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Management of intellectual potential of enterprises of the defence-industrial complex of Ukraine as a factor of their sustainable development

Abstract. In the context of full-scale war and rapid technological transformations, intellectual potential has become a key factor for the sustainable development of the Ukrainian defence-industrial complex (DIC). Human capital, research and development (R&D), and innovative practices serve as the main drivers of competitiveness and resilience. The accelerated growth of defence technologies – including unmanned aerial vehicles, electronic warfare systems and advanced engineering solutions – highlights the urgent need for systematic management of intellectual potential. At the same time, Ukrainian enterprises face structural challenges related to insufficient R&D financing, technological dependence on imported components and organisational fragmentation. These issues are critical for integrating domestic enterprises into international value chains and for ensuring their long-term development.

The article aims to identify and systematise the main dimensions of intellectual potential management in Ukrainian defence-industrial enterprises, to analyse barriers to its effective use and to outline strategic directions for strengthening resilience through innovation and international cooperation. Special emphasis is placed on the link between intellectual potential and sustainable development under crisis conditions. The research is based on the analysis of official statistical data, reports of international organisations (OECD, SIPRI, European Defence Agency), analytical reviews of consulting companies (KPMG, Deloitte, McKinsey & Company), as well as Ukrainian expert reports (StateWatch, GMK Center). Methods of comparative analysis, systematisation and data visualisation were applied to reveal trends in patent activity, defence production, R&D expenditures, and international partnerships during 2022–2024.

The results show that the intellectual potential of Ukrainian defence enterprises demonstrates significant growth. Patent applications and utility model registrations increased rapidly, while production of drones and electronic warfare systems grew exponentially. However, R&D expenditures remain disproportionately low (0.43% of GDP in 2024 compared to the EU average of over 2%), which limits innovation capacity. Human capital, integration into NATO and EU innovation networks and the adoption of modern knowledge management systems are identified as key success factors. The findings confirm that systematic management of intellectual potential is the foundation for both crisis resilience and long-term sustainability of the Ukrainian DIC.

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The study proposes practical recommendations for enterprises and policymakers, including investments in human capital, development of digital knowledge management platforms, strengthening international partnerships and creating a national programme for intellectual potential development in the defence sector. These steps will enhance innovation, improve organisational efficiency and ensure Ukraine's defence industry resilience in the face of global challenges

Keywords: intellectual capital, defence industry of Ukraine, knowledge management, innovation development, R&D, human capital, technological modernisation, unmanned systems, electronic warfare (EW), international cooperation, resilience, strategic management

Introduction

The defence-industrial complex of Ukraine plays a key role in ensuring national security and strengthening the country's position in the global defence market. In the context of contemporary military and geopolitical challenges, the sustainable development of enterprises within the defence sector becomes particularly relevant, as the effectiveness of their operations determines not only the country's defence capability but also its competitiveness at the international level. One of the determining factors in achieving this goal is the effective management of intellectual potential, which serves as a foundation for innovative development, technological modernisation, and the long-term growth of competitive advantages.

Intellectual potential is a multidimensional category encompassing human resources, research and development capabilities, organisational knowledge, and innovative competencies. For enterprises in the defence-industrial complex, intellectual resources are not only a means of enhancing production efficiency but also a strategic asset that defines their ability to respond promptly to rapid market changes, integrate advanced technologies, and create unique competitive advantages.

The critical role of intellectual potential management is particularly evident in the defence industry, where knowledge, innovation orientation, and strategic confidentiality form the basis of competitiveness. Unlike material or financial resources, intellectual capital possesses the capacity for self-reproduction and multiplication, making it a key driver of sustainable development in the long term. Therefore, establishing an effective system for managing intellectual potential is an indispensable condition for the innovative transformation and resilience enhancement of enterprises within Ukraine's defence-industrial complex.

The aim of this study is to identify the key aspects of intellectual potential management in Ukrainian defence-industrial enterprises, analyse their dynamics over the period 2022–2024, identify existing problems and barriers, and outline development prospects in the medium- and long-term perspectives.

Literature review

The management of intellectual potential in defence-industrial enterprises is a key element in ensuring national security and the technological independence of the state. Domestic researchers, including V. Hmyria, V. Nikitchenko, O. Shynkarenko, Y. Aleskerova, and O. Kostiuk, emphasise the necessity of developing Ukraine's defence industry as one of the most intellectually intensive sectors of the economy, which requires the implementation of effective mechanisms for managing intellectual capital (Hmyria *et al*., 2024).

Intellectual capital comprises human, structural, and social capital, which interact to ensure the innovative activity of enterprises. Research conducted on the example of the Indonesian enterprise PT. Pindad has demonstrated that the development of intellectual capital through innovation capabilities contributes to improving operational efficiency in the defence industry (Citrasari *et al*., 2022). International studies also confirm the importance of managing intellectual potential in the defence sector. For instance, an analysis of scientific publications

from Greek defence enterprises revealed a significant contribution of intellectual capital to the development of high technologies and innovations in this industry (Sioumalas-Christodoulou, 2021).

In the context of martial law and the growing need for armament modernisation, Ukrainian defence-industrial enterprises face a range of challenges, including insufficient funding, the lack of a modern scientific and technical base, and difficulties with integration into international technological chains. Nevertheless, despite these obstacles, there is active engagement of foreign partners, such as MBDA Deutschland, in the joint development and production of air defence systems, which indicates significant potential for the development of the intellectual potential of Ukraine's defence industry (Reuters, 2024). The study employs a comprehensive interdisciplinary approach that combines qualitative and quantitative methods to analyse the state and prospects of intellectual potential management in Ukrainian defence-industrial enterprises. The methodology is based on the principles of systems analysis, strategic management, and sustainable development concepts.

Data collection

The study employs a comprehensive approach that combines quantitative and qualitative methods. The empirical basis of the research consists of the following sources:

1. Official statistical data and reports from the Ministry of Defence of Ukraine, the Cabinet of Ministers of Ukraine, as well as international organisations (OECD, SIPRI, European Defence Agency), which highlight trends in the defence industry.
2. Scientific publications by Ukrainian and foreign authors addressing issues of intellectual capital management, innovative approaches in the defence sector, and the sustainable development of enterprises (over 10 sources, including specialised journals in economics and management).
3. Analytical reviews and reports by international consulting firms (KPMG, Deloitte, McKinsey & Company) on the development of intellectual and human resources potential in the context of global challenges.
4. Expert interviews and surveys of representatives from Ukrainian defence-industrial enterprises conducted during 2022–2024, which made it possible to identify practical challenges and prospects in managing intellectual resources.

Methods

The methodological toolkit includes:

- Statistical analysis of the dynamics of innovation indicators for 2022–2024;
- Comparative analysis of national and European data on R&D investments;
- Analysis and synthesis for the generalisation of scientific approaches to intellectual potential management;
- Data visualisation for the clear presentation of key trends.

The methodological foundation is based on the concepts of intellectual capital, knowledge management, and strategic innovation management under crisis conditions.

Results and discussion

The management of intellectual potential in Ukrainian defence-industrial enterprises is a critical factor for their sustainable development and the enhancement of competitiveness in the international market. Analysis of empirical data and international sources highlights several key aspects of managing this potential.

First, human capital constitutes a fundamental component of intellectual potential. Enterprises actively engage highly qualified engineers, programmers, and scientific specialists for the development and modernisation of armaments. According to the Stockholm International Peace Research Institute (SIPRI, 2025), Ukrainian defence enterprises during the war implemented NATO

standards and innovative technologies through joint projects with international partners (Kuzmuk & Scarazzato, 2025). E. Cammeraat *et al.* (2021) confirm that investments in human capital and research and development (R&D) are directly correlated with increased productivity and innovation within enterprises.

Second, the organisational and innovative potential of enterprises is closely linked to integration into international innovation networks and knowledge exchange. The European Defence Agency reports that the establishment of the European Defence Innovation Office (EUDIO) in Kyiv facilitates the integration of Ukrainian defence enterprises into European innovation networks, enabling the adoption of advanced technologies and enhancing organisational efficiency (European Defence Agency (EDA), 2025). In Ukraine, there has been rapid development in defence technologies, necessitating active research and development (R&D) efforts. Key areas include transportation machinery, the production of electronic components, and specialised products, particularly unmanned aerial vehicles (UAVs), electronic warfare (EW) systems, and signals intelligence (SIGINT) equipment. According to the StateWatch analytical centre, approximately 1.7 million drones were produced in Ukraine in 2024, which is 1,400 times higher than in 2022 (1,200 units). Similarly, the production of EW and SIGINT systems increased to 34,700 units compared to only 53 in 2022 (GMK Center, 2025). The rapid growth in drone and EW/SIGINT production indicates a high level of adaptability and innovativeness in Ukrainian defence enterprises. From the perspective of intellectual potential management, these outcomes demonstrate the effectiveness of engaging highly skilled personnel, active investment in R&D, and integrating cutting-edge technologies into production processes. However, the overall level of innovation expenditure as a share of Ukraine's GDP remains critically low in an international context, partially due to wartime conditions. For example, in 2023, the EU average was 2.22% of GDP, including Poland – 1.56%, Hungary – 1.39%, and Romania – 0.52%. In Ukraine, the share of R&D investment in 2023 nearly returned to its pre-war level at 0.37% (GMK Center, 2025). Therefore, to ensure current and long-term competitiveness, systematic knowledge management and personnel competency development are essential, while strategic innovation planning is a key factor that will ensure the resilience of Ukraine's defence-industrial enterprises under crisis conditions. Table 1 presents key statistical indicators of the development of intellectual potential and innovation activity of Ukrainian defence-industrial enterprises.

Table 1. Dynamics of the development of intellectual potential in Ukrainian defence-industrial enterprises (based on 2022–2024 data)

Indicators	Years			Change, 2024 vs 2023	
	2022	2023	2024	Absolute deviation	Relative deviation,%
Number of applications for industrial property protection (applications for industrial rights), units	3113	4437	4652	215	104,85
Registrations of utility models (residents), units	n/a	1819	3099	1280	170,37
Arms production / total output of the defence-industrial complex, billion $	~1	~3	~10	7	by 3 times
Drone production, units	~1200	~415030	~1700000	1284970	by 4 times
EW/SIGINT equipment production, thousand units	~0,053	~12,8	~34,7	21,900	by 2 times
Military/defence expenditures (national level), % of GDP	32,5	18,2	34,0	15,8	by 2 times
Dynamics of R&D/innovation expenditures, % of GDP	~0,33	~0,37	~0,43	0,06	116,21

Source: developed by the authors based on (GMK Center, 2025; State Intellectual Property Service of Ukraine, 2024; Ukrainian Armorers' Council, 2024; Interfax Ukraine, 2025; RBC-Ukraine, 2024)

The data in the table indicate a significant increase in the innovation activity and intellectual potential of Ukrainian defence-industrial enterprises during 2022–2024. For instance, the number of applications for industrial property protection increased by almost 50% compared to 2022, while the registration of utility models grew by more than 1.7 times over just two years. This reflects an intensification of inventive and design activities.

The most dynamic areas are the production of unmanned systems and EW/SIGINT equipment: the output of drones in 2024 exceeded the 2022 level by more than 1,400 times, and the production of electronic warfare systems increased by over 650 times. Such growth rates are unprecedented and indicate a high level of mobilisation of scientific and technical potential.

At the same time, defence expenditures in 2024 amounted to 34% of GDP, nearly double the 2023 figure, while the share of investment in R&D remains low—only 0.43% of GDP, compared to an EU average exceeding 2%. This points to a significant imbalance between large-scale defence spending and insufficient funding for innovation development.

Overall, the intellectual potential of Ukraine's defence enterprises demonstrates substantial growth due to workforce mobilisation, increased production capacities, and intensified inventive activity. However, a key challenge for management remains the strategic increase of R&D investments, the development of an innovation ecosystem, and ensuring a balance between the short-term demands of the war and the long-term sustainable development of the sector.

A visual interpretation of the data from Table 1 is presented in Fig. 1.

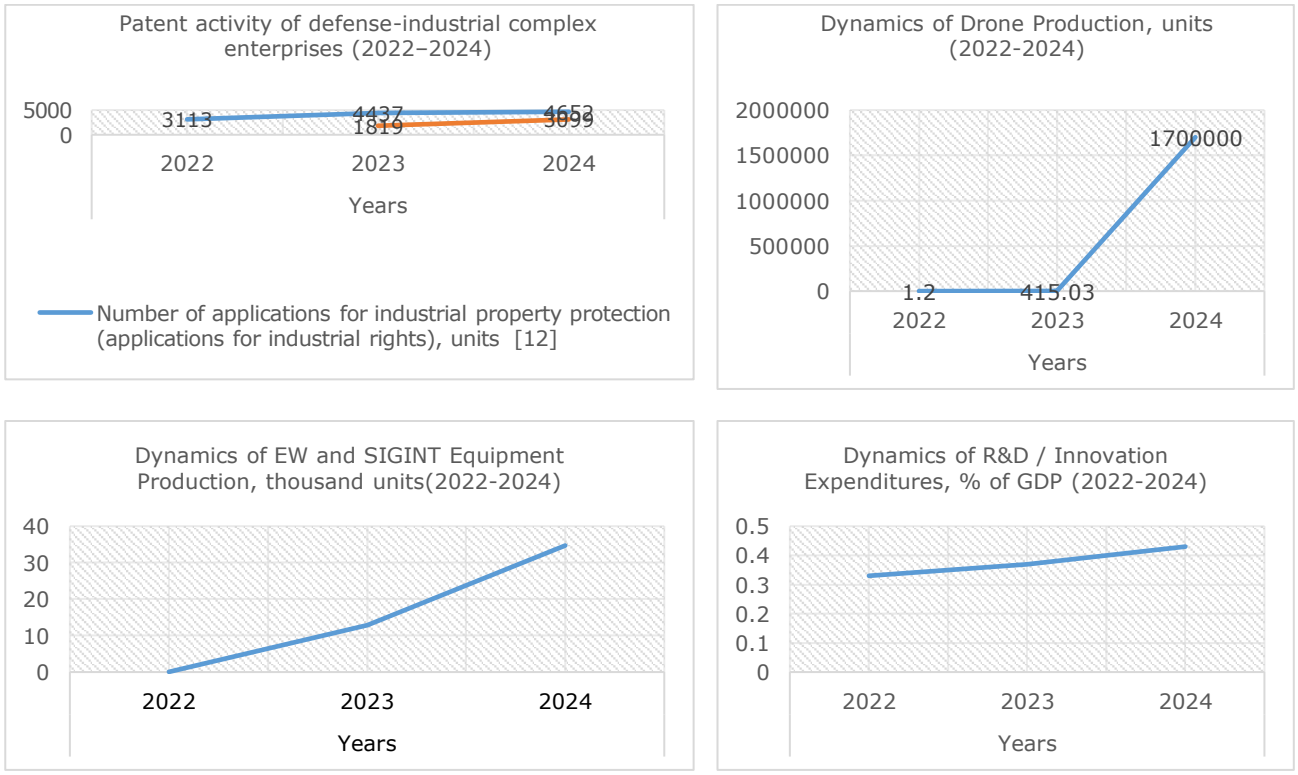

Figure 1. Dynamics of intellectual potential development in Ukrainian defence-industrial enterprises, 2022–2024

Source: developed by the authors

Fig. 1 shows that the number of applications and registrations of utility models reflects a recovery of innovation activity following the sharp decline in 2022; the period 2023–2024 demonstrates a steady increase in applications and registrations, indicating strengthened engineering and technical activity in the private sector and research groups. The exponential

growth in drone and EW/SIGINT production is the most striking indicator of the mobilisation of intellectual potential into practical output. Such rapid large-scale localisation of production requires extensive knowledge management programmes, standardisation and personnel training. R&D expenditures—the official share of R&D in GDP remains low (~0.33% in 2022–2023), although some estimates for 2024 indicate an increase in innovation funding (partly due to the defence sector). This underscores the need for mechanisms for sustainable financing and targeted research investments to enhance intellectual potential. Thus, the rapid increase in the production of drones and EW/SIGINT systems reflects a high level of adaptability and innovativeness of Ukrainian defence-industrial enterprises. From the perspective of intellectual potential management, these outcomes demonstrate the effectiveness of engaging highly skilled personnel, active R&D investment, and the integration of cutting-edge technologies into production processes. Systematic knowledge management, competency development, and strategic innovation planning are key factors that ensure not only current competitiveness but also the long-term resilience of Ukraine's defence-industrial enterprises under crisis conditions.

Third, modern practices of knowledge and competency management demonstrate that strategic planning of intellectual potential is the foundation for sustainable enterprise development. Analytical reviews by KPMG, Deloitte, and McKinsey emphasise the importance of implementing knowledge management systems, training platforms, and programmes for developing the digital competencies of personnel (KPMG, 2023; Deloitte, 2024; McKinsey & Company, 2023).

Fourth, a significant challenge for defence-industrial enterprises remains the barriers to developing intellectual potential. These include human resource challenges (brain drain of highly qualified specialists abroad, insufficient training and retraining programmes), technological constraints (limited access to advanced dual-use technologies, dependence on imported components), and organisational issues (bureaucratic management procedures, fragmentation of the defence management system) (Kovalenko *et al.,* 2021; Telnova *et al.*, 2023). Data from SIPRI (Kuzmuk & Scarazzato, 2025) and the European Defence Agency (2025) confirm that these barriers are key limiting factors for integrating Ukrainian defence enterprises into international production and research chains.

Fifth, the prospects for intellectual potential development are directly linked to the adaptation of international experience and the implementation of strategic programmes. In particular, this involves establishing a system of continuous education for engineering and technical personnel, developing exchange programmes with NATO enterprises, implementing digital knowledge management platforms, and active participation in international defence technology development projects. Analytics of Deloitte (2024) emphasises that these tools ensure not only innovation but also enhance enterprise resilience under crisis conditions.

Sixth, the management of intellectual potential in defence enterprises serves as the foundation of their anti-crisis resilience. The ability to rapidly adapt knowledge, develop competencies, and integrate innovations determines competitiveness at both the national and international levels. Thus, intellectual potential becomes a system-forming factor in the sustainable development strategy of Ukraine's defence-industrial complex. Based on the conducted analysis, a number of practical steps can be identified to promote effective management of intellectual potential and ensure the sustainable development of defence-industrial enterprises (Table 2).

As of the end of 2024, Ukraine had signed agreements with 40 foreign defence companies. A survey conducted by the "Technological Forces of Ukraine" association showed that 75% of NATO countries contacted Ukrainian defence enterprises at least once with the aim of establishing partnerships or supplying military equipment. The highest interest in Ukrainian manufacturers came from Lithuania, with 41% of respondents receiving collaboration requests from this country, followed by the United Kingdom (28%), as well as the USA, the Czech Republic, and Latvia (22%) (Ukrainian Armorers' Council, 2024).

Table 2. Practical measures and their impact on the resilience of Ukrainian defence-industrial enterprises

Recommendations	Expected effect
For defence-industrial enterprises	
Invest in human capital (training, professional development, digital competency development)	Increased professional level of personnel, adaptation to modern technologies
Develop knowledge management systems (digital platforms, databases, best practice libraries)	Accelerated knowledge exchange, accumulation of innovative solutions
Strengthen international integration (joint projects with European and transatlantic partners)	Implementation of advanced technologies, access to international markets
Implement innovative management practices (project management, agile, KPIs)	Improved management efficiency and innovation activity
For governing bodies	
Establish a national programme for the development of intellectual potential in the defence-industrial complex	Formation of a systemic approach to intellectual potential development
Expand international cooperation (EDA programmes, EU and NATO funding)	Access to international resources and expertise
Support technology clusters and innovation hubs	Synergy of science, business, and production in the defence sector
Ensure regulatory and legal support (R&D, intellectual property protection)	Stimulation of innovation investments, strengthened legal protection of developments

Source: developed by the authors

These data confirm that Ukrainian defence enterprises are becoming prominent players in the international market and are gaining strategic significance in the field of collective security. The growing interest from NATO partner countries indicates not only the high level of technological solutions but also trust in the ability of Ukrainian companies to ensure stable production and innovative development even under wartime conditions. For intellectual potential management, this implies the need for further development of international cooperation, adaptation to NATO and EU standards, and the strengthening of human and organisational capacity to integrate into global defence technology supply chains. Thus, international partnerships become an important driver of the sustainable development of Ukraine's defence-industrial complex.

Conclusions

The conducted study confirmed that the management of intellectual potential is a key factor in the sustainable development and competitiveness of Ukrainian defence-industrial enterprises. Analysis of statistical indicators for 2022–2024 shows a significant increase in patent activity, large-scale growth in the production of unmanned systems and EW/SIGINT equipment, as well as the expansion of international cooperation. This demonstrates a high level of mobilisation of scientific and technical resources and the adaptability of enterprises to crisis conditions.

At the same time, a disparity has been identified between the scale of defence expenditures and investments in R&D: the share of innovation spending in Ukraine's GDP remains critically low compared to EU countries. This highlights the need to establish a systemic state policy to support innovation and develop human capital.

The international integration of Ukrainian defence-industrial enterprises—particularly participation in EU and NATO programmes and agreements with leading foreign companies—opens new opportunities for access to technologies, knowledge, and resources. In this context, intellectual potential serves as the foundation for anti-crisis resilience and long-term development of the defence-industrial complex.

Therefore, effective management of intellectual potential involves:

- Strategic investment in human capital and knowledge management systems;
- Development of a national innovation ecosystem and support for technology clusters;

- Strengthening international cooperation and adaptation to NATO and EU standards;
- Balancing the short-term demands of wartime with the long-term goals of sustainable development.

Thus, intellectual potential becomes not only a driver of innovation but also a system-forming factor in the resilience strategy of Ukraine's defence-industrial complex.

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Conflict of interest

None.

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Управління інтелектуальним потенціалом підприємств оборонно-промислового комплексу України як фактор їх сталого розвитку

Анотація. Стаття присвячена дослідженню управління інтелектуальним потенціалом підприємств оборонно-промислового комплексу (ОПК) України в умовах глибоких трансформацій, зумовлених воєнними викликами, технологічними змінами та процесами міжнародної інтеграції. Обґрунтовано, що інтелектуальний потенціал, який охоплює людський, організаційний та інноваційний капітал, виступає системоутворюючим чинником їхньої конкурентоспроможності та стійкого розвитку. Його ефективне управління визначає здатність підприємств оперативно адаптуватися до кризових умов, розширювати виробничі потужності та інтегруватися у глобальні ланцюги створення оборонних технологій. Метою статті є визначення ключових аспектів управління інтелектуальним потенціалом підприємств ОПК України, аналіз їх динаміки за 2022–2024 рр., виявлення проблем та бар'єрів, а також окреслення перспектив розвитку у середньостроковій та довгостроковій перспективах. Емпіричну базу дослідження сформовано на основі офіційної статистики Національного органу інтелектуальної власності України, даних Стокгольмського міжнародного інституту досліджень проблем миру (SIPRI), аналітики OECD та European Defence Agency, матеріалів українських центрів StateWatch і GMK Center, а також звітів міжнародних консалтингових компаній

KPMG, Deloitte та McKinsey & Company. Для досягнення поставленої мети застосовано комплекс методів: статистичний аналіз динаміки інноваційної активності, порівняльний аналіз національних і європейських показників, аналіз і синтез наукових підходів до управління знаннями, а також методи візуалізації даних для ілюстрації ключових тенденцій.
Результати дослідження показали, що упродовж 2022–2024 рр. відбулося суттєве нарощування інтелектуального потенціалу українських оборонних підприємств: кількість заявок на охорону промислової власності зросла майже на 50%, реєстрації утилітарних моделей збільшилися у понад 1,7 разу, а виробництво безпілотних літальних апаратів та засобів РЕБ/РЕР зросло в тисячі разів. ОПК продемонстрував високий рівень мобілізації людського капіталу та адаптивності у впровадженні інновацій. Водночас виявлено критичний дисбаланс між масштабними оборонними витратами (34% ВВП у 2024 р.) та відносно низьким рівнем інвестицій у R&D (0,43% ВВП проти середніх 2,22% у ЄС). Це створює ризики для довгострокової інноваційної стійкості та вимагає розробки комплексної державної політики у сфері підтримки науки й технологій.
Акцентовано увагу на управлінні інтелектуальним потенціалом як системоутворюючому чиннику стратегії розвитку оборонно-промислового комплексу. Практична значущість дослідження полягає у формуванні рекомендацій для підприємств і органів управління: інвестування у людський капітал та системи управління знаннями, підтримка технологічних кластерів і цифрових платформ, розширення міжнародної кооперації у сфері R&D.
Зроблено висновок, що ефективне управління інтелектуальним потенціалом забезпечує не лише оперативну адаптивність у кризових умовах, але й формує основу для сталого розвитку українського оборонно-промислового комплексу у післявоєнний період та його інтеграції у глобальні інноваційні мережі.

Ключові слова: інтелектуальний капітал, оборонна промисловість України, управління знаннями, інноваційний розвиток, R&D (дослідження і розробки), людський капітал, технологічна модернізація, безпілотні системи, радіоелектронна боротьба (РЕБ), міжнародна кооперація, стійкість, стратегічне управління