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THE WAR AND DIGITAL RESILIENCE: ASSESSING THE IMPACT OF MILITARY CONFLICT ON UKRAINE'S IT INDUSTRY

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Abstract. *For more than a year, Ukraine has faced full-scale military aggression from the Russian Federation. The war has disrupted every aspect of national life, including the digital and IT sectors. Under such conditions, it becomes crucial to assess the extent of the damage sustained by the IT industry and to outline strategic directions for its post-war recovery. The aim of this study is to evaluate the current state of Ukraine's IT industry as a cornerstone of the country's future reconstruction, and to measure the scale of losses resulting from wartime challenges. The research employs methods of economic and statistical analysis. The findings indicate that in recent years, the IT industry has become one of Ukraine's top three export sectors, generating substantial foreign currency revenues and contributing nearly 5% of GDP, while providing employment to over 300,000 specialists. Despite the ongoing conflict, the sector has shown remarkable adaptability and resilience, maintaining moderate growth dynamics. However, the war has inevitably slowed the pace of development, with estimated losses during the first year ranging from 0.4 to 3.35 billion USD.*

Post-war reconstruction should rely on the IT sector as a driving force that integrates and modernizes other industries. Priority areas include the digital transformation of the energy, transport, and logistics sectors.

Keywords: *IT industry, IT service exports, wartime losses, digital resilience, post-war recovery*

Introduction.

Before the outbreak of the full-scale war, the Ukrainian economy was characterized by a low level of innovative activity. This manifested in an outdated technological base, a shortage of innovation-oriented professionals, and weak innovation management practices. While advanced economies were developing within the framework of Industry 4.0 and laying the groundwork for Industry 5.0, Ukrainian manufacturing largely remained within obsolete technological paradigms. Over half (58%) of domestic industrial output belonged to the third technological mode, one-third to the fourth, and only 1% of Ukrainian products could be classified within the sixth technological mode (KSE).

The war has caused severe shocks to Ukraine's economy. Russian military aggression triggered widespread economic disruption — GDP contraction, asset destruction, financial instability, and a drastic decline in living standards. By the end of 2022, direct losses to Ukrainian enterprises reached approximately 13 billion USD, with indirect losses estimated at 33.1 billion USD (KSE).

Although it remains premature to fully assess the total damage and define comprehensive recovery strategies amid ongoing hostilities, the groundwork for post-war development is already being laid. The establishment of the National Council for the Recovery of Ukraine from the Consequences of the War (Presidential Decree) and the creation of specialized working groups for infrastructure reconstruction illustrate this proactive approach.

Successful recovery will depend on a clear understanding of economic losses, well-defined development priorities, and secured investment sources. The experience of other countries may provide valuable insights: Poland, Germany, and the Netherlands prioritized strategic recovery planning and external financing, achieving "post-traumatic" economic growth. South Korea focused on export expansion and investment in science and technology, while Japan emphasized anti-oligarchic reforms, scientific advancement, and modernization of labor, land, and tax systems.

Literature Review. Armed conflict represents one of the most severe disruptions a nation can face. War not only takes lives and destroys human destinies, but also devastates economic infrastructure, paralyzes logistics, and undermines long-term development potential. Although certain short-term stimulatory effects may emerge through increased military spending, the overall consequences of war are profoundly destructive, impeding economic growth and eroding national prosperity (Goldstein, 2003) [1]. Cohn and Duncanson (2018) argue that international financial institutions' post-war economic recovery prescriptions often reinforce structural inequalities, while feminist approaches provide a more inclusive and sustainable path toward genuine social and economic recovery [2]. The economic dimension of post-war recovery is therefore fundamental. Without a rapid and well-coordinated economic revival, a nation risks prolonged instability and potential internal conflict. Research shows that

fragility, conflict, and underdevelopment are deeply interconnected (Hoeffler, 2012) [3]. Moreover, economic recovery contributes directly to peacebuilding – sustained growth increases the duration of peace and helps stabilize post-conflict societies (Collier et al., 2009) [4].

Countries emerging from war require comprehensive reforms that not only address immediate reconstruction needs but also lay the groundwork for long-term transformation. As noted by Cohn (2018), the process of recovery extends beyond repairing physical destruction – it must also tackle the structural distortions and institutional weaknesses that war leaves behind [2].

International financial institutions often play a key role in supporting post-conflict economies by providing financial aid and technical assistance. However, the experience of numerous countries demonstrates that external assistance alone is insufficient without a coherent, balanced national recovery strategy. Effective post-war reconstruction depends on clearly defined priorities and a consistent policy framework that integrates both domestic and international resources.

García-Vidal et al. (2019) analyze production efficiency in small and medium-sized enterprises using the *chain substitution and successive approximation method* to optimize throughput and identify key performance constraints [5]. Gerasimov et al. (2019) examine mechanisms of control within human capital management systems as a strategic tool for fostering regional innovative development and ensuring sustainable economic growth [6].

Methodology. The study applies a combination of analytical, statistical, and comparative methods to examine the impact of war on the performance and resilience of Ukraine's IT industry. The methodological framework is grounded in the principles of economic diagnostics, enabling a structured assessment of sectoral dynamics under crisis conditions. Research Design – The research was conducted in two main stages. The first stage involved the collection and systematization of secondary data from official sources – including the State Statistics Service of Ukraine, the National Bank of Ukraine, the Ministry of Digital Transformation, and industry reports from the IT Association of Ukraine. These data sets provided the foundation for analyzing pre-war

and wartime trends in IT exports, employment, and overall sectoral output. The second stage included comparative analysis aimed at evaluating changes in key performance indicators before and after the escalation of the war in 2022. This allowed for identifying both the immediate disruptions caused by the conflict and the adaptive responses of IT enterprises.

Analytical Methods – To quantify the effects of the war, economic and statistical methods were employed, including: trend analysis, to examine changes in IT exports, revenues, and employment levels over time; comparative analysis, to identify structural shifts in the sector's contribution to GDP; estimation of potential losses, based on projected growth rates under a no-war scenario versus actual wartime performance.

Data Interpretation – The obtained data were interpreted using a resilience-based approach, focusing on the IT industry's capacity to adapt to crisis conditions, maintain operations, and support national economic stability. This approach allowed for assessing not only the quantitative losses but also the qualitative aspects of digital transformation and innovation continuity.

Limitations of the Study – Given the ongoing nature of the conflict, the research is subject to several limitations. The accuracy of statistical data may be affected by incomplete reporting, regional disruptions, and migration of IT professionals abroad. Therefore, the results should be interpreted as indicative trends rather than absolute values.

Overall, this methodological approach provides a holistic view of how Ukraine's IT sector has responded to wartime challenges, combining economic indicators with structural and behavioral analysis of industry resilience.

Research Results. The results of the study confirm that the IT industry remains one of the key drivers of Ukraine's economic resilience during wartime. Despite disruptions in infrastructure, migration of specialists, and the relocation of businesses, the sector has demonstrated adaptive capacity and contributed significantly to export revenues and national GDP.

To identify the main determinants influencing the performance of the IT sector, factor analysis was conducted. This method allows for building a model that reflects

the relationship between the resulting indicator – the share of IT product exports in GDP – and its key influencing factors.

Model Construction. The formation of the resulting indicator can be expressed through the following functional model:

$$E_{IT} = \frac{X_{IT}}{GDP} \times 100\% \quad (1)$$

where:

E_{IT}– share of IT exports in GDP (%);

X_{IT}– total value of IT exports (in USD or UAH equivalent);

GDP– gross domestic product of Ukraine (in USD or UAH).

This ratio reflects the contribution of the IT industry to the overall economic output and serves as a measure of digital sector performance within the national economy.

Factor Decomposition. To assess the influence of individual factors on E_{IT}, the model can be expanded as follows:

$$E_{IT} = f(N, P, Q, R) \quad (2)$$

where:

N– number of employees in the IT sector;

P– average productivity per employee (IT service value added);

Q– export orientation ratio (share of exported IT services in total IT output);

R– resilience coefficient, reflecting the sector's adaptability to wartime conditions (business relocation, remote work capabilities, digital infrastructure stability).

Thus, the total value of IT exports can be represented as:

$$X_{IT} = N \times P \times Q \times R \quad (3)$$

Substituting this expression into the initial formula, the model for determining the share of IT exports in GDP takes the following form:

$$E_{IT} = \frac{N \times P \times Q \times R}{GDP} \times 100\% \quad (4)$$

This model enables quantitative assessment of how specific factors – workforce dynamics, productivity levels, export dependence, and sectoral resilience – affect the proportion of IT exports in GDP.

Workforce changes (N): Migration or mobilization of IT professionals directly reduces the human capital available for production. Productivity (P): Depends on access to technologies, stable connectivity, and international demand for IT services. Export orientation (Q): Indicates how dependent the sector is on foreign markets, which remain the main source of income for Ukraine's IT firms. Resilience (R): Represents the ability of enterprises to maintain operations through relocation, cloud technologies, and cybersecurity measures.

Based on data from 2021–2023, the average share of IT exports in Ukraine's GDP ranged between 4.5–5.3%, confirming the sector's strategic role even under wartime stress. Despite temporary declines in early 2022, export volumes stabilized by mid-2023, supported by international contracts and the rapid digital adaptation of firms.

Overall, the factor analysis demonstrates that maintaining workforce stability and enhancing technological resilience are the most influential determinants of IT sector performance during the war. The volume of computer services in Ukraine during 2015-2024 and their share in GDR (fig.1).

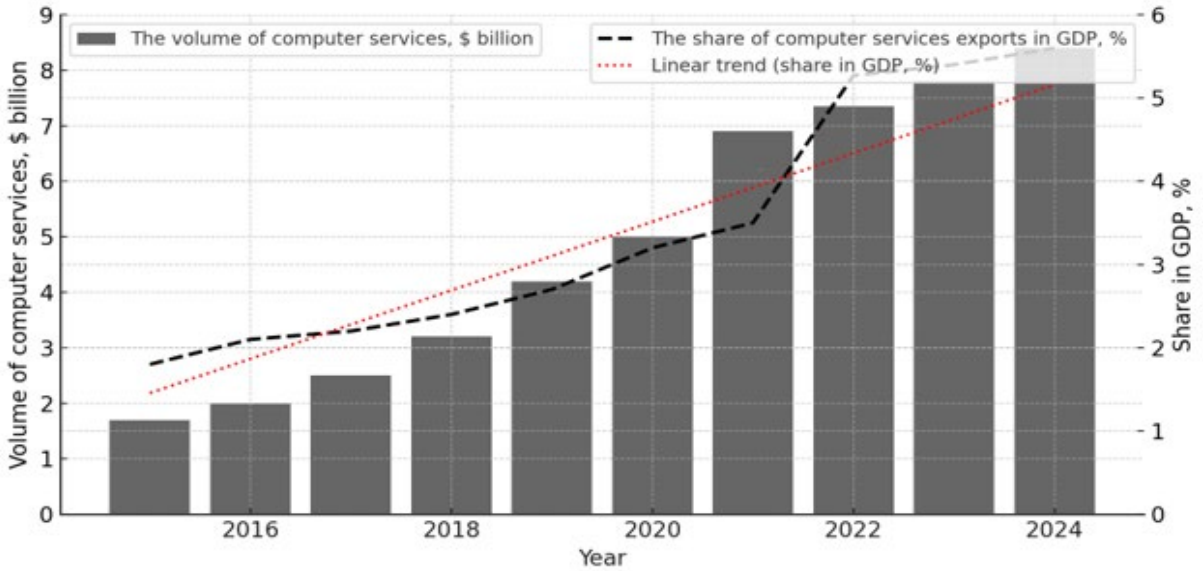

Fig 1. The volume of computer services in Ukraine during 2015-2024 and their share in GDR

** Formed by the authors*

As shown in Figure 1, the volume of computer services exports in Ukraine continued to grow steadily throughout 2015–2024, despite wartime challenges. During

this period, the total export volume increased nearly fivefold, from $1.7 billion in 2015 to approximately $8.4 billion in 2024. The average annual growth rate of exports reached around 25–27%, indicating a high level of resilience and international competitiveness within the Ukrainian IT sector. At the same time, the share of computer services exports in GDP increased from 1.8% in 2015 to about 5.6% in 2024, confirming the sector's growing role in national economic structure. The trendline equation (y = 0.4117x + 1.0435) illustrates a stable upward trajectory, reflecting both the expanding global demand for Ukrainian IT services and the sector's ability to adapt to wartime disruptions [7-8].

The year 2022 marked a temporary slowdown caused by the initial shock of the full-scale invasion; however, by 2023–2024, the IT industry regained its growth trajectory due to successful business relocation, international contracts, and the strengthening of remote work infrastructure. Thus, the data indicate that even under extreme conditions, Ukraine's IT industry maintained positive growth dynamics, reinforcing its status as a key export-oriented driver of economic stability and post-war recovery.

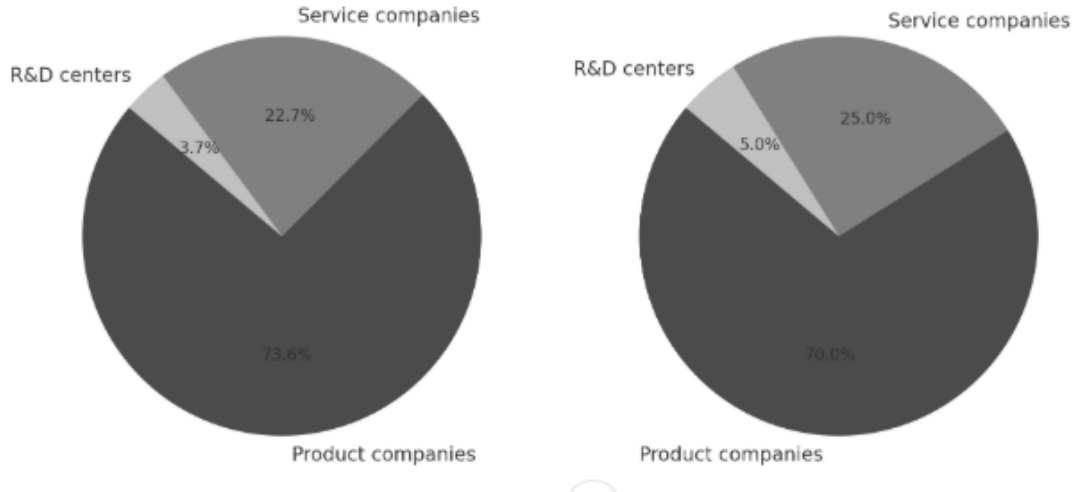

Fig. 2. Types of IT companies in Ukraine (2022-2024)

** Formed by the authors*

As shown in Figure 2, the product-oriented companies dominate Ukraine's IT ecosystem, accounting for approximately 73.6% in 2022. These firms primarily develop proprietary software solutions, SaaS products, and mobile applications for export markets. The service companies, which provide outsourcing and consulting

services, comprised 22.7% of the sector, while R&D centers made up only 3.7%. The projected data for 2024 show a gradual structural diversification: the share of service companies is expected to increase to 25%, and R&D centers – to 5%. This shift indicates a slow but steady movement toward the knowledge-intensive segment of the IT industry, emphasizing innovation, applied research, and technological partnerships with global corporations.

Such transformation aligns with post-war recovery priorities. Strengthening the R&D and service components will not only enhance the innovation capacity of the Ukrainian digital economy but also stimulate the development of domestic technological infrastructure, helping reduce external dependency and increase resilience.

In summary, while Ukraine's IT industry remains predominantly export-driven, emerging diversification trends point toward a more sustainable, innovation-oriented structure, capable of driving both external competitiveness and internal modernization.

The conducted research confirms that Ukraine's IT industry has emerged as one of the most resilient and adaptive sectors of the national economy during wartime conditions. Despite large-scale disruptions, including the destruction of infrastructure, migration of specialists, and general economic decline, the sector has demonstrated sustainable growth, digital flexibility, and export stability.

The analysis of dynamics for 2015–2024 reveals that the volume of computer services exports increased nearly fivefold, while their share in GDP rose from 1.8% to 5.6%. Such outcomes highlight the strategic role of the IT industry as a stabilizing force capable of ensuring foreign exchange inflows and maintaining technological continuity during crisis periods. At the same time, the structure of the IT market shows a strong external orientation, with over two-thirds of companies being product-oriented exporters. This model, although beneficial for foreign earnings, creates an asymmetry: the domestic digital market develops more slowly, limiting the diffusion of technological innovations within the national economy.

From a policy perspective, the key challenge lies in achieving a balance between export orientation and domestic digitalization. The wartime and post-war periods provide a

unique opportunity to redefine Ukraine's IT strategy toward a more innovation-driven, research-intensive, and value-added direction. Key Findings (tab. 1).

Table 1 - Key Findings

1	Sustained Export Growth	The IT sector has maintained high export performance even under military aggression, confirming its role as a critical contributor to macroeconomic stability
2	High Adaptability	The rapid transition to remote work, business relocation abroad, and integration with global digital networks allowed Ukrainian IT firms to minimize operational losses
3	Structural Concentration	The dominance of product companies (over 70%) emphasizes the need for diversification – particularly through the expansion of R&D centers and service-oriented enterprises focused on knowledge transfer and innovation
4	Potential for Domestic Development	Strengthening the internal market for IT products and digital solutions can accelerate post-war recovery across other sectors – energy, logistics, education, and public administration

* *Formed by the authors*

Recommendations for Post-War Development: 1) Promote Digital Transformation of Key Industries. The integration of IT solutions into energy, transport, logistics, and manufacturing should become a core element of Ukraine's post-war modernization strategy; 2) Support the Creation of R&D Centers. Incentives for foreign and domestic investment in research and development will help transition from outsourcing to innovation leadership; 3) Enhance Human Capital. Expanding STEM education, cybersecurity training, and innovation management programs will ensure a steady supply of highly qualified specialists; 4) Stimulate Domestic Demand for IT Solutions. State procurement policies and public–private partnerships can boost the internal digital market, ensuring sustainable growth beyond export revenues; 5) Strengthen Digital Infrastructure and Security. Investments in data centers, cloud systems, and cybersecurity are essential to ensure technological sovereignty and protect critical information resources.

Conclusion.

In conclusion, Ukraine's IT industry has proven its strategic importance and resilience amid one of the most challenging crises in modern history. Its ability to maintain growth under wartime conditions demonstrates both its institutional strength

and human potential. In the post-war period, the IT sector should become not only a driver of economic recovery but also a foundation for the digital transformation of the entire Ukrainian economy.

By combining innovation, diversification, and smart governance, Ukraine can leverage its IT potential to rebuild a more competitive, secure, and technologically advanced national economy – one that stands as a model of digital resilience in the global post-conflict context.

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