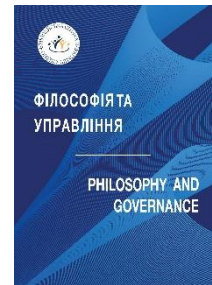




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Innovation Management Under Wartime Shocks and Strategic Priorities for Ukraine's Post-War Recovery

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ABSTRACT

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The article conducts a comprehensive analysis of the Global Innovation Index for Ukraine with a special emphasis on how innovative development affects the socio-economic efficiency of the country in the context of a full-scale war. The study is based on the data of this index for the period from 2020 to 2025 and allows you to trace changes in key indicators reflecting the state of the innovation ecosystem of Ukraine. Despite all the military challenges, Ukraine continues to maintain the status of a country that exceeds expectations in terms of the level of innovation relative to its gross domestic product per capita. This indicates the high resilience and adaptability of the Ukrainian innovation system, which is especially evident in the areas of knowledge creation, technological achievements and business sophistication. At the same time, the war has caused significant damage to the foundations of innovative development. Investment in research and development has been significantly reduced, and the infrastructure necessary to support scientific and technological activities has deteriorated significantly. Socio-economic risks have increased: labor productivity has practically ceased to grow, and the mass emigration of qualified specialists – the so-called brain drain – has become one of the most acute problems. These factors together create serious obstacles to the preservation and development of the country's innovation potential. The results of the study show that innovations in wartime play the role of a kind of shock absorber: they help mitigate economic losses, support the export of services, maintain a certain level of creative and technological activity, and create new opportunities for business and society to adapt. At the same time, the war is blocking the full realization of this potential, exacerbating structural problems and making long-term recovery more difficult. The findings clearly indicate the need to significantly strengthen state policy in the field of innovation as one of the key areas of post-war recovery. Without a systematic increase in funding for science, creating conditions for the return of specialists, developing partnerships with European countries, digitalizing processes and supporting key sectors (including artificial intelligence, creative industries and defense technologies), Ukraine's innovation potential will not be able to fully become a driving force for economic growth and social stability.

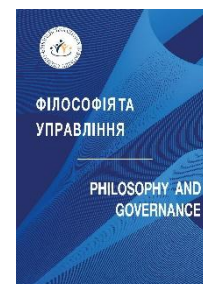
KEYWORDS

Global Innovation Index, innovative development, socio-economic efficiency, business sophistication, knowledge and technologies, economic recovery.



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СТАТТЯ

АНОТАЦІЯ

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У статті проведено комплексний аналіз Глобального індексу інновацій для України з особливим акцентом на те, як інноваційний розвиток впливає на соціально-економічну ефективність країни в умовах повномасштабної війни. Дослідження спирається на дані цього індексу за період з 2020 по 2025 рік і дозволяє простежити зміни ключових показників, що відображають стан інноваційної екосистеми України. Незважаючи на всі воєнні виклики, Україна продовжує зберігати статус країни, яка перевищує очікування за рівнем інновацій відносно свого валового внутрішнього продукту на душу населення. Це свідчить про високу стійкість і адаптивність української інноваційної системи, яка особливо проявляється в сферах створення знань, технологічних досягнень та софістикованості бізнесу. Водночас війна завдала суттєвої шкоди основам інноваційного розвитку. Значно скоротилися інвестиції в дослідження та розробки, суттєво погіршилася інфраструктура, необхідна для підтримки наукової та технологічної діяльності. Зросли соціально-економічні ризики: продуктивність праці практично перестала зростати, а масова еміграція кваліфікованих фахівців – так званий відтік мізків – стала однією з найгостріших проблем. Ці фактори разом створюють серйозні перешкоди для збереження та розвитку інноваційного потенціалу країни. Результати дослідження показують, що інновації в умовах війни відіграють роль своєрідного амортизатора: вони допомагають пом'якшувати економічні втрати, підтримувати експорт послуг, зберігати певний рівень креативної та технологічної активності, а також створювати нові можливості для адаптації бізнесу й суспільства. Водночас війна блокує повноцінну реалізацію цього потенціалу, посилюючи структурні проблеми та роблячи довгострокове відновлення складнішим завданням. Отримані висновки чітко вказують на необхідність суттєвого посилення державної політики у сфері інновацій як одного з ключових напрямів поствоєнного відновлення. Без системного збільшення фінансування науки, створення умов для повернення фахівців, розвитку партнерств з європейськими країнами, цифровізації процесів та підтримки ключових секторів (зокрема штучного інтелекту, креативних індустрій та оборонних технологій) інноваційний потенціал України не зможе повною мірою стати рушійною силою економічного зростання та соціальної стабільності.

КЛЮЧОВІ СЛОВА

Глобальний індекс інновацій, інноваційний розвиток, соціально-економічна ефективність, бізнес-софістифікація, знання та технології, відновлення економіки.

1. Introduction

Innovation is what really drives the economy forward and helps society stay stable, especially when serious problems like war pile up. That is why the Global Innovation Index (GII), which is released annually by the World Intellectual Property Organization (WIPO), has been considered one of the most reliable ways to understand how a country is able to create and implement something new for many years. In the latest report for 2025, it includes 139 economies of the world, and they are evaluated according to 78 different indicators. All these indicators are divided into seven large groups: institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technological results, and creative results.

GII is interesting not only because it simply ranks countries. It also looks at how effectively the state transforms the invested money, education, infrastructure and other resources into real results – new technologies, patents, products, creative solutions. Thanks to this, it is possible to see exactly how innovations affect the overall socio-economic picture of the country.

For Ukraine, which has been living in a full-scale war with Russia for four years, such an analysis makes special sense. The war destroyed a huge amount of infrastructure, moved thousands of specialists abroad, and drastically reduced investments – all this could not but hit innovative development. According to GII 2025, Ukraine ranks 66th among 139 economies (in 2024 it was 60th) [1; 2]. But at the same time, the country continues to hold on to the status of “overperformer” – that is, it shows better results than could be expected based on its level of GDP per capita. Ukraine has held this status for 13 years in a row (from 2012, 2014–2025) [3]. This means that the Ukrainian innovation system has proven to be surprisingly resilient even in such difficult conditions. At the same time, sore spots are immediately visible: institutions in 108th place and infrastructure in 75th place are direct consequences of military destruction, instability, and lack of resources [2].

The purpose of this article is to try to understand how exactly innovative development affects the socio-economic efficiency of Ukraine right now, during the war – and all this through the prism of GII data.

2. Literature Review

A review of the literature on the Global Innovation Index (GII) and its relationship to the socio-economic performance of countries demonstrates that innovation is indeed one of the most powerful engines of growth, especially in times when economies are facing severe shocks like war. Research in recent years can be divided into three main groups: general analytics of the GII and its impact on the economy, research on innovation in crises and wars, and special studies on Ukraine during the war.

Many authors affirm that the higher the GII, the better the indicators of GDP, productivity and well-being. Nasir et al. [4] analyzed data from 105 countries using sophisticated methods (panel quantile regression, 2SLS, etc.) and concluded that innovation inputs (investments, education) and outputs (patents, technologies) are closely related to economic success, but the effect is different depending on the country's income level. For middle-income countries like Ukraine, human capital and R&D are key.

Duarte et al. [5] made a systematic review of 156 articles on the GII (2011–2023) and identified three blocks: what precedes innovation (institutions, finance), the GII sub-indices themselves, and the consequences (growth, sustainability, labor market). They note the explosion of publications after 2020, a focus on efficiency (DEA methods) and configurations (QCA). Conclusion: innovation correlates with GDP, but in crisis conditions you need strong human capital.

Brás et al. [6] compared GII sub-indices by income levels (2011–2022): high-income countries lead in everything, while middle-income countries (like Ukraine) lag in infrastructure and market. This explains why the war hits the weak points so hard.

Nguyen [7], using the SGMM dynamic model, showed that for lower-middle-income countries (Ukraine is here), the decisive factor is HDI and education. In crises, it is advised to focus on urbanization and personnel retention.

Auer et al. [8] estimated the cascading effects of the war: global GDP contraction of 0.7–1.5%, inflation of +1–2.5%, losses of up to 53% of GDP for Ukraine, rising energy prices and food insecurity. Innovations here could help in energy and agriculture, but the war blocks investments.

A scientific and analytical report of the Ministry of Education and Science of Ukraine [9] confirms that Ukraine is one of the countries where innovative development is ahead of economic development

(overperformer in the GII for 13 years), but the war has widened the gap: R&D funding is critically low, and infrastructure is damaged.

Khimich [10] and other Ukrainian authors describe how the war has changed innovation: a focus on defense technologies, the adaptation of IT companies (more than 34% successfully adapted), but a general decline due to a lack of personnel and resources. In addition, this study is based on the works [11–15], which address issues of innovation management in a highly competitive environment.

The Intellectual Property Development Strategy until 2030 (draft 2025) emphasizes: the war has caused brain drain, damage to the IP ecosystem, and a decrease in applications, but at the same time, copyright registration has increased (+22.9% in 2024) [16]. Priorities – AI, digitalization, implementation of the EU acquis.

Thus, innovation is critical for recovery, but the war creates unique barriers (emigration of 5–7 million, destruction, financial shortage). Ukraine holds on thanks to its strengths in knowledge, technology and business sophistication (GII 2025: 66th overall, but 47th in knowledge and technology, 56th in business sophistication). However, without policy tightening (R&D funding, return of personnel, partnership with the EU), post-war recovery will be slow. This is what justifies our further analysis through the prism of the GII.

3. Problem Statement

The full-scale war, which has been going on for the fifth year, has inflicted incredible losses on Ukraine – economy, infrastructure, people – and all this has directly hit innovative development, which is usually the very “engine” that pulls the country out of the crisis. Destroyed laboratories, universities, data centers, technology parks, constant interruptions in electricity and logistics – all this simply does not allow science and technology to work normally. Investment in research and development has fallen to a critical level, state funding for science has become scarce, venture money in startups has almost disappeared, international aid partially saves the situation, but does not close the hole. Thousands of IT specialists, engineers, and scientists went abroad – the losses among qualified personnel are huge. Labor productivity is practically not growing, access to global markets and technologies is limited, and infrastructure is damaged or destroyed in vast areas.

Against this background, Ukraine is still surprising: for many years in a row, we have maintained the status of “overperformer” in the Global Innovation Index – that is, Ukraine’s innovation results are better than could be expected, based on the existing economic level. This means that the Ukrainian innovation system has proven to be surprisingly resilient, especially in IT, defense technologies, and digital solutions. But the main question is this: does innovation in such conditions really help soften the blow of the war – support the economy, reduce poverty, compensate for the loss of personnel and energy problems – or, on the contrary, does the war block its potential so much that long-term problems only deepen? Without a clear answer to this, it is difficult to understand what we really rely on in post-war reconstruction – not only on external assistance, but also on our own innovative resources, which, despite everything, are still breathing.

4. Methods and Materials

To understand how innovative development affects the socio-economic efficiency of Ukraine during the war, we took the Global Innovation Index from the World Intellectual Property Organization as a basis. This index evaluates countries according to many indicators, divided into two large parts: what is invested in innovation (education, investment, infrastructure, institutions) and what comes out of it (patents, technologies, creative products, knowledge exports). We looked at how these parts changed for Ukraine from 2020 to 2025: the overall ranking deteriorated, but the results in knowledge and technology remained stable, while infrastructure and institutions sank significantly. This helped to see where the system is holding up despite the war, and where the war has dealt the biggest blow.

For comparison, we compared Ukraine with other countries – neighbors in Europe and countries with a similar income level. Ukraine continues to exceed expectations in terms of its economic level, unlike many countries where infrastructure and investment are holding up better. We also looked at strengths, such as technology exports or creative products, and weaknesses, such as productivity or energy efficiency. All this is based on official data from Ukraine’s profile in this index – without

additional complex calculations, but with an emphasis on how the war has affected the dynamics and how innovations help (or do not help) the country stay afloat in such conditions.

5. Results and Discussion

General dynamics of ranks and context. The Global Innovation Index (GII), developed by the World Intellectual Property Organization (WIPO), is a comprehensive tool for assessing the innovation potential of countries, based on 78 indicators divided into seven blocks: Institutions; Human capital and research; Infrastructure; Market sophistication; Business sophistication; Knowledge and technology outputs; Creative outputs. For Ukraine, which has been experiencing a full-scale war since 2022, the GII analysis is of particular importance because it reflects the resilience of the innovation ecosystem in times of crisis. According to Ukraine's GII 2025 profile, the country ranks 66th out of 139 economies, down from 60th place in 2024 and a significant drop from 45th place in 2020. The historical dynamics of the ranks are as follows: 2020 – 45th, 2021 – 49th, 2022 – 57th, 2023 – 55th, 2024 – 60th, 2025 – 66th (Figure 1).

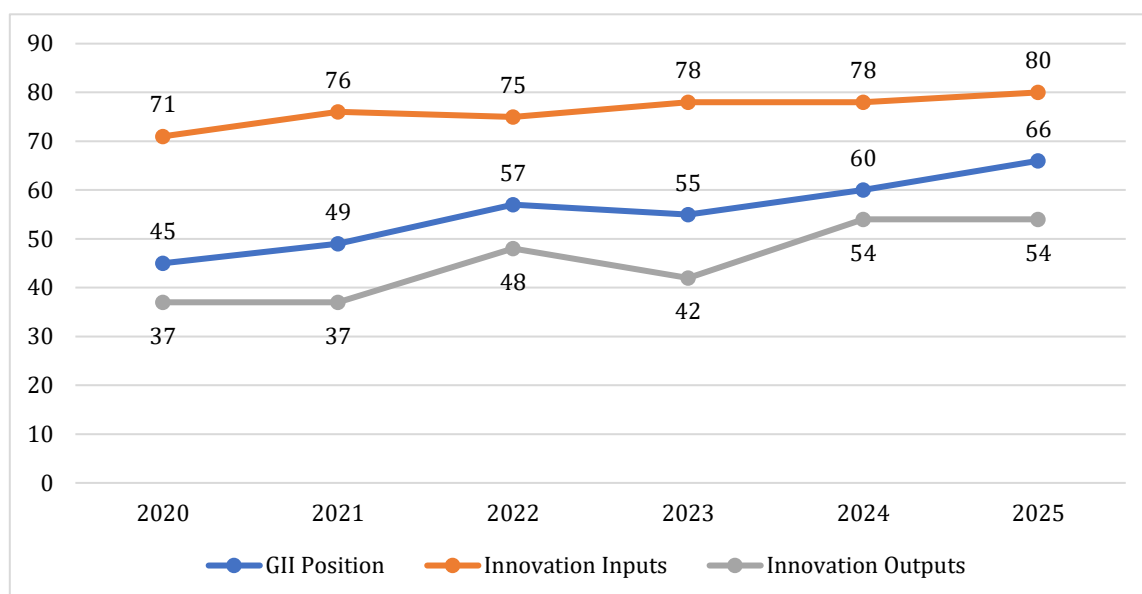


Figure 1. Dynamics of Ukraine's positions in the Global Innovation Index (GII) and its components: overall rank, innovation inputs and innovation outputs (2020–2025)

This indicates a gradual decline in positions, accelerated by the war, which destroyed infrastructure, the emigration of specialists and a reduction in investment. Ukraine ranks 15th among 36 upper-middle-income economies and 35th among 39 European countries, highlighting lagging behind regional leaders but relative resilience in its income group. It is important to note that Ukraine retains the status of “overperformer” – it has exceeded expectations in terms of the level of innovation in terms of GDP per capita for 13 years in a row (from 2012, 2014–2025), demonstrating the effectiveness of converting limited resources into results. However, the absence of Ukrainian clusters in the top 100 global innovation clusters (for example, the lack of Silicon Valley analogues) indicates a lack of concentrated innovation hubs, which complicates scalable growth.

Analysis of innovative inputs and outputs, efficiency. One of the key features of GII is the division into innovative inputs (investments, resources) and outputs (results). In 2025, Ukraine ranks 80th in terms of inputs (deterioration from 78th in 2024), but 54th in terms of outputs (stable from 2024). Dynamics of inputs: 71st (2020), 76th (2021), 75th (2022), 78th (2023–2024), 80th (2025) – stable deterioration, caused by the war, which reduced investment and damaged infrastructure. Outputs: 37th (2020–2021), 48th (2022), 42nd (2023), 54th (2024–2025) – stability first, then fall, but still better than inputs, indicating system efficiency. Ukraine effectively converts inputs into outputs, exceeding the expected performance, which confirms the status of an overperformer. Compared to the upper-middle-income group, Ukraine is stronger in terms of outputs (15th in the group), but weaker in inputs, where the war has exacerbated disparities. In Europe, we are lagging in both aspects, but this is partly due to the high baseline of the region. Methodologically, changes in the GII model and data incompleteness (for example, missing values for some indicators due to the war) affect the comparison,

but the general trend – the resilience of outputs despite the degradation of inputs – indicates the adaptability of the Ukrainian ecosystem, in particular in IT and defense technologies, where creativity compensates for the lack of resources [17].

Detailed analysis of GII blocks and strengths/weaknesses. GII sub-indices allow for a deeper understanding of strengths and weaknesses. In 2025:

- Institutions (score 34.1, rank 108). Weak positions of the institutional environment (31.8, 115), regulatory (35.6, 106), and business environment (34.9, 89), as well as operational stability of business (29.3, 126), and rule of law (30.7, 117). These are the direct consequences of war, instability, and corruption.

- Human Capital and Research (32.5, 65). The secondary education enrolment rate (57.6, 48) is a strong point (education spending 5.9% of GDP, 18th; student funding 25.9%, 16th) but a weak R&D indicator (6.9, 72nd) due to low spending (0.3% of GDP, 73rd).

- Infrastructure (40.7, 75). Strong ICT score (89.9, 23, with government online services 98.2, 5th), but weak overall infrastructure (16, 122) and environmental sustainability (16.2, 91) – energy efficiency (5.6 GDP/unit, 116th) suffered from shelling.

- Market sophistication (32.3, 85). Weak credit (16.7, 98), investment (2.8, 88), but strong trading scale (77.3, 41).

- Business sophistication (31.4, 56). Strong indicators of Mental Workers (41.9, 50) and Women Working with Higher Education (30%, 4th), but weak demographic dividend of young people (24.4%, 125th) and innovation connections (24.1, 72).

- Knowledge and technological outputs (26.5, 47). Strong indicators of knowledge creation (31.8, 30) with utilitarian models (5.5/billion PPP, 1st), ICT exports (10%, 5th), but weak indicators of knowledge impact (18.7, 101) due to negative productivity growth (-2.4%, 130th).

- Creative Outlets (23.9, 67). Intangible assets (28.4, 63) with strong designs (4.5/billion PPP, 16th), mobile apps (75.3, 18th), but weak creative merchandise (5, 95).

Thus, we can highlight the strengths (top 10 indicators): utilitarian models (1st), women working with higher education (4th), online government services (5th), ICT exports (5th), student funding (16th), designs (16th), apps (18th), education costs (18th), trademarks (22nd), software (25th). Weak: productivity growth (130th), capital formation (126th), business stability (126th), demographic dividend (125th), energy efficiency (116th) – most are related to the war. Compared to the income group, Ukraine is strong in knowledge (15th) but weak in institutions (32nd out of 36); in Europe, it is at the bottom of most sub-indices. Methodologically, some indicators are missing (n/a), reflecting military data restrictions.

Global Innovation Tracker analysis and socio-economic consequences [4]. The Global Innovation Tracker captures the current state of innovation, with short-term (1-year) and long-term (CAGR 10-year) changes. In 2025, 6 indicators for Ukraine improved in the short term, and 3 worsened. Investment in Science and Innovation: Publications (-5.2% short, -1.2% long); R&D (5.3% short, -11.3% long) – long-term decline due to chronic underfunding; venture (-17.2% short, -2% long); Patents (24.4% short, -2.7% long) – short-term growth due to defense innovation. Technological adoption: fixed broadband (0.1% short/long, level 92.4/100); Connections (12.2% short, 7.3% long, 19.7/100); electric vehicles (9.1% short, 11.3% long). Socio-economic impacts: labor productivity (0% short, -0.3% long, level 34,185 USD); life expectancy (1.1% short, 0.3% long, 73.4 years); temperature (+3.6°C short, +1.7°C long) – climatic risks are exacerbated by wartime. The long-term decline in R&D (-11.3%) and venture capital (-2%) reflects the impact of the war on investment, but the short-term growth in patents (24.4%) and connections (12.2%) shows adaptation through digitization and defense. Compared to Europe, Ukraine lags in R&D and productivity, but is ahead in ICT adoption. The war has exacerbated negative trends, but has retained the potential in technological outputs.

Comparison with groups and the impact of war. Compared to upper-middle income, Ukraine ranks 15th overall, strong in knowledge (15th) and creativity (15th), but weak in institutions (32nd out of 36th). In Europe, it is 35th, lagging in all sub-indices except knowledge (28th out of 39). The war has led to a drop in ranks from 2022 (from 49th to 57th), exacerbating weaknesses in infrastructure and investment, but the outputs are stable thanks to IT (export 10%, 5th) and designs (16th). Missing data (n/a) for some indicators (e.g., 5G, entertainment) indicates military restrictions. Ukraine is effective in turning inputs into outputs, but without policy tightening (increasing R&D to 1% of GDP, returning personnel), post-war recovery will be slow.

Another important aspect that emerges from the analysis is how the war has changed the very nature of innovation in Ukraine. If earlier innovations were often associated with commercial startups, the export of high-tech goods, or the development of creative industries, now defense technologies have become the main driver. It is in this area that there is the greatest surge in creativity and speed of implementation: drones, electronic warfare systems, intelligence software, cyber defense – all this was born or significantly developed in wartime. These developments not only help at the front, but also create export potential, attract investments from partners, and even form new niches in the global security technology market. At the same time, this creates a certain asymmetry: civilian sectors (except IT) continue to stagnate, because resources, attention, and talents are concentrated on the defense direction. Such concentration can be effective in the short term, but in the long term it threatens to create an imbalance when peaceful industries do not receive enough attention and funding.

Separately, it is worth dwelling on the role of education and human capital. Despite the massive outflow of specialists, Ukraine maintains a relatively high level of spending on education relative to GDP and demonstrates a strong position in terms of student funding and the share of women with higher education. This creates a certain “margin of safety”: even if many specialists are now working remotely from abroad or in new countries, they continue to be part of the Ukrainian innovation ecosystem. Many IT companies have retained their teams thanks to the transition to distributed work models, and some scientists continue to publish and register patents while abroad. This is a unique situation: brain drain has become not only a loss, but also a form of “dispersion” of Ukrainian innovation potential around the world, which in the future may become a source of new partnerships, investments and technology transfer.

The war has also accelerated the digitalization of many processes. The government’s online services, electronic record keeping, digital registers – all this not only survived, but even improved in conditions when physical infrastructure was destroyed. This made it possible to maintain a certain part of innovation activity, especially in the creative industries and the field of copyright, where registrations increased significantly. Such a transition to digital tools was not just a forced step, but a strategic decision that can become the basis for a post-war development model – more flexible, less dependent on physical infrastructure and more integrated into global digital markets.

Comparing Ukraine with other countries that have experienced or are experiencing crises (wars, sanctions, economic shocks), one can see common patterns: innovations become “survivalist”, but their effect is limited by a lack of resources and instability. At the same time, Ukraine stands out precisely because its innovation system not only survives, but retains the ability to generate high-quality outputs – patents, technological solutions, creative products – despite the degradation of inputs. This gives hope that after the war, when the resources return, the country will be able to quickly gain momentum, because the foundation (education, creativity, digital skills) has already been laid and not destroyed.

Thus, the war has not only exacerbated weaknesses, but also revealed the strengths of the Ukrainian innovation system: adaptability, creativity, and the ability to work in conditions of scarcity. These qualities can become the basis for recovery if the state consciously directs resources to strengthen them. Without this, innovation will remain a local “island of sustainability”, and not a driving force of the entire economy. That is why further strengthening of state policy is not an option, but a necessity for the potential that has already been proven in wartime to turn into a real source of growth in peacetime.

6. Conclusions

Analyzing the Global Innovation Index for Ukraine through the prism of recent years, especially since the beginning of the full-scale war, it becomes clear that innovation is not just a buzzword or an abstract indicator, but a real tool that helps the country survive and adapt in extreme conditions. We have seen how Ukraine, despite all the destruction, emigration of specialists and economic losses, continues to stay in the status of “overperformer” – that is, it exceeds expectations in terms of the level of innovation, based on its GDP per capita. It has maintained this status for many years in a row, and this is not a coincidence: the Ukrainian innovation system turned out to be flexible, able to generate results even with limited resources. This is especially noticeable in the areas of knowledge and technology, where the country is consistently in a strong position, or in business software, where creativity and adaptability of business allow it to survive in conditions of instability. For example, the growth in the

export of IT services or copyright registration is not just numbers, but evidence of how people and companies find ways to create new things, even when there is ruin around.

But the war, of course, did not pass without a trace. It hit the basics – investments in research and development that fell to a minimum, infrastructure that suffered from shelling and power outages, human capital, where brain drain was a real disaster. Labor productivity practically does not grow, and in some sectors, it even falls, because there is a lack of qualified hands and stable conditions. Socio-economic efficiency suffers from this: the war increases the risks of poverty, food insecurity, and climate problems, which are already putting pressure on the economy. However, it is innovations that play the role of a shock absorber here – they soften the blow, allowing, for example, through digitalization and defense technologies, to support exports and create new jobs. Without them, the situation would be much worse: imagine, if it were not for the resilience of the IT sector or creative industries, GDP losses would be even greater.

Thus, innovative development in wartime not only survives, but also has a positive effect on socio-economic efficiency, albeit with restrictions. Strengths, such as education, where Ukraine leads in spending on education, or knowledge, where patents and technology exports keep the country afloat, compensate for weaknesses in institutions and infrastructure. This can be seen from the dynamics: the overall rank drops, but the outputs remain stable, which indicates the efficiency of the system. Compared to other countries with similar incomes, Ukraine looks better in terms of outputs. In Europe, Ukraine is lagging, but this is more due to the high starting level of its neighbors than because of the country's weakness. The war has exacerbated the problems, but it has not broken the potential: the growth of copyright or patent registrations in certain sectors shows that people continue to create, even in bomb shelters.

The results clearly indicate the need to strengthen public policy in the field of innovation for post-war recovery. We cannot rely only on natural sustainability – we need to invest in R&D, raise science funding to at least 1–2% of GDP, create programs for the return of personnel from abroad, develop partnerships with the EU, for example, through Horizon Europe or the digital market. Priorities such as artificial intelligence, digitalization, and harmonization with the EU *acquis* are already embedded in the strategies, but they need to be implemented faster. If this is done, innovation will become not just a tool for survival, but a driver of a real revival – with productivity growth, new jobs, and a sustainable economy.

The analysis shows that even in wartime, innovation is a force that keeps Ukraine on its feet. They do not solve all problems, but they give hope for the future, where recovery will not just be a repair, but a transition to a new, stronger development model. Future research could delve into specific sectors, like defense technology or green energy, to see exactly how innovation affects people's daily lives and economies. The main thing is not to stop, because in such conditions, innovation is not a luxury, but a necessity.

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