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Technological Challenges and Opportunities for Ukraine's Postwar Economic Recovery

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ANNOTATION. The relevance of the study is driven by the need to identify key priorities and directions for Ukraine's post-war economic revival, rebuilding its infrastructure and finding opportunities for breakthrough development. The war has caused significant destruction of infrastructure, industrial facilities and economic ties, which makes it difficult to rebuild traditional sectors of the economy, while Ukraine has a unique chance to rethink its economic model, integrate modern technologies and create an innovative economy based on digitalization, automation and sustainable development. The key challenges and opportunities for the high-tech development of the Ukrainian economy, including the main sources of financing and the rapid search for revival resources, are analyzed. The importance of scientific and technological factors for the restoration and provision of new impulses for economic development is confirmed: the dissemination and absorption of innovative technologies, modernization of key industries, digitalization of the economy, building scientific potential and strengthening its importance in economic recovery. The authors analyze the role of innovative technologies in the reconstruction of infrastructure, industrial development, digitalization of the economy and increasing the country's competitiveness in the international arena. Particular attention is paid to the prospects for the development of the IT sector, renewable energy, industry 4.0 and agrotechnology. The authors outline the need to attract investment, create a favorable business climate, and modernize the educational system to train highly qualified personnel. The study proves the need to include scientific and technological drivers through the formation of new economic models that can ensure sustainable and rapid growth. The core of such models is the recognition of technology, science and education as a key priority, cooperation between the state and business to overcome existing barriers and challenges facing Ukraine on the way to economic and technological recovery and integration into global markets. Implementing innovative solutions in key sectors of the economy will not only ensure a sustainable recovery, but also create a competitive economy capable of integrating into global economic processes.

KEYWORDS: economic revival, scientific and technological development, post-war recovery, innovation development.

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Introduction

An important task of modern Ukraine is not only to restore the national economy, but first and foremost to achieve economic revival, to use such impulses that will provide qualitatively new parameters for the development of the postwar economy. Economic science uses two definitions: recovery and revival, which are essentially similar, but in the context of the economy, the difference lies in the emphasis they carry. Thus, recovery is understood as a return to the previous state, reconstruction, and the key goal of recovery may be to rebuild infrastructure, etc. Revival, on the other hand, aims to transform and transform the economy on a qualitatively new basis that can ensure breakthrough development, as modern Ukraine does not have time for long-term evolutionary development. It is crucial for it to create a new foundation for a new economic model, which, through the creation of new development opportunities, deeper large-scale digitalization, greening, and innovation, will ensure an increase in the level of competitiveness and long-term sustainability of the economy. Turning the asset of available intellectual resources and modern technologies into an effective driver of economic revival is an important task that requires scientific research and practical implementation.

Literature review

The development of Ukraine's economy in the postwar period is an important issue in the scientific, political and social spheres. Identification of key aspects of the post-war economic recovery of Ukraine, attraction of international assistance, issues of regional economic recovery, the impact of the war on socio-economic development in the works of Y. Zhalil[3], study of strategic directions of development of the Ukrainian economy after the war, partnership between business and the state in the works of A. Dligach[4], V. Borshchevsky, I. Kuropas[5], even before the full-scale invasion in the works

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[3] Priorities for the development of the real sector in the context of war and post-war economic recovery in Ukraine. 2024. https://niss.gov.ua/sites/default/files/2024-02/ad_realsektor-2023.pdf DOI: https://doi.org/10.53679/NISS-analytrep.2024.03 [In Ukrainian]

[4] Human capital or human resource – what is more important for Ukraine? 2024. https://advanter.ua/blog/lyudskij-kapital-chi-lyudskij-resurs-sho-vazhlivishe-dlya-ukrayini [In Ukrainian]

[5] Borshchevskyi V., Kuropas I., Mykyta O. 2022. "War economy and post-war economic development of Ukraine: problems, priorities, tasks." *Public organization "Public Space"*. URL: https://www.prostir.ua/?news=ekonomika-vijny-ta-povojennyj-ekonomichnyj-rozvytok-ukrajiny-problemy-priorytety-zavdannya. [In Ukrainian]

of S. Ivanov[6], N. Kazyuka and E. Sheketa[7], M. Fedyk[8], O. Bulyk[9], M. Skrypnychenko[10]. However, the search for actual ways of economic revival, increasing the technological capacity of Ukraine's economy, taking into account the growing scale of destruction and the continuation of military aggression, remains an important issue of scientific research.

The purpose of the article is to substantiate the ways of engaging scientific and technological drivers capable of ensuring, on the basis of advancing technologies, digitalization and intellectualization, a rapid and breakthrough economic recovery of Ukraine and its integration into global markets.

Results

Recovery is about rebuilding what has been destroyed, restoring basic services, and quickly resuming economic activity. Revival relies on a long-term perspective, building an institutional framework, and integration into global markets. The optimal combination of these approaches is an important task for the Ukrainian economy, and while the initial stage involves a rapid recovery, the development perspective requires a focus on revival to ensure economic growth and sustainable development. Such a concept implies the formation of a scientific and technological foundation to further expand the innovation base of economic development. The revival of Ukraine's economy is an important task in terms of its export potential and the creation of prerequisites for ensuring competitiveness in the European economic space.

The most important tasks of modern economic development are the restoration of physical, digital and green infrastructure, economic transformation through reforms and deregulation, attracting investment through international assistance and public-private partnerships, supporting innovation and entrepreneurship, developing human capital, integrating into international markets, attracting financing, etc. All of this requires a long-term strategy that takes into account both current needs and long-term goals. It is important to ensure the sustainability of the recovery to prevent a recurrence of crises in the future. In addition, cooperation with international

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[6] Ivanov S. V. 2019. Economic recovery and development of countries after armed conflicts and wars: untapped opportunities for Ukraine. *Economy of Ukraine*. No. 1 (686). pp. 75-89. URL: https://cutt.ly/iJfwVqD. [In Ukrainian]

[7] Kaziuka N. P., Sheketa Y. Y. 2022. Directions and reserves of post-war economic recovery in Ukraine. *The actual problems of regional economic development*. T. 2, No. 18. pp. 255–264. DOI: https://doi.org/10.15330/apred.2.18.255-264 [In Ukrainian]

[8] Voitovych L., Fedyk M. 2024. Strategy of post-war economic recovery of Ukraine in the context of European integration. *Economy and society*. No. 65. DOI: https://doi.org/10.32782/2524-0072/2024-65-112 [In Ukrainian]

[9] Bulyk O. 2023. Strategy of economic recovery of Ukraine after the war. *Economy and society*. No. 48. DOI: https://doi.org/10.32782/2524-0072/2023-48-51 [In Ukrainian]

[10] Skrypnychenko M. 2022. Macroeconomic assessments and forecasts of the post-war recovery of Ukraine's economy. *Ekonomìčna teorìâ*. Vol. 2022, no. 2. P. 29–43. DOI: https://doi.org/10.15407/etet2022.02.029 [In Ukrainian]

partners, donor organizations, and the private sector will play a key role, and funding and opportunities to realize intellectual potential will remain a key issue. However, it is worth noting that the revival of Ukraine's economy is possible only if intellectual capital is effectively realized, ideas and innovations are implemented, which requires significant funding.

Financing includes a significant amount of resources from both the Ukrainian budget and international sources. The revival of Ukraine's economy requires the attraction of significant financial resources that significantly exceed domestic (including credit) capabilities. At the moment, a diversified network of funds is being formed in Ukraine, which implement various tasks (Figure 1).

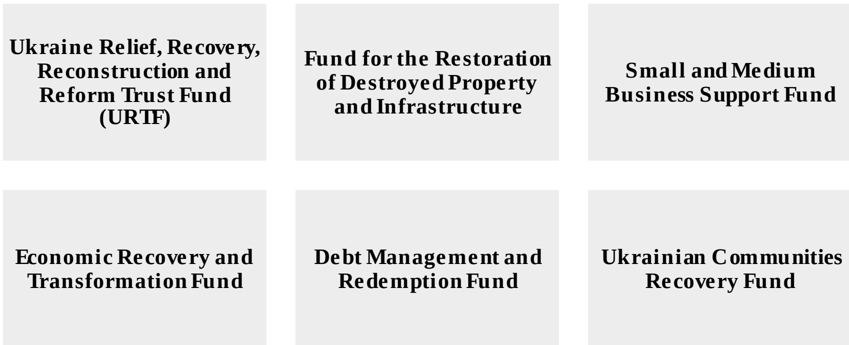

Figure 1: Funds to support the Ukrainian economy

Source: systematized by the authors.

The Ukraine Relief, Recovery, Reconstruction and Reform Trust Fund (URTF) was created by the World Bank[11], which has raised more than USD 50 billion[12], including the program "Improving Access to and Sustainability of Education in Times of Crisis", which has accumulated USD 235 million from the Japanese government, USD 150 million through a special program of the International Development Association for the restoration of Ukraine. Given the fact that separate funds have been allocated for the development of education, we recognize its important role in the further reconstruction of Ukraine and the preservation of intellectual capital. Financial resources are spent on the most urgent development needs identified by the Government of Ukraine.

[11] Ukraine Relief, Recovery, Reconstruction and Reform Trust Fund (URTF). 2024. https://www.worldbank.org/uk/programs/urtf

[12] Financial support mobilized for Ukraine since February 24, 2022. 2024. https://www.worldbank.org/uk/country/ukraine/brief/world-bank-emergency-financing-package-for-ukraine

A significant number of funds direct their resources to the physical reconstruction of the destroyed and improvement of living conditions during the war period. For example, the Fund for the Restoration of Destroyed Property and Infrastructure[13] is focused on the restoration of destroyed infrastructure, including housing, roads, bridges, including the restoration of destroyed educational or scientific institutions that have suffered significant destruction, as 365 educational institutions have been completely destroyed since the beginning of the war, and 3,798 have been damaged or partially destroyed[14].

Increasing technological sophistication and added value is the goal of the Economic Recovery and Transformation Fund[15], which supports Ukraine's economic transformation, in particular by attracting investment and implementing reforms to stimulate economic growth and support the functioning of enterprises that create higher added value by implementing ideas and innovations in business activities.

The SME Support Fund[16] provides financial assistance to small and medium-sized enterprises affected by the war to restore their operations and promote economic stability. Another very important fund is the Debt Management and Redemption Fund[17], which is designed to ensure Ukraine's financial stability by servicing and repaying the state's international financial obligations. The Ukrainian Communities Recovery Fund[18;19] was created with the support of international organizations, and aims to raise USD 300 million over five years to rebuild Ukrainian communities, including support for businesses that offer innovative solutions for the development of war-affected communities.

It is worth noting that Ukraine has a significant potential for the development of intellectually intensive and knowledge-intensive sectors of the economy, which is primarily due to the need to develop a new basis for economic development, the need to develop high-tech industries, including the military-industrial complex, and the possibility of a rapid recovery of economic activity. This targeted focus on the development of intellectual capital is supported by a number of international funds, including:

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[13] Fund for the restoration of destroyed property and infrastructure. 2024. https://mtu.gov.ua/content/fond-vidnovlennya-zruynovanogo-mayna-ta-infrastrukturi.html

[14] 7 million children of war in Ukraine. 2025. https://saveschools.in.ua/

[15] Some issues of financing and granting grants for the creation or development of processing industry facilities. 2023. https://zakon.rada.gov.ua/laws/show/72-2023-%D0%BF#Text

[16] Some issues of financing support for small and medium-sized businesses. 2023. https://zakon.rada.gov.ua/laws/show/1156-2022-%D0%BF#Text

[17] Debt Management and Redemption Fund. 2024. https://mof.gov.ua/uk/fund_for_maintenance_and_repayment_of_the_state_debt-696

[18] The Fund for the Restoration of Ukrainian Communities has approved the allocation of funds for the first projects. 2023. https://mtu.gov.ua/news/35066.html

[19] The Fund for Restoration of Ukrainian Communities approves the first allocation of funds. 2023. https://surl.li/cocyqy

– International Renaissance Foundation, the foundation invests in human capital through skills development, support for civic participation in recovery, and strengthening of local institutions. It pays special attention to the integration of veterans, internally displaced persons and other war-affected people.[20]

– The World Bank plans to provide Ukraine with a USD 1 billion loan and a USD 30 million grant to support private sector reforms, including government business support programs such as "Affordable Loans 5-7-9" [per cent] and "eRobota"[21].

– The European Bank for Reconstruction and Development (EBRD). Together with the Ministry of Economy of Ukraine and other partners, it is working to create mechanisms for human capital development aimed at improving skills and supporting entrepreneurship.[22]

– Ukraine-Moldova Entrepreneurship Development Fund (UMAEF). UMAEF helps small and medium-sized enterprises (SMEs) in Ukraine and Moldova to recover and create jobs by providing access to capital and expertise.[23]

– Innovation Development Fund (Ukrainian Startup Fund). Supports innovative projects and startups by providing grants and investments for the development of technological solutions that contribute to economic revival.[24]

In addition, private companies are involved in financing investment initiatives.[25] Horizon Capital, a leading investment firm, launched Horizon Capital Growth Fund IV with the goal of raising USD 250 million to invest in Ukrainian and Moldovan companies, especially in the emerging technology sector, but the fund raised USD 100 million more, settling on USD 350 million. The International Finance Corporation (IFC) has invested USD 60 million in the fund, the largest investment among all investors in the fund. The largest investments were made in innovative technology companies, which ensures the expansion of research platforms in Ukraine, the expansion of international representation, in particular, of IT companies, which contributes to the expansion of digitalization, the growth of Ukraine's export potential, In particular, it has invested in Preply (language learning, connecting students with tutors through its online platform), GoIT (specialized IT education programs to address the skills shortage in the

[20] Social capital. 2024. https://www.irf.ua/program/social_capital/.

[21] Ukraine and the World Bank will strengthen cooperation to promote economic recovery and attract investment. 2024. https://me.gov.ua/News/Detail?lang=uk-UA&id=a87d8d2f-4e5c-401b-9273-a2f9365627b7&title=UkrainaTaSvitoviiBankPosiliatSpivpratsiuZadliaEkonomichnogoVidnovlenniaKrainiTaZaluchenniaInvestitsii

[22] The Ministry of Economy, together with the EBRD and the FBA, will create a new mechanism for human capital development in Ukraine. 2024. https://me.gov.ua/News/Detail?lang=uk-UA&id=1bcab574-2164-405b-a282-a13a2dc98a36&title=NoviiMekhanizmDliaRozvitkuLiudskogoKapitaluVUkraini

[23] SME development program. 2024. https://umaef.org/uk/programs/sme-development/.

[24] Ukrainian Startup Fund. 2024. https://usf.com.ua/.

[25] Horizon Capital Closes its Ukraine Fund IV at $350m, $100m above Target. 2024. https://horizoncapital.com.ua/news-post/horizon-capital-closes-its-ukraine-fund-ivat-350m-100m-above-target/

technology industry), Viseven (supporting pharmaceutical companies in accelerating their digital transformation).[26]

The EBRD and DFI Joint Investment Platform, established by the European Bank for Reconstruction and Development (EBRD) in cooperation with other financial institutions for joint investments in Ukraine, is aimed at financing investments in the Ukrainian economy. The aim of this initiative is to attract private capital to restore Ukraine's economy, industry and infrastructure. It is planned to create an Investment Fund for the Restoration of Ukraine[27], which will attract private and public capital for the implementation of large-scale business projects in Ukraine. This fund is aimed at supporting economic growth and rebuilding the country. Such funds are intended to attract investment and support entrepreneurship in the country, develop intellectual capital to ensure the strategic competitiveness of Ukraine's economy.

These funds and organizations play an important role in maintaining Ukraine's intellectual capital by promoting human development and innovation, which are critical to the post-war economic recovery. These funds invest resources in strategic sectors of Ukraine's economy that create export potential and strategic advantages that can quickly restore economic activity, ensure export potential, create jobs and integrate into global value chains. These industries include metallurgy and mining, agriculture, energy, construction, defense, IT, machine building, chemical and light industry, tourism, and creative economy.

Metallurgy and mining industry is one of Ukraine's main export industries, generating foreign exchange earnings. With the restoration of destroyed plants and investments in modernization and energy-saving technologies, the industry can significantly strengthen the economy. Ukraine is a world leader in the production of grain crops and sunflower oil, and is a food exporter. The development of agro-processing will increase the added value of products and reduce dependence on raw material exports. Energy sector, which should be more sustainable, with a focus on renewable energy sources and decentralized networks. The development of solar, wind, and bioenergy will reduce dependence on imported energy. The need to rebuild cities, infrastructure, and housing is driving strong demand for the construction industry. The use of innovative materials and construction methods, such as 3D printing of buildings and modular construction.

The military-industrial complex (MIC) is critical to ensuring the country's security and restoring its defense capabilities. The integration of

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[26] Horizon Capital Closes its Ukraine Fund IV at $350m, $100m above Target. 2024. https://horizoncapital.com.ua/news-post/horizon-capital-closes-its-ukraine-fund-ivat-350m-100m-above-target/

[27] Investments worth 16 billion euros. How the creation of an investment fund within the Ukraine Facility will help Ukrainian business. 2024. https://sluga-narodu.com/investytsii-na-16-mlrd-ievro-yak-ukrainskomu-biznesu-dopomozhe-stvorennia-investytsiynoho-fondu-v-mezhakh-ukraine-facility/

modern technologies such as drones, AI, and robotics will allow Ukraine to become a leader in some military developments. The machine building industry produces machinery for agriculture, transportation, energy, and construction. Investments in the modernization of production facilities will allow Ukraine to compete in international markets. Ukraine has the potential to produce fertilizers, polymers, and pharmaceuticals. Focus on exports and domestic demand, development of green chemistry. The IT and digital industries are among the most dynamic and resilient during the war. Its development will contribute to the digital transformation of the economy. Restoring cultural tourism and developing creative industries will create additional jobs and attract investment.

Industries with high export potential, strategic importance for the domestic market, and the ability to integrate innovations will make the greatest contribution to the revival of Ukraine's economy. Metallurgy, agriculture, energy, IT, and construction will be the main drivers of economic growth in the postwar period (Table 1).

Table 1

INDUSTRIES WITH HIGH EXPORT POTENTIAL IN UKRAINE AND THEIR DYNAMICS IN THE ECONOMIC STRUCTURE

Industry	Export potential	Dynamics (before/after the war)	Development trends
Metallurgy	Significant (traditional leader of Ukraine's exports)	Decreased due to the destruction of factories, especially in Donbas; requires modernization and decarbonization.	Restoration of factories, introduction of green metallurgy.
Agricultural sector	Very high (Ukraine is a key food exporter)	Stable demand for products; problems with logistics due to military operations.	Expanding agricultural processing and introducing precision farming.
Energy	Medium (potential for energy exports)	Destruction of energy infrastructure and the need for renewable energy sources.	Development of solar and wind energy, decentralized networks.
IT industry	Very high (dynamically developing)	Resilience even in times of war; IT companies remain competitive.	Expansion of service exports, creation of startups, and digital business transformation.
Chemical industry	High (especially in fertilizers and pharmaceuticals)	Problems with production due to the hostilities; focus on exports and recovery of domestic demand.	Investments in green chemistry and pharmaceutical development.

Completion of the table 1

Industry	Export potential	Dynamics (before/after the war)	Development trends
Mechanical engineering	High (mainly for the domestic market and the CIS)	Decreased production; need to upgrade equipment and technologies.	Modernization of enterprises, implementation of Industry 4.0.
Light industry	Medium (potential for niche export markets)	Recovery depends on supporting small businesses; expanding exports to the EU.	Integration into European markets, use of local materials.
Construction industry	Medium (focused on the domestic market)	Significant growth due to the demand for infrastructure reconstruction.	Use of innovative technologies, development of production of building materials.
Military-industrial complex	High (growing demand in the international market)	Significant growth due to military needs and export potential.	Implementation of modern developments, cooperation with international partners.
Creative industries	Medium (niche industry)	Increase the popularity of Ukrainian culture abroad; support creative initiatives.	Development of cultural exports, stimulation of creative hubs.

Source: systematized by the authors

The key priority for Ukraine's economic recovery should be the development of high-tech industries, changing their share in the economic structure, and increasing their role in the post-war recovery. High-tech industries play an important role in Ukraine's economy, although their share in GDP remains smaller than in developed countries. High-tech industries include information technology, aerospace, pharmaceuticals, energy, military industry, etc. One of the most developed sectors is information technology, which also has significant potential for development, as Ukraine is one of the largest exporters of IT services in Europe.

IT services contribute about 5 per cent to Ukraine's GDP, with positive dynamics, and Ukraine demonstrates a high level of readiness for digital technologies (Fig. 2).

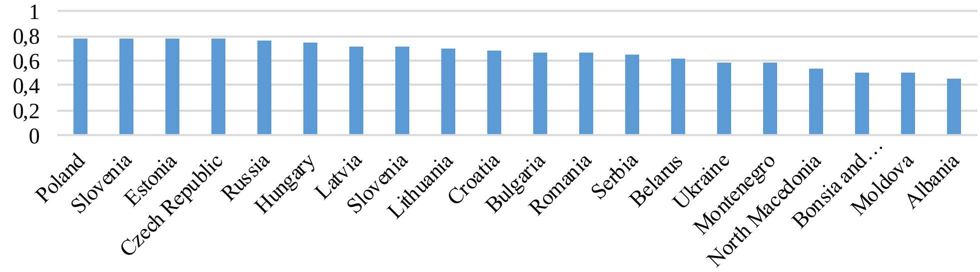

Figure 2. Advanced Technology Readiness Index in Central and Eastern Europe, 2022, by country[28]

Poland, Slovenia, Estonia, and the Czech Republic demonstrate the highest scores, with indices above 0,7. The readiness for advanced technologies reflects the possibility of using Industry 4.0, AI, IoT, blockchain, green technologies, nanotechnology, etc. Ukraine demonstrates a high potential to form a new basis for economic development through human potential. Thus, among the countries of Central and Eastern Europe, Ukraine ranks second in terms of the number of software developers, with 200 thousand developers, after Poland, which has 400 thousand developers.[29]

However, it is worth noting that Ukraine has perhaps the largest share of ICT services exports, and the dynamics indicate a gradual increase in this type of activity (Fig. 3).

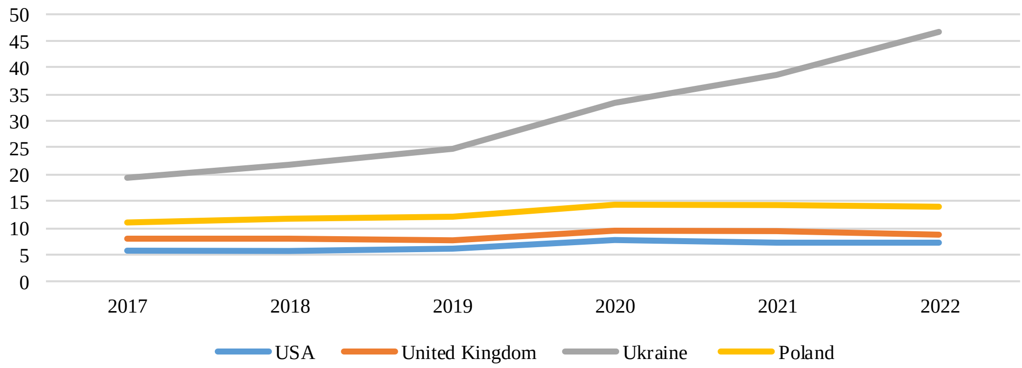

Figure 3. Exports of ICT services, by country, 2017–2022, % of services exports

Source: systematized by the authors based on data from[30]

[28] Readiness for frontier technologies index in Central and Eastern Europe (CEE) in 2022, by country. 2024. https://www.statista.com/statistics/1380936/cee-frontier-tech-readiness-index-by-country/

[29] Number of software developers in Central and Eastern Europe in 2023, by country. 2024. https://www.statista.com/statistics/1429627/cee-number-of-software-developers-by-country/

[30] World Bank, 2024. ICT service exports by Country 2017–2022. https://wits.worldbank.org/CountryProfile/en/Country/BY-COUNTRY/StartYear/2017/EndYear/2022/Indicator/BX-GSR-CCIS-ZS

As we can see, Ukraine demonstrates the highest growth rate of ICT exports in the structure of total exports of services. Digitalization is the most promising area of economic development for Ukraine, as evidenced by the research of McKinsey & Company[31], and the European Bank for Reconstruction and Development. In general, the studies found that digitalization is the most promising option for Ukraine's development, which is typical for all middle-income countries. The EBRD is reducing its forecasts for Central and Eastern Europe, due to relatively low economic activity, but also mainly because of what economic experts call the middle-income trap[32], which was identified for Southeast Asian countries that failed to move up after reaching a certain level of moderate economic development. In this case, it is innovation and digitalization that become a source of development, with digital tools and digital solutions working to enter regional or global markets[33].

It is worth noting that, according to analysts, Ukraine's classic real sector of the economy[34], which requires significant funding, has suffered significantly from the hostilities. This, in turn, raises the issue of time, funding, and the use of territories. A possibility to resolve this issue is the formation of industrial technology parks[35], innovation clusters, etc. Such specialized "zones" can be used to form a pool of proposals aimed at rebuilding Ukraine's economy on a fundamentally new basis. They can be provided with additional funding, specific forms or regimes of taxation, and the involvement of a wide range of active participants who recognize the development of innovative projects as a common goal and direction of development. In this case, an important step would be to create a dedicated international trust fund[36]. This fund could combine funds allocated for reconstruction to implement projects that require significant funds, systemic solutions, and the formation of an infrastructure that is capable of serving large projects. Such funding will allow attracting not only investment resources, but also insurance resources, which can be provided, for example, by the European Bank for Reconstruction and Development, a multilateral investment guarantee agency of the World Bank Group.

Given the dynamic growth rate of high-tech clusters in Ukraine, the formation of such industrial parks is promising. For example, we can note

[31] How Digitalization Supports a New Economic Growth Model in CEE. 2019. https://www.opportunitynetwork.com/insights/digitization-central-eastern-europe/

[32] Ibid.

[33] Ibid.

[34] KSE. 2023. The total amount of direct damage to Ukraine's infrastructure caused by the war reaches $151.2 billion – estimate as of September 1, 2023. https://kse.ua/ua/about-the-school/news/zagalna-suma-pryamih-zbitkiv-zavdanainfrastrukturi-ukrayini-cherez-viynu-syagaye-151-2-mlrd-otsinka-stanom-na-1-veresnya-2023-roku/

[35] Ministry of Economy of Ukraine. 2022. Industrial parks in Ukraine 2022. https://www.me.gov.ua/Documents/Detail?lang=ukUA&id=47454ed4-b60a-4f37-bb77-b7f3127742f8&title=IndustrialniParkiVUkraini2022-Rik.

[36] Priorities for the development of the real sector in the context of war and post-war economic recovery in Ukraine. 2024. https://niss.gov.ua/sites/default/files/2024-02/ad_realsektor-2023.pdf

an increase in the number of IT professionals, more than 285 thousand people in 2023, and exports show an increase of 23 per cent, new startups and innovation platforms have been formed, such as UNIT.City[37]. In addition, investments in green energy need to be scaled up, which requires special attention after significant destruction and damage during the hostilities. In 2022 alone, investments in renewable energy amounted to more than USD 1.5 billion, supported by both government and international programs. Military developments, progress in the production of drones, radars, and electronic warfare equipment have great potential, while demand for defense exports is increasing, which could bring up to USD 2 billion.[38]

The foundation for creating a fundamentally new basis for Ukraine's economic recovery is a radical increase in R&D spending from 0.5 per cent of GDP to 2–3 per cent at the European level (Fig. 4).

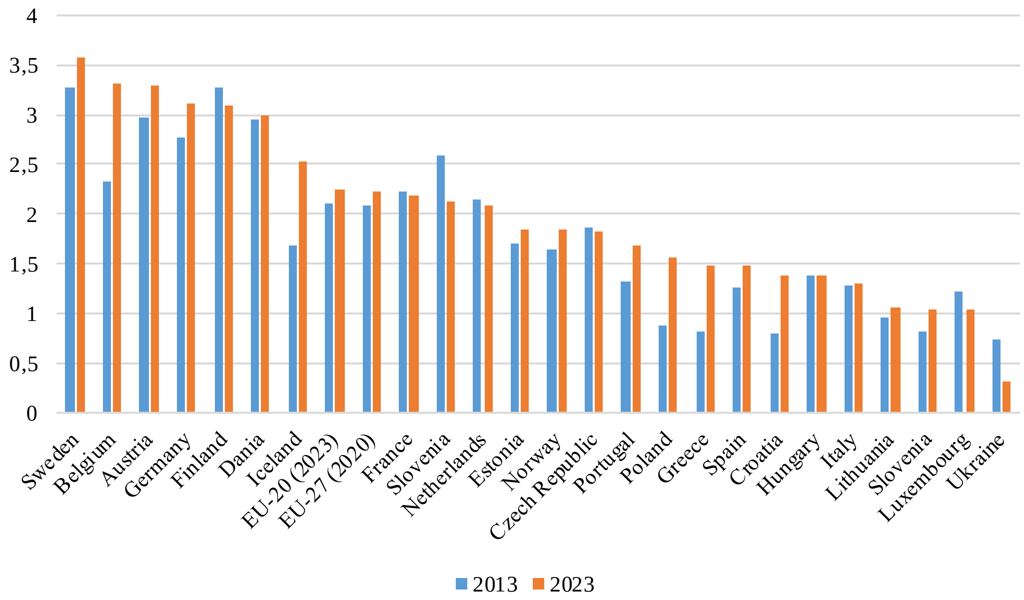

Figure 4. Dynamics of R&D expenditures, selected countries, 2013–2023[39; 40]

[37] UnitCity. 2024. The largest innovation park in Eastern Europe. 2024. https://unit.city/

[38] Export of weapons from excess capacities of the defense industry will bring billions of dollars to Ukraine – NUADI. 2024. https://mil.in.ua/uk/news/eksport-nadlyshkovogo-ozbroyennya-opk-prynese-ukrayini-milyardy-dolariv-nuadi/

[39] Ukraine – Research and Development Expenditure (% Of GDP). 2024. https://tradingeconomics.com/ukraine/research-and-development-expenditure-percent-of-gdp-wb-data.html.

[40] GERD by sector of performance. https://ec.europa.eu/eurostat/databrowser/view/rd_e_gerdtot__custom_14091394/bookmark/table?lang=en&bookmarkId=ba46c5ec-ed70-4957-aa53-77119d317b0d

As we can see, funding for research and development in Ukraine has significantly decreased. Such a level of funding cannot ensure even simple reproduction of the scientific potential, let alone ensure breakthrough development of the country's economy. Another important problem is the outflow of highly qualified personnel, which has significantly increased since the beginning of the full-scale invasion (Figure 5).

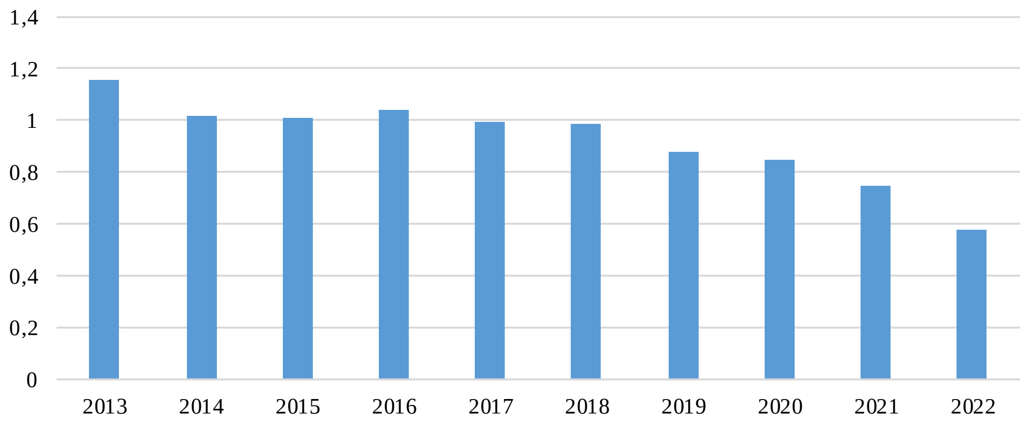

Figure 5. The dynamics of the number of scientists in Ukraine, 2013–2022, thousand people per million population[41]

The dynamics of Ukraine's scientific potential is negative not only in terms of absolute numbers of personnel, but also catastrophic in relative terms. Thus, in highly developed countries, the number of researchers is, for example, more than 8 thousand people per million in Sweden, more than 5.5 thousand in Germany and France, almost 8 thousand in Denmark, more than 6 thousand in Austria and Belgium (Table 2). In Ukraine – only 0.581 thousand people in 2022. Even the war cannot justify this situation.

It is worth noting that despite the hostilities, Ukraine is projected to grow its GDP by the end of 2025[42], which requires additional funding and incentives for the development of high-tech and knowledge-intensive sectors of the economy.

[41] Ukraine – Researchers In R&D (per Million People) https://tradingeconomics.com/ukraine/researchers-in-r-d-per-million-people-wb-data.html
[42] Ukraine Forecast. https://tradingeconomics.com/ukraine/forecast

Table 2

NUMBER OF SCIENTIFIC PERSONNEL IN DEVELOPED COUNTRIES AND SELECTED REGIONS, THOUSAND. PERSONS PER MILLION. POPULATION (2022)[43]

Country/region	Number of scientists, thousand per million population	Country/region	Number of scientists, thousand per million population
Austria	6,342	Dania	7,708
Belgium	6,582	Finland	7,871
Canada	5,076	France	5,175
Switzerland	6,023	Ireland	5,251
Germany	5,536	Iceland	6,940
Japan	5,638	South Korea	9,082
Netherlands	6,074	Norway	7,228
Portugal	5,743	Sweden	8,131
USA	4,452	EU	4,452

Conclusions

The importance of intellectual capital for economic development is undeniable, which was well substantiated in the scientific literature and government documents before the war. The relevance of the use of scientific and technological factors only increased during the war, with the reduced ability to create powerful physical production facilities, concentrate industrial enterprises, and form production chains without the risk of destruction and loss of investment. Given Ukraine's potential for developing high-tech, knowledge-intensive industries, the significant potential for the development of intellectual capital is one of the factors behind Ukraine's recovery from the war. To restore the destroyed economy, we need modern ideas, technologies, and solutions that form the basis for high-quality economic growth. Equally important is the development of new financial solutions and mechanisms that will not only accumulate significant funds but also quickly and efficiently channel them to strategically important goals.

Preserving Ukraine's educational and scientific potential is extremely important for its further breakthrough development. A state strategy for supporting, returning and reintegrating specialists from abroad, as well as large-scale retraining and employment programs for veterans, is urgently

[43] Number of R&D researchers per million people, 2022. https://ourworldindata.org/grapher/researchers-in-rd-per-million-people

needed. Investing in education will help us not to lose our young people, bring them back to the national education system, and train specialists for the industries of the future, such as artificial intelligence, creative industries, etc. This can help to increase the competitiveness of Ukraine's economy on the global market through developments in IT, the pharmaceutical industry, smart solutions in reconstruction, etc. Ukraine has a unique opportunity to use its human potential to create a successful future and integrate into the global economy as a country of knowledge and innovation.

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