

Recovery of the Economy of Ukraine on the Basis of Digital Entrepreneurship: Forecast Expectations, Models and Scenarios of Post-War Development

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Abstract: - The purpose of scientific research is to present tools and measures for the recovery of the economy of Ukraine and to find reserves for accelerating the digitalization of business and entrepreneurship, which will play one of the main ‘violins’ of the innovative and digital development of Ukraine with a bright financial and economic future in the scenario of post-war development. The object of scientific research is the sphere of telecommunications, computer and information services from 2000 to 2023, and the analysis of indicators of the export of services in this sphere, the expansion of digital opportunities of entrepreneurship due to the introduction of products and services of the information and communication sphere as one of the key reserves of innovative and digital development during post-war reconstruction. Types of offset obligations for the purchase of imported products are presented, including: transfer of technologies, opening of joint production in the territory of the importer; direct investments, development of digital infrastructure, and investments in R&D. Measures to promote the digitization of traditional entrepreneurship are named, in particular: the creation of the Digital Bank of Innovative Development of Ukraine and the introduction of preferential taxation of incomes of newly created digital enterprises in the field of digital and innovation. It was determined that the creation of favorable conditions for innovation, investment, and commercial activities of digital enterprises, within the national digital ecosystem in technology parks, will speed up the post-war reconstruction of Ukraine’s economy. The practical significance of the research results is that the content of practical advice, the use of which will make it possible to preserve the positive dynamics of the export of services in terms of telecommunications, computer, and information services, regardless of the state of war in Ukraine, is disclosed. The value of the presented research is that having conducted a thorough analysis of statistical data on the dynamics of the export of business services and the dynamics of the export of services in the field of telecommunications, computer, and information services from 2000 to 2023, the authors managed to determine the relative error of approximation – a criterion for assessing the reliability of the forecast, which was 1.74% and to consider the approximation quality, and the forecast for 2026 is reliable. We consider this to be one of the opportunities for the country to make money by selling a quality product in foreign markets and as a result increasing the GDP. It is proposed to develop a program to support digital entrepreneurship in the field of information and communication technologies and to open regional technocenters for joint work with local entrepreneurs.

Key-Words: - digital entrepreneurship, export of telecommunication services, forecasting, development models of the national economy, foreign direct investment, information and computer services, economic recovery tools, offset obligations, technology transfer.

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1 Introduction

In the conditions of global challenges, economic turbulence, relocation of businesses, and migration of Ukrainians abroad, the task of developing tools and ways out of the extremely complex socio-economic crisis in which the economy and Ukrainian society are currently located becomes urgent. The restoration of Ukraine's economy to the pre-war level and its exits in the post-war period on the path of innovative development lie in the plane of digital transformation at the national, regional, and branch levels and the creation of the necessary effective mechanisms and measures for digitalization of the economy.

For these reasons, the opinion of scientists, [1], is interesting in their study focus on strategic orientations for businesses and issues of commercialization of new products. The authors of the article concluded that strategic orientation at the micro level contributes to the coordination between the company's strategy and resource availability, on the one hand, and adaptation to market conditions, on the other. We share the views of [1], that the successful commercialization of new products by an enterprise depends on the development of critically important, but complementary sets of strategic orientations in a dynamic business environment, and contributes to the economic growth of the country.

In addition, the importance of the question raised by us in this article is confirmed by the publications of researchers, in particular, [2], who claim that manufacturing firms that provide services benefit from strategic partnerships with knowledge-intensive business services firms. Their research presented data from 370 CEOs of large manufacturers worldwide and found that manufacturers in R&D-intensive industries are more likely to benefit from service delivery adoption than firms in other sectors due to industry dynamics and lower customer uncertainty, [2].

Currently, there is an urgent need to develop Ukrainian industries that are priority, promising, and whose products and services are competitive on world markets. The government of Ukraine is expected to develop new quality institutes and institutions of innovative and digital development. We are talking about high quality, honesty and fairness, from the point of view of entrepreneurship, official conditions and rules for a business that digitizes its work; on the development of a new technology transfer format for startups, investors, and international partners. The government faced a challenge: How to return talented Ukrainian youth to Ukraine? How can we encourage her to want to realize her talents in Ukraine and for the good of

Ukraine? How to stimulate researchers and young Ukrainian scientists in the information and communication sphere? After all, it is the products and services of the IT sphere that determine the probability and speed of digitization of entrepreneurship. Currently, the question remains unanswered: How to strengthen the existing ecosystem of innovations and form a digital ecosystem that would work harmoniously and productively within the framework of a chain of the type 'government – university – research institution – startup schools – large and small businesses' in the conditions of martial law. This can be achieved by improving the institutional environment of the Ukrainian economy, which will become an attractive mecca for foreign investments in the development of high technologies and in progressive sectors of the national economy.

2 Problem Formulation

2.1 Literature Review

Foreign scientists do not remain aloof from the urgent problems of rebuilding Ukraine's economy, because Ukraine is located in the eastern part of Europe and has borders with five European countries. Therefore, based on the principles of good neighborliness, it becomes obvious that the EU needs a strong national economy of Ukraine. Researchers, [3], examine the relationship between ownership structures in large European companies and their innovative activity in terms of R&D spending. The team of authors managed to present in their publication tests the impact of 'impatient' institutional investors and provides evidence of their negative influence on R&D spending, [3]. A group of scientists, among whom it is worth noting, [4], [5], carried out a model analysis of environmental innovations for the national transition to decarbonization in the integrated European energy system, which allowed the researchers to present the author's work in terms of improving the quality of management of the renewal of the national economy in the conditions of ensuring energy decentralization.

A team of scientists, namely, [6], devoted their research to exploring the dynamics of openness and formal appropriability and its impact on innovation performance in start-ups. In their publication, they presented their own vision of the evolution of openness-appropriability strategies full sample, balanced subsample, and unbalanced subsample. Scientists, [6], found that start-ups change their openness and formal appropriability strategies over

their development and that a combination of openness and formal appropriability enhances start-ups' innovation performance.

Such well-known scientists as, [7], dealt with the conceptual principles of assessment and forecasting of the innovative development of regions. Researchers, [8], analyzed the flow of information through the different phases of a systematic review and developed an explanatory document to increase the usefulness of PRISMA. A cohort of researchers, [9], [10], worked on increasing the sustainability and monitoring the quality of management of innovative systems.

Scientists, [11], examined 14 firm-level practices, later reduced to four factors, that influence the ability to minimize new product development and introduction times overall relative to competitors. The factors are human resource management, synergistic integration, supplier closeness, and the design-manufacturing interface.

Building on the dynamic capabilities view (DCV), [12], empirically examine the relationships among international entrepreneurship culture (IEC), ambidextrous innovation, dynamic marketing capabilities, and INV (International new ventures) performance under varying levels of environmental dynamism. Scientists managed to come to the conclusion that IEC influences both ambidextrous innovation and dynamic marketing capabilities; and, together, these link to INV performance gains.

Scientific developments in the field of digitization of entrepreneurship and traditional businesses are presented in the scientific work of professors, [13], [14], [15], [16]. These works offer successful examples of the formation and development of digital ecosystems, and ways of implementing startup projects in various EU countries, and indicate tools and mechanisms for rapid digitalization of the economy based on digital entrepreneurship.

Researchers, [17], in their scientific study explained how making a firm structurally faster leads a company to face a 'conversion dilemma', i.e., to choose the proper strategic orientation that can be definitely regarded as affecting its external configuration, visible to the market, or only the internal one, transforming the time advantage into a cost one.

The issue of the fastest possible recovery of the post-war economy of Ukraine and digitalization of the economy of Ukraine on the basis of innovation was reflected in the research of scientists such as, [18], [19], and others. Scientists claim that after the war, Ukraine will face the need to change its strategic plans, including regional development,

given the significant changes in internal and external factors.

Among the Ukrainian researchers who are engaged in revealing the peculiarities of the formation of digital entrepreneurship and the issue of finding investments for the development of breakthrough innovations in the conditions of martial law, and industrialization in times of digitalization of the economy, we can name, [20], [21]. The analysis of the noted recent studies proved that the concept of digital transformation of the economy has advantages: increasing the efficiency of the existing infrastructure due to the synergistic effects of creating digital enterprises; emergence of qualitatively new digital business models; increasing revenue or reducing costs in existing business models.

2.2 Tasks of the Article

The purpose of the publication is to work out ways to restore the economy of Ukraine to present a number of tools and recommendations that would accelerate the formation of digital entrepreneurship renew the innovative and digital development of the national economy and present the forecast volume of exports of services in the field of telecommunications, computer and information services of Ukraine for 2026, having carried out an analytical alignment of the dynamic series based on the analysis of foreign direct investment data, the dynamics of exports of research and development services, professional and consulting services and scientific and technical services from 2000 to 2023 and the volume of exports of services in the field of telecommunications, computer and information services of Ukraine in 2016–2021, in order to understand on the basis of this knowledge whether Ukraine has the economic potential to rebuild the national economy.

Among the tasks set in the article are: to reveal the content of the forecasting of the volume of exports of services in the field of telecommunications, computer and information services of Ukraine for 2026 in a reasoned manner, having carried out an analytical alignment of the dynamic series and presenting the results of forecasting according to the Holt-Winters model; determine and disclose all possible options for offset obligations when purchasing imported products; to present ways and measures to activate small, medium and large digital entrepreneurship in the field of telecommunications, computer and information services in Ukraine; indicate the general trends traced from 2000 to 2023 in the dynamics of exports of other business services; to reveal the

content of practical advice for maintaining the positive dynamics of the export of services in terms of telecommunications, computer and information services in the conditions of martial law; to present tools that would contribute to the digitalization of traditional entrepreneurship in Ukraine.

2.3 Methodology

On the basis of dialectical, systematic, mathematical, and statistical methods, the export of telecommunications, computer, and information services from 2000 to 2023 and the export of other business services from 2010 to 2023 were studied, which determined the prospective available reserve of economic recovery with positive dynamics and indicated the need for a strategic format of digital business work based on innovation. The heat map method was used to analyze foreign direct investments; forecasting was carried out according to the Holt-Winters model and the forecast volume of exports by means of analytical alignment of the dynamic series.

Scientists emphasize that the development of new methodical approaches to scientifically based strategizing of spatial associations is gaining great relevance, especially in the post-war period, [19]. So, [19], concluded that the problem of strategic planning of regional development is timely for both EU countries and Ukraine. The Ukrainian scientist managed to develop strategic scenarios of post-war recovery and adaptation of the development of spatial associations-regions (in the example of the Kharkiv region of Ukraine) to the influence of external and internal threats in order to preserve the trajectory of sustainable development in the medium term and to present an inertial, realistic and optimistic recovery scenario until 2027.

Scientists, [22], [23], devoted their research to studying the features of the application of intellectual capital and the product created on its basis. The researchers studied the characteristic features of the application of management innovations and their application in high-tech and low-tech companies. In their publications, they concluded that ‘The organizational intellectual capital is a conceptual system reflecting the fields of knowledge, emotions and values developed within a generic organization... the potential intellectual capital is transformed into operational intellectual capital due to the work of organizational integrators, especially of those that are nonlinear: leadership, management, and organizational culture’, [22].

In scientific work [24], outline and discuss five dimensions of corporate entrepreneurship including

autonomy, innovativeness, proactiveness, competitive aggressiveness and risk-taking.

A team of scientists [25], in their publication, analyze technical innovations in small and medium-sized enterprises, point out the importance of entrepreneurial orientation and effective use of intellectual capital. They presented exploratory factor analysis for the intellectual capital construct, exploratory factor analysis for the technical innovation construct, mediating effects of entrepreneurial orientation on the effect of intellectual capital dimensions on technical innovation.

Scientists, [18], are actively engaged in the study of world experience in terms of post-war economic recovery and attempt to adapt it to the national economy of Ukraine. They put forward and successfully argued in their scientific publication the hypothesis that the use of the experience of the EU countries, Japan, South Korea, Singapore, and Hong Kong, given the coincidence or identity of the conditions of the sectoral experience with modern Ukraine, will allow adapting foreign models to create a unique model of the post-war development and strategizing of the national economy. The researchers emphasized the need for the Ukrainian economy to have systematic reforms, stable sources of financing, and strong institutions for economic recovery. The strengths and weaknesses of the Marshall Plan (European countries, 1948–1951) and the Rain Plan (Japan, 1949–1965) were revealed, analyzed the regulatory regimes of tax incentives in particular the ‘Celtic Tiger’ model of Ireland, presented the principles of implementing international aid programs that could be effective for the post-war economy of Ukraine, [18].

3 Problem Solution

3.1 A New Socio-Technological Method of Production

The post-war recovery of Ukraine’s economy and the formation of digitized economic business relations will continue to be influenced by global challenges and institutional-structural changes in the world order. The formation of digital entrepreneurship already in today’s economic conditions is characterized by a new institutional and organizational format. This format is designed to strengthen innovative digital development and create a digital macrospace as a result of the digital transformation of the national economy.

In modern business conditions, a successful

combination of industrial and post-industrial production methods already determines the emergence of a new socio-technological production method based on a digitized information technology system. It's clear that the institutional, technological dynamism and the post-war reconstruction of the national economy formed the need for the birth of a generation of digital entrepreneurs, significantly intensified the problem of the continuity of digitalization of entrepreneurial activity, determining the need for an innovative and digital development vector of Ukraine.

The post-war recovery of Ukraine's economy, in our opinion, is closely related and depends on the fact that the country's production and industry operate in a technological framework. The post-war reconstruction of the national economy requires the 6th technical and technological order, which is formed by information and telecommunication technologies and their key factors: microelectronics, computer equipment, and software, which are inherent in the technological order. We are convinced that it is necessary to immediately take a course for a wider application of the principle of co-financing of research by both state and private structures, as well as developers and manufacturers, improvement of the organizational structure of social research, improvement of training of specialists, intensive joining of Ukraine to international cooperation in the field of R&D of TCI services. This is caused by the positive dynamics of the export of services in the field of telecommunications, computer, and information services from 2000 to 2023 (Figure 1 and Figure 2). For Ukraine, this is a good application on the world market of telecommunications, computer, and information services and an increase in the country's GDP on this basis.

Thus, in 2022, the total export of telecommunications, computer, and information services reached \$7,521 million, which was, of course, a record for the past 13 years. But it is worth noting that for objective reasons, among which, first of all, the war on the territory of Ukraine, in 2023 this figure slightly worsened and amounted to \$6,885 million, which is \$636 million less. From the analysis of the data in Figure 2, it becomes obvious that this deterioration of the indicator in 2023 occurred due to a decrease in the export volumes of computer and telecommunication services by \$622 million and \$25 million, respectively. As for information services, a positive trend has developed here, and already in 2023, this indicator has increased by \$11 million. The general trend line for the export of computer services in Figure 2

demonstrates the fact that from 2005 to 2022, systematic growth is observed indicator.

3.2 Practical Advice on Increasing the Export of Services in Terms of Telecommunications, Computer and Information Services

In order for the dynamics of the export of services in terms of telecommunications, computer, and information services to remain positive in the future despite the war in Ukraine, we consider it necessary to provide several practical tips, including:

- Reducing the gap in the technical and technological level of national production and entrepreneurship in comparison with world leaders, by transitioning to new organizational and legal forms of commercialization of R&D;

- Development of new quality standards for national digital enterprises, which would allow for rapid integration into the European market of digital services in the information and communication sphere;

- Provision of grant support during the implementation of high-tech projects in the early stages by national digital enterprises, the specialization of which is in the field of medicine, the military-industrial complex, the processing industry, and the agricultural sector;

- Stimulating the demand for Ukrainian scientific developments, equipment, and technologies from small, medium, and large enterprises of various branches of the national economy by reimbursing (returning) part of the funds to those enterprises that purchase and implement various inventions and achievements in their production (such as products, services, and processes) of national science and education.

Pursuing the goal of a thorough analysis of Ukraine's exports, it is worth paying attention to the overall positive dynamics of the export of business services from 2000 to 2023. Thus, in Figure 3, you can see that in 2023, compared to 2022, the export of other business services increased by \$431 million. If we compare 2023 with 2021 and 2020, the growth was almost \$1,468 million and \$1,715 million, respectively. These data testify to the gradual moderate growth of exports of other business services over the past 4 years.

This happened due to an increase in export volumes in 2023 compared to 2022 in research and development services and technical services, trade services, and other business services by \$62 million and \$374 million, respectively.

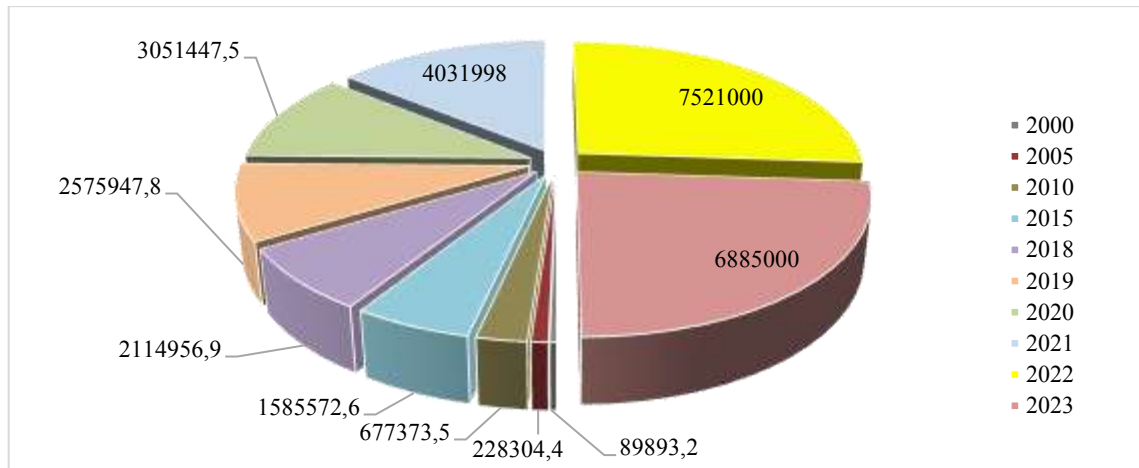


Fig. 1: The general dynamics of the export of services in the field of telecommunications, computer, and information services from 2000 to 2023, thousands of dollars
 Source: Compiled based on data from sources, [26]

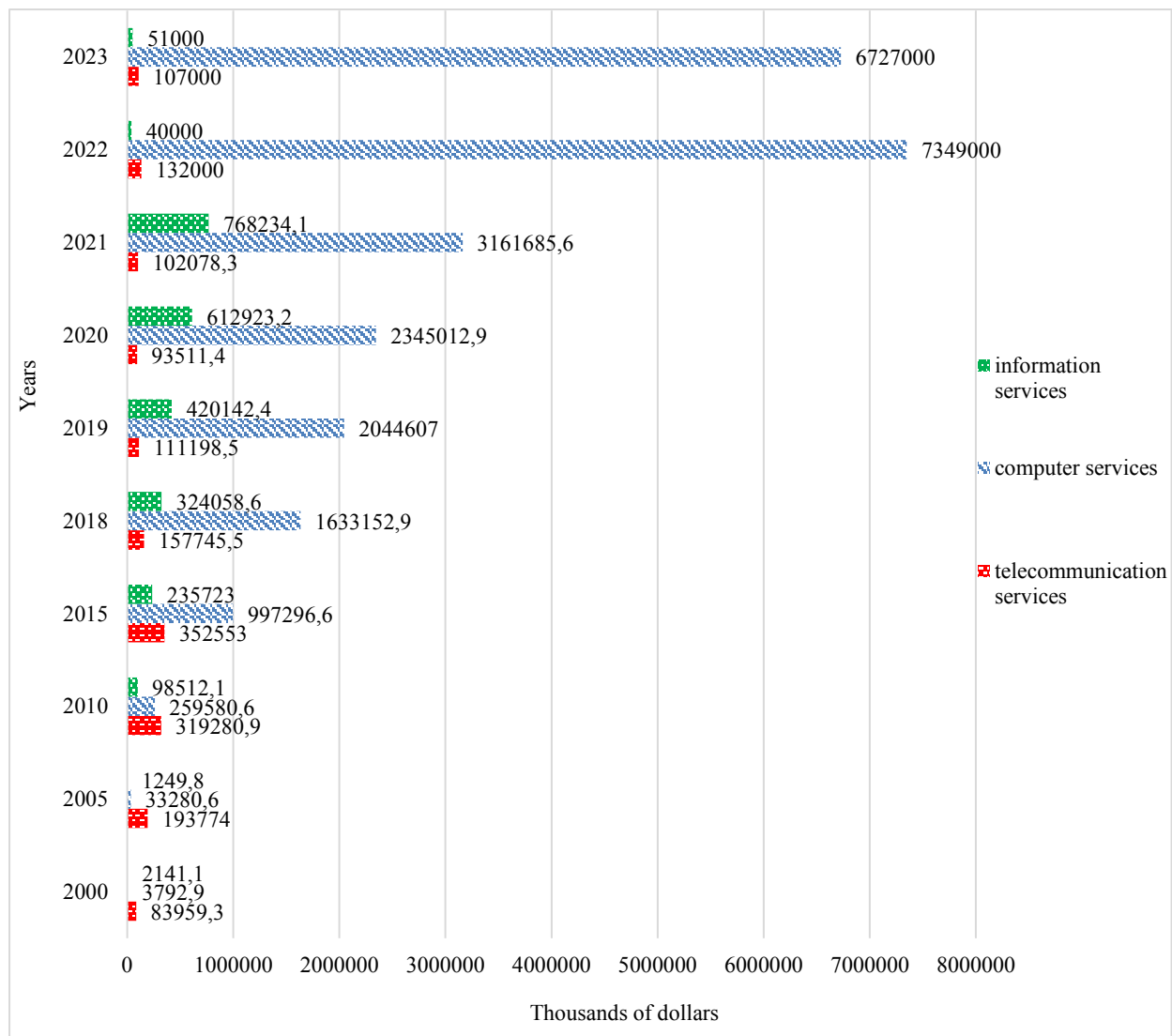


Fig. 2: Dynamics of export of services in terms of telecommunications, computer, and information services from 2000 to 2023
 Source: Compiled based on data from sources, [26], [27]

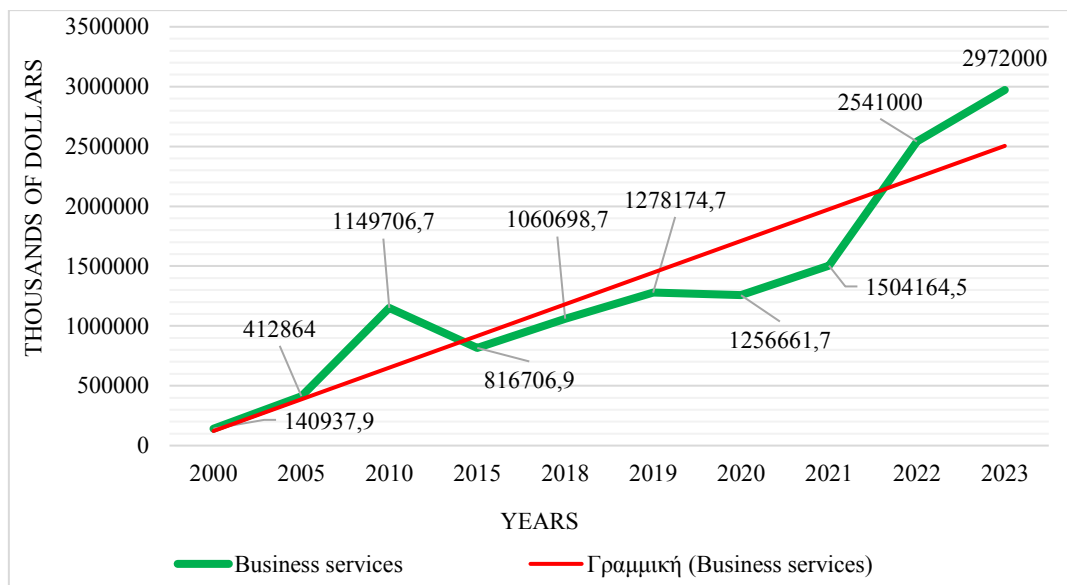


Fig. 3: Dynamics of exports of other business services from 2000 to 2023, thousands of dollars
 Source: Compiled based on data from sources, [26], [27]

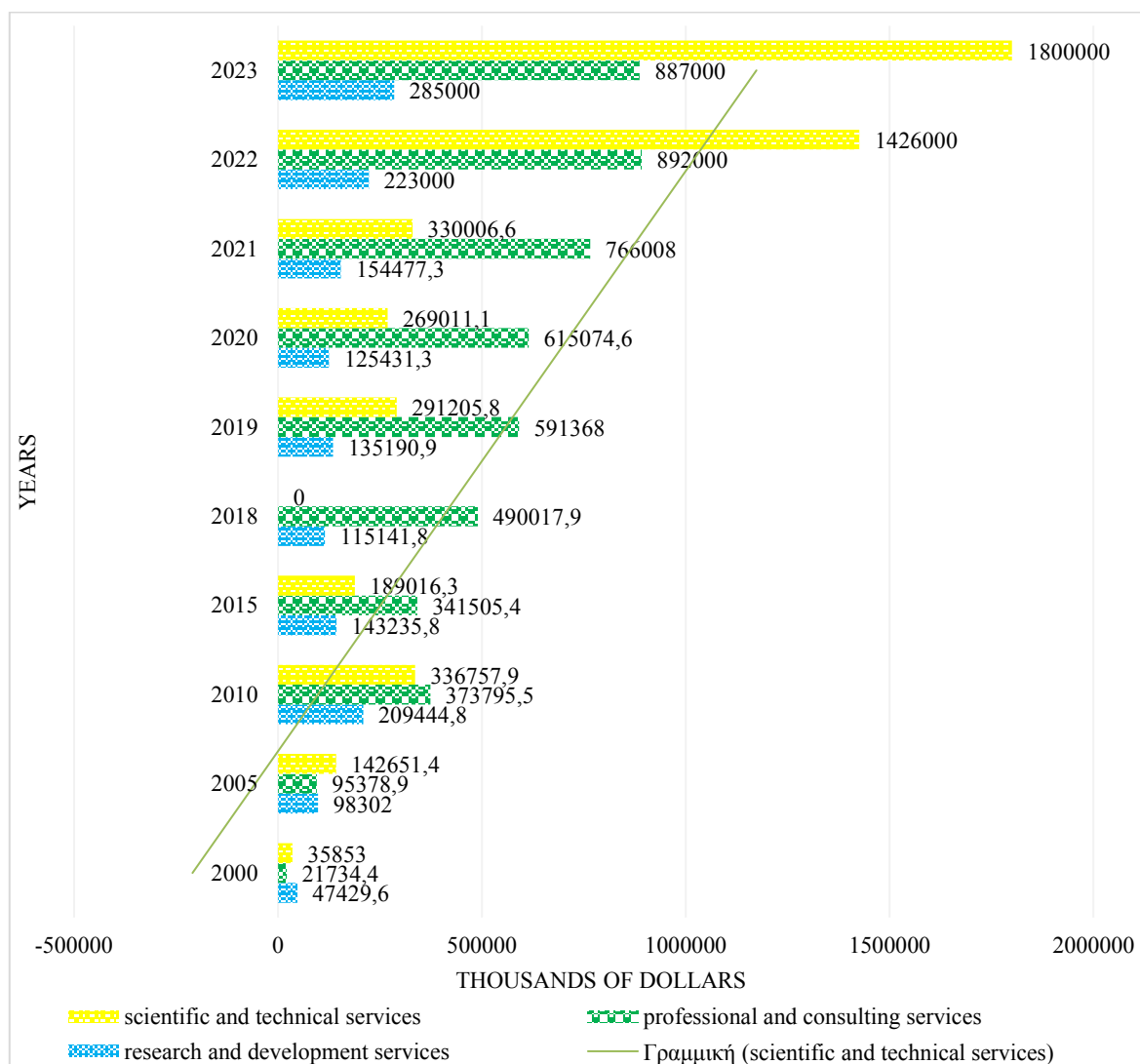


Fig. 4: Dynamics of exports of research and development services, professional and consulting services and scientific and technical services from 2000 to 2023
 Source: Compiled based on data from sources, [26], [27]

However, it is worth noting that in the structure of the 'Other business services' indicator, the professional services and management consulting services component in 2023 shows a decrease in the volume of exports by \$5 million (Figure 4).

The general trend line for scientific and technical services in recent years is positive (Figure 4), which embodies the hope for a further systematic increase in the export of domestic products according to the 'Other business services' indicator. The data in Figure 4 shows that from 2015 to 2022, the dynamics of the export of professional and consulting services was positive and in general increased by approximately \$550 million in 7 years. The dynamics of the export of scientific and technical services was positive from 2020 to 2023. The growth over these 4 years was \$1,531 million. Analyzing the dynamics of the export of research and development services, it is worth noting that it was positive only from 2000 to 2010 and from 2020 to 2023. It was during these years that the policy of supporting researchers and innovators in various sectors of the economy, both on the part of government and private institutions, was followed. We are talking about institutional incentives and, the financial and economic interests of government and business in research and development.

Data for January 2024 allow us to expect high export figures in the 2024 calendar year as well. Thus, in January 2024, Ukraine exported \$521 million worth of telecommunication, computer, and information services, in particular \$8 million worth of telecommunication services, \$508 million worth of computer services, \$5 million worth of information services, which is an increase of \$2 million more compared to January 2023. Other scientific services were exported in the amount of \$273 million in January 2024, which is \$76 million more than in January 2023. In particular, in January 2024, Ukraine exported research and development services worth \$21 million; professional services and provided management consulting services for \$87 million (+ \$28 million more than in January 2023); technical services, trade services, and other business services in the amount of \$165 million (+ \$51 million more than in January 2023), [26].

These indicators are evidence that Ukraine provides high-quality services for the above services because its services and products will continue to be in demand on world markets. The analysis of quantitative indicators in the field of telecommunications, computer, and information services attests to the power of the Ukrainian information and communication technology sector,

whose products are the foundation that determines the speed, quality, and inclusiveness of the country's digital development and the formation of digital entrepreneurship in Ukraine.

3.3 Measures and Tools to Promote Digitalization of Traditional Entrepreneurship

The following measures and tools could contribute to the digitization of traditional entrepreneurship in Ukraine:

- Creation of the Digital Bank of Innovative Development of Ukraine. The main functions of this bank should include financing on an irrevocable basis and concessional lending for the entire cycle of creation and replication of scientific and technical products, promoting the selection of the most effective developments, and mass distribution of innovative goods and digital services of domestic production;

- Introduction of preferential taxation of incomes of newly created digital enterprises in the field of numbers and innovations provided that digital enterprises sell high-tech products and provide digital services to world markets (promotion of Ukrainian in the world); systematic acquisition of new technologies by digital enterprises; receiving income as a result of the application of inventions produced by Ukrainian business entities in TCI services;

- Creation of regional and industry funds for the acquisition of technologies, the purpose of which should be partial reimbursement of costs to traditional enterprises for the purchase of licenses for the improvement, modernization, and renewal of production business processes in the direction of their digitization;

- Creation of favorable conditions for innovation, investment, and commercial activities of digital enterprises within the national digital ecosystem in technology parks. It is worth combining digital enterprises according to industry affiliation, priority of research types, and geographical proximity. We believe that this will allow digital enterprises to work more effectively within the framework of the institutional mechanism, and will make it possible to more effectively 'pump' the use of such functions of this mechanism as control and stimulating. As a result, the percentage of non-targeted use of concessional lending intended for innovative digital projects implemented by digital enterprises will decrease.

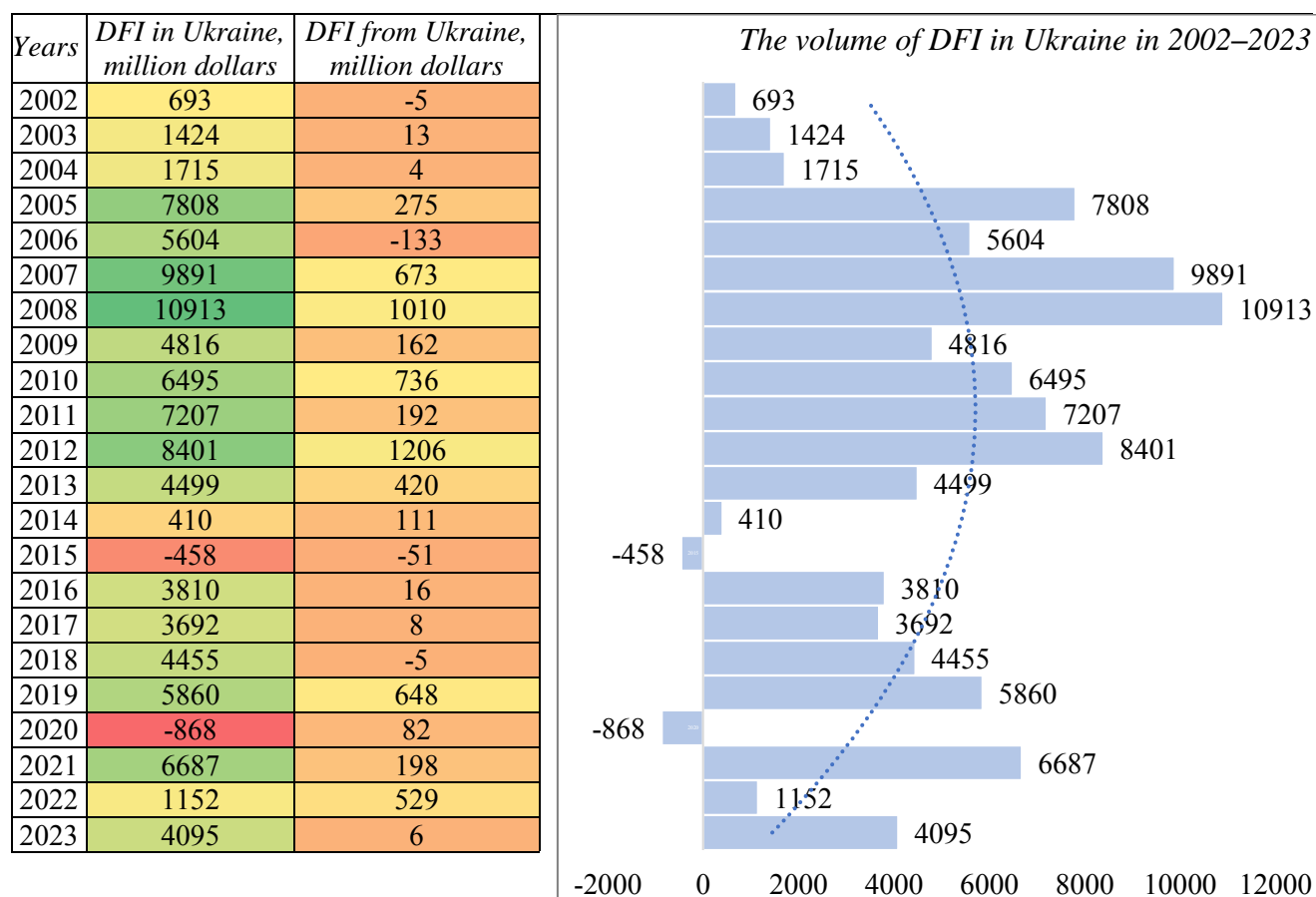


Fig. 5: Heat map of foreign direct investments in and from Ukraine in 2002–2023

Source: Compiled based on data from sources, [28]

In Figure 5, we tried to present the volume of direct foreign investments in and from Ukraine according to the principle of direction that is, according to cash flows, using the visualized capabilities of the heat map method.

The picture shows a color gamut of yellow, orange, red, light green, and green. Red and orange colors indicate the outflow of capital from the country, and green shades indicate the inflow of funds into the national economy.

Foreign direct investment is the most desirable form of capital investment for any economy, especially a developing one. It is this form of capital investment that makes it possible to implement large innovative and digital projects, in addition, new technologies and new practices of corporate management immediately arrive in the country, [28]. We can see from the figure that in 2023, foreign direct investment (DFI) in Ukraine increased by \$2,943 million compared to 2022. Foreign direct investment from Ukraine in 2023 amounted to \$6 million, which is \$523 million less than in 2022 (\$529 million). The balance at the end of 2023 was +556.3%, or \$4,089 million.

3.4 Implementation of State Economic Programs with the Participation of Foreign Contractors

In the conditions of martial law during the implementation of state economic programs with the participation of foreign contractors, offset requirements and the transfer of relevant technologies should become mandatory conditions for state procurement of goods, works, and services. ‘The competitive nature of the international defense market has led to the development of new procurement models that employ an arsenal of carefully thought-out, cost-effective methods. Thus, compensation ‘rules’ are part of trade relations and are increasingly considered an innovative and effective marketing mechanism for capturing a significant portion of a new market or maintaining traditional markets’, [29]. The existing types of offset obligations are presented in Figure 6.

Based on this, we must remember that ‘preparation for offset obligations begins with a price quotation, which can significantly reduce the level of risk, as well as with an analysis of the purchasing power of the project. The company’s production capacity is then determined, including

those that cannot or should not be subcontracted for production, by evaluating non-value-added capacity that can be subcontracted. It is important to determine which technologies can be subcontracted for production. Thinking ‘outside the box’ and transferring capacity that was previously produced by a ‘traditional home supplier’ to new subcontractors will help meet offset obligations. It will not be superfluous to appoint an offset manager who will help the company to better understand the rules and laws in the client’s country (for example, which products and technologies are recognized as belonging to the offset category). It is important to offer support and guidance during the transfer of production from the company to the subcontractor in the client country or from a ‘traditional’ supplier to an additional offset supplier. The professionalism of the offset manager will prevent or at least reduce the risk of non-fulfillment of the project’s offset obligations... Creative and ‘smart’ solutions will help to implement the offset obligations quickly and with minimal costs’, [29].

3.5 Forecasting the Export of Telecommunications, Computer and Information Services

We carried out a thorough analysis of the dynamics of the export of services in terms of telecommunications, computer, and information services from 2000 to 2023, the export of research and development services, professional and consulting services, and scientific and technical services from 2000 to 2023, and the volume of foreign direct investments in Ukraine and from Ukraine in 2002–2023 prompted us to forecast the export of telecommunications, computer and information services of Ukraine for 2024 using the

Holt-Winters model (Figure 7) and determine the forecast volume of exports of services in the field of telecommunications, computer and information services of Ukraine for 2026, having carried out an analytical alignment of the dynamic series. We have data on the export of services in the field of telecommunications, computer, and information services of Ukraine for the period 2016–2021 (Table 1), which will allow us to determine the forecast volume of exports of services in the field of telecommunications, computer and information services of Ukraine for 2026, having carried out an analytical alignment of the dynamic series.

First, let’s check this dynamic series for the presence of a trend, using the Cox-Stewart test. To do this, let’s divide the series into three equal parts and compare the corresponding members of the series of the last and first third.

I third: 1 644,093; 1 760,794.

III third: 3 051,447; 4 031,998.

We get the following signs of level differences (YIII – YI): +; +; +; +.

The levels of the III third are greater than the levels of the I third, then ‘pluses’ accumulate, which means that there is a tendency for the levels to increase in the series. Let’s select the form of the analytical expression of the relationship using the correlation field (Figure 8).

Visually, we conclude that the points fluctuate around a straight line, so we approximate the trend by a straight line:

$$\hat{y}_t = a + b \cdot t \tag{1}$$

Since the number of levels in the series is even $n=6$, we rank the time from 1 to n (by ordinal ranks). We calculate the parameters of the trend equation (Table 2).

Types of offset obligations	1. Investments in R&D
	2. Joint production in the territory of the importing country
	3. Localization of production in the territory of the importing country
	4. Technology transfer
	5. Development of digital, innovative and social infrastructure
	6. Construction of specialized training centers, implementation of programs of training and retraining of specialists in various fields for the importing country
	7. Direct investments (including investments in investment projects not directly related to the product supplier)

Fig. 6: Types of offset obligations when purchasing imported products

Source: Grouped by source, [29]

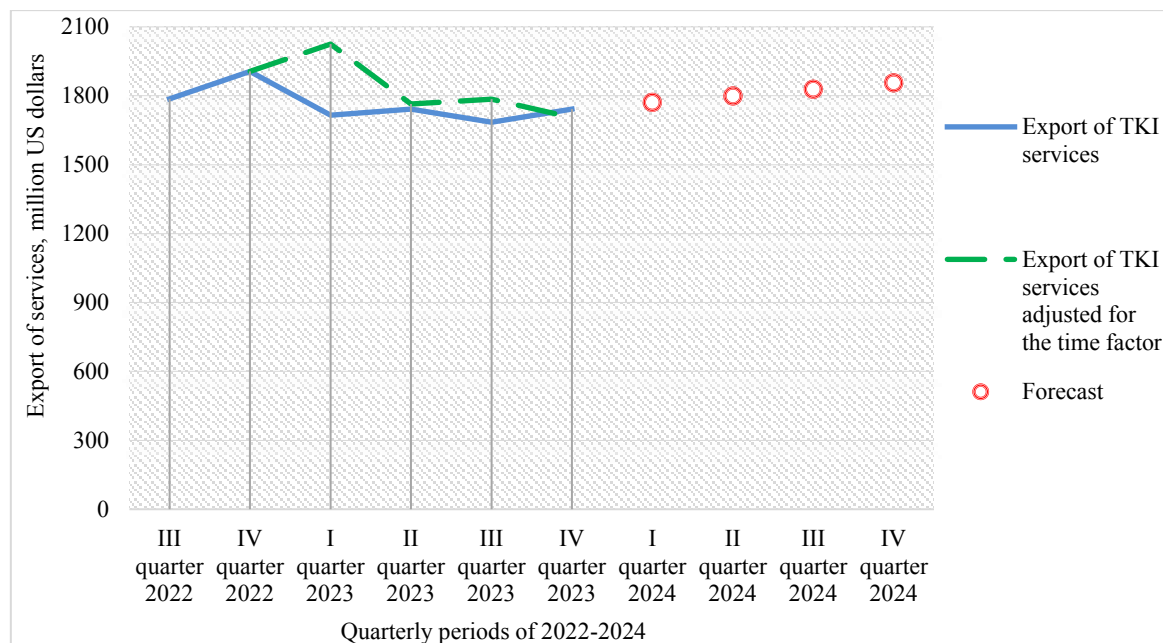


Fig. 7: Forecasting the export of telecommunications, computer, and information services of Ukraine for 2024 according to the Holt-Winters model

Source: Compiled on the basis of data from source, [26]

Table 1. The volume of exports of services in the field of telecommunications, computer, and information services of Ukraine in 2016–2021

Years	2016	2017	2018	2019	2020	2021
The volume of export of services, million US dollars	1 644,093	1 760,794	2 114,956	2 575,947	3 051,447	4 031,998
	I		II		III	

Source: Compiled on the basis of data from source, [27]

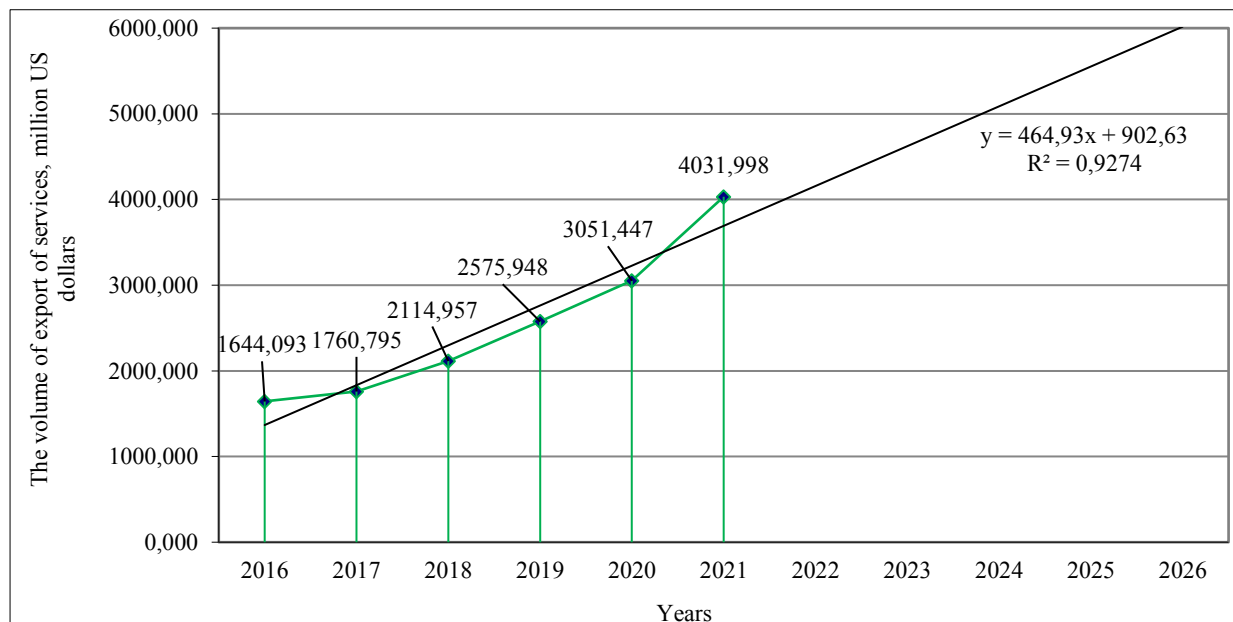


Fig. 8: Correlation field of service export forecasting in the field of telecommunications, computer, and information services of Ukraine in 2016–2026

Source: Built on data from source, [27]

Table 2. Calculation of trend equation parameters of service export forecasting in the field of telecommunications, computer, and information services of Ukraine in 2016–2021

Years	t	y_i	t^2	yt	y^2	\hat{y}_t	$ y_i - \hat{y}_t $	$(y_i - \hat{y}_t)^2$	$\frac{ y_i - \hat{y}_t \cdot 100}{y_i}$
2016	1	1644,0930	1	1644,093	2703041,86	1367,55	276,54	76474,38	16,82
2017	2	1760,7946	4	3521,5892	3100397,55	1832,48	71,69	5138,94	4,07
2018	3	2114,9569	9	6344,8708	4473042,82	2297,41	182,45	33288,76	8,63
2019	4	2575,9478	16	10303,791	6635507,22	2762,34	186,39	34740,92	7,24
2020	5	3051,4475	25	15257,237	9311331,54	3227,27	175,82	30911,81	5,76
2021	6	4031,9980	36	24191,988	16257007,55	3692,19	339,80	115467,41	8,43
Together	21	15179,2378	91	61263,569	42480328,54	15179,24	X	296022,23	50,95
Average value	3,5	2529,8730	15,17	10210,595	7080054,76	2529,87	X	49337,04	8,49

Source: Calculated by the authors.

$$\begin{cases} an + b \sum t = \sum y \\ a \sum t + b \sum t^2 = \sum yt \end{cases}$$

$$\begin{cases} 6a + 21b = 15\,179,2378 \\ 21a + 91b = 61\,263,5693 \div (-3,5) \end{cases}$$

$$\begin{aligned} b &= 464,928 \\ a &= 902,625 \\ \hat{y}_t &= 902,625 + 464,928 \cdot t \end{aligned}$$

Explanation of trend equation parameters:

- parameter $a = 902,625$ – this is the value of exports of services in the field of telecommunications, computer and information (TCI) services of Ukraine in the ‘zero’ period of time (in 2015);

- parameter $b = 464,928$ – this is the annual increase in the export of services in the field of telecommunications, computer and information services of Ukraine in million US dollars. The ‘+’ sign in front of parameter b means increasing levels of the series.

Let’s check the closeness and essentiality of the connection:

a) let’s calculate the linear correlation coefficient:

$$r = \frac{\overline{y \cdot t} - \bar{y} \cdot \bar{t}}{\sigma_t \cdot \sigma_y} \quad (2)$$

$$\sigma_t = \sqrt{\overline{t^2} - (\bar{t})^2} \approx 1,708$$

$$\sigma_y = \sqrt{\overline{y^2} - (\bar{y})^2} \approx 824,498$$

$$r = 0,9629$$

The correlation coefficient (correlation ratio) indicates a close ‘connection’ between the export of services in the field of telecommunications, computer and information services and ‘time’ (that is, a set of reasons that persistently affect the export of the specified services and determine the tendency for their growth).

b) calculate Fisher’s test:

$$F_{calculated} = \frac{(r)^2}{1-(r)^2} \times \frac{k_2}{k_1} \quad (3)$$

where $k_1 = m - 1$, $k_2 = n - m$

n – the number of studied population units (we have $n=6$);

m – the number of parameters in the regression equation (we have $m=2$ (a and b)).

$$F_{calculated} = 50,95$$

Tabular (critical) value of Fisher’s F -test at $\alpha = 0,05, p = 0,95$, $k_1 = 1, k_2 = 4$ is $F = 7,71$. As $F_{calculated}$ (50,95) more than $F_{critical}$ (7,71), then the essentiality of the connection is proven.

Then, the forecast volume of exports of services in the field of telecommunications, computer and information services for 2026, the rank of which will be $t = 11$:

$$\hat{y}_{11} = 902,625 + 464,928 \cdot 11$$

$\hat{y}_{11} = 6\,016,833$ million US dollars, but this is a point forecast.

To obtain an interval forecast, we will find the root mean square error of the model:

$$S_e = \pm \sqrt{\frac{\sum (y_i - \hat{y}_t^2)}{n-m}} \times \sqrt{\frac{n+1}{n} + \frac{3 \times (n+2v-1)^2}{n \times (n^2-1)}} \quad (4)$$

where: v – forecast bias period ($v = 5$ years).

$$S_e = \pm 569,397 \text{ million US dollars}$$

The marginal error of the forecast at $\approx 0,05 \Delta = \pm t \cdot S_e$, where Student’s t -test (for $\alpha \approx 0,05$ and $n=5$ $t_{tabular} = 2,5706$):

$$\Delta = \pm 2,5706 \times 569,397 = \pm 1\,463,692$$

Then, the interval forecast will be:

$$4\,553,141 \leq \hat{y}_{11,0,9272} \leq 7\,480,525$$

That is, in 2026, with a probability of error of 7.28%, the volume of exports of services in the field of telecommunications, computer and information services is predicted to be between 4,553,141 and

7,480,525 million US dollars.

We will also determine the relative error of approximation – a criterion for assessing the reliability of the forecast:

$$\bar{\varepsilon} = \frac{1}{n} \sum \frac{|y_i - \hat{y}_i|}{y_i} \cdot 100 \quad (5)$$
$$\bar{\varepsilon} = \frac{1}{6} \cdot 10,46 = 1,74\%$$

Since $\bar{\varepsilon}$ does not exceed 15%, the approximation is considered qualitative, and the forecast is reliable.

It is worth continuing to follow the path of activation of small, medium and large digital entrepreneurship in the field of telecommunications, computer and information (TCI) services in Ukraine, because from the analysis of statistical data it is obvious that Ukrainian TCI services are ‘consumed’ by the world market, and this has had a positive impact on Ukraine’s GDP for the last 10 years in a row. In order for the positive trend to continue in the post-war economy, the following aggressive (in a positive sense) steps are needed today, including:

- Appropriate for the formation of digital entrepreneurship, financial support for scientific and technical activities in the information and telecommunications sphere, which would be based on the target principle and the plurality of financial sources (concessional and mortgage lending, venture financing, grants, direct and targeted subsidies, risk insurance, franchising);

- Expansion of innovative and digital infrastructure (virtual business techno-incubators, business centers, technohubs, techno-forests, industrial parks, consulting and auditing companies, intellectual property centers);

- Restoring the pre-war level of active cooperation on the implementation of joint international projects and increasing the share of acquisition of rights to patents and licenses from Ukrainian inventors and researchers;

- The progressive development of the Ukrainian market of intellectual property objects and the elimination of existing gaps and contradictions in the legal framework, which currently do not provide and do not fully guarantee the legal protection of this type of objects;

- Strengthening the work of digital enterprises along the ‘business-customer-investor-government’ chain, where all participants receive their expected socio-economic effects;

- The development of digital development programs in which a mandatory condition would be equity financing, which would allow a norm within the limits of 50:50 for entrepreneurship in the ICT

and manufacturing industries.

4 Conclusion

Based on the results of our research, we came to the conclusion that the key to the recovery of the war and post-war economy of Ukraine will be innovations and their support, attracting investments from partners to rebuild entrepreneurship in industry, production, agriculture, and the field of information and communication technologies. The government is expected to develop a mechanism to stimulate innovation and digitization of the national economy, support digital entrepreneurship and high technologies and their export. The Government of Ukraine should pay attention to the possibility of obtaining socio-economic effects from the use of tools for direct project support of innovative digital projects by domestic enterprises. This is due to the fact that the experience of using this tool in the leading countries of the world has repeatedly demonstrated its advantages due to its targeting, flexibility and transparency.

The analyzed statistical data had a positive effect on the professionalism of performing forecast calculations and made it possible to say that in 2026, with a probability of error of 7.28%, the volume of exports of services in the field of telecommunications, computer, and information services is forecast to range from \$4,553.141 to \$7,480.525 million. It is indicated that in the conditions of martial law during the implementation of state economic programs with the participation of foreign contractors, mandatory conditions for state procurement of goods, works and services should become offset requirements and the transfer of relevant technologies.

According to the Holt-Winters model, the expected export volumes for the 4th quarter of 2024 were determined, namely: \$1771 million, \$1799 million, \$1828 million, and \$1857 million, respectively. And for the economy of Ukraine, which is in conditions under martial law, such positive and growing expectations for the size of exports only in the field of telecommunications, computer, and information (TCI) services inspire faith in the bright future of the Ukrainian economy.

Pursuing the goal of the fastest reconstruction of the economy of Ukraine, it is also worth improving the existing scientific and technological network in terms of its branching, with an emphasis on high-quality public-private partnerships. Develop a program to support digital entrepreneurship in the field of information and communication technologies and open regional technology centers

for joint work with local entrepreneurs. Programs for the development of digital entrepreneurship in the regions should have effective targeted mechanisms for encouraging breakthrough and technological innovations. So, for example, in the western and central regions of Ukraine, where there are the most relocated businesses from the eastern and southern regions, it is worth implementing the practice of introducing preferential taxation for traditional enterprises with innovative technologies and enterprises that are widely digitizing their business processes. We consider it a consistent and logical step for digital enterprises to provide preferential loans for the purpose of introducing innovative and breakthrough technologies into production business processes.

Enterprises in which business activities are digitized and which conduct innovative activities must have access to ‘cheap’ money (monetary and credit policy that allows keeping interest rates at a low level, which in turn is carried out with the aim of stimulating digital and innovative entrepreneurship by reducing the cost investments and loans). This would make it possible to reduce official unemployment and shadow employment, which was formed as a result of internal migration of the population, which was provoked by the consequences of martial law, the closure of large enterprises in the eastern regions of Ukraine, and the large-scale relocation of businesses from the territories where hostilities are taking place or the territories that are temporarily occupied.

Those innovative enterprises that created, restored, or preserved jobs during martial law and businesses whose activities are digitized and managed to restore, preserve, and increase the wages of employees should apply for loans. At the same time, the digital enterprise should have an investment goal precisely in terms of acquiring fixed assets from domestic enterprises or carrying out modernization with the participation of business entities by purchasing new equipment from them or receiving the latest services from them. Loans should also be provided to digital enterprises for the acquisition of objects of intellectual property rights, under commercial concession (franchising) contracts related to the implementation by the digital enterprise of a credit and investment project of an innovative direction. A mandatory condition for this should be the fact of receiving dividends and the right to full or partial ownership of the invention to the team of developers and researchers who created an innovative idea, an innovative product.

The role of not the last violin is also played by a high-quality legislative framework, because it is the

legal foundation for the development of digital entrepreneurship in the post-war period. It is transparent and effective legal regulation that allows digital business to be built on the principles of long-term and the economic interest of investors and entrepreneurs. We are definitely talking about stimulating investments in risky entrepreneurship, preferential lending, a number of ‘working’ laws on copyright, trademarks, and forced licensing of technologies. We are convinced that it is worth improving the patent system of Ukraine and the related infrastructure, which would better protect the export of finished products in the field of telecommunications, computer, and information services from our country.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Kateryna Kraus, carry out a forecast of the export of TCI services, write a methodology, formulate measures and tools to promote the digitalization of traditional entrepreneurship, draw up a heat map of foreign direct investments, write a conclusion, draw up a list of used literature.
- Nataliia Kraus, formulate the purpose and objectives of the research, to carry out a literature review, to formulate practical advice on increasing the export of services in the field of TCI services, generalization of state economic programs with the participation of foreign contractors, visualization of the presented material, compilation of the list of used literature.
- Galyna Pochenchuk, writing the abstract of the article, researching the types of offset obligations when purchasing imported products.
- Oleksandr Manzhura, investigate a new socio-technological method of production as a basis for the post-war recovery of the country's economy, a selection of literature.
- Vitaly Kyrpushko, write an introduction to the article, research foreign experience in increasing the export of TCI services.

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