in the emphasis, which focuses on competitiveness through marketing, while T. Kuzmin *et al.* (2024) emphasised the role of meeting the needs of emerging markets for business stability and scaling. Social sustainability in the context of small businesses, particularly in the agricultural sector, remains a challenging aspect to implement, as it often faces conceptual and practical difficulties. Researchers K. Kuipers *et al.* (2024) attempted to integrate the social component into sustainable development strategies and encountered ambiguity in understanding the multifaceted role of farmers, who act not only as entrepreneurs but also as active members of their communities, which complicates the development of effective policies. The results of this study and the research of K. Kuipers *et al.* (2024) share common aspects, as the absence of clear and measurable goals can also limit the effectiveness of small business marketing strategies. The experience of integrating the social component is useful for Ukraine, as considering local social values and interaction with communities will contribute to the sustainable development of entrepreneurship. O. Sakovska & O. Shpykuliak (2020) fragmented interests and outlined that the lack of clear and measurable goals limits the possibility of forming a holistic strategy for the sustainable development of

entrepreneurship that would meet both regional and global challenges. The research materials align with the article of I.F. Balaniuk *et al.* (2021), as they also emphasised the importance of considering social values and the specifics of interaction with communities when applying marketing tools to enhance the competitiveness of small businesses in the economy and agricultural sector, which is a key factor in their social sustainability and adaptation to the regulatory environment. It is appropriate to agree with the assertion of D. Wenyang *et al.* (2024) that for small businesses, ecommerce and marketing tools become key factors in economic growth, as they contribute to attracting foreign investment and developing new sectors. The high correlation between investment, GDP growth, and e-commerce confi ms their interdependence, which is a signifi ant argument for small businesses to integrate electronic commerce into their operations. It can be agreed that information support systems play a key role in the application of marketing tools to enhance the competitiveness of small businesses in the economy and agricultural sector, as they provide access to the analytical data necessary for making strategic decisions (Chudyk *et al.*, 2024).

The World Digital Competitiveness Ranking, according to IMD (Rankings out…, 2024), assessed 67 economies of different countries for their ability to implement technologies for economic and social transformations, taking into account the factors of knowledge, technology, and future-readiness, which influence the introduction of innovations and long-term value creation. Countries with high levels of governance, transparency, and a stable political environment, such as Switzerland and Singapore, consistently rank high due to their effective digital infrastructure and social adaptation to change. The integration of marketing tools, technological advancements, and market knowledge allows small businesses not only to withstand crises but also to leverage new opportunities for growth and scaling. The use of digital platforms, CRM systems, and analytics contributes to increasing business effici cy and flex bility. Thus, small businesses in Ukraine demonstrate high adaptability, an innovative approach, and the ability to remain competitive even in challenging conditions. Th s confi ms their key role as a sector that ensures economic stability and social development.

The development of small entrepreneurship in Ukraine during wartime is characterised by signifi ant challenges that create a high-risk environment for doing business. Despite this, small businesses remain an important element of economic and social stability, acting as a platform for job creation, providing the market with products and services, and adapting to new conditions by implementing innovations. To confi m these statements, D. Mykhailenko (2024) believes that small entrepreneurship is capable of creating an economic foundation that will provide jobs and support the production of essential goods and services. Th s is especially important for territories that require reconstruction, as the development of small businesses contributes to their economic stability and self-suffici cy.

Yu. Lopatynskyi *et al.* (2024) emphasised that a small agricultural enterprise can be successful if it is provided with high-quality human resources, focuses on the production of environmentally friendly products with minimal costs, and involves the creative approaches of employees to increase profitability. Effective human resource management and a focus on the sustainable development of agricultural enterprises can be supported through the implementation of modern accounting systems and cost monitoring, as noted by V. Nahornii *et al.* (2020), which allows for the optimisation of marketing activities and ensures accurate accounting to enhance their operational effici cy. O. Chygryn *et al.* (2021) argued that in the agricultural sector, enterprises are divided into three subgroups depending on their interest in using marketing tools to develop green competitiveness: large agricultural holdings that focus minimally on environmental positioning; producers who partially integrate a green image into their operations; and independent agricultural producers who actively use marketing tools to promote environmental advantages. Th s division refl cts the different levels of motivation and willingness of enterprises to implement sustainable development principles. Financial security is highlighted as the main problem affecting business viability, indicating the need for stable access to funding to ensure growth. At the same time, the formation of a competitive policy for small businesses is based on intellectual resources, flex ble management, motivation, and a stable basic element that supports enterprises even in conditions of uncertainty. Th s combination allows businesses to maintain competitiveness, adapt to changes, and sustain development despite fi ancial challenges.

V. Borshchevskyi *et al.* (2022) argued that the economy during wartime and Ukraine's postwar development requires addressing complex problems, setting priorities, and fulfilling key tasks for the country's recovery and long-term stability. Summarising the aforementioned, it proves that the identifi ation of priority development areas and the fulfilment of key tasks for economic recovery will only be possible if the importance of a systemic approach to these issues is considered, which will ensure the long-term stability and prosperity of the country. Small businesses in Ukraine are skilfully adapting to the challenges posed by hostilities, thanks to the implementation of innovative approaches, the establishment of new forms of cooperation, and the active use of digital technologies. Despite the signifi ant losses suffered by enterprises due to hostilities, their high adaptability and ability to respond quickly to constant changes in the external environment allow them not only to keep the business afl at but also to fi d new ways for development and growth in the extremely difficult situation caused by the war. While generally agreeing with V. Borshchevskyi *et al.* (2022), it can be argued that in the context of rebuilding the economy towards recovery trends, it is necessary to coordinate the efforts of all stakeholders interested in the results, taking into account the sectoral aspect, for example, in the agricultural sector – thus, there is no agreement with the absolutisation of the author's proposals, which are

interpreted in a general context of understanding ways to solve problems. It is appropriate to partially agree with the research of O. Chygryn *et al.* (2021) – the arguments are generally constructive in a conceptual dimension, but it is difficult to agree that the category of business entities argues the motivation to "integrate a green image into activities", since such motivation rather depends on the institutional conditions in which the enterprise operates, implementing measures for market transaction marketing. The solution to the issues of small business development depends not only on state support but also on the activity of entrepreneurs themselves. Business preservation is closely linked to the speed of adaptation to changing conditions, as small businesses in Ukraine face numerous macroeconomic challenges, the main of which is economic instability. Creating favourable conditions for small business development is one of the key ways to overcome the economic crisis in wartime conditions.

Conclusions

In the context of the full-scale invasion and global challenges, such as the COVID-19 pandemic, Ukrainian entrepreneurs have demonstrated a high capacity for adaptation and the digitalisation of business processes. The impact of hostilities on the Ukrainian economy has pushed small businesses towards active digitalisation, which has proven to be key in supporting entrepreneurial activity, particularly in the agricultural sector. Small businesses in Ukraine are skilfully adapting to the challenges posed by hostilities, thanks to the implementation of innovative approaches, the establishment of new forms of cooperation, and the active use of digital technologies. Despite the signifi ant losses suffered by enterprises due to hostilities, their high adaptability and ability to respond quickly to constant changes in the external environment allow them not only to keep the business afl at but also to fi d new ways for development and growth in the extremely difficult situation caused by the war.

Enterprises are actively seeking new opportunities in international markets, which requires the development of a strategy for using marketing tools with an emphasis on sustainable development. In particular, this includes the following directions: market segmentation based on consumers' environmental preferences and targeting marketing campaigns at eco-conscious audiences; the use of digital marketing tools, such as content marketing, SEO, and targeted advertising, to promote organic products among both global and local audiences; the development of partnerships with other eco-oriented companies and participation in sustainable development initiatives to enhance market visibility; securing funding through grants and loans for eco-projects, which will support the implementation of innovations and cutting-edge technologies in production; and the introduction of loyalty systems for eco-conscious customers, such as bonuses or discounts for choosing eco-friendly products, which will stimulate sustainable demand. The outlined actions will help small businesses adapt to market challenges and determine the directions in the strategy of forming competitiveness in the long term. Small agricultural enterprises have a signifi ant impact on ensuring employment and food security. Their active inclusion in foreign markets, which is supported by state programmes, demonstrates a desire for development even in conditions of limited domestic demand. The totality of these factors contributes to strengthening small entrepreneurship and restoring the economy. It is worth emphasising that the successful development of small businesses depends not only on state support but also on the initiative of the entrepreneurs themselves. Their ability to react quickly to changes, implement innovations, and use modern approaches is crucial. The formation of favourable conditions for small entrepreneurship becomes a key factor in overcoming the economic crisis, which requires a comprehensive approach to supporting entrepreneurs in Ukraine. Prospects for further research in this area include two important directions. Firstly, it is advisable to focus on studying the effectiveness of integrating marketing tools for small agricultural enterprises in different regions of Ukraine, taking into account their specifics and access to digital technologies. Secondly, the analysis of the impact of international grant programmes on the development of the "green" course and the study of mechanisms for their effective implementation is relevant.

Acknowledgements

The authors would like to thank the editor and reviewers for their assistance in preparing the article for publication.

Funding

None.

Conflict of Interest

None.

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Маркетингові інструменти у формуванні конкурентоспроможності малих підприємств в економіці та аграрному секторі

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Анотація. Розвиток конкурентоспроможних малих підприємств в інституційно-нестабільних умовах залежить насамперед від дієвості і функціональності маркетингових інструментів збуту продукції. Проблематика маркетингу продукції є актуальною з причин значного штучного обмеження можливостей реалізації через дію воєнного чинника, який в Україні деструктивно регулює формування конкурентоспроможності суб'єктів підприємництва. Метою статті було визначити траєкторію структурних змін у системі підприємницького господарювання та охарактеризувати ролі маркетингових інструментів у формуванні конкурентоспроможності малих підприємств. У дослідженні використано методи економіко-статистичного й порівняльного аналізу, системного підходу для оцінки динаміки малого бізнесу та впливу війни на їх конкурентоспроможність. База включила аналіз інноваційних маркетингових інструментів: сегментації ринку, цифрових технологій, партнерських ініціатив і екоорієнтованих стратегій. Здійснено організаційно-економічні оцінки тенденцій інституціоналізацій малого підприємництва в економіці України із виокремленням тенденцій аграрного, сільського сектору господарювання. Обґрунтовано здатність підприємств ефективно господарювати організовуючи впровадження інноваційних інструментів маркетингу для зменшення трансакційних витрат обміну. Розглянуто ключові напрями, такі як сегментація ринку за екологічними уподобаннями споживачів, впровадження цифрових маркетингових інструментів, розвиток партнерських ініціатив із еко-орієнтованими компаніями, залучення фінансування для еко-проєктів та запровадження систем лояльності для стимулювання попиту. Практична цінність дослідження полягає у тому, що його результати можуть бути використані підприємцями, маркетологами та економічними аналітиками для розробки ефективних стратегій формування конкурентоспроможності малих підприємств, зокрема через впровадження інноваційних маркетингових інструментів, адаптацію до екологічних вимог і оптимізацію бізнес-процесів в умовах воєнного часу

Ключові слова: підприємництво; структура; сталий розвиток; «зелений» курс; екосистеми; продовольча безпека

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 22.11.2024; Revised: 21.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.63

UDC 338:61

Experimental auction design: Enhancing procurement efficiency in Ukraine's healthcare sector

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Abstract. The relevance of this study arises from the urgent need to optimise resource allocation and improve procurement procedures in Ukraine's healthcare sector, particularly under martial law conditions, which underscore the importance of effici t and transparent use of fi ancial resources. Th s study aimed to conduct a comprehensive investigation and objective assessment of the effectiveness of auction-based mechanisms for procuring medical equipment within the Ukrainian healthcare system, taking into account the specific features of the sector. A comprehensive approach was employed, including systemic and comparative analysis of existing auction models and their implementation in the healthcare systems of various countries. Using methods of formalisation and generalisation, an experimental auction model was developed, incorporating multi-attribute evaluation. Statistical methods enabled a quantitative analysis of the proposed model's effectiveness. The fi dings indicated that introducing auction mechanisms into Ukraine's healthcare procurement system holds signifi ant potential for enhancing the effici cy and transparency of medical equipment procurement. The developed experimental model of multi-attribute evaluation, combined with a sealed-bid auction format, allows for the consideration of not only price but also other important criteria, such as the technical specifi ations of the equipment, warranty period, service conditions, and the presence of additional benefits. A detailed analysis was conducted to assess the impact of each of these factors on auction outcomes. The study demonstrated that the proposed approach enables the selection of suppliers offering the best overall value, considering the balance between cost and quality of medical equipment. The research fi dings make a signifi ant contribution to the advancement of both the theory and practice of auction applications in the healthcare sector, broadening the understanding of how auction mechanisms function within the medical fi ld

Keywords: tender bidding; medicine; experiment; healthcare; effici cy; price; quality

Introduction

Like many other countries, Ukraine's healthcare sector continuously faces the challenge of allocating limited resources effici tly and fairly. Th s issue is particularly pressing as public demand for medical services continues to grow while the state's fi ancial capacity remains constrained – conditions further intensifi d by the ongoing

Suggest Citation:
Ivashuk, Yu., Dluhopolskyi, O., & Pikh, I. (2025). Experimental auction design: Enhancing procurement effici cy in Ukraine's healthcare sector. *Innovation and Sustainability*, 5(1), 63-70. doi: 10.63341/vis/1.2025.63.

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war. Traditional procurement methods, often marked by a lack of transparency, bureaucratic hurdles, and vulnerability to corruption, have proven inadequate in ensuring the optimal use of resources or meeting the evolving needs of the healthcare system. In the search for more effective solutions, auction-based mechanisms are gaining increasing traction in the medical fi ld. Due to their ability to enhance transparency, promote competition, and establish market-based pricing, auctions represent a powerful tool for improving the allocation of resources within healthcare. They offer opportunities to attract a wider range of suppliers, encourage fair competition, and achieve better value for medical goods and services.

The literature on auction design in the healthcare sector, although a relatively recent area of research, is developing rapidly and attracting growing interest from both scholars and practitioners. As noted by R. Malani (2020), this interest stems from the potential of auction-based mechanisms to address key challenges facing modern healthcare systems, such as ineffici t resource allocation, limited access to medical services, and high costs. Several studies, including those by V. Pitkänen *et al.* (2020) and A. Hortaçsu & I. Perrigne (2021), have confi med the potential benefits of applying auctions in healthcare. For instance, the study by V. Pitkänen *et al.* (2020) argued that introducing a capacity-rule of acceptance in medicine could, on the one hand, lead to signifi ant public budget savings and ensure higher-quality medical care. On the other hand, it could also require many patients to change service providers and travel longer distances to receive treatment. In their article, G. Németh *et al.* (2023) presented a concept for designing multi-winner tenders for pharmaceuticals, with a focus on supply and distribution guarantees, cost-effectiveness, and equitable access. The authors advocate for the development and implementation of multi-winner tenders for medicinal products, arguing that such mechanisms promote long-term competitiveness in pharmaceutical markets and reduce the risk of supply shortages. Auctions can also contribute to improving access to healthcare services, particularly under conditions of limited resources. Research by J.D. Moody-Williams *et al.* (2024) explored the use of auctions in the allocation of organs for transplantation, demonstrating how this approach can support a more effici t and equitable distribution of life-saving resources. A. Arshad *et al.* (2019) examined the advantages of presumed or deemed consent for organ donation compared to explicit consent, highlighting how this model could enhance the development of a more competitive organ transplantation system.

The literature also highlights several challenges and risks associated with the use of auctions in healthcare. One of the key issues is the problem of information asymmetry, where auction participants possess differing levels of knowledge regarding the quality of medical goods or services. Th s can lead to adverse selection, with lower-quality providers winning contracts simply because they can offer lower prices. Research by D. Powell & D. Goldman (2020) emphasised a positive correlation between the generosity of health insurance coverage and the level of healthcare consumption, while also pointing to th problem of adverse selection within the health insurance market. Another signifi ant challenge is the risk of collusion among auction participants, which may result in artific ally inflated prices or restricted competition. The study by L. Siciliani *et al.* (2022) stressed that proximity to the provider remains a key factor in a patient's choice of healthcare facility. At the same time, demand for medical services varies considerably depending on the quality of care delivered. There are ethical considerations associated with the use of auctions in healthcare, particularly when it comes to the allocation of life-saving resources or services. For example, the articles of M. Gawronski *et al.* (2022) and F.J. Esplugues *et al.* (2024) argued that, even under the general EU directives, the diversity of tendering methods and the wide range of public procurement criteria across individual countries prevent the consistent application of a uniform logic – even within a relatively homogeneous legal framework. Given the inherent complexity of any tendering process, such issues should not be interpreted as evidence of poor governance or deficie t procurement practices. Corruption risks are also common in such procurement processes. The research group led by O. Onwujekwe *et al.* (2020) highlighted widespread pharmaceutical corruption in English-speaking sub-Saharan Africa, particularly in Nigeria. The studies by O. Dluhopolskyi (2024), O. Dluhopolskyi *et al.* (2024), and O. Dluhopolskyi & O. Myronenko (2024) analysed corruption risks using various indicators across different countries, with particular attention to Ukraine, where progress has been observed in certain anti-corruption reforms, while regression has occurred in others.

In the Ukrainian context, research into auction mechanisms in healthcare remains at an early stage. However, recent reforms in the sector, aimed at improving effici cy and transparency, have created favourable conditions for exploring and implementing auction-based approaches. It is worth noting that many of the challenges related to public procurement in Ukraine are, in one way or another, connected to the healthcare sector. V. Datsenko (2022) highlighted the crucial role of the online platform Prozorro in ensuring an effective public procurement process for Ukraine's reconstruction. Amid the full-scale war waged by Russia against Ukraine from 2022 to 2024, the challenges surrounding auctions in the medical fi ld have become even more acute. Th s study aimed to analyse the specific characteristics of Ukraine's healthcare sector and to identify the auction formats most likely to prove effective in this context.

Materials and Methods

A wide range of academic methods was employed to conduct a comprehensive study of the application of auction mechanisms in Ukraine's healthcare sector. Systems analysis enabled the consideration of auction mechanisms as an integral part of the Ukrainian healthcare system, taking into account its complexity and the interconnections between its various components. Th s approach helped to

identify the key factors influencing the effectiveness of auctions, as well as to examine the potential risks associated with their implementation.

Comparative analysis was used to evaluate different auction formats employed in healthcare and to determine their advantages and disadvantages within the Ukrainian context. The use of auctions in the medical sectors of various countries – such as the USA, Australia, and EU member states – was examined to identify best practices. The formalisation method was applied to develop a mathematical model of an auction based on multi-attribute evaluation, allowing consideration of not only price but also other important criteria in selecting the winning bidder.

The formalisation of the proposal evaluation process ensured objectivity and transparency. The generalisation method enabled conclusions to be drawn regarding the effectiveness of auction use in Ukraine's healthcare sector, based on the analysis of hypothetical cases and theoretical models. The synthesis of research fi dings allowed for the formulation of recommendations for the implementation of auction mechanisms within the Ukrainian healthcare system. Simulation modelling was employed to create a hypothetical case of medical equipment procurement using a sealed-bid auction. Th s simulated model made it possible to analyse various scenarios and assess the effectiveness of the proposed procurement approach.

Overall, the application of a comprehensive research framework – incorporating a variety of methods and sources – enabled a thorough understanding of the issues surrounding the use of auction mechanisms in Ukraine's healthcare system. It supported the justifi ation for selecting optimal auction formats and the development of practical recommendations for their effective implementation. One of the key limitations of the study was the restricted availability of data concerning the outcomes of healthcare-related auctions in Ukraine (Advisory Board Sustainability, 2024). The research was based on hypothetical scenarios and theoretical approaches; as such, actual outcomes may vary depending on specific auction conditions and market factors.

Results and Discussion

Auctions have been successfully applied across various sectors of the economy, including telecommunications, energy, and transport. However, the healthcare sector possesses unique characteristics that complicate the direct transfer of practices from other industries. The complexity of medical services, the presence of externalities, information asymmetries, and ethical considerations associated with the provision of care all necessitate a careful approach to the design and implementation of auction mechanisms in healthcare systems. A range of auction formats may be employed in the healthcare sector, each offering specific advantages and limitations. Among the most common formats are the English auction, Dutch auction, sealed-bid auction, and multi-attribute auction (Table 1).

Table 1. Auction formats in healthcare

Auction format	Description	Application in healthcare
English auction	The price starts low and increases incrementally as participants bid. The highest bidder wins	Procurement of medical goods and equipment
Dutch auction	The price starts high and decreases until a participant accepts the current price	Allocation of scarce medical resources (e.g. organ transplantation)
Sealed-bid auction	Participants submit their bids in sealed envelopes. The highest bidder wins	Procurement of complex medical services where quality is difficult to assess in advance
Multi-attribute auction	Bids are evaluated based on price as well as additional criteria (e.g. quality, experience, innovation)	Procurement of healthcare services where quality is a key determinant

Source: developed by the authors

To conduct an in-depth examination of the potential and challenges associated with using auctions in Ukraine's healthcare sector, a hypothetical case study was developed involving the procurement of medical equipment (a computed tomography scanner) through a sealed-bid auction. Th s auction format was selected for several reasons. Firstly, it enables consideration of factors beyond price, such as technical specifi ations, warranty period, and service conditions, all of which are essential to ensuring the quality and reliability of the equipment. Secondly, the use of sealed bids makes collusion between participants more difficult, thus promoting fair competition and transparency. Thi dly, this format reduces the risk of purchasing low-quality equipment at an artific ally low price, since participants cannot see competing bids and therefore cannot adjust their offers based solely on price. As a result, the sealed-bid auction format presents itself as an optimal choice for ensuring efficie cy, transparency, and fairness in the procurement of complex medical equipment.

To enhance the realism of the model, the case study parameters refl cted typical conditions for medical equipment procurement in Ukraine, including the number of participants, price offers, and technical characteristics. The information used to construct the case was drawn from open sources (e.g. medical equipment supplier websites, and tender announcements) as well as expert assessments. The simplicity and clarity of the case allowed attention to be focused on the key aspects of the auction application, making it accessible to a broad audience. Case variability was introduced through the development of several scenarios, each differing in the set of evaluation criteria and their respective weightings.

The fi st scenario (baseline) involved the consideration of all evaluation criteria – price, technical specifi ations, warranty period, and additional benefits – using a multi-attribute evaluation method. The second scenario took price as the sole criterion for selecting the winning bid. The third scenario demonstrated how changing the weights assigned to the evaluation criteria affected the auction outcome. Th s approach enabled an analysis of how different factors influence the selection of a winner and justifi d the use of multi-attribute evaluation in medical equipment procurement auctions. To quantitatively assess the participants' bids and determine a winner in each scenario, a weighted scoring formula was applied:

$$\text{Total score} = (B1 * W1) + (B2 * W2) + (B3 * W3) + (B4 * W4),$$

where $B1$, $B2$, $B3$, $B4$ are scores for each criterion, and $W1$, $W2$, $W3$, $W4$ are their respective weights. The use of this formula enabled a numerical comparison of bids, taking into account the various criteria and their relative importance. The results of these calculations were used to assess the effectiveness of different scenarios and to draw conclusions about the appropriateness of applying a multi-attribute evaluation approach in auction-based procurement. The modelling exercise showed that considering not only price but also other key criteria – such as technical specifi ations, warranty period, and additional advantages – makes it possible to select the supplier offering the best overall value. Th s contributes to more effici t use of public funds and ensures that hospitals are equipped with high-quality medical devices. To provide a practical demonstration of the multi-attribute evaluation approach, a hypothetical example is presented below involving three suppliers, whose offers are summarised in Table 2. The table presents three alternative suppliers of medical equipment, each offering differing price proposals, technical specifi ations, warranty periods, and additional benefits. Supplier A offers equipment priced at 1,500,000 UAH, fully meeting the hospital's requirements. The warranty period is 3 years, and additional benefits include free staff training and servicing throughout the warranty period. Supplier B proposes equipment priced at 1,400,000 UAH, which meets most requirements but with certain limitations. The warranty lasts for 2 years, and the supplier additionally offers a discount on consumables. Supplier C offers the lowest price – 1,300,000 UAH – but the equipment only meets the minimum requirements. The warranty period is just 1 year, and no additional benefits are provided.

Table 2. Comparison of suppliers' offers

Supplier	Price proposal, UAH	Technical specifications	Warranty (years)	Additional benefits
A	1,500,000	Fully meets hospital requirements	3	Free staff raining and servicing during the warranty period
B	1,400,000	Meets most requirements, with some limitations	2	Discount on consumables
C	1,300,000	Meets minimum requirements	1	None

Source: developed by the authors

To ensure an objective selection of a medical equipment supplier, the hospital developed an evaluation system that considers not only price but also other important criteria. Th s system is based on a multi-attribute approach, whereby each criterion is assigned a specific weight refl cting its relative importance. In this case, the criterion price carries a weight of 40%, technical specifi ations 30%, warranty period 20%, and additional benefits 10%. The higher the score for each criterion, the better the supplier's offer is considered to be. A scoring scale was established for each criterion. Price is assessed on a scale from 60 to 100 points, with the lowest price (1,300,000 UAH) receiving 100 points and the highest (1,500,000 UAH) receiving 60 points. Technical specifi ations are scored between 40 and 100 points depending on the degree of compliance with the hospital's requirements. The warranty period is awarded 40 to 100 points, in proportion to its length. The presence of additional benefits scores 100 points, while their absence scores 0.

Based on this scoring scale, points were calculated for each supplier, enabling a quantitative comparison and the identifi ation of the auction winner (Table 3). Supplier A achieved a total score of 84, owing to its superior technical specifi ations, warranty period, and additional benefits. Although its price was the highest, the high quality and advantages offered off et this drawback. Supplier B received 77 points due to a balanced combination of price, technical specifi ations, warranty, and added benefits. While its price was mid-range, its technical performance and warranty were slightly inferior to Supplier A. Supplier C obtained the lowest total score of 60, as – despite offering the lowest price – its technical specifi ations, warranty, and absence of added benefits were signifi antly less competitive.

Table 3. Supplier evaluation

Supplier	Price (40%)	Technical specifications (30%)	Warranty (20%)	Additional benefits (10%)	Total score
A	60 * 0.4 = 24	100 * 0.3 = 30	100 * 0.2 = 20	100 * 0.1 = 10	84
B	80 * 0.4 = 32	70 * 0.3 = 21	70 * 0.2 = 14	100 * 0.1 = 10	77
C	100 * 0.4 = 40	40 * 0.3 = 12	40 * 0.2 = 8	0 * 0.1 = 0	60

Source: developed by the authors

Based on the calculations in Table 3, Supplier A was identifi d as the auction winner, having offered the best overall value despite submitting the highest price. The experimental approach employed in this study demonstrated that the use of multi-attribute evaluation, in combination with sealed-bid auctions, can serve as an effective tool for the procurement of medical equipment in Ukraine. Th s approach allows for the consideration of not only price but also other key criteria, such as technical specifi ations, warranty period, and additional advantages – thereby ensuring the selection of the supplier offering the greatest overall value.

Y. Abdulsalam & E. Schneller (2019) noted that supply-related expenses represent the second-largest cost category in hospitals after payroll, yet they offer greater potential for improving cost effici cy. Th s area of expenditure remains underexplored in the academic literature on health economics. Their research found that, on average, supply costs account for approximately 15% of a hospital's total expenditure; however, in institutions with a high case complexity index – particularly surgical hospitals – this figu e may reach 30%-40%. E. Peters *et al.* (2023) highlighted that within the Dutch healthcare system, a signifi ant mismatch was identifi d between the levels of containment and anticipation strategies: while containment was implemented at the network level, forward-looking strategic planning at that same level was lacking. As a result, the response during the COVID-19 crisis proved to be improvised, placing considerable strain on individual institutions. The study by E. Peters *et al.* (2023) also demonstrated that trust and stable working relationships are critical for effective coordination. However, due to the lack of pre-pandemic collaboration, such relationships had to be established during the crisis itself. The absence of a clearly defi ed command structure, limited experience within key public institutions, and mistrust towards formal leadership undermined the effici cy of supply network management. The conclusions drawn by the researchers appear well-founded, as this study likewise highlights the need for a structured and proactive approach to procurement in the healthcare sector. Emphasis should be placed on transparency, multi-dimensional proposal evaluation, and the consideration of quality – principles that align with critiques of improvised strategies and underscore the importance of trust and systematic preparedness in times of crisis.

Despite the availability of international research on the use of auctions in the healthcare sector, including the study of L. Knight (2023), such approaches cannot always be directly applied to the Ukrainian context due to differences in legislation, the level of development of the healthcare market, and the specifics of local conditions. As noted by B. Tip *et al.* (2022), this may result in certain mechanisms that function successfully in other countries proving less effective in Ukraine. The evaluation of healthcare services through auction-based mechanisms may also raise ethical concerns, particularly in cases where cost or other criteria take precedence over the quality of medical services. Additionally, issues of accessibility for the most vulnerable population groups may arise, as lower-priced offers may fail to meet required quality standards. It is therefore important to consider the experience of other countries that have already successfully implemented auction mechanisms in healthcare and to adapt these practices to the Ukrainian context. The experience of EU countries is particularly relevant, where auctions are widely used for the procurement of medicines and medical equipment. Adapting this experience may involve the introduction of unifi d standards for the quality and safety of medical products, the harmonisation of public procurement legislation with EU norms, and the establishment of a centralised system for monitoring the prices of medicines and medical equipment. The experience of the USA, where auctions are used for the allocation of organs for transplantation, demonstrates the effectiveness of this procurement model, as shown in the studies by A. Arshad *et al.* (2019) and J. Moody-Williams *et al.* (2024). Adapting this approach in Ukraine could involve the development of clear criteria for organ allocation, the introduction of a patient ranking system, and the implementation of transparent allocation procedures. The experience of Australia is also noteworthy, where auctions are employed to attract private investment in healthcare infrastructure. Adapting the Australian model could include the development of public-private partnership mechanisms in the healthcare sector, with an emphasis on transparency and investor accountability. When adapting to international experience, it is essential to consider the specifics of Ukrainian legislation, the level of competition in the medical goods and services market, and the country's socio-economic context. The use of auction mechanisms in Ukraine holds considerable potential for improving the allocation of medical resources, increasing transparency, and reducing costs. A. Shulika (2022) and V. Kolisnichenko (2022) analysed legislative changes in public procurement introduced during wartime, which, although generally unfavourable to competition, are regarded as a necessary and optimal compromise under the conditions of martial law. The introduction of Prozorro as a mandatory tool for most procurement processes, along with the transition of large-scale privatisation to electronic auctions via this system, illustrates the gradual adaptation of public administration to digital innovation. Th s shift not only enhances transparency but also promotes more effici t resource use, a key component of sustainable development. The Prozorro e-procurement system has already proven effective in reducing costs for pharmaceuticals and medical equipment. For instance, in her study based on Kyiv School of Economics (KSE) analytics, N. Bihun (2022) demonstrated that transparent tender procedures can result in budget savings of up to 12.4% in the healthcare sector – an especially relevant outcome in wartime conditions. Such an approach supports not only cost savings but also improved accountability and resilience within the healthcare system, directly aligning with the goals of sustainable development. The simplifi ation of procedures and ongoing digitalisation also enable more

agile responses to economic challenges, while maintaining control and accountability – an aspect of particular importance in the post-war recovery context. To further enhance the effectiveness of these mechanisms, it is essential to integrate them with broader healthcare reforms, particularly in strengthening quality control of medical services.

Conclusions

The study confi med that auction-based mechanisms hold signifi ant potential for improving effici cy, transparency, and fairness in the allocation of resources within Ukraine's healthcare sector. The use of auctions can help reduce procurement costs for medical goods and services, stimulate competition among suppliers, enhance the quality of healthcare provision, and broaden access for the population. The fi dings demonstrated that applying multi-attribute evaluation in combination with sealed-bid auctions can serve as an effective tool for procuring medical equipment in Ukraine. Th s approach enables supplier selection to be based not only on price, but also on other key criteria such as technical specifi ations, warranty period, and additional benefits – ensuring the selection of the offer that provides the best value for money.

Auctions have the potential to become an important instrument for enhancing the effici cy and transparency of Ukraine's healthcare system. Their successful implementation requires a comprehensive approach that takes into account all aspects of the medical sector and ensures a balance between economic and social objectives. Only under such conditions can auctions make a meaningful contribution to improving the quality and accessibility of healthcare for the population of Ukraine. The future development of auction mechanisms in Ukraine's medical sector depends on continued reforms within the healthcare system. Key steps include refini g the regulatory framework, expanding the use of electronic auctions across all stages of procurement, and strengthening training among auction participants. These measures would help reduce the impact of bureaucracy and corruption while making the system more transparent and effective. Further research in this area should focus on examining the long-term effects of auctions on the quality and accessibility of healthcare services in Ukraine, as well as developing recommendations for improving auction design and adapting it to the specific characteristics of different segments of the medical market.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Експериментальний дизайн аукціонів: підвищення ефективності закупівель у медичній галузі України

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Анотація. Актуальність дослідження обумовлена нагальною потребою в оптимізації розподілу ресурсів та удосконаленні процедур закупівель в медичній галузі України, особливо в умовах воєнного стану, що актуалізує питання ефективного та прозорого використання фінансових ресурсів. Метою дослідження було всебічне вивчення та об'єктивна оцінка ефективності застосування аукціонних механізмів для закупівель медичного обладнання в українському секторі охорони здоров'я з урахуванням специфіки галузі. В роботі застосовано комплексний підхід, що включав системний та компаративний аналіз існуючих моделей аукціонів та практики їх застосування в охороні здоров'я різних країн. Методами формалізації та узагальнення було розроблено експериментальну модель аукціону з урахуванням багатоатрибутної оцінки, а статистичні методи дозволили провести кількісний аналіз ефективності запропонованої моделі. Встановлено, що впровадження аукціонних механізмів в систему охорони здоров'я України має значний потенціал для підвищення ефективності та прозорості закупівель медичного обладнання. Розроблена експериментальна модель багатоатрибутної оцінки в поєднанні з аукціоном із запечатаними ставками дозволяє враховувати не лише ціновий фактор, але й інші важливі критерії, такі як технічні характеристики обладнання, гарантійний термін, умови сервісного обслуговування, наявність додаткових переваг тощо. Проведено детальний аналіз впливу кожного з цих факторів на результати аукціонів. Дослідження показало, що запропонований підхід забезпечує вибір постачальника, який пропонує найкращу загальну цінність, враховуючи співвідношення ціни та якості медичного обладнання. Результати дослідження вносять вагомий внесок у розвиток теорії та практики застосування аукціонів в сфері охорони здоров'я, розширюючи розуміння особливостей функціонування аукціонних механізмів в медичному секторі

Ключові слова: тендерні торги; медицина; експеримент; охорона здоров'я; ефективність; ціна; якість

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 17.10.2024; Revised: 10.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.71

UDC 658.8

Analysis of the image component of an enterprise within the framework of sustainable development

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Abstract. A positive image component is a crucial and complex element in shaping an enterprise's competitive standing, serving as a prerequisite for reliable, stable, and successful performance under market conditions aligned with the principles of sustainable development. Consequently, the formation and modelling of an enterprise's image is a multifaceted task that requires thorough research and analysis. Th s study aimed to examine the image component of an enterprise's business system in the context of sustainable development. The research utilised statistical data from the relevant industry and the fi ancial and operational results of the enterprise under study. The methods applied included both quantitative and qualitative analysis, comparative analysis, statistical methods, economic modelling, absolute and relative difference methods, deterministic factor analysis techniques, and graphical methods. The study substantiated the need for a comprehensive approach to image assessment, combining qualitative and quantitative analysis of micro- and macro-environmental factors. The authors proposed a systematic and integrated algorithm for determining the level of a company's image. A positive image component is a highly important and complex factor in shaping the competitive standing of a modern business entity. Th s is particularly relevant in the context of escalating economic and political challenges within the country and the uncertainty of the external environment. Such conditions often lead to hesitation among enterprise managers regarding the future development of the brand and its ability to compete in new markets. As a result, the enterprise's development, competitiveness, and overall image may be signifi antly affected. The application of a systematic and integrated approach to assessing the image component of an enterprise's competitiveness enables the modelling of its competitive position in the market by managing fi ancial and economic indicators and market value. The research fi dings may be used by managers of various enterprises to enhance the effectiveness of competitiveness management in their own businesses

Keywords: enterprise competitiveness; effici cy; competition; quality; reputation; management

Introduction

The image component of an enterprise is both signifi ant and complex, playing a key role in establishing the competitive standing of a modern business. Accordingly, a positive reputation is a prerequisite for the reliable, stable, and successful management of an enterprise under market conditions shaped by sustainable development. Ensuring a favourable image that enhances competitiveness is a more strategically advantageous and cost-effective approach than rectifying a randomly developed negative image. Therefore, research into enterprise image formation should be conducted comprehensively, with consideration for future prospects and the dynamics of the market environment. Th s process is an integral part of sustaining competitive advantage. The challenge of assessing the image component of an enterprise's competitiveness continues to be a subject of study for numerous researchers.

According to L. Antoniuk & K. Anapriiuk (2023), the main levels of the image component of enterprise competitiveness include the desired, traditional, actual, favourable, positive, idealised, and emerging levels. They argued that it is essential to regard competitiveness as an integrated attribute shaped not only by internal factors but also by external influences, such as globalisation, market changes, and public policy. Their research highlighted the need for adaptation and resource optimisation to enhance competitiveness, as well as the critical role of strategic management in

Suggest Citation:
Adler, O. (2025). Analysis of the image component of an enterprise within the framework of sustainable development. *Innovation and Sustainability*, 5(1), 71-82. doi: 10.63341/vis/1.2025.71.

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maintaining and improving market positioning. Researchers such as I. Yepifanova & V. Dzhedzhula (2020) have asserted that the primary driver of a positive enterprise in conditions of sustainable development is the activation of its innovative activity. These authors often consider the relationship between sustainable development and enterprise competitiveness, emphasising the integration of environmental and social dimensions. In the main context of sustainable development, enterprises must account not only for economic indicators but also for environmental and social factors. Firms that invest in innovation and modern technologies can reduce costs, improve production effici cy, and minimise environmental impact. Resource management effici cy – the rational use of natural resources and the reduction of waste are important aspects of competitiveness in the context of sustainable development. Organisational culture and social responsibility in the context of sustainable development, enterprises must act in a socially responsible manner, consider the interests of all stakeholders, and cultivate a strong corporate culture. I. Prychepa *et al.* (2021) considered the image of a manager to be a key element in shaping the image component of an enterprise. The formation of this image includes the manager's professional and social activities, as well as personal characteristics, all of which are analysed over time. Her research focused on examining how businesses and economies can achieve long-term development while maintaining competitiveness on a global scale. Researchers N. Yevtushenko & V. Varnitskyy (2021) defi ed the image component as a complex network of public and media relations. According to this approach, the image component of enterprise competitiveness consists of a set of measures aimed at building a positive image of an enterprise or organisation, including its promotion to achieve corporate objectives and secure a stable competitive position in the market. In an article by P. Brin & M. Nehme (2021), the image component of an enterprise was described as its main external competitive advantage, comprising key success factors that differentiate it from competitors and contribute to establishing a stable leading position in a specifi market at a given time. A. Vitiuk *et al.* (2023) argued that in a market economy, the assessment of the image component cannot be carried out comprehensively through a single approach. A modern enterprise is goal-oriented and, based on this, must select appropriate methods and conduct a well-founded evaluation of its image component. L. Shymanovska-Dianych *et al.* (2022) emphasised that securing a positive image component and strong reputation typically results from a long and complex process. Furthermore, the development and shaping of the image component of enterprise competitiveness will contribute to the evolution of the enterprise's broader philosophy. Th s research aimed to explore the image component of enterprise competitiveness in the context of sustainable development using a comprehensive and systematic approach, thereby enabling the modelling of an appropriate level of competitive advantage.

Materials and Methods

Since the assessment of the image component of an enterprise's competitiveness is a key aspect in understanding how the company is perceived in the market, its reputation, and how this perception influences its competitive advantages, a comprehensive methodological approach was adopted in the study. Th s approach involved determining the enterprise's image index through the lens of goodwill assessment by analysing relevant criteria, as well as through an internal evaluation of fi ancial and economic indicators. The selection of this method for assessing the image component of enterprise competitiveness is justifi d by the availability, accessibility, and quality of informational resources, the research objectives, and the technical and mathematical capabilities available, all of which enabled informed managerial decision-making regarding the image component of competitiveness.

Analytical research into the image component of enterprise competitiveness was conducted on the basis of the company's offi al fi ancial reports for 2020-2022. (Financial information, n.d.), alongside analytical and market research, and offi al statistical data (Agrana Fruit Ukraine LTD, n.d.). The image component of Agrana Fruit Ukraine LLC's competitiveness for the 2020-2022 period was selected as the object of study. The choice of this enterprise is due to its position as a leading producer of fruit ingredients for the food industry. The company actively implements the principles of sustainable agriculture, offering products that comply with standards of environmental safety and organic farming. It consistently invests in advanced production technologies that reduce environmental impact. Furthermore, the company maintains active cooperation with local farmers, thereby supporting local economic development and contributing to the sustainable advancement of rural areas. Agrana Fruit Ukraine LLC is engaged not only in production but also in social initiatives, focusing on community support, employee health and safety, and the integration of ethical principles into its operations.

The analysis of this enterprise enabled the research to focus on important aspects of sustainable development, such as environmentally friendly production, efficie t resource use, innovative technologies, and social responsibility. These elements represent a signifi ant step towards achieving sustainable and long-term outcomes at the industry level. To determine the position of the selected enterprise within the market, an assessment of its absolute and relative market shares was conducted, and the Herfi dahl-Hirschman Index (HHI) was calculated. Th s was undertaken because analysing the absolute and relative market share of an enterprise is essential for evaluating its image and competitiveness within the market. A high market share may indicate that the enterprise exerts considerable influence on the market, enjoys popularity among consumers, and is capable of meeting their needs. A high relative market share refl cts the enterprise's ability to remain competitive, as it not only holds signifi ant market power but also competes effectively with key

rivals. Th s can contribute to securing market leadership under the principles of sustainable development. The enterprise's market share (D) is the percentage (or proportion) of the enterprise's product volume in the total sales volume of the market:

$$D = \frac{Q_v}{Q_{\Sigma t}} \cdot 100\%, \quad (1)$$

where Q_v is the volume of the company's product sales in physical or monetary terms; $Q_{\Sigma t}$ is the total volume of product sales in the market in physical or monetary terms.

Relative market share (DMI) is defi ed as the ratio of the company's market share to the combined market share of the main competitors:

$$DMI = \frac{D}{D_{k1} + D_{k2} + D_{k3}}, \quad (2)$$

where D is the enterprise's market share; D_{k1}, D_{k2}, D_{k3} are the market shares of the three combined competitors, respectively. To analyse the competitive environment, the level of market monopolisation was assessed using the HHI, which considers the market share of each participant and is calculated as the sum of the squares of the shares of all enterprises operating within the market, according to the following formula:

$$HHI = \sum_{i=1}^{n} D_i^2, \quad (3)$$

where n is the number of enterprises in the market; D_i is the market share of the i-th enterprise. Based on the principles of comprehensiveness and systematic analysis, achieved through a combination of the aforementioned methods and techniques for evaluating the image component of enterprise competitiveness, an appropriate analytical algorithm has been developed and is recommended for use in similar studies.

Results and Discussion

Sustainable development is becoming an increasingly important factor in assessing the competitiveness of enterprises in the modern market for several key reasons. The growing signifi ance of environmental and social standards: there is a rising global focus on environmental and social issues, which requires enterprises not only to ensure economic effici cy but also to minimise negative impacts on the environment and society. Enterprises that implement sustainable development principles can gain additional trust from consumers, investors, and partners.

Modern consumers are increasingly inclined towards companies that comply with environmental and ethical standards. Enterprises that invest in sustainable development can obtain competitive advantages by offering products and services that meet these criteria, thereby enhancing their market appeal. Simultaneously, investors are increasingly drawn to companies that demonstrate resilience and the capacity to adapt to economic and environmental challenges. By integrating sustainable development principles, companies can attract additional investment, as they are perceived as more stable and forward-looking. In addition, many countries have introduced strict environmental regulations and standards, compelling enterprises to adopt sustainable development practices. In this context, sustainable measures become not only a competitive advantage but also a legal necessity (Kruglikova, 2023). Th s shift towards sustainability also stimulates innovation, encouraging enterprises to reduce energy consumption and optimise production processes. As a result, overall efficie cy increases and costs are reduced, thereby enhancing competitiveness. Furthermore, enterprises that actively engage in sustainable development cultivate a positive image among the public. Such efforts contribute to building a loyal customer base, strengthening brand reputation, and increasing market competitiveness. Finally, sustainable development refl cts a company's ability to adapt to changes in the external environment, such as climate change or economic crises. Th s adaptability helps mitigate risks and ensures greater long-term stability for the enterprise.

Given these factors, sustainable development emerges not only as an ethical imperative but also as a strategic necessity for maintaining competitiveness in the contemporary market. In the Ukrainian context, only a limited number of enterprises are actively committed to implementing sustainable development principles. These companies not only contribute to environmental preservation but also enhance their competitive standing and public image. For example, Nestlé Ukraine is actively working to reduce plastic packaging and has implemented measures to conserve water and energy. Th ough such initiatives, Nestlé strengthens its reputation as a responsible business (Nestle ESG score…, 2023). Kyivstar exemplifies sustainable development through initiatives in social responsibility, support for environmental projects, and energy conservation (VEON's Kyivstar extends…, 2024). Myronivskyi Khliboproduct, an agricultural holding, is also taking active steps towards sustainable development in the agricultural sector (The largest companies in Ukraine, n.d.). It employs modern technologies to reduce resource consumption, improve working conditions, and advance social initiatives.

Such measures enable the rational use of resources and energy, enhance investment attractiveness, attract talented personnel, and provide opportunities to enter new markets. Accordingly, the implementation of sustainable development principles signifi antly improves a company's image, increases its recognition, and strengthens trust in its brand. An increasing number of companies in Ukraine are beginning to recognise the importance of sustainable development for their operations. Th s approach allows enterprises not only to maintain competitiveness but also to contribute to the broader development of society and the environment. It may become one of the key factors in determining market leaders across various industries. Agrana Fruit Ukraine LLC is actively integrating sustainability principles into its strategic planning. The company is committed to achieving carbon neutrality, with plans to reduce

energy consumption by 5% by 2025 to reach carbon neutrality in its operations by 2040 (The Agrana Fruit…, n.d.). It is also working to reduce water usage and to implement regenerative agricultural practices aimed at improving biodiversity and soil health. By 2025, the company intends to trace 100% of its fruit and sugar back to farmers, and by 2040, to ensure that all fruit is sourced sustainably. In addition, Agrana Fruit Ukraine LLC has attained gold status in the GLOBALG.A.P. Farm Sustainability Assessment, which refl cts the high sustainability standards embedded in its operations. The company also invests in production modernisation, particularly in the fruit fillers workshop, which has led to a 30% increase in fin shed product output.

Furthermore, Agrana Fruit Ukraine LLC actively implements programmes focused on supporting employees, creating favourable working conditions, promoting career development, and upholding the principles of equality (Our employees are…, n.d.). The company has optimised recruitment, onboarding, adaptation, and employee development processes, and has established a "Training Sector" that facilitates continuous professional development without requiring staff to be absent from work. The training is centred on practical skills and knowledge, thereby increasing overall work effici cy. In terms of employee motivation, the company has introduced a differentiated wage system, established performance benchmarks, and ensured payroll transparency. These initiatives encourage employees to maintain high work standards and contribute to increased effici cy. Agrana Fruit Ukraine LLC also actively collaborates with the Vinnytsia Regional Employment Centre, ensuring legal employment and supporting local communities. In 2020, the company submitted 678 vacancies, of which 665 were through the employment service. In 2021, 198 vacancies were submitted, with 191 successfully filled.

These initiatives have a positive impact on the company's image, enhancing its reputation as a socially responsible employer that prioritises employee well-being and actively contributes to the development of local communities. To gain an understanding of the overall market trends in which the analysed company operates, a general analysis of the juice and juice-based products industry was fi st conducted. The analysis of the product market, which represents the core activity of the company under study, revealed that since 2013, the market capacity has been steadily declining. In 2013, the market capacity was 624.8 thousand tonnes; in 2014, it fell to 596.6 thousand tonnes; and in 2015 – to 353.8 thousand tonnes. In 2015, the production of juice concentrates decreased by 45% (255 thousand tonnes), and juice blends by 18% (202 thousand tonnes). In 2016, total market capacity declined further by 15% compared to 2015. In 2017, the market remained at the 2016 level; in 2018, it stood at 198 thousand tonnes, in 2019 – 176 thousand tonnes, in 2020 – 167 thousand tonnes; in 2021 – 156 thousand tonnes, and in 2022 – 149 thousand tonnes (Fig. 1). Th s downward trend is primarily associated with fluctuations in exchange rates, rising utility costs, and the fact that a large proportion of products in this industry are imported.

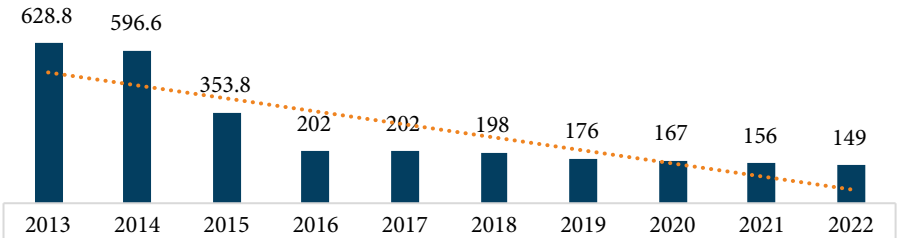

Figure 1. Dynamics of the market capacity of juice concentrates in Ukraine (thousand tonnes)
Source: developed by the author based on the Market research report on juices, smoothies and fruit purees in Ukraine (2023)

Ukraine ranks among the world's five largest exporters in this sector. Products are exported to EU countries (Poland, Austria, Germany), as well as Kazakhstan and Moldova. Only 5% of the products in this segment of the Ukrainian market are imported. As the industry does not deal with essential goods, demand is highly variable. On average, juice consumption in Ukraine is around 10 litres per person per year. Products targeted at children are particularly in demand. When choosing a juice brand, consumers typically consider environmental sustainability, taste, composition, and brand reputation. Packaging design and price also play a signifi ant role in the purchasing decision.

As one of the leading juice producers on the Ukrainian market, Agrana Fruit Ukraine LLC was selected as a representative research object. A practical assessment of the image component of the company's competitiveness was conducted using Agrana Fruit Ukraine LLC as a case study for the period 2020-2022.

STAGE 1. At the fi st stage of the analysis of the image component of the competitiveness of Agrana Fruit Ukraine LLC, the market conditions of the relevant industry will be examined by analysing the company's market share, its relative market share, and the level of market concentration (using the Herfi dahl-Hirschman Index), in the context of the activities of its main competitors. The relevant calculations are summarised in Table 1. The market position of an enterprise is a key factor in determining its competitiveness. It refers to the enterprise's standing in relation to other market participants based on various indicators, such as market share, brand image, pricing, product quality, innovation, and other relevant factors. The fi dings of the market situation analysis are also presented in Table 2.

Table 1. Results of the analysis of the state and degree of competition in the market for Agrana Fruit Ukraine LLC for 2020-2022, taking into account the positions of its main competitors

Parameter	Total volume of sold products, million UAH			Agrana Fruit Ukraine			T.B.Fruit (Galicia)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Volume of sold products, thousand UAH	22,500	21,400	19,600	780,798	1,124,498	970,327	473,999	321,749	357,068
Market share, %	–	–	–	3.47	5.25	4.95	2.11	1.50	1.82
Relative market share	–	–	–	0.084	0.080	0.079	0.050	0.022	0.028
Herfi dahl-Hirschman Index	941	3,299	2,876	–	–	–	–	–	–

Source: compiled by the author based on Financial information (n.d.)

Table 2. Results of the analysis of the state and degree of competition in the market for Agrana Fruit Ukraine LLC for 2020-2022, taking into account the positions of its main competitors

Parameter	PepsiCo			Fruit Capital			Witmark-Ukraine		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
Volume of sold products, thousand UAH	6,423,969	12,118,128	10,341,642	663,660	91,783	210,521	2,257,293	1,687,551	1,554,559
Market share, %	28.55	56.63	52.76	2.95	0.43	1.07	10.03	7.89	7.93
Relative market share	1.735	3.867	3.588	0.070	0.006	0.016	0.287	0.124	0.133

Source: compiled by the author on Financial information (n.d.)

According to the calculated Herfindahl-Hirschman Index, in 2020 the market was characterised as weakly concentrated, with a high level of competition. In 2021 and 2022, the market became highly concentrated, indicating an increased risk of monopolisation. In this context, it is essential for enterprises operating in such a market to enhance their competitiveness and image to avoid becoming marginalised in comparison to a potential monopolist (in this case, PepsiCo LLC could take on that role). The dynamics of the market share and relative market share of the company under study are shown in Figure 2.

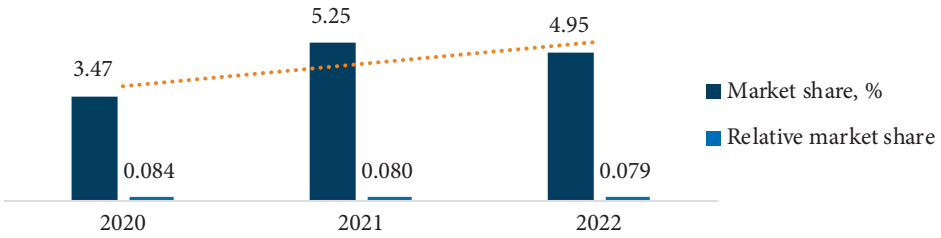

Figure 2. Dynamics of the market share and relative market share of Agrana Fruit Ukraine LLC for the period 2020-2022

Source: compiled by the author on Financial information (n.d.)

STAGE 2. The next step involves selecting the most appropriate method for assessing the image component of the competitiveness of Agrana Fruit Ukraine LLC. It is important to note that the assessment should incorporate both quantitative and qualitative indicators. Quantitative measures enable the evaluation of the image component at the macro level of the enterprise, while qualitative measures are more suitable for the micro level.

STAGE 2.1. Taking this into account, the present study considers it appropriate to apply the costbased approach to estimate the image component by calculating the value of goodwill. The advantage of this method lies in its ability to provide a quantitative assessment of the company's image value, as well as to evaluate the impact of intangible assets on profitability. One limitation of this approach is the difficulty of accurately determining the market value of the enterprise, along with the requirement for a signifi ant volume of industry-specific data. The estimation of goodwill refl cts the value of resources that motivate customers to choose a particular product, ultimately generating additional profit for the company. A key characteristic of goodwill is that it is the only type of intangible asset that cannot be analysed independently of the enterprise as a whole.

The value of goodwill may be either positive or negative. Goodwill will have a negative value if the enterprise's market value is lower than the book value of its net assets. A positive image is refl cted in a situation where the value of the enterprise exceeds the value of its assets and liabilities. Th s implies the presence of a certain level of quality or advantage not captured by the company's tangible assets

alone. It is this intangible quality a combination of assets that motivates consumers to purchase the products of the studied company. Goodwill for Agrana Fruit Ukraine LLC will be determined for the period 2020-2022 using the reputation evaluation method based on product sales volume. Th s involves defini g goodwill as the difference between net operating profit and the product of sales volume and the profitability ratio. Th s method allows for the assessment of the company's current reputation value. The relevant calculations are summarised in Table 3.

Table 3. Analysis of indicators forming goodwill for Agrana Fruit Ukraine LLC for the period 2020-2022

Indicator	Years			Deviation			
				2020/2021		2021/2022	
	2020	2021	2022	Absolute deviation	in %	Absolute deviation	in %
Net operating profit, thousand UAH	151,365	160,632	90,416	9,267	6.12	-70,216	-43.71
Volume of sold products, thousand UAH	780,798	1,124,498	970,327	343,700	44.02	-154,171	-13.71
Profit, thousand UAH	110,465	131,362	76,495	20,897	18.92	-54,867	-41.77
Asset value, thousand UAH	892,172	1,007,557	1,055,231	115,385	12.93	47,674	4.73
Coeffici t of profitability	0.123816	0.130377	0.072491	0.006561	5.30	-0.05789	-44.40
Goodwill, thousand UAH	**54,689.8**	**14,023.6**	**20,075.7**	**-40,666.2**	**-74.4**	**6,052.1**	**43.16**

Source: compiled by the author based on Financial information (n.d.)

The positive value of goodwill for Agrana Fruit Ukraine LLC during the analysed period already indicates a favourable image component of the company. However, in 2021, there was a signifi ant decrease in this indicator by 74.4% the company appeared to be losing its position in the market. In 2022, Agrana Fruit Ukraine LLC, despite the challenging situation in the country, slightly improved its position according to this indicator. Nevertheless, this improvement was not due to enhanced company performance, but rather the market exit of several competing enterprises operating in territories annexed by Russia. The dynamics of goodwill of Agrana Fruit Ukraine LLC during 2020-2022 are presented in Figure 3.

STAGE 2.2. The image component of the researched company will be evaluated by analysing a set of fi ancial and economic indicators, namely: relative gross income (which refl cts the administration's ability to manage production costs), inventory turnover ratio, accounts receivable turnover ratio, accounts payable turnover ratio, average salary level, and current liquidity ratio (Table 4).

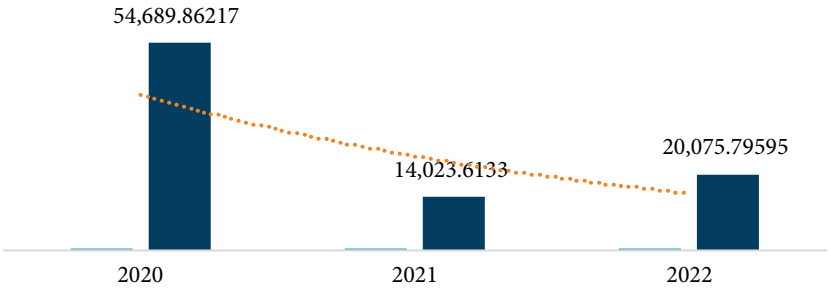

Figure 3. Dynamics of goodwill of Agrana Fruit Ukraine LLC during 2020-2022
Source: compiled by the author based on Financial information (n.d.)

Table 4. Key fi ancial and economic indicators of the image component of the competitiveness of Agrana Fruit Ukraine LLC during 2020-2022

Indicator	Years			Deviation			
				2020/2021		2021/2022	
	2020	2021	2022	Absolute deviation	in %	Absolute deviation	in %
Relative gross income	**1.34**	**1.24**	**1.26**	**-0.10**	**-7.76**	**0.02**	**1.36**
Gross income, thousand UAH	1,050,054	1,394,881	1,219,996	344,827	32.84	-174,885	-12.54
Volume of sold products, thousand UAH	780,798	1,124,498	970,327	343,700	44.02	-154,171	-13.71
Inventory turnover ratio	**1.19**	**1.17**	**1.18**	**-0.02**	**-1.58**	**`0.01**	**0.86**
Average annual cost of stocks, thousand UAH	657,400	962,000	823,000	304,600	46.33	-139,000	-14.45
Accounts receivable turnover ratio	**71.95**	**67.51**	**73.60**	**-4.44**	**-6.17**	**6.09**	**9.02**

Continued Table 4

Indicator	Years			Deviation			
				2020/2021		2021/2022	
	2020	2021	2022	Absolute deviation	in %	Absolute deviation	in %
Average annual receivables	207,000	258,000	246,000	51,000	24.64	-12,000	-4.65
Accounts payable turnover ratio	**4.04**	**4.63**	**4.91**	**0.60**	**14.74**	**0.28**	**5.94**
Average annual payables	260,000	301,000	248,500	41,000	15.77	-52,500	-17.44
Average salary level, UAH/year	**285.23**	**307.88**	**299.03**	**22.65**	**7.94**	**-8.85**	**-2.87**
Salary expenses, thousand UAH	84,714	91,132	92,101.00	6,418.0	7.58	969.00	1.06
Number of employees, person	297.00	296.00	308.00	-1.00	-0.34	12.00	4.05
Current liquidity ratio	**1.47**	**2.33**	**1.38**	**0.85**	**57.78**	**-0.95**	**-40.82**
Average annual value of current assets, thousand UAH	655.50	769.00	816.50	113.50	17.32	47.50	6.18
Short-term liabilities, UAH thousand	444.50	330.50	593.00	-114.00	-25.65	262.50	79.43

Source: compiled by the author

The company under analysis recorded a positive profitability measure relative gross income over 2020-2022. Th s indicates that Agrana Fruit Ukraine LLC enjoyed a relatively high degree of selfsuffici cy. Although this indicator fell by 7.76% in 2021, it recovered by 1.36% in 2022. The inventory turnover ratio refl cts how effici tly the company manages its stock and how many times the stock is turned over within a year. In 2021, this ratio declined to 1.17, but in 2022 it rose slightly to 1.18. Overall, the ratio remained largely stable, suggesting that the company has not prioritised improvements to its inventory-management policy. Figure 4 presents the dynamics of the principal fi ancial and economic indicators that shape the image component of Agrana Fruit Ukraine LLC's competitiveness in 2020-2022.

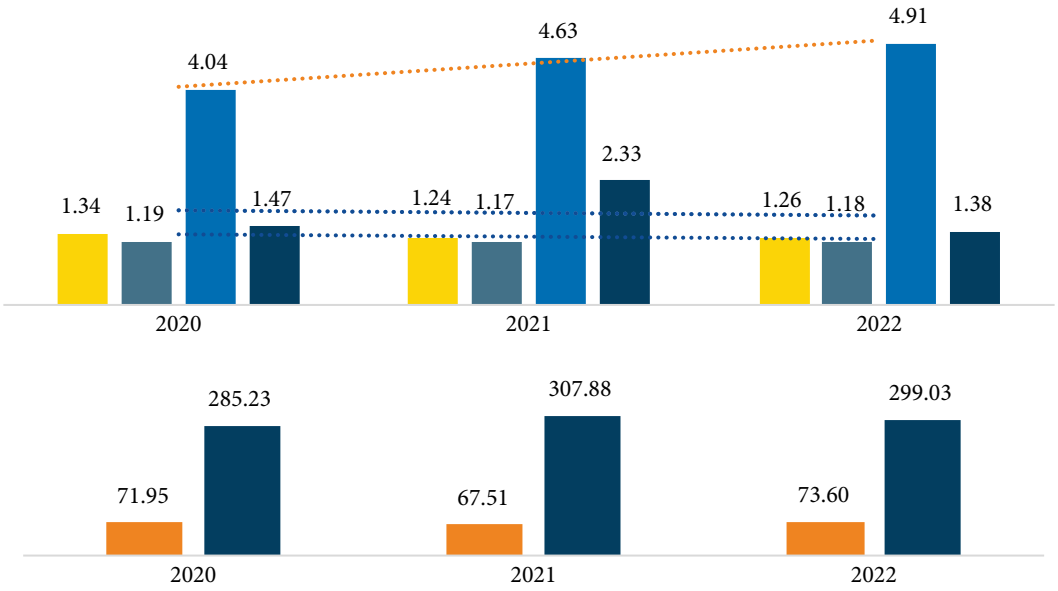

Figure 4. Dynamics of the principal fi ancial and economic indicators that form the image component of the competitiveness of Agrana Fruit Ukraine LLC, 2020-2022

Source: compiled by the author based on Financial information (n.d.)

The accounts receivable turnover ratio increased markedly in 2022 – by 9.02% compared with 2021 and 2020 – indicating higher business activity. The accounts-payable turnover ratio also trended upwards, albeit from a lower base; the absolute values of average annual receivables and payables did not differ signifi antly. Th s pattern shows that the company is, in effect, fi ancing its debtors at its creditors' expense. Nevertheless, throughout 2020-2022, the ratio remained within the recommended threshold for Agrana Fruit Ukraine LLC. In 2022, compared to 2021, there is a 2.87% decrease in the average salary paid by the company fell by 2.87 % relative to 2021, owing to the impact of the full-scale Russian invasion and the consequent reduction in consumers' purchasing power. The current liquidity ratio rose by 57.78% in 2021 compared with 2020; however, it declined by almost 40% in 2022, although it still remained above the minimum acceptable level. Th s ratio measures the company's capacity to meet current

liabilities by deploying current assets. The most favourable position was recorded in 2021 when the ratio reached 2.33. In 2022, the ratio dropped to 1.38, which is still within the norm, but any further deterioration could undermine the company's solvency.

In general, it can be concluded that Agrana Fruit Ukraine LLC operates in a dynamic market environment, saturated with a large number of competing enterprises. The company possesses considerable potential for maintaining a strong image component of its competitiveness and strives to sustain it at an appropriate level. However, given the dynamics of the market, the actions of competitors, the consequences of russian aggression, declining consumer purchasing power, and the specific of the industry (the product is not a commodity), Agrana Fruit Ukraine LLC must implement modern, effective measures to maintain its market position, prevent monopolisation by competitors, and ensure continued development and enhanced competitiveness through strengthening the image component.

Based on the analysis conducted, it is recommended that Agrana Fruit Ukraine LLC implement new measures related to product innovation and assortment expansion. In particular, the development of new products with low sugar content is advisable. Additionally, it is proposed that the company introduce functional products (e.g., those enriched with vitamins or prebiotics) to meet the growing demand for healthy food options. In terms of environmental sustainability, a key step would be the introduction of technologies that reduce carbon emissions and pollution, along with a shift to environmentally friendly packaging materials. The implementation of automated systems for monitoring and quality control will help reduce costs and improve product quality. The company could also benefit from adopting digital platforms to facilitate interactions with suppliers and customers, as well as to optimise inventory and logistics management. Partnerships with major online retailers such as Rozetka, ATB Online, or specialised health food stores would enable an increase in sales volumes. The implementation of these measures will enable Agrana Fruit Ukraine to remain competitive in the market, expand its market share, and attract new consumers. Taking all the above analysis into account, the approach proposed by the authors can be presented as an algorithm for determining the level of an image component of the enterprise's competitiveness Figure 5.

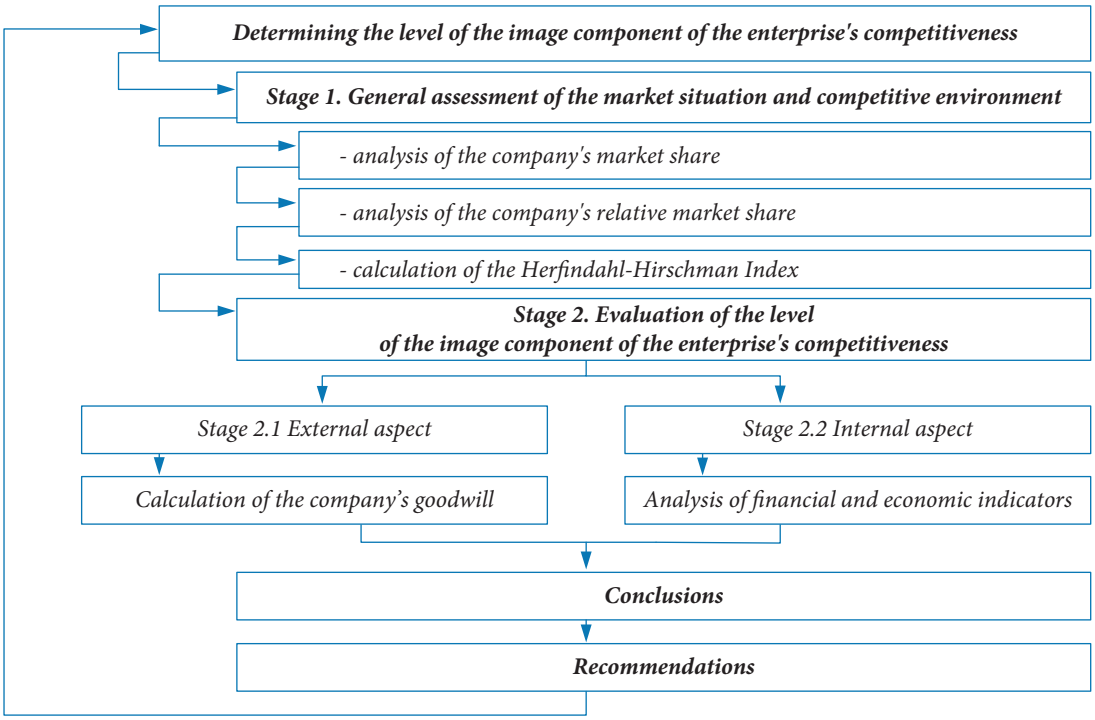

Figure 5. Algorithm for determining the level of the image component of an enterprise's competitiveness
Source: compiled by the author based on Financial information (n.d.)

According to the chosen approach to analysing the image component of the enterprise, it is possible to establish the degree of market dynamism, determine the level of competition, and assess the enterprise's ability to maintain its competitive standing. In addition, this approach enables the identifi ation of key factors that negatively affect the enterprise's development potential. Based on the results of the analysis, a set of practical recommendations can also be developed to ensure the enterprise's market stability and continued operation. Th s approach to assessing the image component of enterprise competitiveness adheres to the principles of a comprehensive and systematic methodology and also aligns closely with the conditions of sustainable development.

Several approaches are widely used for the quantitative and qualitative evaluation of an enterprise's image component of competitiveness. During the analysis of image parameters, a synthesis of both quantitative and qualitative approaches is generally applied. Relying on a single method would not provide a suffici tly comprehensive evaluation, that is, one capable of determining both the value and interrelationship of the available parameters. Moreover, the image component of an enterprise's competitiveness represents a set of actions aimed at creating a positive perception of the enterprise or organisation. Th s includes its promotion to achieve strategic objectives and to secure a stable, competitive position in the market (Brin *et al.*, 2020). The image component of competitiveness is typically divided into internal and external aspects. External image factors include product quality, the price-quality ratio, relationships with partners, the level of reliability, social policy, fi ancial policy, and communication strategy. Internal image factors include the team's socio-psychological climate; systems of incentives and motivations; fulfilment of duties; employee qualifi ations; and organisational policy on career planning.

The image component provides the enterprise with a primary external competitive advantage a combination of success factors that distinguish it from competitors and contribute to securing a stable market-leading position at a given time (Taran-Lala *et al.*, 2020). The image component is perceived differently by various stakeholder groups, as their expectations and behaviour towards the enterprise may vary. Th s means that identical attributes may be interpreted differently by consumers, investors, the state, and the industry at large. For instance, forming a positive image among the general public largely depends on consumer perception, while for business partners, characteristics such as reliability and constructiveness are of greater importance. Furthermore, the enterprise's personnel also hold distinct views of the organisation and its management. It can therefore be concluded that the enterprise possesses multiple elements contributing to its overall image. The synthesis of these perceptions through the lens of diverse stakeholder groups produces a more comprehensive understanding of the business entity, thereby constituting its corporate image. The image component of a company's competitiveness among consumers is defi ed by their perception of specific attributes that, in their view, the company's products possess such as quality, design, brand recognition, service provision and systems, product pricing, and consumers' interpretation of the company's stated mission, strategies, and corporate identity. Several methods are actively employed to evaluate the image component of an enterprise's competitiveness. The semantic differential method has become the most widely used (Leskova & Pastuschyn, 2023), alongside scaling methods, the calculation of integral indicators, and image valuation through goodwill assessment.

In the study of V. Shumkova *et al.* (2024), the importance of adhering to the principle of comprehensiveness during the analysis, planning, implementation, and evaluation of an enterprise's image is also emphasised. The study highlighted, in particular, the social and innovative dimensions of image formation for a modern enterprise operating in a dynamic market environment. V. Yazina *et al.* (2023) stress in their research that approaches to the analysis of image and reputation should incorporate both internal and external aspects of enterprise activity, in line with the principle of comprehensiveness. G. Studinska (2020) confi med that brand and image formation is an integral component of competitive enterprise activity under conditions of sustainable development. Furthermore, the processes of sustainable development and globalisation demand continuous management in order to enhance operational efficie cy. The influence of globalisation and sustainable development on enterprise competitiveness viewed through the lens of image is supported by qualitative changes in the structure of both domestic and global markets.

I. Rudenko *et al.* (2020) emphasised that image, as a component of enterprise competitiveness, is highly sensitive to shifts in the business environment and must be adapted to refl ct the needs of all stakeholders in business processes. Accordingly, sound management decisions regarding image development should be based on an analysis of current competitive advantages, corresponding to both the absolute and relative market share held by the enterprise and the degree of market monopolisation. An important stage in analysing the image component of enterprise competitiveness is its valuation through the calculation of goodwill (S. Labunska & M. Sobacar, 2022). Th s approach allows for a quantitative appraisal of the enterprise's image value and enables the analysis of how intangible assets influence profitability. In this context, the reputation of an enterprise is shaped by the effective utilisation of its intangible resources. However, the exclusive use of this method is not universal and thus necessitates a comprehensive approach that also considers a range of other factors that contribute to enhancing the company's image. Yu. Kovtunenko & Ya. Kolisnichenko (2024) proposed a broader range of methodological approaches for determining an enterprise's level of competitiveness: the indicative method, the analytic hierarchy process, the expert assessment method, and the analysis of external factors and competitive advantages. However, their study demonstrates that the most accurate and objective results can be obtained only through the combined application of various methods, thereby ensuring that all relevant aspects of the business entity's operations are considered. I. Dmitriev *et al.* (2020) argue that the image component of enterprise competitiveness can be analysed through the lens of fi ancial and economic indicators, namely: relative gross income, which refl cts the ability of enterprise management to control production costs; inventory turnover ratio; accounts receivable turnover ratio; accounts payable turnover ratio; average wage level; and current liquidity ratio. However, this approach reveals only the internal dimension of the image component.

M. Mashchenko *et al.* (2024) interpreted the image component in terms of the enterprise's product range. Nevertheless, this approach is relatively narrow in scope, and

the authors themselves consider it primarily in relation to profitability, which they view as the main indicator of how consumers perceive the enterprise's products. Similarly, S. Khaminich *et al.* (2020) emphasised the importance of assortment policy as a key determinant of an enterprise's competitive standing. Yet, given the volatility of the market environment, a more comprehensive and systematic approach to managing competitiveness is required. Conversely, V. Rozhko (2023) defi ed and justifies the relevance of analysing the external conditions of enterprise activity as part of the image-building process. The study underlined that when selecting an enterprise, consumers are guided by its image. A positive image enhances consumers' confide ce in the high quality of products and the enterprise's broader competitive advantages. The image component represents a signifi ant factor in enterprise competitiveness, as it influences the perception of the company among consumers, partners, investors, and the general public. An enterprise's image determines how it is viewed in the marketplace and serves as a key element in attracting and retaining customers, as well as in building trust and credibility at all stages of engagement.

Conclusions

It has been established that, under conditions of sustainable development and a dynamic market environment, the continuous maintenance of an appropriate level of competitiveness is an integral part of an enterprise's successful operation. The positive image component of an enterprise constitutes a signifi ant and multifaceted element in shaping the competitive standing of a modern business entity. Th s is particularly relevant in light of the current exacerbated economic and political situation in the country, coupled with external uncertainty. These factors create strategic hesitation among enterprise managers regarding brand development and the ability to compete in new markets, which in turn slows down enterprise growth, weakens its competitive position, and negatively impacts its overall image.

According to the fi dings of the study, the assessment of the image component of enterprise competitiveness should be of an enterprise from the standpoint of systematicity and complexity. Such an approach enables the modelling of an enterprise's competitive market position through the management of fi ancial and economic indicators and market value. The chosen combination of methods for assessing the image component of competitiveness provides both qualitative and quantitative insights, aligning with the study's objectives. Future research may focus on the development of an automated decision-making system for modelling enterprise competitiveness and formulating long-term development strategies. Furthermore, accounting for market factors will enable the selection of an appropriate strategy for future growth and safeguard market positions against competitive threats. The approach proposed by the authors for assessing enterprise image can also be applied in future research, with the potential to incorporate an expanded system of indicators that considers the specific features of enterprise management and industry-specific characteristics.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Аналіз іміджевої складової підприємства в умовах концепції сталого розвитку

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Анотація. Позитивна іміджева складова підприємства – це важливий і складний елемент формування конкурентоспроможного його рівня, що є передумовою надійного, стійкого та успішного господарювання в ринкових умовах сталого розвитку. Тому формування та моделювання іміджевого образу підприємства є комплексним завданням, що потребує ретельного дослідження та аналізу. Метою дослідження було проведення аналізу іміджевої складової бізнес-системи підприємства в умовах сталого розвитку. Під час досліджень використано дані статистичного обліку відповідної галузі та результати фінансово-господарської діяльності об'єкту досліджень. Застосовано методи кількісного і якісного аналізу, метод порівняння, метод статистики, економічного моделювання, методи абсолютних та відносних різниць, прийоми детермінованого факторного аналізу, графічні методи. У роботі обґрунтовано необхідність застосування комплексного підходу до оцінки іміджу компанії з використанням якісного та кількісного аналізу факторів мікро- та макросередовища. Авторами запропоновано системно-комплексний алгоритм визначення рівня іміджу компанії. Позитивна іміджева складова підприємства є досить важливим і складним елементом у формуванні конкурентоспроможного рівня сучасного суб'єкта господарювання. Це пов'язано із загостренням економічної та політичної ситуації в країні та невизначеністю зовнішнього середовища, що породжує певні вагання у керівників підприємства щодо майбутнього розвитку бренду та можливості конкурувати на нових ринках збуту, внаслідок чого зростає розвиток підприємства, рівень його конкурентоспроможності та імідж в цілому. Застосування системно-комплексного підходу до оцінки іміджевої складової конкурентоспроможності підприємства дасть змогу моделювати його конкурентний статус на ринку шляхом управління його фінансово-економічними показниками, ринковою вартістю. Результати досліджень можуть бути використані управлінцями різноманітних підприємств з метою підвищення ефективності управління конкурентоспроможністю власного бізнесу

Ключові слова: конкурентоспроможність підприємства; ефективність; конкуренція; якість; репутація; управління

INNOVATION AND SUSTAINABILITY
Volume 5, No. 1. 2025
Journal homepage: https://inns.com.ua/en
Received: 28.10.2024; Revised: 26.02.2025; Accepted: 27.03.2025
DOI: 10.63341/vis/1.2025.83

UDC 331.101.1

Safe and productive digital workplace: Eco-ergonomic principles of organisation

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Abstract. The digitalisation of all work processes characterises the current reality. Consequently, information has emerged as the fundamental unit of these processes, with core operations revolving around the creation, reception, use, and exchange of information. Th s shift has prompted a fundamental transformation in work content, labour market dynamics, and the requirements concerning safety and ergonomic principles in workplace organisations. Th s research aimed to devise a strategy for developing digital workplaces, leveraging eco-ergonomic principles in their organisation. The "Work 4.0" concept was a foundational starting point for this research. Under the "Work 4.0" framework, traditional workplaces are evolving into digital ones by integrating digital devices and tools, alongside information ergonomics, green ergonomics, and ergoecology principles into work processes. The research introduced a model for a digital workplace and emphasised the necessity of adopting new eco-ergonomic principles for its organisation. The study also examined the company's safety culture, as new working conditions necessitate a revision of the principles for ensuring worker safety. A connection between digitalisation and the development of a company's safety culture was established, and the advantages of using digital technologies and tools to support this development were demonstrated. The formation of the digital workplace development strategy marked the fi al stage of the study. The "Work 4.0" concept, the revision and updating of ergonomic principles of work organisation under digitalisation, and the development of a company's safety culture provided the foundation for the strategy. Its implementation ensures flex ble work schedules, increased worker mobility, and a new level of workplace safety and comfort

Keywords: "Work 4.0" concept; ergoecology; green ergonomics; safety culture; sustainability

Suggest Citation:
Protasenko, O., Ivashura, A., Yermolenko, O., & Ponomarenko, Ye. (2025). Safe and productive digital workplace: Eco-ergonomic principles of organisation. *Innovation and Sustainability*, 5(1), 83-91. doi: 10.63341/vis/1.2025.83.

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Introduction

Workplace stressors, increasingly acknowledged as significant barriers to employee well-being, can profoundly affect health, safety, and overall productivity. Organisations often strive to cultivate a supportive and conducive working environment to address these challenges, taking into account each worker's unique characteristics and needs. Research consistently demonstrates that a well-structured and thoughtfully organised workspace, aligned with employees' strengths and limitations, can signifi antly mitigate stress and fatigue. Th s reduction not only enhances individual well-being but also decreases the likelihood of errors in daily operations. In this context, the role of designers is paramount. They are instrumental in fostering environments that promote workers' health, comfort, and productivity. By ensuring that materials, equipment, and overall workspace design correspond with individuals' psychological and physical attributes, designers contribute to a more effective working experience. Designers must embrace ergonomic principles to enhance both productivity and health in the workplace. Ergonomics optimises the interaction between people and their environments, creating efficient spaces that support the well-being of every employee.

O. Protasenko & G. Mygal (2023) have highlighted that the issue of information load has predominantly been addressed through cognitive ergonomics until recently. Researchers have emphasised the critical need to tailor information systems to align effectively with human cognitive capacities, although they have often overlooked the nuanced factors contributing to the complexities of intellectual labour. These neglected elements include challenges such as information overload and the negative effects of multitasking. A new interdisciplinary fi ld has since emerged within ergonomics: information ergonomics. L. Shahrzadi *et al.* (2024) noted that its primary objective is to investigate and manage the burdens associated with information load, which signifi antly affect employees in high-demand, information-intensive work environments. Researchers emphasised that the essence of information ergonomics lies in synchronising user activities with the demands of the digital workspace. Th s fi ld does not merely seek to remedy observable problems; it also aims to enhance employee productivity and overall well-being amid increasingly complex digital environments, while simultaneously developing effective strategies to optimise workplace organisation.

A. Moko *et al.* (2023) observed that information overload may stem from various sources, including complex work processes, convoluted organisational structures, diverse work environments, and prevailing behavioural patterns within teams. The research conducted by M. Caterino *et al.* (2023), along with the earlier studies of S. Schlund *et al.* (2022), and O. Protasenko & G. Mygal (2024), underscored several recurring scenarios that contribute to information overload. A key concern is the complexity involved in managing, using, and storing vast amounts of information. When the volume of incoming information surpasses its quality, employees often fi d themselves overwhelmed, dedicating excessive time to sifting through data to locate essential information, which inevitably results in information overload. Another substantial contributor to this problem is the constant state of multitasking and an incessant barrage of interruptions. By defin tion, multitasking involves the simultaneous execution of multiple tasks, leading to unavoidable disruptions as individuals switch between varied activities. Th s continuous shift demands additional cognitive resources and intensifies the experience of information overload. Intentional breaks that diverge from primary work tasks, such as checking emails or scrolling through social media, further compound this mounting pressure.

A poorly structured workplace can signifi antly increase employees' cognitive and temporal demands as they attempt to manage, memorise, and reallocate information effectively. For example, multiple information systems can drastically increase cognitive load, especially when employees face lengthy and intricate task chains that can overwhelm working memory. Research by J. Pongsak *et al.* (2020), O. Lazko *et al.* (2021) and M. Khan *et al.* (2024) has identifi d information overload as a leading contributor to office syndrome among workers. Th s syndrome is associated with a range of detrimental health conditions, including obesity, hypertension, diabetes mellitus, dry eyes, neurological disorders, and carpal tunnel syndrome, highlighting the urgent need to address the growing challenges of information ergonomics in modern workplaces. The amount of time individuals dedicate to digital work environments has steadily and signifi antly increased in recent years. While opening new avenues for productivity, this shift has also introduced the challenge of information overload, which can adversely affect worker well-being and overall effici cy.

To effectively address this complex issue, it is imperative to recalibrate the volume and organisation of information presented to employees and to implement innovative strategies for workplace arrangement. The fi ld of ergonomics is central to this endeavour and plays a crucial role in developing principles that ensure optimal workplace conditions amidst the ongoing wave of digital transformation. Focusing on the ergonomic aspects of the workspace may mitigate the adverse effects of prolonged digital engagement and lay the foundation for more sustainable practices in the future. Th s study aimed to apply eco-ergonomic principles in digital workplace design to enhance health and productivity, and to develop a strategy for its further advancement.

Materials and Methods

The study employed an integrated blend of general scientific and specialised research methodologies to enable a rich, multidimensional exploration of the subject matter. Among the general scientific methods used were analytical reviews, systematic and interdisciplinary approaches, and comparative analysis. These methodologies were instrumental in identifying essential trends, recurring patterns, and complex interconnections within the research landscape. The

systemic approach considered workplace optimisation under digitalisation as a multifaceted phenomenon shaped by numerous interrelated factors that require careful examination. The interdisciplinary approach drew upon various scientific fi lds to construct a cohesive and comprehensive understanding of the subject, while comparative analysis yielded valuable insights through the evaluation of existing research, methodologies, and workplace optimisation strategies across different contexts and disciplines.

The methodological and theoretical framework of this study was fi mly rooted in the contributions of leading experts in ergonomics, ecology, psychology, and information technology. Drawing upon these established theoretical perspectives and principles effectively guided the research process. In the domain of ergonomics, core principles relating to workplace design, human-machine interaction, and productivity were integrated into the analysis, deepening understanding of optimal digital workplace arrangements (Wodajeneh *et al.*, 2024). Eco-centric perspectives were adopted to examine the sustainability of workplace environments, ensuring that digital transformation does not lead to increased resource consumption or negative ecological consequences (Reiman *et al.*, 2021). Psychological theories were carefully applied to explore employees' cognitive and behavioural dynamics as they adapt to evolving digital work environments. Meanwhile, insights from information technology highlighted the role of digital tools and technological developments in shaping modern workplace configur tions. The interdisciplinary nature of this research stemmed from the growing need to synthesise developments across diverse academic disciplines. The study drew upon multiple domains to establish a more comprehensive and practically applicable framework for workplace optimisation (Amani & Akhavian, 2024).

The empirical basis of the research was formed through a detailed analysis and critical evaluation of workplace ergonomic provisions, incorporating both qualitative and quantitative data sources. It examined ergonomic conditions and their effects on employee productivity, health, and well-being (Souchet *et al.*, 2023). The study also included fi dings by Ukrainian scholars (Chigrin & Scherbak, 2011) concerning workplace eco-friendliness, assessing sustainable practices and environmental considerations central to workplace design. Th ough this extensive exploration of multiple dimensions, the research offered a thorough evaluation of how workplace organisation can be improved in the digital era while adhering to human-centred and environmentally responsible approaches.

The eco-ergonomic structuring of the digital workplace was based on practical studies focused on workplace organisation. These studies helped to identify existing challenges and explore potential solutions related to digital workplace design. Between 2019 and 2023, a series of investigations was undertaken into the eco-ergonomic organisation of workplaces. Specifi ally, the eco-ergonomic conditions of work environments for managers, students, and engineers in both offl e and online settings were evaluated. These roles were selected as the participants performed similar types of tasks. A total of 108 participants took part in the study, which was carried out following the European Commission's Guidance Note on Ethics and Data Protection (2021). The research was conducted at the printing company "Polyemos" (Kharkiv, Ukraine) and the Simon Kuznets Kharkiv National University of Economics (Kharkiv, Ukraine). A simplifi d example of the eco-ergonomic assessment of digital workplace organisation (covering only a few selected elements from the complete list) is presented in Table 1.

Table 1. Sample eco-ergonomic assessment of digital workplace organisation

No.	Characteristics of the digital workplace	Eco-ergonomics (points)
	Eco-friendliness of enterprise infrastructure:	
1	dedicated parking areas	5
2	unregulated car parking	1
	Building eco-friendliness:	
3	concrete structure	5
4	brick structure	4
5	breeze block construction	3
	⋮	⋮
	Overall score:	

Source: compiled by the authors

The eco-ergonomic assessment of the digital workplace organisation included sixteen characteristics. Each feature was evaluated on a scale from 1 to 5 points. One point indicated an unsatisfactory level of eco-ergonomics, while five points refl cted a satisfactory level. Upon completing the assessment, it was necessary to determine the overall eco-ergonomic rating of the digital workplace. Th s was categorised as unsatisfactory, average, or satisfactory. For research convenience, the assessment was offered in two formats: a printed version for offl e participation and an online version via the free web-based platform "Online Test Pad" for remote participation. The format used was determined by the participants' work schedules.

Results and Discussion

The research led to the identifi ation of several eco-ergonomic principles for workplace design. The use of eco-friendly materials is pivotal in the construction of

workplace furniture and technical equipment. Th s principle underscores the importance of selecting sustainable materials that minimise environmental impact, alongside ergonomically designed components that support physical wellbeing. Careful consideration was given to the sustainability of fin shing materials used in offic decor – including, but not limited to, fl oring, ceiling tiles, wall coverings, and other aesthetic features of the workspace. The choice of these materials can signifi antly influence the environmental footprint of the offic as well as the health and comfort of its occupants.

The implementation of eco-safe and energy-effici t systems is essential to enhancing the overall workplace quality of life. Th s includes key support systems such as advanced ventilation, intelligent air conditioning, energy-effi cie t heating, and a balanced integration of artific al and natural lighting. Workspace design should go beyond the interior layout to encompass external infrastructure. Th s involves evaluating the sustainability of construction materials, organising parking facilities to support greener modes of transport, and integrating green spaces that promote biodiversity and employee well-being. Energy effici cy assessments, including audits and retrofitting initiatives, are also vital components of sustainable workplace planning.

Engaging employees in comprehensive eco-safety training programmes is a critical practice for raising awareness of environmental safety both in the workplace and at home. These sessions introduce employees to key principles of a safety-oriented workplace culture and emphasise their contribution to broader sustainability goals. It is equally important to monitor and assess the sociopsychological climate of the team. Th s includes analysing employees' psychological responses to changes in their working environment, thereby fostering a responsive and supportive organisational culture. By embedding eco-ergonomic principles into workplace organisation, companies can enhance multiple aspects of sustainable development. A focused effort within the ecological dimension aims to mitigate the adverse effects of hazardous workplace factors on employee health. These impacts can be quantitatively reduced through the use of environmentally friendly materials and the adoption of eco-safe and energy-effici t technologies, thereby decreasing the organisation's overall environmental footprint.

The social dimension addresses the eco-ergonomic needs of employees, with the goal of reducing the likelihood of negative psychological outcomes such as depression, stress, and absenteeism. It highlights the importance of a holistic approach to promoting employee well-being and productivity. From an economic perspective, the integration of environmental and ergonomic principles not only improves staff performance and satisfaction but can also enhance fi ancial outcomes by lowering costs related to sick leave, medical treatment, and energy use. Ultimately, the adoption of eco-ergonomic practices improves both safety and effici cy in the workplace while aligning with the principles of sustainable development. A model of the digital workplace has been proposed, building on this foundation. It integrates the principles of information ergonomics, green ergonomics, and ergoecology. Th s model aims to provide safe and comfortable working conditions while mitigating the negative impacts of human activities on the environment (Fig. 1).

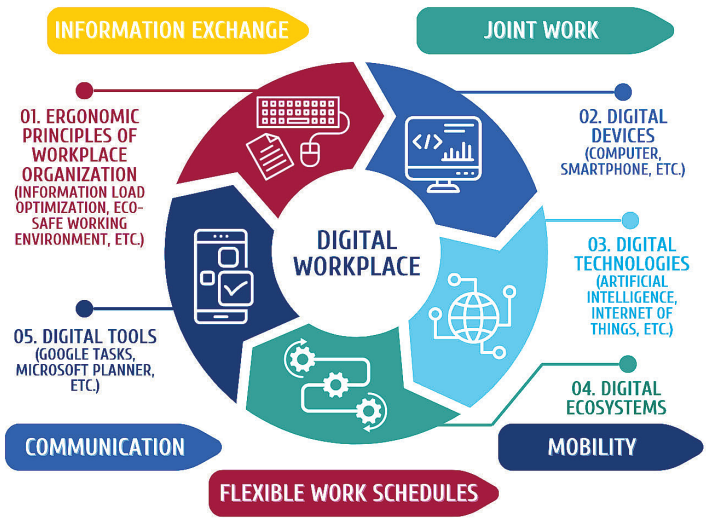

Figure 1. Model of the digital workplace

Source: author's development

The model outlines that the digital workplace comprises several key components, including digital devices such as smartphones, computers, and tablets; technologies such as cloud computing, the Internet of Thi gs (IoT), Big Data, machine learning, and virtual reality; ecosystems such as ehealth and fi tech; and tools like Zoom, Google Meet, Padlet, and Google Docs. Central to this model is the application of ergonomic principles to workplace organisation, which ensures the coordinated functioning of these components. It is important to note

that the structure of the digital workplace is non-standardised, allowing for a diverse range of business applications, online meeting platforms, email services, and other digital tools to be effectively combined into a cohesive digital workspace.

External indicators within the model illustrate the advantages that companies gain by integrating digital workplaces into their operations. Th ough digitalisation, organisations can enhance communication and foster interaction among employees both within and across departments. Digitalisation accelerates the processes of information retrieval and exchange, thereby improving employee effici cy. The digital workplace supports fle - ibility in task execution, encourages collaboration and interaction, and enhances the ability to locate and share information. It fosters a mobile and interactive work environment and offers a wide array of technological options for task completion. Furthermore, the benefits of adopting a digital workplace include reduced costs associated with hardware, offic space, and business travel, among others (Attaran *et al*., 2020; Stahn *et al*., 2022; Kolade & Owoseni, 2022). For instance, by implementing cloud-based solutions, businesses can minimise reliance on physical servers and hardware, as most data storage and software tools are accessible online. Th s reduces the need for expensive equipment upgrades and ongoing maintenance. Remote working capabilities diminish the requirement for physical offic space and infrastructure, enabling employees to work from home using their personal devices. As for business travel, video conferencing platforms, online collaboration tools, and project management software reduce the need for in-person meetings, thus lowering travel expenses.

According to expert forecasts, future success will be achieved by companies that can effectively unite their workforce into cohesive teams, increase workplace mobility and flex bility, and empower employees to remain productive and creative regardless of location. The adoption of digital workplaces will be key to accomplishing these objectives. Digital transformation plays a critical role in fostering a culture of safety within organisations, where behavioural change paves the way for improved human safety across a variety of operational contexts. A strong safety culture is fundamental to a company's sustainable development, requiring staff members to coordinate various activities to ensure seamless operations. As the nature of work evolves and workplaces transition into digital environments, the interplay between safety culture and digital transformation is becoming increasingly signifi ant. A robust safety culture enables an organisation to maintain a secure working environment for its employees. When individuals within a company prioritise safety, operations are conducted with the highest level of care, signifi antly reducing the risk of accidents. Conversely, a weak safety culture suggests that safety may not be taken seriously by all, leading to complacency and unnecessary risks, which increase the likelihood of incidents that compromise employee health and safety. A strong safety culture within a company serves as an effective means of promoting employee safety in the workplace. Consequently, analysing the transformation of safety culture in the context of digitalisation and its effects on workplace development is essential. Research on safety culture amid digitalisation has yielded the following fi dings.

Digitalisation signifi antly enhances workplace safety through various means. Firstly, the adoption of digital safety monitoring tools allows for more effective identification and management of potential hazards. These technological advancements enable rapid responses to emerging issues, providing employees with immediate access to crucial data and facilitating timely corrective actions. Digitalisation also streamlines safety reporting within organisations. Simplifying processes such as incident reporting ensures that a company's safety status is monitored in real time, allowing swift resolution of issues and resulting in improved health and safety conditions for all workers. Digital tools foster improved team communication and collaboration when addressing safety concerns. With real-time hazard monitoring, teams can analyse situations swiftly and make informed decisions that uphold workplace safety standards. Another important benefit of digitalisation is its role in strengthening regulatory compliance. Digital technologies assist organisations in tracking and documenting safety-related activities, helping them demonstrate adherence to relevant regulations and standards. By implementing digital workplace safety solutions, companies can actively mitigate risks and cultivate a strong safety culture. Th s commitment not only enhances regulatory and industry compliance but also strengthens the company's reputation. By demonstrating a commitment to employee welfare and continuous improvement, organisations can project a positive image within the industry and to customers, emphasising their dedication to workplace safety and employee well-being.

The research yielded the following conclusion: digitalisation has led to the widespread adoption of digital technologies and ecosystems, resulting in transformations in labour organisation and changes in labour market demands. Consequently, there emerged a need to establish a new approach to work organisation, known as the "Work 4.0" concept. Th s innovative framework has prompted the exploration of new ergonomic solutions aimed at enhancing workplace safety and comfort, thereby supporting the development of a robust safety culture within organisations. Establishing the "Work 4.0" concept, revising and enhancing ergonomic work organisation principles in response to digitalisation, and promoting a company's safety culture have laid the groundwork for a digital workplace development strategy. Th s strategy integrates digital technologies, tools, and ecosystems into a cohesive framework, enabling flex ble work schedules, enhancing employee mobility, and elevating workplace safety and comfort to a new standard. Based on these insights, a digital workplace development strategy was formulated (Fig. 2).

Figure 2. Digital workplace development strategy

Source: author's development

Such a strategy will improve the effici cy, safety, and comfort of the digital workplace. Digitalisation has prompted a re-evaluation of strategies aimed at ensuring human safety. Th s transformation is evident in the evolving perspectives of both workers and employers regarding safety issues. There has been a signifi ant rise in demand for safe digital work environments, increased expectations around workplace risk levels, and a growing need to foster a strong safety culture.

M. Hovanec *et al.* (2024) and F. Tomelleri *et al.* (2024) have observed that the integration of innovative technologies in production has expedited the digital transformation of management and operational processes while altering the skill sets required of workers. Accordingly, enterprises require effici t digital solutions for routine processes in business environment. Implementing these technologies can signifi antly reduce the time needed to complete tasks, alleviate work monotony, and enhance overall productivity. As a result, this reduces production risks and injuries while fostering an improved safety culture. Consequently, as noted by A. Kolot & O. Herasymenko (2020) and K. Kraus *et al.* (2022), the integration of digital technologies, robotics, nanotechnology, artific al intelligence, and other innovations is transforming labour dynamics, labour market conditions, and workplace safety requirements, giving rise to the concept of "Work 4.0".

The "Work 4.0" concept signifies a new era in labour relations, characterised by a signifi ant rise in digitalisation within work processes and increased organisational flex - bility. Research fi dings indicate that the primary drivers of the "Work 4.0" movement are Industry 4.0 and digital ecosystems. These developments underscore the need to incorporate aspects into digital workplace organisation that were previously overlooked: structuring work processes to enable flex ble schedules for remote employees, regardless of geographic location; developing employee competencies to create a new skill set encompassing effective digital communication and collaboration, self-directed growth in uncertain conditions, creative problem-solving, information and data management, and critical thinking; and prioritising safety measures aimed at designing ergonomic workplaces to minimise injury risks and promote a robust safety culture. Th s concept has prompted O. Kolade & A. Owoseni (2022) and C. Stahn *et al.* (2022) to redefi e the notion of the workplace. With the advent of digitalisation, jobs have become more mobile, and work schedules have gained flex bility. These changing working conditions necessitated a re-evaluation of the principles governing ergonomic workplace organisation. As a result, the "Work 4.0" concept has transformed the traditional workplace into a digital one. As A. Thomas *et al.* (2023), O. Protasenko & G. Mygal (2023) and B. Hasanain (2024) have observed, a digital workplace encompasses digital devices, technologies, ecosystems, tools, and the principles of information ergonomics, green ergonomics, and ergoecology.

The fi dings of independent investigations conducted by B. Hasanain (2024) and O. Protasenko & G. Mygal (2024) indicated that implementing the principles of green ergonomics and ergoecology in the digital workplace is essential, as the digitalisation of human activity is inseparable from the need for environmental sustainability. Th s conclusion is reinforced by the results of the present study. Digitalisation facilitates the rapid resolution of complex problems, while ecological practices reduce environmental burdens. Working in tandem, digitalisation and ecological integration act as key drivers of society's gradual transformation into an eco-digital society. Evidence of this is refl cted in the widespread adoption of Industry 4.0 technologies, digital ecosystems, digital workplaces, cloud technologies, and "green" energy solutions (such as wind farms, solar panels, and tidal stations), along with the implementation of zero-waste technologies and the greening of work and domestic environments. Th s shift has led to the progressive replacement of human labour with digital technologies

and tools, the adoption of automation and robotisation, and the transition from traditional offl e formats of work and study to online modes. These developments reduce the need for face-to-face interaction, promote the selection and use of eco-friendly products, and minimise reliance on energy-intensive technologies and devices. It should be noted that the transformation into an eco-digital society is a global phenomenon; however, its intensity varies across different world regions. Accordingly, O. Protasenko & G. Mygal (2024) emphasise that the ecologisation of work is an integral component of the digital workplace.

Scientific studies by T.A. Norton *et al.* (2021) and K. Değer & H. Başak (2022) have demonstrated that a fundamental principle of green ergonomics and ergoecology is the provision of eco-safe workplaces; without this, ensuring comfort and safety at work is unattainable. Th s conclusion is worth endorsing. Green ergonomics, ergoecology, and information ergonomics have emerged in response to the need to reconsider approaches to safeguarding worker well-being in modern workplaces. In the context of ongoing environmental degradation, sustainable development cannot be achieved without rethinking workplace organisation. Thus, green ergonomics and ergoecology prioritise the enhancement of ecological aspects within ergonomic workplace design. Accordingly, these disciplines focus on developing eco-friendly workplaces and systems that foster environmentally responsible behaviour among workers. Their primary tool is the eco-ergonomic organisation of the workplace – an approach aimed at achieving an optimal combination of working conditions and technical support that aligns with contemporary engineering, environmental, social, and psychophysiological standards. Th s tool was applied in digital workplace research and yielded positive outcomes, as previously described.

Conclusions

A defini g hallmark of contemporary organisational activities is the comprehensive digitalisation of work processes. Integrating advanced digital technologies, cutting-edge tools, expansive ecosystems, artific al intelligence, and various digital solutions is fundamentally transforming the nature of work, reshaping labour market dynamics and intensifying demands for workplace safety. Th s evolution gives rise to the "Work 4.0" concept, which represents a signifi ant shift in labour relations and workplace paradigms. Within the "Work 4.0" framework, the traditional workplace is signifi antly redefi ed, evolving into what may be described as a digital workspace. Th s innovative organisational model relies heavily on various digital devices and tools that facilitate seamless communication, collaboration, and productivity. It also incorporates the principles of information ergonomics – optimising information fl w and usability, green ergonomics, prioritising sustainability in design and processes, and ergoecology, which focuses on the broader ecological implications of workplace design.

The research proposes a comprehensive model for the digital workplace, underscoring the essential role those ergonomic principles play in its practical implementation. The study strongly emphasises the importance of cultivating a robust safety culture within organisations. As the work environment continues to evolve, there is a pressing need to reassess and adapt traditional workplace safety frameworks. The fi dings illustrate a clear connection between the ongoing digitalisation of work processes and the enhancement of organisational safety culture, demonstrating how the effective use of digital technologies can foster a safer, more responsive work environment. A well-structured digital workplace development strategy was formulated during the fi al phase of the study. Th s strategy is anchored in the principles of "Work 4.0", involving a thorough reassessment and modernisation of ergonomic standards in light of digitalisation, as well as a forward-thinking approach to strengthening organisational safety culture. Implementing this strategy is expected not only to support more flex ble work schedules and enhance employee mobility but also to signifi antly improve workplace safety and overall comfort. As organisations transition into this new paradigm, the potential for increased operational effici cy and employee satisfaction becomes increasingly achievable. Further research could examine the practical implementation and long-term effects of the proposed digital workplace development strategy across various sectors. Comparative case studies could evaluate how eco-ergonomic principles affect employee well-being, productivity, and safety culture in digital settings. In addition, future studies should explore emerging technologies, such as AI, IoT, and virtual reality, and their role in shaping the next generation of digital workplaces, particularly about adaptability, inclusivity, and sustainable development.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Безпечне та продуктивне цифрове робоче місце: еко-ергономічні принципи організації

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Анотація. Характерною рисою сучасною дійсності є цифровізація всіх робочих процесів, через що інформація стала їх основною одиницею. Основні операції зосереджені навколо створення, отримання, використання та обміну інформацією. Ця зміна спонукала до фундаментальної трансформації змісту роботи, динаміки ринку праці та вимог щодо безпеки та ергономічних принципів організації робочого місця. Метою дослідження було розробити стратегію розвитку цифрових робочих місць із застосуванням еко-ергономічних принципів у їх організації. Під час роботи було застосовано системний та міждисциплінарний підходи, порівняльний аналіз, ергономічні, екологічні, психологічні та інформаційно-технологічні теоретичні засади. Концепція "Робота 4.0" стала основоположною відправною точкою для цього дослідження. Визначено, що у рамках концепції "Робота 4.0" традиційні робочі місця перетворюються на цифрові шляхом інтеграції цифрових пристроїв та інструментів разом із принципами інформаційної ергономіки, зеленої ергономіки та ергоекології в робочі процеси. У дослідженні представлена модель цифрового робочого місця та підкреслена необхідність прийняття нових еко-ергономічних принципів для його організації. У роботі приділена увагу вивченню культури безпеки на підприємстві, оскільки нові умови праці вимагають перегляду принципів забезпечення безпеки працівників на робочому місці. У процесі дослідження встановлено зв'язок між цифровізацією та розвитком культури безпеки компанії, а також показані переваги використання цифрових технологій та інструментів для її розвитку. Завершальним етапом дослідження стало формування стратегії розвитку цифрового робочого місця. Концепція "Робота 4.0", перегляд та оновлення ергономічних принципів організації праці в умовах цифровізації та розвиток культури безпеки компанії створили основу для формування стратегії. Її впровадження забезпечує гнучкий графік роботи, мобільність працівників, новий рівень безпеки та комфорту на робочому місці

Ключові слова: концепція "Робота 4.0"; ергоекологія; зелена ергономіка; культура безпеки; сталий розвиток

INNOVATION AND SUSTAINABILITY
Scientific Journal

Volume 5, No. 1,
2025

Signed to the print 27.03.2025
Format 210x297
Conventional Printed Sheet 10.9
Circulation 100 copies
Ord. №2025-031

Editors office address:
Vinnytsia National Technical University
21021, 95 Khmelnytske Shose Str., Vinnytsia, Ukraine
Email: info@inns.com.ua
https://inns.com.ua/en

Publishing Address:
Vinnytsia State Technological University
21021, 95 Khmelnytske Shose Str., Vinnytsia, Ukraine
Email: rvv@vntu.edu.ua
https: //press.vntu.edu.ua

INNOVATION AND SUSTAINABILITY
Науковий журнал

Том 5, № 1,
2025

Підписано до друку 27.03.2025 р.
Формат 210x297
Умовн. друк. арк. 10,9
Наклад 100 примірників
Зам. № 2025-031

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Свідоцтво суб'єкта видавничої справи
серія ДК № 3516 від 01.07.2009 р.