SCIENTIA FRUCTUOSA

Scientific journal

Established: 1998

№ 1 (165) 2026

To October 2000 had been published under the title "Herald of Kyiv State University of Trade and Economics"
To February 2022 had been published under the title "Herald of Kyiv National University of Trade and Economics"
From March 2022 it will be published under the title "Scientia fructuosa"
It is published six times a year

The journal is recognized by the Ministry of Education and Science of Ukraine as the professional edition in economic sciences of Category "B"

Founder, edition, publisher and manufacturer
State University of Trade and Economics

Director of periodicals – KRYVYTSKA I.

Editors: KYRYCHENKO E., KRYVENKO O., DUBKO M.
Artistic and Technical Editor
PSHENICHNA T.

Entered into the Register of entities in the field of print media by decision of the National Council of Ukraine on Television and Radio Broadcasting No. 798 dated August 31, 2023 and assigned the identifier R30-01229

Index of the magazine in Catalogue of publications in Ukraine in 2026 – 21910

Signed 10.02.2026.
Conventional print. pages. 11
Circulation 250. Order 27

Address of the Editorial board, publisher, manufacturer:
St. Kyoto, 19, Kyiv-156, Ukraine, 02156.
Contact us at 531-31-16
visnik@knute.edu.ua
http://journals.knute.edu.ua/scientia-fructuosa/pro_journal

Printed on equipment of SUTE.

Certificate of subject of publishing industry series DK № 7656 of 05.09.2022

Published on the recommendation of the Academic Council of SUTE (minutes № 1 of 29.01.2026)

The journal is represented in international scientometric databases, repositories and search engines, such as Index Copernicus, Register of Scientific Publications of Ukraine, Vernadsky National Library of Ukraine, Crossref, Dimensions, Research Bible

Kyiv · SUTE · 2026

C O N T E N T

ECONOMY

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ЕКОНОМІКА

ЦИФРОВИЙ ПРОСТІР

DOI: http://doi.org/10.31617/1.2026(165)01
UDC 316:330.3:[355.01(477:470)=111

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SOCIO-ECONOMIC CONSEQUENCES OF THE RUSSIAN-UKRAINIAN WAR

The object of the research is the social and economic processes triggered by the russia-Ukraine war, in particular their impact on migration, international trade, and the institutions involved in conflict resolution mediation. The aim of the article is to identify the interrelationship among these processes, assess their implications for Ukraine's social and economic development, and determine the prospects for post war recovery.

The scientific hypothesis of the article is that the russia–Ukraine War has generated interconnected migration, trade, and institutional shocks that mutually reinforce negative social and economic effects in Ukraine, while the effectiveness of international mediation mechanisms remains insufficient to mitigate these impacts without a comprehensive alignment of economic and migration policies.

The methodological framework is based on a systems approach, comparative analysis, statistical methods for evaluating macroeconomic indicators, and structural functional analysis of mediation institutions. The results of the research indicate that the war has led to large-scale external and internal migration (over 6 million people), a significant decline in exports—particularly in metallurgical products—and an increased share of the agricultural sector (up to 32.4% of total exports). The trade deficit in 2023 reached – USD -27.3 billion, driven by reduced production

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СОЦІАЛЬНО-ЕКОНОМІЧНІ НАСЛІДКИ РОСІЙСЬКО-УКРАЇНСЬКОЇ ВІЙНИ

Об'єктом дослідження є соціально-економічні процеси, спричинені російсько-українською війною, зокрема їхній вплив на міграцію, міжнародну торгівлю та інститути посередництва у врегулюванні конфліктів. Метою статті є визначення взаємозв'язку між зазначеними процесами, їхніх наслідків для соціально-економічного розвитку України та перспектив відновлення у повоєнний період.

Наукова гіпотеза дослідження полягає в тому, що російсько-українська війна спричинила взаємопов'язані міграційні, торговельні та інституційні шоки, що взаємно посилюють негативні соціально-економічні наслідки для України, тоді як ефективність міжнародних механізмів посередництва є недостатньою для їхнього пом'якшення без комплексного узгодження економічної та міграційної політики.

Методологічну основу становлять системний підхід, порівняльний аналіз, статистичні методи оцінювання макроекономічних показників і структурно-функціональний аналіз діяльності інституцій посередництва. Результати дослідження свідчать, що війна призвела до масштабної зовнішньої та внутрішньої міграції (понад 6 млн осіб), суттєвого скорочення експорту, особливо металургійної продукції, та зростання частки аграрного сектору (до 32,4% у структурі експорту). Від'ємне сальдо зовнішньої торгівлі у 2023 р. сягнуло -27,3 млрд дол. США, що зумовлено зниженням виробництва у прифронтових регіонах і зростанням

in frontline regions and rising logistics costs. Mediation institutions (the UN, OSCE, EU, Turkey) demonstrated limited effectiveness due to political divergences and asymmetric interests, although their efforts laid the foundation for new formats of economic and diplomatic coordination (including the Black Sea Grain Initiative). The most adverse consequences of the war manifest in regional export disparities, demographic imbalances, and declining trust in international negotiation frameworks.

The findings highlight the need for a comprehensive approach to overcoming the consequences of the war, which should include a coordinated migration policy, diversification of foreign trade, and reforms of international mediation mechanisms. Future research perspectives involve the empirical assessment of regional trade and migration shocks and the development of adaptive mediation models in protracted conflict settings.

Keywords: russian-Ukrainian war, migration processes, international trade, mediation institutions, social and economic development, conflict, recovery, export, import, diplomacy.

логістичних витрат. Інститути посередництва (ООН, ОБСЄ, ЄС, Туреччина) продемонстрували обмежену ефективність через політичні розбіжності та асиметричні інтереси сторін, однак їхня діяльність стала основою для створення нових форматів економічного та дипломатичного врегулювання (зокрема, Чорноморська зернова ініціатива). Найбільший негативний вплив війни проявляється у регіональній диференціації експорту, демографічному дисбалансі та втраті довіри до міжнародних переговорних форматів. Результати дослідження свідчать про необхідність комплексного підходу до подолання наслідків війни, який включає узгоджену міграційну політику, диверсифікацію зовнішньої торгівлі та реформу механізмів міжнародного посередництва. Перспективи подальших досліджень пов'язані з емпіричною оцінкою регіональних торговельних і міграційних шоків та розробкою моделей адаптивної медіації в умовах затяжних конфліктів.

Ключові слова: російсько-українська війна, міграційні процеси, міжнародна торгівля, інститути посередництва, соціально-економічний розвиток, конфлікт, відновлення, експорт, імпорт, дипломатія.

JEL Classification: F35, H56, O15, O19.

Introduction

The russian-Ukrainian war, which began in 2014 with the annexation of Crimea and the conflict in Donbas, and escalated into a full-scale war in February 2022, has become one of the most serious crises in contemporary Europe. It has caused profound social and economic, demographic, and political changes not only in Ukraine but also in neighbouring countries and in the global context. The conflict has highlighted the high sensitivity of international trade systems, migration flows, and mediation institutions to violent and politically unstable processes.

One of the most significant consequences of the war has been changes in migration processes, affecting both internally displaced persons and refugees abroad. Mass migration has created new demographic and economic challenges, ranging from a shortage of skilled labour to increased pressure on infrastructure and social systems in recipient countries. A significant proportion of displaced persons consists of women, children, and the elderly, which further exacerbates structural imbalances in Ukraine's demographics and economy.

The war has also had a substantial impact on international trade, which has experienced serious disruptions due to restricted access to seaports, blockade of logistics corridors, and disruptions in production chains in frontline regions. Ukraine, as one of the world's key exporters of grains,

oilseeds, and metal products, has lost a significant share of its traditional markets, leading to a sharp decline in exports and an increase in the negative trade balance. At the same time, the agricultural sector has become dominant in the export structure, necessitating its modernization and diversification of external markets.

In the context of armed conflict, international mediation institutions (UN, OSCE, EU, Turkey) have faced a range of challenges. Their effectiveness is limited by political disagreements, asymmetrical interests of the parties, and difficulties in ensuring compliance with ceasefires. At the same time, international initiatives, such as the Black Sea Grain Initiative, have demonstrated the potential of combined economic-diplomatic approaches to conflict resolution, which represent an important element in the post-war economic recovery.

The scientific interest in these issues is driven by the need for a comprehensive understanding of the interconnection between migration processes, international trade, and the activities of mediation institutions. Most existing studies examine these aspects in isolation, without exploring their mutual influence and the broader social and economic consequences. This highlights the relevance of the present research, which allows for the assessment of the scale of transformations, identification of risks for the economy and society, and the development of recommendations for recovery and development policies.

An analysis of recent research on the impact of the Russian-Ukrainian war on migration processes, international trade, and mediation institutions in conflict resolution confirms significant changes in the global dynamics. Based on analytical work reflecting the effects of the war on migration processes, international trade, and mediation institutions, we have compiled the following *Table*:

Table

Key findings of recent studies on the impact of the war on migration processes, international trade, and mediation institutions

Sphere of impact	Main findings of recent studies	Sources
Migration processes	Ukrainians became refugees; mass migration to the EU; demographic and economic changes in recipient countries; forced deportations to Russia; violations of children's rights.	Ophoke (2024), Yves Bossavie et al. (2025), Adema et al. (2024)
International trade	Disruptions in the supply of food and energy resources; disturbances in global trade chains; changes in wheat export patterns; crop losses in Ukraine; rising prices on global markets	Paryan et al. (2024), Ophoke (2024)
Mediation institutions	Limited effectiveness of third parties in achieving peace agreements; challenges in the activities of the UN, OSCE, EU, and Turkey; geopolitical barriers and loss of trust; need to combine diplomacy with social and economic recovery programs	Ophoke (2024), GPPi (2025)

Source: compiled by the author.

Despite numerous studies on individual aspects of the russian-Ukrainian war–such as migration, changes in trade, or diplomatic mediation – a comprehensive analysis of the interconnections between these spheres remains insufficiently developed. The majority of existing works examine demographic and economic consequences in isolation, without considering the impact of migration on trade structure and the international capacity of the state, as well as the effects of sanctions and humanitarian crises on the effectiveness of mediation institutions. This highlights the relevance of the present study.

The aim of the article is to identify and substantiate the social and economic consequences of the russian-Ukrainian war for Ukraine through the interaction of migration processes, international trade transformations, and the functioning of mediation institutions, as well as to determine priority directions for post-war recovery and institutional reform.

The research hypothesis is that the russian-Ukrainian war has generated interrelated migration, trade, and institutional shocks that mutually reinforce negative social and economic outcomes in Ukraine, while the effectiveness of international mediation mechanisms remains insufficient to mitigate these effects without integrated economic and migration policy adjustments.

The methodological framework of the research is based on a systemic approach, comparative analysis, statistical evaluation of macroeconomic indicators, and structural-functional analysis of the activities of mediation institutions.

The first section examines the impact of the russian-Ukrainian war on migration processes, focusing on the scale, structure, and social and economic consequences of forced internal and external displacement.

The second section analyses changes in Ukraine's international trade under wartime conditions, including export contraction, shifts in commodity structure, regional trade disparities, and the dynamics of the negative trade balance.

The third section explores the role and effectiveness of international mediation institutions in conflict resolution, assessing their limitations and the emergence of hybrid economic-diplomatic mechanisms, such as the Black Sea Grain Initiative.

The final section summarizes the key findings of the study and outlines priority directions for Ukraine's post-war recovery, emphasizing integrated migration policy, trade diversification, and the reform of international mediation mechanisms.

1. Impact of the russian-Ukrainian war on migration processes

Military actions have led to a range of consequences and impacts (*Figure 1*), primarily including the mass displacement of the population both internally and beyond Ukraine's borders. According to the Migration Data Portal, over 6 million people have left Ukraine as a result of the conflict

(Migration Overview, n. d.). Such migration affects not only the demographic burden in Ukraine but also has a significant impact on the economies of recipient countries. For example, expenditures by Ukrainians abroad in 2022 reached approximately USD 2 billion per month, stimulating consumer demand in host countries such as Poland and Estonia (Poharska et al., 2023, March 7).

Military actions have led to a wide range of social and economic consequences, foremost among which is the mass displacement of the population both within Ukraine and beyond its borders (*Figure 1*). According to the Migration Data Portal, over 6 million people have left Ukraine as a result of the conflict. Such large-scale migration has significantly affected the country's demographic structure, exacerbating labour shortages and increasing demographic pressure in certain regions.

Figure 1. Impact of the war on migration processes, international trade, and mediation institutions

Source: compiled by the author.

At the same time, migration has had a noticeable economic impact on recipient countries. For instance, expenditures by Ukrainians abroad in 2022 reached approximately USD 2 billion per month, stimulating consumer demand in host countries such as Poland and Estonia. (Poharska et al., 2023, March 7). Migration flows are heterogeneous and predominantly consist of women, children, and the elderly, as men of conscription age are generally restricted from leaving the country. In the long term, these trends contribute to structural imbalances in the labour market, particularly in sectors that were critical to Ukraine's economy before the war, such as agriculture and industry.

2. Transformation of Ukraine's international trade under wartime conditions

The russian-Ukrainian war has caused substantial disruptions to Ukraine's international trade due to restricted access to seaports, the blockade of logistics corridors, sanctions and counter-sanctions, and production losses

in frontline regions. According to WTO estimates, exports of key agricultural products declined sharply following the blockade of the Black Sea, with grain exports falling by more than 90% during the summer of 2022 compared to pre-war levels.

The introduction of the Black Sea Grain Initiative partially restored maritime exports; however, even with alternative logistics routes and "solidarity corridors," trade volumes remain below pre-war indicators. Increased transportation and insurance costs have reduced the competitiveness of Ukrainian exports. As a result, the structure of exports has shifted significantly, with the agricultural sector becoming dominant, while metallurgy and heavy industry have experienced substantial declines. These factors contributed to the sharp deterioration of the trade balance, which reached USD -27.3 billion in 2023.

3. Role of mediation institutions in economic and diplomatic regulation

Armed confrontation has significantly complicated traditional diplomatic conflict resolution mechanisms, increasing the role of international mediation institutions such as the UN, OSCE, the EU, and Turkey. However, their effectiveness remains limited due to political disagreements, asymmetrical interests of the parties, fragile ceasefires, and challenges in enforcing agreements.

Despite these limitations, certain mediation initiatives have demonstrated practical results. The Black Sea Grain Initiative serves as an example of a hybrid economic-diplomatic mechanism that combines security guarantees with trade facilitation. Such initiatives highlight the potential of mediation institutions to mitigate economic risks even in conditions of ongoing conflict. At the same time, changes in the global trade system have expanded the scope of institutional involvement in resolving disputes related to export-import contracts, transit routes, and sanctions regimes.

4. Regional and global social and economic implications

Before the war, Ukraine and russia played a crucial role in global markets, supplying a significant share of wheat, sunflower products, and energy resources. The disruption of these supplies led to rising global food and energy prices, disproportionately affecting import-dependent countries in the Middle East and North Africa. Within Ukraine, the war has intensified regional economic disparities. Eastern and northern regions, where heavy industry was concentrated, experienced the most severe export declines, correlating with increased migration flows. In contrast, western regions and Kyiv maintained relatively stable import dynamics and became key logistical hubs. These regional imbalances underscore the need for targeted economic recovery policies, modernization of production capacities, and diversification of foreign trade relations.

As Ukrainians increasingly sought employment abroad, wages earned in host countries became the primary source of financing for migrants' expenses. Migration flows are heterogeneous–predominantly women, children, and the elderly–since men of conscription age are generally restricted from leaving due to mobilization (Havlin, 2025). In the long term, this leads to a labour shortage, particularly in the agricultural sector, which was a key component of the Ukrainian economy before the war (Kilfoyle, 2023, October 24). Before 2022, economic and educational motives dominated migration; after the full-scale Russian invasion, the primary reason shifted to threats to personal safety (Lytvynchuk, 2023).

Restrictions on access to seaports, the introduction of sanctions and counter-sanctions, and disruptions in logistics have drastically affected Ukraine's import-export flows. According to WTO estimates, trade volumes, especially of agricultural products, declined significantly due to the blockade of the Black Sea. Between June and August 2022, grain exports fell by over 90% compared to pre-war levels (How the russian invasion of Ukraine, 2025). As a mitigation measure, the Black Sea Grain Initiative was established, partially restoring maritime grain shipments (Black Sea Grain Initiative, 2025). However, even with the rerouting of logistics through "solidarity corridors", exports remain below pre-war levels, and increased transit costs and logistics expenses have reduced competitiveness. Additionally, the conflict undermines trust and social capital between goods and trade partners, especially across regions, which has reduced trade even in non-conflict areas due to the loss of intergroup trust (Korovkin & Makarin, 2023).

Conditions of armed confrontation complicate traditional diplomatic resolution, necessitating greater involvement of multilevel mediation institutions. Their effectiveness is limited by inconsistent intervention, diplomatic bias, fragile ceasefires, and the military advantage of the parties involved (Ophoke, 2024; Aji & Setiyono, 2023). Mediation models – including bilateral, multilateral, and digital approaches – are applied to facilitate reconciliation, but success depends on the willingness of parties to make concessions, the pressure of sanctions, and international oversight (Lintang & Farida, 2025). Changes in the global economic and trade system also transform the role of institutions in resolving disputes over export-import contracts and transit flows (Ma, 2025).

Before the war, Ukraine and russia supplied a significant share of global food and energy resources – approximately 25% of wheat exports, 45% of sunflower products, and 20% of fossil fuels (WTO, 2023). The armed conflict disrupted these supplies, leading to rising food and energy prices, which were particularly burdensome for import-dependent countries such as Egypt, Lebanon, Tunisia, and Turkey.

The full-scale war has significantly affected the volumes, directions, and commodity composition of Ukraine's exports and imports. The conflict has sharply exacerbated the problem of *a negative trade balance*: the balance fell from *USD -6.2 billion in 2021* to *USD -27.3 billion in 2023*, due to declining exports and rising imports. This negative trend has been mitigated only by international financing and restrictions on capital mobility, which were critically important for maintaining the stability of the hryvnia.

Changes in Ukrainian trade are directly influenced by the actions of mediation institutions and international support: *unilateral trade preferences granted by the EU in 2022* significantly increased the EU's share in exports, mainly in the agricultural sector, while the operation of the Black Sea Grain Initiative and the establishment of the Ukrainian maritime corridor after its suspension proved critically important. The war has also intensified *regional disparities*: exports from the eastern and northern regions, where heavy industry was concentrated, fell by 80%, correlating with increased migration; western regions and Kyiv maintained stable import dynamics, serving as logistical gateways; the Odesa region remained a key agro-hub due to the maritime corridor. Regions that lost access to CIS markets face logistical challenges and require modernization of production, implementation of European standards, and the search for new EU markets (Okhrimenko, 2024).

The results of this study and directions for further research are presented here. The russian-Ukrainian war has had a substantial impact on migration processes and international trade: Ukraine's population has decreased, its demographic structure has changed, and agricultural exports have experienced logistical shocks, blockades, and sanctions, while trade routes and models are being reformed. The war has deepened the negative trade balance and reduced export diversification, particularly in metallurgy, which has amplified regional disparities in the East and North. Mediation institutions have limited effectiveness in a large-scale conflict; however, there is an urgent need for adaptive, hybrid mechanisms, including digital mediation and economic instruments.

Future research should focus on the empirical assessment of migration and trade shocks across Ukrainian regions, as well as on experimental mediation models that account for multilevel interests and conflict asymmetries.

Conclusions

Impact on migration processes: the russian-Ukrainian war has triggered large-scale internal and external migration, affecting over 6 million people. This has led to demographic imbalances, labour shortages in the agricultural and industrial sectors, and changes in the social and economic burden on recipient countries. Migration flows are uneven, predominantly consisting of women, children, and the elderly, which exacerbates regional challenges in economic recovery and workforce replenishment.

Impact on international trade: the war has caused a significant reduction in exports, particularly in metallurgy, and an increase in the share of agricultural exports, including grains and crop products. Ukraine's negative trade balance reached USD -27.3 billion in 2023 due to port blockades, production disruptions, and increased logistics costs. The conflict has also intensified regional export disparities, especially in the eastern and northern regions, highlighting the need for production modernization and diversification of foreign economic relations.

Role of mediation institutions: international organizations (UN, OSCE, EU, Turkey) have demonstrated limited effectiveness in ensuring

peaceful conflict resolution due to political disagreements and asymmetrical interests of the parties. However, initiatives such as the Black Sea Grain Initiative have shown the potential of hybrid economic-diplomatic mediation models, combining trade and security instruments.

Need for a comprehensive recovery approach: to stabilize Ukraine's social and economic situation post-war, it is necessary to implement coordinated migration policies, diversify foreign trade, modernize production, and reform international mediation mechanisms, taking into account hybrid, digital, and multilevel mediation models.

Future studies should focus on the empirical assessment of regional trade and migration shocks, the long-term demographic and economic consequences of the war, and the development of adaptive mediation models for protracted conflicts with asymmetric interests.

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Conflict of interest. The author certifies that she doesn't have financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations, or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript. Given that the author is affiliated with the institution that publishes this journal, which may cause potential conflict or suspicion of bias, the final decision to publish this article (including the reviewers and editors) is made by the members of the Editorial Board who are not the employees of this institution.

The authors received no direct funding for this study.

Almuzoughi, S. (2026). Socio-economic consequences of the russian-Ukrainian war. *Scientia fructuosa, 1*(165), 4–13. http://doi.org/10.31617/1.2026(165)01

Received by the editorial office 17.11.2025.
Accepted for printing 22.01.2026.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)02
UDC 339.9:330.1=111

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DEGLOBALIZATION SCENARIOS OF THE WORLD ECONOMY

In recent years, globalization processes have slowed down, driven by a rise in isolationism in the foreign policies of various countries, the escalation of trade and economic wars, intensifying military-political conflicts, and the consequences of the pandemic. The reconsideration of globalization as an inevitable and integral feature of global development makes it relevant to explore future scenarios for the new economic order. Therefore, the aim of this research is to verify world economic order scenarios from the financial crisis of 2008–2009 to the present, to test the hypothesis of deepening deglobalization trends in the development of the global economy. To confirm the proposed hypothesis, the research analyzes the key global economic order scenarios proposed by the consulting firm A.T. Kearney, which are characterized by a certain slowdown in economic growth and international economic integration: globalization 3.0, polarization, islandization, and commonization. Selected global development indicators are used, whose dynamics allow for conclusions regarding the proximity of the global economy to a particular scenario of the world order. Using the method of time series analysis, the research transitions from linguistic assessments of indicators to ranges of quantitative values. The results of the global development indicator analysis provided grounds for verifying the scenarios of the global economic order from the 2008–2009 financial and economic crisis to the present, which confirmed the hypothesis about the deglobalization trends in the development of the global economy.

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ДЕГЛОБАЛІЗАЦІЙНІ СЦЕНАРІЇ СВІТОВОЇ ЕКОНОМІКИ

Протягом останніх років спостерігається сповільнення глобалізаційних процесів, що зумовлено посиленням ізоляціонізму у зовнішній політиці країн світу, розгортанням торговельно-економічних війн, інтенсифікацією воєнно-політичних конфліктів, наслідками пандемії тощо. Переосмислення невідворотності та невід'ємності глобалізації як ознаки світового розвитку актуалізує дослідження у площині прогнозування сценаріїв нового економічного порядку. Відтак, метою статті є верифікація сценаріїв світового економічного порядку від фінансової кризи 2008–2009 рр. до сьогодення задля підтвердження гіпотези про поглиблення деглобалізаційних тенденцій у розвитку світової економіки. Для перевірки висунутої гіпотези проаналізовано базові сценарії світового економічного порядку консалтингової компанії A. T. Kearney, які передбачають певне сповільнення темпів економічного зростання та міжнародної економічної інтеграції: глобалізація 3.0, поляризація, острівізація, комонізація. Обрано індикатори глобального розвитку, динаміка яких дозволить зробити висновки щодо наближеності світової економіки до певного сценарію світового порядку. З використанням методу аналізу часових рядів здійснено перехід від лінгвістичних оцінок індикаторів до діапазонів кількісних значень. Результати аналізу динаміки індикаторів глобального розвитку створили підстави для верифікації сценаріїв світового економічного порядку від фінансово-економічної кризи 2008–2009 рр. до сьогодення, що дозволило підтвердити гіпотезу щодо деглобалізаційних тенденцій у розвитку світової економіки. Перспективи подальших

The author sees prospects for further research in the development of a scenario-based planning methodology for the world economic order by incorporating indicators that assess the role of geopolitical factors in accelerating deglobalization processes.

Keywords: world economic order, scenario, deglobalization, economic development indicators, trend.

досліджень автор вбачає у розвитку методології сценарного планування світового економічного порядку шляхом врахування індикаторів, які дозволяють оцінити роль геополітичних факторів у прискоренні деглобалізаційних процесів.

Ключові слова: світовий економічний порядок, сценарій, деглобалізація, індикатори економічного розвитку, тренд.

JEL Classification: F01, F02, C22.

Introduction

In recent years, the course of globalization processes has undergone significant transformations. The slowdown in the pace of globalization is confirmed, among other things, by the dynamics of the KOF Globalization Index of the Swiss Economic Institute, which is a well-known measure of the intensity of globalization processes (*Figure 1*).

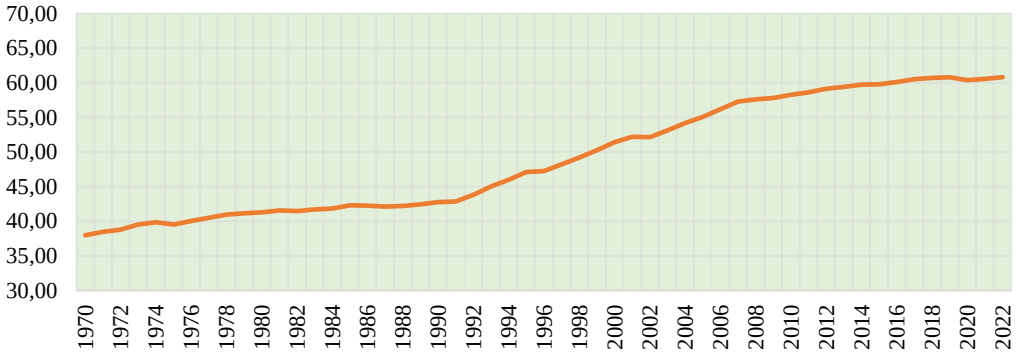

Figure 1. Dynamics of the KOF Globalization Index in 1970–2022.

Source: compiled by the author based on data from (KOF Swiss Economic Institute, n. d.).

Since the global financial crisis of 2008–2009, the globalization index has not shown a noticeable upward trend, which is due to the strengthening of isolationism in the foreign policy of the world's countries, the development of trade and economic wars, the intensification of military and political conflicts, etc. The coronavirus pandemic has become a factor in additional suppression of globalization, which, despite the rather rapid recovery of economic activity, has demonstrated the potential for the negative impact of force majeure events on global integration processes. Rethinking the inevitability and indispensability of globalization as a sign of world development makes research in the field of forecasting scenarios of a new economic order relevant.

Future scenarios are based on different approaches to understanding the sources of global uncertainty and the stability of the security environment. Thus, the Rockefeller Foundation report (2010, May) proposed scenarios for

the development of the global security environment, considering the consequences of the financial and economic crisis of 2008 and the progressive influence of technology on the course of globalization processes. The basic hypothetical scenarios were: strict state control of all spheres of life ("total blockade"), division of the world into competing blocs ("smart bargaining"), an economically unstable world with dangerous technological innovations ("hacker attack"), and a globalized world with successful strategies for solving humanity's problems ("smart community"). All scenarios, except the last one, predicted economic decline and increased deglobalization.

In the 2010s, the trend of economic fragmentation is becoming more pronounced due to growing geopolitical tensions and the crisis of the neoliberal, pro-Western model of economic development. The world order scenarios developed during this period consider interstate competition as a basic variable of the global landscape. Thus, the Atlantic Council study (Atlantic Council, 2015) formulated four scenarios for the future: "a new "cold war" caused by the rise of nationalism and the revisionist policies of the world's leading countries; "Eurasian leadership", in which, due to the influence of American and European sanctions after the annexation of Crimea, Russia reorients itself towards a strategic partnership with China; "a new global concept", which involves a revision of established pro-Western models of global settlement taking into account growing multipolarity; "disintegration" as a consequence of internal social and political crises and dysfunction of global regulators. Therefore, all scenarios except the third assume the inevitability of world deglobalization – from fragmentation ("new "cold war", "leadership of Eurasia") to destruction ("disintegration"). The growing competitive struggle between the world's leading countries is considered a key factor in global development, not only from the perspective of confrontation, but also in the context of technological leadership. In Mykhailovska's work (2012), based on the extrapolation of economic development trends, a pool of attractor countries is determined that will influence the global economy (USA, Great Britain, Germany, France, Japan, China). According to the author, competition between these countries in the field of IT as a driving force of progress can lead to the implementation of the following global scenarios: "inertial development of technologies", "IT development on a new paradigm", "nanotechnological revolution", "biotechnological revolution".

A new impetus to the scenario planning of the world order was given by the COVID-19 pandemic, which demonstrated the fragility of globalization ties under conditions of forced social and economic restrictions. In the work (Bonaparte, 2020), published during the period of greatest uncertainty in Q1 2020, depending on the duration and intensity of the spread of the coronavirus, three potential scenarios of global development were formulated: "delayed consumer boom" (a surge in consumer activity in Q2 2020 due to a forced pause in Q1); "moderate recession" (in the event of an extension of quarantine restrictions in Q2); "full-scale recession" (in the

event of an expansion of the pandemic and its prolonged course). The study (Sułkowski, 2020), also published at the beginning of the pandemic, assumes a high probability of the world economy entering a global recession, which could lead to irreversible deglobalization. A new feature of society will be the virtualization of social and economic life, the experience of which was gained during the pandemic. Separately, it is worth focusing on the study of Ukrainian scientists (Dronova & Nagorny, 2021), in which the term "global break" is used to characterize the pandemic period – a phenomenon caused by three phenomena: the global financial crisis, the COVID-19 pandemic, and the significant self-isolation caused by it. The study notes a high probability of increased disintegration after the end of the pandemic and provides forecasts for the development of Ukraine under the conditions of the realization of various future scenarios ("globalization 3.0", "polarization", "islandization", "communization"). When determining the options for such scenarios, the authors rely on the results of scenario planning by the well-known consulting company A. T. Kearney (Foreign Policy, 2001), which were used as the basis for the research and by the author of this article.

The russian-Ukrainian war and the escalation of other military-political conflicts in recent years have finally confirmed the need to consider the prospects of globalization through the prism of the national interests of leading geopolitical actors (Jurakovaitė & Gaigaliene, 2024; Sveshnikov et al., 2020; Khomanets, 2024; Mazaraki & Bokhan, 2022; Kalyuzhna, 2023; Chunikhina et al., 2024). Scientists note that contradictions between the centers and peripheries of the world are becoming an integral feature of global development (Mazaraki & Bokhan, 2022), and geopolitical instability leads to the fragmentation of the world economy into partnership alliances and regional trading blocs (Chunikhina et al., 2024). In one of the author's previous works (Kalyuzhna, 2023), it is emphasized that the development of realistic scenarios of the future should consider the rapid escalation of geopolitical risks and the intensification of interstate economic rivalry. The study (Jurakovaitė & Gaigaliene, 2024) notes that the world is steadily moving towards multipolar regionalization with the main dominant blocs. Competition between such blocs can lead to the implementation of deglobalization scenarios: "mosaic of geographical regionalization", "bipolar regionnalization based on allies", and "ongoing globalization".

Scenarios of the future world economic order predict a slowdown in globalization processes and are based on the assumption of their further stagnation, reinforced by the recent pandemic and geopolitical tension. But the first signal to the awareness of deglobalization trends in the world economy was the financial and economic crisis of 2008–2009. Its consequences created an impetus for the development of scenarios of a new world order, the verification of which can be concluded today. Therefore, we consider testing forecast scenarios of the world economic order to assess their compliance with the realities of globalization processes to be an important scientific and practical task. The aim of the research is to verify the scenarios of the world economic order from the financial and economic crisis of

2008–2009 to the present. The hypothesis is formulated that deglobalization trends dominate the formation of the world economic order, which indicates a systemic slowdown in globalization and a transition to a new paradigm of world development based on the fragmentation and regionalization of the system of international relations.

To achieve the aim, the methods of analysis and synthesis (to determine indicators of the world economic order), the method of time series analysis (to transform linguistic assessments of indicators into ranges of quantitative values), abstraction and generalization (to describe the scenario framework of global development after the global financial and economic crisis of 2008–2009), and graphical modeling (to summarize the results of the analysis of scenarios of the world economic order) were used. The theoretical and methodological basis is the results of research by scientists on globalization issues and scenario planning of world economic development. The research is supported by statistical data from the World Bank, UNCTAD, Statista, World Inequality Database, Migration Data Portal, and World Trade Organization.

To confirm the hypothesis put forward, it is necessary to analyze the basic scenarios of the world economic order (first section), the dynamics of global development indicators that will allow us to conclude the verification of these scenarios (second section), and to determine the trends of the world economy's attraction to certain scenario frameworks after the globalization pause of 2008–2009 (third section).

1. A. T. Kearney's scenarios for the global economy after the 2008–2009 globalization pause

The first attempts to quantitatively measure the intensity of globalization processes are associated with the development of the FPG index (Foreign Policy Globalization Index) by the international consulting company A. T. Kearney (Foreign Policy, 2001). The FPG index was calculated from 2001 to 2007, gradually increasing the number of countries represented from 62 to 72, covering 88% of the world's population and 97% of global GDP. However, the impact of the financial and economic crisis of 2008 led to the cessation of the annual publication of the FPG index, and later, analysts of A. T. Kearney put forward assumptions about the inevitability of the deglobalization of the world economy (Kearney, 2016).

According to researchers A. T. Kearney, the global financial crisis of 2008–2009 led to a transition to a new long-term phase of slowing economic growth and international economic integration. Globalization under such conditions has been on pause and has become too unpredictable. The new reality of the world economy is permanent uncertainty, which is multiplied by the growth of geopolitical tension in the 2010s. Experts A. T. Kearney consider the annexation of Crimea by russia, the civil war in Syria, the factor of Islamism, and the intensification of contradictions in US-China relations to be the key events of this period that significantly influenced the course of international relations and the structure of trade cooperation. Researchers provide four scenarios for world economic development after the end of the

globalization pause: globalization 3.0, polarization, islandization, and commonization (*Figure 2*).

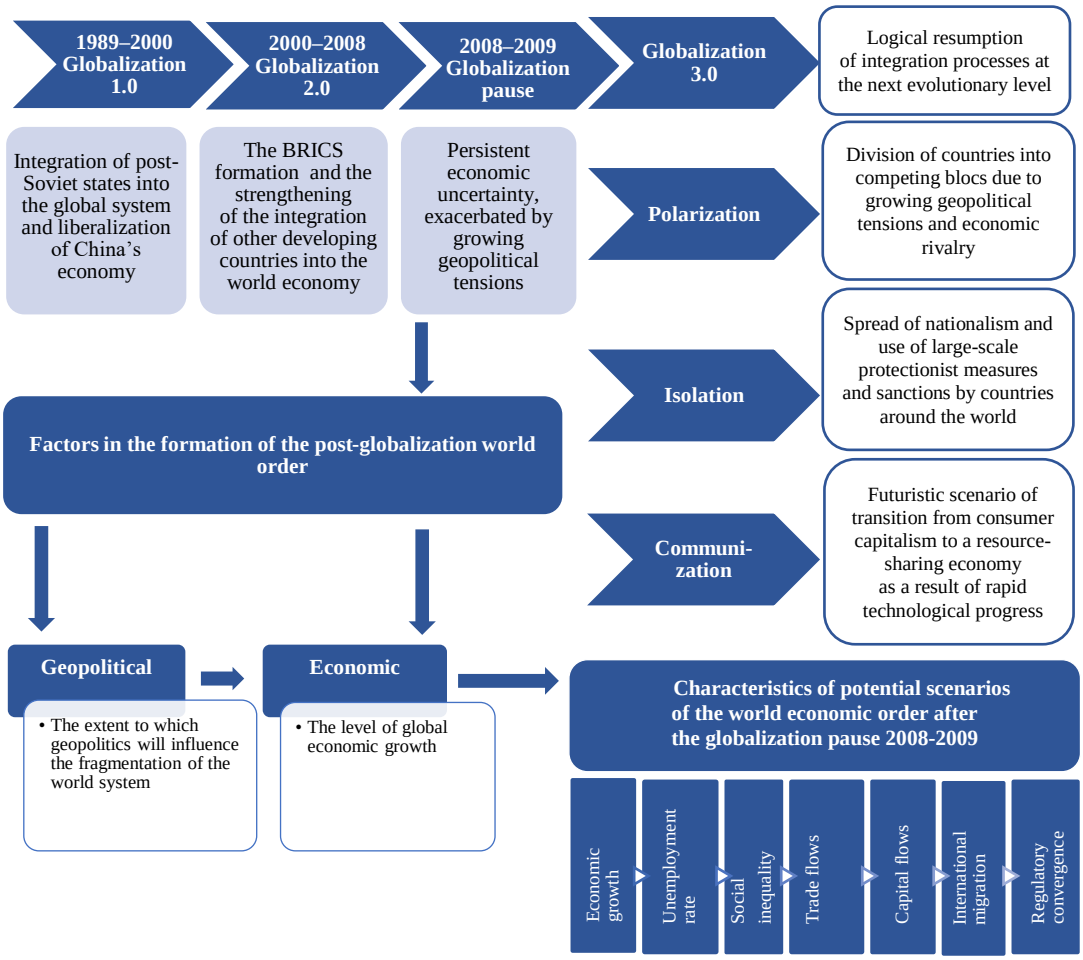

Figure 2. Stages of transformation and scenarios for global economic development after the 2008–2009 globalization pause

Source: compiled by the author based on (Kearney, 2016).

Globalization 3.0 involves the restoration of international integration above the pre-crisis level; that is, it is a new evolutionary stage in the development of globalization, as Globalization 1.0 and Globalization 2.0 did at one time. Globalization 1.0 (1989–2000) was marked by a rapid increase in the cross-border movement of goods, services, capital, and people due to the integration of the countries of the former USSR into the global system and the liberalization of the Chinese economy. Globalization 2.0 (2000–2008) is due to the formation and expansion of the BRICS and the strengthening of the integration of other developing countries into the world economy. It is obvious that the Globalization 3.0 scenario, as a logical restoration of integration processes at a higher evolutionary level, is considered the most desirable scenario for ending the globalization pause after the global financial crisis of 2008–2009, but it has few prerequisites for

implementation. In the context of growing global uncertainty, less positive scenarios should be expected. Thus, the polarization scenario envisaged the division of countries into competing blocs because of growing geopolitical tension and economic rivalry. The islandization scenario consisted of the spread of nationalism and the use of large-scale protectionist measures and sanctions by countries around the world, which resulted in a reduction in global economic flows. Finally, communization was seen as a futuristic scenario for the formation of a new world order, in which rapid technological progress leads to a transition from consumer capitalism to a resource-sharing economy. Under such conditions, globalization loses its traditional meaning in the form of trade and investment but acquires a new meaning as the unhindered spread of ideas and innovations in world space.

A. T. Kearney experts emphasize the complexity of assessing the likelihood of one scenario or another coming true and identify two key factors that will influence the future of global economic development after the end of the globalization pause: geopolitical (the degree to which geopolitics will influence the fragmentation of the world system) and economic (the level of global economic growth). Combining linguistic assessments of these two factors allows us to position scenarios of the global economic order in the segments of the corresponding matrix (*Figure 3*).

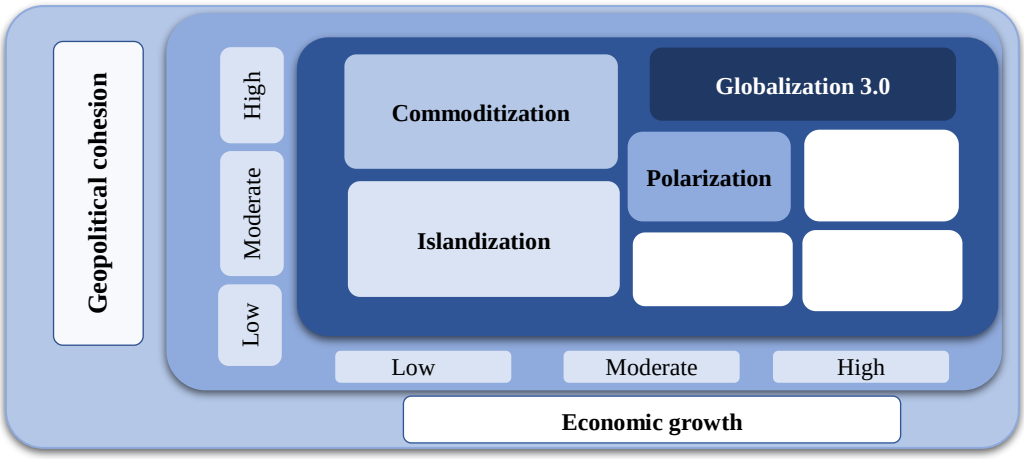

Figure 3. Positioning of global economic order scenarios on the "Geopolitical cohesion" – "Economic growth" coordinates

Source: compiled by the author based on (Kearney, 2016).

As can be seen from Figure 3, when implementing the most optimistic scenario of globalization 3.0, sustainable economic growth is accompanied by an increase in the geopolitical cohesion of the world's countries, and the governments of the countries tend to deepen international economic integration as opposed to the introduction of protectionist measures and manifestations of nationalism in foreign policy. The polarization scenario assumes the development of the world economy within the framework of separate blocks of geopolitical allies. Significantly, this scenario is described by experts A. T. Kearney as a "return to normalcy" or "regression to the

mean", meaning the high probability of the world returning after a globalization pause to the historical model of geopolitical rivalry between decision-making centers, characteristic of the Cold War period. The driver of a new wave of global competition, which will lead to the realization of the polarization scenario, is the growing tension in bilateral relations between the United States and China. In an economic sense, polarization will lead to the shortening of value chains, the localization of sales markets, and restrictions on the unhindered development of international business within the framework of geopolitical blocs.

A more dramatic version of the polarization of the world is the scenario of islandization, in which states turn into isolated political and economic systems that function based on nationalist and populist narratives. In trade relations, liberalization gives way to protectionism, which leads to a reduction in global trade and investment flows. This economic order leads to deep imbalances in regional development, fragmentation of world production, and increased social and economic inequality. Countries with fuel, energy, and land resources have become leaders in economic development. It is significant that a study by A. T. Kearney, dated 2016, considers islandization as the most likely scenario for the development of the world economy after Trump's victory in last year's US elections. Indeed, during Donald Trump's first presidential term, several deglobalization initiatives outlined in his campaign program were implemented: the US withdrawal from the Trans-Pacific Partnership Agreement and the Paris Climate Agreement, revision of the terms of participation in NAFTA, resolution of trade and economic wars, etc. The logical consequence was the spread of nationalism in the foreign trade policy of countries around the world as a reaction to US actions, the crisis in the functioning of the WTO and other institutions of intergovernmental cooperation, the revival of national socialism, and the strengthening of geopolitical polarization. The beginning of D. Trump's second term as president is characterized by even more radical actions and intentions, which, if implemented, will consolidate the "island" scenario of the development of the world economy for the coming years.

Finally, the communization scenario assumes that the rapid development of scientific and technological progress, automation of production, the spread of the Internet, and the digitalization of trade will lead to regional localization of industry and an increase in the role of small businesses. A parallel rethinking of the ideas of excessive consumption, provided that the scenario is implemented, leads to the construction of a "zero marginal cost society", in which the significance of international trade, investment, and transnational capital is leveled. Goods and services are considered public property, and the priorities of society are socialization, building relationships, and developing cooperation of local "communes".

According to experts at A. T. Kearney, the realization of each of the potential scenarios would correspond to the stabilization of key characteristics of the development of the world economy at a certain level (*Table 1*).

Table 1

Characteristics of global economy scenarios

Indicator	Scenarios			
	Globalization 3.0	**Polarization**	**Islandization**	**Communization**
Economic growth	High	Moderate	Low	Low
Unemployment rate	Low	Moderate	Moderate	Low
Social inequality	Moderate	Moderate	High	Low
Trade flows	Large	Moderate	Negligible	Moderate
Capital flows	Large	Moderate	Negligible	Negative
International migration	Significant	Moderate	Negligible	Negative
Regulatory convergence	Significant	Moderate	Negligible	Negative

Source: compiled by the author based on (Kearney, 2016).

Assessing the dynamics of these characteristics after the globalization pause of 2008–2009 will allow us to establish which scenario of world order came true or, at least, turned out to be as close to reality as possible.

2. Analysis of the dynamic indicators of post-globalization scenarios for the global economy

In quantitative terms, the characteristics of global scenarios (*Table 1*) can be described by indicators, most of which are obvious characteristics of world development (*Table 2*). Thus, the most representative indicator of global economic growth is world GDP at current prices, which demonstrates the actual monetary value of all economic activity in the world at a certain point in time, which allows us to track changes in the value of the economy in a global context. The indicator of the intensity of trade flows is the world volume of exports and imports, and capital flows are the volume of foreign direct investment, which reflects the real transnational integration of economies. The global unemployment rate is measured by the same name, which determines the share of the labor force that is not working, but is taking active steps to find a job. The Gini coefficient was chosen as an indicator of social inequality – a statistical indicator of the stratification of the world by the level of economic inequality, which takes values in the range from 0 to 1. The level of international migration is measured by the number of international migrants. It should be noted that due to the growth of the world population, the absolute number of international migrants (as well as, for example, the annual growth rates in percentage terms) will have an upward linear growth trend. For adequate measurement of both this and other indicators of global development, the dynamics of most of which have similar patterns, it is proposed to analyze not the absolute values of the indicators, but the deviations from the trend lines, which will be implemented at a later stage of the research. Finally, the most problematic is the definition of an indicator of regulatory convergence that would have a quantitative assessment at the level of the world economy and an available range of annual values for analysis, at least from 2008 to the present. It is proposed to use the percentage of world imports subject to regulatory

restrictions as such an indicator (WTO, 2024, November). The dynamics of this indicator (*Table 2*) indicate a systematic increase in regulatory restrictions in world trade, i.e., the absence of prerequisites for regulatory convergence in the foreseeable future.

At the next stage of the research, it is necessary to determine which ranges of values of world order indicators correspond to the linguistic assessments of the characteristics "high", "average", and "low" (see *Table 1*). To do this, it is advisable to compare the real values of the indicators with the trend lines of their time series. If the value of the indicator deviates insignificantly from the trend of its time series, then such a value can be considered average. If the indicator deviates significantly from the trend in a larger or smaller direction, then its value can be characterized as high and low, respectively. As a rule, the deviations of the real values of random variables from the linear trend are distributed according to the law of the Gaussian normal distribution with a zero mean value and a variance that characterizes the dispersion of values around the mean. The standard deviation σ, which is calculated as the square root of the variance, is usually considered as a measure of the deviation of a random variable from the mean value. For a normal distribution, the probability that a random variable is in the range ±σ is 68%, in the range ±1.28σ 80%, and in the range ±2σ 95%. We will consider a significant deviation exceeding $\pm 1.28\sigma$.

Figure 4 shows the dynamics and trend lines of the trend scenario indicators. *Figure 5* shows the deviation of the indicator values from the trend lines, and the deviation levels ±1.28σ are indicated. The values of the world economic order on a logarithmic scale (to increase the degree of linearity, indicators that are outside the range can be verified as "high" (>+1.28σ) and "low" (<-1.28σ). Otherwise, the indicator values correspond to the linguistic assessment "average".

3. Verification of post-globalization scenarios for the world economy

The obtained quantitative interpretation of the linguistic estimates of the indicators (*Table 1*) allows us to verify the scenarios of the world economic order – that is, to establish which scenario from those proposed by A. T. Kearney (Kearney, 2016) the combination of indicator values corresponds to in a certain period after the globalization pause of 2008–2009. To simplify visualization and the possibility of isolating certain patterns of global development, we will interpret the values of the indicators as "average" if they are directly on the border of deviations of +1.28σ (for example, the value of GDP in 2011) or -1.28σ (for example, the value of the Gini index in 2019). As can be seen from *Table 3*, it is quite expected that the entire period from 2008 cannot be considered as one of the four basic scenarios of the global order. But the stabilization of global development indicators within certain ranges allows us to determine which of these scenarios the world economy is closest to during 2008–2024.

Table 2

Dynamics of indicators for the global economy in 2008–2024

Period	Characteristics of scenarios						
	Economic Growth	Unemployment rate	Social inequality	Trade flows	Capital flows	International migration	Regulatory convergence
	Global development indicators						
	World GDP in Current Prices, USD billion	Unemployment rate, % of labor force	Gini index	World exports and imports, USD trillion	Foreign direct investment, USD million	Number of international migrants, million	World imports under regulatory restrictions, %
2008	64.361	5.80	0.847424	39.16	1.488	205	0.9
2009	60.956	6.40	0.840471	31.55	1.174	213	0.6
2010	66.796	6.30	0.841183	37.49	1.393	221	0.8
2011	74.181	6.20	0.844046	44.33	1.613	230	1.2
2012	75.628	6.20	0.839792	44.95	1.469	238	1.6
2013	77.866	6.10	0.836655	46.18	1.468	244	1.8
2014	79.983	6.00	0.836661	47.05	1.412	248	2.1
2015	75.519	6.00	0.83498	41.95	2.056	250	3.2
2016	76.817	6.00	0.834756	41.17	2.003	260	3.1
2017	81.715	5.90	0.835883	45.37	1.645	267	4.2
2018	86.771	5.80	0.834125	49.84	1.375	274	7.1
2019	88.027	5.60	0.832184	49.11	1.708	278	7.7
2020	85.764	6.60	0.833808	44.37	0.962	281	7.7
2021	97.843	6.10	0.839607	55.3	1.478	288	8.8
2022	101.948	5.30	0.838676	62.32	1.294	292	8.5
2023	106.431	4.90	0.835848	61.38	1.300	298	10.5
2024	110.549	4.90	0.835738	62.83	1.485	304	11.8

Source: compiled by the author based on data from (Statista, 2025; World Bank, 2025, January 07; World Inequality Database, 2025; World Bank, n. d. a, b; UNCTAD, 2023, May 5; Migration Data Portal, 2025; WTO, 2024, November 20).

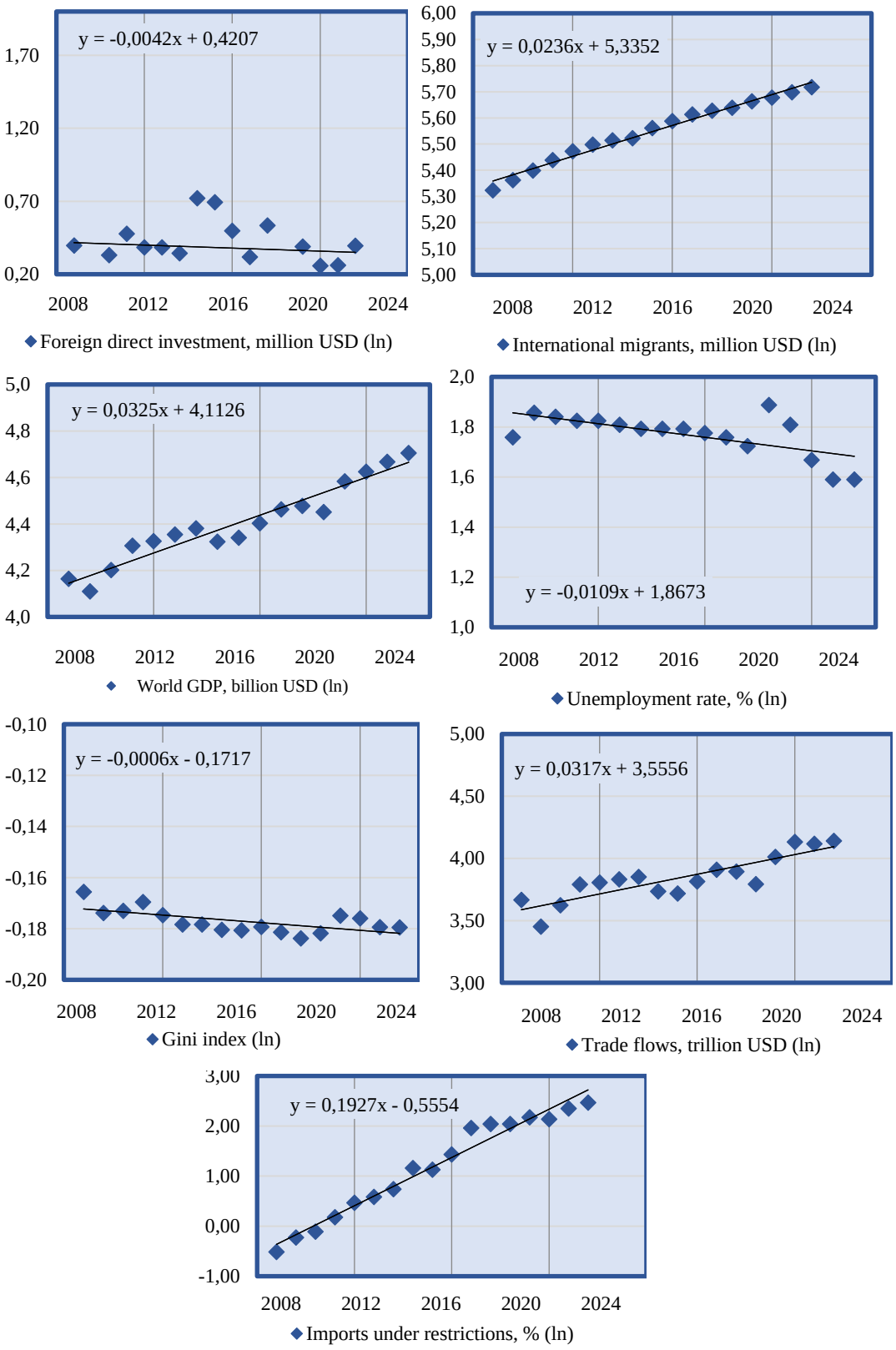

Figure 4. Dynamics and trend lines of indicators for scenarios of the global economic development (on a logarithmic scale)

Source: compiled by the author

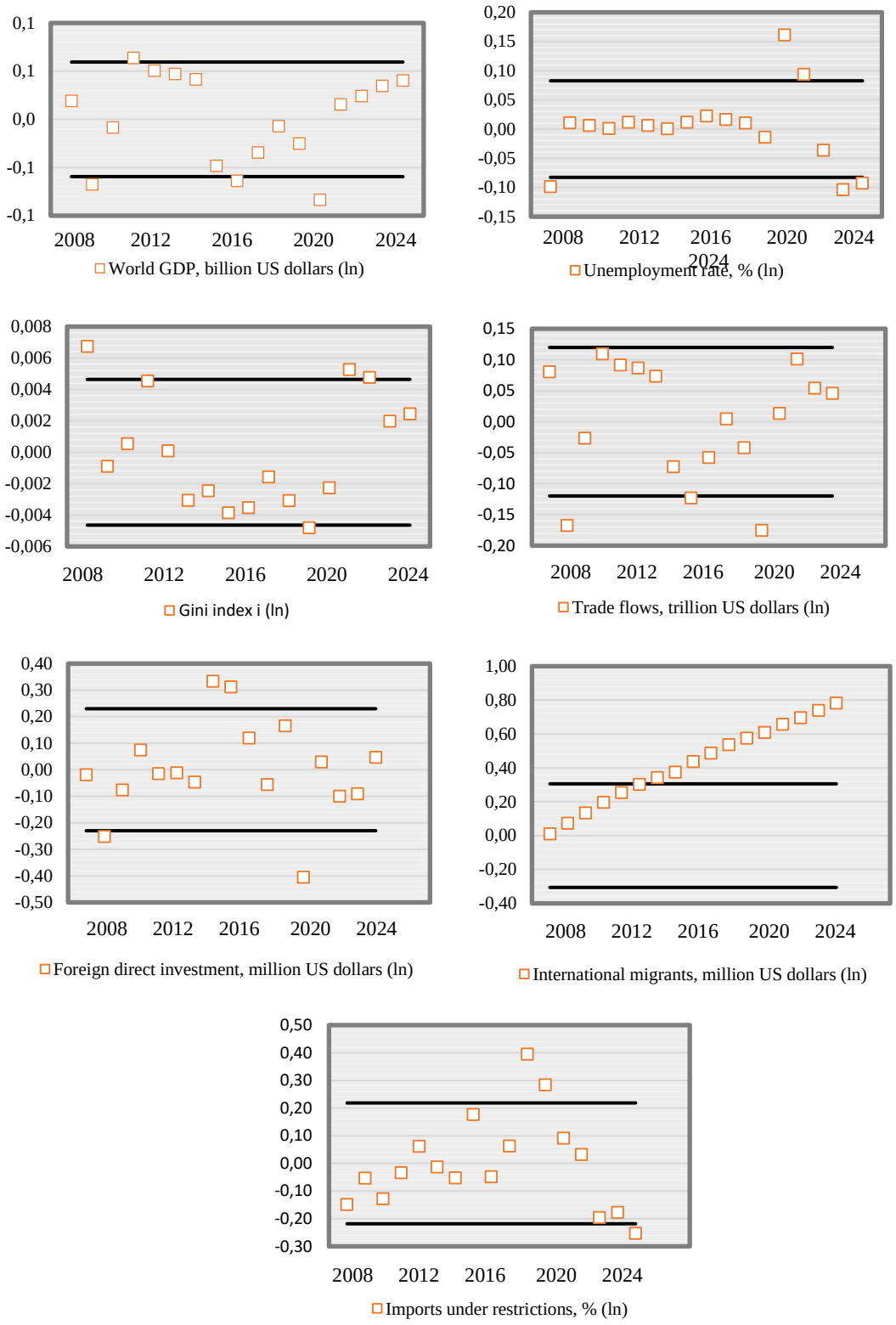

Figure 5. Dispersion of logarithmic values of indicators of global economic development scenarios relative to trend lines

Source: compiled by the author

Table 3

Results of verification of global economy scenarios in accordance with the dynamics of global development indicators in 2008–2025*

Period	Characteristics of scenarios						
	Economic Growth	Unemployment rate	Social inequality	Trade flows	Capital flows	International migration	Regulatory convergence
	Global development indicators						
	World GDP in Current Prices, billion USD	Unemployment rate, % of labor force	Gini index	World exports and imports, trillion US dollars	Foreign direct investment, million USD	Number of international migrants, million	World imports under regulatory restrictions, %
2008	Medium	Low	High	Medium	Medium	Medium	Medium
2009	Low	Medium	Medium	Low	Low	Medium	Medium
2010	Medium	Medium	Medium	Medium	Medium	Medium	Medium
2011	*Medium*	Medium	Medium	Medium	Medium	Medium	Medium
2012	Medium	Medium	Medium	Medium	Medium	Medium	Medium
2013	Medium	Medium	Medium	Medium	Medium	Medium	Medium
2014	Medium	Medium	Medium	Medium	Medium	High	Medium
2015	Medium	Medium	Medium	Medium	High	High	Medium
2016	*Medium*	Medium	Medium	*Medium*	High	High	Medium
2017	Medium	Medium	Medium	Medium	Medium	High	Medium
2018	Medium	Medium	Medium	Medium	Medium	High	High
2019	Medium	Medium	*Medium*	Medium	Medium	High	High
2020	Low	High	Medium	Low	Low	High	Medium
2021	Medium	High	High	Medium	Medium	High	Medium
2022	Medium	Medium	High	Medium	Medium	High	Medium
2023	Medium	Low	Medium	Medium	Medium	High	Medium
2024	Medium	Low	Medium	Medium	Medium	High	Low
2025*	Medium*	Low*	Medium*	Low*	Low*	High*	High*

Notes: Low level | Medium level | High level | *At the limit of the scale* | 2025* – forecast

Source: compiled by the author

ISSN 2786-7978; eISSN 2786-7986. SCIENTIA FRUCTUOSA. 2026. № 1

Comparing the combinations of scenario characteristics (*Table 1*) with the actual dynamics of economic development indicators (*Table 3*), we will determine which post-globalization scenarios correspond to the stages of transformation of the world order during 2008–2024 (*Table 4*).

Table 4

Correspondence of the world economy to basic scenarios after the globalization pause of 2008–2009

Period	Approximate base scenario	Main features
2008–2009	Recovery from the effects of the global financial and economic crisis (globalization pause 1.0)	Decline in global GDP, trade flows, and foreign direct investment
2010–2013	Polarization scenario	Return of global development indicators to pre-crisis trends and their stay at the average level
2014–2017	Gravitation toward globalization scenario 3.0	Acceleration of international migration and an increase in foreign direct investment
2018–2019	Gravitation toward the islandization scenario	Increase in regulatory restrictions and slowdown in foreign direct investment.
2020–2021	Globalization pause 2.0 with elements of the commonization scenario	Decline in economic growth, trade flows, and FDI due to the coronavirus crisis
2022–2024	Gravitation towards the polarization scenario	Increased digitalization of the global economy
Від 2025 р. (прогноз)	Gravitation towards the islandization scenario	Return of most global development indicators to pre-pandemic trends while maintaining a high level of international migration

Source: compiled by the author.

The starting point for the analysis of the gradual transformation of the world order is the globalization pause of 2008–2009, which led to a decline in key indicators of economic development – GDP, trade flows, and foreign direct investment. The post-crisis economic recovery led to a return of the values of the indicators to pre-crisis trends and their presence during 2010–2013 in the "average" range, which allows us to assume that during this period, the world economy is developing according to the polarization scenario. This scenario of "return to normality" (Kearney, 2016) is characterized by relative economic and geopolitical stability in the relations of competing countries and integration blocs.

During 2014–2017, a trend towards acceleration of international migration and an increase in the volume of foreign direct investment was recorded, which caused the transition of their values to the "high" range. The combination of values of world development indicators currently is closest to the globalization 3.0 scenario, in which countries tend to deepen international integration and liberalize trade and economic relations. But already in 2018–2019, we can note the deployment of the world economy to the islandization scenario, which, on the contrary, is characterized by a return to protectionism, which leads to a slowdown in the growth rates of foreign

direct investment and trade flows. A key sign of the strengthening of protectionist measures during this period is the presence of the corresponding indicator (the percentage of world imports under regulatory restrictions) in the “high” range. The activation of economic nationalism at this stage is directly related to deglobalization initiatives and the deployment of trade and economic wars during Trump’s first presidency.

The coronavirus pandemic in 2020 led to negative changes in the dynamics of the main indicators of world development, like the situation during the globalization pause of 2008–2009. Despite the rapid recovery of the world economy (as can be seen from Fig. 4, already in 2021, GDP resumed its pre-crisis growth trend), the pandemic demonstrated the fragility of international integration processes in conditions of isolation restrictions. Its consequence was an increase in the tendency towards fragmentation and regionalization of value chains, while the role of digital technologies and the online format of social interaction grew in conditions of restrictions on physical mobility. Regional localization of production and digitalization of the economy are the main features of the futuristic scenario of globalization, elements of the forced implementation of which we can observe during the pandemic globalization pause.

Finally, we can observe another change in the combination of values of global development indicators in 2022–2024, when most indicators return to pre-pandemic trends. After the financial and economic crisis of 2008–2009, the recovery process is close to the parameters of the polarization scenario. This scenario, typical of the Cold War period, is characterized by increasing geopolitical tensions and the fragmentation of the world into competing allied blocs. Security interests within such a model take priority over the economic efficiency of cooperation, which leads to an even greater increase in tension in the relations of competing political actors (USA – China, EU – russia, USA – Canada / Mexico / Japan, India – Iran, etc.). And it cannot be ruled out that the ongoing escalation of regional conflicts and aggressive US protectionism will again bring the world economy closer to the islandization scenario in 2025. Such a scenario is characterized by the isolation of political and economic systems, which leads to increased regulatory restrictions, reduced trade and investment volumes, and increased deglobalization processes in general.

Conclusions

The results of the analysis of the dynamics of global development indicators created the basis for verifying the scenarios of the world economic order from the financial and economic crisis of 2008–2009 to the present, which allowed us to confirm the hypothesis of the dominance of deglobalization trends in the development of the world economy. The considered time is characterized by dynamism and turbulence, which quite predictably leads to the impossibility of considering it as a single clear scenario. Depending on the change in the global political and economic

situation in certain years, the attraction of the world economy to a specific scenario is recorded, but all of them predict a slowdown in integration processes. The only exception is the period of 2014–2017, when the dynamics of world development indicators most closely correspond to the globalization 3.0 scenario, which is characterized by high rates of international migration and an increase in the volume of foreign direct investment.

Additional distortions in the dynamics of global development indicators, which cause changes in scenario parameters, are due to the influence of force majeure circumstances and increased geopolitical tension. In the period after the financial and economic crisis of 2008–2009, at least two more significant events occurred that further strengthened deglobalization trends – the COVID-19 pandemic and the russian-Ukrainian war. The corona crisis led to a large-scale suppression of globalization processes and, despite the rapid recovery of the world economy, had an impact on it comparable to the globalization pause 1.0. In contrast, the russian-Ukrainian war, despite the expectations of experts (Goldberg & Reed, 2023), did not cause a global economic crisis comparable to the globalization pauses of 2008–2009 and 2020–2021. The consequences of the russian aggression led to increased fragmentation of the world economy, highlighted new risks of international specialization, and actualized competition for access to key production resources between competing blocs – in other words, led to a scenario of polarization, rather than the destruction of globalization processes. But the ongoing escalation of military-political conflicts is bringing the world closer to the deglobalization scenario of islandization, which is characterized by the isolation of national economies, the priority of import substitution, and aggressive protectionism in international relations.

Therefore, the transformation of the geopolitical landscape becomes a marker of a new economic order and a key prerequisite for further deglobalization. Therefore, we see prospects for future research in the development of a methodology for scenario planning of the world economic order by considering indicators that allow us to assess the role of geopolitical factors in accelerating deglobalization processes.

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Conflict of interest. The author certifies that she has no financial or non-financial conflicts of interest with respect to this publication; he has no relationships with government agencies, commercial or non-commercial organizations that could be interested in presenting this point of view. Given that the author works at an institution that publishes the journal, which could cause a potential conflict or suspicion of bias, the final decision to publish this article (including the selection of reviewers and editors) was made by members of the editorial board who are not affiliated with this institution.

The author received no direct funding for this research.

Kalyuzhna, N. (2026). Deglobalization scenarios of the world economy. *Scientia fructuosa, 1*(165), 14–32. http://doi.org/10.31617/1.2026(165)02

Received by the editorial office 23.06.2025.
Accepted for printing 10.09.2025.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)03
UDC 339.9(477+061.1ЄС)=111

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UKRAINE–EU TRADE UNDER GLOBAL FLUCTUATIONS

The practical value of this research lies in highlighting trends in trade relations between Ukraine and the European Union, particularly in the context of geopolitical conflicts and the implementation of European integration principles in the Ukrainian economy. The dynamism of changes in the economy and politics has led to the emergence of new challenges facing Ukraine's international trade, necessitating further research. The research is based on the hypothesis that, in the context of geopolitical changes and globalization, Ukraine's trade in goods with EU countries is undergoing structural changes, which, in turn, affects the state of the country's economic stability and international partnerships. It is necessary to develop an econometric model that reflects the impact of logistics efficiency and the regulatory environment on the state of international trade. To achieve this goal, the methods of theoretical generalization, analysis, and synthesis were used. The results of research by leading scholars are considered to identify the main challenges that accompany the process of EU-Ukraine integration in the field of trade and the complicated, unstable conditions of international cooperation. The research applies statistical analysis of trade flows, structural diagnostics of export and import composition, and a multifactor econometric model incorporating GDP, logistics performance, and economic freedom indices. The model's adequacy is confirmed through regression diagnostics and statistical tests. The analysis reveals a reorientation of Ukrainian exports toward agricultural and food products, a decline in metallurgical exports, and growing technological

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ТОРГІВЛЯ МІЖ УКРАЇНОЮ ТА ЄС В УМОВАХ ГЛОБАЛЬНИХ КОЛИВАНЬ

Практичне значення цього дослідження полягає у висвітленні тенденцій торговельних відносин між Україною та Європейським Союзом в контексті геополітичних конфліктів та процесу впровадження принципів європейської інтеграції в українську економіку. Динамічність змін в економіці та політиці зумовлює появу нових викликів для міжнародної торгівлі України та потребує подальших досліджень. Дослідження ґрунтується на гіпотезі, що в умовах геополітичних змін та глобалізації торгівля України товарами з країнами ЄС зазнає структурних трансформацій, що, у свою чергу, впливає на стан економічної стабільності країни та міжнародного партнерства. Необхідно розробити економетричну модель, яка відображатиме вплив ефективності логістики та регуляторного середовища на стан міжнародної торгівлі. Для досягнення цієї мети використано методи теоретичного узагальнення, аналізу та синтезу. Враховано результати досліджень провідних науковців для визначення основних викликів, що супроводжують процес інтеграції України до ЄС у сфері торгівлі та складні, нестабільні умови міжнародного співробітництва. У дослідженні застосовано статистичний аналіз торговельних потоків, структурну діагностику складу експорту та імпорту, а також багатофакторну економетричну модель, що включає ВВП, індекс ефективності логістики та індекс економічної свободи. Адекватність моделі підтверджено за допомогою регресійної діагностики та статистичних тестів. Аналіз виявив переорієнтацію українського експорту на аграрну та харчову продукцію, зниження експорту

and energy dependence in imports. The econometric model demonstrates high explanatory power (R^2 = 0.979), confirming the significance of institutional and logistical factors. Comparative advantage calculations identify priority export sectors and underrepresented product groups with development potential. Ukraine's trade with the EU is undergoing structural diversification, driven by geopolitical shocks and regulatory shifts. To strengthen resilience and deepen integration, Ukraine must enhance logistics, support priority sectors, and adapt trade policy to reflect national interests within the framework of the Association Agreement.

Keywords: trade in goods, European integration, stability of the economy, export, import, benefits, and challenges, development, global fluctuations, logistics, geopolitics.

металургійної продукції та зростання технологічної й енергетичної залежності імпорту. Економетрична модель демонструє високу пояснювальну здатність (R^2 = 0,979), що підтверджує значущість інституційних та логістичних чинників. Розрахунки порівняльних переваг визначають пріоритетні експортні сектори та недопредставлені групи товарів із потенціалом розвитку. Торгівля України з ЄС зазнає структурної диверсифікації, зумовленої геополітичними шоками та регуляторними змінами. Для зміцнення стійкості та поглиблення інтеграції Україна має вдосконалити логістику, підтримати пріоритетні сектори та адаптувати торговельну політику до національних інтересів у рамках Угоди про асоціацію.

Ключові слова: торгівля товарами, європейська інтеграція, стабільність економіки, експорт, імпорт, переваги та виклики, розвиток, глобальні коливання, логістика, геополітика.

JEL Classification: F17, F20, E69.

Introduction

Global fluctuations in the world economy caused by the COVID-19 pandemic, the energy crisis, russia's full-scale aggression against Ukraine, and structural changes in global supply chains have significantly affected the dynamics of foreign trade. For Ukraine, which is integrating into the European economic space, trade with the European Union (EU) has become a determining factor in economic stability. Assessments by leading international organisations show that the trajectory of global trade remains unstable, and risks are increasing due to tariff conflicts and regulatory changes that directly affect trade flows, prices, and logistics. In particular, in 2025, the WTO recorded a sharp deterioration in forecasts for trade dynamics amid escalating trade barriers, while the IMF emphasizes 'fragile stability' with significant risks from politics and geopolitics (World Trade Organization, 2025, April; Poidevin & Blenkinsop, 2025, April 16; International Monetary Fund, 2025).

Cooperation with the European Union, which has been Ukraine's main trading partner since 2014, is of particular importance for Ukraine. The Deep and Comprehensive Free Trade Area (DCFTA) has provided the legal and institutional framework for the growth of bilateral trade flows, but global crises have posed new challenges:

- disruptions in logistics and transport, due to the blocking of traditional routes and the need to develop alternative routes (Solidarity Routes through the EU);
- growing trade policy uncertainty (TPU), which reduces investment activity and makes it difficult for Ukrainian companies to enter new markets;
- increased regulatory pressure due to global and regional changes, including new requirements for product quality and environmental standards;

• structural changes in supply and demand, which have resulted in a reorientation of Ukrainian exports from the CIS and Asian markets to the EU.

Thus, the problem lies in the need for a scientifically sound assessment of how global fluctuations transform the intensity and structure of Ukraine's trade with the EU, which sectors are most vulnerable, and which ones are gaining new opportunities. Solving this problem is critical for shaping Ukraine's economic integration strategy into the European market and adapting national trade policy to new realities.

Both foreign and domestic scholars have paid attention to the study of the transformation of international trade and its sensitivity to global fluctuations. At the same time, the growing turbulence of the global socio-economic environment is creating new challenges that require in-depth study (Poidevin & Blenkinsop, 2025).

Thus, Prokop (2024) emphasizes that the war started by russia has become a key factor in the destruction of established logistical links between Ukraine and the EU. The author analyses changes in the product mix of Ukrainian exports and outlines the main trends in trade between Ukraine and the EU during the war.

An article by a group of authors (Lyzun et al., 2024) highlights the uneven concentration of Ukrainian exports to EU countries and describes the main barriers hindering the development of trade relations in the context of growing security risks.

Polish researchers Darvas and Martins (2022) emphasize that the war against Ukraine has overlapped with the post-pandemic recovery of the global economy, exacerbating inflationary pressures. They conclude that although Ukraine's share in world trade remains relatively small, the sanctions pressure on russia weakens its production potential and thus changes Ukraine's foreign trade position.

A group of Asian authors (Cui et al., 2022) considers war as a factor that increases the risk of disruption to global supply chains. The researchers emphasize the vulnerability of international energy flows, although their findings have broader implications for understanding the relationship between geopolitical conflicts and the global economy. A similar line of research is being pursued by a group of researchers (Zhang et al., 2024) who analyze the impact of war on international energy trade, emphasizing the need for diversification of export strategies and flexible mechanisms for adapting to geopolitical shocks.

The work of Galetska et al. (2022), which traces the evolution and variations of the gravity model of international trade, deserves special attention in the domestic scientific tradition. The authors conclude that it needs to be further adapted to consider new global factors, which is consistent with the need to develop improved econometric approaches to analysing foreign trade relations between Ukraine and the EU.

Hanna Duginets interprets crises in international trade as systemic and cyclical phenomena triggered by global shocks – financial, energy-related, pandemic, or military. They destabilize production and trade chains, intensify

protectionist tendencies, and expose the vulnerability of economies. At the same time, crises act as catalysts for structural change, stimulating adaptation and the search for new formats of integration and cooperation (Duginets, 2022).

The study by Zhabynets, "Factors of Global Changes in International Trade and the Military Aggression of russia: Impact on the Development of Export Activities of Ukraine's Regions" (2022) analyzes how global economic transformations and russian aggression affect the exports of Ukrainian regions. The research reveals that these factors generate significant challenges requiring adaptation of regional export activities, particularly through market reorientation, product diversification, and the search for new logistical routes.

Thus, existing studies form a broad scientific base, but there is a shortage of works that combine the analysis of global shocks and the specifics of Ukrainian-European trade through an improved econometric model. This determines the niche for the novelty of this article.

The research hypothesis is that Ukraine's trade with the EU in 2014–2024, under the influence of global fluctuations (COVID-19, war, sanctions, and logistical shocks), underwent structural changes and asymmetry, and the use of an improved econometric model allows for a quantitative assessment of the impact of these factors on export and import volumes.

The aim of the research is to comprehensively analyze the dynamics and structure of Ukraine's trade with the European Union in 2014–2024 in the context of global economic fluctuations, as well as to identify key challenges and opportunities for Ukraine's further integration into the EU internal market.

The research methodology includes analysis of export, import, balance, and trade turnover dynamics, econometric modelling using an improved econometric model, and justification of Ukraine-EU trade flows through the identification of comparative advantages.

The following tasks are aimed at achieving the aim of the article, sequentially implemented in four sections of the main part of the article: the first is to investigate the dynamics of exports, imports and trade balance between Ukraine and the EU in 2014–2024; the second is to identify the main structural shifts in bilateral trade and identify the most sensitive sectors; the third is to develop and build an improved econometric model (a new part of the study) that integrates classical trade determinants with indicators of uncertainty and logistical shocks, and apply it to quantify the consequences for 2014–2024; the fourth is to identify a list of key challenges between Ukraine and the EU, taking into account the current state of world trade.

1. Analysis of trade trends between Ukraine and the EU

Trade relations with European Union member states play a prominent role in international cooperation. Relations with the EU are of particular importance for Ukraine in determining its prospects and reserves for

increasing the level of international trade contacts and the competitiveness of the domestic economy in the global market. Research into the problems of integration, the structure of integration processes, and the prospects for the development of the domestic economy in the context of strengthening foreign economic ties is the subject of study by domestic and foreign experts.

Data for 2014–2024 (*Table 1*) show significant dynamics in bilateral trade between Ukraine and the European Union.

Table 1

Data on Ukraine's foreign trade in goods and services with the European Union in 2014–2024, USD billion

Year	Exports from Ukraine to the EU	Imports from the EU to Ukraine	Balance	Foreign trade turnover
2014	20	24	–4	44
2015	15	18	–3	33
2016	16	19	–3	35
2017	20	23	–3	43
2018	23	27	–4	50
2019	24	29	–5	53
2020	22	27	–5	49
2021	30	32	–2	62
2022	29	31	–2	60
2023	26	34	–8	60
2024	26	45	–19	71

Source: State Statistics Service of Ukraine (n. d.).

In 2014–2015, Ukraine's exports to the EU amounted to approximately USD 15–20 billion, while imports exceeded USD 18–24 billion, resulting in a negative balance for Ukraine. The period 2016–2018 was characterized by a gradual increase in exports to USD 23 billion in 2018, with imports growing in parallel (USD 27 billion in 2018).

The years 2019–2020 were marked by a decline in exports to USD 22 billion in 2020, which can be explained by the consequences of the COVID-19 pandemic and disruptions in global supply chains.

2021 saw a recovery, with exports reaching USD 30 billion and trade turnover growing to USD 62 billion, demonstrating the economy's rapid response to post-pandemic recovery.

In 2022, despite the outbreak of full-scale war, exports to the EU grew to USD 29 billion, reflecting a reorientation of trade flows towards EU markets and the use of alternative logistics routes.

2023–2024 are characterised by stabilization of exports (USD 25–28 billion) and a sharp increase in imports to USD 45 billion in 2024, resulting in a record negative balance (USD 19 billion).

Throughout the period, the balance remained negative for Ukraine, but there were periods of deficit reduction, particularly in 2022 (USD -5 billion),

thanks to the reorientation of exports and temporary EU trade liberalisation. The deepest deficit was recorded in 2024, indicating increased import dependence and the intensification of programmes to restore and purchase critically important products.

Tables 2 and 3 show the commodity structure of foreign trade with EU countries for goods with a share of more than 5%.

Table 2

Commodity structure of Ukraine's exports to the EU with a share of more than 5% in 2014–2024, %

Title by Ukrainian Classification of Commodities in Foreign Trade	2014	2016	2018	2020	2022	2024
Plant products	22.5	24.8	26.3	28.1	29.5	27.3
cereals	10.2	11.5	13.4	14.1	16.7	15.8
oil seeds and fruits	7.3	8.1	8.7	9.2	10.1	9.7
Animal or plant fats and oils	9.5	10.4	11.8	12.7	14.2	13.6
Finished food industry products	6.8	7.2	7.6	7.9	8.4	8
Mineral products	6.2	5.9	6.3	7.1	7.8	8.2
Base metals and preparations thereof	15.1	14.6	13.9	12.2	11.3	11.6
Machines, equipment, and mechanisms, electric and technical equipment	8.0	8.4	9.1	9.6	10.0	10.2

Source: State Statistics Service of Ukraine (n. d.).

Table 2 shows that plant products consistently maintain their leading position in the export structure. Its share peaked in 2022 (29.5%), which is associated with a sharp increase in exports of grains and oilseeds after the blockade of Black Sea ports and the active use of alternative logistics routes (rail corridors, Danube ports). From 2014 to 2022, grain crops almost doubled their share (from 10.2% to 16.7%), but in 2024, the figure declined slightly (15.8%) due to export difficulties and competition from other suppliers. Fats and oils (mainly sunflower oil) showed growth throughout the period and peaked in 2022 (14.2%). This indicates Ukraine's transformation into a key exporter of edible oils in the world. Metallurgy (base metals) had a significant share in 2014 (15.1%) but gradually declined due to the destruction of industrial capacity in the combat zone, logistical difficulties, and a structural shift towards agricultural products.

Machinery, equipment, and electrical engineering grew from 8% in 2014 to 10.2% in 2024. This is due to the integration of Ukrainian enterprises into EU production chains (in particular, the automotive industry, cable harnesses, and electrical components). Mineral products and prepared food products maintain a secondary but stable share in exports (6–8%), reflecting the gradual diversification of exports.

Table 3

Commodity structure of imports from the EU to Ukraine with goods whose share is more than 5% in the period 2014–2024, %

Title by Ukrainian Classification of Commodities in Foreign Trade	2014	2016	2018	2020	2022	2024
Finished food industry products	6.2	6.5	6.9	7.2	7.5	7.0
Mineral products	15.5	14.8	16.2	17.0	18.1	17.4
mineral fuel, petroleum, and petroleum distillation products	14.9	14.2	15.8	16.4	17.6	17.1
Products of chemical and allied industries	11.8	12.3	12.9	13.1	13.5	13.7
Polymeric materials, plastics, and articles made from them	5.3	5.4	5.7	5.8	6.0	5.6
Machines, equipment, and mechanisms, electric and technical equipment	14.2	14.6	15.1	15.4	15.6	15.2
Ground, air, and water transport facilities	10.5	10.7	11.0	11.4	11.6	11.1

Source: State Statistics Service of Ukraine (n. d.).

An analysis of *Table 3* clearly shows the following:

- Machinery and equipment continue to play a leading role in the import structure (≈15%). This indicates Ukraine's active integration into EU production chains and its dependence on technological imports (equipment for industry, energy, and IT).
- Mineral products remain consistently high (15–18%), mainly due to imports of petroleum products and gas. The peak was in 2022 (18.1%) due to the reorientation of supplies from russia and Belarus to EU markets.
- Chemical products (12–14%) include pharmaceuticals, fertilisers, and organic chemicals. The growth reflects increased demand for medical supplies (COVID-19 pandemic) and fertilisers during the war.
- Polymers and plastics consistently account for 5–6% of imports. They are critical for packaging, the light industry, and construction.
- Transport vehicles (≈11%) are showing growth, which is explained by an increase in imports of passenger cars (in particular, used cars from the EU after the liberalisation of customs rules in 2022), as well as equipment for infrastructure restoration.
- Ready-made food products have a moderate but stable share (6–7%), reflecting the high demand for ready-made European food products in Ukraine.

Thus, Ukraine's imports from the EU are characterised by technological and energy dependence: the key items are machinery, petroleum products, and chemical products. This creates risks during periods of global price fluctuations and at the same time stimulates the development of import substitution programmes.

2. Econometric factor model of international trade

A study of the works of foreign and domestic scientists on the gravitational model of international trade has revealed their great diversity. Over time and with changing economic conditions, the forms of this model have also changed. Galetska et al. (2022) provide a detailed review of the development of scientific thought on econometric modeling of the dependence of international trade volume on various factors. Thus, in the work of Tinbergen (1962), the model included only three factor variables. His follower, Linneman (1966), expanded the list of factors to seven. In recent studies, Ukrainian scientists (Sholom & Kazakova, 2019) proposed using logarithmic dependencies of exports, considering institutional changes.

Having examined several studies (Linneman, 1966; Nasodyuk, 2012; Handley & Nuno, 2015; Galetska et al., 2022) and rating systems for assessing the position of countries in the world, we will analyze the relationship between the volume of international trade and key indicators by constructing an econometric model.

As of 2025, Ukraine's main trading partners remain China, Poland, Germany, Turkey, and the United States. Among them, Germany demonstrates logistics performance indicators that are closest to the average European level, according to the Logistics Performance Index (LPI). Therefore, the parameters characteristic of Germany – as a representative model of the European logistics system – were used for constructing the econometric function.

Let us examine trade activity (Y – the volume of foreign trade turnover between the EU and Ukraine) to formalize the factors influencing it. The influencing factors include (*Table 4*):

Table 4

Input data for the multivariate model

Year	The volume of foreign trade turnover between the EU and Ukraine	Ukraine's gross domestic product, in USD billion	The gross domestic product of the European Union countries, in USD billion	Ukraine's logistics performance index points *	Germany's logistics performance index points, *	Ukraine's economic freedom index points	Germany's economic freedom index points
2014	44	131.8	15800	2.98	4.12	49.3	73.4
2015	33	90.6	13700	2.82	4.18	46.9	73.8
2016	35	93.3	14000	2.74	4.23	46.8	74.4
2017	43	112.2	14900	2.81	4.2	48.1	73.8
2018	50	130.8	16100	2.83	4.2	51.9	74.2
2019	53	153.8	15800	2.82	4.21	52.3	73.5
2020	49	155.6	15500	2.81	4.2	54.9	73.5
2021	62	199.8	17500	2.8	4.18	56.2	72.5
2022	60	162.0	17000	2.8	4.14	54.1	76.1
2023	60	181.2	18600	2.7	4.1	49	73.7
2024	71	190.7	19400	2.7	4.1	49	72.1

**Data not available in reports was calculated based on trend forecasts*

Source: The Heritage Foundation (2025, February); World Trade Organization (2025, April).

X_1 – Ukraine's gross domestic product, USD billion;

X_2 – the gross domestic product of the European Union countries, USD billion;

X_3 – Ukraine's logistics performance index points;

X_4 – Germany's logistics performance index points

X_5 – Ukraine's economic freedom index points

X_6 – Germany's economic freedom index points.

Let's use the extended power function of the form:

$$Y = a_0 \cdot X_1^{a1} \cdot X_2^{a2} \cdot X_3^{a3} \cdot X_4^{a4} \cdot X_5^{a5} \cdot X_6^{a6} \quad , \qquad (1)$$

Let us bring the function to a linear form using logarithms and obtain a function of the form:

$$lnY = \ln A + \alpha \cdot lnX_1 + \beta \cdot lnX_2 + \gamma \cdot lnX_3 + \delta \cdot lnX_4 + \theta \cdot lnX_5 + \vartheta \cdot lnX_6 \quad . \qquad (2)$$

Let's build a multifactorial exponential model using Excel functions (*Figure 1*):

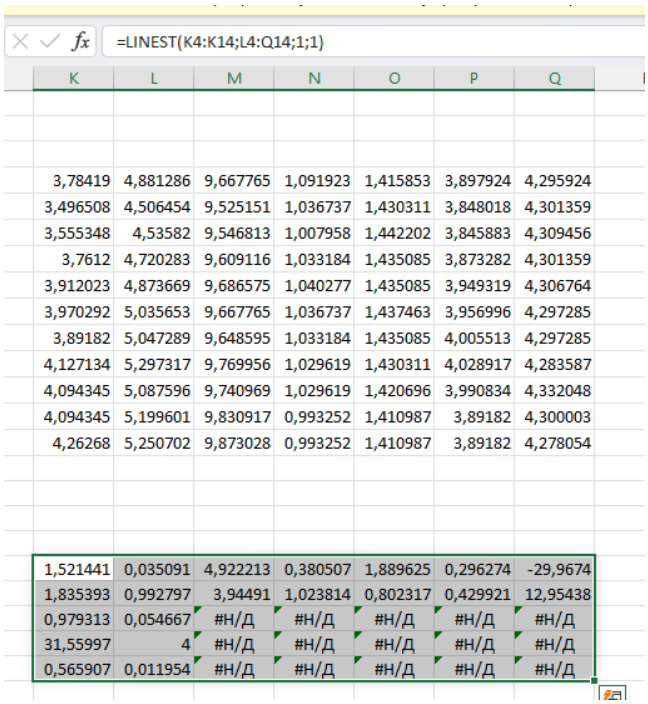

Figure 1. Calculation of the parameters of the functional dependence of the volume of foreign trade turnover using the power model

Source: calculated by the author.

The result of the calculation is:

A´= –29.968, α=0.296; β=1.889; γ=0.381, δ=4.922, θ=0.035, υ=1.521.

The logarithmic model looks like this:

$$lnY = 0.296lnX_1 + 1.889lnX_2 + 0.381lnX_3 + 4.992lnX_4 + \\ +0.035lnX_5 + 1.521lnX_6 - 29.967 + \varepsilon \quad , (3)$$

where: ε is the random error.

r model has the form:

$$Y_{calc} = (\exp(-29.967)) \cdot X_1^{0.296} \cdot X_2^{1.889} \cdot X_3^{0.381} \cdot X_4^{4.992} \cdot X_5^{0.035} \cdot X_6^{1.521} + \varepsilon$$

$$Y_{calc} = 0{,}0000001 \cdot X_1^{0.296} \cdot X_2^{1.889} \cdot X_3^{0.381} \cdot X_4^{4.992} \cdot X_5^{0.035} \cdot X_6^{1.521} \quad . (4)$$

The coefficient of determination is 0.979, which confirms the relationship between the variables. There is little dispersion of residuals in the statistical information in the power model, so we conclude that the power form of dependence better describes the relationship between the variables.

Verification of the model for reliability using the F-criterion showed that the model is reliable (Fcalc = 31.56 > Ftab = 4.76 at a significance level of α = 0.05).

Analysis of the parameters of the regression dependence shows that all factors influence the volume of foreign trade turnover between Ukraine and EU countries.

To test the significance of the correlation coefficient R, we calculate the Student's t-test:

$$t_\alpha = \frac{R\sqrt{(n-m)}}{\sqrt{1-R^2}} = \frac{\sqrt{0{,}979^2(10-6)}}{\sqrt{(1-0.979^2)}} = 9.652. \quad (5)$$

Using statistical tables with a significance level of α=0.05 and 6 degrees of freedom, we select ttab = 1.895. Since t > t_{tab}, we can conclude that the correlation coefficient is significant and the constructed model is adequate.

Let us check the model for adequacy by analyzing the direction and magnitude of deviations of the resulting feature according to actual and calculated values (*Table 5*).

Table 5

Determining the accuracy of the constructed model by calculating the sign and magnitude of deviations between the dependent variable calculated using the model and the actual values

Y	Y`	e = Y`– Y
44	46.47	2.47
33	33.61	0.61
35	37.50	2.50
43	42.94	–0.06
50	52.73	2.73
53	53.19	0.19
49	50.89	1.89
62	65.91	3.91
60	60.13	0.13
60	65.74	5.74

Source: calculated by the author.

The model is constructed correctly. The model can be used both for researching partial factors of influence and for forecasting.

The model is adequate, as confirmed by calculations. In addition to traditional gross domestic product (GDP) indicators, this model integrates additional variables that reflect the impact of contemporary economic and institutional factors. In particular, the following were used:

Logistics Performance Index (LPI): This indicator helped to assess the quality and reliability of transport infrastructure and services. Its analysis confirmed that improving logistics links is critical to reducing trade costs and accelerating export flows.

Economic Freedom Index: the use of this index made it possible to quantitatively assess the impact of the regulatory environment, property rights protection, and market openness on trade volumes. The study showed that economic liberalization is a significant stimulus for trade growth.

In the future, by studying the factors that influence the formation of the factor characteristics of this model, it will be possible to develop action programs that will contribute to the "improvement" of individual components, resulting in a multiplier effect of increased international trade.

3. Ukraine – EU trade trends

To determine priority commodity groups for trade with the EU, relative comparative advantages in the structure of exports and imports by commodity groups were calculated using the formula

$$KP_{ij} = \ln\left[\frac{\frac{Ex_{ij}}{Im_{ij}}}{\frac{Ex_i}{Im_i}}\right], \quad (6)$$

where KP_{ij} is the indicator of comparative advantage of the i-th country for the j-th product;

Ex_i, Im_i are exports and imports of the i-th country;

Ex_{ij} and Im_{ij} are exports and imports of the j-th product of the i-th country.

If KPij>0, then for the jth product, this means that the ith country has a comparative advantage in exports to other countries. If KPij<0, then this means that it is not advisable to export this product to Ukraine.

Calculations of the comparative advantages of product groups of Ukraine in 2019–2024 showed that in Ukraine, among the 96 product groups listed in the nomenclature, only 28 have comparative advantages and only they are advisable to sell on the world market. As of 2024, this is only 15 positions. The results are summarized in *Table 6*.

Table 6

Priority commodity groups of Ukrainian exports for sale on the EU market 2021–2025

Code and name of the commodity item	CPij	Code and name of the commodity item	CPij
Currently sold on the EU market and has high advantages			
10 cereals	4.28	12 seeds and fruits of oil plants	1.66
26 ores, slag, and ash	2.93	23 residues and waste from the food industry	1.58
15 Fats and oils of animal or vegetable origin	2.73	44 wood and wood products	1.51
72 ferrous metals	2.17		
Currently, they are poorly represented on the EU market but have significant advantages and development prospects.			
14 plant materials for making wickerwork	2.45	86 railway locomotives	0.81
43 natural and artificial fur	2.04	28 inorganic chemistry products	0.81
89 vessels	1.79	25 salt; sulfur; earth and stones	0.61
78 lead and articles thereof	1.47	94 furniture	0.56
02 meat and edible offal	1.35	49 printed products	0.49
XV. Base metals and articles thereof	1.27	17 sugar and sugar confectionery	0.33
11 products of the flour and cereal industry	0.89	19 prepared grain products	0.33
Currently sold on the EU market, but has no advantages			
73 ferrous metal products	0.11	74 copper and articles thereof	0.09
46 straw products	0.09	04 milk and dairy products, poultry eggs; natural honey	–0.04

Note: Italic highlights what was traded in 2021 but not in 2024.

Source: calculated by the author.

The calculations in the table show that the highest comparative advantage ratio in 2025 will be observed in the following commodity groups: cereals (4.38), ore, slag and ash (3.03), animal or vegetable fats and oils (2.83), plant materials for making wickerwork (2.55), natural and artificial fur (2.14), products of vegetable origin (2.05), wood and wood products, etc.

Ukrainian exports to the EU are concentrated in the agro-industrial sector, food products, metallurgy, and wood. Imports are mainly represented by machinery, equipment, transport vehicles, pharmaceuticals, and chemical products. This confirms the asymmetry of trade: Ukraine exports raw materials and semi-finished products, while importing high-tech products.

The 2020 pandemic led to a drop in exports and a temporary decline in trade turnover.

The start of full-scale war in 2022 caused a rapid reorientation of exports to the EU and a partial reduction in the balance deficit. The period 2023–2024 is characterised by an increase in imports due to purchases of critically important goods, the restoration of logistics, and aid programmes.

The analysis shows that Ukraine's trade with the EU remains stable but asymmetrical. Global shocks (COVID-19, war, and sanctions) have radically affected the structure and volume of trade, highlighting the need to adapt the Ukrainian economy and strengthen integration into the European market.

4. Key challenges in trade between Ukraine and the EU

In June 2022, the EU took an unprecedented step, completely lifting restrictions on Ukrainian goods to support the Ukrainian economy during a large-scale war. At the same time, Ukraine stopped importing goods produced in aggressor countries and increased imports from the EU. Of all Ukrainian industries, agriculture benefited the most. Already in June 2022, exports in the 'Food and live animals' category were 14.7% higher than in June 2021; subsequently, the growth rate of exports in this category continued to increase. This confirms the general understanding that Ukraine has a comparative advantage in the agricultural and food sectors in terms of European markets. At the same time, it is impossible to clearly identify the reason for the decline in industrial goods exports. Most industrial enterprises are located in eastern and south-eastern Ukraine, territories that are under occupation or have been most affected by the russian invasion. Azovstal alone produced about 4.3 million tonnes of steel in 2021, which is more than 10% of Germany's total steel production for the same period. Therefore, the Ukrainian industry has suffered from the war, not from competition with European producers.

Until 2022, significant restrictions on imports of Ukrainian agricultural products protected EU farmers from competition. The removal of administrative barriers clearly demonstrated the competitiveness of the Ukrainian agricultural sector. The European Union remains Ukraine's main trading partner, as evidenced by official data from the State Statistics Service: in 2024, 59% of all Ukrainian exports went to the EU market. However, the growth rate of exports to the EU slowed down somewhat compared to 2022, when the war and logistical restrictions made the EU virtually the only option for Ukrainian exporters. The slowdown in export growth is linked to the restoration of maritime logistics, which has allowed some businesses to return to alternative supply routes.

In April 2023, Poland and Hungary announced a ban on imports of Ukrainian grain and several other agricultural products. In May, the European Commission agreed to this ban until 5 June as an exception. However, on 6 June, an EU decree came into force allowing restrictions on imports of four Ukrainian goods (wheat, corn, rapeseed, and sunflower seeds) if imports of these goods destabilise domestic markets (no restrictions were imposed on transit shipments). Accordingly, the embargo was imposed in five countries (including Bulgaria, Romania, and Slovakia) until 15 September 2023. The main reason for trade protectionism was protests by

farmers (particularly in Poland). It is believed that the increase in imports of Ukrainian grain crops undermines market stability and lowers prices. In total, Poland imported 2.5 million tonnes of Ukrainian grain in 2022 (while, according to preliminary estimates, the Polish grain harvest amounted to 26.6 million tonnes), meaning that supply increased by less than 10%.

Given russia's blockade of Black Sea ports, restrictions on land exports could prove costly for the Ukrainian economy in a state of war. On the other hand, the position of Ukraine's neighbours that have imposed an embargo is not unanimous.

For the import of certain agricultural products from Ukraine under the agreement with the EU, which will be in force from 6 June 2025 until the end of the year, temporary tariff quotas have been established, in particular for wheat, corn, poultry meat, and other goods. There is also a temporary suspension of import prices for fruit and vegetables.

During the war, the EU extended the trade liberalisation regime three times. Initially, it removed all duties and fees on Ukrainian products. Subsequently, the situation changed, and from 2024, tariff quotas were applied, which were corrective measures that directly affected Ukrainian-produced oats, eggs, sugar, and honey.

It is most likely that the EU's liberalisation measures for our food products will continue. At the same time, certain restrictions can be expected to be introduced.

The following main challenges in trade between Ukraine and the EU are highlighted:

War and high security measures. According to the World Bank, in 2022–2023, the damage to Ukraine's logistics infrastructure exceeded USD 40 billion, and the cost of cargo insurance increased 3–5 times. This significantly increases the cost of exports.

The problem of selective protectionism. In 2023, some EU countries (Poland, Hungary, Slovakia) imposed restrictions on imports of Ukrainian grain, affecting up to 20% of Ukrainian agricultural exports to the EU. This creates precedents for 'selective' protectionism.

Tariff and non-tariff restrictions. Despite the autonomous trade preferences, in 2023, more than 14% of Ukrainian exports faced technical barriers (certification, sanitary requirements).

Uncertainty about the future of autonomous trade preferences. EU preferences are valid until June 2025, but there are no guarantees that they will be automatically extended. This creates risks for exporters in the grain and metallurgy sectors, which account for over 40% of exports to the EU.

Logistical and administrative constraints. Due to the blockade of ports in 2022–2023, up to 65% of exports were redirected to land routes through Poland, Romania, and Slovakia. This led to infrastructure overload and a 30–50% increase in logistics costs.

Energy supply issues. In 2022–2023, attacks on energy infrastructure resulted in the loss of over 50% of generating capacity, limiting the operation of industrial enterprises and reducing export potential.

Labour shortage. According to IOM estimates, more than 5 million Ukrainians are abroad as refugees or temporarily displaced persons, creating a shortage of skilled labour in export-oriented sectors.

Structural constraints on the economy. Agricultural exports account for over 40% of trade with the EU, while high-value-added products account for less than 15%. This creates a risk of 'raw material dependency'.

Need for harmonisation of standards. According to the European Commission, about 25% of Ukrainian producers have not yet adapted their products to EU technical and sanitary requirements. This limits their access to the market even under the preferential regime.

Summarizing the challenges outlined above, it can be argued that trade between Ukraine and the EU is under significant pressure from both external factors (war, energy crisis, logistical barriers) and internal ones (structural imbalances, labor shortages). Taken together, these factors generate multi-dimensional risks that undermine the stability of export flows and complicate Ukraine's trajectory of institutional convergence with the European market.

The long-term sustainability of the EU's autonomous trade preferences remains uncertain, reflecting broader issues of institutional uncertainty and the political economy of integration. At the same time, Ukraine's persistent commodity dependence raises concerns regarding its ability to leverage comparative advantage beyond primary goods, thereby limiting prospects for deeper economic integration. Equally salient is the need to reconcile the trade-offs between EU member states' domestic market protection and the strategic imperative of supporting Ukrainian producers. Addressing these tensions requires innovative formats of dialogue, regulatory harmonization, and a rethinking of integration strategies within the framework of global trade governance.

Conclusions

The results of the modeling confirm the proposed hypothesis: in 2014–2024, Ukraine's trade with the EU underwent significant structural changes under the influence of global fluctuations. In particular, the COVID-19 pandemic led to a contraction of exports, the war and sanction regimes resulted in an asymmetric redistribution of trade flows, and logistical shocks caused a substantial increase in transportation costs. The application of the econometric model made it possible to quantitatively assess these factors, confirming their significant impact on the volumes of exports and imports.

An analysis of the dynamics of Ukraine's international trade with the European Union amid global fluctuations has revealed the multifaceted nature of its development. The research confirms that, despite numerous external challenges – from the COVID-19 pandemic to geopolitical shifts and full-scale invasion – there is a steady trend towards deeper integration of the Ukrainian economy into the EU market.

The main findings of the research indicate that the Association Agreement and DCFTA+ have been key instruments in stimulating export growth.

Ukrainian exports to the EU are concentrated in the agro-industrial sector, food products, and timber. Imports are mainly represented by machinery, equipment, transport vehicles, pharmaceuticals, and chemical products. This confirms the asymmetry of trade: Ukraine exports raw materials and semi-finished products while importing high-tech products.

The 2020 pandemic led to a drop in exports and a temporary decline in trade turnover. The start of full-scale war in 2022 prompted a rapid reorientation of exports towards the EU and a partial reduction in the balance of trade deficit. The period 2023–2024 is characterized by an increase in imports due to purchases of critically important goods, the restoration of logistics, and aid programs.

The analysis shows that Ukraine's trade with the EU remains stable but asymmetrical. Global shocks (COVID-19, war, restrictions) have radically affected the structure and volume of trade, highlighting the need to adapt the Ukrainian economy and strengthen integration into the European market. However, in the context of global turmoil, trade faces new challenges, including logistical obstacles, supply chain disruptions, and the need to reorient export flows. These factors require Ukraine to pursue further structural reforms, strengthening institutional capacity, developing transport infrastructure, and introducing innovative technologies. Future cooperation will require not only the removal of existing barriers, but also the formation of new partnership models that consider constantly changing global conditions.

A modified model has been developed and tested to assess and forecast trade flows. The relevance and convenience of this model lie in its ability to provide more accurate forecasts in conditions of high uncertainty. It allows for the rapid adaptation of parameters to analyze the impact of unpredictable events, such as pandemics or armed conflicts.

Currently, trade between the EU and Ukraine faces several challenges and threats:

- war and high security measures;
- the problem of separate protectionism;
- tariff and non-tariff restrictions on exports of Ukrainian goods;
- uncertainty about the future of autonomous trade preferences;
- logistical and administrative restrictions;
- energy supply problems;
- labour shortages;
- structural constraints on the economy;
- the need to harmonize standards.

Ukraine has chosen the path of European integration, which requires substantial work, changes, and transformations in many aspects of public life. The main challenges today are inadequate efficiency of the management system in Ukraine, certain complications directly in the EU, russia's war against our country, and the ongoing COVID-19 pandemic. At the same time, the EU's support is felt during this difficult time for Ukrainians, as confirmed by the start of the procedure for obtaining EU candidate status.

For successful cooperation with the EU, Ukraine's priority areas for change should be:

- updating the Agreement with a view to liberalizing mutual trade;
- changes in product certification in accordance with EU legislation;
- creation of a common aviation area;
- deepening cooperation in science and technology;
- cooperation in the field of health and pharmacy;
- increasing business collaboration and ensuring employment.

A promising direction for further research within this topic is the in-depth substantiation of mechanisms for developing international trade between Ukraine and the European Union. Particular attention should be paid to addressing the structural asymmetry in trade and logistics relations, which has been exacerbated by the full-scale war. An important task also lies in shaping the institutional and infrastructural foundations that will facilitate Ukraine's integration into the European economic area and contribute to the mutual prosperity of both parties.

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Conflict of interest. The author certifies that she doesn't have financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations, or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript. Given that the author is affiliated with the institution that publishes this journal, which may cause potential conflict or suspicion of bias, the final decision to publish this article (including the reviewers and editors) is made by the members of the Editorial Board who are not the employees of this institution.

The authors received no direct funding for this study.

Zubko, T. (2026). Ukraine–EU trade under global fluctuations. *Scientia fructuosa, 1*(165), 33–50. http://doi.org/10.31617/1.2026(165)03

Received by the editorial office 19.09.2025.
Accepted for printing 18.11.2025.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)04
UDC 336.741.242

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MONETARY DETERMINANTS OF BANKING STABILITY

Monetary policy is mainly considered as a separate type of financial policy aimed at ensuring the stability of the national currency, in particular based on achieving the target level of inflation. A separate branch in the hierarchy of central bank goals is defined as ensuring the stability of the country's banking system. Various departments of central banks, and sometimes even various bodies, in particular in the EU, are responsible for the operational implementation of these goals. Accordingly, the question arises regarding the coherence of monetary and macroprudential policies, thanks to which it is possible to achieve a synergy effect. However, this problem has not found an adequate solution either in the scientific or practical realm. The answers to the questions of whether monetary policy takes into account the aspect of financial and banking stability, and vice versa, whether it affects the landscape of the banking sector, remain unclear. The channels of such interactive connection have not been established and the nature of their functioning has not been determined. The authors hypothesize that there should be a rational link between monetary policy and the policy of ensuring financial and banking stability, and the use of monetary policy instruments should take into account the functioning cycle of the banking system. In addition, the impact

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МОНЕТАРНІ ДЕТЕРМІНАНТИ СТАБІЛЬНОСТІ БАНКІВСЬКОЇ СПРАВИ

Монетарну політику розглянуто переважно як окремий вид фінансової політики, спрямований на забезпечення стабільності національної грошової одиниці, зокрема на основі досягнення цільового рівня інфляції. Окремою гілкою в деревині цілей центральних банків визначено забезпечення стабільності банківської системи країни. За операційну реалізацію цих цілей відповідають різні підрозділи центральних банків, а інколи й різні органи, зокрема в ЄС. Відповідно постає питання щодо узгодженості монетарної та макропруденційної політик, завдяки чому можна досягти ефекту синергії. Натомість ця проблема не знайшла адекватного вирішення як в науковій, так і в практичній площині. Нечіткими залишаються відповіді на питання, чи враховує монетарна політика аспект фінансово-банківської стабільності, і чи впливає вона на ландшафт банківського сектору. Не встановлені канали такого інтерактивного зв'язку та не визначено характер їх функціонування. Автори висувають гіпотезу, що між монетарною політикою і політикою забезпечення фінансово-банківської стабільності повинен бути раціональний зв'язок, а застосування інструментів монетарної політики має враховувати цикл функціонування банківської системи. До того ж має бути

of monetary policy on the stability of the banking sector should be assessed. To test this hypothesis, the study examined the relationship between the NBU discount rate and the financial stress index; the impact of reserve norms on the business activity of banks in different countries, and the sensitivity of bank deposit rates to changes in the NBU discount rate. For this purpose, the methods of grouping, correlation, and graphical analysis were used. The results indicate the need for greater consideration of the financial stress index cycle when forming accounting policy, giving preference to reflationary and disinflationary monetary policies over expansionary and restrictive ones, as well as broader use of instruments such as reserve norms of funds attracted by banks. These results can be used when applying monetary policy instruments by central banks.

Keywords: monetary policy, discount rate, reserve requirements, financial stability, banking stability.

оцінений вплив монетарної політики на стабільність банківського сектору. Для перевірки цієї гіпотези ув досліджено взаємозв'язок між обліковою ставкою НБУ і індексом фінансового стресу; вплив норм резервування на ділову активність банків у різних країнах, чутливість ставок за депозитами банків до зміни облікової ставки НБУ. Для цього використані методи групування, кореляційного, графічного аналізу. Результати свідчать про необхідність більшого врахування циклу індексу фінансового стресу під час формування облікової політики, надання пріоритету рефляційній та дезінфляційній монетарним політикам порівняно з експансіоністською та рестрикційною, а також ширшого використання такого інструменту, як норми резервування залучених банками коштів. Зазначені результати можуть бути використані центральними банками при застосуванні інструментів монетарної політики.

Ключові слова: монетарна політика, облікова ставка, норми резервування, фінансова стабільність, банківська стабільність.

JEL Classification: G18, G21, G28.

Introduction

Article 6 of the Law of Ukraine "On the National Bank of Ukraine" (1999) defines the main functions of the NBU, which encompass three components: ensuring the stability of Ukraine's currency, which is the goal of monetary policy, promoting financial stability, in particular the stability of the banking system, and sustainable economic growth. These components are considered comprehensively in the NBU's monthly inflation reports, which underscores the relevance of the issue of their synergistic unity, particularly regarding the nature of the impact of monetary policy on banking stability. The combination of these goals in a single list of central bank tasks encourages researchers to analyse their synergistic relationship.

Agénor and Pereira da Silva (2012) argue, that monetary policy should respond to financial instability. The authors note that the traditional Taylor rule, which focuses solely on inflation and the GDP gap, is insufficient to prevent financial crises. They also put forward the concept of the "Virtuousness Paradox", which describes a situation where successful low and stable inflation policy can inadvertently lead to excessive optimism, increasing lending and asset prices, thereby creating financial vulnerability. Maddalonia and Peydró (2018) provide empirical evidence on how monetary and macroprudential policies interact and affect the stability of the banking system, and conclude that both types of policies influence banks' risk-taking.

For their part, Grubisic and Ivanovic (2012) analyse how different monetary policy regimes affect the financial stability of Southeast European

(SEE) countries. The authors argue that countries with "hard" regimes (Bosnia and Herzegovina) ensure high macroeconomic stability, very low inflation, and exchange rate stability. However, this makes the banking system more vulnerable to liquidity shocks. The inflation targeting regime (Serbia) gives the central bank more flexibility in managing liquidity and fulfilling its role as a lender of last resort, which promotes financial stability but creates a risk of exchange rate instability.

De Graeveet al. (2008) provide convincing quantitative evidence that monetary policy and financial stability are interconnected. Their integrated micro-macro model demonstrates that central bank decisions affect the stability of the banking system mainly through the overall economic consequences of those decisions. This was an important step in recognizing that central banks should take financial stability into account when conducting monetary policy. Rubio and Carrasco-Gallego (2014), based on a study of the synergy between monetary and macroprudential policies, conclude that these two types of policies are complementary but have different objectives, and their coordination allows for better results than using either of them alone. Ahumada and Fuentes (2004) emphasize that the banking system is not simply a "passive conduit" through which monetary impulses are transmitted. Its internal structure, level of competition, regulation, and financial stability independently and powerfully affect how central bank policy reaches the real sector. Therefore, the analysis of monetary policy would be incomplete without a thorough study of the banking industry.

Akinci et al. (2013), based on an analysis of the 2008–2009 crisis, examined the unconventional approach of the Central Bank of Turkey, which combined monetary and macroprudential tools and had significant and quite unique effects on the banking sector. Instead of putting pressure on profitability, it promoted its growth through higher interest margins, while simultaneously fulfilling its macroprudential role of slowing down the credit boom.

In their article, Nikhil and Deene (2023) emphasize an important trade-off faced by central banks in developing countries such as India. Aggressively combating inflation by raising interest rates may “clash” with the need for a stable and profitable banking system. This confirms the necessity of using macroprudential tools to protect the banking sector from the side effects of monetary policy.

Boyarchenko et al. (2022) believe that ignoring financial stability when formulating monetary policy can be risky. Interest rate policy is a powerful tool not only for combating inflation but also for reducing systemic financial risks. This issue is also in the focus of the European Central Bank (ECB, 2024). His main thesis is that monetary policy and financial stability are closely interconnected. Although the primary task of the ECB is to maintain price stability, it must systematically take into account the

consequences of its policies for financial stability, since financial crises pose a direct threat to the fulfilment of its main function. Therefore, this topic is relevant not only for Ukraine.

In the current conditions, the topic of the impact of monetary policy on the stability of the banking system is extremely relevant. When making decisions, central banks simultaneously face two challenges: on the one hand, it is important to achieve price stability, and on the other – to prevent financial shocks. A tight monetary policy restrains the inflation growth, but at the same time generates significant risks for the banking sector due to the decline in the market value of assets that banks accept as collateral when issuing loans; it leads to an increase in funding costs; exacerbates the problem of transforming short-term liabilities into long-term investments; and potentially leads to a deterioration in the quality of the loan portfolio. On the contrary, prolonged periods of overly accommodative monetary policy encourage excessive risk-taking, the accumulation of vulnerabilities, and increase the likelihood of future borrower defaults.

The main objective of the article is to study the relationship between monetary policy and the maintenance of financial and banking stability in the following areas: the discount rate and the financial stress index, the impact of reserve requirements on bank activity indicators in the credit and deposit markets, and the speed and closeness of banks' responses in household deposit rates to changes in the discount rate of the NBU.

The main hypothesis of the study is based on substantiating the close relationship between the use of monetary tools and indicators of the stability of the banking system. In the course of the study, mathematical and statistical methods, comparative analysis, and synthesis were used.

The main part of the article consists of three interconnected sections: the first one examines the relationship between the dynamics of the NBU discount rate and the financial stress index, the second section explores the impact of changes in reserve requirements on the volumes of banks' credit and deposit operations, and the third one examines changes in the discount rate on household deposit interest rates (UIRD).

1. Synergy of the discount rate and the financial stress index

Let us consider the relationship between the NBU's discount rate and such a key integrative financial stability indicator as the Financial Stress Index (FSI), and, in particular, with its important sub-index, the Banking Stress Index (BSI). Theoretically, monetary policy decisions, particularly regarding changes in the discount rate, should be correlated with changes in the FSI: in the case of its increase amid inflationary pressure, raising the key rate is appropriate, whereas a decrease in the FSI would justify lowering it. At the same time, the result of the central bank's corresponding measures should be a reduction in the level of financial stress. To test this hypothesis, a dataset from the NBU (n. d.) on the discount rate for the period from

2014 was used, from which 47 instances of rate changes – both increases and decreases – were selected. For each date of the interest rate change, the values of the FSI published by the NBU ("Financial Stress Index", 2025) were matched, in particular on the first day of the month of the discount rate change and on the first day of the previous month–to assess the impact of the FSI on the rate decision; and on the first day of the following month and the month after it–to analyse the impact of the discount rate change on the FSI dynamics. As a result, linear correlation coefficients were obtained (*Table 1*).

Table 1

Relationship between the FSI and the discount rate, correlation coefficient

Indicator	On the first day of the month, rate changes	For the month until the rate change	By the first day of next month	On the first day in a month
Impact of the FSI on the rate	0.589030474	0.530881854	–	–
Impact of the rate on the FSI	–	–	0.605845625	0.427334518

Source: compiled by the authors based on (National Bank discount rate, 2025; On the Financial Stress Index, 2025).

The closest response of the discount rate to changes in the FSI was observed one month before the month of its change, and, conversely, the highest correlation values between the FSI and the discount rate were recorded based on the data for the first day of the month following the rate change. However, in all cases, the relationship remained moderate (since the correlation values did not exceed 0.7).

Based on the obtained results, a graphical dependence of the reaction of the discount rate on the value of the FSI on the first day of the month preceding the month of its change was constructed. The polynomial function proved to be the most optimal, unlike the linear or logarithmic ones (*Figure 1*).

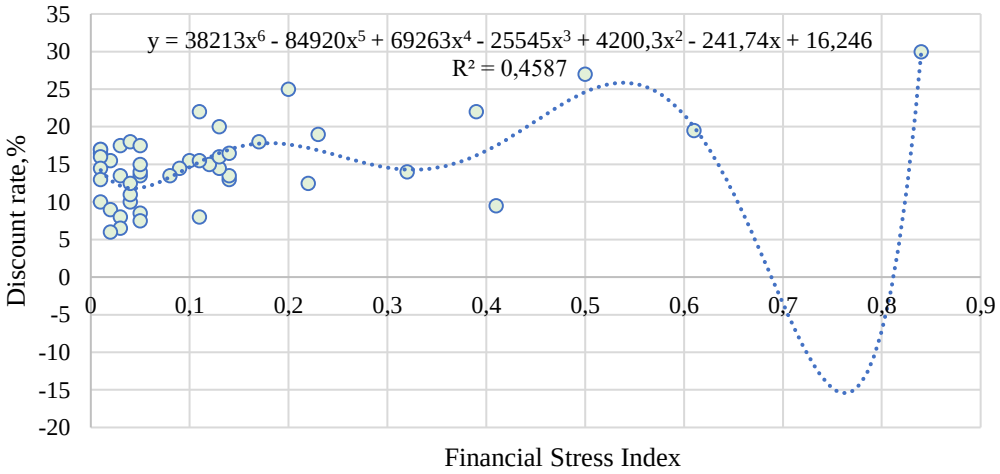

Figure 1. The impact function of the FSI on the decision to change the NBU discount rate

Source: compiled by the authors based on (National Bank discount rate, n.d.; NBU. On the Financial Stress Index, n. d.).

A coefficient of determination of 0.4587 is relatively small, which allows us to conclude that changes in FSI were not significantly taken into account when determining the size of the discount rate, nor was there a significant reverse effect of changes in the discount rate on the FSI.

To study the impact of the FSI on rate changes, the dates were selected when it changed most significantly, as well as the first date following a change in the discount rate. In total, 9 "extreme" values of the BSI were considered (*Table 2*).

Table 2

The relationship between the BSI and the NBU discount rate
for the period from 01.03.2014 to 29.08.2022

Date of BSI	BSI index, coeff.	Rate, %	Rate change date
01.03.2014	0.001	9.5	15.04.2014
18.07.2014	0.02	14	13.11.2014
09.04.2015	0.1	30	25.04.2015
27.07.2016	0.01	15.5	29.07.2017
22.12.2018	0.005	18	01.02.2019
01.04.2019	0.001	17.5	26.04.2019
01.03.2022	0.1	10	04.03.2022
01.08.2022	0.05	25	03.06.2022
29.08.2022	0.09	22	04.09.2022

Source: compiled according to (National Bank discount rate, n.d.; NBU. On the Financial Stress Index, n. d.).

Based on these data, the constructed correlation coefficient was 0.42825, which also indicates a minor influence of the BSI, as well as the FSI, on decision-making regarding the size of the NBU discount rate.

2. The impact of changes in reserve requirements on banks' business activity

A special instrument of monetary policy is the establishment of reserve requirements for banks' funds in the correspondent account at the central bank depending on the volume of clients' funds attracted. In the field of monetary policy, its effect is similar to changing the discount rate. Within the framework of a restrictive policy, increasing them, on the one hand, slows down lending, thereby restraining the growth of the money supply based on the increasing credit multiplier, but on the other hand, banks are not interested in resources with a high reserve requirement and set low deposit rates, thereby making clients more inclined to spend money rather than save, which can negatively affect inflation trends. However, these resources can be directed by the population and businesses into other areas, particularly the

foreign exchange market or – in the best case – the stock market. For banks, this means a compression of net interest income and a loss of profits, but maintaining a high level of liquidity.

The opposite situation occurs with an expansionary policy, when reserve requirements are lowered and banks are given the opportunity both to attract funds and to deploy them. Credit multiplication increases, the money turnover accelerates, which is beneficial for the economy but may also affect prices. At the same time, by expanding the scale of deposit and lending operations, banks' net interest income grows even if the margin level remains stable. Thus, this instrument has a dual nature: it simultaneously contributes to achieving monetary goals and strengthening the financial stability of banks through its impact on their liquidity and financial results (*Table 3*).

Table 3

The impact of reserve requirements
on monetary policy goals and banking stability

Indicator	Impact on monetary policy		Impact on banks
The equation of money circulation	Money supply x = Prices x Volume Velocity of production turnover		x
Increasing reserves	The money supply is stable, the velocity of circulation is decreasing	Prices and/or production are stabilizing	Lending volumes are not increasing, liquidity is rising, and incomes are decreasing
Reduction of reserves	The money supply and the velocity of circulation are increasing	Prices and/or production are increasing	The volumes of active operations (as well as credit risks) are increasing, profits are rising, and liquidity is decreasing

Source: compiled by the authors.

Historically, reserve requirements were not a tool of monetary policy but served as insurance reserves, acting as buffers in case of a liquidity crisis. This is exactly the function they performed in the United States after the creation of the Federal Reserve System in 1913 following the severe liquidity crisis of 1904. However, after the establishment of the Federal Deposit Insurance Corporation (FDIC) in 1933, this instrument ceased to be used both for ensuring banking stability and for monetary purposes, and today in the US, the reserve requirement is 0%. A similar situation exists in the European Union, where it is equal to 1% and practically unchanged, indicating its very limited use as a monetary policy tool.

However, developing countries use this tool more extensively, simultaneously addressing issues of both monetary policy and banking stability. An important feature of it is that it does not directly affect the cost of money, as the discount rate does, and has less psychological impact on businesses and society without losing its functional significance. Reserve requirements vary considerably depending on the country, and there is no

specific law or methodology for determining them, unlike the Taylor rule for determining the level of the key (discount) rate. Based on the data presented in *Table 4*, it is only possible to note a tendency for higher reserve requirements with a higher central bank key rate.

Table 4

Reserve requirements of banks in central banks of several countries (as a percentage of attracted deposits)

Country	Latest	Previous	Assessment date
Brazil	21	21	December 2022
China	11	11	January 2023
Czech Republic	2	2	November 2022
Hungary	5	5	December 2022
India	4.5	4.5	January 2023
Indonesia	9	7.5	September 2022
Malaysia	2	2	December 2022
Moldova	40	40	November 2022
Nigeria	32.5	32.5	January 2023
Poland	3.5	3.5	December 2022
Turkey	25	25	
USA	0	0	November 2022
European Union	1	2	

Source: (Trading Economics, 2023).

The study of the channels through which reserve requirements affect both the goals of monetary policy (in particular, the volume and structure of the money supply) and the ultimate goal-managing inflation – as well as indicators of banks' financial stability (liquidity level, profitability, volumes of asset-liability operations) is complicated by the lack of sufficient statistical data. Reserve requirements change infrequently, and statistics on changes in official reports are not accumulated. In addition, the statistical database of the international company SEIC regarding reserve requirements in different countries was used (SEIC data, 2025). The object selected includes several countries in Central Europe. In the first stage, countries where reserve requirements did not change in 2024 were studied, and how this affected indicators such as the dynamics of loans and deposits. These indicators largely characterize banking stability: if they increase, it can be assumed that stability is strengthening due to the growth in the scale and profitability of banks (*Table 5*).

Table 5

Dynamics of individual indicators of several Central European countries in 2024, %

Country	Reservation standards	Credit dynamics	Deposit dynamics
Czech Republic	2	–4.1	1.6
Poland	3.5	2.7	0
Bulgaria	10	10.5	0.5

Source: calculated based on (CEIC data, 2025).

The dynamics of loans and deposits in the countries considered in *Table 5* are diverse, and it is evident that a stable reserve requirement did not affect the dynamics of banks' asset-liability operations. To deepen the analysis, two countries were selected where reserve requirements were reduced, namely Croatia in the second half of 2022 and Moldova from May 2024 to January 2025. The results of the dynamics of reserve requirements, loans, and deposits of the banking systems of these countries are shown in *Figures 2* and *3*.

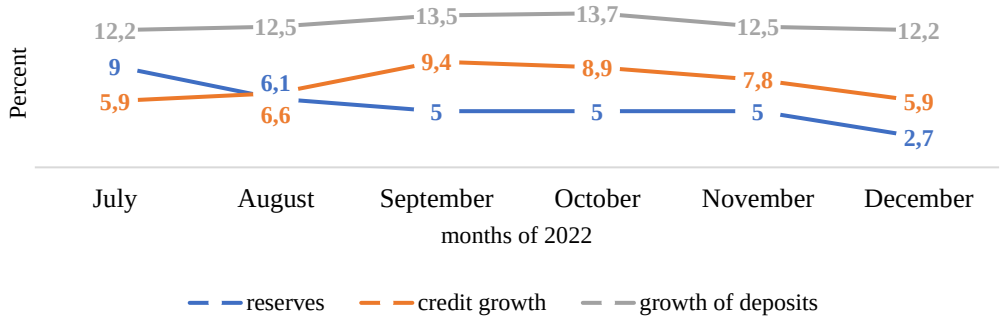

Figure 2. Reserve requirements, growth rate of loans and deposits compared to the previous year in the banking system of Croatia in 2022

Source: compiled according to (CEIC data, 2025).

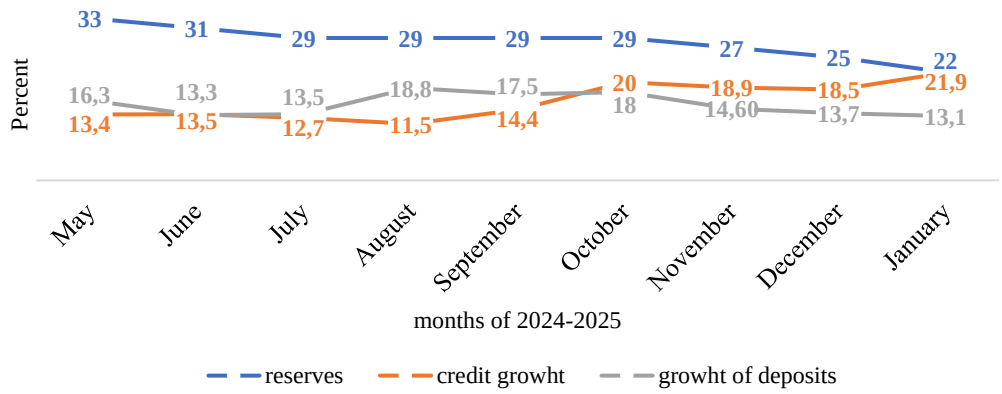

Figure 3. Reserve requirements, growth rate of loans and deposits compared to the previous year in the banking system of Moldova in 2024

Source: compiled according to (CEIC data, 2025).

As can be seen from *Figures 2* and *3*, especially at the first stage of the reduction in reserve requirements, there was a positive trend in loans and, to some extent, deposits. To test this hypothesis, a correlation analysis tool was used, which showed that the closest connection between the dynamics of loans and deposits in Croatia and reserve requirements was observed during the first three months, when the most intensive reduction of this indicator occurred. The correlation coefficient was -0.83224 for loans and

-0.84959 for deposits. In the banking system of Moldova, a close connection between the reduction of reserve requirements and loans was observed throughout the entire period: the correlation coefficient was -0.74265473. In contrast, no correlation was observed between deposit dynamics and changes in reserve requirements. This allows us to conclude – with some reservations due to the small set of statistical data – that banks' lending activity responds more strongly to significant changes in reserve requirements over a short period of time, particularly reductions, than to a slow change over time. As for deposit dynamics, it is not so closely related to changes in reserve requirements and also depends on changes in other factors, including the discount rate. Further research in this area requires the formation of a substantial statistical dataset and its purification from the influence of other factors, including changes in the discount rate.

The reserve requirement serves a similar stability function as contributions to the deposit guarantee fund, but it has three key advantages:

- it can be differentiated depending on the currency and terms of deposits, and possibly also on banks' business models;
- it can be adjusted quickly over time depending on monetary policy goals and challenges to the stability of the banking system;
- it can be linked to the quality of risk management; for example, banks with a higher share of non-performing loans (NPLs) may have increased reserve requirements as a liquidity buffer.

In the EU, the deposit insurance system has a commercial basis and is implemented, among others, by private companies. Moreover, the EU has a centralized bank resolution fund, the SRB (2025). Banks from 21 EU countries contributed about 1% of deposits to it, depending on the risk profile of their activities, and replenished it to the target level at the beginning of 2024. These contributions, along with the task of ensuring the stability of the banking system, also fulfilled an important monetary function – to some extent, they slowed the growth of lending volumes. All this indicates prospects for redesigning the deposit insurance system to solve monetary policy objectives and ensure banking stability with a single tool – reserve requirements combined with the creation of an insurance fund.

3. Analysis of the sensitivity of bank deposit rates to changes in the discount rate

The third element of the study was an analysis of the sensitivity of changes in rates on three-month household deposits in UIRD banks to changes in the NBU discount rate. The presence of such a dependence indicates not only the operation of the monetary policy deposit channel but also a transformation of the banking activity landscape. Banks attract more or fewer deposits, which accordingly change the volume and structure of the asset portfolio and financial results, and thus the capital and other indicators

that characterize the financial reliability of the banking system.

To conduct the study, statistical data were selected on: 47 cases of changes in the discount rate since 2014 and changes in the UIRD rate for each day during the 10 days following each discount rate change (including the day of the rate change). A correlation analysis was then conducted, according to the results of which the linear correlation coefficient between these rates was slightly above 0.5. If one rate change date is excluded, namely June 3, 2022, when it was raised immediately from 10% to 25%, the correlation coefficient (C cor.) increased to over 0.7 (*Table 6*).

Table 6

Correlation coefficient between the change in the NBU and UIRD discount rate for the period 2014–2025

Indicators/ days	Days									
	0	1	2	3	4	5	6	7	8	9
C correl.	0.558	0.565	0.567	0.561	0.555	0.569	0.563	0.568	0.561	0.563
C correl. without 03.06.22	0.708	0.713	0.718	0.712	0.705	0.712	0.706	0.711	0.706	0.705

Source: compiled by the authors based on (NBU, 2025; National Bank discount rate, n. d.).

The correlation coefficient remains stable throughout the entire 10-day period following the rate change (correlation may increase over a longer horizon). This indicates that banks were not in a hurry to adjust their deposit rates for the public after the change in the discount rate. However, the correlation coefficient increases significantly if the date of the significant rate increase from 10 to 25% on 03.06.2022 is excluded. Thus, bank deposit rates are more sensitive to slow changes in the discount rate than to its sharp fluctuations.

In order to determine when bank deposit rates responded more closely to a decrease or an increase in the discount rate, the entire period from 2014 to 2025 was divided into corresponding zones, and correlation coefficients were constructed for each of them (*Table 7*).

Table 7

Correlation coefficients for the period of increase and decrease of the NBU discount rate (2014–2025)

Period	C cor.
rate increase	
2014–2015	0.925
2017–2018	0.278
2021–2022	0.006
2025	–0.508
rate decrease	
2016–2017	0.881
2019–2020	0.868
2023–2024	0.438

Source: compiled by the authors based on (NBU, 2025; National Bank discount rate, n. d.).

Analysis of the data in *Table 7* shows that deposit rates responded more closely to a decrease in the discount rate (except in 2023–2024), whereas their reaction was weak during rate increase (except in 2014–2015). This indicates a multifactorial impact on banks when making decisions about changing deposit rates, which, in turn, reduces the effectiveness of the monetary policy deposit channel. A key factor among these is the level of banks' liquidity. During periods of excess liquidity, such as during the pandemic and martial law, banks were not in a hurry to raise their rates following the trajectory of the NBU rate.

The analysis of the UIRD rate dependency configuration on the second day after the key rate change identified the logarithmic function as the most adequate, with a coefficient of determination of 0.55, that is, a probability of 55% (*Figure 4*).

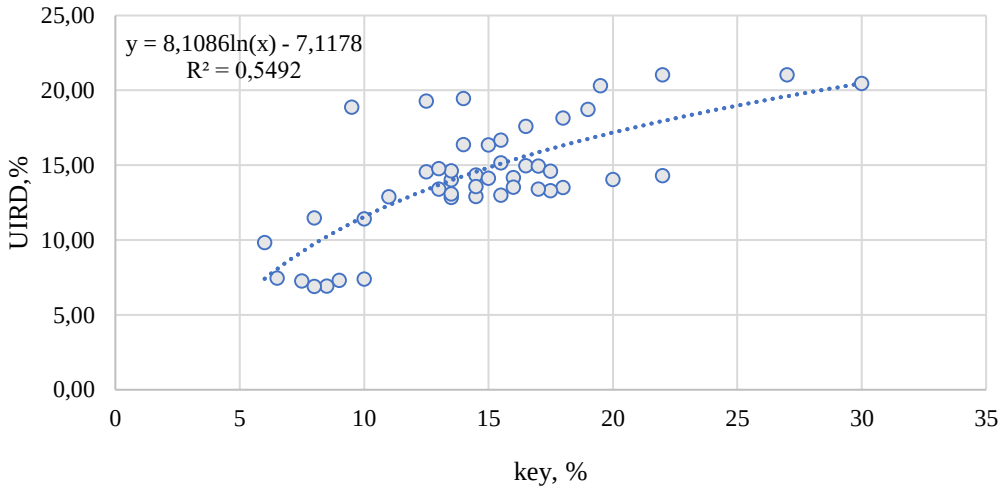

Figure 4. Dependence of the UIRD rate level on the second day after the change in the key rate (excluding the change on 03.06.2022)

Source: compiled by the authors.

These calculations can be used to study and predict the degree and timing of the impact of changes in the central bank's discount rate on the deposit rates of bank clients within the interest rate channel of monetary policy.

Conclusions

The research hypothesis regarding the close relationship between the use of monetary tools and indicators of the stability of the banking system, which should exist de jure, is not fully confirmed de facto based on statistical analysis.

The financial stress index and its sub-index of banking stress are important complex indicators of the stability of the financial and banking system, so they should be taken into account when choosing a monetary

policy regime, in particular, changing the discount rate. In addition, it is important to take into account the trajectory of their movement, and not just a static value, which will make it possible to more effectively influence economic processes with monetary policy instruments.

Reserve requirements as a monetary policy tool, which simultaneously performs the functions of regulating money circulation and ensuring banking stability, remain underestimated not only in Ukraine but also in other countries. At the same time, the NBU uses it more flexibly even than the central banks of developed countries. Its effectiveness is not inferior to the tool of changing the discount rate, and unlike the latter, it has a smaller psychological impact on businesses and society.

It is advisable to consider the possibility of using reserve requirements as an alternative, for example, to increasing the amount of contributions to the Deposit Guarantee Fund, which could focus more on problem banks.

It is important to enhance the effectiveness of the influence of the interest rate channel of monetary policy on banks' deposit and lending policies, in particular by taking into account the factor of their excess liquidity, including through the use of reserve requirements and the possibilities of placing it in certain liquid assets.

Monetary policy and the NBU's role in ensuring financial and banking stability have significant synergy. Without a stable system, it is impossible to effectively implement monetary policy, and conversely, monetary measures significantly affect the reliability of the banking system. Therefore, this issue requires further research.

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Conflict of interest. The authors certify that they have no financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript. Given that one of the authors are affiliated with the institution that publishes this journal, which may cause potential conflict or suspicion of bias and therefore the final decision to publish this article (including the reviewers and editors) is made by the members of the Editorial Board who are not the employees of this institution.

The authors received no direct funding for this study.

Savluk, S., & Drozdov, Ye. (2026). Monetary determinants of banking stability. *Scientia fructuosa, 1*(165), 51–64. http://doi.org/10.31617/1.2026(165)04

Received by the editorial office 03.12.2025.
Accepted for printing 14.01.2026.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)05
UDC 504:338.45}:620.92=111

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GREEN INDUSTRIAL POLICY: A CRITICAL EVALUATION OF STATE AID FOR RENEWABLES

Evaluating State aid measures is not only good practice contributing to the closed policy cycle, but it has also become a mandatory exercise for large aid schemes following the State Aid Modernisation initiative. Evaluations support some of the key State aid principles: i) verify incentive effect or to what extent the measure realises projects that would not materialise in the absence of the aid, ii) map proportionality or the minimum public funding needed to leverage the level of required private resources, and iii) analyse the appropriateness of the

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ЗЕЛЕНА ПРОМИСЛОВА ПОЛІТИКА: КРИТИЧНА ОЦІНКА ДЕРЖАВНОЇ ДОПОМОГИ ДЛЯ ВДЕ

Оцінка заходів Державної допомоги є не лише гарною практикою, що сприяє замкненому циклу політики, але також стала обов'язковою процедурою для великих схем допомоги в рамках ініціативи Модернізації Державної Допомоги. Оцінки підтримують деякі ключові принципи Державної допомоги: і) перевіряти ефект стимулювання або в якій мірі захід реалізує проєкти, які не відбулися б за відсутності допомоги; іі) оцінювати пропорційність або мінімальний обсяг державного фінансування, необхідного для залучення потрібного рівня

measure to achieve the policy objectives in the least distortive way. This Article reviews the ex-post evaluations of large schemes for renewables that have been carried out and are kept in the systematic catalogue of the Commission's Competence Centre on Microeconomic Evaluation. After detailing the case selection process, a descriptive analysis outlines the renewables aid schemes that have been evaluated per energy type, duration and evaluation methods. In addition, we present a timeline with the diverse evaluation steps and point to common pitfalls. Finally, we review the results of the evaluations and present the main takeaways and challenges for aid schemes supporting the transition to renewable energy. By systematically reviewing these ex-post evaluations, we aspire to present a comprehensive list of good practices as well as actions to avoid and as such to contribute to more efficient 'clean' policies in support of the energy transition.

Keywords: Renewable energy, State aid, Green transition, Industrial policy.

приватних ресурсів, та iii) аналізувати доцільність заходу для досягнення політичних цілей найменш спотворюючим способом. У цій статті розглядаються фактичні оцінки великих схем підтримки відновлюваних джерел енергії, які були проведені та зберігаються у систематичному каталозі Центру Компетенцій Комісії з Мікроекономічної Оцінки. Після детального опису процесу відбору випадків проводиться описовий аналіз схем допомоги відновлюваним джерелам енергії (ВДЕ), які були оцінені за типом енергії, тривалістю та методами оцінки. Крім того, ми надаємо хронологію різних етапів оцінювання та вказуємо на типові помилки. Нарешті, ми розглядаємо результати оцінок та представляємо основні висновки та виклики для схем допомоги, що підтримують перехід до відновлюваної енергетики. Систематично переглядаючи ці фактичні оцінки, ми прагнемо представити комплексний перелік кращих практик, а також дій, яких слід уникати, і таким чином сприяти більш ефективним "чистим" політикам на підтримку енергетичного переходу.

Ключові слова: відновлювана енергія, державна допомога, зелена перехід, промислова політика

JEL Classification: D62, H54, L90, O14.

Introduction

The resurgence of industrial policy within the EU reflects a shift in policy thinking following geopolitical realignments. The EU's industrial strategy focuses on a transition to a green, digital and resilient economy. Central to the EU's evolving green industrial strategy is the acceleration of the energy transition, underpinned by the large-scale deployment of renewable energy sources. This shift is intended not only to meet climate neutrality targets but also to strengthen the EU's energy sovereignty and economic resilience in the face of increasing external dependencies.

To support this transformation, State aid has been used extensively to stimulate investment in renewable technologies such as solar, wind, and energy storage. While Member States had different types of aid schemes, practically all EU countries have aid schemes in place to support investment in renewables. However, as the scale and complexity of support mechanisms grow, so too does the importance of systematic evaluation. In this context, ex-post evaluation, the assessment of a policy after its implementation, is an essential component of a closed policy cycle. It enables policymakers to determine whether aid measures have achieved their intended objectives, assess their efficiency, and identify potential distortions to competition or unintended side effects.

Ex-post evaluations of State aid in the energy sector are particularly relevant, given the need to balance public support with internal market rules under Articles 107 and 108 TFEU (Article 107 TFEU, 1957; Article 108

TFEU, 1957). Evaluations typically examine multiple dimensions, including the incentive effect, whether the aid changed the behaviour of the recipient. Could the aid help realise projects that would not have been possible without the aid, or has the aid increased the scale or scope of a project. It is important that the aid triggers as much as possible additional projects, rather than crowding out private investment. Next to the incentive effect, an evaluation will also check the proportionality and appropriateness of an aid scheme. An encompassing evaluation entails an analysis of direct and indirect effects regarding the objectives of the aid, the affected markets and society. While such evaluations are only obligatory for selected large-scale aid schemes under the Commission's State Aid Modernisation initiative, and published via the EVALSA database, they represent a broader good practice in evidence-based policymaking (European Commission, 2014a; 2025a; 2026).

Extant literature on EU green industrial policy and energy State aid has examined, first, how the Commission's evolving guidelines recalibrated compatibility assessment toward market integration, competitive allocation, and stricter scrutiny of the incentive effect (Musardo, 2021; Nicolaides & Kleis, 2014). A closely related strand evaluates the legal status and steering function of soft-law instruments, such as guidelines and frameworks, in shaping Member States' scheme design, including the balance between environmental ambition and competition safeguards (Ezcurra, 2014; Banet, 2020). More recent contributions emphasise that "additionality" and the construction of a credible counterfactual are pivotal but operationally difficult in practice, particularly where firms may adapt project timing or structure to meet eligibility thresholds (Nicolaides, 2023a). Parallel work in energy and policy evaluation points to the importance of complementing scheme-level impact estimation with institutional and implementation analysis which covers administrative constraints, stakeholder incentives, and information asymmetries, when assessing effectiveness and proportionality (Haak & Brüggemann, 2016; Parcu et al., 2020). Finally, the literature increasingly situates renewable support within a broader governance environment, arguing that infrastructure bottlenecks, regulatory instability, and market volatility can dominate outcomes even where aid is well-targeted and formally compliant (Verschuur & Sbrolli, 2020).

In line with the rapidly expanding scholarship on EU green industrial policy and energy State aid, this Article situates itself within recent research that assesses how renewable support schemes perform against core compatibility benchmarks (most notably the incentive effect, proportionality, and appropriateness) while also examining wider market and system constraints (e.g. grid access, regulatory stability, and price volatility) that hinder policy effectiveness. The purpose of the article is to provide a structured, comparative synthesis of the most recent ex-post evaluations of large renewable energy aid schemes (solar, wind, and storage) published in the Commission's evaluation ecosystem (European Commission, 2026). We aim to distil lessons for future scheme design and, correspondingly, draw conclusions on good practices and recurrent pitfalls for more efficient "clean

energy" policies. Building on this purpose, the Article advances the following hypothesis: ex-post evaluations of renewable energy State aid systematically reveal (i) heterogeneous incentive effects across technologies and project characteristics (tending to be stronger for wind and storage than for stand-alone solar) and (ii) a predictable relationship between proportionality and project attributes (notably a negative relationship between aid intensity and project size).

This implies that proportionality safeguards are more effectively operationalised when aid design incorporates competition-enhancing mechanisms, such as variable aid intensities. Methodologically, we apply a structured qualitative review protocol to the available evaluation plans, interim reports and final reports. Against this backdrop, the present article contributes by systematically synthesising the Commission-linked ex post evaluation corpus for large renewables schemes, allowing cross-scheme comparison of incentive effects, proportionality patterns, and recurrent design pitfalls.

The remainder of this Article is structured as follows: Section 1 reviews the relevant literature and conceptual underpinnings. Section 2 outlines the methodology and data used. Section 3 presents the empirical findings regarding direct and indirect effects of aid for solar, wind and storage capacity. Section 4 offers policy conclusions and recommendations.

1. Fuelling the future: the evolving framework for energy State Aid

Notwithstanding the in principle prohibition under Article 107(1) TFEU, EU Member States have granted an enormous amount of aid in the energy sector over the past decades. The General Block Exemption Regulation (GBER) is one of the more general frameworks enabling Member States to develop aid measures where the benefits clearly outweigh potential distortions to competition (Commission Regulation (EU) No 651/2014, 2023). The GBER allows for example that aid for renewable energy production, energy efficiency, energy storage, charging infrastructure, and clean mobility is granted without ex-ante notifying the European Commission if it fulfils the conditions set out by the Regulation. Over time, the scope of the GBER has expanded to reflect evolving EU policy priorities, particularly the green and digital transitions. Recent amendments have further aligned its provisions with the European Green Deal and Fit for 55 objectives, facilitating swift and consistent rollout of energy aid across the Union (Council of the EU and the European Council, 2024; European Parliament, 2025).

Next to the GBER, energy specific rules were also developed in the early nineties and have been evolving since. In the energy sector, the evolution of EU State Aid guidelines also reflects the growing ambition of EU climate and energy policies, from early environmental protection goals to the current push for climate neutrality under the European Green Deal (Council of the EU and the European Council, 2024). The European Commission’s guidelines provide an operational framework for support to renewable energy, energy efficiency, and related infrastructure without

violating competition rules under Articles 107 and 108 TFEU. This section provides an overview of the policy context guiding State Aid to energy, starting with the sector specific guidelines, then going into other relevant developments of the State aid rules *(Figure 1).*

Figure 1. Energy sector specific State aid guidelines

Source: Constructed by the author based on the evolution of the guidelines.

The first relevant State aid guidelines on environment and energy can be traced back to 1994 (Community Guidelines on State Aid for Environmental Protection, 1994). These guidelines can be seen in the light of increasing environmental awareness and laid the foundation for later developments, introducing core principles such as necessity, proportionality, and the polluter-pays principle. While their scope was relatively limited compared to subsequent editions, they permitted aid for activities such as pollution abatement, the early adoption of environmental standards, and to a limited extent, the promotion of renewable energy and energy-saving technologies. At the time, support for renewables was considered primarily within the environmental context, rather than as part of a broader energy or industrial strategy. These guidelines remained in force until the adoption of the more expansive 2001 guidelines, which introduced clearer and more comprehensive provisions for aid to renewable energy and co-generation, responding to growing international climate commitments and the rising importance of sustainable energy policy in the EU (Community Guidelines on State Aid for Environmental Protection, 2008a).

The 2001 Guidelines on State Aid for Environmental Protection marked a significant expansion and clarification of the EU's framework, responding to increasing EU-level environmental ambitions in light of the Kyoto Protocol (Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1997) and the growing interest in supporting renewable energy, energy efficiency, and combined heat and power. While still grounded in the principles of necessity, proportionality, and avoiding undue distortions, the 2001 guidelines provided more detailed rules on investment and operating aid for environmentally beneficial projects. Notably, they allowed for aid to promote renewable energy generation, recognising environmental externalities (Community Guidelines on State Aid for Environmental Protection, 2001). In a way, they set the stage for the more transformative 2008 and 2014 guidelines, by introducing clearer eligibility criteria and acknowledging the role of public support in scaling up

clean technologies across Member States (Community Guidelines on State Aid for Environmental Protection, 2008a; Guidelines on State Aid for Environmental Protection and Energy 2014–2020, 2014a). At this early stage, support mechanisms such as feed-in tariffs (FiTs) were widely used, justified by the market failures associated with externalities from fossil fuel consumption. However, aid levels were capped, and the guidelines remained cautious in tone, particularly given the absence of binding EU-wide targets for renewable energy deployment.

The 2008 Guidelines updated the 2001 framework in light of the EU's growing climate commitments, particularly the adoption of the Climate and Energy Package targeting a 20% reduction in greenhouse gas emissions, 20% share of renewables, and 20% improvement in energy efficiency by 2020 (Community Guidelines on State Aid for Environmental Protection, 2008a). They permitted both investment and operating aid, including for biofuels, combined heat and power (CHP), and early adoption of higher environmental standards. The 2008 guidelines gave greater recognition to the role of public support in promoting market entry, acknowledging the continued cost gap between conventional and renewable energy. Overall, the 2008 guidelines represented an incremental but important evolution, offering Member States more flexibility while maintaining safeguards against overcompensation and undue distortion (Community Guidelines on State Aid for Environmental Protection, 2008). They served as a transition point between the environmental focus of earlier frameworks and the market-oriented approach that would define the 2014 guidelines.

The 2014 Guidelines on State Aid for Environmental Protection and Energy 2014–2020 (EEAG) marked a decisive shift, aligning it more closely with the goals of market integration, cost efficiency, and the maturing of renewable energy technologies (Guidelines on State Aid for Environmental Protection and Energy 2014–2020, 2014). Important to note is that they mention 'energy' explicitly for the first time in the title and introduced far-reaching reforms aimed at making support schemes more competitive, transparent, and harmonised. No consensus was reached in extant literature on the success of avoiding potential distortion on the market, as is for example in detail explained by Nicolaides and Kleis (2014), who called for, amongst others, a more robust application of the assessment of an incentive effect. Musardo (2021) also argues in favour of this concept, and notes that the EEAG had to adopt a more rigorous interpretation of the incentive effect, ensuring aid measures deliver additional environmental benefits beyond normal practice and align with Green Deal objectives. Only measures that achieve the intended outcome with minimal environmental harm would then be deemed compatible (Musardo, 2021). A key innovation of the EEAG was the general requirement for aid to renewable energy to be granted through competitive bidding processes (e.g. auctions), replacing administratively set

feed-in tariffs with market-based premiums.[1] Technology-neutral allocation became the default, with exceptions for emerging technologies or small-scale projects. The EEAG also introduced rules on support for energy infrastructure, capacity mechanisms, and exemptions for energy-intensive industries exposed to international competition. These changes reflected the increasing maturity and cost-competitiveness of wind and solar technologies. It laid the groundwork for an even more comprehensive CEEAG adopted in 2022.

The most recent and ambitious update came with the 2022 Guidelines on State Aid for Climate, Environmental Protection and Energy (CEEAG), which entered into force on 27 January 2022 (Guidelines on State Aid for Climate, Environmental Protection and Energy, 2022). The CEEAG can be seen within the context of the EU's heightened climate ambitions under the European Green Deal, the Fit for 55 Package, and the goal of climate neutrality by 2050. The guidelines expand the scope of eligible aid to include not only traditional areas such as renewables and energy efficiency but also to areas such as renewable hydrogen, energy storage, carbon capture and storage, and clean mobility. Competitive bidding remains the preferred mechanism for allocating aid, but exemptions are maintained for innovative or small-scale projects. The CEEAG reflects a broader shift in the Commission's thinking, viewing State aid not just as a correction for market failure but also as a strategic tool to support the EU's industrial and geopolitical goals, particularly in critical sectors relevant to energy security.

Alongside the formal guidelines on climate and energy, it is worth mentioning two sets of other important State aid rules related energy, i.e. Important Projects of Common European Interest (IPCEI) and the Temporary Crisis and Transition Framework (TCTF) (Criteria for the Analysis of the Compatibility with the Internal Market of State Aid to Promote the Execution of Important Projects of Common European Interest, 2021; Amendment to the Temporary Crisis and Transition Framework for State Aid Measures to Support the Economy Following the Aggression against Ukraine by Russia, 2023).

IPCEIs allow Member States to provide State Aid for cross-border projects that are strategically important for the EU and address clear market failures. Reinforced under the 2022 CEEAG, IPCEIs are particularly relevant for clean technologies such as hydrogen, batteries, and industrial decarbonisation. Projects must involve cooperation across countries, generate positive spillovers, and support key EU objectives like the Green Deal and strategic autonomy. By enabling large-scale, riskier investments that may not materialise otherwise, IPCEIs complement traditional aid instruments and play a growing role in Europe's green industrial policy.

The Commission has adopted several crisis frameworks in the past two decades, of which the one regarding the war with Ukraine is probably most relevant for energy. The TCTF directly targeted the energy crisis and

[1] Fixed tariffs provide a guaranteed price for renewable electricity, thus shielding producers from market fluctuations. This offers investment certainty, but the risk of overcompensation is larger. In contrast, market-based premiums supplement the market price.

expanded support for among others clean tech investments but also towards companies that are energy intense or are trading heavily with Ukraine. These temporary tools underscore the Commission's responsiveness to crisis contexts, also in the field of energy (Amendment to the Temporary Crisis and Transition Framework for State Aid Measures to Support the Economy Following the Aggression against Ukraine by russia, 2023).

Finally, the Commission has published guiding templates for aid under the Recovery and resilience facility, where also a lot of attention is being dedicated to energy measures, such as under the Power Up, Renovate, Refuel and Recharge initiatives.[2]

Over the past two decades, the EU's State aid guidelines for energy clearly have evolved to a comprehensive policy framework supporting the green transition and strategic autonomy. The move from fixed tariffs and administrative schemes to competitive, market-based instruments reflects both the maturity of renewable technologies and the EU's ambition to align industrial, environmental, and energy goals. As the green transition accelerates, the role of State aid will remain central to achieving climate neutrality while preserving fair competition within the internal market.

Following the positive policy context towards aid for renewable energy, Member States have been very active when it comes to designing aid schemes. The 2024 State Aid Scoreboard identifies environmental protection and energy savings as the main objective of State aid measures across Member States, surpassing other, more traditional goals, such as regional development and R&D&I. This trend continues to strengthen, with a 20% increase in related expenditure in 2023 compared to 2022. These measures now represent 30% of total State Aid expenditure in the EU (European Commission, 2025). Consequently, a strand of literature has developed on the evaluation of such support and has attracted increasing academic attention in recent years, especially as governments scale up investment in the green transition (Ezcurra, 2014; Haak & Brüggemann, 2016; Milne, 2017; Banet, 2020; Musardo, 2021). The literature spans economics, energy policy, and legal studies, and addresses both ex-ante and ex-post evaluations of aid schemes.

Many evaluations aim to assess the effectiveness of aid schemes in terms of increased renewable energy capacity, investment leverage, or cost reductions. These works often use econometric models focused on the counterfactual, or what would have happened in the absence of aid. While the literature on the evaluation of renewable energy support is clearly expanding, it is still rather fragmented across jurisdictions and specific aid schemes. Often, data limitations hamper rigorous evaluation and comparability of results across studies. More encompassing views are needed to soundly advise future aid schemes, integrating the results of several studies and combining best practices. In addition, the time for focusing support only to the push of renewables seems to have passed, and broader policy perspectives including regulatory change and attention for infrastructure bottlenecks are needed.

[2] State Aid templates regarding RRF can be retrieved at the website of the European Commission (2023).

2. Research questions and common methodologies

2.1. Research objectives, research scope and research questions

To contribute to a more evidence-based approach to green industrial policy, this Article undertakes a comparative review of multiple ex-post evaluations of State Aid schemes targeting solar, wind, and storage capacity. These technologies are not only central to the EU's climate and energy goals, but also increasingly interlinked within the broader energy system. By examining a diverse set of evaluations, the analysis aims to identify cross-cutting lessons, differences in design and effectiveness, and emerging trends in how aid influences investment behaviour and market outcomes. Such a review offers valuable insights into the incentive effect, proportionality and appropriateness of support measures. In doing so, it contributes to institutional learning, supports the refinement of future aid design, and provides input into the continuous development of EU State aid control. The findings also speak to the growing need for coherence and strategic alignment in how State Aid is used to support the green transition while ensuring efficient use of public resources and preserving competition in the internal market.

The literature review revealed a substantial interest to study aid for the green transition, including detailed evaluations of aid that aims to boost renewable energy. Projects. From a State aid policy perspective, the State Aid Modernisation (SAM) package, launched in 2012, has developed obligations for the ex-post evaluation of specific State aid schemes (EU State Aid Modernisation (SAM), 2012). The Member State that developed the scheme has to deliver evaluation reports to the Commission and is guided through the process by means of feedback on the proposed methods, analyses and draft reports. The purpose is to ensure that lessons learnt are taken forward into future policy cycles. These evaluation plans and (interim) report are published on the EVALSA website (European Commission, 2026). Filtering on the criterion "energy", leads to 44 cases where an evaluation has been carried out or is ongoing.[3]

Table 1

EVALSA energy evaluations per country

Country	Energy evaluations	Country	Energy evaluations
Austria	1	Poland	5
Belgium	1	Portugal	2
Czech Republic	1	Romania	2
France	2	Spain	3
Germany	14	Sweden	4
Ireland	1	Slovakia	1
Italy	4	UK	1
Netherlands	2	Total	44

Source: own composition based on EVALSA (European Commission, 2026).

[3] Latest search carried out on 19. April 2025.

Not all evaluations have been completed. We work with the available information in the evaluation plans, interim as well as final reports and other information that is available. The aid schemes under evaluation cover a broad range of aid instruments and supported technologies. The instruments entail diverse tax incentives as well as direct grants and loans. The supported technologies do not only cover solar, wind and storage capacity, but also include, among others, biofuels, capacity mechanisms, decarbonisation initiatives, emission trading systems and R&D&I. As many evaluations deal with aid instruments targeted at multiple objectives or technologies, we focus only on the findings that relate to the scope of this article, being solar, wind and storage and hence single out these sections of the available documents.

We provide an overview of most common research questions in these evaluations. Those are also the questions that will be answered in Section 4 Results. Most studies entail evaluation questions that are descriptive as well as analytical. They entail direct impacts of the aid, as well as indirect effects of the aid, and proportionality and appropriateness. Regarding the direct impact of an aid scheme, we focus on the following questions in line with the primary objective of the support mechanism:

- RQ1: Have the aid schemes increased investment in renewable energy projects, in terms of solar, wind and storage capacity?
- Regarding the indirect impact and other aspects of the aid schemes, we investigate both market effects and characteristics of the measure. We include the following questions:
- RQ2: Was the aid proportionate and appropriate? Where the former asks whether the aid is kept to the minimum necessary to reach its objectives, the latter wonders whether other policy measures would have been able to reach the same objectives in a less distortive way?

RQ3: Did the aid schemes and supported projects have an impact on the electricity market (such as energy prices, and energy mix)?

2.2. Common ex-post evaluation methodologies for aid to renewable energy

Ex-post evaluations of aid for renewable energy and storage projects cover a diverse range of methodologies, typically entailing quantitative, qualitative or mixed-method approaches.

Ex-post evaluations of State aid for renewable energy most frequently rely on quantitative methods to assess the causal impact of support schemes on measurable outcomes such as investment levels, installed capacity, cost efficiency, and emissions reduction. Among the most widely used approaches are counterfactual analyses, which estimate what would have happened in the absence of aid. Techniques that are commonly used include difference-in-differences (DiD) models that compare treated and untreated

groups over time, by means of matching techniques that pair beneficiaries to non-aided, comparable entities based on observable characteristics.[4] Regression-based models are also common, allowing for multivariate analysis of the relationship between aid and project-level or firm-level outcomes while controlling for confounding variables such as energy prices, policy stability, or firm size.

Complementing these quantitative approaches are a range of qualitative methods, which are essential for understanding how aid schemes are implemented and perceived, study their incentive effect, and for assessing dimensions that are harder to quantify. Semi-structured interviews with aid recipients, non-successful applicants, non-applicants, policymakers, regulators, and stakeholders (such as grid operators or financial institutions) provide valuable insights into how aid influences investment decisions, how eligibility criteria are interpreted, and whether aid is seen as proportionate and appropriate. Also focus groups or stakeholder workshops can deliver added value when group discussion dynamics can further finetune the insights, validate findings, gather feedback, and explore forward-looking policy options. Case studies allow for in-depth analysis of specific schemes, technologies, or regional contexts, revealing factors that may affect the effectiveness of the aid. Document analysis can be required to study how schemes were designed and whether they were implemented as planned.

Given the complexity of renewable energy markets and the multifaceted aspects of several State aid schemes, some evaluations adopt a mixed-methods approach. This integration of quantitative and qualitative methods allows for a more comprehensive understanding of policy outcomes and implementation processes. Quantitative techniques provide the empirical backbone for assessing effectiveness and efficiency, while qualitative insights help interpret the findings, validate assumptions, and uncover mechanisms that are not easily observable in the data. For example, a quantitative analysis may reveal that aid recipients increased their investment compared to a control group, while interviews explain that this response was due not only to financial support but can also highlight issues of regulatory uncertainty and grid access. By triangulating findings from multiple sources and methods, mixed-method evaluations offer a richer, more robust evidence base for improving aid design, reducing distortive effects, and aligning support measures with the evolving goals of EU energy and climate policy. Consequently, mixed-method evaluation is recommended.

[4] Matching techniques include, among others, propensity score matching, covariate matching, and synthetic control methods in cases of limited data. Propensity score matching constructs comparable groups of aid beneficiaries and non-beneficiaries with similar estimated probabilities of receiving the treatment. Covariate matching involves forming groups based on similarity in observed characteristics. The synthetic control method creates a counterfactual by combining untreated units into a weighted composite that closely replicates the treated unit's pre-treatment characteristics.

2.2.1. Results

This section discusses the results in three parts. We first discuss the main findings of the ex-post evaluations regarding effectiveness or incentive effect, i.e. did the aid trigger additional investment or realised projects that would not have been carried out in the absence of the aid. Next, we look into the question regarding proportionality of the aid and appropriateness. Finally, we present other findings regarding the industry that, while not being at the core of the support scheme, are nevertheless very relevant to take on board in future policy cycles.

2.2.2. Incentive effect of aid for solar, wind and storage capacity

Ideally, the aid disbursed enables beneficiaries to undertake investments that would not have occurred without. It generates additional investment in areas considered valuable by the aid grantor (Parcu et al., 2020). The incentive effect can be assessed through interactions with beneficiaries, non-beneficiaries, a combination of both, or exclusively via modelling approaches. Each method has distinct implications. For instance, one approach involves constructing a counterfactual based on beneficiaries' responses and their estimation of project size in the absence of aid. This method typically results in a relatively high response rate, as beneficiaries are often more inclined to participate in evaluation exercises, sometimes due to contractual obligations. [5] However, these beneficiaries have a clear incentive to provide responses favourable to the scheme. Ex-post evaluations of aid for renewable energy have demonstrated heterogeneous impacts across beneficiaries, particularly concerning the incentive effect. Broadly speaking, the results can be categorised into three distinct groups.

First, in the optimal case, the aid was found to be a decisive factor, indicating that, in the absence of such support, the initiatives would not have been implemented. In these cases, the aid demonstrated a strong incentive effect, as the scheme catalysed investments that were otherwise financially unviable or would not occur. In principle, each euro granted generated a corresponding additional investment equivalent to that euro. It is in these projects that a behavioural shift is observed, whereby the aid truly creates results that would not have been achieved in absence of the aid. This effect is observable not only in the realisation of projects but also quantifiable through indicators such as (the difference in) project scale, investment additionality, implementation timing, etc.

Second, in some cases the results are more nuanced, with a partial incentive effect observed. In these cases, projects would have proceeded regardless, but on a smaller scale or at a later date, underscoring the scheme's role in accelerating implementation or enhancing project scope. In such instances, the public expenditure generated additionality, though not equivalent to the full amount spent.

[5] See for example the following evaluation by the Swedish Environmental Protection Agency (2023).

Third, and in a non-negligible number of cases, beneficiaries indicate that projects would have occurred irrespective of the aid, often because they were already planned or in progress, partly driven by market factors such as volatile energy prices. These are precisely the cases to be avoided, as the public expenditure fails to generate substantial additional investment and the incentive effect cannot be demonstrated. The State Aid did not induce investment that would not have materialised otherwise, but instead acts as a market distortion, as beneficiaries perceive it as a business opportunity that reduces the payback period and enhances the return on investment (Werner & Verouden, 2025).

These results and the absence of a distinctive incentive effect in a number of cases, are largely in line with the suggestions put forward in extant literature. For example, Nicolaides argues that the current funding gap approach to assessing the presence of an incentive effect is only appropriate in case of discretionary projects.[6] Otherwise, an undertaking familiar with State Aid rules may simply adjust the timing of its investment plans to meet the eligibility criteria, even if the aid is not genuinely necessary (Nicolaides, 2023b).

Further analysis differentiates the presence of the incentive effect by project characteristics. Wind projects typically showed a stronger full incentive effect compared to solar, potentially due to higher average investment costs. Smaller projects (under 1MW) appeared more responsive to Aid, suggesting that financial constraints are more binding at lower capacity scales. Project destination (e.g. whether the renewable energy generated is for self-consumption or for sale) does not show a clear pattern of influence on the incentive effect, although many respondents struggled to isolate the role of aid in complex investment decisions. A common finding is that the incentive effect of aid is higher for projects with storage capacity. Whereas pure solar or wind project would often be carried out without aid, investment in storage would mostly not be possible without support considering the high costs and current state of technological advancement.

Interestingly, the financial characteristics of the beneficiaries such as turnover, net profit, or assets, do not seem to correlate significantly with the presence or absence of the incentive effect. This suggests that project-level factors, rather than firm-level financials, may better explain responsiveness to aid.

While the schemes did not universally trigger new investment, they played a crucial role in enabling and accelerating renewable energy deployment, especially among smaller-scale, wind, energy and storage projects. In cases where the aid did not have an incentive effect, it for sure increased the return on investment of the project, freeing resources for

[6] For example, if a project is critical to an undertaking's continued operation and would be pursued despite imposing a financial burden, the provision of State aid is unlikely to induce a behavioural change, as the undertaking would, in all likelihood, proceed with the project also in the absence of aid (Nicolaides, 2023a).

investments in additional projects. In practice, any aid scheme includes beneficiaries across all three categories. For some, the scheme served as a strong incentive for additional investment, while for others, it primarily was a business decision by enhancing the profitability of a project that would have proceeded regardless of the aid.

2.2.3. Proportionality and appropriateness

Next to incentive effect, a key objective of ex-post evaluations is to assess the proportionality and appropriateness of the State Aid scheme supporting investment in renewable energy projects. These concepts are central to EU State Aid control and reflect whether aid was limited to the minimum necessary to trigger investment (proportionality), and whether the aid was the most effective and least distortive means to achieve policy objectives (appropriateness).

2.2.4. Proportionality and aid intensity

Proportionality is probably one of the more interesting and complicated topics from an aid design and evaluation perspective. Whereas the incentive effect investigates whether aid is necessary for the project to go ahead, proportionality takes a more nuanced approach and aims to uncover the amount of aid minimum necessary to trigger the new investment. More precisely, it aims to uncover the minimum percentage of the full cost of the project that should be supported through State Aid for the project to be able to go ahead (Werner & Verouden, 2025). Because the results on effectiveness of the aid schemes are so diverse (three groups with no incentive effect, partial incentive effect, and full incentive effect), it does not make sense to fix one aid intensity. Often, the required aid intensity depends on the characteristics of the beneficiary and type of project.

Thereto, an innovative feature was detected, i.e. applicants are invited to propose their own desired aid intensity, or percentage of eligible costs for which they sought public funding. Aid intensity was then taken on board as one of the evaluation criteria to determine which company received aid. Suggesting own aid intensities and knowing that it influences chance of success, represents a self-assessment mechanism and introduces a competitive and reflective dimension, encouraging applicants to request only the aid deemed necessary. From a policy perspective, this feature aimed to enhance cost-efficiency, reduce overcompensation, and function as a safeguard for proportionality.

The projects that introduced such mechanism show a large range of proposed aid intensities, spanning from as little as 7% to as much as 98% of eligible costs. It is also clear that most companies agree that relatively modest aid intensities (40-60%) are sufficient to trigger investment, particularly for established technologies such as solar and wind. Importantly, the evaluations

show a negative relationship between aid intensity and project size. Larger projects, measured in terms of total budget, approved aid value, and capacity, tended to require lower aid intensities. This outcome aligns with economic expectations regarding economies of scale and greater access to capital among larger and more experienced firms. Conversely, no relationship is found between aid intensity and firm-level financial indicators such as turnover, assets, or profit. This suggests that project characteristics, rather than company characteristics, are more predictive of aid requirements. In addition, a positive relationship between aid intensity and cost per megawatt installed (aid per MW) suggests that higher aid levels are needed to compensate for more capital-intensive or technologically demanding projects. This is especially true for projects incorporating storage components, which often face higher costs and less mature market conditions. For storage, substantially higher aid intensities are necessary to ensure viability.

It is important to bear in mind that the mechanism allowing applicants to propose their own aid intensity involves a trade-off embedded in the scheme's design. Although the flexible model encourages reflection and competition, thereby constraining aid intensities and total aid amounts, it may also generate uncertainty or advantage more experienced participants, who are better equipped to estimate the maximum acceptable aid intensity than less experienced undertakings.

2.2.5. Appropriateness and aid instrument

Overall, State aid is considered to be an essential way to support and expedite investments in renewable energy. While removing other obstacles in the energy market would certainly help, they cannot replace the function of State Aid. When it comes to aid measures, diverse instruments have been chosen by the Member States to support investment in renewables, including direct grants, reimbursable expenses, soft loans and tax measures.

In terms of appropriateness, a reimbursable expenses model is widely regarded as effective. It offers both financial support and flexibility during implementation, but can be less fraud prone than for example a direct grant as it enables the granting authority to review the expenses before releasing the aid. Nevertheless, also alternative instruments are identified that could have supported renewable investment in a less burdensome or more accessible way, as reimbursable expenses require pre-financing. Implementing an advance-payment mechanism that disburses a portion of the aid ex-ante can reduce financing risk and catalyse co-financing by financial institutions, whereas a soft loan constitutes a valuable alternative, particularly for firms with constrained access to capital markets. This could be in addition to the reimbursable expenses model rather than replacing it. A loan by itself might not be able to sufficiently incentivise new projects. A minority of cases mentions tax deductions as a potentially attractive and less administratively complex alternative.

These preferences were particularly salient among small and young firms, which often face structural challenges in obtaining sufficient pre-financing. The evaluations also reveal that in some projects, potential beneficiaries were established as special purpose vehicles (SPVs), complicating the link between project characteristics and firm-level financial indicators. Such structures often render firms "small" in conventional datasets despite substantial off-balance-sheet support, complicating credit assessment procedures and impeding dialogue with financial institutions.

Beyond the choice of aid instrument, a significant number of cases emphasised the critical importance of grid infrastructure. Delays and limitations in grid connection were frequently cited as major bottlenecks, particularly in certain geographic regions. Even well-designed aid schemes may fall short if the physical infrastructure required to deliver renewable electricity is lacking. This underscores the need for policy complementarity, where financial support is accompanied by regulatory and infrastructure improvements.

2.2.6. Other findings

The evaluations of aid for renewables also highlight several critical factors that influence project success beyond the aid itself. *First*, grid infrastructure consistently emerges as a top priority, often seen as more critical than the financial support provided through aid schemes. The fact that companies do not have certainty on the possibility to connect their project to the grid, or might have to temporarily disconnect in peak times causes uncertainty about the feasibility, profitability and return on investment of new renewables projects. *Second*, clear communication and regulatory predictability are both essential for confidence and smooth project implementation. Multiple changes to the policy and regulatory environment have recently created too much instability for companies to confidently plan and invest. Certainly, the combination of regulatory changes, evolving energy policy objectives, changes to aid schemes and their evaluation, render it very difficult for companies to thrive. A *third* element in the broader findings of the evaluations concerns price stability. The last years have been characterised by extreme price instability for electricity. This constitutes an additional barrier to investment in renewables by undermining the return on investment and disrupts project planning. *Fourth*, the evaluations regularly document administrative hurdles, particularly in the permitting process and grid connection applications. These can significantly delay or even block renewable energy projects. Finally, the evaluation underlines the importance of early and transparent communication on data sharing, which is vital for conducting meaningful and accurate assessments. Without prior commitment of the aid applicants (beneficiary as well as unsuccessful applicants) regarding the sharing of data required for the evaluation, it becomes difficult to obtain the necessary input to carry out a sound evaluation.

Conclusions

This article reviewed evidence from ex-post evaluations of State Aid schemes aimed at supporting investment in renewable energy projects, with a particular focus on solar, wind, and storage technologies. We focus on the assessment of the effectiveness of aid schemes in triggering additional investment, and its proportionality and appropriateness characteristics. The aim was to generate evidence on how public support has influenced project decisions on renewable energy and to inform the future design of aid measures that contribute to the EU's green transition goals in an efficient and targeted manner.

The evaluations of aid for renewables reveal a varied incentive effect. While most companies report an either full or partial incentive effect, a non-negligible number of cases also indicated the aid replaced rather than complemented private investment. The current geopolitical climate makes it obviously wise to invest in autarkic renewable energy sources to not depend too much on price volatility. This entails that several companies can, and probably will, develop financially viable energy projects, even in the absence of aid. This highlights the importance of carefully designing aid schemes to target projects that genuinely require support, while recognising that aid can still play a role in accelerating timelines or enhancing project scale.

From a proportionality perspective, the innovative practice of permitting applicants to propose their own aid intensity offers strong safeguards for ensuring proportionate support. By introducing a competitive dimension, this mechanism promotes cost-efficiency and incentivises potential beneficiaries to limit their aid requests to the minimum necessary. There is typically a negative relationship between aid intensity and project size, suggesting that larger projects benefit from economies of scale and require less public support per unit. By contrast, smaller projects, and those involving storage, tended to require higher aid levels to be viable.

With respect to appropriateness, we find that multiple aid instruments are theoretically viable and selecting the right one is of course very much context dependent. In practice, we see that a system with reimbursable expenses is generally suitable. Nonetheless, several alternatives were suggested to better address the financing constraints faced by smaller or younger firms. These include preferential loans, advance payments, and tax deductions, all of which could enhance access to capital and reduce barriers to participation.

Beyond the core findings, the evaluations also uncovered additional impacts of aid schemes. Companies report relatively frequently strategic benefits that extend beyond the specific project, such as accelerated investment timelines or freed-up capital for other initiatives. Several more structural issues were also frequently reported. Mostly infrastructure issues can hamper the development and implementation of future renewables projects, even with very generous aid schemes.

The evaluation findings emphasise the need to adopt a holistic approach in renewable energy policy that complements State aid with

regulatory reform, infrastructure investment, and streamlined administrative processes. Ensuring grid readiness and maintaining a stable and predictable policy environment can greatly enhance the effectiveness of aid measures and accelerate the deployment of renewable energy.

Future studies might focus on the interplay between aid schemes and other or non-financial barriers, such as local permitting practices or market design, as well as develop methodologies for integrating infrastructure constraints into the design of State aid schemes and the assessment of aid applications. More case-specific data and longitudinal studies would also strengthen the evidence base for policy design.

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Conflict of interest. The authors certify that they have no financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript.

The authors received no direct funding for this study.

Buts, C., Maes, S., Botrel Lima, C., & Songyue, Li. (2026). Green industrial policy: a critical evaluation of State Aid for renewables. *Scientia fructuosa, 1*(165), 65–83. http://doi.org/10.31617/1.2026(165)05

Received by the editorial office 15.12.2025.
Accepted for printing 19.01.2026.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)06
UDC 355.02:[504:339.137.2=111

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DEFENCE INDUSTRY POLICY AND GREEN COMPETITIVENESS

The defence industry, as a key player responsible for implementing the strategic defence policy of the state, should be part of the broader discussions on sustainability and the green transition. Rapid environmental changes and high uncertainty in the global and national security sectors are heightening the urgency of such transformations. Implementing environmentally friendly approaches within the defence industry can significantly enhance national competitiveness. The paper aims to show the direction of transformations in defence industry policy during the process of green transition. This research hypothesizes that prioritising sustainability practices within defence industry policy has the potential to enhance both national security and economic competitiveness. This study combined qualitative and research methods, specifically a systematic literature review and case studies. Green practices in the defence industry policy may contribute to the resilience of the sector during periods of high-risk uncertainty and tight fiscal constraints by allocating public and private funds and improving efficiency. Russia's full-scale military invasion of Ukraine in 2022 involved our country in high-intensity warfare and required major shifts

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ОБОРОННО-ПРОМИСЛОВА ПОЛІТИКА ТА ЗЕЛЕНА КОНКУРЕНТО-СПРОМОЖНІСТЬ

Оборонна промисловість як ключовий гравець, відповідальний за реалізацію стратегічної оборонної політики держави, повинна бути частиною ширших дискусій щодо сталого розвитку та зеленої трансформації. Швидкі зміни навколишнього середовища та висока невизначеність у глобальному та національному секторах безпеки підвищують нагальність таких трансформацій. Впровадження екологічно дружніх підходів у оборонній промисловості може значно підвищити національну конкурентоспроможність. Мета дослідження – показати напрям трансформацій в політиці оборонної промисловості під час процесу зеленої трансформації. Висунуто гіпотезу, що пріоритетизація практик сталого розвитку в політиці оборонної промисловості має потенціал підвищити як національну безпеку, так і економічну конкурентоспроможність. У цьому дослідженні поєднано якісні та дослідницькі методи, зокрема систематичний огляд літератури та дослідження випадків. Застосування "зелених" практик у політиці оборонної промисловості може сприяти стійкості сектору у періоди високої невизначеності та жорстких бюджетних обмежень шляхом розподілу державних та приватних коштів і підвищення ефективності. Повномасштабне вторгнення росії в Україну у 2022 р. залучило нашу країну

in our defence and economic policies. In addition, the intensification of the European integration process requires the adjustment of our local practices to those in the European Union, including the Green Deal. Implementing green practices in Ukraine's defence industry can be equally beneficial for the national military sector (by cost- and resource-efficiency), and national economic growth (by encouraging innovation and creating jobs in new or related areas). The research highlights the importance of the implementation of greener defence plans for enhancing competitiveness by integrating the national economy into global aerospace and defence industry value chains. For Ukraine, facing existential challenges, it has the potential to create opportunities for defence industrial manufacturers and suppliers to enter the global financial market and allocate resources with higher efficiency. The relevant recommendations were identified in the paper, as well as critical issues for the defence industry's green growth.

Keywords: green transition, defence industry, resilience, industrial base, the European Green Deal.

до інтенсивних бойових дій і вимагало суттєвих змін у нашій оборонній та економічній політиці. Крім того, посилення процесу європейської інтеграції потребує адаптації наших місцевих практик до практик Європейського Союзу, зокрема до Зеленого курсу. Впровадження "зелених" практик в оборонній промисловості України може бути однаково корисним для національного військового сектору (шляхом підвищення ефективності витрат і використання ресурсів) та для економічного росту країни (шляхом стимулювання інновацій і створення робочих місць у нових або суміжних сферах). Дослідження підкреслює важливість впровадження більш екологічних планів оборони для підвищення конкурентоспроможності шляхом інтеграції національної економіки у глобальні ланцюги створення вартості аерокосмічної та оборонної промисловості. Для України, яка стикається з екзистенційними викликами, це має потенціал створити можливості для виробників та постачальників оборонної промисловості вийти на глобальний фінансовий ринок та більш ефективно розподіляти ресурси. У статті були визначені відповідні рекомендації, а також критичні питання для зеленого розвитку оборонної промисловості.

Ключові слова: зелений перехід, оборонна промисловість, стійкість, промислова база, Європейський зелений курс.

JEL Classification: H56, O38, O14.

Introduction

The implementation of green technologies in modern industrial processes transforms technological cycles and decreases the negative ecological impact. The defence industry is one of the largest pollutants in the economy, whose impact is complex to measure due to its nature. The changes are possible through the integration of green approaches into the industrial cycle in the defence sector. The concept of the green defence industry outlines the incorporation of sustainable decisions within organisations working in the defence sector.

The paper analyses the foundations of the green defence industry concept and the implementation of environmentally adjusted strategies aimed at solving key challenges. Basic strategic approaches and the institutional framework are considered in the paper. Projects focused on green practices in defence industries were analysed (infrastructure and capacity development). The positive outcomes for economic development through investments in green defence projects were highlighted. Ukrainian defence industry prospects in the green transition path were underlined.

Existing research shows that it is beneficial to understand the complex greening of all components of the defence industry as a continuous and purposeful process of fundamental introduction of new technologies,

technological, economic, organisational, information and other solutions that provide an intermediate opportunity to achieve the maximum possible balance of military, economic and environmental goals, ensure the protection of ecosystems and create conditions for their self-renewal, significantly increase the efficiency of the use of resources of all kinds and improve the quality of products and services (Zakharchenko et al., 2023). Wigell and Hakala (2022), argue that climate change represents a shaping threat by also framing the way it manifests itself. The move to renewables presents a significant challenge to the armed forces, but one to which they will need to adapt. At the same time, renewables and new technologies represent an opportunity in the way a greener defence approach may catalyse new capabilities.

Scientists are highlighting key challenges facing green defence: fuel consumption, reliability of energy supply, climate change, and defence spending (Vincorion, 2022). Then, the green defence industry is a sector that can provide the defence sector with the required goods and services for protecting states' territory and interests, and at the same time, is implementing agile systems and resilient processes for decreasing the potential negative impact on the environment.

In the green defence industry is necessary to reconcile circular economy and lean principles in the context of the defence industry, to create customer-oriented solutions that minimize resource consumption and improve added value for the end user (Reis et al., 2022). The process of implementation may be insufficient to change well-established approaches in the infrastructure and capabilities development without such integration.

In the European context, Pisani-Ferry and Tagliapietra (2024), advocate that it is in the EU's interest to push ahead with the green transition, for at least three reasons. First, global decarbonization is vital for the EU in its efforts to limit increasingly expensive climate damage in the future. Second, it will help the EU enhance its economic competitiveness and economic security. Third, it represents a clean-tech export opportunity for Europe. Reis et al. (2022), agree that circular economy policies in the EU defence industry focus on higher targets, which are aimed at extending the lifespan of defence products and their parts, as well as using and manufacturing smarter defence products.

Another research issue is related to the financial aspects of green defence policy implementation. Allocating this investment to the right priorities – including areas that link decarbonization and military spending – can also help address other critical EU security challenges, such as economic and energy security. A resilient industrial base is essential for a strong defence effort (Popov, 2024).

The current transformation of the Ukrainian defence industry could be intensified through the implementation of green principles. Current research in this area is limited due to a low level of integration of the defence industry into global value chains (Zakharchenko et al., 2022). In general, Ukraine's defence industry has a significant impact on the country's economy and plays a key role in ensuring national security. The low level of competitiveness of

domestic defence products can be a serious problem, but attracting young professionals can contribute to the development of innovations and improve this situation (Nikitchenko et al., 2024). Effective prioritization, relevant data, political enforcement, and social consensus are needed to transform defence industry and implement green practices into it. The paper aims to show the direction of transformations in defence industry policy during the process of green transition. The research problems, outlined in the paper: green defence industry – economic benefits and risks; green practices and national competitiveness.

This research hypothesizes that prioritizing sustainability practices within defence industry policy has the potential to enhance both national security and economic competitiveness.

This study combined qualitative and exploratory research methods, specifically a systematic literature review and case study research.

The paper is organized as follows: Section 1 outlines green transition and defence policy foundations. Section 2 analyses the development and deployment of the green defence industry principle, and Section 3 describes the implementation of green defence principles in Ukraine.

1. Green transition and defence policy

Green transition is an approach based on a range of concepts and ideas created in the second half of the 20th century and the early 21st century. The main aim of the green transition is to create a space and opportunities for adjusting the economic system to climate change and other environmental challenges. The changes were established in both public and business sectors. Governments have developed instruments based on strategies and policies, supporting the green transition. The business environment has developed and applied ESG (Environmental, Social, Governance) strategies aimed at assessing sustainability goals, including green transition.

Government-supported green transition instruments include carbon pricing, green subsidies, climate regulation, green innovation, green preferences, and green investments. Their macroeconomic effects vary by their scale and durability (*Table 1*).

Table 1

Macroeconomic effects of green transition instruments

		Impacts on output	Impacts on inflation
Transition drivers	Carbon pricing	Impact on output depends heavily on revenue recycling	Headline inflation moves up temporarily, while core inflation may be unaffected
	Green subsidies	Subsidised sector activity is likely to increase, while overall impact depends heavily on how subsidies are financed	Prices in subsidised sector are likely to fall, while impact on overall inflation is ambiguous
	Climate regulation	Some types of regulation can create stranded capital, temporarily lowering output	Adjustment costs, and hence prices, are likely to increase temporarily
	Green innovation	Higher productivity and knowledge spillovers can support output	May reduce costs and dampen inflationary pressures
	Green preferences	Reallocation across products and sectors, but uncertain impact on aggregate output	Green price premium and reduced-price competition via product differentiation affect relative prices

End of Table 1

		Impacts on output	Impacts on inflation
Other transition impacts	Increased green investment	Overall impact depends on whether investments are additional or redirected from other sectors	Potential volatility and upward price pressures from short-term imbalances in energy markets, critical minerals and labour skills
	Transition uncertainty	Higher climate policy uncertainty tends to lower aggregate investment and output, but has asymmetric impacts across sectors	Higher climate policy uncertainty can increase consumer prices

Source: (Network for greening the financial system, 2024).

According Eurostat calculations, the EU will require additional annual investments of about two percent of GDP between 2025 and 2030, comparable to EU R&D spending in 2022 – estimated at 2.2 percent of GDP (Pisani-Ferry & Tagliapietra, 2024). The cost of non-intervention into human-created environmental changes could be higher in the next decades, so it is necessary not to postpone decisions on green transition. The policy capacity level could be a crucial indicator for an accurate assessment of the government's ability to implement changes.

Defence alliances and government defence offices are also analysing the impact of environmental changes and developing corrective strategies, including the assessment of climate and other threats. For instance, NATO declares climate change as a "threat multiplier".

Climate change and political challenges are transforming the traditional approach to planning defence industry activities. The industry, operating in an over-regulated market and limited by market opportunities due to its dependence on contracts with governments, requires creative solutions and innovative approaches.

Therefore, defence sectors are facing a strategically sensitive issue to adapt at the same time to the modern high-intensity warfare and climate change. Green defence industries could provide proper green solutions that are suitable for existing legal norms.

The green defence framework was created by NATO in 2014 and contained no specific targets or demands for activities, instead highlighting a several initiatives capable of supporting or facilitating the development of green initiatives within NATO and in the member nations. Green defence was defined in a Framework as 'a multifaceted endeavour cutting across a wide range of activities, including operational effectiveness, environmental protection and energy efficiency (Knus Larsen & Center for Militære Studier, 2015). At the 2021 Summit in Brussels, NATO Heads of State and Government (HOSG) endorsed a Climate Change and Security Action Plan (CCSAP) and agreed that NATO should aim to become the leading organization when it comes to understanding and adapting to the impact of climate change on security (NATO, 2013, July 11).

Governments have developed an institutional framework for the green transition within the defence industry to outrun the green challenges (*Table 2*).

Table 2

Key strategic approaches and initiatives in implementing the Green Defence policy

Country	Strategy/Plan	Targets/Goals	Key Actions/Initiatives
Netherlands	Energy and Environment Strategy for the Defence Sector; Action Plan for the Energy Transition in the Defence Sector	Reduce fossil fuel use by 20% by 2030, 70% by 2050 (from 2010 levels); 50% energy from renewables by 2030; energy self-sufficiency by 2050	Setting targets for fossil fuel reduction and renewable energy generation
United Kingdom	British Ministry of Defence energy transition investigation	Net-zero emissions by 2050; Royal Air Force: carbon neutral by 2040	Thorough investigation of energy transition in defence sector
France	Energy Strategy for the Defence Sector 2020	Energy efficiency in procurement; hybrid demonstrator "Griffon" by 2025; energy-autonomous "Eco Camp 2025"	Hybridization of powertrains, biofuels for aviation, optimizing marine energy use, pilot training for fuel efficiency
United States	Defence Climate Risk Analysis and Climate Adaptation Plan; Sustainability Report and Implementation Plan; Plan to Reduce Greenhouse Gas Emissions	Address climate change; climate change mitigation strategies	Plans and measures focused on climate risk and adaptation

Source: our elaboration based on (Vincorion, 2022; International Military Council on Climate and Security, 2024).

The strategies and action initiatives mostly include targets in the energy transition in the analysed countries. It is necessitated by high fuel consumption levels and emissions of pollutants, including air defence, marine, and other types of forces.

Defence companies Airbus, Safran, GE, Rolls Royce, Dassault, Boeing and Pratt & Whitney committed to reaching net zero carbon emissions for civil aviation by 2050 (Pugnet, 2023, July 17).

The European Union, as one of the leaders in the green transition, has approached the framework aimed at the creation of a general system of norms and stimulating instruments for enterprises working in the green defence industry (*Table 3*).

Table 3

The institutional framework of the European Union, shaping green defence practices

Document	Main tasks	Defence sector impact
Green Deal	The EU's growth strategy. Launched in 2019, it consists of a package of policy initiatives, which set the EU on the path to a green transition, with the goal of reaching climate neutrality by 2050	The European Defence Fund Regulation allows funding topics for defence-oriented solutions contributing to energy resilience and the reduction of the defence environmental and carbon footprint

End of Table 3

Document	Main tasks	Defence sector impact
Circular Economy Action Plan	The Circular Economy Action Plan (CEAP), aimed at fostering a sustainable and resilient economy by transitioning from a linear to a circular model	Electronics, batteries, and materials management are targeted by the CEAP. Defence organisations may voluntarily adopt aspects of the CEAP to enhance sustainability, improve operational efficiency, and align with broader EU environmental goals
Critical Raw Materials Act	The Critical Raw Materials Act is aimed at ensuring a secure, sustainable, and resilient supply of critical raw materials (CRMs)	Member States shall not be required to submit information regarding certain strategic stocks when such information could compromise its defence and national security. In this case, it shall present a justified notice." (Article 22)
Eco-design for Sustainable Products Regulation	A framework to set eco-design requirements for specific product groups to significantly improve their circularity, energy performance and other environmental sustainability aspects	Products whose sole purpose is to serve defence or national security shall be excluded from the product group" (Article 5)
EU Strategy for Sustainable and Circular Textiles	It aims to make the textile industry more sustainable by promoting durable, reusable, and recyclable materials while reducing waste and pollution	this strategy can be applied by designing and procuring sustainable uniforms and gear, implementing waste reduction and recycling programs, and minimizing the use of hazardous chemicals
The Strategic Compass	The Strategic Compass, the EU's military strategy, also spelt out that armed forces and operations must participate in the green transition	The aim is to develop full spectrum forces that are agile and mobile, interoperable, technologically advanced, energy efficient and resilient. Defence Innovation Hub within the European Defence Agency is responsible for technological solutions
The ReArm Europe Plan/Readiness 2030	Plan proposes to leverage over EUR 800 billion in defence spending through national fiscal flexibility, a new EUR 150 billion loan instrument (SAFE) for joint procurement, potential redirection of cohesion funds, and expanded EIB support	Prioritizing defence R&D: enhances military preparedness through cutting-edge technology; strengthens the competitiveness of European industries in high-tech sectors; and drives economic growth by supporting innovation ecosystems

Source: our elaboration based on (European Defence Agency, n. d.; European Defence Agency, 2024; Pugnet, 2023, July 17; Popov, 2024; AeroSpace and Defence Industries. Association of Europe, 2022; European Parliament, 2025).

The developed institutional framework can be considered as a support infrastructure aimed at increasing the number of green initiatives in the EU defence sector.

At the same time, the requirements for the green transition are rather demanding for civil and defence industries and require investments to fuel strategic actions and technological innovation.

When it comes to financing defence, non-regulatory constraints introduced voluntarily by financial-market participants out of reputational concerns are likely to matter more than regulatory constraints. Draghi (2024, September 9) argued that access to financing for EU defence companies is partly hindered by the way financial institutions *interpret* EU sustainable finance rules (Merler, 2023).

Defence industries are facing difficulties in attracting financial resources during periods of fiscal constraints and social challenges. On the one hand, the defence expenditures are increasing significantly in numerous countries; on the other hand, the possibilities to accumulate additional resources are restricted due to the factors highlighted above (*Table 4*)

Table 4

Military expenditures, 2022–2024, USD billion

Rank	Country	2022	2023	2024
1	USA	877	916	997
2	China	292	296	314
3	russia	86.4	109	149
4	India	81.4	83.6	86.1
5	Saudi Arabia	75.0	75.8	80.3
6	United Kingdom	68.5	74.9	81.8
7	Germany	55.8	66.8	88.5
8	France	53.6	61.3	64.7
9	South Korea	46.4	47.9	47.6
10	Japan	46.0	50.2	55.3
11	Ukraine	44.0	64.8	64.7

Source: Stockholm International Peace Research Institute (2023, 2024, 2025).

The russian aggression against Ukraine has intensified the discussion concerning the defence capabilities of the states. The military expenditures are now associated with the necessity, not the option, due to the transition state of the world order and its institutional characteristics. We can see an increase in military spending, including European Union member states and Ukraine, in this rating. Governments are investing in a wide range of weapons, ammunition, and communication systems to strengthen their defence level.

2. Development and deployment of green defence industry principles

The European defence technological and industrial base (EDTIB) consists of large multinational companies, mid-caps, and over 2 000 SMEs. The Commission estimates its annual turnover at EUR 70 billion, with substantial exports amounting to EUR 28 billion in 2021. The European defence industry is dominated by companies based in France, Germany, Italy, Spain, and Sweden. However, 23 Member States are home to the prime manufacturers of the 46 most urgently needed items, according to the Defence Joint Procurement Task Force's industry mapping. The EDTIB is also a major employer with around 500 000 people employed in the sector (European Defence Agency, 2024).

The Portuguese case of developing green defence industry principles could serve as a model for other countries. The Portuguese DTIB is highly segmented (+20 segments), and with a representation of more than

380 organizations, the Portuguese Ministry of Defence decided to create a consortium called "AuxDefense". At the same time, high-level defence projects were developed in parallel, such as the ACU (Advanced Combat Uniform) and SCS (Soldier´s Combat System) led by CITEVE (Technological Centre for Textile and Clothing Industries). The AuxDefense consortium and ACU/SCS projects are operated within the scope of the triple helix, bringing together the Portuguese Armed Forces (Army and Air Force), Universities (e.g., University of Minho), Technological Platforms (e.g., Fibrenamics), and Centres (e.g., CITEVE), as well as several private companies (e.g., LMA–textiles). This technological centre developed multilayer textiles with innovative auxetic structures, using fibrous materials and advanced structures with high mechanical properties, used in the manufacture of clothing components, aiming at high performance. Before being produced on a large scale for the Portuguese Army, under the qualification system for military systems or equipment, the BDUs received the Army Tested/Combat Proven certificate (Reis et al., 2022).

To sum up, establishing a comprehensive planning system and integration of businesses, universities, technological centres, and armed forces can transform traditional approaches in developing goods for the defence sector and lead to increased resilience, environmental responsibility, and cost-efficiency.

We can find other examples of effective cooperation between the business sector, academic institutions, and armed forces in the advancement of infrastructure and capabilities (*Table 5*, *6*).

Table 5

Projects focused on green practices in defence industries (infrastructure development)

Project/ Organisation	Focus	Key Actions/Solutions	Outcomes/Benefits
AECOM and BAE	Decarbonisation of air and maritime estates	Energy efficiency projects, improved insulation, plant replacement, high efficiency air source heat pumps, solar PV, battery storage, new heat network, heat recovery plant	Onsite power generation, increased energy security, reduced operational costs, 50% reduction in operational carbon emissions
Cardno-AECOM - Pacific Joint Venture	Installation Energy Roadmap (IER)	14 MW solar facility, 70 MWh battery storage, renewable energy, grid reliability, electrification of fleet vehicles, carbon off-setting, sustainable carbon sinks	Net-zero carbon emissions Navy base by 2035, improved resilience, decarbonisation and resilience mutually supporting
QinetiQ	Naval Fuels analysis	Analysis of oil fuel depots, infrastructure options, fuel demand, interdependencies, risks and benefits	£166 million capital savings, reduced fuel demand and storage, reduced carbon emissions, meets capability, efficiency and financial goals
Rolls-Royce	Microgrids project for Strat Com Efficiency	mtu microgrid, 2MW reliable power, CHP plants, battery storage, standby generators, renewable integration	99.9% power reliability, security of supply, flexibility, resilience, cost efficiency, used in U.S. military bases
CeraPhi	Geothermal Systems	CeraPhiWell deep geothermal, pumps cold water, heats underground, returns hot water	Significant ROI, low maintenance, supports self-sufficient bases, humanitarian/refugee support
Newcastle University	ViTAL Living Lab RAF Leeming	High risk/gain experimentation, decarbonising tech, renewable power, operational efficiency	Supports RAF Net Zero, proven operational results, upscaling possible

Source: our elaboration based on (UK Ministry of Defence, 2021).

A significant portion of projects was concentrated on finding green solutions to improve energy efficiency in the defence sector. Projects, realized by AECOM, BAE, Cardno, QinetiQ, Rolls-Royce, CeraPhi, and Newcastle University, were aimed at transforming current energy systems by increasing their resilience, sustainability, and independence. The outcomes included a reduction in operational carbon emissions, the construction of a net-zero carbon emissions Navy base, reduced fuel demand and storage, security of energy supply, and geothermal systems that support self-sufficient bases. As follows, it is preferable to analyse the positive effects of the implemented projects and disseminate the results in the defence sector. The infrastructure development investments could not only have energy efficiency effects but also be cost-efficient in the medium and long terms.

Table 6

Projects focused on green practices in defence industries (capabilities development)

Project/ Organisation	Focus	Key Actions/Solutions	Outcomes/Benefits
BAE and AIRBUS Typhoon	Typhoon decarbonisation	Synthetic training simulators, high-fidelity simulators, Gladiator synthetic environment	80% synthetic training by 2040, saves 9.6 tonnes carbon per flight, 75 million litres fuel saved, 184 000 tonnes carbon saved
MBDA/QinetiQ/ Leonardo	Dragonfire high energy laser systems	Laser Directed Energy Weapon, high power laser, reduced logistics chain, sustainable power potential	Reduced emissions from transport, future trials to reduce size/weight/power, logistics pressure reduction
Abrams hybrid tank	Hybrid-electric main battle tank	Hybrid-electric drive, 50% more fuel efficient, lighter weight, unmanned turret, AI-driven C2	Reduced resupply, improved survivability, silent watch/mobility, reduced logistics burden, supports modernization
Frazer-Nash	Synthetic environments case study	Simulation for robotic autonomous systems, 3D models, ground platform dynamics, SE for testing	Reduced experimentation cost, faster equipment service, test tech for efficiency or alternative power

Source: our elaboration based on (UK Ministry of Defence, 2021).

The capability development is another essential element of the defence sector's strategic development. The focus was on aircraft decarbonization, the development of high-energy laser systems, the construction of a hybrid-electric main battle tank, and simulation for robotic autonomous systems. Solutions that prioritize green initiatives in the capability and infrastructure development are increasing optionality and variability for productive defence decision-making.

3. The implementation of green defence principles in Ukraine

Ukraine's path to sustainable development and green transition is challenged by russia's full-scale invasion of Ukraine in 2022 and ongoing war, which, among other negative factors, is consuming limited financial and intellectual resources and narrow policy and business options for implementing green defence industry principles. Nonetheless, restricted access to resources is forming opportunities for creative and innovative decisions in the defence sector.

In the EU integration process, green transition is a key to national resilience. It is crucial to modernize the main industries by adopting EU-aligned emissions trading, circular economy practices, and green finance tools. Investments in clean technologies, such as hydrogen, electrification, and resource efficiency, must be secured to rebuild a resilient and competitive industrial base (Stockholm Environment Institute, 2025, June 26).

Here are some key areas in which Ukraine is developing its defence industry:

artillery and heavy ammunition: the development of the production of artillery shells and armoured vehicles, in particular NATO standard ammunition, increases the combat effectiveness of the Armed Forces of Ukraine and their ability to operate in a modern combat environment;

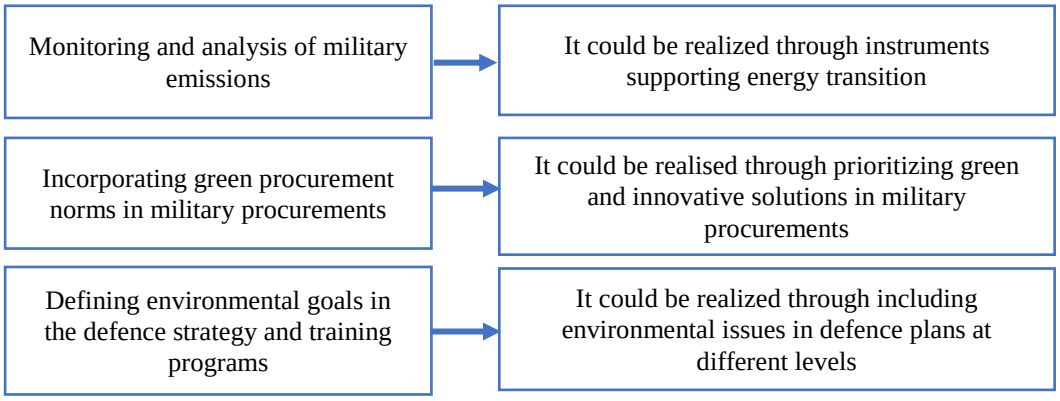
armoured vehicles: the increase in the production of armoured personnel carriers contributes to the increased mobility and protection of Ukrainian troops on the battlefield;

drones: the development of the production of unmanned aerial vehicles and ammunition for them allows the Ukrainian army to have an effective means of reconnaissance, monitoring and striking potential threats;

electronic warfare: the development and production of electronic warfare systems is an important element for protecting Ukrainian troops from modern technological threats, in particular from drones (Nikitchenko et al., 2024).

It is essential to continue the adaptation of the European institutional framework for the green transition in the defence sector with a deep understanding of local limitations and opportunities. This work remains in progress despite the ongoing challenges. For instance, Ukrainian military ecologists completed training in Belgium on assessing war-damaged soils, and it helped them. They also acquired advanced expertise and best laboratory practices, as well as protocols for soil sampling and conducting laboratory analyses (Ministry of Defence of Ukraine, 2024, April 3).

Based on the previous analysis and current difficulties facing the Ukrainian defence sector due to the current war and limited access to resources, it is advisable to start the green transition of the defence industry in key directions, including operational effectiveness, environmental protection, and energy efficiency (*Figure*).



Recommendations for the implementation
of green defence industry principles

Source: our elaboration based on (Nadarajah, 2025, August 12; International Military Council on Climate and Security, 2024).

The defence industry has the potential to become a driver of Ukrainian economic competitiveness. Companies (private and government-owned), representatives of the sector, could increase their global presence based on the current level of investments and technological potential. Nevertheless, further expansion could be limited due to the absence of ESG strategies. The development of ESG strategies can open the international investment markets and partnerships with global industry players. The Ukrainian government's priorities could be concentrated on the implementation of the European Union's institutional basis, devoted to the green transition.

Conclusions

Green transition practices can reinforce the foundations of the defence industry and correct the direction of defence industry transformations. The realization of such practices lies in rethinking strategic approaches in infrastructure and capabilities development. The paper contributes to a deeper understanding of the green transition and defence policy foundations, the development and deployment of the green defence industry principle, and the implementation of green defence principles in Ukraine.

The results of the research serve to confirm the hypothesis that prioritizing sustainability practices within defence industry policy has the potential to enhance both national security and economic competitiveness. The green defence policy has the potential to enhance countries' competitiveness in the global economic landscape, which is shifting to higher uncertainty and risk. Prioritizing sustainability practices within defence industry policy has the potential to strengthen both national security and economic competitiveness. But it could be possible if the government, as the main purchaser of the defence industry products and services, creates a space and mechanisms for constant communication and cooperation between itself, industry representatives, and academia.

Ukraine, facing an unconventional threat, could analyse the experience of the partner countries in the implementation of environmentally adjusted defence solutions and adapt them to the local wartime conditions. For instance, energy-efficient solutions for the Armed Forces of Ukraine can remarkably decrease energy dependence on other countries. The sector, equipped with effective green solutions, is more resilient during periods of military, financial, and political uncertainty. Ukrainian enterprises have already been a party to the European procurement plans in the defence efforts. It is essential to intensify the process of the Ukrainian legislation adjustment to the European one in green transition (European Green Deal, Critical Raw Materials Act, The Strategic Compass, etc.) for expanding opportunities and multiplying competitive benefits for the economy.

Further research should focus on the analysis of the medium-term and long-term efficiency of the strategies that embed green solutions into the defence sector. Also, future studies should concentrate on the identification of factors that hinder the green solutions, particularly in the infrastructure and capabilities development.

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Conflict of interest. The authors certify that they have no financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript. Given that the authors are affiliated with the institution that publishes this journal, which may cause potential conflict or suspicion of bias and therefore the final decision to publish this article (including the reviewers and editors) is made by the members of the Editorial Board who are not the employees of this institution.

The authors received no direct funding for this study.

Duginets, G., & Sarkisian, L. (2026). Defense industry policy and green competitiveness. *Scientia fructuosa, 1*(165), 84–97. http://doi.org/10.31617/1.2026(165)06

Received by the editorial office 01.10.2025.
Accepted for printing 24.11.2025.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)07
UDC 352:394.6}:338.439=111

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MUNICIPAL MARKETS: FROM FOOD PROVISION TO URBAN CENTRALITY

The reorganisation of cities around the idea of proximity has become central to contemporary urban debate, as a response to the effects of functional fragmentation, car dependency and the loss of everyday urban life. In this context, regular pedestrian access to fresh food plays a key role in territorial equity and social cohesion. This article analyses the local fresh produce market as an infrastructure of the city of proximity, exploring its contribution to daily food supply, urban sociability and neighbourhood centrality. Based on a critical review of the literature on urban proximity, public space and local food systems, the article develops a conceptual reading of the market as an everyday space, characterised by frequent shopping, the logic of "slow time" and the building of relationships of trust between traders and consumers. This approach is complemented by a synthetic empirical analysis of two municipal markets in Lisbon, Portugal, which allows us to contrast models of rehabilitation oriented towards everyday proximity with processes of transformation associated with occasional consumption and touristification. The results show that the contribution of markets to the city of proximity depends less on their physical centrality or the architectural quality of the intervention and more on the preservation of their regular food function and their integration into the daily routines of residents. The article concludes by defending the municipal fresh produce market as a strategic facility for

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МУНІЦИПАЛЬНІ БАЗАРИ: ВІД ПРОДОВОЛЬЧОГО ЗАБЕЗПЕЧЕННЯ ДО МІСЬКОЇ ЦЕНТРАЛЬНОСТІ

Реорганізація міст навколо ідеї близькості стала центральною темою сучасних урбаністичних дискусій як відповідь на наслідки функціональної фрагментації, залежності від автомобілів та втрати повсякденного міського життя. У цьому контексті регулярний пішохідний доступ до свіжих продуктів харчування відіграє ключову роль у територіальній рівності та соціальній згуртованості. У цій статті аналізується місцевий ринок свіжої продукції як інфраструктура найближчого міста, досліджується його внесок у щоденне забезпечення їжею, міську соціальність та центральність населення. Спираючись на критичний огляд літератури про близькість міста, його громадські простори та локальні продовольчі системи, стаття розробляє концептуальне бачення ринку як повсякденного простору, який характеризується частими покупками, логікою "повільного часу" та побудовою довірчих відносин між продавцями та споживачами. Цей підхід доповнюється синтетичним емпіричним аналізом двох муніципальних ринків у Лісабоні, Португалії, що дозволяє нам порівняти моделі відновлення, орієнтовані на повсякденну близькість, із процесами трансформації, пов'язаними з випадковим споживанням і формуванням туристичної привабливості. Результати показують, що внесок ринків у близькість міста менше залежить від їхньої фізичної центральності або архітектурної якості втручання, а більше від збереження їхньої регулярної функції харчування та їх інтеграції в повсякденні справи мешканців. Стаття завершується захистом муніципального ринку свіжих продуктів як

building more walkable, relational, and socially inclusive cities.

Keywords: Municipal markets; Proximity city; Food supply; Urban daily life; Sociability

стратегічного об'єкта для побудови більш придатних для прогулянок, взаємопов'язаних і соціально інклюзивних міст.

Ключові слова: муніципальні ринки; близькість міста; постачання продуктів; повсякденне міське життя; соціальні взаємодії.

JEL Classification: A13, A14, D63, D91, I38.

Introduction

The functional structure of the 20th-century city, marked by the separation between living, working, consuming and recreating, contributed to the spatial fragmentation of everyday urban life and to a growing dependence on motorised transport, particularly in accessing essential goods such as food. This urban model, associated with the expansion of large out-of-town shopping centres, has produced a city that is increasingly less walkable, less relational and more unequal in terms of access to basic services (Jacobs, 1961; Gehl, 2010).

In recent decades, this paradigm has been challenged by approaches that advocate a reorganisation of the city around proximity, functional diversity and the enhancement of everyday life. Concepts such as the compact city, walkable city or, more recently, the 15-minute city seek to refocus urban planning on the neighbourhood scale and pedestrian accessibility to essential facilities (Calthorpe, 1993; Moreno et al., 2021). In this context, daily access to fresh food emerges as a central element for urban quality of life, public health and social cohesion.

It is in this context that municipal fresh produce markets are regaining relevance as local city infrastructure. Historically, markets have played a structuring role in the formation of European and Latin American cities, functioning simultaneously as spaces for food supply, social gathering and urban centrality (Braudel, 1985; Zukin, 1995). However, throughout the 20th century, many of these facilities declined, pressured by competition from mass food retail, changing consumption habits and the loss of centrality of traditional urban centres.

Paradoxically, it is in a context marked by the acceleration of urban rhythms, the digitisation of consumption and the standardisation of commercial spaces that the municipal market reveals a renewed relevance. As a place for frequent, small-scale shopping, often promoting nearby food basins and deeply rooted in the territory, the fresh market differs from other supply formats in that it promotes a direct relationship between producer, trader and consumer, based on trust, recognition and the repetition of everyday practices (Hinrichs, 2000; Watson & Studdert, 2006).

In addition to its important economic function, the municipal market can be understood as a relational space, where food shopping is linked to informal socialising, lingering and meeting people. This social dimension brings the market closer to the notion of public space, even though it is a commercial facility, reinforcing its capacity to produce urban life and a sense

of belonging at the neighbourhood level (Low, 2000; Carmona, 2015). In a context of demographic ageing and growing social isolation in urban areas, this relational function takes on particular relevance.

In the contemporary debate on the city of proximity, municipal fresh produce markets can thus be understood as everyday infrastructure, capable of linking access to essential goods, local economies, pedestrian mobility and urban centrality. Unlike other food facilities that are often dependent on cars or located in single-function spaces, markets tend to be located in consolidated urban areas, integrating into networks of street trade, services and public spaces. This allows food shopping to be integrated into daily routines, reinforcing sustainable urban practices and reducing unnecessary travel.

However, the survival of this function is not guaranteed. Recent processes of municipal market rehabilitation, often geared towards restaurants, tourism or occasional consumption, have called into question the role of these facilities as spaces for daily shopping and social interaction. The replacement of fresh produce trading with more profitable uses, increased rents and changes in user profiles tend to remove markets from the daily lives of residents, transforming them into specialised and less inclusive urban destinations (González & Waley, 2013).

Based on this framework, this article proposes to analyse the relationship between the municipal fresh produce market and the city of proximity, focusing on its role as urban everyday infrastructure. The aim is not to discuss markets as heritage or tourist attractions, but to understand how these spaces contribute (or fail to contribute) to pedestrian access to fresh food, neighbourhood sociability and the construction of vibrant urban centres. Through a conceptual approach supported by empirical evidence, the article seeks to contribute to the debate on urban proximity policies, defending the municipal market, beyond its economic function, as a key element in the construction of more liveable, inclusive, and socially dense cities.

The article begins by outlining a conceptual framework that views municipal fresh produce markets as everyday infrastructure in the neighbourhood city. It then presents two contrasting case studies from Lisbon to examine how different regeneration models affect daily use, sociability, and the centrality of neighbourhoods. The final section discusses the implications of these findings for urban policies geared towards proximity and inclusive urban development.

1. The municipal market as a space for everyday urban life

1.1. Food supply and proximity

Daily access to fresh food is a fundamental aspect of urban life, often underestimated in debates on urban planning and form. Throughout much of the 20th century, the reorganisation of the urban food system around large retail outlets contributed to the delocalisation of food supply, making it dependent on cars and disconnected from neighbourhood walking routines

(Pothukuchi & Kaufman, 1999). This process had significant impacts on territorial equity, public health and the quality of daily life, particularly for elderly or less mobile populations, but also had environmental consequences.

In this context, municipal fresh produce markets stand out as local food infrastructure, based on frequent, small-scale purchasing habits that are integrated into daily routines. Unlike the concentrated weekly supply typical of hypermarkets, the market promotes food practices based on repetition, seasonality and adaptation to immediate daily needs. This form of supply favours a closer relationship between consumption and territory, reducing travel and reinforcing food autonomy at the neighbourhood level (Wrigley et al., 2012).

The location of markets in established urban areas, often associated with street trading, public facilities and meeting places, reinforces their ability to function as local hubs within the city. Pedestrian accessibility to the market allows food shopping to be integrated into daily routines, on the way home, to work or to other services, contributing to a more walkable city that is less dependent on motorised transport (Gehl, 2010). In this sense, the market should not be understood solely as a commercial facility, but as an infrastructure of everyday life, whose relevance is measured by the frequency of use and its integration into daily urban rhythms.

1.2. Slow time, repetition, and daily practices

Beyond its functional dimension, the municipal market is characterised by its own temporality, often described as a space of 'slow time'. This temporality does not correspond to inefficiency, but to a specific way of experiencing the city, based on permanence, observation and informal interaction. Shopping at the market often involves brief conversations, choices mediated by the seller's experience and a sensory relationship with the products, practices that contrast with the accelerated, protected and automated consumption that dominates other commercial formats (Oldenburg, 1999; Gehl, 2010).

The daily repetition of shopping practices in the market plays a central role in building stable urban routines. By returning regularly to the same space, consumers build relationships of mutual recognition, familiarity and trust, which reinforce their sense of belonging to the neighbourhood (Lofland, 1998). This repetitive dimension of use distinguishes the market from occasional consumer goods, bringing it closer to other spaces that structure everyday life, such as schools, neighbourhood cafés or squares.

The 'slow pace' of the market is particularly relevant in urban contexts marked by the general acceleration of activities and the growing technological mediation of consumption. It almost becomes reactionary behaviour. While digital platforms tend to dematerialise the shopping experience and reduce social contact, the market preserves a physical and situated urban experience, anchored in physical space and co-presence. This condition contributes to the diversity of urban rhythms and the coexistence of different ways of experiencing the city, which are fundamental elements for urban vitality (Jacobs, 1961).

1.3. Market, sociability and neighbourhood centrality

The social dimension of the municipal market is one of its main contributions to the city of proximity. In addition to being a place to shop, the market functions as a social space, where buying food is intertwined with meeting people, chatting and observing. This everyday sociability, often informal and unscheduled, plays an important role in social cohesion and in building neighbourhood ties (Watson & Studdert, 2006).

Unlike other more controlled commercial spaces, which are uninviting and homogeneous, the market is characterised by the diversity of its users, the overlapping of uses and its permeability to the surrounding urban space. This condition reinforces its role as a neighbourhood hub, capable of generating pedestrian traffic, boosting surrounding commerce, and contributing to the vitality of the adjacent public space (Carmona, 2015). The market thus acts as an urban anchor, not only because of the concentration of supply, but also because of its ability to structure local social life.

In the context of the proximity city, this centrality takes on particular importance. Pedestrian accessibility to the market, combined with the diversity of uses in its surroundings, allows the space to function as a convergence point for everyday activities, reducing the need for long journeys and reinforcing the neighbourhood's autonomy. More than just physical distance, it is the relational density of the market, the intensity of interactions and the frequency of use that sustains its role in the proximity city.

However, this central function is not immune to urban transformation processes. The replacement of fresh produce trading with uses geared towards occasional consumption, catering or tourism tends to profoundly alter the profile of users and the temporality of the space, weakening its connection to the daily lives of residents (González & Waley, 2013). When the market is no longer regularly frequented by the local population, it gradually loses its ability to structure neighbourhood life, becoming a specialised and less inclusive urban destination.

By highlighting the municipal market as everyday infrastructure, a space of slow time and relational centrality, this section conceptually frames the following empirical analysis, where these dimensions will be explored based on specific cases, allowing us to assess how different rehabilitation models reinforce or compromise the role of the fresh produce market in building a city of proximity.

2. Fresh produce markets and local communities: empirical evidence

This empirical analysis does not aim to establish an exhaustive comparison between municipal market models, but rather to illustrate, through two contrasting cases, how different regeneration strategies reinforce or weaken the role of the fresh produce market as a local urban infrastructure.

The selected cases (the Campo de Ourique Market and the Ribeira Market, both in Lisbon, Portugal) show how decisions regarding the programme, management and target audience have a direct impact on daily use, sociability and neighbourhood centrality.

2.1. Daily proximity and neighbourhood centrality: the case of Campo de Ourique Market

The Campo de Ourique Market (*Figure 1*) is a particularly relevant example of a municipal market which, despite a recent renovation process, maintains a functional and social relationship with the daily life of the neighbourhood. Located in a dense, predominantly residential urban area with a strong local identity, the market continues to play a central role in the local food supply, and is regularly visited by residents who mostly travel there on foot.

Figure 1. Campo de Ourique Municipal Market

Source: Lisbon Municipality (https://informacoeseservicos.lisboa.pt/contactos/diretorio-da-cidade/mercado-campo-de-ourique#gallery-1, acessed on 21 December 2025).

The market's refurbishment introduced new uses, namely catering, with the aim of increasing the space's appeal and extending its opening hours. However, unlike more polarised interventions, the trade in fresh produce was maintained as a structural component of the programme. This coexistence allows the market to respond simultaneously to everyday needs, such as food shopping, and to social practices, without losing its main function as a neighbourhood food infrastructure.

The spatial organisation of the market plays a decisive role in this balance. The central layout of the food court forces shoppers to pass through the fresh produce stalls, promoting cross-flows and avoiding functional segmentation of the space (*Figure 2*). This configuration encourages

different groups of people to linger and interact, reinforcing the relational dimension of the market and its integration into the daily life of the neighbourhood. Studies on urban markets show that this overlap of uses is fundamental to the economic vitality and social sustainability of these facilities (Watson & Studdert, 2006).

Figure 2. The proximity between the catering area and the fresh produce stalls

Source: Lisbon Municipality (https://informacoeseservicos.lisboa.pt/contactos/diretorio-da-cidade/mercado-campo-de-ourique#gallery-1, acessed on 21 December 2025).

From the perspective of proximity to the city, the Campo de Ourique Market shows how frequency of use and integration into daily routines are more decisive factors than isolated programmatic diversity. The regular purchase of fresh food, combined with pedestrian accessibility and links to surrounding street shops, contributes to the creation of a lively urban centre, where the market acts as an anchor for the neighbourhood and not just as a specialised destination.

2.2. Occasional consumption and loss of proximity: the case of the Ribeira Market

In contrast, the Ribeira Market (*Figure 3*) illustrates a rehabilitation process which, despite its economic and media success, has resulted in a weakening of the market's role as a local infrastructure. The partial concession of the building to a private operator and the creation of a gastronomic market geared towards catering and tourism have profoundly transformed the functional and social profile of the space.

Figure 3. Ribeira Municipal Market, Lisbon

Source: Lisbon Municipality (https://informacoeseservicos.lisboa.pt/contactos/diretorio-da-cidade/mercado-da-ribeira#gallery-4, acessed on 21 Decenber 2025).

The divide between the traditional fresh produce market and the concession area is particularly evident. The two systems operate almost autonomously, with different audiences, opening hours and operating logic. This separation undermines the idea of the market as an integrated space and significantly reduces the frequency with which local residents use the fresh produce market. Most users of the concession area are occasional visitors, for whom the market functions as an urban destination rather than an everyday facility.

From the perspective of the neighbouring city, this transformation has clear implications. Although the market is located in a central area well served by public transport, its dominant function no longer meets the daily needs of the surrounding neighbourhood. The regular purchase of fresh food has been replaced by sporadic consumption practices associated with leisure and gastronomic experiences. This phenomenon is consistent with processes described in the literature as touristification and gentrification of traditional markets, where economic valorisation occurs at the expense of the social and food function of the facility (González & Waley, 2013).

The change in user profiles and increased economic pressure on traditional retailers have also contributed to the loss of the relational dimension of the market. Relationships of trust and recognition, built up over time through the repetition of everyday practices, have been progressively replaced by ephemeral and standardised interactions. In this context, the market is becoming more of a specialised consumer space than a neighbourhood hub.

2.3. Comparative summary

The two cases analysed show that the contribution of municipal fresh produce markets to the city's proximity depends less on their central location or the architectural quality of their refurbishment and more on maintaining their role as a space for everyday use. The presence of fresh produce markets, pedestrian accessibility, functional integration of uses and frequency of use by local residents emerge as key factors for the urban sustainability of these facilities.

While Campo de Ourique Market reinforces the centrality of the neighbourhood and everyday sociability, Ribeira Market highlights the risks associated with the transformation of markets into urban destinations geared towards occasional consumption. These results reinforce the need to frame interventions in municipal markets within a logic of proximity, recognising them as food and social infrastructures that are fundamental to everyday urban life.

Table summarises the main differences between the two case studies, highlighting how programmatic and management choices directly shape the role of municipal markets as infrastructures of the proximity city.

Table

Comparative synthesis of the two municipal fresh food markets in the context of the proximity city

Analytical dimension	Campo de Ourique Market	Ribeira Market
Dominant function	Everyday fresh food provision	Occasional consumption and gastronomy
Role of fresh food retail	Central and structuring	Residual and marginal
Frequency of use	Regular, embedded in residents' daily routines	Sporadic, linked to leisure and tourism
Main user profile	Local residents	Visitors and tourists
Accessibility	Predominantly pedestrian	Good physical accessibility, limited everyday use
Functional integration of uses	High (fresh food and food services interlinked)	Low (segmentation between traditional market and concession area)
Relational dimension and sociability	Strong, based on repetition and mutual recognition	Weak, characterised by brief and standardised interactions
Relationship with the surrounding neighbourhood	Neighbourhood anchor and everyday centrality	Specialised urban destination
Contribution to the proximity city	Reinforces proximity, centrality and everyday sociability	Weakens the proximity function

Source: compiled by the author.

Conclusion

This article sought to analyse the role of the municipal fresh produce market as a local city infrastructure, based on the premise that daily access to

fresh food is a fundamental aspect of urban life that is often neglected in planning and regeneration policies. By shifting the focus from markets as heritage sites or tourist destinations to their daily functioning, the study contributes to a more situated and socially anchored reading of these urban facilities.

The theoretical framework demonstrated that municipal markets differ from other food supply formats in that they are integrated into the daily rhythms of the city, are accessible on foot, and have the capacity to combine economic and social functions in the same space. As everyday infrastructures, markets operate according to a logic of frequent, small-scale and repetitive purchasing, favouring more sustainable urban practices and a direct relationship between consumption, territory and neighbourhood life. This condition reinforces their role as spaces of "slow time", a relevant counterpoint to the acceleration and dematerialisation of contemporary consumption.

The two empirical cases analysed show that the contribution of markets to the neighbourhood depends less on their geographical centrality or the architectural quality of their renovation and more on the preservation of their daily food supply function. The Campo de Ourique Market illustrates how maintaining fresh produce trade, functional integration of uses and frequency of use by residents can reinforce neighbourhood centrality and local sociability. In contrast, the case of the Ribeira Market demonstrates that rehabilitation processes geared towards occasional consumption, catering, and tourism tend to weaken the proximity function, transforming the market into a specialised and less inclusive urban destination.

These results allow us to draw a key implication for the debate on the city of proximity: proximity is not measured solely in terms of physical distance, but in the intensity and regularity of everyday practices that an urban space supports. A market that is accessible but little used by residents fails to fulfil its function as everyday infrastructure. On the contrary, a market that is regularly frequented, integrated into daily routines and socially recognised contributes significantly to urban vitality and social cohesion.

From an urban policy perspective, it is suggested that municipal fresh produce markets should be recognised as strategic facilities for urban life, rather than merely opportunities for economic or tourist development. Protecting the fresh produce trade, limiting excessive specialisation and paying attention to residents' daily practices are key criteria for ensuring that these spaces continue to serve the local community.

In short, defending the municipal fresh produce market means defending a more walkable city, concerned with short supply chains, more relational and more anchored in the daily lives of its inhabitants. In an urban context marked by inequalities of access, accelerating pace of life and loss of local centres, markets remain discreet but essential infrastructure for building closer, more inclusive and more liveable cities.

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Conflict of interest. The author certify that he doesn't have financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript.

The author received no direct funding for this study

Gonçalves, J. (2026). Municipal markets: from food provision to urban centrality. *Scientia fructuosa, 1*(165), 98–108. http://doi.org/10.31617/1.2026(165)07

Received by the editorial office 10.12.2025.
Accepted for printing 19.01.2026.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)08
UDC 004.8:[330.341.1:334.72=111

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ARTIFICIAL INTELLIGENCE AND INNOVATION IN THE FIRM: CHALLENGES AND THREATS

Artificial Intelligence (AI) is reshaping the competitive landscape and increasingly functions as a crucial driver of innovation and organizational transformation. The interaction between AI and innovation management raises several critical questions concerning strategic business decisions, ethical considerations, and the long-term sustainability of innovative activities. This research aims to develop a conceptual framework that outlines the key challenges and risks associated with the

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ШТУЧНИЙ ІНТЕЛЕКТ ТА ІННОВАЦІЇ НА ПІДПРИЄМСТВІ: ВИКЛИКИ ТА ЗАГРОЗИ

Штучний інтелект (AI) трансформує конкурентне середовище й дедалі більше виступає ключовим чинником інновацій та організаційних змін. Взаємодія між AI та управлінням інноваціями порушує низку критичних питань, що стосуються стратегічних бізнес-рішень, етичних аспектів та довгострокової стійкості інноваційної діяльності. Це дослідження має на меті розробити концептуальну рамку, яка окреслює основні виклики та ризики, пов'язані з впровадженням

adoption of AI technologies in innovation-oriented firms. The guiding research question is as follows: to what extent does current scholarly literature address the challenges posed by the risks associated with implementing AI solutions in the context of sustainable innovation? The foundation of this work is the risk-based approach outlined in the EU AI Act, with particular attention to its differentiated levels of regulatory requirements applied to distinct categories of AI systems. To investigate the existing academic landscape, we conducted a scoping review in accordance with PRISMA standards and established methodological guidelines, relying on the Scopus and Web of Science databases. The research concludes with a discussion of the theoretical and managerial implications derived from the review.

Keywords: Artificial Intelligence, sustainable innovation, EU AI Act.

технологій AI у компаніях, орієнтованих на інновації. Керівне дослідницьке питання сформульоване таким чином: у якій мірі сучасна наукова література розглядає виклики, зумовлені ризиками, пов'язаними з упровадженням рішень AI у контексті сталих інновацій? Підґрунтям дослідження є підхід, заснований на оцінці ризиків, запропонований у Законі ЄС про штучний інтелект (EU AI Act), з особливим акцентом на диференційованих рівнях регуляторних вимог, що застосовуються до різних категорій систем AI. Для аналізу наявного академічного дискурсу проведено скоупінгогляд відповідно до стандартів PRISMA та усталених методологічних настанов, з використанням баз даних Scopus і Web of Science. Дослідження завершується обговоренням теоретичних та управлінських наслідків отриманих результатів.

Ключові слова: штучний інтелект, сталий розвиток інновацій, Закон ЄС про штучний інтелект.

JEL Classification: M13, K34, L21.

Introduction

In recent years, Artificial Intelligence (AI) has become an increasingly relevant force, reshaping business models, industrial dynamics, and innovation systems. The pervasiveness of AI technologies and solutions across heterogeneous sectors has generated unprecedented and unexplored opportunities for productivity, creativity, and innovation, sustainability, and competitiveness, while simultaneously introducing different forms of risk and uncertainty (Brynjolfsson & McAfee, 2017; von Krogh, 2018). Indeed, the existing literature on AI has also stressed its important role in addressing digital transformation and competitiveness (Lee & Falahat, 2019), even if recent studies call for a more responsible approach, by recognizing that technological evolution must align with ethical, social, and environmental imperatives (Stilgoe, 2020; von Schomberg, 2013).

In the field of innovation management, AI is mainly observed as both a technological driver and a source of disruption, by challenging firms to balance efficiency and sustainability (Cockburn et al., 2018; Nambisan et al., 2019) and to face the inevitable transformations. The complex relationship between AI and sustainable innovation is controversial. On one hand, AI supports sustainability goals through process improvement, predictive analytics, and data-driven decision-making (Rohde et al., 2023; Kanellopoulou et al., 2025). On the other hand, its adoption introduces several risks, ranging from ethical bias to environmental externalities, that can undermine its potential to foster long-term sustainability (Floridi & Cowls, 2022; Bolte & van Wynsberghe, 2025). As firms increasingly rely on AI technologies, managing these pressuring tensions is becoming central to

defining and implementing innovation strategies and to adopting governance mechanisms (Stahl, 2021; Owen et al., 2013). In this respect, AI is no longer viewed as a performance-enhancing technology but as a governance challenge by requiring transparency, accountability, and trust (Floridi & Cowls, 2022; Stahl, 2021).

From this underlined perspective, this study aims to provide a conceptual framework for understanding the key challenges and threats associated with AI applications in innovative firms. The research question is as follows: to what extent does current literature delve into the challenges posed by the risk associated with the implementation of AI solutions in sustainable innovation? The starting point of this work is the risk-based framework of the European Union AI Act, which introduces a graduated system of regulation proportional to the level of risk posed by different AI applications, ranging from minimal oversight for low-risk systems to important requirements for high-risk technologies that may affect several rights, safety, and trust (European Commission, 2025). This framework positions the EU as a global pioneer in AI regulation, promoting transparency, accountability, and sustainability.

The study conducts a scoping review based on PRISMA standards and appropriate guidelines (Page et al., 2021), using academic databases Scopus and Web of Science. By analyzing co-occurrence patterns in keywords, abstracts, and titles from a corpus of 314 peer-reviewed papers indexed in Scopus and Web of Science, the research identifies four main thematic clusters:

- ethical and social risks;
- economic and structural risks;
- environmental risks;
- security and governance risks.

The remainder of the paper is structured as follows. Section 1 presents the theoretical background, while Section 2 describes the methodology, outlining the scoping review design. Section 3 discusses the research context and legal aspects, focusing on the EU AI Act and its implications for firms. Section 4 reports the findings, highlighting thematic clusters. Finally, Section 5 discusses the theoretical and managerial implications and outlines directions for future research.

1. Theoretical background

The starting point of our work is twofold, concerning AI challenges and threats (Abbate et al., 2025). By moving from a theoretical perspective, several scientific contributions in the stream of the socio-technical transition theories (Talaviya et al., 2020; Floridi & Cowls, 2022) suggest that innovation systems are shaped not only by technological potential but also by institutional, cultural, and regulatory factors. AI has the potential to accelerate sustainable innovation more than traditional methods (Kanellopoulou et al., 2025; Rohde et al., 2023). This integration could also

introduce critical challenges. While numerous studies have highlighted the positive potential implications of AI technologies and solutions, there remains a pressing need to critically examine its "dark side" (Abbate et al., 2025). In this respect, it concerns particularly how risks, such as ethical, social, or environmental impacts, are theorized, framed, and addressed at the intersection of AI and sustainable innovation (Stahl et al., 2023; Zhao & Gómez Fariñas, 2023; Bolte & van Wynsberghe, 2025). The effective integration of AI within sustainability-oriented frameworks requires navigating these related tensions by balancing efficiency gains with mechanisms of risk anticipation and mitigation (Bolte & van Wynsberghe, 2025).

By assuming a practical perspective, the EU AI Act proposes a risk-based regulatory approach, establishing progressively stringent requirements depending on the potential risks that AI systems pose to fundamental rights (European Commission, 2025). Low-risk applications are subject to minimal rules, whereas high-risk systems must comply with robust measures oriented to ensure transparency, accountability, and trustworthiness (*Figure 1*).

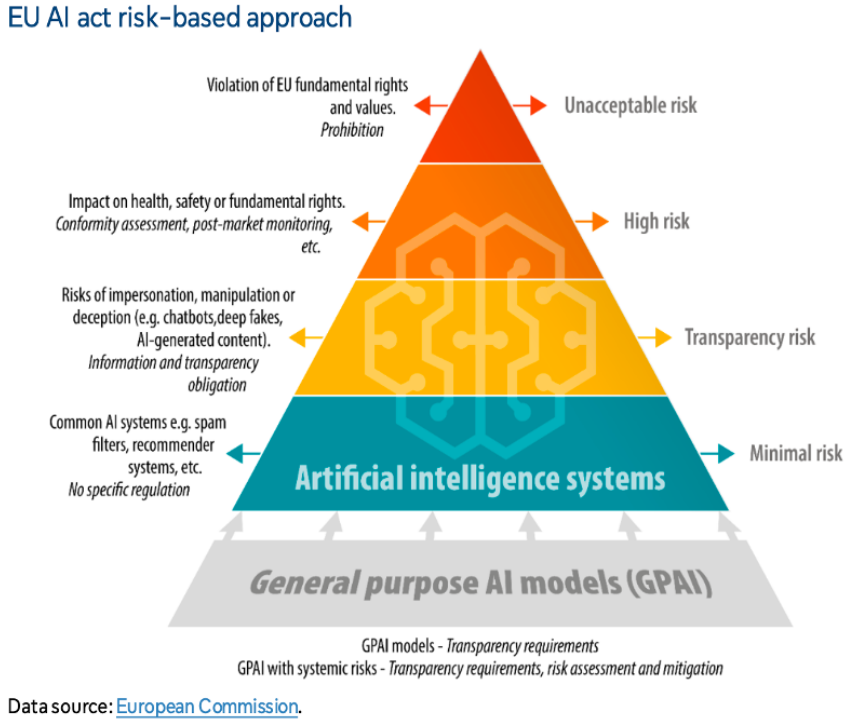

Figure 1. The European AI Act

Source: (European Parliamentary Research Service, 2025. https://epthinktank.eu/2021/11/18/artificial-intelligence-act-eu-legislation-in-progress/ artificial-intelligence).

The responsibilities imposed on developers and users are proportionate to the assessed level of risk, with a clear priority placed on safeguarding individuals' health, safety, and fundamental freedoms. Additionally, trust in AI systems is fostered through documentation requirements and specific disclosure obligations. For instance, users must be explicitly informed when they are interacting with AI technologies and solutions rather

than human beings. By assuming this clear position, the EU can be considered a pioneer in AI governance, potentially shaping international standards and regulatory best practices. Nevertheless, several critical aspects remain, particularly the effective implementation and enforcement of the Act across different EU member states. Divergences in national interpretations and administrative practices may hinder uniform compliance, thus challenging the effectiveness of the risk-based approach and its harmonization across the European single market.

Both theoretical and practical perspectives here underlined converge in highlighting multiple dimensions characterizing the relationship between AI solutions and sustainability. While AI offers transformative potential for advancing sustainable innovation, the associated risks remain scarcely examined within the existing literature. Specifically, the challenges arising from ethical, environmental, social, and technical risks are often acknowledged but rarely investigated in depth. This suggests the existence of a critical gap in current research, by underlining the need for more analyses that consider the dual nature of AI as both an enabler and a potential source of risk. Addressing this gap is essential for improving our understanding of how current studies engage with the complexities of AI implementation in sustainability-oriented contexts. This is directly aligned with the research question addressing our study, oriented to assess the extent to which current researchers theorize, contextualize, and respond to the risks embedded in the adoption of AI-driven solutions for sustainable innovation.

2. Methodology

We conducted a scoping review based on PRISMA standards and guidelines revised for this typology of review (Tricco et al., 2018; Page et al., 2021). The choice here assumed is due to our exploratory research question aimed at mapping key concepts by systematically searching, selecting, and synthesizing existing knowledge (Colquhoun et al., 2014). For data collection, we used academic databases such as Scopus and Web of Science, searching for the string (TITLE-ABS-KEY (risk OR threat) AND TITLE-ABS-KEY (AI solution) AND TITLE-ABS-KEY(sustainable innovation) (last access, Oct. 2025). These databases were opportunistically selected for data collection because they are widely recognized as the most authoritative and comprehensive sources for peer-reviewed research in management and innovation literature. Their rigorous indexing criteria, extensive journal coverage, and citation-tracking capabilities can ensure access to high-quality publications (Podsakoff et al., 2005; Archambault et al., 2009). In addition, their combined use enhances the robustness, transparency, and reproducibility of the scoping review.

The keywords used are strictly related to the research question, and the choice of scoping review is in line with mapping the key occurrences in the study of risks of AI and sustainable innovation research.

We adopt a search strategy designed to ensure access to all relevant publications, without any restrictions in terms of language, publication year, or document type. After an initial screening, based on titles and abstracts, after excluding duplicates, a total of 314 papers were identified.

Then, we used Vos Viewer (Van Eck and Waltman, 2010, 2017) to identify and analyze the main co-occurrences and picture the network. A text – mining analysis of the co-occurrences (using binary counting) in the titles and abstracts was carried out. Out of 9,131 extracted terms, 181 co-occur at least 10 times. Among them, those with greater relevance (60%) were 109. To enhance the interpretability of the map, 14 generic terms were excluded because they provide very little information, such as *topic*, *way*, *focus*, *contribution*, and/or decrease the usefulness of the map, highlighting academic descriptors, such as *article, book, case, chapter, comprehensive review, literature, and future directions*.

2.1. Data visualization

Based on text data (title and abstract), presented in *Figure 2*, the co-occurrence map highlights the issues related to the risks of AI solutions for sustainable innovation that can be traced back to four strongly interrelated clusters.

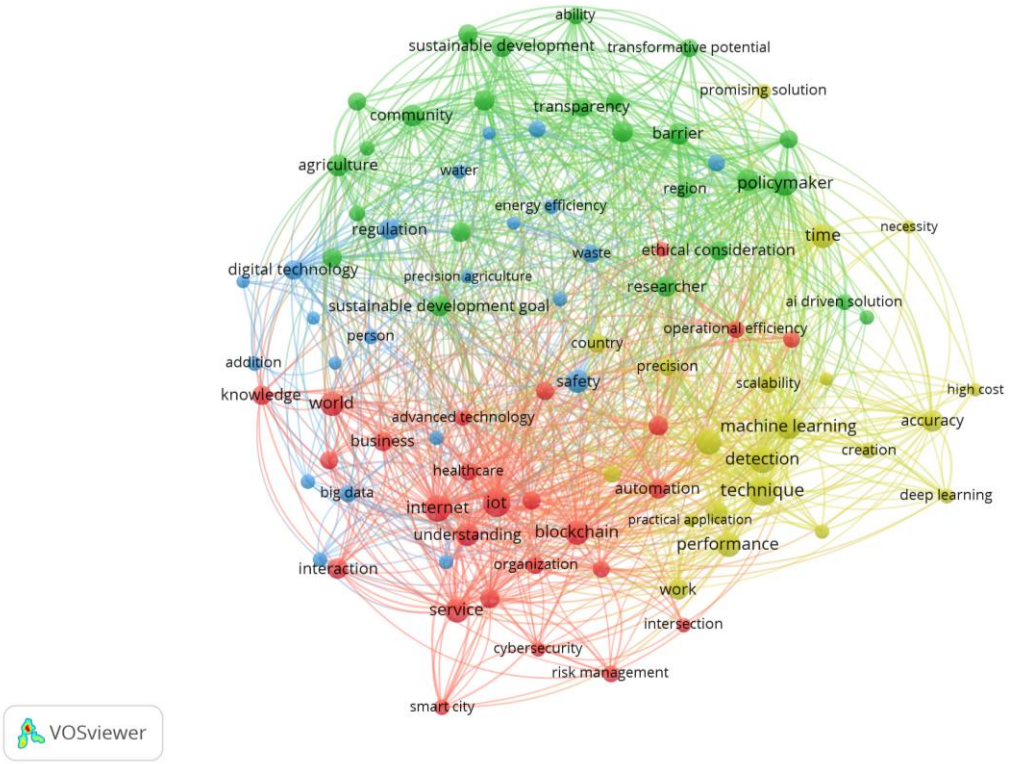

Figure 2. Map of the co-occurrences

Source: elaboration by VOS viewer software.

Each cluster captures specific thematic areas by reflecting the key challenges that innovation for sustainability through AI seeks to address. However, the analysis presented underlines a high degree of interconnection among clusters, suggesting an overarching and integrated research domain rather than isolated clusters.

The central themes that emerged here are broad, encompassing ethical and sustainable development goals (green cluster), safety (blue cluster), precision (yellow cluster), AI application, and advanced technology (red cluster). Surrounding these underlined themes, in recent years, specific fields – such as education, healthcare, finance, and agriculture – have fertilized their studies and practices by adopting digital technologies. These studies show the practical implementations of AI in different contexts and contribute empirical evidence that enriches the studies' conceptual developments and theorizations.

The text analysis here conducted and related to titles and abstracts, illustrated through the overlay visualization of *Figure 3*, reveals how chronologically the focus on AI has progressively shifted from issues strictly connected to technical implementation and development, to issues related to user interaction and the ethical and environmental implications, and more recently to the growing emphasis on *accuracy* (*Figure 4*). This evolution reflects a relevant maturation of the research field, by moving from a technology-oriented perspective to a more holistic, social, and technical understanding of AI within a sustainable innovation context.

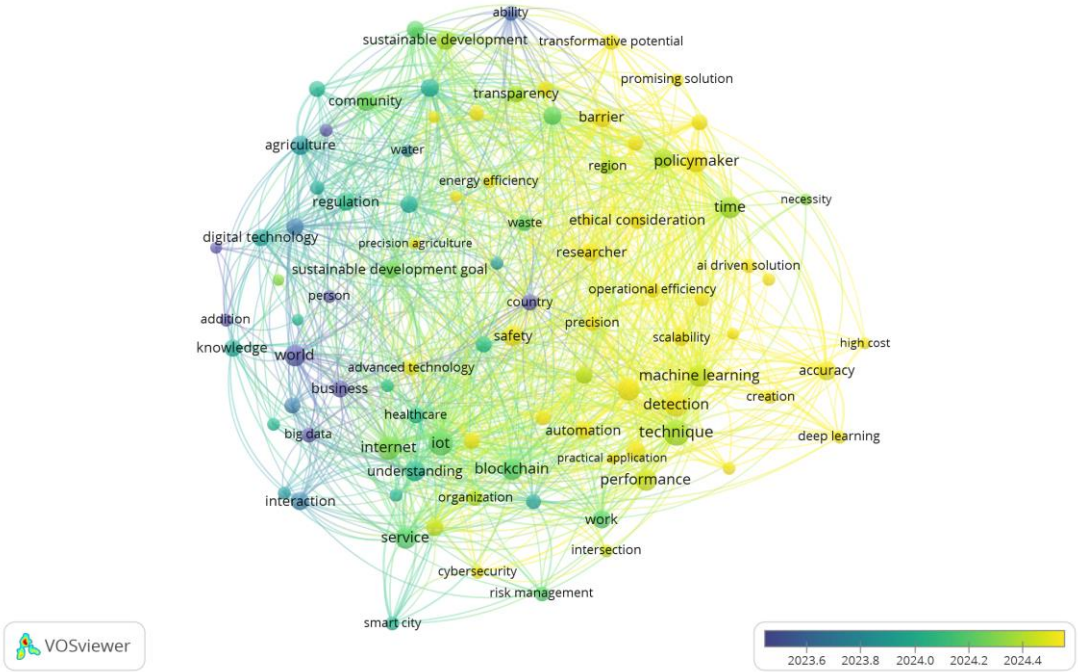

Figure 3. Overlay visualization

Source: elaboration by VOS viewer software.

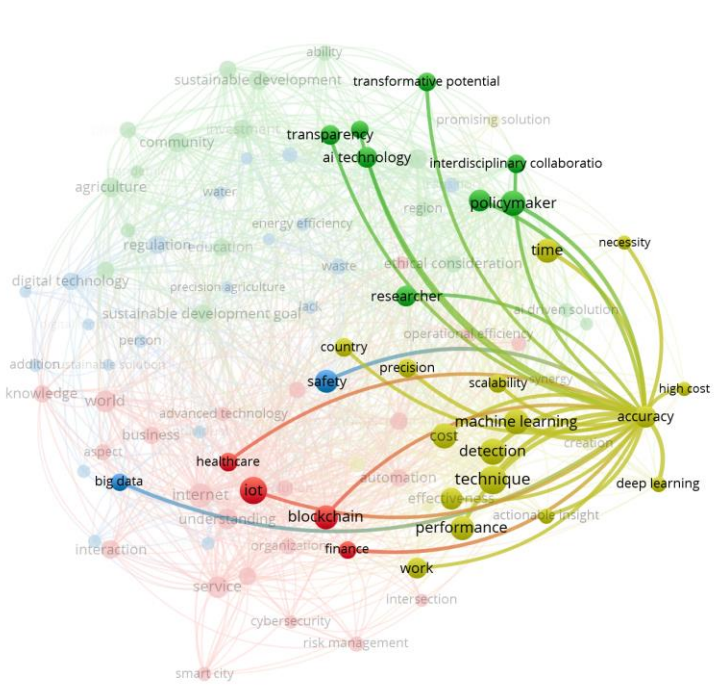

Figure 4. Focus on Accuracy and its links

Source: elaboration by VOS viewer software.

We have chosen to emphasize the term "accuracy" because it seems to characterize the most recent stream of studies, particularly within sectors such as healthcare and finance. This concept frequently emerges in connection with themes including big data processing, the Internet of Things (IoT), security, machine learning, and data-driven policymaking. Building on this observation, the next step of our analysis focuses on the role of regulation and policymaking, addressing the delicate task of governing AI adoption in sustainability-oriented innovation contexts.

3. Research context and legal aspects

The application of AI in tax management and policy highlights both opportunities and challenges (Fidelangeli & Galli, 2021). In general, opportunities are linked with the capacity of AI to examine intricate interactions, helping tax policymakers define more effective strategies and address economic behaviors. Regarding the business ecosystem, there is a connection to the possibility of predicting tax management levels by using models such as decision trees, random forests, and neural networks, while maintaining sustainable tax practices. More precisely, automation can evaluate intricate tax legislation, regulations, and case law to uncover opportunities to optimize and evaluate the tax consequences of business choices, detecting transactions that pose a high risk, forecasting the results of audits, and aiding in crafting efficient defense strategies. In addition to this, data extraction and tax return preparation reduce errors and free tax

professionals for strategic work. In other words, sustainable tax management reduces costs, freeing resources for operational activities (Han et al., 2025). Finally, AI contributes to corporate digital innovation. At the same time, it is important to underline that there are challenges and risks in the variety of corporate behaviors. Indeed, paying attention to the impact on the efficiency of Tax Authorities, the data collected from online users enriches the information technology services, due to the possibility of registering transactions and analyzing them, creating forms of predictive analytics by identifying patterns useful in managing tax assessment. Therefore, tax authorities worldwide have begun to incorporate AI into their auditing and management processes. In fact, those adopting digital technologies early could gain a significant competitive advantage in terms of efficiency by detecting tax fraud and optimizing the revenue collection system. Nevertheless, this peculiar possibility impacts on taxpayers' lives and legal spheres, especially firms, creating a risky challenge because the framework resulting involves their performances and affects a loyal relationship with the Tax Authorities. It is also important to underline the social value of privacy due to the fact that protecting personal data is considered a fundamental right. To summarize, the intersection of artificial intelligence and tax policy creates a sort of connection, where the quest for effectiveness inevitably meets long-standing societal principles regarding fairness and transparency. In this context, the social significance of privacy is not merely an individual concern but affects society as a whole. The European Union's General Data Protection Regulation (GDPR) upholds the essential principle that protecting individuals in relation to their data processing is a fundamental right. The European Union established an innovative regulatory system on artificial intelligence systems (commonly referred to as the AI Act) in early December 2023. The recent intervention balances innovation and rights protection and proposes suitable safeguards to uphold the fundamental rights of taxpayers, considering these new modalities. This cooperative choice guarantees that AI acts as a resource for collective economic benefit by enforcing a uniform interpretation of fairness, instead of serving to unintentionally strengthen current disparities in the interaction.

4. Findings and discussions

The scoping review clearly reveals an interesting evolution trajectory in academic research on AI within the context of sustainable innovation. Recent scientific contributions underline a growing emphasis on the accuracy of evaluation, observing a multidimensional construct encompassing reliability, validity, and quality of the information. Accuracy emerges as a critical bridge between technical performance, ethical governance, and sustainability objectives. However, while existing literature prioritizes accuracy, the broader systemic risks remain scarcely addressed in relation to accuracy, highlighting several gaps for future inquiry.

Consequently, accuracy may become the central lens through which AI is currently theorized and debated in sustainable innovation, providing several opportunities for diverse explorations in terms of methodologies and approaches.

In this perspective, the conceptual framework in this research (*Figure 5*) illustrates the evolving relationship between Artificial Intelligence, Risks/Threats, and Sustainable Innovation. Both AI and Sustainable Innovation contribute to and are shaped by the Risks/Threats (i.e., ethical, economic, environmental, and governance). The arrows show the bidirectional influence: AI enables sustainability goals, yet the risks constrain its potential and implementation.

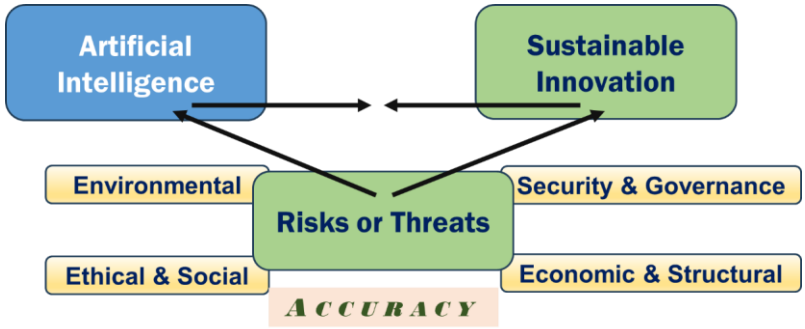

Figure 5. Conceptual framework

Source: elaboration by the authors.

Additionally, AI acts as a strategic enabler. Risks & threats (ethical, economic, environmental, governance) emerge from its implementation. Sustainable innovation applications (energy efficiency, supply chains, agriculture, urban systems) are the outcomes. A bidirectional tension exists between risks and sustainability goals, at the intersection between categories of AI-related risks and the three pillars of sustainability: social, economic, and environmental.

Ethical and social risks, such as unequal access to AI technologies and solutions, lack of social sustainability, can weaken accountability. The "black-box" nature of AI complicates responsibility for decisions with social impact.

Economic and structural risks, including job displacement and market concentration, threaten economic sustainability by constraining inclusive growth and fostering technological dependence on a small number of dominant players.

Environmental risks, such as high energy consumption and e-waste AI infrastructure, challenge environmental sustainability by conflicting with carbon reduction targets and circular economy principles.

Security and governance risks, from data privacy concerns to weak regulatory frameworks, cut across all dimensions by impacting trust and governance mechanisms essential for sustainable development.

5. Conclusions, implications, and future directions

By mapping the existing body of literature, this study contributes to a deeper understanding of how AI interacts with sustainable innovation. The findings underline that while AI can accelerate and drive progress toward sustainability goals, such as optimizing energy use, advancing circular economy practices, or enabling smarter urban planning, its adoption introduces several risks that have concrete implications beyond the technical side. These implycations consider ethical, economic, environmental, and governance domains.

From a theoretical perspective, the study underlines a need for an integrated approach that links technological innovation, ethical governance, and sustainability outcomes. In this respect, accuracy is observed as a core dimension of risk evaluation in sustainable innovation processes and activities.

From a managerial point of view, the results highlight the importance of governance and risk integration to ensure that accuracy supports sustainnability outcomes. Managers must implement governance structures that ensure monitoring and evaluation of accuracy. This requires interdisciplinary teams combining technical, ethical, and sustainability expertise. Companies need to monitor these interactions to implement effective strategies.

Policymakers should focus on regulatory frameworks that ensure transparency and promote equitable access to the benefits of AI.

Future research should deepen the conceptualization of accuracy within the broader framework of sustainable innovation. This entails exploring how accuracy interacts with other dimensions, such as transparency and inclusiveness, and how firms can manage these interdependencies through strategic and operational mechanisms. Further empirical work is needed to assess how accuracy-based risk management influences organizational performance, innovation outcomes, and stakeholder trust across sectors.

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Conflict of interest. The authors certify that they don't have any financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations, or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript.

The authors received no direct funding for this study.

Abbate, T., Accordino, P., Coppolino, R., & La Rocca, E. T. (2026). Artificial intelligence and innovation in the firm: challenges and threats. *Scientia fructuosa, 1*(165), 109–121. http://doi.org/10.31617/1.2026(165)08

Received by the editorial office 11.11.2025.
Accepted for printing 25.12.2025.
Published online on 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)09
UDC 339.13:338.46:[004.4:316.3=111

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TRANSFORMATION OF THE SOFTWARE DEVELOPMENT SERVICES MARKET IN SOCIETY 5.0

The research is due to the structural transformation of the global software development services market, caused by the explosive growth of investments in digital technologies, AI (GenAI) and the shift in demand from the production of abstract IT programs to the requirements of fast, measurable ROI in the context of systemic crises, global imbalances and structural and functional changes in the markets of digital products and services. For the Ukrainian software and digital technologies market, the relevance is increasing in the context of the implementation of the principles of society 5.0, which is determined by global digitalization, the shortage of qualified human resources (Senior experts), and the need to integrate the requirements of the EU AI Act into service contracts and digital products. It is hypothesized that stabilizing the operating margin of service providers is possible through a strategic reorientation of management focus on productized GenAI-offers with a short ROI cycle (4-12 weeks) and priority investments in Data/AI-engineering with increased regulatory compliance of activities. To diagnose the market conditions for software development services, a

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ТРАНСФОРМАЦІЯ РИНКУ ПОСЛУГ З РОЗРОБКИ ПРОГРАМНОГО ЗАБЕЗПЕЧЕННЯ У СУСПІЛЬСТВІ 5.0

Дослідження зумовлено структурною трансформацією світового ринку послуг з розробки ПЗ, спричиненою вибуховим зростанням інвестицій у цифрові технології, ШІ (GenAI) та зміщенням попиту від виробництва абстрактних ІТ-програм до вимог швидкого, вимірюваного ROI в умовах системних криз, глобальних диспропорцій та структурно-функціональних змін ринків цифрових продуктів і послуг. Для українського ринку програмного забезпечення та цифрових технологій актуальність посилюється у контексті імплементації принципів суспільства 5.0, що визначається глобальною цифровізацією, дефіцитом кваліфікованого людського ресурсу (Senior-фахівців) та необхідністю інтеграції вимог EU AI Act у сервісні контракти та цифрові продукти. Висунуто гіпотезу, що стабілізація операційної маржинальності постачальників послуг можлива через стратегічну переорієнтацію фокусу менеджменту на продуктизовані GenAI-пропозиції з коротким циклом ROI (4–12 тижнів) та пріоритетні інвестиції у Data/AI-інженерію з посиленням регуляторного комплаєнсу діяльності. Для діагностики кон'юнктури ринку послуг з розробки ПЗ застосовано комплексний

comprehensive system analysis, corporate benchmarking (Gartner, EPAM), and regional competitiveness analysis (CEE, LATAM) were used. The projected growth of global IT spending to 5.43 trillion. USD dictates the concentration of strategic management decisions on the business processes "finance" and "retail". The results confirm that optimal strategies require a focus on ROI cases and systematic investment in the competencies of IT personnel.

Keywords: software (software), artificial intelligence (AI), service market, market conditions, cloud technologies, projects, project management, digitalization, digital technologies, competitiveness, innovation, Society 5.0..

JEL Classification: L86; C52; M21; O33; F42.

системний аналіз, корпоративний бенчмаркінг (Gartner, EPAM) та регіональний аналіз конкурентоспроможності (CEE, LATAM). Прогнозоване зростання глобальних IT-витрат до 5.43 трлн дол. США диктує концентрацію стратегічних управлінських рішень на бізнес-процесах "фінанси" та "ритейл". Результати підтверджують, що оптимальні стратегії вимагають фокусу на ROI-кейсах та системного інвестування в компетенції IT-персоналу.

Ключові слова: програмне забезпечення (ПЗ), штучний інтелект (ШІ), ринок послуг, кон'юнктура ринку, хмарні технології, проєкти, менеджмент проєктів, цифровізація, цифрові технології, конкурентоспроможність, інновації, суспільство 5.0.

Introduction

The research is due to the structural transformation of the global market for software development services, caused by the explosive growth of investments in digital technologies, artificial intelligence (AI), and the shift in demand from the production of abstract IT programs to the requirements of a fast, measurable ROI (Return on Investment) in the context of systemic crises, global imbalances, and structural and functional changes in the markets of digital products and services. For the Ukrainian software and digital technology market, the relevance is increasing in the context of the implementation of the principles of society 5.0, which is determined by global digitalization, the shortage of qualified human resources (Senior experts), and the need to integrate the requirements of the EU AI Act (2024, June 13) into service contracts and digital products.

Stabilization of operating margins for service providers is possible through a strategic reorientation of management focus on productized GenAI offerings with a short ROI cycle (4–12 weeks) and priority investments in data and AI engineering, along with increased regulatory compliance. The global software development services market is undergoing a profound transformation caused by the explosive growth of the scale of digitalization, the production volumes of digital services and products, investments in AI, especially in generative AI (GenAI) and machine learning operations (MLOps), as well as the implementation of the principles and foundations of Society 5.0 – from the information industry to a human-centered digital society (Fonseca and Palomes, 2026, January 15). Despite the projected growth in global IT spending, digital service and product providers are facing a critical shift in customer expectations: from abstract transformation programs to the demand for rapid, measurable results (ROI). The relevance of the research is enhanced by the complexity of the situation in the Ukrainian IT market, which, while demonstrating the resilience of IT production and IT exports, faces a shortage of highly qualified Senior

specialists and the need to quickly adapt to new international regulatory requirements, in particular the European AI Act (EU AI Act, 2024, June 13).

Thus, the problem lies in the need for a comprehensive analysis and forecasting of market dynamics, monitoring of conditions and factors that determine its situation in the conditions of society 5.0, which will allow software suppliers to develop optimal development strategies, solve issues of effective positioning, choose competitive pricing models and justify the feasibility of investments in technological competencies of IT personnel (Data/AI engineering) to stabilize margins.

A critical analysis of theoretical and applied research in the field of digitalization and development of the IT services and products market indicates a scientific interest in the issues of IT market development and monitoring of factors and conditions that determine its trends and development strategies. In particular, the analysis focused on identifying global trends (AI-adoption, regulation, costs), substantiating AI as the main driver of economic growth was carried out in the works of Gartner (2025, July 15), Craig Hale (2025, July 16), GitHub (2024, October 29), at the same time, the researchers put forward a hypothesis about the possibility of a decrease in the competitiveness of Ukrainian IT companies due to a large-scale war; according to McKinsey analytical reports, AI ceases to be an experiment and becomes the main source of value creation for McKinsey business (2025). Monitoring of the global market and financial results of IT companies was carried out by EPAM (2025, August 7), Accenture (2025, June 20), and Globant (2025, May 15), which proved that the global demand for quality digital services and products is growing.

The issue of ensuring the stability of the IT market and the diagnosis of signs, conditions, and factors of its development, the problem of IT spending growth, and global stagnation is quite seriously worrying the markets. In the Ukrainian context, this is confirmed by the stagnation of IT export volumes, which in the first half of 2025 showed a minimal growth of only 0.1% (3.21 billion USD), stopping at the level of the previous year. Even though the industry provides almost half of all Ukrainian service exports (43%), its stability is under pressure due to unstable dynamics: the June figure of 526 million USD was one of the lowest for the year, which indicates the absence of a stable trend for recovery. Global stagnation is manifested in the reduction of demand in the largest markets, in the USA (a drop of 6.4%) and Israel (by 13.1%). This forces companies to work in conditions of strict cost optimization. Thus, the market faces a double challenge: the need to adapt to internal military risks and overcome the consequences of the global cooling of interest in technological outsourcing (Khandusenko, 2025, August 12; Pikalo, 2025, June 2; Zakhalov, 2025, July 31). The focus of scientific interest to ensure sustainable economic growth in the context of overcoming the consequences of global crises through the implementation of social transformations from Industry 4.0 to Society 5.0 was formed by Mazaraki et al. (2020). Diagnostics of Ukraine's competitive position in the global IT market are

provided by TECHVIFY (2025, February 7), Inno8world (2025, July 23), ScaleupAlly (2025, April 1), FullStack Labs (Jackson, 2025, October 1). The regulatory environment for the functioning of the IT market was analyzed by White & Case (Hickman et al., 2024, July 16).

The arguments presented allow us to state that currently in the scientific community there are no studies of the root causes and the impact of factors on the stagnation of the Ukrainian IT market (loss of qualified personnel, difficulties with sales in wartime, changes in the structure of customer demand); insufficient attention has been paid to the diagnosis of structural changes, in particular, the problem of reorientation of companies from classical outsourcing to AI, GenAI and other high-margin areas; no analysis of the impact of AI on the business models of companies and their development strategies has been carried out. Instead, the presented scientific discourse has formed a theoretical framework for interpreting the global trend of digitalization, and AI has been substantiated as a technological basis for building Society 5.0.

The existing scientific research also does not consider the peculiarities of the functioning of the Ukrainian IT market, which is focused on the outsourcing of IT products and risks remaining an "executor" rather than an "architect" of the global digital socio-economic society. The promising task of IT companies in the current conditions is to move from performing technical tasks to participating in the creation of comprehensive, human-oriented solutions that meet the principles of Society 5.0.

The aim of the research is to substantiate the theoretical and applied principles of forming an adaptive strategy for the development of IT service providers, based on the results of diagnostics of the global and national market situation, scenario modeling until 2027, and taking into account the transformational effects of the concept of Society 5.0.

To achieve the aim, the following tasks were formulated and solved:

- Diagnostics of the state and conditions of the software development services market at the global and national levels were carried out.
- Benchmarking of software development markets was carried out according to key indicators of the effectiveness of the functioning of IT markets by countries of the world.
- Scenario forecasting of the short-term strategy of a software development company until 2027 was substantiated.
- Strategic recommendations were developed for IT service providers in the context of the formation of Society 5.0, structural changes, and transformations.

The research is based on the hypothesis that the IT sector of Ukraine has a positive impact and is of strategic importance for the country’s economy; The strategic success of IT service providers in the conditions of Society 5.0 will be determined not so much by absolute export volumes, but

by their ability to transition from the category of "Outsourcing Performers" to the category of "Leading Suppliers" by forming their own product strategy, implementing AI technologies, integrating the principles of responsible AI into the business processes of companies, and flexibly adapting the business models of companies to the new market conditions of the global digital space.

The research methodology is based on a comprehensive analysis of data from primary sources, including statistical data from Gartner, McKinsey, and ISG Index; financial reports of leading IT companies (Accenture, EPAM, Globant); and official data from the NBU and IT Ukraine Association. The methods of strategic analysis, comparative benchmarking of software development markets, and scenario forecasting of market development were used.

The main part of the article is divided into three sections. The first reveals the current state and global market conditions of the software development services market, highlights the impact of the Society 5.0 concept and investments in artificial intelligence on the dynamics of global IT spending, and also diagnoses the level of resilience of the Ukrainian IT sector in the context of a systemic crisis. The second is devoted to comparative benchmarking of key global IT markets in terms of hourly rates, human resource potential, English language proficiency, and regulatory compliance, which allows us to determine Ukraine's competitive position in the regional dimension. The third section substantiates a scenario forecast of the development of the IT market until 2027 and develops strategic recommendations for service providers on adapting business models to the requirements of the EU AI Act, integrating MLOps, and using cloud marketplaces to increase operating margins.

1. Analysis of the software development services market

The global software development services market in 2025 is in a phase of sustained recovery after the correction of 2023–2024. According to Gartner (2025, July 15) (*Figure 1, 2*), global IT spending in 2025 should exceed USD 5.43 trillion (+7.9%), with the data center infrastructure segment remaining the growth leader – primarily due to the boom in artificial intelligence; at the same time, spending on application software is growing at double-digit rates. This directly fuels the demand for cloud modernization, building Data platforms, MLOps, and security by default. At the same time, leading analysts warn: generative artificial intelligence in large companies is moving from a peak of excessive attention to moderate expectations – some of the initiatives in 2024 did not bring the expected ROI, so budget decisions are being made more carefully and in relation to quickly measurable results (Craig Hale, 2025, July 16).

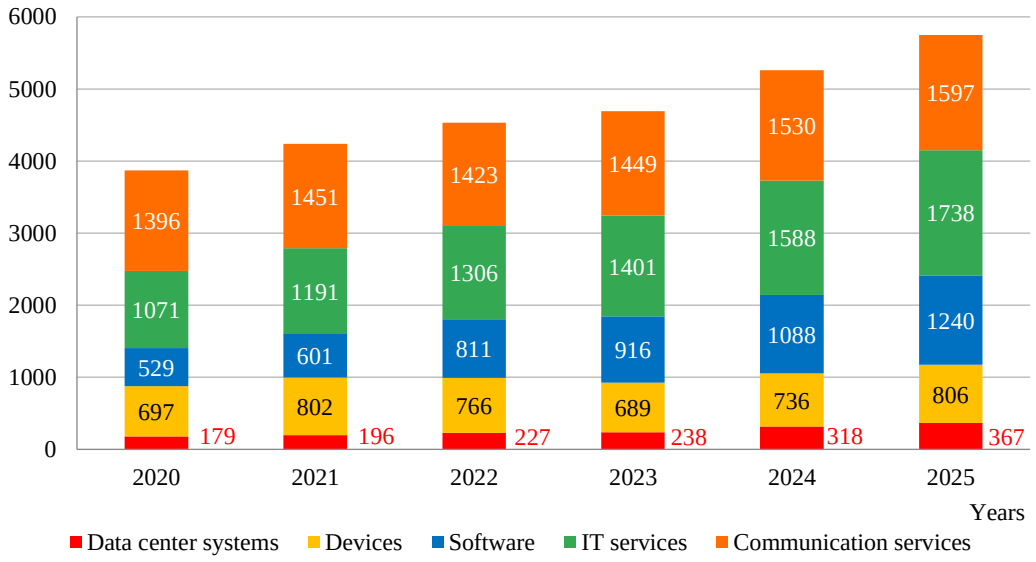

Figure 1. Global IT services spending, 2025,
in USD millions

Source: Compiled by the authors based on Gartner (2025, July 15).

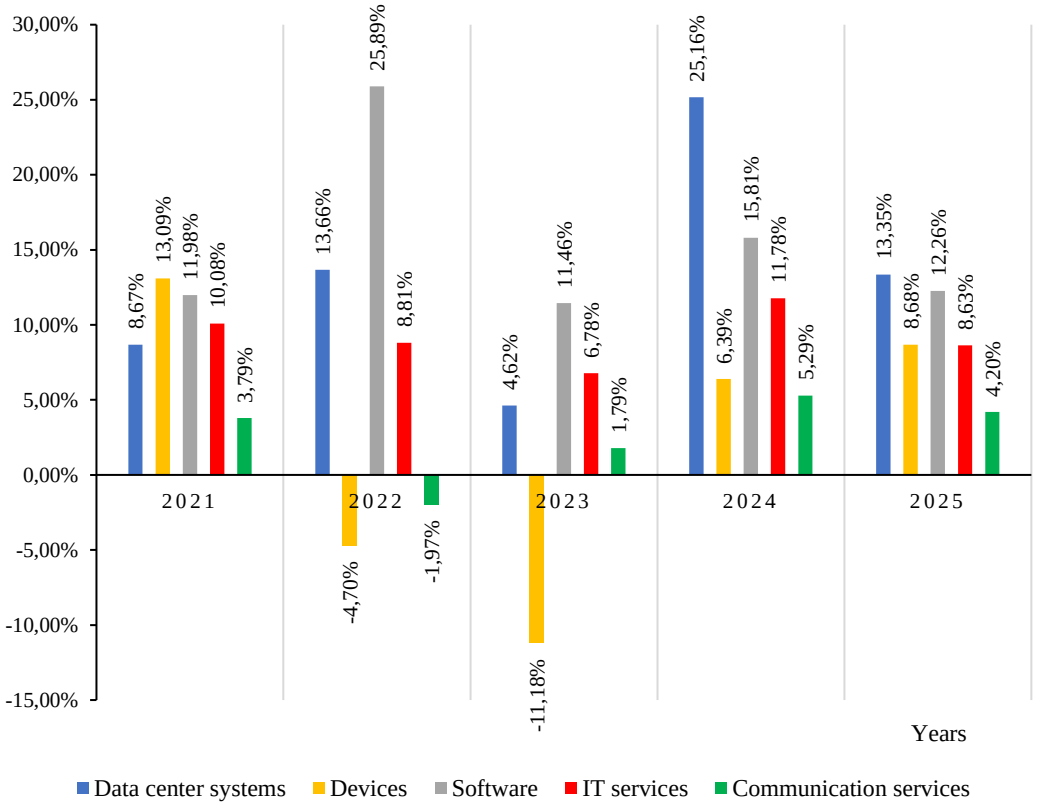

Figure 2. Level of IT service spending worldwide, 2025, %

Source: Compiled by the authors based on Gartner (2025, July 15).

Corporate benchmarks confirm the recovery of effective demand for engineering services with a clear trace of artificial intelligence. Accenture estimates USD 17.7 billion in revenue (+8%) from IT services in Q3 2025, of which USD 1.5 billion is for generative artificial intelligence projects (Accenture, 2025, June 20). Analysts directly point to a shift in client priorities towards implementations that accelerate productivity and reduce costs. Engineering and service players demonstrate a similar dynamic: EPAM increased revenue to USD 1.3 billion in the second half of 2025 (+18%) (EPAM, 2025). Globant (2025) recorded USD 0.6 billion in revenue in Q1 2025 (+7%). Collectively, these signals indicate that corporate customers are resuming medium and large-scale modernization programs with an emphasis on artificial intelligence components.

The Ukrainian market segment remains resilient despite high uncertainty (*Figure 3*, *4*). In the first half of 2025, IT services exports amounted to about USD 3.21 billion, which is 0.1% more annually than in 2024 (IT Ukraine Association, 2025, August 12; Handusenko, 2025, August 12). Monthly dynamics confirm a "flat" corridor with seasonal fluctuations: in April – USD 569 million (local peak of the year) with a seasonal decrease of -5% in subsequent months, which is explained by the dynamics of new contracts; the share of IT services in all services exports in the first half of 2025 increased to 43% (Pikalo, 2025, June 2; Zakhalov, 2025, July 31).

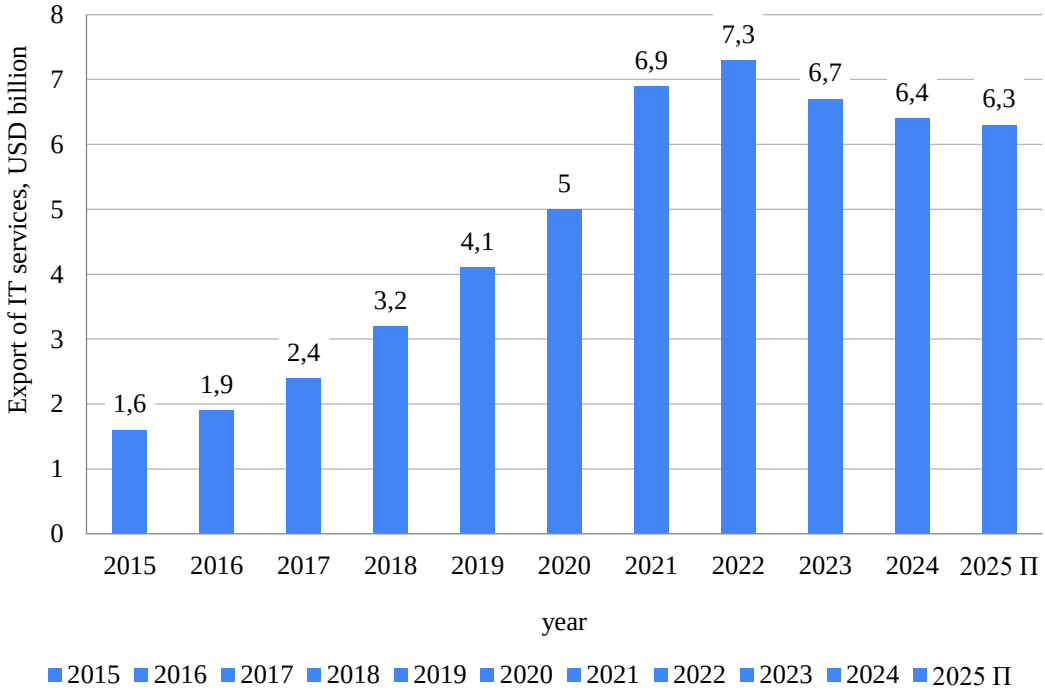

Figure 3. Dynamics of IT services exports from Ukraine, USD billion, 2015–2025

Source: Compiled by the authors based on NBU (2025, August).

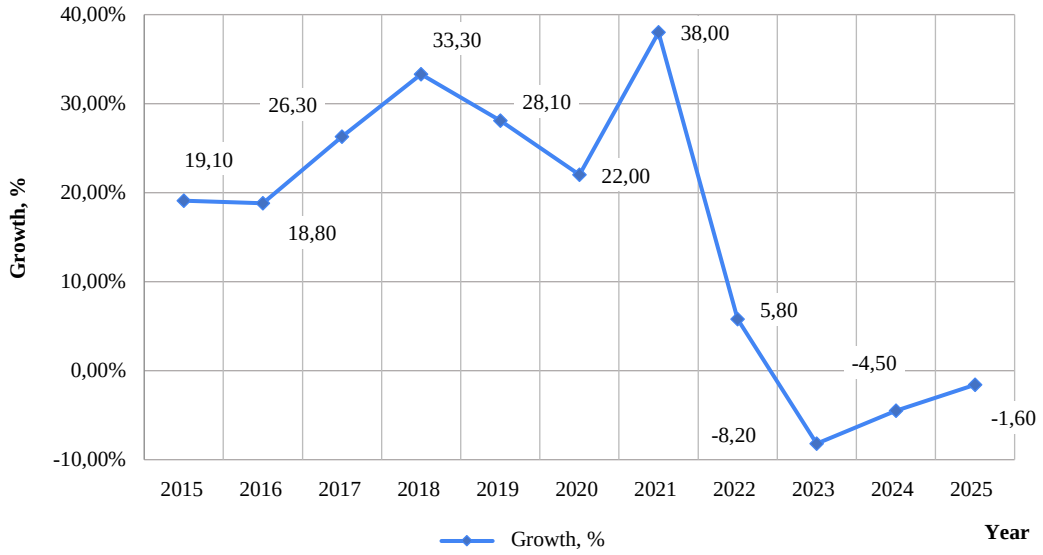

Figure 4. Dynamics of IT services exports from Ukraine, %, 2015–2025

Source: Compiled by the authors based on NBU (2025, August).

The demand structure in 2025 is more pragmatic and result oriented. The typical trajectory of deals – from a short Discovery to a Minimum Viable Product/Proof of Concept (MVP/PoC) with subsequent phased scaliresult-oriented reducing the risks of expectations mismatch and quickly recording the effect in the performance metrics of the software development life cycle (SDLC). Application scenarios of generative artificial intelligence (integration of the Large Language Model (LLM) (Federico et al., 2025, April 29) into internal services, knowledge automation), building and "landing" of Data-Foundation, MLOps/observability, and data and model protection come to the fore. According to McKinsey research, 78% of organizations are already using artificial intelligence in at least one business function; most often in IT, development, marketing, and sales, which correlates well with the growth of RFPs for data platforms and LLM tooling (McKinsey, 2025, March 19).

The labor market supply has stabilized, but "senior" roles in Data/ML, Platform/Cloud, DevSecOps (Development, Security, & Operations), and SRE (Site Reliability Engineering) remain scarce. Public salary cuts record the convergence of medians and a gradual normalization after the turbulence of 2022–2023. According to DO, the median for Middle-level developers is kept at around USD 2,500 "on hand", while in QA in the summer of 2025, the average payment increased to around USD 2,200. When interpreting these indicators, it is important to consider that DOU surveys reflect a cross-section of active IT market participants and are not official statistics but remain the most representative open source for quarterly dynamics (DOU, 2025, July 31).

The pricing environment in 2025 demonstrates a wide inter-regional range of rates, and this is what shapes the competitive niches of suppliers. According to specialized guides and benchmarks, the spread of hourly rates for teams and specialists ranges from approximately USD 20–50/h in some countries of the Asia-Pacific region (APAC) to USD 35–70/h in the Latin American region (LATAM) for mid-levels, while in Central and Eastern Europe (CEE) (in particular, in Ukraine, Poland, Romania) the "median" corridor for most roles lies in the range of USD 25–60/h, with higher values for Senior/Lead and for AI/LLM competencies (TECHVIFY, 2025, February 7; Inno8world, 2025, July 23). In Western Europe and North America, rates are significantly higher; for mid-sized and enterprise-class projects, US providers often operate in the range of approximately USD120–250/h and higher (ScaleupAlly, 2025, April 1; David Jackson, 2025, October 1).

The technology landscape highlights why AI competencies have become systemic. GitHub reports a 59% increase in contributions to AI projects and a 98% increase in new AI projects in 2024 (GitHub, 2024, October 29). These markers reflect the instrumentalization of AI in the daily practice of teams – from code generation and automated documentation to building Retrieval-Augmented Generation (RAG) architectures on top of vector knowledge bases.

The regulatory background in the EU significantly affects the requirements for service contracts and proposals. The European AI Act (EU) 2024/1689 (AI Act, 2024, June 13) entered into force in August 2024 and is being applied in stages: from February 2025, prohibited practices and AI literacy requirements will be in effect, from August 2025, the obligation for general-purpose models to comply with the Global Partnership on Artificial Intelligence (GPAI) will be in effect, while some of the requirements for high-risk systems will be implemented in 2026–2027 (Hickman et al., 2024, July 16). An analysis of the current state of the software development market in the world and Ukraine is summarized in *Table 1*.

Table 1

Strategic diagnosis of the software development market in Ukraine and worldwide as of 2025

Block	Indicator	Value	Description of impact
Global Market	Global IT Spending 2025	$5.4 trillion (+7.9% YoY)	Growth driven by data centers (AI infrastructure) and software; demand for modernization, data platforms, MLOps, and security
	Growth Segments 2025	Data Centers: +42% YoY; Software: +11% YoY (Gartner estimates)	AI servers and infrastructure drive CAPEX boom; Software sees double-digit growth driven by embedded AI
Corporate Benchmarks	Accenture (Q3 2025)	Revenue $17.7 billion (+8%); GenAI revenue $700 million in Q3 2025	AI orders peak; shift to measurable ROI cases; steady demand for AI-enabled digital engineering
	EPAM (Q2 2025)	Revenue $1.3 billion (+18%) in Q2 2025	
	Globant (Q1 2025)	Revenue $0.6 billion (+7%) in Q1 2025	

End of Table 1

Block	Indicator	Value	Description of impact
Market in Ukraine	IT Services Exports H1 2025	Revenue $3.2 billion in H1 2025; share in all services exports – 43%	AI orders peak; shift to measurable ROI cases; steady demand for AI-enabled digital engineering
	Salaries (Summer 2025)	Middle Software Engineer: $2,500 net; QA mid: $2,200 net	Normalization after 2022-2023; Data/ML, Cloud/Platform, DevSecOps, SRE shortfall
Technology Demand	Global Adoption of Artificial Intelligence (McKinsey Survey)	78% of organizations use AI in at least one business function	Most often, AI is used by organizations in IT and marketing-sales, fuels RFPs for Data platforms and LLM integrations
	Community Activity (GitHub Octoverse 2024)	+59% contributions to GenAI projects; +98% number of such projects; Python is the #1 language on GitHub	Confirms the instrumentalization of AI in the daily practice of teams
Prices and developers' labor rates	Hourly Rate Ranges (Estimated)	APAC regions: $20–45/hr; CEE: $45–70/hr; LATAM: 35-70 USD. US/h; NA: $120-$250. US/h	Wide interregional dispersion forms niches; a premium for LLM competencies
Regulatory field (EU)	AI Act – Implementation Stages and Penalties	Starting August 2024; Prohibited Practices February 2025; GPAI & Governance August 2025; High-Risk AI Systems August 2026; Fines up to €35 million or 7% of turnover	Increases requirements for transparency, data, and model documentation, security; affects contract terms and compliance
Stage of the GenAI cycle	Market Expectations	Moving from peak hype to "moderate expectations"	Some of the 2024 initiatives did not deliver the expected ROI; the priority was to quickly achieve measurable results

Source: compiled by the authors.

A combination of factors forms a cautiously optimistic forecast for 12–24 months. At the global level, investment cycles are recovering, but customers demand a quick materialization of the effect of AI productivity. In Ukraine, IT exports retain their endurance, moving in a narrow corridor. Growth is most likely to occur in niches where AI is an applied "module" of processes, in data platforms, and automation of service operations – if attention is paid to security and compliance issues.

It is most rational to build the focus of software development service providers where there is already tangible solvent demand. According to the International Data Corporation (IDC), in 2024, the three largest consumers of the public cloud – banking, software development, and retail – together provided about USD 190 billion in spending; in 2025, these verticals remain the "anchors" of demand. Geographically, North America and Europe remain the top priorities; however, the Middle East and North Africa (MENA) region is seeing acceleration, with IT spending growing by nearly 9% in 2025 and reaching USD 169 billion in 2026, according to Gartner; the fastest growth is in data center systems (estimated at +69% in 2025). This is directly fueling demand for core modernization, cloud analytics, and enhanced

security across finance, retail, manufacturing, and government across the EU and UK, as well as the Gulf Cooperation Council (GCC) region (UAE, Saudi Arabia).

The value proposition should directly reflect a rapid return on investment (ROI) against the backdrop of overall growth in IT budgets and cloud consumption. Gartner expects total IT spending to exceed USD 723 billion in 2025 (+21.5%). This means that customers are willing to pay for data platforms, MLOps, and built-in security with a measurable impact on a 4–12 week time horizon. "Discovery – MVP" trajectories with clear KPIs (such as Digital Operational Resilience Act (DORA), Mean Time to Repair (MTTR), Cost-To-Serve) and productized packages of the "Data Foundation in 8–10 weeks" or "MLOps-Ready in 6–8 weeks" level work best for this, replacing abstract "resource" sales with concrete business value.

Pricing and contract models should be linked to customer benefit and minimize friction in the procurement phase. For projects with high uncertainty, a Time and Materials (T&M) model with an upper "ceiling" is appropriate; for recurring tasks – Fixed-Fee model; for mature areas, elements of result-oriented agreements (bonus for achieving agreed metrics). Cloud marketplaces additionally accelerate the deal cycle: according to the Total Economic Impact assessment for AWS Marketplace, suppliers selling through the marketplace reduce procurement stages by 45%, speed up the sales cycle by approximately 40%, and increase the share of won deals by 27%.

Investments in competencies should reflect the real structure of demand. Today, 78% of organizations already use artificial intelligence in at least one function, and in the structure of global IT spending, data center systems are growing the fastest precisely because of the load of artificial intelligence.

Security certifications directly affect access to Enterprise tenders and compatible sales with hyperscalers. A public and up-to-date dossier of controls, policies, and audit trails significantly increases conversion at the Due Diligence stage and reduces the time spent by the client on inspections.

Partnerships with cloud vendors and independent software vendors (ISVs) have become an independent growth channel. According to Canalys, sales through hyperscale marketplaces will reach USD 45 billion in 2025 and USD 85 billion by 2025. USD 16 billion in 2028 (already doubled to USD 16 billion in 2023). According to 2025 surveys, 89% of companies are currently transacting in at least one marketplace, and 59% are seeing higher win-rates in co-sale deals – but without process discipline, these benefits are difficult to scale.

Accordingly, the optimal strategy for a software development service provider in 2025–2027 is to focus on verticals with the largest cloud budgets (banking, IT, retail) in the EU, the UK and North America with targeted initiatives in the Arabian Peninsula markets; a transition to productized offerings with a measurable effect in a 4–12 week horizon; contractual models that remove unnecessary procurement barriers; and systematic investments in Data/AI engineering and compliance.

Benchmarking analysis (*Table 2*) indicates that the Central and Eastern European region (Poland, Romania, Ukraine) currently provides the best balance of cost and capacity in IT markets. Typical rates for mid-level engineers here are in the range of approximately USD 45–70 (Poland: USD 50–70/h; Romania: USD 45–65/h; Ukraine: USD 45–65/h). The quality of communication is confirmed by the EF EPI index: Poland has 588 points, Romania has 593, and Ukraine has 535. According to the Corruption Perceptions Index (CPI 2024), Poland has 53 points (53rd place), Romania has 46 (65th), and Ukraine has 35 (105th), which correlates with the difference in regulatory risks. The Peace Index (GPI 2024) records relatively stable conditions in Poland (32nd place) and Romania (36th) and a high security risk in Ukraine (159th place). At the same time, this particular cluster has a high human (staff) development potential: approximately 400–650 thousand developers in Poland, 200–250 thousand in Romania and about 302–346 thousand IT employees in Ukraine; time zones conveniently overlap with the EU (7–9 common working hours) and partially with North America (1–4 hours). For compliance, it is important that Poland and Romania, as EU countries, are naturally compatible with the General Data Protection Regulation (GDPR), while Ukraine works through standard contractual mechanisms, such as the Data Processing Annex and Standard Contractual Clauses (SCC), DPA, and industry security standards.

Table 2

Benchmarking results for software development markets in key countries

Location	Typical rates, USD/hour (Middle)	*EF EPI* 2024 (score)	*CPI* 2024 (score/rank)	*GPI* 2024 (rank)	Estimated talent availability	Overlap hours with CET / ET	Compliance
Ukraine	45–65	535	35 / 105	159	302–346k in IT	7–8 h / 1–2 h	Non-EU; GDPR via SCC/contracts
Poland	50–70	588	53 / 53	32	400–650k developers	8–9 h / 3–4 h	EU; full GDPR compliance
Romania	45–65	593	46 / 65	36	200–250k developers	7–8 h / 2–3 h	EU; full GDPR compliance
Portugal	19-48	605	57 / 43	7	230k IT professionals	8–9 h / 4–5 h	EU; full GDPR compliance
India	18–30	490	38 / 96	116	15.4m IT professionals (GitHub)	1–2 h / 0–1 h	Non-EU; widespread ISO/IEC 27001
Vietnam	28–35	498	40 / 88	97-108	530–560k IT professionals	1–2 h / 0 h	Non-EU; active implementation of ISO 27001
Brazil	40–65	466	34 / 107	131	630k	3–5 h / 8–9 h	Non-EU; compliance via ontracts/SOC/ISO

Source: compiled and calculated by the authors.

Asian hubs vary significantly in profile. India offers the lowest rates among major locations (USD18–30/hr.; average USD 29.4) and the largest

talent pool in the world (estimated 15.4 million developers on GitHub), but has a more modest EF EPI[1] score (490), an average CPI score[2] (38; 96th place), and a lower overlap of working hours with Europe and the US. Vietnam maintains a price corridor of USD 28–35/h. (average USD 31.8), EF EPI: 498, and CPI: 40 (88th place), and is in the third quartile of the GPI[3] 2024 rating; at the same time, the market is growing rapidly and has about 530–560 thousand IT professionals. In both countries, security standards are typically confirmed through ISO/IEC 27001, which is an acceptable standard for most corporate procurement.

South America, in terms of benchmarking, is a compromise between cost and time zones for US customers. In Mexico, Brazil, and Argentina, typical rates for mid-level specialists are in the range of USD40–65/h, with Argentina having a relatively higher level of English proficiency (EF EPI: 562) compared to Mexico (464) and Brazil (466). The CPI/GPI risks are moderately higher here (e.g., Mexico – 26 points CPI and 138th place in GPI), but the talent pools are significant: Brazil alone is estimated to have around 630k developers. A key advantage is the large overlap with the ET time zone (8–9 shared hours), which reduces transaction costs for communication.

From a compliance perspective, the situation is relatively simple: in EU countries (Poland, Romania, Portugal), "Out-of-the-Box" within the framework of GDPR is in effect; outside the EU (Ukraine, India, Vietnam, South American countries), standard contractual instruments and security certifications are required. In addition, according to ISO Survey 2023, the number of ISO 27001 certificates in EU countries is growing significantly (for example, an additional 1.782 certificates in Poland, 3.184 in Romania, and 2.672 in Portugal per year), which simplifies admission to regulated tenders.

2. Strategic recommendations for IT service providers in the context of the formation of Society 5.0, structural changes, and transformations

Based on the analysis, a short-term forecast and development scenario for 6–12 and 12–24 months is presented. As of September 2025, the market for software development services for service providers is determined by three interrelated trends. First, the general acceleration of IT spending

[1] The EF English Proficiency Index is the world's largest annual ranking of countries and regions based on the English proficiency of adults, published by the education company EF (Education First). It serves as an important international standard, using data from the free EF SET test to assess average proficiency levels and compare nations, ranking them by proficiency level (from Very High to Very Low).

[2] The Corruption Perceptions Index (CPI) is an indicator that has been calculated by the international organization Transparency International since 1995.

[3] The Global Peace Index is a ranking of peaceful countries by the Institute for Economics and Peace.

continues; second, budgets are noticeably redistributed in favor of cloud solutions and cybersecurity; third, expectations from the "revolutionary" nature of artificial intelligence projects are leveling off to more pragmatic ones. The scenario framework is formed by expectations of market dynamics (according to Gartner, total IT spending in 2025 is expected to be USD 5.43 trillion (+7.9%), end-user spending on public cloud at USD 0.7 trillion (+21.5%), which directly supports the demand for data modernization, MLOps implementation, and security enhancement. Also, Gartner's forecast of information security spending growth to USD 213 billion in 2025 (from approximately USD 193 billion in 2024) effectively establishes the "mandatory" nature of cyber controls in contracts and tenders. The outsourcing channel confirms this picture with real orders. According to the Information Services Group Index (ISG Index), in Q3 2025, the "combined" market (Managed Services + Anything as a Service (XaaS) grew in actual monetary value (ACV – Actual Cash Value) by 17% to USD 29.2 billion. The driver was cloud XaaS models (+28%), while Managed Services added only +2%. In Europe, over the same period, the combined market grew by 14%, but a decline of 4% was recorded in managed services, indicating caution with long transformation programs and the preference for shorter work waves.

The results of leading integrators confirm the recovery of demand, albeit uneven: Accenture in Q3 2025 had USD 17.7 billion in revenue and USD 19.7 billion in future contracts, of which $ 1.5 billion was for generative artificial intelligence. The market interprets these figures as normalization after the wave of pilots. EPAM in Q2 2025 grew by 18% to USD 1.3 billion, and Globant in Q1 2025 showed USD 0.6 billion in revenue (+7%) and an operating income margin of 8.2%, which is a guideline for "healthy" service margins.

The labor market, ahead of the conjuncture, demonstrates mixed dynamics. According to CompTIA, in June 2025, employers opened 455 thousand technical vacancies (about 47% of them were posted in June), while IT unemployment was held at around 2.8% – an annual low. At the same time, Indeed Hiring Lab records that ads for developers in the US remain 36% below the level of the beginning of 2020, which reflects a combination of cyclical factors and structural shifts (automation, artificial intelligence tools, normalization after the peak of 2021–2022). For IT product providers, this means demand for senior roles and platform competencies is increasing, and internal replacement of middle and junior positions at clients is recovering more slowly.

Another early indicator is the capital expenditure of hyperscalers. Alphabet/Google has raised its 2025 capital investment plan to approximately USD 85 billion; Microsoft's quarterly capital investment is approaching $30 billion; Amazon is targeting $118 billion for the year, with Amazon Web Services (AWS) leading the way. Dell'Oro estimates that data center infrastructure spending in Q1 2025 grew 53% year-on-year. Such investment levels directly correlate with the flow of Request Proposals (RFPs) for cloud engineering, migrations, data platform building, and

security hardening. Over the 6–12-month forecast horizon (mid-2026), the baseline scenario assumes a stable or moderately growing flow of RFPs with a shift towards short MVPs/PoCs with clear KPIs. After strong ACV in Q2 2025 and weaker Managed Services in Europe, it is reasonable to expect a 0–10% increase in cloud/XaaS requests due to AI use cases and unchanged budgets for classic transformations. Rates in the CEE region are likely to remain flat with a possible increase of 0-3% (typical ranges according to Indexed: Poland USD 50-70/h., Romania USD 45–65/h, Ukraine USD 45–65/h), while prices in Asia remain the lowest. The expected workload of the teams is about 77–83% (working "norm"), gross and operating margins, without sharp changes, which is consistent with the benchmarks of public companies (Globant operating income margin: 9% for 2025; EPAM: 9% for 2025). With this configuration, the average margin of the portfolios is more likely to stabilize in the range of 1 bp with a gradual increase in the cloud component.

The optimistic scenario for 12–24 months (mid-2027) is based on three drivers: sustained growth in cloud spending, increased security budgets, and increased private capital in the AI and cybersecurity sector. The forecast for public clouds is USD 723.4 billion in 2025 (+21.5%), and cybersecurity is about USD 213 billion. According to ISG, the growth rate of XaaS is about 21%, and ACV in Q2 2025 set a historical maximum. On the venture investment side, according to Crunchbase, global financing is recorded at $91 billion in Q2 2025 (+11%), with deals dominated by the AI sector. In North America, AI startups raised USD 34.5 billion in Q2 2025, and cybersecurity attracted USD 9.4 billion in the first half of 2025. US dollars. In such a situation, the volume of RFPs may increase by 15–25%, rates increase by 5–8% in scarce competencies (Data/ML, Platform, Security), workload shifts to the range of 82–88%, and operating margin expands by 1–3 bp due to better workload and productized service packages.

A stress scenario is possible in the event of budget cooling or a wave of skepticism about the real ROI from projects in the artificial intelligence sector. The following signals are already noticeable: –4% in Managed Services in Europe in Q2. 2025, muted demand for technical vacancies on Indeed (–36% compared to the level of the beginning of 2020) and spot bookings at large integrators (for example, a decline of 6–7% year-on-year at Accenture in Q3 2025). In this case, RFPs fall by 10–20%, workload is reduced to 70–76%, and margins are compressed by 1–3 pp. This can be partially compensated for by cloud marketplaces and result-oriented models that reduce the procurement cycle and increase the probability of winning even in the "cool" phase of the market.

To avoid "blind" movement, it is advisable to maintain a regular panel of key indicators. An indicator of demand for services is the volume of RFP/ACV according to the ISG Index (globally and by region). For a quick sense of the labor market, it is worth monitoring the number of active vacancies in CompTIA reports (in June, about 455 thousand) and the Indeed Hiring Lab index trends (the software category is still -36% to the base).

The budget "ceiling" is set by Gartner estimates for the public cloud (USD 723.4 billion, +21.5%) and cybersecurity (USD 213 billion), and the "shoulder" of long programs is the capital expenditures of hyperscalers for 2025 (Google about USD 85 billion; Microsoft – USD 90 billion; Amazon USD 118 billion). An additional predictor is venturing capital investments: USD 91 billion of global financing in Q2. 2025, USD 34.5 billion for AI startups, and USD 6.5 billion for cybersecurity in North America in Q2 2025 – all of which indicate where the next corporate initiatives will come from. The analysis by strategy is summarized in *Table 3*.

Table 3

Scenario forecasting of the short-term development strategy of a software development company until 2027

Indicator	Current signal	Scenarios for 6–24 months		
		Basic	Optimistic	stressful
Demand (RFP/ACV, ISG)	Combined ACV Q2 2025: +17% year-on-year	0–10% growth (short MVP/PoC)	15–25% growth (scaling of artificial intelligence cases)	10–20% decline (pause in long programs)
Demand model (XaaS vs MS)	XaaS: +28% year-on-year; MS: +2% (EU: –4%)	XaaS dominates; MS recovers slowly	20%+ growth in XaaS; productized packages	Postponement of large MS; shift to marketplaces
Hourly rates (CEE region)	USD 45–70/hour	0–3% growth	5–8% growth	Decrease of 0–3%
Team workload, %	80	77–83	82–88	70–76
Presence of corporate culture in teams, value orientation, %	75	72–78	77–85	68–71
Portfolio operating margin	Benchmark for public companies: 9% in 2025	±1 bps	+1–3 bps	-1–3 bps
Cloud and security (budgets)	Public Cloud: USD 723.4 Billion; Cybersecurity: USD 213 Billion	Sustained Prioritization	Expanding "Default" Controls	Selective Cloud Pauses; Security Is Inertial

Source: compiled and calculated by the authors.

Therefore, until early 2026, it is worth focusing on the basic trajectory – moderate growth with a focus on short, measurable work with flexible rates. Over the horizon of 12–24 months, demand is likely to increase, thanks to the infrastructure wave of the AI cloud and a steady increase in cybersecurity budgets. In the event of a deterioration in the macro background or a decrease in the strategic potential of AI projects, the best response should be productized packages, marketplaces, sales channels, and result-oriented flexible business models that shorten the approval cycle and stabilize margins.

Conclusions

The current stage of global economic development is characterized by the formation of a new social and economic paradigm – Society 5.0, in which advanced technologies, in particular artificial intelligence (AI),

the Internet of Things (IoT), and robotics, are integrated into all sectors and industries of the economy to solve complex social and economic problems. The software development services market plays a key role in this transformation, acting as the main driver and tool for implementing the principles of Society 5.0. The global software development services market is in a phase of accelerated growth driven by investments in AI. The projected growth of IT spending to USD 5.43 trillion (+7.9%), together with the rapid expansion of the data center infrastructure segment (+42%) indicate the formation of a new wave of technological transformation, where AI is becoming the main driver of its development. The Ukrainian IT market maintains structural stability in the conditions of a systemic crisis and full-scale war. Despite the minimal growth in services exports (+0.1% in the first half of 2025), the share of the IT sector in total services exports reached 43%, which confirms the strategic importance of the industry for the country's economy.

There is a significant transformation of the demand structure in the context of the implementation of result-oriented models with an emphasis on rapid return on investment. The typical trajectory has become "Discovery – MVP/PoC – phased scaling" with clear KPIs, which allows minimizing risks and demonstrating a tangible effect in the planning horizon of 4–12 weeks. The competitive position of Ukrainian companies in the regional dimension of the global market remains stable. The range of rates of 45–65 USD/h for mid-level specialists is competitive, and the existing human potential of Ukraine (302–346 thousand specialists) and technological expertise allow maintaining market positions.

Regulatory changes, particularly the European AI Act, are forming new requirements for the quality of IT services and products (Alejandra, 2025, February 14). The gradual introduction of requirements for transparency, documentation, and security of AI systems creates additional barriers, but at the same time opens opportunities for companies that can adapt quickly. The most promising areas of strategic development for IT companies are productized offers in the field of cloud technologies, MLOps, and cybersecurity. The forecast of growth in spending on public cloud technologies in the world to USD 723 billion (+21.5%) and cybersecurity to USD 213 billion indicates the significant potential of these markets.

Scenario forecasting indicates stable development of the IT market in the medium term. The base scenario assumes a growth in demand of 0–10% with a focus on short MVP/PoC projects, while the optimistic scenario can provide an increase of 15–25% by scaling successful cases in the field of AI.

To achieve strategic success in the new conditions, Ukrainian IT service providers are recommended to focus on implementing the principles of Society 5.0, developing a product approach, deepening expertise in the field of AI and digital security, and intensifying work through cloud marketplaces to shorten sales cycles and increase competitiveness in the market.

The development of research on the transformation of the IT market in the Society 5.0 ecosystem along defined strategic directions will contribute to the improvement of existing methodologies, increasing the efficiency of technological innovations, and ensuring a flexible response to relevant feedback from the business environment:

- monitoring of regulatory impact: detailed study of the long-term consequences of the full implementation of the EU AI Act (2026–2027) on the operating models of Ukrainian service companies, in terms of compliance costs for high-risk AI systems;
- transformation of human capital: study of the dynamics of changes in the requirements for the competencies of IT specialists (Data/AI engineering, MLOps) and development of methodological approaches to adapting higher education educational programs to new market needs in conditions of a shortage of Senior specialists;
- evolution of business models: analysis of the effectiveness of the transition of Ukrainian IT companies from the classic outsourcing model to a "product-oriented" service and integration into global cloud marketplaces as a tool for stabilizing margins in the face of global stagnation;
- industry specification: in-depth analysis of the implementation of human-oriented technologies of Society 5.0 in specific verticals of the economy (finance, retail, healthcare), where the largest increase in IT spending and the most pronounced effect from the use of generative AI are expected;
- scenario adjustment: verification and refinement of the developed market development scenarios until 2027, considering the actual pace of recovery of global investment cycles and changes in the security situation in Ukraine.

Further development of these issues will allow for the formation of a stable scientific and practical basis for strengthening the competitive positions of the Ukrainian IT sector as the architect of the future digital, social, and economic society.

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Conflict of interest. The authors certify that they don't have no financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations, or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript. Given that one of the authors is affiliated with the institution that publishes this journal, which may cause potential conflict or suspicion of bias, the final decision to publish this article (including the reviewers and editors) is made by the members of the Editorial Board who are not the employees of this institution.

The authors received no direct funding for this research.

Bosovska, M., & Pilyukov, A. (2026). Transformation of the software development services market in society 5.0. *Scientia fructuosa, 1*(165), 122–141. http://doi.org/10.31617/1.2026(165)09

Received by the editorial office 12.11.2025.
Accepted for printing 24.12.2025.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)10
UDC 004:339.138]:615.1:659.126=111

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DIGITAL MARKETING STRATEGIES FOR CORPORATE PHARMACEUTICAL BRANDS

The article examines the features and development of the pharmaceutical market in Ukraine. The hypothesis is formulated that the choice of digital marketing strategies and tools, digital platforms, and services for the development of corporate brands of pharmaceutical companies should be based on brand positioning, considering the specifics of the activity, market segment, and stage of the consumer journey in this segment. To test the hypothesis, a complex of general scientific and special research methods was applied, during which the subjects of the pharmaceutical market were distributed according to the stages of the economic process "production-distribution-exchange-consumption" and market segments B2B and B2C. Key external environmental factors for pharmaceutical companies have been identified: political, economic, demographic, and technological. Three strategic groups of corporate brands of industrial pharmaceutical companies are identified according to the criteria of "tradition – innovation" and "specialization – scale": large-scale universal brands, specialized innovative brands, and large-scale traditional brands. The balance between these strategic groups of industrial brands creates competitive conditions for the sustainable technological development of the industry. Key tools for implementing image, conversion, and reputation strategies in digital marketing for pharmaceutical companies have been identified: website improvement, web analytics, search marketing, digital

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СТРАТЕГІЇ ЦИФРОВОГО МАРКЕТИНГУ КОРПОРАТИВНИХ ФАРМАЦЕВТИЧНИХ БРЕНДІВ

Досліджено особливості й розвиток фармацевтичного ринку в Україні. Сформульовано гіпотезу, що вибір стратегій та інструментів цифрового маркетингу, цифрових платформ та сервісів для розвитку корпоративних брендів фармпідприємств має базуватися на позиціонуванні брендів з урахуванням специфіки діяльності, ринкового сегмента та етапу шляху споживача у даному сегменті. Для перевірки поставленої гіпотези застосовано комплекс загальнонаукових та спеціальних методів дослідження, у ході якого розподілено суб'єкти фармацевтичного ринку за етапами економічного процесу "виробництво–розподіл–обмін–споживання" та ринковими сегментами B2B та B2C. Окреслено ключові чинники зовнішнього середовища для фармацевтичних підприємств: політичні, економічні, демографічні, технологічні. Виділено три стратегічні групи корпоративних брендів промислових фармацевтичних підприємств за критеріями "традиції–інновації" та "спеціалізація–масштаб": масштабні універсальні бренди, спеціалізовані інноваційні бренди, масштабні традиційні бренди. Баланс між стратегічними групами промислових брендів формує конкурентні умови для стійкого технологічного розвитку галузі загалом. Виділено ключові інструменти для реалізації іміджевої, конверсійної та репутаційної стратегій цифрового маркетингу фармацевтичних підприємств: покращення роботи вебсайту, вебаналітика, пошуковий маркетинг, цифрова реклама, автоматизація маркетингу, контент-маркетинг, маркетинг у соціальних медіа,

advertising, marketing automation, content marketing, social media marketing, and mobile marketing. Digital platforms and services for B2B and B2C markets have been systematized for use by industrial pharmaceutical companies to develop corporate brands, using the See, Think, Do, Care digital consumer journey model. Strategic digital marketing measures have been proposed for selected strategic groups of corporate brands of pharmaceutical companies, using the digital marketing tools, digital platforms, and services systematized in the article. A differentiated approach to brand development in the digital environment has been applied, ensuring transparency, evidence-based communication, and personalization, and, as a result, strengthening trust in corporate brands.

Keywords: digital environment, digital marketing, digital marketing strategies, pharmaceutical industry, pharmaceutical companies, brand management, corporate pharmaceutical brands.

мобільний маркетинг. Систематизовано цифрові платформи та сервіси для ринків B2B та B2C для використання промисловими фармацевтичними підприємствами для розвитку корпоративних брендів, з урахуванням моделі цифрового шляху споживача See, Think, Do, Care. Для виділених стратегічних груп корпоративних брендів фармацевтичних підприємств запропоновано стратегічні заходи цифрового маркетингу, з використанням систематизованих у статті інструментів цифрового маркетингу, цифрових платформ і сервісів. Застосовано диференційований підхід до розвитку брендів у цифровому середовищі, що забезпечує прозорість, доказовість і персоналізацію комунікації, та, як наслідок, підсилює довіру до корпоративних брендів.

Ключові слова: цифрове середовище, цифровий маркетинг, стратегії цифрового маркетингу, фармацевтична промисловість, фармацевтичні підприємства, бренд-менеджмент, корпоративні фармацевтичні бренди.

JEL Classification: I11, O30, L10, M30.

Introduction

Digital marketing is becoming a crucial tool for the strategic management of corporate pharmaceutical brands, particularly in the context of increased competition and a high level of regulatory policy influence on the pharmaceutical market. The integration of digital technologies into the marketing processes of pharmaceutical companies (PCs) opens new opportunities for interaction with stakeholders and changes approaches to communication and sales. In such conditions, there is a need for systematic research and justification of digital channels, platforms, and services, tools for implementing digital marketing strategies, and developing corporate brands of PCs.

Research over the past 20 years indicates a sustained interest among scientists in finding effective means of promoting medicines in the digital environment and identifying its impact on consumer behavior, in particular: using advertising (Huh & Becker, 2005; Koinig et al., 2017), social networks (Kim, 2022), messengers (Ge et al., 2023), web analytics (Alperstein, 2024), etc.

The works of scientists are currently aimed at identifying the attitudes and awareness of pharmacists regarding the use of digital tools in the activities of FPs (Sakhnatska et al., 2023), as well as substantiating the need to utilize digital channels and technologies in the marketing of pharmaceutical brands. In particular, the studies are devoted to: digitalization of marketing processes of commodity pharmaceutical brands; the use of websites and online advertising in the sales of prescription and non-prescription medicines (Melnychenko, 2024); modeling of advertising

campaigns of medicines (Dalyk et al., 2024); substantiating an integrated marketing approach to strategic marketing management using digital tools to promote pharmaceutical brands in the international market (Chunikhina & Prus, 2025) and others.

The analysis of scientific literature allowed us to identify features in studies related to the development of pharmaceutical brands in the digital environment: the main attention is paid to the promotion of commodity pharmaceutical brands; There is no clear structure of pharmaceutical market participants; the directions of using digital technologies in marketing are outlined without systematizing digital marketing strategies and tools; brand positioning is not taken into account when justifying digital marketing activities.

The aim of the research is to substantiate a differentiated approach to the selection of digital marketing strategies and tools for the development of corporate brands of pharmaceutical companies in the digital environment.

To achieve this aim, it is necessary to solve the following main tasks: identify the features and highlight the factors of development of the pharmaceutical market in Ukraine; systematize the entities of this market based on current legislation, taking into account the stages of the economic process and market segments B2B and B2C; formulate value propositions, positioning of corporate brands of pharmaceutical companies, identify their strategic groups; systematize digital marketing tools, digital platforms and services by stages of the consumer's digital journey for market segments B2B and B2C; justify strategic digital marketing measures for the development of the brands under study.

To achieve this aim, a hypothesis has been formulated that the choice of digital marketing strategies and tools, digital platforms, and services for the development of corporate brands of pharmaceutical companies should be based on brand positioning, taking into account the specifics of the activity, market segment, and, accordingly, the stage of the consumer journey in this segment.

To test the hypothesis, the following general scientific and special research methods were used: analysis and synthesis, induction and deduction, systemic, structural analysis, comparison (to formulate the purpose of functioning, identify key factors of the external environment, identify pharmaceutical market entities; to identify strategic groups of corporate brands of industrial pharmaceutical enterprises; to systematize digital platforms and services, digital marketing tools for their justified choice by corporate brands, taking into account the specifics of the activities of pharmaceutical enterprises, based on a differentiated approach to positioning); graphic (to build a positioning map of the brands under study); logical generalization (to substantiate strategic measures for brand development and formulate conclusions from the research).

The research is made up of regulatory and legal acts of current legislation in Ukraine in the field of regulating the pharmaceutical market, domestic and foreign scientific sources, in particular from the scientometric database Scopus, industry and official corporate websites of pharmaceutical companies, data from the State Statistics Service of Ukraine, financial reporting data of pharmaceutical companies from the open database Opendatabot, forecast data on the development of the Ukrainian economy for 2025 from the National Bank of Ukraine, the Ministry of Economy of Ukraine, the World Bank, the Ukrainian Institute of the Future, forecast data on the development of the domestic market of medicines from the Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine together with Proxima Research International.

In two sections of the main part of the article, the purpose of the functioning of the pharmaceutical market is defined, and the subjects of this market are systematized, for the most important of which, namely, industrial pharmaceutical enterprises, a differentiated approach to the development of corporate brands is justified. This approach includes the division of enterprises into strategic groups based on the specifics of their activities and brand positioning. This allows for a well-founded choice of digital marketing tools, digital platforms, and services for each stage of the consumer's digital journey in the B2B and B2C markets for the implementation of digital marketing strategies and relevant measures.

1. Features and development of the pharmaceutical market in Ukraine

The activities of pharmaceutical market enterprises as business entities are regulated by the legislation of Ukraine, in particular the Constitution of Ukraine, the Commercial Code of Ukraine, the Laws of Ukraine "On Medicinal Products", "On Consumer Protection", "Fundamentals of the Legislation of Ukraine on Health Care", "On Licensing of Types of Economic Activities", the Resolution of the Cabinet of Ministers "On Approval of the Licensing Conditions for Conducting Economic Activities in the Production of Medicinal Products, Wholesale and Retail Trade in Medicinal Products, Import of Medicinal Products (Except for Active Pharmaceutical Ingredients)" and other regulatory legal acts. Analysis of documents ("On Medicines", 2025, June 5; "On Consumer Rights Protection", 2024, December 12; "Fundamentals of the Legislation of Ukraine on Healthcare", 2025, September 27; "On Licensing of Types of Economic Activities", 2025, October 31; "On Approval of the Licensing Conditions for Conducting Economic Activities in the Production of Medicines, Wholesale and Retail Trade in Medicines, and Import of Medicines (Except for Active Pharmaceutical Ingredients) ", 2025, October 2) allowed us to formulate the main goal of the functioning of the pharmaceutical market as a

management system – providing the population with high-quality, effective, safe and affordable medicines through regulated interaction between business entities, the state and consumers in accordance with the requirements of the current legislation of Ukraine. The achievement of this goal is ensured through the coordinated activities of business entities of various forms of ownership, state regulatory and control bodies, as well as consumers in the processes of production, import, export, wholesale and retail sale of pharmaceutical products in accordance with the requirements of the legislation and industry standards adapted to the legislation of the European Union: GMP (Good Manufacturing Practice) – good manufacturing practice, GDP (Good Distribution Practice) – good distribution practice (wholesale trade), GPP (Good Pharmacy Practice, Good Pharmaceutical Practice) – good pharmacy practice, which concerns the provision of services to the population. The main purpose of the GMP standard is to establish requirements for the production and quality control of medicines, which provides guarantees of their compliance with quality and safety standards. The main purpose of the GDP standard is to regulate the rules for the storage and transportation of medicines to maintain their quality at all stages of wholesale trade. The GPP standard defines the quality standards of pharmaceutical services provided to the population in pharmacies, including the provision of recommendations and assistance to patients ("On Medicines", 2025, June 5).

The pharmaceutical market is closely and inextricably linked with the healthcare sector, in which the following key functions are implemented: social – providing quality medical services to the country's population based on quality medical education, in particular in the training of specialists in the field of pharmacy and industrial pharmacy; economic – developing the pharmaceutical market, eliminating obstacles to the movement of goods – medicines, medical devices, cosmetics, dietary supplements; security – providing guarantees for sustainable supply chains, compliance with regulatory policy, guaranteeing the quality and safety of drugs for patients, ensuring uninterrupted access to medicines (Apteka.ua, 2025, September 15). Based on the above, as well as based on the key stages of the economic process "production-distribution-exchange-consumption", a distribution of pharmaceutical market entities in the digital environment is proposed, considering the B2B and B2C market segments (*Figure 1*).

Industrial enterprises in such a distribution are the fundamental production element. Subsequent entities carry out actions aimed at the distribution, exchange, and consumption of products of industrial enterprises. From the point of view of marketing activities, the stages of distribution and exchange involve the use of marketing promotion and sales channels. At the consumption stage, it is possible to obtain feedback for manufacturing enterprises, which is the basis for improving products and adjusting their

output in the production process. The process of interaction between entities of the pharmaceutical market at the stages of production, distribution, exchange, and consumption is cyclical and requires systematic maintenance and increasing its efficiency, taking into account the regulatory influence of the state and the capabilities of digital platforms and services that improve the customer experience at the stages of the consumer's digital journey.

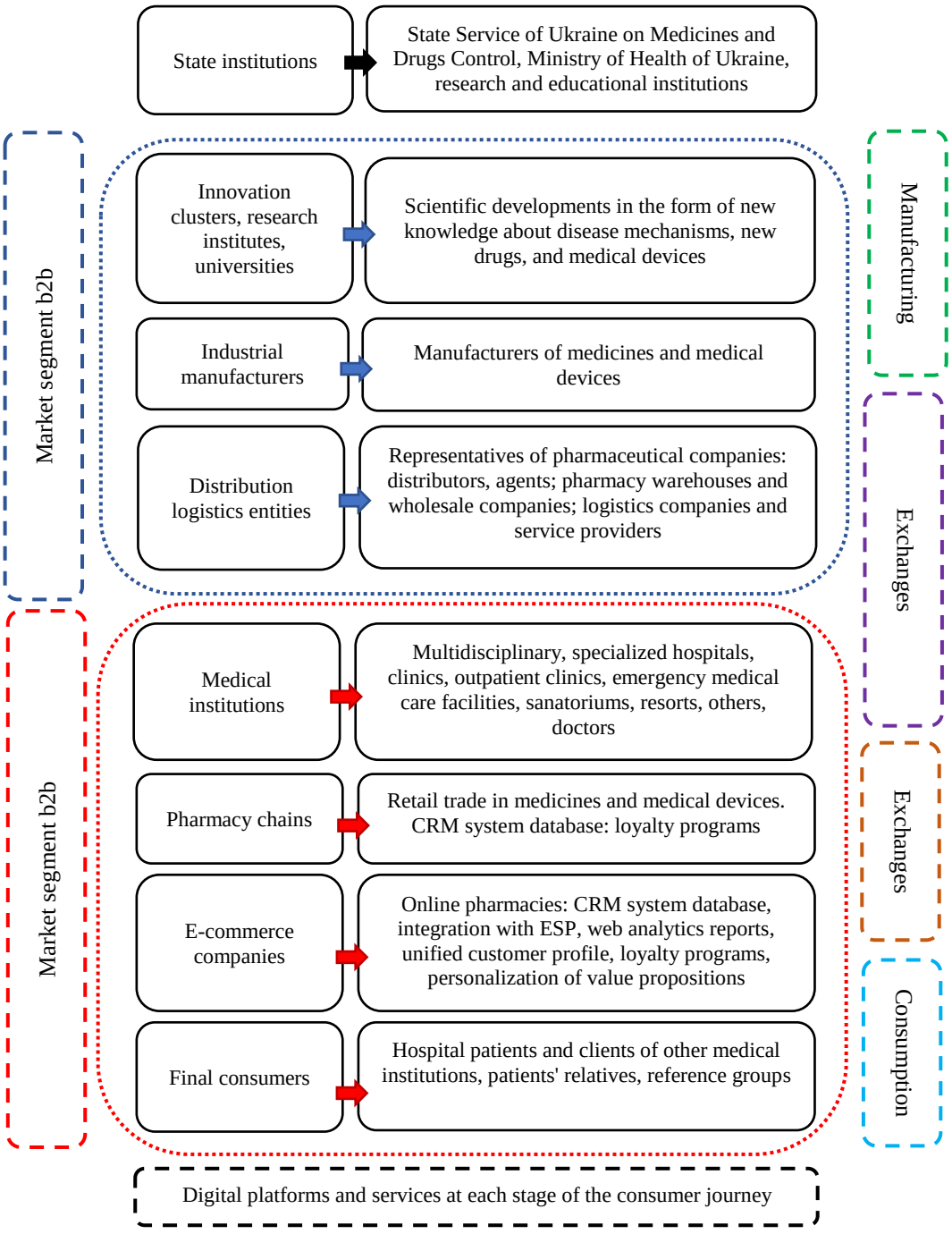

Figure 1. Pharmaceutical market players

Source: compiled by the author.

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The development of the pharmaceutical market is significantly influenced by external factors, such as political, economic, demographic, and technological factors. Political factors are manifested through the regulatory influence of the state on the pharmaceutical market. Economic factors are due to the outstripping development of the pharmaceutical market compared to the development of the country's economy. Thus, the National Bank of Ukraine (NBU) has worsened the forecast for the growth of the Ukrainian economy in 2025: according to its assessment, real GDP will grow by 2.1%. The Ministry of Economy of Ukraine has set 2.7% in the draft State Budget for 2025. The IMF has left the estimate at 2–3%. The World Bank estimates the growth of the Ukrainian economy in 2025 at 2%. The most pessimistic forecast is provided by the Ukrainian Institute of the Future – 1.8% (Apteka.ua, 2025, September 15). According to the moderate forecast for the development of the Ukrainian pharmaceutical market, developed by the Institute of Cybernetics named after Glushkov of the NAS of Ukraine together with specialists from Proxima Research International, the volume of pharmacy sales of medicines will increase by 16.1% in 2025, and by 15.5% in 2026 (Apteka.ua, 2025, September 15).

The key demographic and economic factors for the development of the pharmaceutical market in Ukraine in 2025 include:

- a total increase in the consumption of medicines by 20% in national currency (by 13% in dollar terms), while in real terms, a decrease of 0.5% is recorded (for the period January–August 2025). Since government spending covers 13% of the total consumption of medicines, their main consumers are patients. Even with the restoration of wage growth rates to the pre-war level, the negative impact on consumption in real terms is reduced under the influence of the worsening demographic situation in the country. According to the IMF, with an annual decrease in the population, 32.9 million people were living in the country (UNIAN, 2025, April 25). The number in the age category 20–35 years has significantly decreased. In the age category over 45 years, the share of women prevails. The Office of the United Nations High Commissioner for Refugees records 5.6 million Ukrainians with refugee

status. The number of Ukrainian students studying abroad is also growing (Apteka.ua, 2025, September 15).

• Growth in retail trade in medicines: like the noted trend of overall consumption growth, with a slight increase of 3%, retail sales in the national currency for the period January – August 2025 increased by 16.6% (by 10.6% in dollar equivalent). This is primarily due to inflation and the corresponding increase in prices. At the same time, compared to the overall level of inflation in the consumer market in August 2025 at 14.2%, this indicator in the market of pharmaceutical products, medical goods, and equipment was 13.7% (State Statistics Service, 2025).

• Increase in drug prices: as of the end of August 2025, the cost of one package of a medicine increased by 16% compared to the beginning of the year, which is a consequence of inflation and redistribution of consumption towards more expensive goods (Apteka.ua, 2025, September 15).

In summary, the growth of the market volume occurs because of inflationary processes and price increases, which, given the reduction in the population, necessitate an increase in specific income per capita. At the same time, at the national level, there is a negative trend towards an increase in the incidence rate and, accordingly, the volume of drug consumption due to the high level of chronic stress caused by the war in the country, as well as the long-term consequences of the COVID-19 pandemic. These factors have a significant impact on the development of the pharmaceutical market, on the one hand. On the other hand, the development of the market is facilitated by the spread of digital technologies and the improvement of the marketing activities of enterprises in it.

2. Digital marketing strategies for corporate brands of industrial pharmaceutical companies

Pharmaceutical campaigns with strong corporate brands that had the highest revenue levels in 2024 (Opendatabot, 2025) were selected for the study (*Table 1*).

Table 1

Financial indicators of the economic performance of industrial pharmaceutical companies in Ukraine for 2024

Enterprise	Net income, thousand UAH	Net profit, thousand UAH	*Rprod., %*	R_A, %	*ROE, %*
JSC Farmak	10783728	1639670	15.21	10.86	12.47
PJSC Pharmaceutical Company Darnitsa	6875780	678952	9.87	8.36	10.96
LLC Yuria-Farm	5741656	752103	13.10	12.05	19.02
PJSC Kyiv Vitamin Plant	4944130	171731	3.47	5.31	7.08
JSC Kyivmedpreparat	3568427	73165	2.05	2.17	6.48
Biofarma Plasma LLC	3550542	852408	24.01	27.48	42.54

End of Table 1

Enterprise	Net income, thousand UAH	Net profit, thousand UAH	*Rprod., %*	*R_A, %*	*ROE, %*
Pharma Start LLC	2337352	764592	32.71	21.93	26.46
Borshchahivskyi Chemical and Pharmaceutical Plant Scientific and Production Center PJSC	2078848	273402	13.15	8.84	9.33
Pharmaceutical Company Zdorovya LLC	2031665	146468	7.21	7.14	9.64
Galichpharm JSC	1844194	13705	0.74	0.45	1.65
Interchem TDV	1212205	200561	16.55	15.95	17.73

Note: Rprod – return on sales; RA – return on assets; ROE – return on equity.

Source: compiled by the author based on OpenDataBot (2025, September 20).

The data in *Table 1* indicate the absence of a relationship between net income indicators and net profit and profitability indicators. Therefore, higher efficiency is demonstrated by enterprises that are focused on innovation, specialization, and the active use of digital technologies. This hypothesis requires further verification, so the study further analyzed the specifics of the activity, value propositions, and brand positioning, which allows us to identify strategic groups according to the proposed criteria of "tradition–innovation" and "specialization–scale".

Using the Customer Value Proposition Canvas tool by Alex Osterwalder, value propositions were formulated for the studied corporate brands of FP based on identified client tasks, pain (client problems), and benefits (advantages of using the product) (Osterwalder et al., 2023). Based on the formulated value proposition, brand positioning was determined (*Table 2*).

Based on the analysis of the positioning of the studied brands, three strategic groups of companies were identified according to the specified criteria of "tradition-innovation" and "specialization-scale" (*Figure 2*):

1. JSC Farmak, PrJSC Pharmaceutical Firm Darnytsia are leaders in scale and versatility, with an orientation towards the mass consumer and the gradual introduction of digital innovations. The value propositions of the enterprises are based on a high level of corporate brand recognition, innovation, and supply stability, which form consumer trust and choice.

2. LLC Biopharma Plasma, LLC Yuriya-Pharm, TDV Interkhim, LLC Pharma Start specializes in innovative brands whose activities are related to complex biotechnological areas and the development of solutions within narrow therapeutic areas. The companies actively invest in scientific research and international expansion. The value propositions are based on innovation, quality, and professional recognition in the field of medicine, both in Ukraine and abroad. It is these enterprises that demonstrate the highest indicators of profitability of sales, assets, and equity (*Table 1*).

Table 2

Value offerings and positioning of corporate pharmaceutical brands

Pharmaceutical companies	Client objectives	Problems (suffering)	Advantages (benefits)	Value proposition	Key value	Positioning
1	2	3	4	5	6	7
JSC Farmak	Obtain effective, proven, high-quality medicines	Distrust of domestic drugs, shortage of modern solutions	European standards, a wide range, and innovative developments	High-quality, affordable, and innovative medicines with a guarantee of safety	Innovative quality, trust, stability	National innovation leader
PJSC Pharmaceutical Company Darnitsa	Obtain affordable medicines at any pharmacy	Difficulty of choosing among analogues, need for a stable supply	Digitalization, social responsibility, and sustainability	A large-scale brand that combines reliability, accessibility, and digital innovations	Scalability and digitalization	Digital mass segment leader
LLC Yuria-Farm	Effective solutions for critical medicine	Dependence on imports, lack of comprehensive solutions	Specialization, innovation, international presence	Innovative medical solutions for life, created in Ukraine	Innovation in critical care	Specialized hi-tech manufacturer
PJSC Kyiv Vitamin Plant	Get affordable vitamins and preventive products	Deficiency of high-quality vitamins of domestic production	Many years of experience, natural ingredients, and accessibility	A traditional manufacturer that ensures health through quality vitamins	Tradition and prevention	Classic vitamin manufacturer
JSC Kyivmedpreparat	Get effective generics and antibiotics	High cost of imported analogues	Stable quality, GMP production, wide range	Time-tested medicines for basic medical needs	Essential drugs and antibiotics	Standard generic manufacturer
Biofarma Plasma LLC	Obtain biologics from human plasma	Shortage of modern immunobiological drugs	Unique production, high safety standards, innovation	*National leader in plasma preparations for immune support*	Biotechnology from human plasma	*Leader in biopharmaceuticals*

End of Table 2

1	2	3	4	5	6	7
Pharma Start LLC acino PART OF ARCERA	Access to modern drugs of international standards	Insufficient localization of innovative products	Cooperation with Abbott, high-tech production	Synergy of global experience and Ukrainian production	Integration with global brands	Partner of international companies
Borshchahivskyi Chemical and Pharmaceutical Plant Scientific and Production Center PJSC БХФЗ bcpp	Get proven broad-spectrum drugs	Need for stable and affordable medicines	Many years of reputation, quality, and social orientation	A reliable Ukrainian manufacturer with a tradition of quality	Reliability and traditions	Socially responsible manufacturer
Pharmaceutical Company Zdorovya LLC Здоров'я фармацевтична компанія	Purchase affordable analogues of branded drugs	High price of imported drugs	Optimal price-quality ratio, wide range	Effective medicines at a fair price for every Ukrainian	Price - quality	Mass Ukrainian brand
Galichpharm JSC ГАЛИЧФАРМ АКЦІОНЕРНЕ ТОВАРИСТВО	Get natural and high-quality medicines	Distrust in the effectiveness of herbal medicines	A combination of natural ingredients and modern technologies	A health brand based on the power of nature and pharmaceutical precision	Naturalness and traditions	Natural pharmacy
Interchem TDV InterChem	Get highly effective drugs with our own developments	Limited access to innovations in neuropharmacology	Own R&D, unique formulas, international recognition	Innovative center for the development of drugs for psychoneurology and oncology	Scientific developments and precision	Innovative R&D center

Source: compiled by the author based on (Farmak, n.d.; Darnitsa, n. d.; Yuria-Pharm, n. d.; Kyiv Vitamin Plant, n. d.; Kyivmedpreparat, n. d.; Biopharma, n. d.; Acino, n. d.; BHFZ, n. d.; Zdorovye, n. d.; Galichpharm, n. d.; Interkhim).

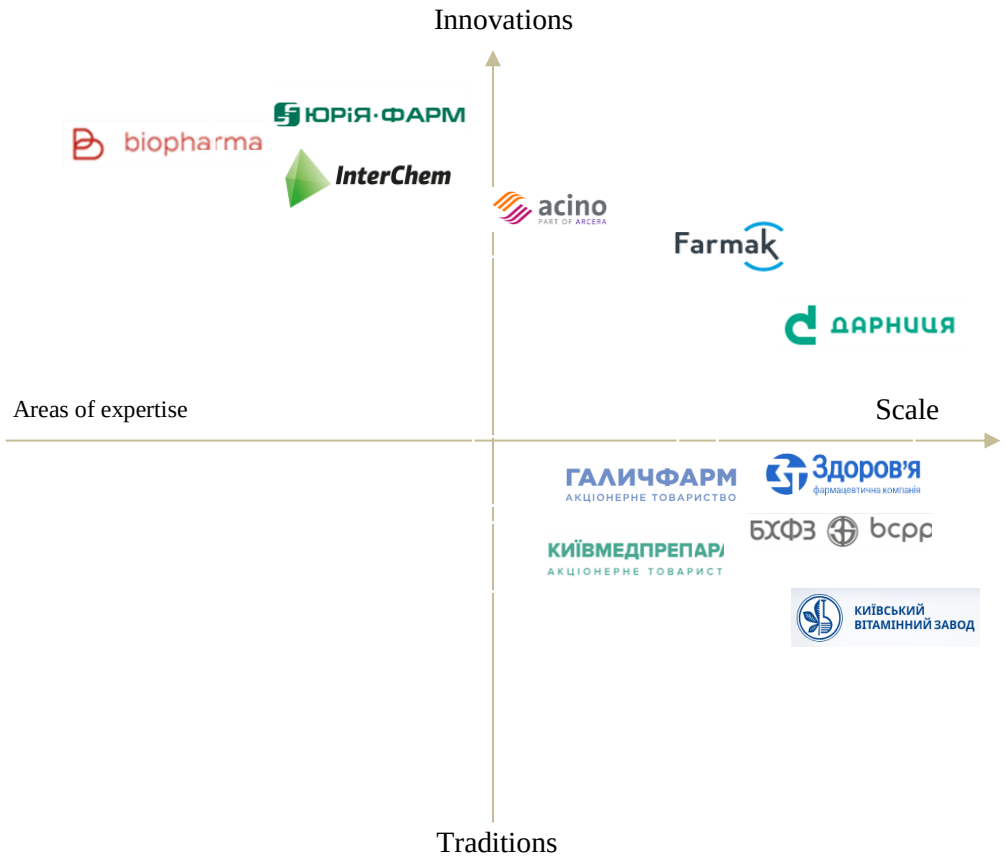

Figure 2. Positioning map of corporate pharmaceutical brands

Source: compiled by the author

PrJSC "Kyiv Vitamin Plant", JSC "Kyivmedpreparat", PJSC "Scientific and Production Center "Borshchagov Chemical and Pharmaceutical Plant", LLC "Pharmaceutical Company "Zdorovya" – large-scale traditional brands with a classic positioning and focus on social responsibility, stability, and accessibility – support the reputation of reliable suppliers of basic medicines, ensuring the pharmaceutical safety of the country.

In general, the positioning results show that the national pharmaceutical market is characterized by a balance between large-scale universal brands and innovative and specialized manufacturers, which form competitive conditions for the sustainable technological development of the industry.

Promotion and development of corporate brands of the studied enterprises in the digital environment involves the simultaneous implementation of digital marketing strategies: image, conversion, and reputation (Yankovets, 2022, p. 102). The image strategy aims to disseminate information about the brand using digital marketing tools to increase its recognition. The conversion strategy aims to increase sales. The reputational strategy aims to generate feedback from consumers and manage the brand's reputation in the digital environment.

For corporate pharmaceutical brands, it is proposed to use the following basic digital marketing tools:

*website improvement and web analytic*s: improving the quality of the corporate website as a strategic asset of a pharmaceutical company, through high-quality content and convenient usability, ensures the interest of the target audience and improves the behavioral factors of potential and regular customers of the B2B and B2C segments: people are engaged, spend more time on the site, view more pages, return to the site to obtain useful information, etc. To track such interactions, web analytics program counters are installed on each page of the site, the main task of which is to collect statistics and present data in reports on traffic, user behavior, the effectiveness of traffic channels, etc. This information allows you to quickly identify problems, optimize marketing and advertising campaigns, and improve both the quality of the site and the value proposition:

search Engine Marketing (SEM) includes search (contextual) advertising (SEA) and search engine optimization (SEO). The use of search engine marketing by pharmaceutical companies is because people search in search engines for what interests them right now. That is, demand is updated. And the task of SEM is to provide users with information about the company, brand, research results, innovative products, etc., relevant to search queries. For the use of contextual advertising, the company pays the search engine for a click on the advertisement and the user's transition to the site. When using search engine optimization, the search engine does not charge a fee for a click. The use of both tools by the company through the synergy effect provides traffic to the company's website up to 90% (Yankovets, 2025, p. 234);

digital advertising: this digital marketing tool is key in providing traffic to the site. Digital advertising effectively solves the image, conversion, and reputational tasks of the FP. Thanks to digital advertising, brand knowledge is spread, which allows the target audience to identify the brand and its product. Advertising is an effective tool for attracting new customers, as well as maintaining and improving the brand image, which forms and increases the loyalty of regular customers. There are many types of digital advertising, which differ in types of content, advertising creatives, distribution channels, and use of technologies. At the same time, they are all combined into three large groups by format: text, banner, and video advertising. Affiliate Marketing is closely related to this digital marketing tool;

marketing automation includes e-mail marketing, the use of CRM systems, and their integration with the enterprise software resources, which allows you to form a single user profile of each client. This approach provides an analysis of interactions between potential and regular customers both with the website and with company employees, which allows you to develop personalized value propositions and use dynamic pricing based on objective data;

content marketing: associated with the creation, distribution, and expansion of content that is relevant, interesting, and useful for the target audience. The effectiveness of this digital marketing tool is ensured by a competent justification of the content concept, which has its main idea, themes, formats, and stories. Managing this process involves developing a content strategy and a corresponding content plan;

social media marketing (SMM) includes social media optimization (SMO) and social media advertising (targeted advertising) (SMA). This digital marketing tool involves building long-term relationships between the FP and customers by engaging in communication and forming a loyal brand audience. Social media marketing also involves working with opinion leaders: bloggers, influencers (Influence Marketing), etc;

mobile marketing involves the use of mobile sites, mobile applications, and mobile promotion to provide easy and quick access to information through customers' mobile devices.

The choice of digital marketing tools within the framework of implementing image, conversion, and reputation strategies in the digital environment is enhanced by the use of digital platforms and services at the stages of the consumer's digital journey (See, Think, Do, Care), depending on the B2B and B2C market segment (*Tables 3, 4*).

Table 3

Digital platforms and services for industrial corporate pharmaceutical brands in the B2B market

Stages of the consumers' journey	Brand goals	Digital platforms and services
Interest (See)	Increase brand awareness, improve brand image, attract attention from medical institutions, pharmacy chains, and online pharmacies.	Social networks (Facebook, LinkedIn, YouTube), GoogleAds advertising cabinets, Meta Ads, medical portals (MD Explorer, thePharmaMedia, others)
Intention (Think)	Build interest and trust through educational and expert content and build an engaged audience.	Professional online communities, blogs, ESP systems for email mailing, analytical resources for collecting statistics, and SEO promotion: SimilarWeb, PR-CY, Serpstat, Semrush, Ahrefs, GA 4, others
Decision (Do)	Stimulate interaction and close deals	E-commerce platforms (b2b supplier platforms, Prozorro Market), CRM (Proxima Cloud, VeevaCRM, KeepinCRM, Creatio, others), chatbots for orders
Loyalty (Care)	Customer retention through increased trust and loyalty, repeat purchases, and the development of stable partnerships.	Partner platforms and loyalty programs (manufacturers' own systems), training platforms (LMS, PharmaEdu), analytical resources and reports (Google Analytics 4, Power BI, others), messengers for support (Viber, Telegram, others)

Source: compiled by the author.

Table 4

Digital platforms and services for industrial corporate pharmaceutical brands in the B2C market

Stages of the consumers' journey	Brand goals	Digital platforms and services
Interest (See)	Increase brand, product, and healthy lifestyle awareness, increase brand knowledge, and improve brand image.	Social networks (Facebook, Instagram, TikTok), YouTube, GoogleAds advertising cabinets, Meta Ads, content projects on medical portals (Medikforum, others)
Intention (Think)	Generate interest, engage users with the brand, increase trust, and awareness.	Webinars on prevention, FAQ pages, blogs with doctors' advice, SEO promotion service, ESP systems for email mailing, online appointment booking services (Helsi.me), telemedicine services (Google Health, System Carebits, Teledoc Health, others), electronic forms for user feedback on forums, etc.
Decision (Do)	Motivate purchase or consultation, improve omnichannel experience, increase conversions and purchases.	Portals and applications for ordering medicines (Liki24, tabletki.ua, others), digital platforms of laboratories, mobile applications of brands, programs "order online – receive offline", promo codes, push notifications, etc.
Loyalty (Care)	Customer retention, build a healthy community, increase repeat purchases, and build emotional attachment to the brand.	Applications for monitoring health indicators (Apple Health, Google Fit, MedM Health, MISU, others), loyalty programs (bonus cards, digital offices), telemedicine services, support chatbots, and personal recommendations

Source: compiled by the author.

Therefore, for the selected strategic groups of industrial enterprises – corporate pharmaceutical brands, strategic digital marketing measures are proposed:

1. Large-scale and universal brands of JSC "Farmak", PrJSC "Pharmaceutical Firm "Darnytsia" with a wide product portfolio and a high level of recognition are recommended to maintain business reputation, consumer trust and loyalty, reputation in the digital environment, and develop the employer brand. To do this, it is advisable to develop an omnichannel approach in communication and sales, implement corporate storytelling in social media with an orientation towards innovation, the formation and development of corporate culture, and the demonstration of social responsibility. To attract a professional audience, it is important to create expert content. Searching for marketing and digital advertising will help increase sales.

2. Specialized innovative brands with a research orientation and digitalization of B2B communications, such as Biopharma Plasma LLC, Yuriya-Pharm LLC, Interkhim Joint Stock Company, and Pharma Start LLC, find it important to deliver complex scientific and technical content to the target audience through understandable digital tools: webinars, popular science podcasts, YouTube videos, etc. To ensure quick and convenient interaction between representatives of pharmaceutical, wholesale, and logistics companies, it is advisable to create and maintain digital B2B platforms. Integration with professional medical systems and applications ensures the dissemination of information about drugs. The use of BigData and AI technologies allows for identifying the needs of doctors and patients for targeted advertising. An alternative to classic marketing communication measures can be virtual conferences and product demonstrations using AR/VR/XR technologies to provide impressions as an economic offer.

3. Large-scale traditional brands with classic positioning focused on the mass segment, such as PrJSC "Kyiv Vitamin Plant", JSC "Kyivmedpreparat", PJSC "Scientific and Production Center "Borshchagov Chemical and Pharmaceutical Plant", LLC "Pharmaceutical Company "Zdorovya", need to improve communication without losing traditional values and consumer trust. To do this, it is advisable to update the visual identity with a focus on modernity and accessibility, as well as taking into account the requirements of UX/UI design in the digital environment. To increase and maintain patient loyalty, it is advisable to create and promote mobile applications with functions such as reminders about taking medications, accruing bonuses, etc. Partnerships with pharmacists, bloggers who cover medical topics, influencers – doctors with powerful personal brands, the creation of information portals with advice on prevention and proper medication administration, as well as their SEO promotion and content marketing in the health sector, collaborations with pharmacies and e-commerce platforms (Liki24, tabletki.ua, apteka24.ua), etc., will contribute to the formation and maintenance of "public trust."

The proposed digital marketing strategies and corresponding strategic measures reflect a differentiated approach to developing brands in the digital environment, depending on their market positions and strategic orientations. Large-scale brands are recommended to focus on maintaining corporate trust through analytics and communications, innovative brands – on knowledge and partnerships, traditional brands – on image renewal and digital accessibility for the mass consumer.

Conclusions

The features and development of the pharmaceutical market in Ukraine are determined by political, economic, demographic, and technological factors, as well as a high level of state regulation aimed at guaranteeing the quality and safety of medicines and medical devices. Demographic

challenges and the spread of digital technologies determine the advanced development of the market and actualize the role of marketing activities and the development of corporate brands of pharmaceutical enterprises.

The systematization of pharmaceutical market entities in the digital environment is based on taking into account the stages of the economic process and a clear division of participants into B2B and B2C market segments.

The defining production element in the structure of the pharmaceutical market entities is industrial manufacturers. In terms of the intensity of competition, this market is a differentiated oligopoly, which implies a differentiated approach to marketing and branding. According to the results of the research of value propositions and positioning of corporate brands of industrial pharmaceutical enterprises, three strategic groups of companies were established according to the selected criteria of "tradition–innovation" and "specialization–scale": large-scale universal brands with an orientation towards the mass consumer and the gradual introduction of digital innovations (JSC "Farmak", PrJSC "Pharmaceutical Firm "Darnitsa"); specialized innovative brands, whose activities are related to complex biotechnological areas and the development of solutions within narrow therapeutic areas (LLC "Biopharma Plasma", LLC "Yuria-Pharm", TDV "Interkhim", LLC "Pharma Start"); large-scale traditional brands with classic positioning and focus on social responsibility, stability, and accessibility. (PJSC "Kyiv Vitamin Plant", JSC "Kyivmedpreparat", PJSC "Scientific and Production Center "Borshchagov Chemical and Pharmaceutical Plant", LLC "Pharmaceutical Company "Zdorovya"). Interaction and balance between certain strategic groups of industrial brands ensure the formation of a competitive environment that contributes to the sustainable technological development of the industry.

Industrial pharmaceutical companies, working simultaneously in the B2B and B2C markets, implement digital marketing strategies to develop corporate brands in the digital environment. For each strategic group, the implementation of these strategies involves the use of appropriate tools, digital platforms, and services, distributed according to the stages of the consumer’s digital journey using the digital model See, Think, Do, Care.

A differentiated approach to the selection of digital marketing strategies and tools allows for the effective development of corporate brands of pharmaceutical companies in the digital environment. It considers the values, positioning, and affiliation of brands to strategic groups, which ensures precise targeting of marketing efforts.

The results of the research confirmed the hypothesis that the selection of digital marketing strategies and tools, digital platforms, and services for the development of corporate brands of pharmaceutical companies should be based on their positioning, taking into account the specifics of the activity, market segment, and stage of the consumer’s digital journey. This allowed us to form a differentiated approach to justifying strategic digital marketing

measures, increase the effectiveness of corporate brand management, and ensure the rational use of marketing resources of the enterprise, which will contribute to increasing the competitiveness and development of brands in the digital environment.

Further research involves the development of scientific-methodological and scientific-organizational approaches to evaluating and increasing the efficiency of using digital marketing tools, digital platforms, and services to strengthen the competitiveness of corporate brands of pharmaceutical companies in the B2B and B2C segments.

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Conflict of interest. The author certifies that she doesn’t have financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations, or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript. Given that the author is affiliated with the institution that publishes this journal, which may cause potential conflict or suspicion of bias, the final decision to publish this article (including the reviewers and editors) is made by the members of the Editorial Board who are not the employees of this institution.

The author received no direct funding for this study.

Iankovets, T. (2026). Digital marketing strategies for corporate pharmaceutical brands. *Scientia fructuosa, 1*(165), 142–161. http://doi.org/10.31617/1.2026(165)10

Received by the editorial office 17.11.2025.
Accepted for printing 24.12.2025.
Published online 17.02.2026.

DOI: http://doi.org/10.31617/1.2026(165)11
UDC 004.93:316.772.5=111

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EMOJI-RICH VS EMOJI-POOR COMMUNICATION ACROSS CULTURES

Since digital communication is geographically unlimited, emojis have become a ubiquitous yet culturally sensitive means of expressing emotions and intent. The research question that is presented in this study is: How do cross-cultural trends relate to the use of emojis, emoji-intensive and emoji-light methods of communication, and the influence they have on the outcome of conversations, namely emotional clarity, perceived friendliness, and suitability? With the help of the mixed-methods design, we gathered and processed the information based on the controlled conversational simulations and participant surveys, including various cultural cohorts. Perceptions and emotional resonance were reviewed using sentiment analysis and qualitative feedback. The findings indicate that although there is a universal improvement in the expressiveness of emotions and warmth in interpersonal interaction by using emojis at a high density, there are considerable differences in their use across different cultures, in formal or sensitive situations. On the other hand, communication that is emoji-sparse is always viewed as more neutral and professional, regardless of the culture, at the expense of engagement perceived. These results demonstrate that although the main uses of emojis are universal, their practical use and social acceptability have their roots in cultural rules of communication. The research enhances a more refined view of computer-mediated communication, which can be used to understand how to engage in successful and

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ВПЛИВ ІНТЕНСИВНОСТІ ВИКОРИСТАННЯ ЕМОДЗІ НА МІЖКУЛЬТУРНУ КОМУНІКАЦІЮ

Оскільки цифрове спілкування не має географічних обмежень, емодзі стали повсюдним, проте культурно чутливим засобом вираження емоцій та намірів. У цьому дослідженні ставиться таке питання: як міжкультурні тенденції пов'язані з використанням емодзі, методами спілкування, що активно або мало використовують емодзі, та впливом, який вони мають на результати розмов, а саме на емоційну чіткість, сприйману дружелюбність та прийнятність? За допомогою дизайну змішаних методів зібрано та оброблено інформацію на основі контрольованих симуляцій розмов і опитувань учасників, включаючи різні культурні когорти. Сприйняття та емоційний резонанс оцінювалися за допомогою аналізу настроїв та якісних відгуків. Результати дослідження свідчать, що, хоча і є загальне покращення виразності емоцій та теплоти у міжособистісному спілкуванні при використанні емодзі у великій кількості, існують значні відмінності у їх застосуванні в різних культурах та у формальних або чутливих ситуаціях. З іншого боку, спілкування з обмеженою кількістю емодзі завжди сприймається як більш нейтральне та професійне, незалежно від культури, хоча й зменшується сприйнята залученість. Ці результати демонструють, що, хоча основні способи використання емодзі є універсальними, їх практичне застосування та соціальна прийнятність беруть початок із культурних правил комунікації. Дослідження дозволяє отримати більш

culturally sensitive digital communication using the global platforms.

детальне уявлення про мережеве спілкування, яке можна використовувати для розуміння того, як брати участь у успішній та культурно чутливій цифровій комунікації за допомогою глобальних платформ.

Keywords: Emoji, Cross-Cultural Communication, Computer-Mediated Communication (CMC), Digital Communication, Cultural Differences, Social Media, Emotional Expressiveness, Communication Norms.

Ключові слова: емодзі, міжкультурна комунікація, комп'ютерно-опосередкована комунікація (КОК), цифрова комунікація, культурні відмінності, соціальні медіа, емоційна виразність, норми комунікації.

JEL Classification: L14, M39.

Introduction

Nowadays, emojis no longer constitute mere pictographs but have become a widespread language in communication through computer-mediated communication (CMC) and can express feelings, intentions, and contextual overtones (Barbieri et al., 2018; Derks et al., 2008). The fact that they are used worldwide highlights a primary human desire to add emotional and nonverbal communication to text-based interactions and alleviate the constraints of plain text (Riordan, 2017; Lo, 2008). Availability of emojis on different platforms and national borders indicates the presence of a strong, normative role, and some researchers even claim that emojis have become a global visual language, uniting the users and overcoming the generational gap (George et al., 2023). Nonetheless, behind this facade of cultural acceptance is a woven web of cultural difference that disproves the idea of an absolutely universal emoji vocabulary.

Emojis also play a basic socio-emotional role in online writing by substituting non-verbal cues people usually have during in-person communication, to introduce emotional context to otherwise perfunctory text (Boutet et al., 2021). They ease emotional clarity and ambiguity and enhance the communicative experience through affective cues (McShane et al., 2021). Emojis are more useful than just a means of emotional expression, and decoding the world in terms of social relationships, as they are employed to establish solidarity, make requests softer, and keep relationships alive online (Skovholt et al., 2014). However, the qualia of these functions are culturally determined. The cross-cultural studies in the field of psychology have always discovered universal and culture-specific means of expressing emotions, a dichotomy that is directly echoed in the use of emojis (Guntuku et al., 2019). Although emojis may help to have inter-cultural communication and make sure that people can communicate their feelings more accurately and avoid misunderstandings, they can also be interpreted differently in various cultures and, in certain instances, their use can even evoke feelings of defensiveness (Chen, 2023).

Taking into consideration this multi-layered interaction between the universalist and cultural particularity of emojis, the proposed study will contribute to the available cross-cultural research. This study aims to explain

how emoji patterns, which are embedded in a culture, can affect the perceived friendliness, emotional clarity, and appropriateness of communication between Eastern and Western communicators in digital communication by examining the effects of the density of emojis on the perceived friendliness, emotional clarity, and appropriateness of communication.

Research Objectives

To compare the effect of using emojis in communication and using emojis deprived of emotion on the understanding of emotions, perceived friendliness, and user interaction.

To find out the perceived contextual appropriateness of emoji density in a formal and informal digital environment.

To determine and examine cross-cultural disparities in the perception and consequences of emoji-rich and emoji-scarce communication.

Research Questions

What is the effect of emoji density (rich vs. poor) on perceived emotional precision and user experience of digital communication?

How does emoji content affect the impression of friendliness and situational propriety of interpersonal digital communication?

What is the moderating effect of cultural backgrounds on the attitudes of these conversational outcomes with emoji density?

Literature Review

The use of emojis across the globe has made them a major ingredient in computer-mediated communication (CMC) as they are visual representations that aid in the expression of feelings, intentions, and contextual interpretation (Barbieri et al., 2018; Derks et al., 2008). The amount of their use on different platforms underlines the necessity to make the text-based interaction evocative of emotions on a universal scale (Riordan, 2017; Lo, 2008). Even some scholars go as far as to assume that emojis have become a global visual language that can overcome generational and cultural barriers (George et al., 2023). Nevertheless, at this layer of apparent international tolerance, there is a complicated web of cultural diversity that puts the idea of an exceptionally universal emoji vocabulary into question.

The use of emojis is essentially a replacement of facial expressions, tone, and gestures in online communication, which is otherwise nonverbal (Prada et al., 2022). They make emotional transparency, decrease ambiguity, and make the communicative experience richer through critical affective cues (McShane et al., 2021). Their usefulness goes beyond the emotional expression to the control of interpersonal relationships, an indicator of politeness, and strengthening of social bonds (Jones et al., 2020). However, the use of these functions is so ingrained in the work of culture. Cross-cultural psychology studies have always found both universal and culture-specific patterns in the expression of emotions, which are directly manifested

in the use of emojis (Guntuku et al., 2019). On the one side, emojis can be used to communicate in intercultural contexts with subtle emotions, minimizing the risk of misunderstanding, but, on the other hand, emojis are perceived differently in different cultures, and the use of these elements can even provoke a defensive reaction (Chen, 2023).

These differences in culture have been officially recorded in big empirical studies. A seminal analysis of Twitter data by Li et al. (2019) found that the categories and frequency of emojis employed are an excellent source of information on the cultural differences, finding that the use of emojis with preference corresponds with the Cultural Dimensions Model by Hofstede. It was also confirmed by Lu et al. (2016) in their study of smartphone users, which revealed that the preferences of users in various countries are considerably different, which provides strong indicators of cultural differences. In their study, Guntuku et al. (2019) specifically focused on the East-West dichotomy and compared emoji usage between Eastern (China, Japan) and Western (United States, United Kingdom, Canada) nations, which showed familiar normative and culture-specific patterns. The difference in frequency relative to the context and topic association of emojis was found to be significant, and their analysis was mapped to more profound cultural ideas.

These variations are evident in different patterns of using and interpreting them. An example is that in Western cultures, the positive emotion emoji rate is the highest, and in Eastern ones, the contextual and subtle forms of emotion are prevalent (Wang et al., 2024). Such semantic differences suggest that cultural background is one of the key factors that determine the use and interpretation of emojis. It is also complicated by the fact that personal characteristics like age, gender, and culture are of great influence on understanding emojis (Chen et al., 2024). These trends have deep origins, which can be traced even in the period of pre-emoticon emoticons. The authors Park et al. (2013) examined the semantic and social features of emoticon use on Twitter and found that they are socio-cultural conventions and that their meaning is different depending on the speaker, and particular styles such as Western horizontal :) And Eastern vertical [ˆ _ ˆ] emoticons circulate through the social networks.

Experimental studies also give additional support to culturally motivated usage. The series of experiments carried out by Togans et al. (2021) looked at cross-cultural variations in emoticons and emoji utilization, and the experimenters concluded that East Asians utilized much more Computer-Mediated Communication (CMC) cues in general and demonstrated more situational sensitivity (i.e., employed more situationally-congruent cues) than Americans. It was positively linked to scores of collectivism and interdependent self-construal, and this supported the idea that emojis can play a face-management role as higher politeness issues in collectivistic societies. This is in line with what Sun et al. (2022) established that cultural identification with individualism and collectivism is a major factor in the

interpretation and choice of emojis widely used in South Korea by the Americans.

On a smaller level, platform and functional differences have been analyzed. Ge-Stadnyk (2021) discovered that the most common speech act in conjunction with emoji sequences in both Weibo and Twitter was Claim, but the emojis themselves had different, and the most prominently used functions: on Twitter, the emojis served a stance and action purpose much more often, whereas on Weibo, they served a concept purpose more oftentimes. It indicates that the pragmatic application of emojis could be culturally skewed even in cases when the textual communication is comparable. Moreover, the studies on the emoji preference, frequency of use, and meaning may differ greatly among different cultural and gender groups in a single country, becoming a "cultural thermometer of the virtual world" (Alzara & Mellor, 2025).

There is, hence, a high possibility of miscommunication. Due to the nature of some emojis and the presence of cross-cultural differences in interpretation, they may cause misunderstandings and unwanted social blunders. This is compounded by the fact that, according to the findings, people from other cultures place more weight on the eyes versus the mouth of emojis when decoding emotions, and Westerners use the mouth and Easterners the eyes, similar to how it is when interacting in person (Gao & VanderLaan, 2020). What one culture might take as a friendly gesture can be construed as being too close or even offensive in another culture, making it very difficult to engage in cross-cultural digital communication.

Summing up, the available literature is very clear in its affirmation that although emojis have some universal appeal, the way they are interpreted, used, and accepted in society is seriously governed by cultural norms. This poses a serious naivety gap in the explanation of how such abstract cultural dimensions are applied to tangible communication, results in regulated, comparative contexts, especially in analyzing the direct effect of emoji density (emoji-rich vs. emoji-poor communication) between Eastern and Western cultures.

Methodology

The goal of the study was to thoroughly explore the effect of the number of emojis in a message on the manner in which individuals interpret and respond to a conversation, and whether individuals in other cultures respond differently. We adopted a mixed-method approach to obtain a full picture, which implies that we have gathered not only numbers (such as ratings on a scale) but also personal opinions (such as written comments) of our participants.

We started by employing 300 participants online. We particularly sought a varied sample, and we had 150 subjects who considered themselves to be part of Eastern culture (China, Japan, and South Korea) as well as 150 who considered themselves part of Western culture (United States,

United Kingdom, and Canada). All of them were frequent users of digital communication apps such as WhatsApp, Instagram, or Twitter, and each one of them felt comfortable using emojis in their everyday life.

Our research consisted of the development of seemingly real, text-messaging dialogues. To portray some of the typical forms of digital communication, we came up with three different situations. The former was no more than a chat between friends about what they were going to do on the weekend. The second one was an emotional support talk, whereby one party tells the other person about a personal issue, such as having a stressful day in the workplace. The third one was a professional exchange where one of the colleagues requests another colleague to assist him or her with some work-related activity. We developed two versions in each of these three scenarios. The initial one was emoji-heavy, which is, we added a lot of emojis, which are just in line with the conversation, such as smiley faces, laughing, and hearts in the informal chat, or supportive and sad faces in the emotional one. The second version was an emoji-poor version, where all the emojis have been taken out; otherwise, the words are the same. This enabled us to be certain that the variations in the feelings of people were due to the emojis, and not the text itself.

The participants were selected randomly into one of the three scenario groups (casual, emotional, or professional). Each of the participants was then asked to read both the emoji-rich and the emoji-poor version of the scenario that they were given. We crossed out the order to ensure that having read one version did not affect the opinion that they had on the second version. Fifty percent of the participants were exposed to the emoji-rich version, and the other half were exposed to the emoji-poor version.

Participants were provided with a comprehensive survey immediately after they had read each version of the conversation. In this survey, the participants were required to respond to particular statements on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree). The questions were meant to be used to assess the most important results to us (or, to be more precise, the clarity of the feelings being expressed by the sender, the attractiveness of the sender, the level of engagement between the user and the sender, and the appropriateness of the use of emojis to the situation at hand). There were also open-ended questions in the survey, including a question of how the emojis (or the absence of emojis) made you feel about who you are communicating with, to obtain additional personal and detailed explanations.

In order to analyze all this information, we applied two key techniques. To test the number ratings of the surveys, we applied statistical tests first. The tests assisted us in computing the mean rating disparity in the emoji-abundant and emoji-deficient conversations. They also enabled us to determine whether these differences were greater or lesser among the participants of Eastern cultures than those of the Western cultures. Second, in the case of the written comments, we conducted thematic analysis. This

entailed reading through all the comments so as to establish the popular themes and repetitive ideas. To say it differently, when several individuals wrote that they found the emoji-poor professional message more serious and credible, that would become a significant theme.

During the whole process, we focused on ethical research practices. All the participants had clear information about the purpose of the study and gave their consent before participation. Their responses were utterly confidential and they could discontinue the survey whenever they wished. The painstaking and thorough way in which we did this enabled us to collect good and solid evidence regarding the authentic effect of using emojis in our online discussions.

1. Theoretical Framework

The framework of the study is constructed around three theories that are also interconnected, which explain the purpose of emoji density in intercultural communication. It is based on the Social Presence Theory, which determines that communication media vary in terms of allowing salience of a fellow person to be transmitted. This principle is later reiterated by other media theory frameworks, according to which nature of the lean digital media is described as lacking the non-verbal expressive nature of non-verbal communication, the gap that is frequently filled with emojis (Daft & Lengel, 1986). This theory is essential in the way people employ the given cues to achieve a human touch in the virtual world (Gunawardena, 1995). Digital communication using text is regarded as low presence due to the fact that it deprives the communication of nonverbal communication features such as facial expressions and the tone of voice. Emojis are the digital replacements of these lost cues, bringing the human aspect of the computer-mediated communication back. This is why the messages with a lot of emojis tend to make it easier to see emotions and make it look friendlier, as they add the feeling that there is a real emotional person behind the messages.

Media Richness Theory provides a very important point since it states that the effectiveness of communication should be based on the ability to match the complexity of a message with the relative richness of a medium. Emojis enhance a relatively flat piece of text with added emotional and contextually detailed detail, which can be missing in the words alone. An ordinary okay is not clear but okay with an emoji makes it clear that he meant well. This theory describes how the density matters of emojis: messages of high complexity (emojis) can be better received through richer communication, but simple information can be overwhelming. It also indicates the explanation of why optimum richness is context-specific, which explains why professional communication (where clarity is of utmost importance) is frequently well-served by the reduced use of emojis.

The framework is then completed by the Communication Accommodation Theory that elucidates the social and cultural aspects of the use of

emojis. It examines the way individuals change their communication in order to highlight similarities (convergence) or differences (divergence). As individuals send emojis that identify with the style of the person they are talking to, they create a rapport with convergence. The problem of cultural differences in interpreting emojis is critical in this case; in case Eastern and Western participants have different standards, convergence efforts can go awry, thereby leading to misunderstanding. This theory is the reason cultural background mediates the effects of emojis- individuals adapt to various communication norms. High density of emojis may appear over-emotional to Western users, whereas low density may appear impersonal to Eastern users.

All these theories form a complete framework. There is a theory that describes the relevance of emojis to human interaction, which is Social Presence Theory. Media Richness Theory describes the influence of the density of emojis on the effectiveness of communication. Communication Accommodation Theory helps to understand why the issues of cultural differences do not disappear in emojis use. This combined view anticipates that communication enriched in emoji positively relates to social presence and clarity of emotion, especially in emotional situations, and that cultural background is systematically related to emoji decoding and suitability. The framework sheds light on how the same individual may employ the use of a large number of emojis to their friends and few in the workplace, and how the same amount of emojis used may be seen as appropriate in one culture and improper in another, which is crucial to the study of digital communication across cultures.

2. Results

The overall data analysis of the responses obtained with 300 respondents of the Eastern and Western cultural groups provided a very complicated, nuanced image of the ways emoji density impacts the final results of conversations. The findings depicted both dramatic general trends and numerous cultural differences that directly answer the research questions and tasks in relation to emotional clarity, perceived friendliness, user engagement, and suitability of different communication scenarios.

The quantitative data made it clear that messages that are rich in emojis always scored higher than those that are emoji-poor in terms of clarity of emotion and engagement of the user in all three communicative contexts. Paired t-tests were used to statistically analyze the data and showed that there was a significant difference ($p < 0.001$) between the two conditions, and the effect size (Cohen's d) was large (greater than 0.8) in casual and emotional scenarios.

The respondents in the casual conversation condition also gave emoji-rich messages 1.9 points higher on the 5-point emotional clarity scale than their emoji-poor counterparts. The average rating of emoji-rich messages was

4.3 (0.6) as compared to 2.4 (0.8) of emoji-poor messages. This trend was further increased in the emotional support scenario in which the presence of emojis had a 2.2-point difference (4.5 +0.5 versus 2.3 +0.9). Respondents always cited emojis as important emotional triggers that made the emotions of the sender unambiguous. One of the participants of the West was a bit more detailed, citing that when I read the version with only text, I had to decide whether my friend was really excited about what was going on or was simply being polite. The emojis, in particular, the party popper and smiling faces, made their excitement look authentic and physical.

The thematic analysis of qualitative responses showed that there were three main mechanisms by which emojis increased emotional clarity: they gave visual cues of emotion that substituted missing nonverbal information, they made textual messages potentially confusing clearer, and they made messages more emotionally weighted. Most of the respondents used terms such as flat, robotic, and emotionless to describe emoji-poor messages and used words like vibrant, human, and emotion-driven to describe emoji-rich messages. This emotional improvement was directly transferred into the score of increase of user engagement, with emojis-rich messages rated 1.7 points higher on average in any scenario. The participants said that they felt more connected to the conversation partner and more involved in the conversation when there were emojis.

Although the very positive results were observed concerning the emotional expressiveness, the difference in favor of emoji-enhanced communication disappeared entirely in the workplace, which also demonstrates a key condition of successful emoji usage. The outcome was quite opposite in the professional case, where emoji-poor message scores were considered much more appropriate (mean = 4.2 +0.5) compared to emoji-rich messages (mean = 2.1 +0.9), a difference of 2.1 points, which was significant ($p < 0.001$).

The qualitative information was very informative on this turnaround. The language employed by the participants of both cultural groups to explain their negative reactions towards emojis used in professional communication was strikingly similar. Such words as unprofessional, not serious, distracting, and undermining credibility were very common in Eastern and Western replies. One of the western members (35, UK) said, When I saw the winking face and the thumbs-up on what was a professional request, I was instantly questioned at the judgment and professionalism of the person who had sent the message. It was not right for the situation. A participant (31, Japan) who was actually an Eastern supported this statement, saying that clarity and respect are essential in a work environment. The emojis helped to make the message casual and reduce the seriousness of the task under discussion.

This trend brings to the fore a general realization that various communicative situations will require various norms of expressiveness. Although emojis improve the connection between people in less formal environments, they are seen as breaking professional etiquette and may undermine the gravity of work communication. Cultural appropriateness

appears to be the agreeable limitation of emoji effectiveness that cuts across cultures, based on what the consensus across cultures indicates.

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3. Discussion and Conclusions

This study aimed to examine the subtle contribution of emoji density in online communication and further compare its relevance across cultures between Eastern and Western end users. The results form a very clear but complicated picture. Emojis are not only the elements of decor but significant communicative tools, the effectiveness of which is predetermined by a fragile combination of universal psychological laws and firmly embedded cultural standards. The conclusions that were made as a result of the analysis give substantive responses to the research questions and have considerable implications for the theory and practice of computer-mediated communication.

The findings strongly prove that communication with emojis makes emotional understanding, perceived friendliness, and involvement of user in informal and emotional situations universal. The respondents in the two cultural groups were also consistent in that messages that had a greater number of emojis were perceived as warmer, more emotionally open, and more interpersonally welcoming. This result is highly indicative of the theoretical assumption that emojis serve as efficient alternatives to nonverbal expression, and this kind of approach satisfies one of the most important human requirements: the ability to express their emotions through text.

Nevertheless, this advantage expresses an important boundary condition in workplaces, where the communication with emojis is predominantly favored cross-culturally. The professional appropriateness agreement shows that the contextual norms may, in some cases, override the cultural differences in order to establish common expectations on communicative restraint in formal settings.

The greatest contribution of this study is that it sheds light on how these general trends are mediated by cultural background. Although the two categories of participants found emojis helpful in casual situations, Eastern participants were more tolerant of, and expected a greater variety of circumstances permitting the use of emojis. Their perceptions were less direct and context-specific, and they saw emojis as the means of preserving relational balance instead of just conveying personal feeling. Western respondents, though compliant with emojis, had more logical interpretations and more concerns regarding possible overuse. These similarities are an exact representation of the larger cultural aspects found in the literature, specifically the collectivistic relational maintenance orientations of Eastern culture in comparison with the Western focus on direct expression.

This study has had a number of significant implications on the theoretical knowledge of computer-mediated communication. First, it builds upon the Social Presence Theory by showing that the ability of a medium to be warm and human is open to change, systematically depending not only on the cultural background but also on the communicative situation. Second, it builds upon Media Richness Theory, demonstrating that the richness injected by emojis is culturally coded; what is appropriate richness in one cultural context can be viewed as excess in another. Third, the results give concrete evidence supporting the idea of culturally-implanted visual literacy, indicating that proficiency regarding digital visual clues entails not only a technical, conceptualized comprehension but a cultural knowledge that influences interpretation and application.

The research also contributes to the research on cross-cultural communication in the digital world. The observation that simple emotional displays using emojis are universally recognizable and that more specific social processes are culturally specific is indicative of a more complex digital communication relying on the idea of universal and cultural specifics co-existing. That is why the global popularity of emojis and the constant risk of cross-cultural confusion, even in the case of seemingly universal symbols, are explained.

The practical use of these results is enormous to people and organizations that work in digital global contexts. In personal communication, the user is expected to be aware of the fact that their emoji patterns are cultural styles of communication that may not necessarily cross cultural boundaries. Eastern communicators would think that western counterparts may value high density of emojis as being too emotional or fake, and western

communicators need to know that their eastern partners would view low density of emojis as cold or impersonal. It is essential to develop this metacultural awareness, i.e., being aware of how other people perceive oneself in terms of their communication style, to conduct successful cross-cultural interaction by means of digital communication.

In professional and organizational settings, these results indicate that the culturally-focused communication rules should be applied instead of the uniform policies. Digital communication styles should be somewhat flexible as well because global organizations must be cognizant that expectations regarding appropriate professional communication are different across cultures. International team training should contain certain instructions regarding cross-cultural digital etiquette that should cover not only the language difference but also the differences in using visual means of communication, such as emojis.

This research can also make valuable contributions to platform designers and developers. Emoji recommendation algorithms and autocorrect need to be developed with cultural parameters to propose emoji use that is culturally and contextually appropriate. Interfaces can be improved by providing culturally-specific emojis keyboards or by providing instructions in form of tooltips on what common cross-cultural differences in understanding ambiguous emojis could be.

Although this research gives useful information, there are a number of weaknesses that ought to be recognized. Controlled conversational simulations, though methodologically needed, might not sufficiently reflect the intricacies of the genuine-world digital communication in which relationships, history, and current context may have an impact on emoji interpretation. The sample size was also not that large, and it was culturally diverse only to a certain degree, which might restrict external validity to the population with other demographic variables.

There are some promising directions that should be studied in the future. Adaptation patterns and learning might be seen with the help of longitudinal studies of how the use of emojis in cross-cultural relationships changes over time. Some domain-specific results may be obtained by investigating the use of emojis in particular professional settings (e.g., healthcare, education, international business). Studies that investigate the nature of individual differences among cultural groups (e.g., personality traits, foreign language proficiency, or intercultural experience) would assist in narrowing our view of the issues that moderately influence cultural patterns. Also, since the standards of emoji keep changing, and other new types of visual communication are introduced, one will have to do additional studies to observe how cultural patterns are adjusted to the shifts in the field.

Overall, the present study shows that successful use of emojis in the digitized globalized world demands both general principles and cultural specifics of the interpretation. It is established that although emojis may serve as a ubiquitous language by being pictorial and thus universal, there is a large

gap between how the emojis set is perceived and how the standard emoji set is perceived, proving the idea of a universal visual language (Kimura-Thollander & Kumar, 2019). Empirical research indicates the existence of emoji-emotion associations and usage patterns between different platforms and national settings, like Twitter and Weibo (Li & Guntuku, 2019; Kejriwal et al., 2021). Moreover, certain cultural beliefs of certain groups, such as the Malays, Chinese and the Indians in Malaysia, may result in different interpretations and subsequent semantic misinterpretation of the same emoji (Yazid et al., 2025). Hence, the savvy digital speakers will be the ones that will be able to maneuver not only the universal grammar of the emojis but also their regional dialects and learn to strategically use them depending on the context, audience and purpose. Digital communication is still tying people together due to geographical and cultural boundaries, so this type of visual-cultural literacy is not only beneficial, but it is a tool that is necessary to achieve meaningful and error-free relationships in the digital world across the globe.

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Conflict of interest. The authors certify that they have no financial or non-financial interest in the subject matter or materials discussed in this manuscript; the authors have no association with state bodies, any organizations or commercial entities having a financial interest in or financial conflict with the subject matter or research presented in the manuscript.

The authors received no direct funding for this study.

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Received by the editorial office 03.10.2025.
Accepted for printing 10.12.2025.
Published online 17.02.2026.