

Economic and legal aspects of the functioning of the IT sphere in the conditions of war

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Abstract. As of 2024, Ukraine has been enduring military aggression from the Russian Federation for over two years. This war has affected all aspects of the country's life, including the IT industry. In such circumstances, it is essential to evaluate the losses incurred by the digital sector due to military operations and devise strategies for its post-war rehabilitation. The purpose of this study was to assess the state of IT sector in Ukraine, regarded as the main driver of post-war recovery of Ukraine, and to gauge the extent of the damage inflicted by the war. The study was conducted using economic and statistical analysis methods. The findings revealed that in recent years, the IT industry has become one of the top three export sectors, contributing significantly to foreign exchange earnings and comprising about 5% of GDP. The industry also provides jobs for over 300,000 people. During the war, the IT sector demonstrated resilience, adapting to critical conditions and maintaining positive growth trends. However, despite these achievements, the war negatively impacted the sector, slowing its growth. During the first year of the war, the potential losses of the IT sector ranged from 0.4 to 1.9 billion US dollars. Areas requiring the development of regulatory support are identified. The post-war recovery of Ukraine should be centred on a progressive sector that integrates and unites all areas of the IT industry. Primarily, a digital transformation of the energy sector, transport, and logistics systems is proposed. The results of this study can inform the development of strategies for the post-war recovery of the Ukrainian economy and the forecasting of its development indicators

Keywords: volume of IT services; export of IT services; advantages of the digital economy; potential losses of the IT sphere from the war; threats to the development of the IT sector during wartime; post-war recovery

Suggested Citation

Article's History: Received: 29.02.2024 Revised: 24.05.2024 Accepted: 26.06.2024

Vysotska, I., Holovach, T., Vysotskyi, Vysotskyi., Nahirna, O., & Korchynskyi, V. (2024). Economic and legal aspects of the functioning of the IT sphere in the conditions of war. *Social & Legal Studios*, 7(2), 119-129. doi: 10.32518/sals2.2024.119.

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Introduction

A defining characteristic of the Ukrainian economy in the pre-war period was its low level of innovative activity. This was evident in its outdated technological base, the absence of innovative specialists, and poor innovation management. While leading countries worldwide have been developing industries based on Industry 4.0 technologies and laying the groundwork for Industry 5.0, the Ukrainian industry was producing outdated products. Over half (58%) of Ukrainian industrial products belong to the third technological mode, a third to the fourth, and only 1% of Ukrainian products can be attributed to the sixth technological mode (Kyiv School of Economics, 2023). Today, the Ukrainian economy is experiencing significant losses due to the war. The military aggression of the Russian Federation against Ukraine has caused economic upheaval, manifesting in a substantial reduction in Gross Domestic Product (GDP), destruction of assets, disruption of the financial sector, and a decline in the population's standard and quality of life. By the end of 2022, direct losses of Ukrainian enterprises amounted to \$13 billion, with indirect losses reaching \$33.1 billion (Kyiv School of Economics, 2023). Given the ongoing hostilities, it is too early to assess the losses and outline recovery areas fully. However, steps are already being taken towards post-war development. The National Council for the Recovery of Ukraine from the Consequences of the War (Decree of the President of Ukraine No. 266/2022, 2022) and working groups for the reconstruction of infrastructure in settlements have been established. Post-war recovery of Ukraine requires a clear understanding of the scale of losses incurred, areas for future economic development, and sources and volumes of investment needed. In this context, it is beneficial to consider the experiences of other countries.

International financial institutions develop and implement programmes to provide financial assistance to countries in the post-war period. However, the experiences of individual countries demonstrate that without a balanced strategy for post-war recovery and proper prioritisation, financial assistance is ineffective. Returning a country to normalcy requires a well-developed recovery policy. The post-war economic recovery of European countries has been extensively explored. E. Reinert (2019) noted that all currently prosperous European countries used a similar strategy for the post-war reconstruction of their economies: they shifted from a raw material orientation to the processing industry and underwent a period where emulation – the desire and aspiration to match or surpass – was their main priority. The post-war restoration of Ukraine should focus not merely on reproducing destroyed capacities and technologies but on developing Ukrainian industry to modern standards. Consequently, the starting point for local drivers of economic recovery is to conduct an initial assessment of post-conflict needs and identify priorities. Moreover, as R. Sirop (2023) noted, for success, local drivers must analyse the political economy to understand why and how people can contribute to the economic recovery.

Post-war recovery should provide Ukraine with the opportunity to move away from outdated and inefficient technologies and modernise its economy. The reconstruction of post-war economy of Ukraine offers a significant chance to modernise the nation, develop high-quality transportation and logistical infrastructure linked to European countries, and integrate Ukraine into the Euro-Atlantic community. As

S. Bandura and J. Staguhn (2023) noted, technology will play a crucial role in this process. Currently, the Ukrainian government emphasises the development of digital technologies as central to the country's future recovery. V. Gerasimov *et al.* (2019) observe that many developed nations have initiated systematic shifts towards fostering the digital economy in anticipation of future changes. C. Cohn and C. Duncanson (2018) accurately noted that war-weakened countries need deep reform measures that will not only contribute to recovery but also create a basis for further development. Beyond repairing the damages caused by war, Ukraine aims to address the broader economic implications of recovery, including disruptions and distortions. A key objective in the post-war recovery plan is to increase the IT sector's contribution to GDP to 10 percent (IT Ukraine Association, 2023a).

The purpose of the study is to diagnose the state of the IT sector in Ukraine as the main core of the post-war recovery of the country and to assess the extent of the damage caused by the war.

Methodology

The study utilised methods of economic and statistical analysis, including factor analysis, extrapolation, and GAP analysis. During the analysis of trends in the development of the IT sector from 2015 to 2023, an economic analysis method was employed based on a dialectical approach to understanding. This means that the main parameters of IT sector development were examined in accordance with the principles, laws, and categories of dialectics, which involve studying economic phenomena in terms of dynamics, movement, and development. All indicators were considered with their interconnections and interdependencies in mind (Stetsyuk, 2010).

To assess the losses in the IT sector due to hostilities, forecast values of key indicators obtained through the extrapolation method were compared with actual values. The calculation of forecast (potential) levels of IT service export volumes and their share in GDP was performed by extrapolating the trend. The aim of the forecast is to illustrate potential future outcomes by sustaining the trends observed in previous periods. The forecasting of indicators was based on the hypothesis that the development trends identified through statistical analysis of time series will continue into the future. Trend extrapolation is a primary approach for forecasting market dynamics. The defining feature of trend extrapolation methods is that they rely solely on historical values of a variable to determine its future values (Trend Extrapolation Methods, 2002). The extrapolation method used data on the volume of IT services exports and their share in GDP for the period 2015-2023, which are considered time series (Official website of the State Statistics Service of Ukraine, n.d.; IT Ukraine Association, 2022; IT Ukraine Association, 2023b). From this data, a trend was identified, representing the overall pattern of changes in indicators over a specific period. Simple extrapolation methods, including linear, geometric, and exponential approaches, require minimal data, have straightforward mathematical structures, and are easy to implement (Trend Extrapolation Methods, 2002).

The application of simple extrapolation methods is based on the assumption that the trends in IT product export volumes and their share in GDP, derived from dynamic series, will persist into the future. The trend of changes in indicators is described by a specific function:

$$y = f(t), \quad (1)$$

where t is a time variable. Next, the time series is standardised and forecasts are made for the further development of the process. In the case of a linear trend in the development of the phenomenon, it is advisable to extrapolate the trend using the average absolute increase. The forecasted level value is determined based on this average absolute increase. This value is then added to the base level of the dynamic series used for extrapolation:

$$y = y_0 + \Delta y, \quad (2)$$

where y_0 represents the baseline level of the series for extrapolation; Δy – average absolute growth; y – forecasted value of the series dynamics level. The absolute increase will be determined using the fundamental method of substitution according to the formula:

$$\Delta y = y_i - y_0. \quad (3)$$

Forecast values for the export volume of IT services and its share in GDP are derived from the statistical properties of the dynamic series using the following formulas. To compute forecast values based on average absolute growth:

$$y''_{n+T} = y_n + \Delta \bar{y}T. \quad (4)$$

To calculate forecast values based on the average growth rate:

$$y''_{n+T} = y_n * K_p^T, \quad (5)$$

where y''_{n+T} is the forecast value of the indicator for the period $n+T$ (T-1;2;3;4;5); y_n represents the actual value of the investigated indicator for the last period before the forecast period; T denotes the number of periods for which the forecast is prepared; K_p stands for the average growth rate for the period preceding the forecast; and Δ represents the average absolute growth over the historical period.

When comparing forecast (potential) and actual indicators, the GAP-analysis method was employed. GAP analysis functions as a tool or process aimed at identifying the locations of gaps and discerning the distinctions between an organisation's current state and its desired situation or "what ought to be" in place. GAP analysis can be described as an organisational effort to bridge the gap between desired and forecasted activities (Kim & Ji, 2018). Methodologically, GAP analysis involves creating two graphs: one showing the trends in the volume of IT product exports and their share in GDP under stable conditions, and the other displaying the expected results under the influence of a military invasion. By drawing these graphs, the scale of the gap is estimated and appropriate measures are taken to fill it. Essentially, GAP analysis entails computing and contrasting the potential level of indicators with the levels attained under wartime conditions.

Factor analysis methods were used to determine the impact of factors on the share of IT services exports in the country's GDP. Factor analysis allows for the determination of the impact of individual factors on changes in the resulting indicator using deterministic or stochastic methods of

research. In this study, a deterministic factor analysis of the influence of the volume of IT services exports and the volume of GDP was conducted using the method of chain substitutions. The method involving chain substitution and a successive approximation approach enables a gradual determination of the impact that each analysed variable has on the throughput per hour (García-Vidal et al., 2019).

Factor analysis involves building a model of the formation of the resulting indicator. The model for calculating the share of IT product exports in GDP can be presented as a formula:

$$F = \frac{Exp}{GDP}. \quad (6)$$

The use of the chain substitution method involves a step-by-step replacement of the factor values from planned to actual:

$$F^1 = \frac{Exp \text{ act}}{GDP \text{ pl}}. \quad (7)$$

$$\Delta Exp = F^1 - F \text{ pl}. \quad (8)$$

$$F^2 = \frac{Exp \text{ act}}{GDP \text{ act}}. \quad (9)$$

$$\Delta GDP = F^2 - F^1. \quad (10)$$

$Exp \text{ pl}$, act refer to the planned and actual volume of IT services exports, measured in billions of US dollars. Similarly, $GDP \text{ pl}$, act denote the planned and actual volume of gross domestic product, also in billions of US dollars. ΔExp represents the impact of changes in IT product exports on its share in GDP, while ΔGDP indicates the impact of changes in GDP volume on the share of IT services exports in GDP. For the calculations, 2021 was chosen as the baseline year. This study utilised a set of indicators for the development of the IT sector from 2015 to 2023.

Results

The state of IT sector development in the pre-war period. The war is a profound upheaval for the country, taking lives, destroying destinies, demolishing infrastructure and logistics, and stifling economic development (Gavrysh et al., 2024). While short-term military stimulation may yield some positive effects, such as immediate economic activity, the long-term consequences of destruction and reconstruction typically impede economic progress and undermine national prosperity (Goldstein, 2003). The economic component of the country's post-war revival is crucial; without ensuring rapid recovery, the nation risks falling into the trap of internal civil conflicts. Conflict, fragility, and poor development are intricately interconnected (Hoefler, 2012). Higher growth rates in economic recovery prolong the duration of peace, thereby stabilising the country (Collier et al., 2009).

The hallmark of modern economic development is the use of knowledge as a means of production. Against the backdrop of increasing information flows, knowledge and information become decisive factors in economic growth. The process of digitalisation permeates various spheres of societal life. Under such conditions, the global trend is the growing demand for "digital" products, the transformation of business models, and the restructuring of the economy.

Therefore, countries striving for progress create attractive conditions for conducting IT business, and the scientific and expert environment stimulates research in this area.

The IT sector has rapidly emerged as a primary driver of the global economy, catalysing fundamental changes and transformations across numerous industries in a short period. In recent years, the IT sector has been one of the most dynamically developing spheres in Ukraine. More and more Ukrainian industrial enterprises are implementing Big Data technologies, 3D printing, cloud services, and robotics. Pharmaceuticals, mechanical engineering, and equipment manufacturing are leading in these technologies (IT Ukraine Association, 2022).

However, a notable feature of the national IT sector is its focus on the external market. The Ukrainian IT industry has become a formidable competitor globally, serving

as a reliable source of foreign exchange earnings that help sustain the hryvnia exchange rate. Consequently, the importance of IT services in the export structure is also increasing. Between 2015 and 2022, the export volume of computer services increased 4.3 times, reaching \$7.35 billion, with an average growth rate of 26.8%. In 2023, for the first time in a long period, there was a decrease in the volume of computer services provided (Fig. 1).

This trend is characteristic of the export-oriented segment of the IT industry. The Ukrainian market for digital technologies has not developed at the same rapid pace. The export focus is also reflected in the types of IT companies. According to the Tech Ecosystem portal, the vast majority of IT companies (73.75%) are product companies, 22.7% are service companies, and only 3.7% are R&D centres (Fig. 2) (IT Ukraine Association, 2023).

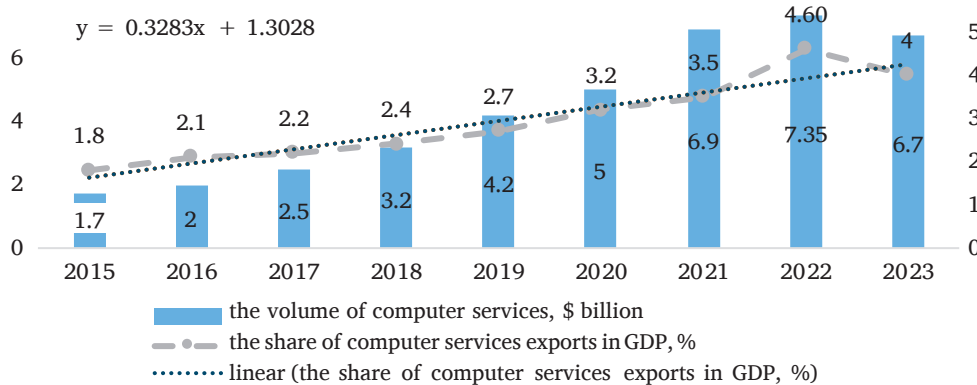


Figure 1. The volume of computer services in Ukraine during 2015-2023 and their share in GDP

Source: based on data from IT Ukraine Association (2023b)

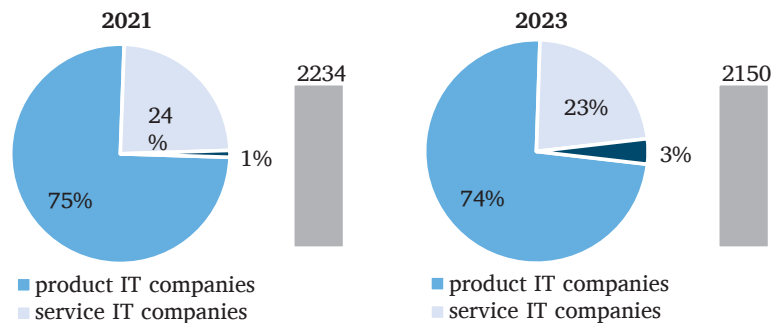


Figure 2. Number and structure of IT companies in 2021-2023

Source: based on data from IT Ukraine Association (2023b)

The modern Ukrainian IT sector comprises about 2,500 companies actively operating in the market. Human capital is the driving force behind the development of the IT sector. As of the end of 2023, the IT sector employed more than 346 200 specialists. At the beginning of 2024, the 50 largest IT companies in Ukraine employed over 74.7% of these specialists. In 2022, nearly half of the IT companies observed negative growth dynamics, with the total number of IT specialists decreasing by almost three thousand. More than 60% of IT companies have not suspended hiring in Ukraine since the war began. However, the hiring structure has changed: 9.5% of companies have increased the number of vacancies, 27.1% are hiring specialists at pre-war levels, 49.5% have reduced the number of vacancies,

and 3% have completely stopped hiring employees (Nahatkin, 2023). The hiring structure also varies depending on company size – the largest (1000+ employees) and smallest IT companies have reduced the number of vacancies the most, by 66% and 58%, respectively. In companies with 11-50 employees, the number of vacancies decreased by 56%, with 51-100 employees – by 45%, with 101-1000 employees – by 43%, with 1000+ employees – by 66% (Nahatkin, 2023). A specific feature of the IT sector is that most IT specialists work with companies as sole proprietors, which affects taxation. The majority of IT specialists who cooperate with companies as individual entrepreneurs pay taxes independently under the simplified taxation system and pay a single tax. It should also be noted that the

single tax paid by individual entrepreneurs remains 100% in the local budgets where they are registered. Therefore, it can be stated that IT workers contribute to local budgets and regional development.

As of January 1, 2024, the amount of taxes and fees paid by the IT business to the consolidated budget of Ukraine amounted to UAH 35.9 billion, which is UAH 4.4 billion

(11.5%) more than in 2022 (IT Ukraine Association, 2022; IT Ukraine Association, 2023b). In the structure of taxes paid by IT companies, the largest components are personal income tax and the single social contribution (Fig. 3). Consequently, over the past decade, the IT sector has tended to grow rapidly and has gradually become the driving force of the entire Ukrainian economy.

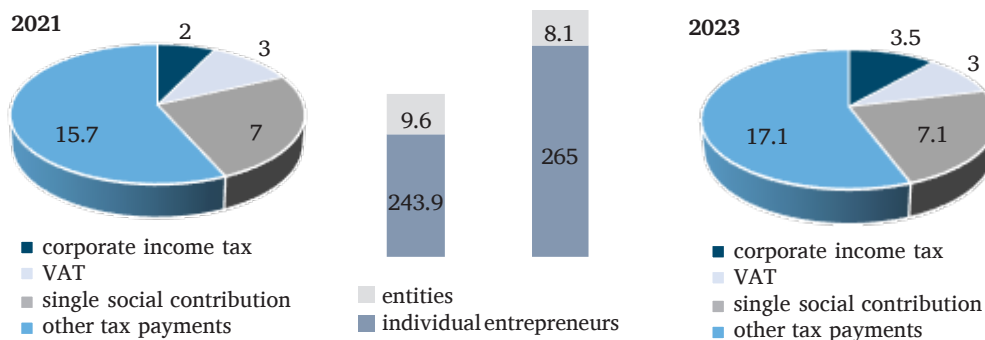


Figure 3. Taxes paid by IT companies during 2021-2023

Source: based on data from IT Ukraine Association (2023b)

Predictive assessment of the IT sector development.

The development of the IT sector in the pre-war period was characterised by positive dynamics. As noted earlier, even under the conditions of a full-scale invasion, the IT industry is showing positive dynamics. However, the war has affected all sectors of the economy, including the IT sector. An analysis of deviations (GAP) in the development of the industry allows for prompt corrective measures in the short term and strategic decisions in the medium and long term. The development gap of the IT industry is calculated as the difference between the actual volume of IT services provided and its potential level. Unlike the main statistical indicators of the industry's development (such as the volume of IT services provided, the share of IT services exports in GDP, and the number of employees in the industry, etc.). The potential volume of IT services and the discrepancies therein are not

captured in official statistics. Consequently, both quantitative and qualitative evaluations utilising statistical methodologies are necessary. Forecasting anticipated indicators is conducted using historical data, with trend extrapolation representing one of the straightforward forecasting techniques. This method takes a historical trend over time and extrapolates the dynamics of indicators if the existing trend persists in the future. The general assumption is that whatever happened in the past will continue in the future.

The results of calculating the statistical characteristics of the dynamic series of volumes of IT services provided during 2015-2023 and their forecast are shown in Table 1. To mitigate the influence of fluctuations in the exchange rate of the national currency on the forecast indicators, the volume of IT services provided in hryvnias is converted into the dollar equivalent using the average annual official exchange rate.

Table 1. Analytical characteristics of the time series of IT services volumes provided

| Years | Share of IT services export in GDP, % | Export volume of IT services, \$ billion | Increase in export of IT services, \$ billion | |
|--|---------------------------------------|--|---|----------|
| | | | Absolute | Relative |
| 2015 | 1.8 | 1.7 | - | - |
| 2016 | 2.1 | 2 | 0.3 | 17.65 |
| 2017 | 2.2 | 2.5 | 0.5 | 25.00 |
| 2018 | 2.4 | 3.2 | 0.7 | 28.00 |
| 2019 | 2.7 | 4.2 | 1 | 31.25 |
| 2020 | 3.2 | 5 | 0.8 | 19.05 |
| 2021 | 3.5 | 6.9 | 1.9 | 38.00 |
| 2022 | 5.27 | 7.35 | 0.45 | 6.52 |
| 2023 | 4 | 6.7 | -0.65 | -8.84 |
| Average value for 2015-2023 | 3.02 | 4.11 | 0.63 | 19.58 |
| Forecast data | | | | |
| Forecast value of IT services exports in 2024, \$ billion | | | 7.33 | 8.25 |
| Forecast value of IT services exports in 2025, \$ billion | | | 7.95 | 10.44 |
| Forecast value of the share of IT services exports in GDP in 2024, % | | | 4.28 | 4.48 |
| Forecast value of the share of IT services exports in GDP in 2025, % | | | 4.56 | 5.02 |

Source: calculated by the authors based on IT Ukraine Association (2023b) and Official website of the State Statistics Service of Ukraine (n.d.)

The results of the IT sector development dynamics in 2015-2023 indicate that in Ukraine, there was a trend towards rapid qualitative growth in the volume of IT service exports and their share in GDP. The prevailing economic conditions suggest the gradual establishment of a foundation for the industry's continued progressive development.

Calculation of the impact of the war on the IT sphere. The full-scale invasion by the Russian Federation caused a decline in the development rate of the IT industry. The GAP analysis method was used to assess the impact of the war on the development of the IT sphere. In the GAP analysis method, the initial step involves calculating the projected development indicators of the IT sector to pinpoint disparities between their anticipated volumes during peacetime and the volumes observed under war-

time conditions. Forecasts from previous years serve as the basis for projecting expected indicators, with data from 2023 used as a reference point. Subsequently, upon computing all indicators, discrepancies between the anticipated values during peaceful times and their actual values were identified.

Since the IT sphere of Ukraine is export-oriented, the main indicator that characterises it is the volume of IT services exports. As mentioned above, the IT sphere is the only sphere that managed to ensure growth in the conditions of active hostilities. However, the obtained results are significantly worse than the predicted values. The gaps between predicted and actual values can be considered lost opportunities due to the war. To visualise the results, the data are presented in the form of a graph (Fig. 4).

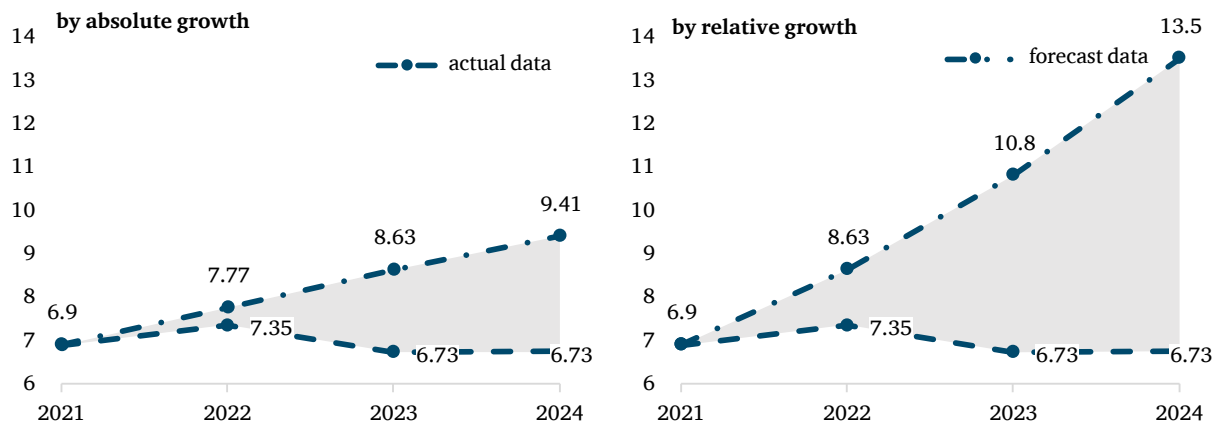


Figure 4. Projected assessment of the decline in IT services export volume due to the war, \$ billion USD

Source: calculated by the authors based on IT Ukraine Association (2023b) and Official website of the State Statistics Service of Ukraine (n.d.)

As shown in Fig. 4, the Ukrainian IT sector missed out on revenue from IT services exports in 2022, ranging between \$4.07 million and \$1.9 billion, depending on the calculation method. The war had a synergistic negative impact on the overall economy, particularly on the IT sector. Another reason for the decline in IT services exports is the overall global downturn in the IT sector. The war in Ukraine slowed the development of the worldwide

economy, which in turn affected the demand for IT services. In addition, foreign customers have cited growing risks in cooperating with Ukrainian IT companies. Under these assumptions, in 2023, losses in the IT sector due to the war will range from \$1.21 billion to \$3.92 billion. Another crucial indicator for evaluating the IT sector development is the share of IT services exports in the country's GDP (Fig. 5).

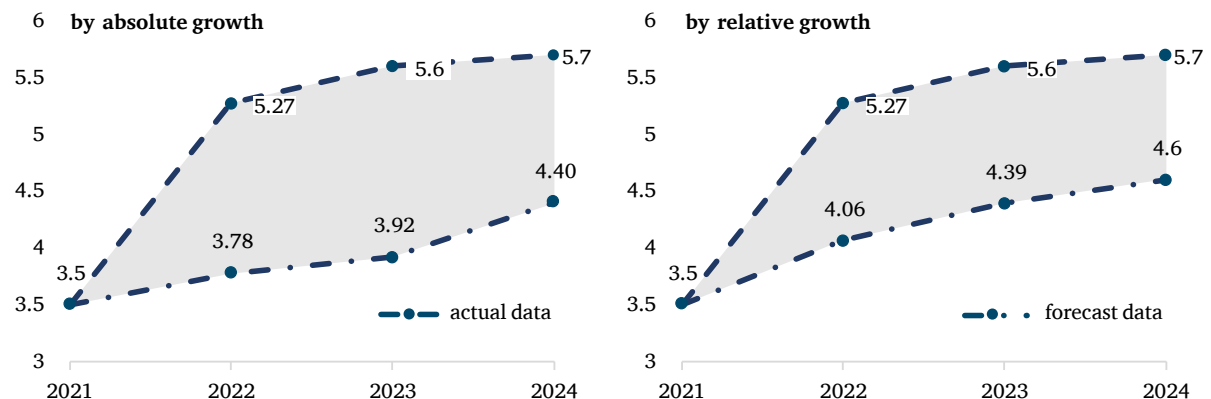


Figure 5. Predictive assessment of the gaps between the forecast and actual values of the share of IT services exports in GDP

Source: calculated by the authors based on IT Ukraine Association (2023b) and Official website of the State Statistics Service of Ukraine (n.d.)

The dynamics of the share of IT services exports in GDP show diametrically opposite trends compared to the indicators of the volume of IT services exports. This situation can be explained by the opposing influences of factors such as the volume of IT services exports and the volume of GDP in natural units of measurement on the resulting indicator, which is the share of IT services exports in GDP. During 2022, there was an increase in the volume of IT services exports alongside a simultaneous reduction in GDP. To determine the influence of these factors, it is necessary to build

a factor model, establish causal relationships between the factors, and determine the influence of each factor on the resulting indicator.

It is advisable to apply the chain substitution method to identify the influence of factors on the change in the performance indicator compared to the base value (Table 2). The essence of this method is to gradually replace the basic values of the factors with the current ones to find the adjusted calculated values of the generalising indicator and then compare each subsequent calculation with the previous one.

Table 2. Factor analysis of the share of IT services exports in GDP by the method of chain substitutions (adjusted indicators)

| Years | Interactive factor indicators | | Share of export of IT services in GDP, % | Influence of factors, % |
|--|--|-----------------|--|-------------------------|
| | Export volume of IT services, \$ billion | GDP, \$ billion | | |
| 2021 | 6.9 | 200.1 | 3.5 | - |
| | 7.35 | 200.1 | 3.675 | $3.675 - 3.5 = +0.175$ |
| 2022 | 7.35 | 140 | 5.27 | $5.27 - 3.675 = +1.595$ |
| Change in the share of IT services exports in GDP, % | | | $5.27 - 3.5 = 1.77$ | |

Source: calculated by the authors based on IT Ukraine Association (2023b) and Official website of the State Statistics Service of Ukraine (n.d.)

The data in Table 2 show that both the increase in the volume of IT services exports and the reduction in GDP volumes positively affected the share of IT services exports in GDP. While the reduction of GDP volumes cannot be considered positive in itself, the inversely proportional relationship between the resulting indicator and GDP ultimately contributed to an increase in the share of IT services exports in GDP. Based on the results of all calculations, it can be concluded that with an increase in the export of IT services by \$0.45 billion, the share of IT services exports increased by 0.175%, and the reduction of GDP volumes by 30% caused an increase in the share of IT services exports by 1.595%. Thus, the impact of the fall in GDP was twice as significant as the impact of the increase in exports, which cannot be considered positive.

Areas of the post-war recovery of the IT industry.

The recovery of the Ukrainian economy must be based on the latest digital technologies. IT industry can act as the catalyst for the modernisation of the national economy. During the first year of the war, the digital space demonstrated resilience to changing operating conditions and the ability not only to adapt but also to develop in critical conditions.

To achieve a rapid digital transformation of the domestic economy, it is advisable to implement several measures that will synergistically enhance the overall effect:

- digital transformation of certain industries. The energy sector is among the reconstruction priorities. This industry requires urgent modernisation since critical infrastructure has become the primary target for enemy attacks (with more than half of energy infrastructure destroyed by early 2023) (Labyak, 2023). Priority measures include implementing “digital power plant” projects, digitalising the energy sector, and using smart meters.

- development of digital infrastructure. Digital transformation is impossible without ensuring access to the Internet. High-speed broadband connectivity is crucial for digitalisation. Therefore, restoring services provided by telecommunication operators in liberated territories is a priority. However, the extent of damage to the networks is

significant, and therefore, Ukraine will not be able to restore them quickly without donor support.

- expansion of digital public services. In the pre-war period, several projects were implemented to ensure transparency and reduce corruption risks in Ukraine, which were well-received by the public. To continue reforms and integrate Ukraine into the European digital age, it is essential to digitise customs, trade documentation, transport and logistics, and other sectors.

- development of regulatory and institutional support for the “digital” recovery of the economy. In 2022, the “Ukraine Recovery Plan” was introduced, outlining 850 projects (Ukraine National Recovery Plan, 2022). An important aspect of post-war recovery is the “Fundamentals of Recovery: Digital State” programme. The implementation of the Ukraine Recovery Plan requires the development of appropriate legislation, in particular regarding the regulation of the use of blockchain technology in public administration, the operation of information platforms (regulation of ownership relations, labour relations, the taxation system, anti-monopoly policy, cross-platform and national-international exchange and data protection), and the introduction of artificial intelligence technologies. Ukrainian legislation can be based on the United Kingdom National AI Strategy (2021), which recognises AI’s ability to increase sustainability, productivity, growth, and innovation in the private and public sectors. A detailed study of the experience of Estonia, which, as a post-Soviet country, is a leader in digital governance in Eastern Europe, should be an important area of legal regulation in this area (ISA², 2019).

- Over the past decades, the IT sector has driven the development of the Ukrainian economy. Digital transformations have facilitated the modernisation of other sectors of the economy (Frączkiewicz-Wronka, 2021; Liepert, 2024; Zarichuk, 2024). Digitalisation has had a synergistic effect on the entire economy (Pidubna & Gorobynskaya, 2023). However, the war has impeded the IT sector’s growth, reducing the export volumes of “digital” products and slowing the development pace. This is particularly highlighted by the

European Commission when discussing the principles that should underpin Ukraine's post-war recovery (Communication from the European Commission No. COM(2022) 233 final, 2022). Post-war recovery in Ukraine should be based on the use of digital technologies. Therefore, it is advisable to establish an appropriate regulatory framework to supplement the current Law of Ukraine No. 1667-IX (2023), particularly in the development of information platforms, the use of artificial intelligence technologies, cloud technologies, and the regulation of relations in the information sector.

In recent decades, cutting-edge technologies have become a driving force for economic growth. As noted by A. Toffler (1980), the "third wave" of human civilisation's development (the transition from an industrial to a post-industrial society) signifies that information becomes the most important item of production, and cumulative knowledge, as accumulated information, increases exponentially. A distinctive feature of the current stage of global economic development is the proliferation of digital technologies across all spheres of human activity – education, the economy, medicine, finance, public administration, and more. The spread of digital technologies confers substantial benefits to the state, the business environment, and the populace. At the state level, according to A. Pomaza-Ponomarenko *et al.* (2020), the positive impact is seen in the improvement of the population's quality of life and the productivity level of social labour. Scientists identify various manifestations of the positive impact of digital technologies. The main advantages of the digital economy, as outlined by A. Hlazova *et al.* (2021), include optimising business processes within the country, fostering the creation of new products and services utilising Internet technologies, cloud services, virtual reality, and artificial intelligence. Moreover, benefits encompass cost reduction achieved by minimising personnel through the automation and robotisation of business processes, as well as the creation of entirely new business solutions such as interaction platforms, contemporary insurance models, mobile educational applications, alternatives to banking services, personalised advertising, and individual targeting of online customers.

The process of digital transformation not only creates advantages for the economy but also presents certain risks and threats. A group of authors led by A. Spitsina *et al.* (2022) emphasises the impact of the proliferation of digital technologies on the social sphere – job loss, changes in wages, inequality, the use of health-preserving technologies, efficient resource utilisation, personal safety, and societal security. Agreeing with the authors' viewpoint, it is worth noting that besides risks in the social sphere, risks also arise in the technological, economic, political, legal, and personal spheres.

Regarding the development of the IT sector under martial law, most researchers note that despite the complexities in fulfilling export contracts, the industry continues to develop dynamically. The IT sector remains the only export industry that is currently operating at almost pre-war levels (Spitsina *et al.*, 2022). Disagreeing with the authors' opinion, it is contended that simply maintaining pre-war development rates neglects to recognise the scale of missed opportunities. The pace of IT services exports during 2015-2023 outpaced all other sectors of the economy and stood at 26.8% (IT Ukraine Association, 2023b). Maintaining export volumes at pre-war levels indicates the loss of about a quarter of service volumes. Among the reasons for such deceleration,

researchers mention cyberattacks on information systems of institutions, enterprises, and organisations; disruption and damage to Internet networks due to enemy actions, as well as a decrease in IT specialists due to migration and military service (Spitsina *et al.*, 2022). Other challenges include limited access to financial resources for small and medium-sized enterprises, insufficient systematic and sustained backing for domestic ICT advancement, recurring macroeconomic fluctuations, and low household income levels (Verbivska *et al.*, 2023). Overall, while agreeing with the authors' opinion, it should be noted that one of the significant reasons for the reduction in IT services exports is the risk associated with war. The risk of project non-fulfilment due to military actions on the territory of Ukraine is too high, so clients prefer companies from other countries. It should be noted that maintaining such a trend poses several threats: firstly, during times of war, a significant portion of the population remains without means of subsistence, shifting the burden of social security onto the state; secondly, the state budget misses out on tax revenues; thirdly, after the war, it will be challenging to lure clients back to the Ukrainian IT market.

Researchers have differing opinions on the pathways to support the development of the IT sector. V. Yanovska (2019) emphasises the role of the government, which, in her opinion, should play a key role in preparing, developing, and promoting national digital strategies. Relying solely on governmental bodies for the development of the digital economy during wartime is not advisable. Private business structures, international organisations, and civil organisations can also undertake measures to stimulate the spread of digital products.

Conclusions

This study examined the role of the IT industry in the economy of Ukraine during the pre-war period, assessed the predicted losses from the war, and developed measures for its modernisation. The study demonstrated the dynamic development of the IT industry over the past decades. The IT sector has emerged as one of the top three export industries, contributing foreign exchange earnings to the country and accounting for approximately 5% of the GDP. The IT industry also serves a social function, providing jobs for over 300,000 people with wages five times higher than the national average. The main advantage of the IT industry is its alignment with ultra-modern global trends and its dynamic growth. Even in times of war, the industry has shown an ability to adapt to critical conditions and maintain positive growth trends.

However, the war has impacted the development of the IT industry. Although the sector overall has shown an increase in the volume of services export, more than half of the companies report a decrease in the volume of orders. This has led to a reduction in both the number of employees and job vacancies. Not all consequences of war can be quantified statistically. In this context, potential economic losses were assessed, including hypothetical outcomes that would have been realised in the absence of an armed conflict on Ukrainian territory. The estimated losses in the volume of IT services exports due to the war in 2022 alone range from \$400 million to \$3.35 billion. However, it is incorrect to limit the assessment of war losses solely to the drop in IT services exports. The impact of war is complex, and the resulting negative effect is synergistic.

Considering this, the IT industry should become the main driver of the post-war recovery of the national economy. The military invasion of the Russian Federation destroyed a large part of infrastructure objects, the restoration of which should be conducted based on digital technologies. Given the destruction and economic importance, it is necessary to prioritise the digital transformation of the energy industry, transport, and logistics sectors. The post-war recovery of the IT sector should be based on a developed

economic restoration strategy, including a regulatory framework for its implementation, which will guide further research areas.

Acknowledgements

None.

Conflict of interest

None.

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Анотація. Станом на 2024 рік Україна вже більше двох років перебуває під військовою агресією з боку Російської Федерації. Війна вплинула на всі сфери життєдіяльності країни, в тому числі й на ІТ-індустрію. За таких умов виникає потреба в оцінці втрат цифрової сфери від ведення бойових дій та розробці напрямів її післявоєнного відновлення. Метою дослідження була діагностика стану ІТ-сфери України, як основного ядра післявоєнного відновлення України, а також масштабів збитків, завданих їй війною. Дослідження проводилося з використанням методів економічного та статистичного аналізу. За результатами дослідження було встановлено, що за останні роки ІТ-індустрія увійшла до трійки провідних експортних галузей, забезпечуючи країну валютними надходженнями та формуючи близько 5% ВВП. Забезпечуючи робочими місцями понад 300 000 людей. Під час війни галузь продемонструвала здатність адаптуватися до критичних умов і змогла зберегти позитивні тенденції зростання. Однак навіть при таких результатах війна негативно вплинула на цю сферу, сповільнивши темпи її зростання. За перший рік війни потенційні втрати ІТ-сектору становлять від 0,4 до 1,9 млрд доларів США. Визначено сфери, які потребують розвитку нормативно-правового забезпечення. В основу післявоєнного відновлення України має бути покладена прогресивна сфера, яка пронизує та об'єднує всі сектори та напрямки ІТ-індустрії. Насамперед, пропонується здійснити цифрову трансформацію енергетичного сектору, транспорту та логістичних систем. Результати дослідження можуть бути використані при розробці стратегій післявоєнного відновлення української економіки та при прогнозуванні показників її розвитку

Ключові слова: обсяг ІТ-послуг; експорт ІТ-послуг; переваги цифрової економіки; потенційні втрати ІТ-сфери від війни; загрози розвитку ІТ-сектору у воєнний час; післявоєнне відновлення