!!!

Transforming the Research and Innovation system for Post-War Recovery

White Paper

January 2024

“Sciecne at Risk” project

scienceatrisk.org

ALFRED P. SLOAN FOUNDATION

The project is supported by Alfred P. Sloan Foundation

Authors:
Nataliia Haraschenko, Oleksandra Pravdyva, Oleksandr Skorokhod, Nadiia Vasylieva, Olena Pareniuk, Maryna Horokhovatska, Vitalii Omelianenko, Olena Tsyplitska

Editor:
Yuliia Bezvershenko

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

GDP – Gross domestic product
VRU – Verkhovna Rada of Ukraine
RI – Research infrastructure
R&D – Research and development
HEI – Higher education institution
CMU – Cabinet of Ministers of Ukraine
IMF – International Monetary Fund
MESU – Ministry of Education and Science of Ukraine
NASU – National Academy of Science of Ukraine
RIS – Research and innovation system
SI – Scientific institution
NRFU – National Research Foundation of Ukraine
UNO – United Nations Organisation
UNDP – United Nations Development Programme
UKRISTEI – State Scientific Institution “Ukrainian Institute of Scientific and Technical Expertise and Information”
UANIPIO – State Organization “Ukrainian National Office for Intellectual Property and Innovations”
CEB – Central executive bodies
SDG – Sustainable Development Goals
EIC – European Innovation Council
TRL – Technology Readiness Level

SUMMARY

The post-war recovery of the national economy is impossible without the involvement and transformation of the research and innovation system (RIS). This white paper uncovers the multifaceted aspects of the Ukrainian RIS, analyses the reasons for its fragmentation and disintegration, and proposes the changes necessary for its transformation, considering its potential for post-war recovery.

The analysis of Ukraine's post-war reconstruction plans has revealed a wide range of challenges and tasks that can be addressed with the help of its RIS. Simultaneously, the vision of the role of science in these documents is extremely limited. Similarly, little attention is paid to the revival of Ukrainian science and overcoming the challenges it has faced due to many years of inconsistent government policy and the war with Russia.

There is an extremely long list of issues that need to be addressed and are currently discussed in the expert community in the context of Russia's full-scale invasion of Ukraine, related to the functioning of Ukrainian science in wartime and the post-war future. This paper focuses on those components, the establishment of which is crucial now and key to the further transformation of science. These include:

- ability of the state to develop evidence-based policies with the involvement of scientific expertise;
- readiness of scientists to perform the tasks of post-war reconstruction and availability of the necessary research infrastructure;
- quality of communication between science and various post-war recovery stakeholders to address the relevant challenges;
- degree of integration of the RIS scientific and innovation subsystems;
- alignment of the model for financing scientific, technological, and innovative activities with the scope and specificity of post-war recovery tasks.

To solve these problems and tackle the challenges, the authors suggest the following:

1. Bring the legislation governing academic, scientific, technical, and innovation activities in line with internationally accepted terminology.
2. Implement EU practices in the process of public policymaking according to evidence-based and science-based principles.

3. Develop the institutional capacity of regions for innovative development and their recovery based on smart specialisation.
4. Create a model of multi-channel funding to support knowledge-intensive innovative products throughout their entire life cycle.
5. Introduce innovation procurement into the procurement practice for post-war recovery.
6. Implement a pilot project to create a special legal and tax space in Ukraine for knowledge-intensive innovative companies and academic startups.
7. Form an ecosystem of support for scientific institutions and HEIs in their interaction with the users of R&D results.
8. Create a unified systematised register of domestic scientific developments in the areas and priorities of post-war recovery.
9. Improve institutional support for technology transfer and support of the full life cycle of innovations.

Ukraine's research and innovation system needs to be transformed to overcome the many challenges the state and society will be facing after the war. Moreover, its effective operation is a key to the implementation of Ukraine's European integration vector and the Sustainable Development Goals. Even though the war is ongoing, it is important to take a number of steps towards the transformation of the RIS today.

INTRODUCTION

Ukraine's research and innovation activities are in danger.

Negative processes in science had intensified way before the full-scale war began, including a reduction in the number of researchers and the share of research and development funding in GDP, a decrease in the weight of scientific expertise in political decision-making, and many others. This led, among other things, to a decline in scientific potential indicators, including human capital, commercialisation of developments, and cooperation among scientists, businesses, and the government. The full-scale war, which has been ongoing for over a year and a half, is worsening the situation.

During the war, society has been widely debating the effectiveness of the research and innovation system (RIS) and the approaches to its management. The role of science and innovation is being reassessed and their importance as social phenomena for post-war recovery is being emphasised.

Domestic legislation currently does not utilise the term "research and innovation system"; however, it is becoming increasingly prevalent in practice [1] in the context of inseparability of science and innovation as social phenomena and the systemic relationship highlighted in EU documents [2].

European documents do not have a single established definition of the concept of "research and innovation system". However, the phrase "science [or research] and innovation" is used to refer to both the system and the policies implemented by the state [3; 4], "the environment in which partnership participation takes place" [5]; " a system of networks and collaboration that foster efficiency in the society and provide a stable environment for research" [6]; and a system that carries out "excellent science and generates new knowledge, transforms fundamental scientific knowledge into concrete solutions, by funding and performing excellent fundamental and targeted research" [7].

The RIS components include government authorities that formulate and implement science and innovation policy, universities, research institutions, investment funds and donor organisations that fund science [6], as well as researchers, citizens, politicians,

businesses, and third sector organisations that cooperate with each other throughout the entire process of research and innovation [3].

Thus, it can be said that **the research and innovation system** *is a system of interconnected organisations and institutions involved in the processes of conducting scientific research and development and creating innovations, their organisational and financial support, as well as in the implementation of R&D results and promotion of innovations in the real economy.*

For more than 30 years since gaining independence, the Ukrainian RIS has experienced stagnation. On the one hand, after the collapse of the USSR, Ukraine still had hundreds of scientific institutions and design bureaus employing more than 300,000 scientists who demonstrated high-level results in many fields, and on the other hand, broken production process chains, the economic crisis of the 1990s, lack of attention from the state, further loss of personnel and infrastructure obsolescence — all this led to the gradual degradation of the RIS and its fragmentation.

Today, Ukraine finds itself in a unique situation where the existing challenges and threats can turn into incentives for the rapid restoration of its research and innovation potential, which in turn will become a key element to significantly accelerate the country's post-war reconstruction. However, this is not an automatic process but rather an opportunity that should be seized. The restoration of Ukraine's RIS requires a strategic vision, the development and implementation of a well-thought-out set of policies, mutual coordination among many stakeholders and actors, and the attraction of sufficient funding.

The aim of this paper is to substantiate the directions of RIS transformation for the restoration of Ukrainian science and Ukraine.

To this end, the authors have carried out the following activities during their study:

1. definition of the role of the RIS in overcoming the challenges of post-war recovery;
2. analysis of the institutional conditions for the RIS functioning and key problems identification;
3. preparation of recommendations for the transformation of the RIS for post-war recovery.

RIS is a complex system that brings together various institutions and actors involved in scientific, scientific, technical, and innovation activities, as well as the infrastructure that supports their functioning. The war in Ukraine had a negative impact on all its levels and elements,exhibiting multiple manifestations of this destructive influence, including physical, financial, demographic, emotional and psychological. The recommendations for overcoming these consequences, presented in this and other papers of the Science at Risk! project, can be applied universally to restore the RIS in different countries that may suffer from armed conflicts, wars, man-made or natural disasters. These recommendations include ways to involve the scientific community in post-war recovery processes, establish communication between RIS actors and the environment (such as the state, business, and society), and expand the range of funding mechanisms for research, development, and innovation.

METHODOLOGY

To identify gaps in the RIS functioning, its detailed mapping was carried out along with desk research on the state and changes in the research and innovation systems, the nature of the institutional environment for the RIS, and international (including European) experience in RIS development.

The analysis of the current legislation regulating science and innovation and the level of implementation of its norms during the pre-war and war periods in the context of ensuring the necessary conditions for the functioning of science and reducing bureaucratic barriers allowed to identify certain obstacles and legal opportunities for implementing the necessary changes.

The authors studied the best domestic and foreign experience and practices regarding the principles and foundations of state policy in research and innovation, scientific activity organization, R&D process management, funding instruments, and financial models to support the development of research and innovation. Over 190 different documents, sources of information, and results of expert interviews, were processed.

35 interviews were conducted with experts from various fields of science and education, as well as representatives of the government and non-governmental organizations with experience in cooperating with SIs and HEIs, knowledge-intensive businesses, and business associations. This enabled a thorough assessment of the existing range of evaluations of the current state and prospects of development of the Ukrainian RIS. The study included interviewing representatives from various sectors including Ukrainian authorities, businesses, domestic and foreign scientific and pedagogical communities, and civil society. The interview was intended to provide detailed answers to 24 questions divided into the following blocks: 1) information about the respondent (3 questions); 2) the state and role of science in society (7 questions); 3) problems of RIS development in Ukraine (4 questions); 4) science and innovation for post-war recovery (6 questions); 5) post-war development of research infrastructure (4 questions) (see Annex A).

Three focus groups were conducted to discuss the prospects for the development of science, innovation, and human capital in Ukraine during the post-war period. The first group consisted

of 15 Ukrainian scientists who are either based in Ukraine or temporarily relocated abroad. The second group consisted of 12 representatives from member organizations of the Ukrainian Cluster Alliance. The third group consisted of 8 representatives from the Ukrainian Nuclear Society. For each focus group, the scenario presented a set of questions regarding the interaction between science and business, the role of science in post-war recovery, the motivation of scientists, and the vision of RIS design in the post-war future of Ukraine.

The White Paper was prepared using information from open sources as of the end of October 2023. The information and data that appeared later were not considered in the study.

SECTION 1. POST-WAR RECOVERY: TASKS, CHALLENGES, AND OPPORTUNITIES

1.1. Understanding post-war recovery

World history provides numerous examples of countries' recovery after suffering from wars and hostilities. Some of the most well-known cases include the restoration of the Federal Republic of Germany, Japan, and South Korea. In light of the ongoing hostilities and Russia's full-scale invasion of Ukraine a year and a half ago, it is clear that the issue of reconstruction is already urgent today. Firstly, without short- and medium-term measures to restore critical infrastructure, economic capacity, and military capabilities, such a large-scale and protracted war will simply be impossible to win. Secondly, many recovery issues are related to long-term planning, so before laying the first brick in the foundation of a new building, a clear understanding of the project is necessary.

Therefore, it is not surprising that **post-war recovery** is understood as a complex, holistic and multidimensional process encompassing effort to simultaneously improve military (restoration of law and order), political (governance), economic (rehabilitation and development) and social conditions (justice and reconciliation) [8]. One should realize that post-war reconstruction involves *not only the physical rebuilding* of destroyed infrastructure, but also the restoration of social services, creating the right conditions for private sector development, democracy, restoration of the justice system and social capital [10], distribution of humanitarian aid, implementation of critical structural reforms for macroeconomic stability and sustainable growth. These tasks fall under the economic dimension of post-war reconstruction [11, p. 45].

As for the **post-war reconstruction of Ukraine**, it should both address the above issues and become "a comprehensive transformation of the country [...]. It is not about rebuilding Ukraine to its pre-war state but rather about deep modernisation of the country. To help Ukraine shed its post-Soviet legacy and become a full-fledged democracy with a modern economy, strong institutions, and a robust

defence sector" [9], infrastructure, technology, business environment, institutions, education, healthcare, and other critical elements of the economy and society must be reformed. It includes coverage of the entire territory of Ukraine, its entire socio-economic space and not just the de-occupied and affected areas.

The European Commission's report acknowledges that Ukraine's post-war reconstruction will require comprehensive support to establish a free and prosperous country based on European values, well integrated into the European and global economy [12]. The report identifies the following four pillars of reconstruction:

- rebuilding the country's infrastructure, healthcare, housing, and schools, as well as ensuring digital and energy resilience in line with European policies and standards;
- continuing to modernise the state and its institutions to ensure good governance and the rule of law;
- implementation of the structural and regulatory agenda to deepen Ukraine's economic and social integration into the EU;
- supporting the recovery of Ukraine's economy and society by promoting sustainable and inclusive economic competitiveness, sustainable trade and private sector development, and the country's green and digital transformation.

The World Bank distinguishes three stages of post-war recovery, each of which addresses a different task: "Relief", when the priority is to maintain the functioning of the economy and protect the population; "Recovery", which involves the implementation of rapid and coordinated actions to stimulate recovery immediately after the cessation of hostilities; "Resilient Reconstruction", which includes the development and coordination of a sustainable reconstruction strategy in the medium term, rebuilding institutions and infrastructure [13].

It is hard to predict the exact unfolding of these stages in Ukraine, as global history has shown significant differences in the recovery experience of countries [14] and the duration of recovery. While some countries have fully recovered within 25 years or less, others are still suffering from economic insolvency. The financial investment in recovery is often inadequate or depleted over time. Additionally, the ability of governments and politicians to unite society and political forces for the sake of recovery is often limited. Therefore, the amount of aid does not always determine the speed and completeness of post-war reconstruction. For instance, in Iraq and Afghanistan, which have similar populations to Ukraine, USD 145 and 220 billion were respectively spent on reconstruction [14]. However, despite the significant investment, stable recovery was not achieved.

Recovering science in Ukraine

The restoration of Ukraine's research and innovation potential is a complex issue. First of all, this applies to scholars, which include scientists[1] (postgraduate students, doctoral students, research and teaching staff), inventors, inventors whose activities result in a knowledge-intensive product, and engineering and technical staff who are professionally engaged in research and development and directly participate in the creation of new knowledge, products, processes, methods and systems, as well as administrative and managerial staff who directly oversee the research process. At the same time, this study analyses only the set of scientists officially recorded by national statistics, namely researchers[2].

[1] A scientist is an individual who conducts basic and/or applied scientific research and obtains scientific and/or scientific and technical (applied) results, as defined in clause 4 of Article 1 of the Law of Ukraine On Scientific and Technical Activities.
[2] The category of "researchers" includes scientific, engineering, and technical employees who are professionally engaged in research and development and are directly involved in the creation of new knowledge, products, processes, methods and systems, as well as administrative and managerial staff who directly manage the research process (including heads of scientific organisations and units that perform research and development) (State Statistics Service of Ukraine).

Prior to the full-scale invasion of Russia, Ukraine had been experiencing a constant brain drain for decades. Out of over 312,000 researchers in 1990, only about 58,000 remained in the country at the outbreak of the war [15; 16]. The research infrastructure is outdated and has hardly been updated. Funding for research has declined from 1.19% of GDP in 1997 to 1.07% of GDP in 2003 and further to 0.41% of GDP in 2020 [9].

In February 2022, Russia invaded Ukraine, causing significant damage to the country's RIS. The invasion resulted in the destruction of around 120 research institutions, forced more than 10% of scientists to emigrate, and halted funding and implementation of many research projects. The country incurred losses of approximately USD 500 million [17].

However, for perhaps the first time in several decades of independence, the war has led to an increased demand for science and innovation from both the state and business. This includes military research, medicine, materials science, and artificial intelligence, among other industries that require scientists with their knowledge and competencies. Furthermore, international cooperation with European countries such as Poland, Germany, and the United Kingdom, as well as the United States and Japan, has intensified. For the first time in many years, cooperation with non-Russian science carries more weight than cooperation with Russian science [18]. The opportunities for Ukrainian institutions and organisations to participate in various EU programmes have expanded. This includes research foundations of different countries, scientific organisations, and private donors. Also, thanks to support programmes and grants, thousands of Ukrainian scientists are able to work in leading Western laboratories, and tens of thousands of Ukrainian students are able to study at foreign universities.

Ukraine is already preparing for post-war recovery. Discussions are underway to create a vision, draw up recovery plans, and create a database of projects in various areas. Infrastructure is also being rebuilt. Similarly, the RIS requires implementation of some urgent wartime recovery measures to maximize its potential to overcome current and future challenges.

1.2. Challenges, tasks, and opportunities of post-war recovery

1.2.1. Post-war recovery plans

Since the beginning of the war, the government has been developing various versions of post-war recovery plans. In 2022, the National Council for the Reconstruction of Ukraine from the Consequences of War, in accordance with Presidential Decree No. 266/2022 of 21 April 2022, developed a draft Action Plan for the Post-War Reconstruction and Development of Ukraine, a list of proposals for priority reforms and strategic initiatives, draft regulations, the adoption and implementation of which is necessary for the effective work and recovery of Ukraine in the war and post-war periods [19]. As of autumn 2023, the Plan identified a list of 17 National Programmes to achieve key results and presented 850 projects [20].

However, the experts interviewed for this study noted that formulating a vision of economic development prospects is a "high-level futurism" (H. Mozolevych) and deemed

it unlikely to find specialists capable of doing so, given the many unpredictable factors.

As of October 2023, several documents can be considered as draft recovery plans prepared both in Ukraine and abroad:

- Fast Recovery plan [21], proposed by the Office of the President of Ukraine;
- RebuildUkraine [22], prepared by the European Commission;
- Relief, Recovery and Resilient Reconstruction: Supporting Ukraine's Immediate and Medium-Term Economic Needs, "an informal concept paper prepared by World Bank Group staff" [13];
- A Blueprint for the Reconstruction of Ukraine by the Centre for Economic Policy Research (CEPR) [23];
- Designing Ukraine's Recovery in the Spirit of the Marshall Plan by the German Marshall Fund of the United States (GMF) [24];
- Resilience, Recovery and Reconstruction Action Plan (2023-2026) for Ukraine by the Committee of Ministers of the Council of Europe [25], among others.

Ukraine's post-war reconstruction plans were presented at four international conferences[3], but none of them was approved by the government or finally endorsed by potential donors. While the Ukrainian versions of the plans focus on ensuring the economic viability of the state, the European versions focus on institutional capacity and the principles of sustainable development [13]. The vision of post-war recovery, as discussed at the London Conference in June 2023 [26], focuses on greening the economy and implementing sustainable approaches to socio-economic development.

As a result, the European Commission proposed to launch a new instrument to support Ukraine's recovery, reconstruction and modernisation: Ukraine Facility [27] in the amount of up to €50 billion in grants and loans. The Ukraine Facility should provide consistent and predictable support for Ukraine from 2024 to 2027, within the framework of the European integration agenda. This programme includes support for the resumption of Ukraine's reconstruction and modernisation; support for reforms on the path to EU accession; ensuring Ukraine's financial needs for the uninterrupted provision of public services (schools, hospitals, social benefits, etc.); mobilising investment in Ukraine's private sector for economic recovery and reconstruction; broad support for Ukrainian society and overcoming the social consequences of the war [28]. Consultations with the EU regarding joint work on the Reconstruction Plan for Ukraine are still ongoing.

Visions and plans for post-war recovery are also presented by representatives of the public sector, academia and business community. It is worth noting the analytical note "Green Post-War Recovery of Ukraine: Vision and Models" [29] (August 2022), the scientific report of the State Institution "Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine" "Recovery and Reconstruction of the Post-War Economy of Ukraine" [30] (July 2022), and the position paper of the Ukrainian National Platform of the Eastern Partnership Civil Society Forum "Post-War Recovery of Ukraine Should be Green" [31] (December 2022). The report "Study of post-war reconstruction initiatives" [32] provides a comprehensive list of both foreign and domestic initiatives on post-war reconstruction.

An analysis of publications [33-35] reveals that there is currently no consensus on

[3] Conference in Lugano, Switzerland (URC 2022) 4–5 July 2022; International Expert Conference on the Recovery, Reconstruction and Modernisation of Ukraine, Germany, 25 October 2022; Ukraine Recovery Conference, Rome, Italy, 26 April 2023; Conference in London, UK (URC 2023) 21–22 June 2023.

Ukraine's recovery, either domestically or globally. The publication 'Study of post-war recovery initiatives' highlights that, "as of June 2023, there is no single national recovery plan for Ukraine developed by the authorities that would have legal force and be used by other recovery actors as a strategic document [...]. Representatives of Ukrainian civil society have criticised both the process of preparing this plan and its effectiveness. The National Reconstruction Council, which was intended to be the main coordination platform for the participants of the reconstruction, is not fulfilling this function" [32]. The main criticism of the Recovery Plan of the National Recovery Council of Ukraine is the following: lack of a concept of recovery and a clear state strategy; low public involvement in the development of the plan, unsatisfactory level of transparency of the process; lack of a finalised version of the draft Recovery Plan that takes into account the comments and suggestions of the public; low awareness of all participants in the process, which creates overlap issues; lack of a well-grounded typology of areas for recovery and analysis of real needs and progress in recovery[4]; a shift towards simplification of subsoil use and an emphasis on the raw material economy.

As this study is being conducted, the next stage of planning for Ukraine's post-war recovery is underway. However, as of October 2023, there is little involvement of the scientific community in shaping the vision of what Ukraine's recovery should consist of and how it should be carried out. This is largely due to the government's unsystematic approach to developing plans and the lack of transparency in engaging experts and scientists in working groups.

The recovery plan should take into account Ukraine's commitments and be based on the chosen political course of European integration, but at the same time, recovery should be for each and every citizen of Ukraine. It is necessary to seek both consensus at the highest levels of government and understanding and acceptance by all segments of society of the importance and feasibility of all recovery processes. The importance of involving society in these processes at the planning stage is also emphasised in studies of post-conflict reconstruction [36].

Based on the analysis carried out in this project, it can be stated that the formation of a public consensus should take the following into account:

1. **The enormous scale of destruction of physical infrastructure caused by the war.** Decisions need to be made about what should be rebuilt and what should be created instead.
2. **Coordination of recovery and reconstruction processes with European integration processes.** It is important to take into account Ukraine's commitments to prepare for EU accession.
3. **Reorientation of economic policy towards reindustrialisation of the country.** The development of the Ukrainian economy over the last decade shows that the country has lost significant industrial potential, and Ukraine has been experiencing a steady process of deindustrialisation for several years in a row. In 2022, it had the lowest share of manufacturing in the GDP structure among its neighbours — 8%, compared to 20% in Slovakia, 18% in Poland and 22% in Turkey [37].
4. **Changing approaches to industrial development planning.** Ukraine's post-war recovery comes at a time when the world is rethinking the paradigms of both economic and social development in general, which should also be taken

[4] Following the publication of the Study of Post-War Reconstruction Initiatives [32], CMU Resolution No.831 of 18.07.2023 "On Approval of Procedures for the Restoration and Development of Regions and Territorial Communities" was adopted. This resolution defines the requirements for indicators used to classify territorial communities and micro-regions as recovery areas, defined as one of the functional types of territories. *https://www.kmu.gov.ua/npas/pro-zatverdzhennia-poriadkiv-z-pytan-vidnovlennia-ta-rozvytku-rehioniv-i-terytorialnykh-s731-180723*

into account when planning recovery. In particular, this is about the EU's double transition — the simultaneous digital and green transformation — and the transition to Industry 5.0, which puts people at the heart of technological progress.

5. **Restoring the state and strengthening its role in economic recovery.** The experience of countries that have undergone post-war recovery processes shows that stability and recovery require a strong and inclusive state that can quickly restore its capacity and budgetary potential and spend it effectively [38]. For Ukraine, for one thing, this means adhering to the principles of good governance.
6. **The main donors of reconstruction will be the European Union, the United States and other partner countries.** This is supported by documents signed at the highest level, formalised intergovernmental agreements, and official government documents. Japan and the United Kingdom are also participating in the reconstruction. Therefore, the internal political situation and interests of these countries may influence the implementation of Ukraine's recovery plans.
7. **"Build back better and greener[5]" is the main principle of Ukraine's reconstruction.** This makes research and innovation key to the reconstruction process.
8. **Sustainable Development Goals (SDGs) as benchmarks for the development of programme and forecast documents.** Their priority was enshrined in the Decree of the President of Ukraine (2019) [39]. The CMU Regulations (amendments of 2020) [40] stipulate that the need to achieve the SDGs is taken into account in the process of formulating and implementing Ukraine's state policy. Despite numerous challenges due to Russia's attack, Ukraine has shown commitment and interest in achieving critical SDG benchmarks[6].

The scale of the recovery challenges faced by Ukraine is impossible to handle without the active involvement of the scientific community; however, this requires appropriate institutional mechanisms.

1.2.2 Science in post-war recovery plans

Upon reviewing all post-war reconstruction plans prepared by the government, it is evident that science and innovation have not been given due attention in them. It is worth noting that a separate national programme for science has not been allocated. The Post-War Recovery Plan, which was developed in 2022 by the Education and Science Working Group of the National Council for the Recovery of Ukraine from the Consequences of the War and finalised by the Ministry of Education and Science of Ukraine [41], includes proposals for the development of the research and innovation sector:

- establishment of the Defence Technology Agency (analogue of DARPA, Defence Advanced Research Projects Agency, USA);
- gradual increase in budgetary funding for science, increasing the share of grant

[5] This is an approach to post-disaster recovery that reduces vulnerability to future disasters and builds community resilience to address physical, social, environmental (natural), and economic vulnerabilities and shocks, including consideration of green transition (URL: *https://www.gfdrr.org/sites/default/files/2017-09/Building%20Back%20Better%20Guidance%20Note_0.pdf*; *https://wedocs.unep.org/bitstream/handle/20.500.11822/41641/Perspective-Issue42.pdf?sequence=3&isAllowed=y*).

[6] On 25 November 2022, the Secretariat of the Cabinet of Ministers of Ukraine announced its intention to conduct and submit the Voluntary National Review in 2023. In June 2023, the United Nations Development Programme (UNDP) in Ukraine, in cooperation with the Ukrainian authorities, completed a series of strategic sessions to update the targets and indicators of the localised SDGs. In cooperation with the Secretariat of the Cabinet of Ministers of Ukraine, UNDP organised events dedicated to each of the 17 SDGs. The strategic sessions were attended by over 150 experts from 30 national-level ministries and government agencies.

support through the National Research Foundation of Ukraine;
- formulation and implementation of a comprehensive state strategy for the development of science and technology in synergy with the economy;
- ensuring the development of human resources;
- establishment of the scientific infrastructure;
- full integration of Ukraine into the European and global research area.

Another important proposal of the document is to change the status of a budgetary institution for scientific institutions in order to make it more relevant to the specifics of scientific activity and to ensure flexibility in raising and using extra-budgetary funds [41].

Since the science and education restoration plan should establish the basis for the long-term development of domestic science and innovation, it is important to address the structural and functional issues of the RIS in the plan. In particular, it is necessary to analyse systemic gaps in its operation, develop and implement policies to establish and strengthen links between the elements of the system, and provide for the adaptation of institutions and legislation to the best European and domestic experience in conducting research, organisational and administrative work within the RIS.

Science will play a key role in Ukraine's post-war recovery and development. This was stated by representatives of the EU Council and the European Commission, as well as by participants of the URC2022 conference (Lugano, Switzerland) [42] and participants in a discussion at the London School of Economics and Political Science (LSE), which took place as part of the preparation and holding of the URC 2023 conference in London [43], according to the ERAC report [44].

1.2.3 Post-war recovery challenges

Whatever plan emerges from the discussions and government decisions that will form the basis of Ukraine's post-war recovery, it should address the following complex challenges:

1. Security challenges and defence capability. Ensuring the state's defence capability will require expanding the defence sector, deepening cooperation with foreign partners in the military sphere, preparing for NATO membership and cooperation with allies, demining, designing and building bomb shelters, and taking other measures to protect the population. Additionally, strategic decisions must be made to deter potential Russian aggression in the future.

According to the RAND think tank, post-war reconstruction cannot be successful without security guarantees [45]. The organisation also expressed concern that if the sources of funds for reconstruction were to dry up before the frontline areas could be rebuilt, it could deepen regional disparities and affect national unity [46].

2. Migration and labour resources. As of September 2023, the number of Ukrainian migrants abroad was about 6.2 million, and the number of internally displaced persons was 5.1 million [47]. According to various surveys, only 41-67% of those who left intend to return, of which about 35% will return only after the end of the war [48; 49], and according to some expert estimates, only a third will return [50]. A considerable proportion of migrants are women aged 25-49 (29%), of whom almost 70% of women aged 35-49 (20%) have higher education and lived in urban areas before leaving [49]. The decline in the birth rate (by

about 28% in 2022 compared to 2021 [51]) and forced migration pose a threat to the country's demography, economy, defence capability, and cultural, educational, scientific, and other spheres. Facilitating the return of migrants will require solving complex problems—from the availability of jobs to the restoration of housing and social infrastructure, quality healthcare and education, reintegration of territories and guarantees of life safety.

On the other hand, there is a risk that a substantial number of scientists who were unable to leave earlier due to legal restrictions (both to continue their careers abroad and to reunite with their families) will leave after the war. A comprehensive approach to migration, social, science and innovation policies is needed to prevent brain drain.

3. Environmental consequences of the war and the state of natural resources. The war has caused irreparable environmental damage to the ecosystem of Ukraine. The country's nature reserve fund and forests have been partially destroyed (direct losses are estimated at over USD 4 billion [52]); the content of toxic substances in water bodies and soil has increased as a result of flooding of mines, shelling of chemical plants, accumulation of military scrap metal, use of illegal weapons against the population; agricultural and forest lands have been mined. Russia's detonation of the Kakhovka hydroelectric power plant dam caused, among other things, a catastrophic impact on the environmental situation in the regions of southern Ukraine. It not only raised the question of compensation for the damage to people, the natural ecosystem, industry and agriculture; there is also a broad discussion among scientists and experts about the feasibility of restoring the plant. Scientists are already looking at ways of repairing the environmental damage.

4. The need for rapid infrastructure reconstruction. As of June 2023, the amount of direct damage to Ukraine's infrastructure caused by the full-scale invasion of Russia was estimated at $150.5 billion, of which $55.9 billion was the loss of housing stock [53]. The restoration of socio-economic infrastructure will be one of the key factors in solving the problem of migrant return, reviving business activity in the affected areas and integrating them into interregional and international socio-economic ties. The speed of recovery will be crucial, depending on the financial, human, and capital resources available, as well as access to modern green energy and construction technologies.

5. Restoration of public health, integration of veterans and inclusion. War has a significant and negative impact on the health of citizens [54; 55]. It not only poses an immediate danger of injury to humans but also induces the spread of infectious diseases, aggravation of chronic diseases, stress, and causes long-term mental disorders and PTSD [56]. The negative impact of war affects not only adults but also children, and its consequences will be felt by several generations in the future [54]. This increases the role of medical professionals, as well as the role of psychology, psychotherapy, neurology, and psychiatry. The burden on the healthcare sector after the war will also be high, with an increased need for rehabilitation and reintegration services for veterans. Global experience shows that wars lead to significant increases in public health expenditures, but few political leaders pay sufficient attention to addressing health and humanitarian issues. In addition, health professionals are rarely involved in the development or implementation of these policies [55].

6. Strengthening the financial and economic system. Economic recovery and further development are impossible without investment resources. According to an IMF report published in July 2023 [57], investment inflows in the baseline scenario start in 2025, but reach a significant level for economic growth in 2028, when they account for 5.6% of GDP. By the end of 2033, the net inflow of foreign direct investment will not exceed USD 12.4 billion. For comparison, in Poland

this figure was USD 27.8 billion in 2022 [58]. According to the World Bank's forecast [59], economic growth rate in Ukraine will increase from 3.5% (2023) to 6.5% (2025). However, this pace will only partially compensate for the decline in GDP in 2022. To return to the level of 2021, the Ukrainian economy must grow by 6.5% for at least four consecutive years. At the same time, Ukraine's economy will depend on assistance from external partners in the first years of recovery. The EU, the US, the IMF, the International Bank for Reconstruction and Development (IBRD), and Canada continue to provide, and have increased, macro-financial assistance to Ukraine during wartime; however, these are mostly loans that increase the state's debt and must be repaid in the future while maintaining the financial stability of the economic system.

A difficult legal task is to obtain reparations from Russia, for which agreements will have to be reached, especially regarding seized and confiscated Russian assets abroad, and legal mechanisms have to be created for their recovery and transfer to Ukraine. Russian aggression has already cost the economy an estimated $11.4 billion; more than 400 large and medium-sized businesses and state-owned enterprises have been damaged or destroyed, and the number is growing as the shelling continues [60].

Western partners believe that addressing institutional and structural constraints related to the rule of law, labour supply and competition, and minimising corruption will be crucial to fostering a sustainable recovery, as will reform efforts to accelerate Ukraine's accession to the EU. Finally, it will be important to use the incoming aid as efficiently and transparently as possible, as this will send a signal to foreign partners and investors that the prospects for investment in the Ukrainian economy are improving.

7. Reconstruction and transformation of regional economic systems. The uneven socio-economic development of the regions has been inherent in Ukraine throughout the years of independence. This is due to differences in their resource potential and the specifics of the location of production facilities. The war proved that the proximity of strategically important sectors of the economy to the border poses significant risks of destruction and damage to businesses and infrastructure, and disruption of economic ties and value chains. This necessitates a review of the concept of the spatial organisation of the economy in Ukraine in the post-war period to mitigate future risks. Local communities have already acquired an important role in regional development, as their leadership is the most trusted out of all public authorities, and their role in post-war recovery will continue to grow. It is likely that local communities will be the biggest beneficiaries of international assistance. The strategy of smart specialisation[7] of regions will need to be reviewed and rethought, considering the consequences for communities caused by the war (see paragraphs 2.1 and 2.2.3 for more details).

8. Capacity at all levels of government and trust in the State. The insufficient competency of central and local executive authorities in implementing the expected changes has led to an extremely low level of public trust. In 2023, Ukraine is among the twenty countries with the lowest trust in government and ranks 97th out of 107 countries [61]. A high level of trust in government is recognised as an essential condition for the effectiveness of reforms and public policies [62]. It is therefore important for policymakers to quickly acquire new competencies in the context of war, which is also important for post-war recovery. The authorities should be strengthened by advisory bodies consisting of experts, academics, and civil society representatives. Positive

[7] Smart Specialisation is a place-based approach characterised by the identification of strategic areas for intervention based both on the analysis of the strengths and potential of the economy and on an Entrepreneurial Discovery Process (EDP) with wide stakeholder involvement. It is outward-looking and embraces a broad view of innovation including but certainly not limited to technology-driven approaches, supported by effective monitoring mechanisms. (European Commission. What is Smart Specialisation? Retrieved from: *https://s3platform.jrc.ec.europa.eu/what-we-do*)

transformations in society and the economy and the achievement of Ukraine's geopolitical goals, including EU accession, also require the prevention of corruption, especially in the areas where it is most prevalent—customs, construction and land relations, services for the connection and maintenance of electricity, gas, water supply and sewage systems, law enforcement, control and supervision of business activities, the judiciary and tax authorities [63].

9. Promoting innovation and transition of production to a new technological basis. The global challenges that have led to the emergence of the SDGs require the development and implementation of new conceptual approaches, as well as management and technological solutions in the economy. De-industrialisation and technological lagging have accompanied Ukraine's economic development since it gained independence. During this period, the share of industry in GDP decreased by 2.8 times, falling to 19.2% in 2022 [64]. High-tech exports fell to 4.5% in 2021, while the global level is more than 20% [65]. During the war, capital investment fell by 48.1% in 2022 [66]. In other words, along with the significant destruction of industrial infrastructure, there was a loss of financial potential for its restoration.

The deterioration also occurred in the innovation activity of the real sector, where the number of types of innovative products introduced and the share of innovative products sold have significantly decreased since 2020 [67]. The reason for the technological decline is the weak production and management capabilities, as well as the constant deterioration of the research and development system in Ukraine [43]. It will not be possible to overcome these challenges without the restoration and development of advanced science and technology in Ukraine.

10. Reintegration of the occupied territories. Finding effective approaches and means to address the humanitarian, socio-economic, environmental, and other problems of the de-occupied territories, the social integration of their populations and the integration of their economies into the national economy will be a major challenge. The Ministry of Reintegration of the Temporarily Occupied Territories is developing an action plan [68] to address the full range of problems in the territories that have been under occupation for a long time (Donetsk and Luhansk regions and the Autonomous Republic of Crimea). However, according to some estimates, full reintegration may take up to 25 years [69].

11. The need to Build Back Better. Tackling the challenges of the past requires not only the levelling of consequences and reconstruction of what was destroyed, but also the radical reconstruction of the socio-economic system, innovative development, and modernisation of production, as well as development of science and culture. And this will require not only enormous amounts of resources, but also the political will of the government and the concentration of society's efforts. The implementation of this ideology will require the formation of a global, holistic, and progressive vision of the planned transformations — energy transition, greening the economy, digitalisation, and more. Experts acknowledge that the proposals for the Post-War Recovery Plan available as of 2023 "appear to be more of a 'shopping list' and contain several incorrect decisions" [32], suggesting their inadequate justification.

12. Ensuring respect for national interests and coordinated management of investment funds and international assistance. A major global financial effort will be required to rebuild Ukraine once the war is over. The EU and other countries are already contributing substantially to boost the country's ongoing resilience, but more support will be needed in the medium to long-term for economic and social stabilisation, reconstruction, and recovery from the war's consequences [70]. Foreign countries' experiences point to cases when governments lose control over the

distribution of financial resources entering the country, and are unable to direct them towards areas that form the backbone of the national economy or meet the strategic vision of the country's development, particularly the manufacturing industry. Ukraine needs to tackle this challenge by defending its interests and developing the internal potential of the economy to gradually reduce its dependence on external support.

1.2.4 Post-war recovery tasks

An assessment of the post-war recovery plans that have been, and are still being, drawn up in Ukraine for government approval results in a substantial expansion of the tasks for reconstruction. In the first version of the plan presented in Lugano (2022), these tasks were only to ensure macro-financial stability, regional modernisation, defence and security [71]. The range of tasks presented at the London conference [72], united by a solid vision of the future model of the Ukrainian economy, has become broader. It contains the following:

- building a strong economy and reducing the role of the state in the economy;
- increasing the country's investment attractiveness;
- green industrial transition;
- development of the food production sector;
- extraction and advanced processing of critical minerals;
- reorientation of transport flows to the trans-European network and integration with EU networks;
- implementation of state policy favourable to economic development;
- ensuring investments in the development of energy equipment, transport and machinery, chemicals and oil refining, construction, metallurgy and critical materials, energy resources and wood processing.

The implementation of these post-war development tasks requires a more in-depth assessment, calculations, qualitative expertise and selection of the most effective tools. Ukrainian science is an important stakeholder in this process — it has some of the developments needed to solve these problems, or is able to create them in a short period of time.

1.3. The role of science

The challenges and tasks of post-war reconstruction for science cover a wide range of issues that require both practical solutions and scientific expertise. Without science, none of the proposed models of post-war reconstruction or those that will be proposed in the future can be fully implemented. Moreover, it is scientists who can provide a systematic approach and a comprehensive vision of post-war recovery, which, as of October 2023, is being formulated by government agencies and working groups. Ukrainian scholars are ready to engage in post-war reconstruction — in 2022, almost three-quarters of respondents said they were ready to do so on a volunteer basis [73].

ERAC's report on the role of research and innovation in Ukraine's recovery [44] contains important provisions on the inclusion of science in the recovery process in Ukraine, in particular:

- human capital, scientific knowledge and data, as well as technology will accelerate Ukraine's recovery towards a modern economy underlined by the green and digital transition.
- R&I priorities and concrete actions should be well-reflected in Ukraine's National Plan for Reconstruction and Development and the work of the Multi-Agency Donor Coordination Platform;
- a share of the planned multi-billion technical and financial assistance for Ukraine's recovery should be allocated to address the R&I needs and priorities.

Specific cases of EU Member States (Finland) and EU global partners (South Korea, Japan) show that massive investments in education and research & innovation are a key trigger for rapid and sustained economic growth.

As for the post-war reconstruction and the tasks of science, during the surveys for this project, several experts noted that it will only be possible to formulate specific tasks for science when the state develops a coherent strategy for post-war recovery. The range of tasks faced by science in post-war recovery, according to experts, includes the following:

- development of materials and technologies for physical infrastructure;
- solving the problem of Kakhovka HPP;
- green energy, reducing environmental impact, ensuring compliance with the requirements of the European Green Deal;
- innovative defence technologies (knowledge-intensive, high-tech weapons, robotic modules, data collection and analysis systems, and more);
- biomedicine;
- information technologies;
- energy security;
- cybersecurity;
- construction, transport, logistics;
- demining and restoration of access to land.

Scientists have already made several developments in these and other areas that could be used to solve key tasks both during the war and in the post-war period (see sidebar).

In addition to sectoral tasks, where science should undoubtedly play a key role, there are other more global issues that require scientific expertise:

- evidence-based policymaking;
- developing an ambitious model and strategy for post-war recovery for the country as a whole and for individual sectors of the economy;
- participation in the development of recovery plans, as well as the methodology for organising the planning process;
- development of methods to assess damage from war and related disasters;
- scientific support of projects in environmental protection, climate change, hydrology, agronomy, mechanical engineering, robotics, and more;
- scientific expertise and consultations to address pressing social issues (actions to be taken regarding the territories affected by the hostilities, reintegration of deoccupied territories, legal status of migrants, and more);
- identifying and creating opportunities for domestic processing of raw materials that were previously mainly exported (agricultural products, metal ores and concentrates);
- improving legislation and aligning it with EU legislation;
- assistance in fulfilling the obligations under the EU Association Agreement and facilitating the achievement of key performance indicators for EU membership;
- ensuring adherence to the principles of sustainable development, including the environmental and climate component, in all recovery plans and government initiatives in line with the European Green Deal.

Needless to say, besides scientists, a wide network of practitioners, society organisations, business associations, trade unions, and foreign experts should be engaged in the implementation of the global tasks mentioned above. After all, the degree of "science intensity" of the recovery tasks varies. And the need to resolve them

promptly will force the government and society to choose whether to buy or copy and implement ready-made foreign solutions, technologies, and innovative products, or rather rely on domestic science, existing off-the-shelf developments, or developments that can be quickly upgraded to a finished product.

It should be emphasised that in order for Ukrainian science to contribute to solving the above tasks, the RIS must become fully operational — only close cooperation between post-war recovery stakeholders and science will turn it into an effective tool for addressing numerous challenges

EXAMPLES OF RELEVANT DEVELOPMENTS BY UKRAINIAN SCIENTISTS FOR POST-WAR RECOVERY

New hemostatic agent

Rostyslav Bilyi, a professor at Lviv Medical University, and his team have developed a new hemostatic agent consisting of microgranules that form a viscous gel upon contact with blood, stopping the bleeding. The product is a Ukrainian analogue of Celox, a British hemostatic (blood-stopping) granules that volunteers brought in from abroad massively at the beginning of the war in 2014. The product developed by the Lviv team provides for blood clotting three times faster than Celox and is almost three times cheaper. This product can be used in both military and civilian medicine [74].

Soil restoration

Scientists at the M.M. Gryshko National Botanical Garden of NASU have developed an innovative technology to restore the structure of soils that have been mechanically damaged and contaminated by oil refining products, organic components of explosives and other pollutants. During the first stage, the soil's potential fertility is evaluated based on the quantity of melanin-containing micromycetes, laccase activity, and the content of labile and stable humus forms. During the second stage, an information resource matrix is formed by introducing silicon-containing mixtures that optimise the agrophysical, agrochemical, and biological characteristics of the soil. Finally, during the third stage, phytoremediation is carried out using plants that have a barrier-free effect of pollutant accumulation (representatives of genera Sinapis, Crambe, Miscanthus and others) [75].

Bionic prosthetic arm from Esper Bionics

Esper Bionics develops prosthetics for people with amputations. They have specifically designed the Esper Hand, which is the first cloud-based AI robotic prosthesis. The prosthesis has 24 sensors that detect and process brain impulses and muscle activity to activate certain movements of the hand module. The invention was ranked among the best inventions of 2022 by the American magazine Time [76].

Roboneers

National Defence Tech Cluster Brave1 has brought together the best national innovation initiatives to develop military and dual-use products. Ukrainian company Roboneers [77] has developed a unique remote weapon system (RWS), the Sabre, a silent 4WD bulletproof vehicle ready to repel enemy attacks at any time of day or night. A module equipped with cameras and sensors is mounted on top of the vehicle, capable of detecting enemy vehicles at a distance of over 5 km and individual soldiers at 1.5 km. The vehicle is controlled by remote operators via encrypted NATO-standard communication channels. Drones work alongside the Sabre to provide a complete picture of the landscape and detect any threats in real time. The Sabre is armed with interchangeable modules: from M240 (7.62) to a 50 calibre Browning machine gun, with an accuracy of 0.2 MOA (5 cm per 1 km). Roboneers has supplied over 150 RWS to the Armed Forces of Ukraine at the request of the Ministry of Digital Transformation of Ukraine, using the company's working capital, donations, and charitable foundation funds [78].

1.4. New opportunities for science

The international community has been providing extraordinary support to Ukraine during the war, especially in the military sphere, and to maintain macroeconomic and social stability. If the war ends within the next one to two years, one could hope that Ukraine's recovery in the post-war period will also be supported. Foreign investment should also be expected to flow in, primarily in sectors that provide a quick ROI (metallurgy, agriculture, engineering, etc.), including knowledge-intensive sectors.

The ERAC 2023 report says that "Ukraine's R&I needs imply physical reconstruction, effective policy reforms, institutional capacity-building to implement these reforms and the availability of financial resources to reignite R&I activities in the country and reverse the brain drain" [44, page 4]. This means that, although the research, education and innovation sectors that are in crisis are likely to receive external support, such external assistance will be ineffective without an internal shift in priorities and policies (as shown by the examples of Iraq and Afghanistan mentioned in Section 1).

After the war, the following opportunities for science will arise in Ukraine:

- the need to ensure the processes of social and technological evolution, as well as the "double transition", both digital and green, based on the quadruple helix principle;
- development of technologies and innovations: opportunities for technological leapfrogging in many sectors;
- a vast multi-area research field (including social and psychological sciences, economics, health and medicine, and more), which will create the need in domestic researchers and open up opportunities to receive international funding and set up cooperation with foreign scientists;
- availability of a testing ground to establish and test innovations in the defence sector, as well as in areas critical in wartime—medicine, light industry, mechanical engineering, ecology, and others;
- a place for talent development, if innovative ecosystems, a flexible scientific environment, access to multi-channel financing, professional and competent personnel, and research infrastructure are created for this purpose;
- the need to restore or create physical infrastructure (civil, research) from scratch on a new technological basis.

Significant support from European and other partners during the full-scale war helped to preserve the existing potential of domestic science to some extent and take important steps to develop it. However, to fully realise the potential of science in post-war recovery, a favourable "scientific climate" within the country must complement the opportunities created by donors.

SECTION 2. INSTITUTIONAL CONDITIONS FOR THE FUNCTIONING OF RESEARCH AND INNOVATION SYSTEM IN UKRAINE

2.1. Problematic issues of institutional development of RIS

The institutional environment for the development of the RIS during the period of independence failed to foster sustainable productive relations between stakeholders and the sustainable development of effective and capable institutions. This has specifically led to a catastrophic devaluation of science in the eyes of society and the government, as confirmed by most of the experts interviewed.

Elements of the innovation ecosystem have long been developing separately from the scientific system due to imperfect strategic planning of scientific development and chronic underfunding [79]. Since 2018, Ukraine's innovation development has been declining. In 2022, Ukraine dropped from 49th to 57th place in the Global Innovation Index [80]. The adoption in 2019 of the Strategy for the Development of the Innovation Sector for the Period up to 2030, which set new priorities for innovation development, and the approval of the action plan for 2021-2023 for its implementation [81] in late 2021 failed to have a significant effect in the field of innovation. The reasons for this include a lack of resources for implementation, a lack of horizontal coordination between authorities and stakeholders, the Covid-19 pandemic, and a full-scale war. Additionally, the war virtually completely froze the rapid growth of the startup ecosystem.

At the highest level of scientific management (NASU and MESU), a strategic vision for the post-war restoration of science is only just beginning to emerge. The main document that defines the strategic European integration movement of the scientific system is the Roadmap for the Integration of RIS of

Ukraine into the European Research Area, last updated in 2021 [1]. At the same time, the implementation of the tasks presented in the document is not enough to revive science and transform the country's RIS. MESU commenced work on the National Strategy of Education and Science of Ukraine only in 2023, presenting a vision of the future of education and science in summer [82]; however, as of the conclusion of this study, the draft strategy has not yet been presented to the public.

Government institutions, local communities, and most sectors of the real economy as potential consumers of knowledge-intensive innovations have poor communication with the scientific sphere due to the lack of information about R&D in the system of MESU and NASU, sectoral academies of science, the underdeveloped innovation culture, and the lack of dedicated state support for knowledge-intensive industries [83]. Consequently, Ukrainian scientists often implement their innovative ideas and developments [84] abroad rather than in Ukraine (for example, deep-tech start-ups with the participation of Ukrainian scientists, such as SmartNanotubes [85], Firefly Aerospace [86], Sila [87] and others [88]).

Experts have noted the low levels of commercialisation of innovations, technology transfer and intellectual property protection (the level of patent protection in Ukraine is 6 points out of 10 [89]). Legislative restrictions on technology transfer instruments, including spin-offs, and distorted mechanisms for stimulating the creation of intellectual property have also been identified [90; 91]. Regarding institutional arrangements, there is a deficiency and inefficiency in certain elements of the innovation ecosystem, such as technology and science parks [92], technological [93] and communication platforms. In the context of post-war recovery concepts [29] that can be implemented in Ukraine, the role of science and knowledge-intensive innovations has not yet been clearly defined [9].

At the regional level, innovation policy in Ukraine was to be implemented mainly through smart specialisation strategies that form part of the development strategies for the country's regions and the city of Kyiv for 2021-2027. Smart specialisation is an approach to strategic planning for regional development that ensures economic growth by unleashing innovative potential, leveraging unique existing assets, and maximising the competitive advantages of the region. The implementation of these strategies has been suspended in many regions due to lack of funding, and their relevance has sometimes been lost, especially in regions that have experienced (or are experiencing) occupation or have suffered significant damage. However, in August 2023, a CMU resolution [94] introduced a new procedure for the development of regional strategies, where smart specialisation remained a mandatory component.

The war had a significant impact on the material and technical base of scientific activity. As of 2022, it is estimated that over 35% of the research infrastructure was destroyed [44]. Therefore, restoring and facilitating access to it is a priority [95].

The performance indicators of science have also deteriorated considerably, including in the period before the full-scale invasion. Between 2010 and 2019, the share of R&D gross added value in Ukraine's GDP decreased from 0.69% to 0.55% [96; 97]. For comparison, in Germany, this figure was 2.49% in 2020 [98]. From 2010 to 2021, the productivity of scientific activity in NASU, measured by the number of new developments implemented in the national economy per 1000 researchers, decreased from 86 to 33 units. During the full-scale invasion in 2022, it further declined to 26.7 units [99].

The negative dynamics in science may be attributed to the inefficient model of funding scientific institutions and universities, which relies mainly on budgetary funds. Before the war, activities to raise extra-budgetary funds

(except for funds for paid higher education institution educational services) were irregular. Additionally, regardless of their origin, part of the funds is credited to the accounts of budgetary institutions, and therefore their use is subject to many restrictions [100].

Management problems at various levels in the scientific and educational systems are also worth noting. For instance, experts have noted a lack of awareness among the heads of HEIs and research institutions regarding the opportunities available in Ukraine for research and development and international cooperation. Many institutions have no strategic planning of their activities, which means that they do not systematically work on attracting younger staff and promoting generational change, do not consider alternative funding sources, and may not encourage or even prevent researchers from participating in academic mobility programmes. The quality of staff development is often overlooked, with only formal requirements being met. Additionally, there are no clear performance indicators to assess the quality of science management. As a result, international cooperation does not grow, and there are few scientists who speak foreign languages and are able to manage international projects (act as principal investigators). These and other management problems in science are highlighted in various national publications [101-103].

Identifying opportunities for immediate and long-term improvements requires a more detailed analysis of these problems, which is presented below, as well as finding ways to address them in the context of the current post-war challenges.

2.2 Critical challenges of RIS hindering the unleashing of its full potential for post-war recovery

2.2.1. State capacity to develop evidence-based policies with the involvement of scientific expertise

As defined by the European Commission, "evidence-based policymaking" is an approach that is based on conducting policy discussions and making decisions on the best available evidence. Evidence refers to "multiple sources of data, information, and knowledge, including quantitative data such as statistics and measurements, qualitative data such as opinions, stakeholder input, conclusions of evaluations, as well as scientific and expert advice" [104].

The National Council of Ukraine for the Development of Science and Technology is a permanent advisory body at the level of the Cabinet of Ministers. Its purpose is to facilitate effective interaction between representatives of the scientific community, executive authorities, and the real economy in the formation and implementation of a unified state policy in the field of scientific and technical activities. According to the law, the meetings of the committee are held as required, but at least four times annually. In practice, the committee convenes on average less than once a year. The Scientific Committee comprises 24 scientists who represent the scientific community, are scientific leaders, have outstanding scientific achievements, impeccable scientific reputation and trust in the scientific community, and are not heads of universities, research organisations or HEIs. One of the functions of the Scientific Committee is to review the regulatory acts of the CMU and CEBs for compliance with the interests and principles of state policy on scientific and technical activities, and to provide relevant recommendations. In particular, draft acts related to the field of scientific and technical activities are submitted to it on a mandatory basis. At the same time,

since the Scientific Committee does not have a full-fledged analytical unit, its ability to process acts of the CMU and CEBs is limited. Additionally, the lack of involvement of scientists during the development stage of acts significantly reduces the possibility of improving the relevant drafts as recommendations provided at the last stages of approvals are least likely to be considered.

The CMU Regulations [40] limit the involvement of scientists to consideration of issues related to scientific and technical activities. For example, a representative of the Scientific Committee of the National Council of Ukraine for the Development of Science and Technology may be invited to a meeting of a government committee. Clause 7 of §33 of the Regulations allows for the involvement of MPs of Ukraine, scientists, other experts, and representatives of citizens' associations in the development of a draft act of the Cabinet of Ministers of Ukraine, provided they give their consent.

The Secretariat of the Cabinet of Ministers of Ukraine is responsible for providing expert and analytical support for digital, legal, anti-corruption, and European integration matters. The relevant government agencies carry out the expertise directly. Thus, the preparation of expert and analytical materials on the state of affairs in a particular area is carried out by CEBs under the coordination of the CMU Secretariat. The only reference to science in the Regulation on the CMU Secretariat is §27, clause 17, which indicates that the structural units of the Secretariat "prepare proposals for commissioning research and development work in accordance with their competence". The professional expertise is carried out by the Secretariat itself and the CEBs.

Therefore, scientists and the public are often not considered as mandatory participants in the preparation of policy and strategic documents, as well as other draft legal acts.

At the level of CEBs, there is a practice of establishing expert councils that work under ministries and agencies. These councils have the power to make proposals for legal acts and conduct expert and analytical evaluations. However, there are several issues with their work. In particular, the procedure for selecting and approving members of expert councils lacks transparency. For example, according to the Order of the Ministry of Finance [105], the expert council was approved to consist of 35 members, including representatives of state and non-governmental institutions and organisations, businesses and associations of enterprises, as well as one scientist and two representatives of a relevant HEI with academic degrees. Since 2017, the composition of the Council has only been revised once, in 2022. Notably, the Regulation on the Expert Council approved by this order does not specify either the term of office or the procedure for electing its members.

However, there are exceptions. The share of scientists in the scientific and expert councils of sectoral ministries and agencies (including environmental and agricultural) is high [106].
The VRU Rules of Procedure, as well as the Law of Ukraine On Committees of the VRU and Regulations on the VRU Staff contain provisions on the involvement of the scientific and expert community in the process of legislative drafting (see Annex B). For instance, Article 103 of the Law of Ukraine On Committees of the Verkhovna Rada of Ukraine [107] contains provisions on the need to obtain expert opinions from NASU, despite the fact that scientific expertise can be carried out by five other national sectoral academies of sciences, as well as by HEIs and other research institutions.

Mandatory comprehensive scientific and legal expertise of draft laws is carried out only by the Main Scientific and Expert Department of the VRU Staff. Until 2022, the VRU had the Institute of Legislation of the Verkhovna Rada of Ukraine, which provided scientific and legal support. However, following the recommendations of the European Parliament Mission, this legal entity was renamed the Research Service of the Verkhovna Rada of Ukraine. Its functional purpose has now been changed to provide research, information, and analytical support to the activities of the Verkhovna Rada of Ukraine, its bodies, MPs,

parliamentary factions in the VRU, as well as professional training (advanced training) of MPs of Ukraine, employees of the VRU Staff and assistant consultants of MPs of Ukraine [108]. The Research Service conducts scientific research and develops scientific concepts for the development and legislative regulation of public relations, prepares analytical reports based on their results and information briefs upon request of officials or specialised VRU committees. In general, the activities of both institutions should contribute to better provision of scientific and expert support to the lawmaking process. However, restricting the expert examination to them alone makes it impossible to consider the views and use the expertise of a wider range of scholars, including those from NASU and HEIs.

Another structure is the National Institute for Strategic Studies (NISS) [109], providing scientific and analytical support to the President of Ukraine and the National Security and Defence Council (NSDC), and is an advisory body to the President of Ukraine. The Institute conducts scientific, analytical, and forecasting research on the development issues of Ukraine and its national security, prepares analytical materials, drafts policy documents and regulatory acts.

Certain ministries and departments also have research structures that are intended to support decision-making in these institutions with analytical materials. For example, the Central Research Institute of the Armed Forces of Ukraine [110], Kyiv Scientific Research Institute of Forensic Expertise of the Ministry of Justice of Ukraine [111], State Research Institute of the Ministry of Internal Affairs of Ukraine [112], Financial Policy Research Institute of the State Tax University [113], Ukrainian Institute of Scientific and Technical Expertise and Information [114], and others.

In Ukraine's scientific community, these and other universities and higher education institutions have developed a substantial body of knowledge and high-quality sectoral developments. These include concepts and models of social phenomena, proposals for legislative improvements, and innovative solutions in scientific and technical fields. Due to the limited involvement of scientists in government decision-making processes, these resources are not being utilized in the development of post-war recovery plans. In the absence of this scientific and analytical justification and in-depth scientific expertise, the quality of post-war recovery plans is questionable.

At the same time, Ukrainian legislation stipulates that basic and competitive funding of scientific institutions is also carried out for the purpose of "developing scientific principles of state policy" [115]. Accordingly, wider involvement of scientific expert examination in policymaking should be a priority for the authorities and donors, as it will significantly increase the efficiency of the use of funds. Moreover, scientific justification of policies is one of the recommendations outlined in the European Commission's Toolkit for Effective Regulation [116].

The Law of Ukraine On Lawmaking [117], which was adopted in 2023 and will be enforced one year after the termination or cancellation of martial law in Ukraine, partially considers and institutionalises the involvement of scientific expertise. It also obliges the Ministry of Education and Science of Ukraine to track scientific results presented in defended dissertations in the field of law (Article 22, paragraph 5). This means that scientific knowledge and developments in the field of law will be more accessible to the government, but developments in other fields of knowledge can only be recommended and used optionally. The law also introduced into law-making the concepts of "green paper" and "white paper" as analytical documents of public policy. This aligns with the recommendations of the European Parliament's Mission, developed in 2016 in the Report and Roadmap on Internal Reform and Institutional Capacity Building of the Verkhovna Rada of Ukraine [118].

At the same time, the Law contains a number of restrictions on the list of regulatory acts that are supposed to "strengthen interaction between participants in law-making activities in the process of drafting regulatory acts, as well as control over

their implementation, and ensure the participation of civil society in law-making activities". The possibility of actual implementation of the rules on engagement of scientific expertise specified in the legislation, which should be ensured procedurally (developed and clearly established mechanisms of interaction with the scientific community), financially and institutionally, is also questionable.

To strengthen the relationship between science and policymaking, in February 2021, Ukraine joined the UN Global Pilot Programme to support countries in developing roadmaps for achieving the Sustainable Development Goals through science, technology, and innovation [2; 119]. The recommendations and registers developed by the Ministry of Education and Science of Ukraine as part of implementation of the programme's tasks can be used for institutional development of the system of scientific and analytical support for decision-making.

The interviewed public sector experts point out that science in general has helpful developments for shaping public policies, and scientists are involved in developing strategies, but science is still not ready to work at the faster pace required by military events and recovery. Respondents also indicate that there is little demand for scientific services from the state. And although science, as noted by some experts, has something to offer in various areas of post-war reconstruction, there is a lack of systematic communication of available opportunities with the authorities and promotion of R&D results. Instead, European practices are moving towards strengthening the scientific component in the public decision-making system.

On the whole, despite the weak involvement of the scientific community in policymaking in Ukraine, during the war, ministries and agencies began to seek advice from experts from NASU, sectoral academies and HEIs to provide expert assessments of the extent of damage caused by the war, European integration matters, institutional reforms, and more. Accordingly, the national experience of scientists' participation in policymaking should be significantly expanded.

2.2.2. Readiness of RIS to perform post-war recovery tasks

It is impossible to fulfil the full range of post-war recovery tasks in a research and innovation system that is underfunded and weakened by employee drain and general instability. The internal motivation of scientists, reinforced by patriotic aspirations, is a powerful driver, and yet insufficient in the absence of appropriate conditions and resources.

An important aspect of ensuring the effectiveness of the RIS is to address the institutional problems of Ukrainian society in a broader context. For example, according to several experts, the problems of corruption and shadow economy are a demotivating factor that negates the importance of science and innovation for enhancing business competitiveness.

In the area of science governance, experts identified a key weakness, such as the lack of a long-term state strategy and consistent state policy that should ensure the integrity and systemic nature of the RIS, addressing a range of issues from personnel training and establishing a financial model to research infrastructure and academic integrity, and promote the growth of demand for innovation and science. Such a strategy, according to respondents, should include the following:

- openness of the national science, primarily to Europe. Most experts see Ukraine's European integration as a crucial factor for the necessary changes in the RIS;
- close integration of the research and innovation systems, which should develop inseparably and in a coordinated manner;
- prioritising the development of high technologies;

- strengthening the state–science–business triad and establishing public relations;
- focus on research teams as centres of research and innovation, which are flexible structures capable to adapt quickly and meet the challenges of post-war recovery;
- development of an effective model of multi-channel funding for science.

The ability of the RIS to overcome the challenges of post-war reconstruction depends not only on the science management system, but also on human capital and research infrastructure.

Human capital is the main driving force of science. It is a pool of scientists and support staff who generate ideas and hypotheses, test them experimentally, develop concepts and new theories, and solve applied problems in various sectors of the economy.

Before the war, between 2010 and 2020, Ukraine had already lost at least 57% of scientists with a PhD or doctorate (from 58.7 thousand to 25.0 thousand), and 61.5% (or 82.3 thousand) of the total number of researchers involved in R&D between 2010 and 2020 [120; 121]. In 2022, the total number of individuals involved in research and development was 54.2 thousand, with 35.7 thousand being researchers [122]. Over 6 thousand of these researchers left the country, with some being internally confined and lacking access to necessary infrastructure, while others joined the Armed Forces of Ukraine.

One significant challenge for post-war recovery could be the age structure of the scientific workforce. Only 50% of researchers are aged between 25 and 45, while scientific youth (aged 25–35) make up less than 15% [122]. The low level of material rewards, significant bureaucratization of the scientific sphere, and difficulties with technology transfer from state scientific institutions to business pose problems for effective human capital engagement. The focus group revealed that a strong Soviet tradition, differences in the structure of higher education and research administration, and limited knowledge of English have led to weak participation of Ukrainians in international research teams and academic mobility processes that are important for the development of scientific thought and technology. A significant limiting factor is the lack of soft skills among scientists, which hinders effective communication and professional networking. The respondents would like to develop skills, such as command of English language, research project management, digital skills, teamwork, self-presentation, and intercultural communication.

Anxiety, cognitive impairment, and difficulties in planning R&D due to loss of attention, motivation, and problems with access to workplaces also complicate the situation. Nevertheless, more than 50% of respondents expressed interest in participating in cross-sectoral meetings, training seminars and events to expand communication with business representatives and colleagues in their field. Even based on the results of the focus groups, it was possible to launch an initiative for informal communication between nuclear experts, initiated by the scientific secretary of the Ukrainian Nuclear Society.

Most scientists interviewed for this project are highly motivated to continue their research in Ukraine or to work on projects with Ukraine as the ultimate beneficiary.

The Ukrainian scientific diaspora, which currently includes thousands of scientists in leading universities and research institutions abroad, can be an important resource for restoring staff potential. Today, many of these scientists have modern methodological approaches, soft skills, are able to work with the most sophisticated equipment, and have successful experience in interacting with businesses, obtaining competitive funding, and managing research projects. Most importantly, many of them have retained close ties (scientific and family) to Ukraine and are highly motivated to help Ukrainian science. Therefore, the engagement of scientists from the "scientific diaspora" in post-war recovery is an opportunity to overcome many challenges at once, including the multidisciplinary nature of the tasks, establishing interaction with various

customers (government, business, society), organising productive teamwork of research teams, establishing international cooperation, and many others.

However, the experience of many countries shows that effective engagement of the scientific diaspora requires significant effort. This includes establishing institutions for interaction, networks for exchanging experiences and cooperation, as well as return programmes and incentive systems.

The creation of a favourable climate for science and the stimulation of research and innovation activities among scientists within the country as a whole will undoubtedly be a determining factor for both the scientists in Ukraine and the scientific diaspora or foreign scientists.

Research infrastructure (RI) is another important component of the RIS, enabling scientists to solve research problems and develop innovative products. Unfortunately, the lack of sufficient funding for science over the years of Ukraine's independence has had an extremely negative impact on its research infrastructure, much of which has remained outdated since Soviet times. As a result, none of Ukraine's research infrastructures are currently included on the European map due to non-compliance with the criteria used to define research infrastructures, such as the set of equipment, facilities, number of users, and access conditions to certain laboratories/centres [123].

After the occupation of Crimea and parts of Donetsk and Luhansk regions (2014–2015), Ukraine lost, along with the territories, much of the valuable RI that remained there. And after the outbreak of a full-scale war with Russia in 2022, the situation deteriorated considerably. As of June 2023, over 120 research institutions had been damaged, and the damage is estimated at UAH 500 million [17]. Meanwhile, at the time of this writing, the war is ongoing, leading to new destruction and significant restrictions on research.

Participation in European research infrastructure sharing programmes could improve the situation with Ukrainian scientists' access to modern RI. However, until 2022, Ukraine's participation was limited to only a handful of individual projects [1]: the European Organisation for Nuclear Research (CERN), the large-scale infrastructure project European Social Survey (ESS), the EuroFusion consortium, research infrastructures under construction (DANUBIUS-RI, EISCAT_3D and CTA acting as partners performing individual tasks but not beneficiaries of large projects); in 6 projects of the Horizon 2020 programme in the area of Research Infrastructures.

The current situation requires a thorough analysis of available resources, development of a strategy for RI development, with the identification of priority areas and opportunities to use the research infrastructures of partner countries.

The issues of human capital development in science and research infrastructure are discussed in more detail in the following white papers: *Ukrainian Scientists in Post-war Recovery, Scientific Diaspora — a Unique Asset for Post-war Recovery of Ukraine, and Research Infrastructure in the Post-War Recovery: From Rescue to Growth.*

2.2.3. Quality of communication between science and stakeholders to address post-war recovery challenges

Science and the other quadruple helix actors—government, business, and civil society — are often viewed as isolated from each other. This is due to the rather weak interaction between science and the components of the "helix", differences in communication skills, and insufficient popularisation of science.

A survey of experts showed that both the state and businesses have little knowledge of what science does. Inadequate education about science also occurs at the lower levels of personnel training — at schools. Among the few opportunities for the younger generation to get familiar with scientific activities is the Junior Academy of Sciences of Ukraine and its initiatives (such as the Futurum training centre for the youngest generation) [124].

According to experts, the current legislation governing the functioning of state research and educational institutions and R&D is not favourable for launching a knowledge-intensive business.

Most researchers lack the entrepreneurial skills required to transform their research into a product, and there is a shortage of additional professional staff. Some of the known positive examples are attributed to the leadership of research institutions and HEIs.

During interviews, experts indicated that scientists are not sufficiently aware of how to communicate their needs and achievements, and that the lack of facilitation of such cooperation and understanding of the realities of the knowledge-intensive products market often prevents them from establishing a dialogue with other actors. The language of scientists is difficult for business, government, and society. Society has little understanding of the nature and structure of science, the difference between basic and applied sciences. These problems are typical for EU countries as well [125]. The challenge is to spread a positive image of science through the media, politicians, artists and actors, and business.

According to experts, it is possible to establish a system of communication between the scientific and other spheres of activity by developing a networking infrastructure and creating an open space of science for business, government and society (see sidebar), ensuring that government and business are open to communication with science through cooperation, a system of public or private commissioning, establishing joint research units and laboratories with business, and expanding acceleration programmes for large businesses for knowledge-intensive start-ups. The interviewees also expressed the opinion that the process of establishing cooperation between business and science is evolutionary, and that it should eventually become mainstream in Ukraine. For more details about science communication, please see papers ***Advocating Science at Risk and Science Popularization During Wars and Crises: Challenges and Opportunities.***

NETWORKING BETWEEN SCIENCE AND BUSINESS IN EDMONTON: EDMONTON TECH WEDNESDAYS

A space for the free exchange of ideas, opinions and networking called “Edmonton Tech Wednesdays” has been set up in Edmonton, Canada. Its organisers describe the event as “open to anyone who loves tech, whether you work in the industry or just have a passion for it. There’s no set agenda, so you can mingle and connect with others in the tech sector in a casual and relaxed environment. Whether you’re a developer, marketer, entrepreneur, or just interested in tech, this is the perfect opportunity to meet like-minded individuals, exchange ideas, and build relationships” [126]. The event promotes the creation of an interdisciplinary environment, a “community” that can generate new ideas that can be transformed into innovative products in the future.

For businesses, scientific institutions are not the primary source of information about new technologies and developments. According to a survey conducted by MESU [127] in 2020, business representatives ranked scientific institutions and HEIs only 9th. Instead, communication in the professional community, conferences, fairs or exhibitions, the media, and foreign suppliers of technology and equipment were identified as the main sources of information. The respondents also noted the lack of interest of research institutions and HEIs in technology transfer. Cooperation with domestic HEIs and research institutions was reported by 72.5% of respondents, of which 48.6% noted long-term cooperation. The cooperation involved 37 scientific institutions of NASU, 34 HEIs and 1 vocational school. The most popular areas of cooperation were chemical technology, technical areas, information technology and product sales.

Meanwhile, Ukraine is already implementing several initiatives to establish a link between business and science: The Open Innovation Platform [128], developed as part of a number of international projects by the Ukrainian Institute of Scientific and Technical Expertise and Information (UKRISTEI), acting as an aggregator of existing scientific developments; the Science2Business Platform [129] of the Ministry of Education and Science of Ukraine; and the Nazovni.Tech Platform [130] of the Ministry of Foreign Affairs of Ukraine.

The EU has developed the New European Innovation Agenda [131], which helps deep-tech developers implement projects and commercialise them by gaining access to funding, innovation ecosystem services, and opportunities for knowledge and skills development. As part of the agenda, the Regional Innovation Valley initiative [132] was launched to unite the interests of regional authorities, innovative businesses and their stakeholders along the entire added value chain, both regionally and internationally. Another EU initiative is the establishment of Excellence Hubs [133], aiming to strengthen regional innovation advantages by bringing together and creating strong links between academia, business, governments, and civil society. Since 2023, Ukraine has also had the opportunity to join these initiatives by creating its own or joining consortia.

The EU COST (The European Cooperation in Science and Technology) programme [134] promotes cooperation between researchers and innovators from different countries, providing opportunities for establishing links between researchers and innovators to strengthen Europe's capacity to address scientific, technological, and society challenges.

The Enterprise Europe Network (EEN) has a significant impact on the development of network effects in business and science cooperation. With the help of the EEN, in addition to finding business partners and customers, Ukrainian SMEs have the opportunity to promote their innovations and technologies in the EU markets, as well as to seek investors and partners [135].

Smart specialisation is another tool for establishing communication between government, business, communities, and science. It includes the following:

- establishment of effective partnerships between regional authorities and HEIs and research institutions (joint projects, knowledge exchange, including analytical support for priority regional development measures);
- establishment of an institution to administer cooperation (under the aegis of regional development agencies) and support the involvement of scientists in monitoring smart specialisation pathways and coordinating knowledge-intensive projects;
- creation of innovation clusters (technology parks) for the implementation of joint projects;
- allocating regional funding (grants, scholarships) for R&D promoting the development of smart specialisation;
- creation of theme-based research

centres (laboratories) where scientists and entrepreneurs could work on the development of new technologies and products;
- organisation of training for smart specialisation projects, and more.

However, the scientific potential, including the existing research infrastructure and technology transfer options, was hardly taken into account in the development of smart specialisation strategies, and even if it had been, the interaction in the innovation triangle at the regional level was fragmented. During the focus group with representatives of HEIs/SIs that run centres for the shared use of scientific equipment, it was unanimously noted that the potential of research infrastructures is not part of regional development programmes. This poses a threat to the implementation of smart specialisation strategies that should rely on RIS at the regional level.

Ukrainian businesses are gradually joining initiatives to support education and science. For example, in 2021, SoftServe implemented the Educational Grants programme [136], and in 2023, the ITeachers Meet-Ups initiative with the support of MESU [137]; during the full-scale invasion, Softserve also provided financial support for the restoration of universities [138].

Among the opportunities for cooperation and development of the scientific ecosystem, one should mention charitable foundations known to a limited number of scientists. For example, BioUkraine [139], founded with the support of the Ukrainian diaspora, aids in equipping laboratories and building a professional network to help Ukrainian scientists unleash their potential to solve global problems such as diseases, food security, climate change, and more. The Bohdan Hawrylyshyn Family Foundation [140] supports researchers in the humanities and sciences in integrating successful European experience and shaping an ecosystem to accelerate qualitative changes in society. The Fedir Shpyg Foundation [141], among other things, supports cross-sectoral research, promotes communication of science, and helps to integrate the achievements of scientists into the spheres of society activities. The Victor Pinchuk Foundation's Zavtra.UA scholarship programme [142] supports the development of Ukrainian youth and promotes the implementation of research projects by talented young people.

The current initiatives for cooperation between science and business offer scientists a wider range of opportunities, but they are typically limited to providing support during the initial stages of innovative product development.

2.2.4. Low integration level of research and innovation systems

The post-war recovery creates new challenges where science needs to be more closely integrated with the innovation system — to implement the country's innovation development priorities laid out in national strategies and, expectedly, in the post-war recovery plan. At the same time, several respondents noted that without the development of the innovation ecosystem, the scientific system will not develop either.

According to experts, science is literally cut off from the innovation infrastructure, which is difficult to access in terms of commercialisation of R&D results as it requires specific skills and resources. The cultures of scientific activity and innovation activity differ in terms of project management pace and rhythm, in the stable informal rules of work in a research group, as well as in goals and expected results. Thus, in order to integrate these two components, it would be necessary to remove certain barriers, such as the ineffective legal mechanism for technology

transfer, the complexity of creating a spin-off, and the development of a model for financing R&D throughout the life cycle of innovations.

Despite the fact that Ukraine continues to align its intellectual property legislation with that of the EU [143] (progress in fulfilling European integration obligations is estimated at 98% as of 2023 [144]), experts from the Ukrainian National Office of Intellectual Property and Innovation (UANIPIO) note that the current Law of Ukraine On State Regulation of Activities in the Field of Technology Transfer does not bring the transfer process closer to European practices. In Ukraine, created intellectual property is not evaluated as part of GDP, so society does not understand its role.

Analytical data of the UKRISTEI for 2012–2021 [145] show that even before the full-scale war, the innovation activity of industrial enterprises in Ukraine had critically declined. The share of industrial enterprises that implemented innovations fell from 13.6 to 5.8% during this period. The results of surveys of industrial enterprises conducted by the Institute for Economic Research and Policy Consulting [146] in 2023 show that 18% of enterprises have never engaged in innovation at all, while 31% have determined that innovation is irrelevant under martial law. Enterprises in industries that were crucial for the post-war recovery, such as construction materials production, woodworking, food and light industry, turned out to be the least involved in innovation.

In the period 2012–2021, 13,233 technologies created with budget funds were transferred, of which 4,889 or 36.9% were transferred to industrial enterprises, and the largest share (51%) was transferred to the agricultural sector. Overall, the number of technologies transferred to industrial enterprises increased almost tenfold between 2012 and 2021. Technology transfer took place mainly on the domestic market, which accounted for 95.7% of all transferred technologies, and only 4.3% on the foreign market. Technology transfer is most prevalent in the renewal and development of the agro-industrial complex, while the least transferred technologies are those related to the development of new technologies for high-tech transport systems, rocket and space industry, aircraft and shipbuilding, armaments, and military equipment [145]. The transfer's positive dynamics did not resolve the issues with its quality. In 2021, the smallest share of revenues from technology transfer agreements came from patent and know-how rights and technology transfer agreements (0.59% and 3.42%, respectively) [147].

Due to the focus on quantitative indicators of intellectual property creation in the evaluation systems of HEIs and research institutions, there are limited scientific developments with high technological readiness levels (TRL) suitable for commercialisation and of interest to angel and venture capital investors in Ukraine [148]. This has resulted in a low share of innovative projects with a knowledge-intensive component during the process of bringing a product or technology to market. During an expert interview, a representative of the Ukrainian Startup Fund noted that it is no more than 30% in Ukraine; Andriy Kolodyuk, founder of the Ukrainian Venture Capital and Private Equity Association, estimates the share of startups involving scientists, financed by venture investors, is no more than 5%.

Simultaneously, Ukraine's innovation ecosystem grew rapidly in 2019–2021; a significantly higher number of organisations entered the market (57 out of 83 surveyed) than in 2011–2018 [149]. This positive trend was disrupted by Russia's full-scale invasion of Ukraine. In 2022, only five companies were established, four of which were founded just before the war began. However, the evaluation of startup activity during the war varies. The results of a survey of investment funds in 2023 [150] show that startups are highly resilient in turbulent times: only one

startup out of the surveyed closed during the 17 months of the war, and three more have been on hiatus since 24 February 2022. At the same time, Startup Wise Guys [151] reports that more than 60% of startups left Ukraine during the war, and several startups lost up to 90% of their revenue. In total, investments in Ukrainian startups fell by 74% in 2022 compared to 2021 [152].

Ecosystem participants that support startup development have also demonstrated their resilience in challenging circumstances. Examples include the State Research Institution "Kyiv Academic University", which has established an Innovation Centre [153]; the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", which has organised the Sikorsky Challenge Innovation Ecosystem [154].

UANIPIO and UKRISTEI have intensified their efforts to develop the innovation ecosystem. UANIPIO has launched the National Intellectual Property and Innovation Hub (IP&I Hub) project aimed at promoting business incubation and acceleration, searching for grants and supporting innovators, creators and inventors. The IP&I Hub offers innovators a range of tools, such as the Single Window, an information cluster, an open innovation platform, patent analytics, and entrepreneurship programmes for innovators (Lab2Market) [155]. An important area of UANIPIO work to support innovation is the expansion of the network of Technology and Innovation Support Centres (TISCs) [156].

The Automated System of Formation of Integrated Interstate Information Resources (ASFIMIR) is currently in pilot operation at UKRISTEI. Its purpose is to create and distribute integrated information resources provided by countries and organizations with which scientific and technical agreements have been concluded, and with which cooperation is planned in the coming years [157]. The system provides access to databases, as well as paid (investor search, consulting, and marketing services) and free (posting information about a project/development in databases) services [157]. In July 2023, UANIPIO and UKRISTEI signed a Memorandum of Cooperation to develop the innovation ecosystem [158].

One of the obstacles to commercialisation of knowledge-intensive innovations as results of the activities of research institutions and HEIs is the difficulty of forming commercial companies ("spin-offs") and transferring rights to intellectual property created with budget funds. In Ukraine, Article 60 of the Law On Scientific and Technical Activities outlines the procedure for state research institutions and higher education institutions to participate in the establishment of business entities for the purpose of utilizing intellectual property rights. However, this process requires interaction with government agencies, such as the State Property Fund of Ukraine and MESU, which can create additional barriers for startups. This practice is better regulated in the EU, where universities have developed policies that facilitate the establishment of knowledge-intensive businesses by researchers based on developments made with the financial support of the university [159].

In order to support startups and better protect investments and intellectual property in Ukraine, a pilot project for startups related to IT, cybersecurity, artificial intelligence, and now defense has been launched—DIIA City. Residency in DIIA City provides significant tax benefits for both the company and its employees. However, knowledge-intensive startups from other fields currently do not have the opportunity to take advantage of these benefits.

Among the programmes supporting innovations, Ukrainian organisations and companies can participate in the European Innovation Ecosystems programme by the European Innovation Council (EIC),

programmes for the development of innovation ecosystems under the Horizon Europe Pillar III programme, and competitions of the European Institute of Innovation and Technology (EIT) in various industry areas under the EIT Food, EIT Energy, EIT Digital, EIT Manufacturing, EIT Health partnerships, and more. The European Innovation Ecosystems programme focuses on building interconnected, inclusive, and efficient innovation ecosystems that support the scaling up of companies and drive innovation. The European Institute of Innovation and Technology's competitions support projects that help innovative SMEs increase their research and innovation capacity and performance, and successfully engage in global value chains and new markets.

The EIC Pathfinder, EIC Transition, and EIC Accelerator competitions provide grant support to finance the full cycle of development of knowledge-intensive innovations (deep tech). To finance the innovation chain, special financial mechanisms have been developed, combining grant support with financial market instruments through the EIC Fund, established by the European Commission with the support of the European Investment Bank. An important feature of these competitions is that the topics are linked to EU priorities. In addition, there are fast-track participation plans for innovative projects and start-ups that have been previously funded under national grant programmes and need further funding to enter the market and scale up.

The EIC also announces several prizes each year, including the European Prize for Women Innovators, the European Capital of Innovation, and the European Social Innovation Competition. In 2023, Kyiv and Lviv participated in the European Capital of Innovation Awards, and Lviv was one of the three winners.

The EIC Business Acceleration Services (BAS), EIC Community platform, EIC Marketplace, EIC Innospace, EIC Forum were created as additional support for innovation, providing various services at each stage of the implementation of a EIC-funded project and supporting communication between project participants and other actors in the research and innovation system.

The EIC Forum is a platform for collecting, discussing, and testing new ideas and proposals from stakeholders and their possible implementation and expansion at the European level. It is an important channel for discussing innovation and other policies and for supporting the Horizon Europe programme. The platform enables the avoidance of overlaps by sharing data on programmes, implementation, resources, experience, analysis, and monitoring of technological and innovation trends. It will also bring together relevant communities of innovators.

The establishment of the European Innovation Council and the EIC Forum, grant programmes and various innovation support instruments can significantly contribute to the transformation and development of Ukraine's RIS. An important step to support innovation in the process of Ukraine's recovery could be the introduction of a similar programme to finance the full "from-idea-to-market" chain of innovation creation, similar to the EIC programme.

In general, Ukrainian projects supported by European grant competitions have formed a base of project ideas, research and development that can be implemented in Ukraine's recovery programmes.

2.2.5. Evolution of the financing model for research and innovation activities in Ukraine

It is difficult to find a country that has achieved long-term economic development while reducing R&D expenditures. This is supported by the experiences of Ukraine and other countries. At that, R&D expenditures in countries that were initially funded by the state at the early stages of post-war recovery were later increasingly financed by private industry capital, particularly in the United States [160].

In Ukraine, real R&D funding decreased by 27.4%[8] between 2010 and 2020. The largest share of budget funding is directed to academic science (NASU and five national sectoral academies of sciences), followed by university science and other scientific activities, and international cooperation. The smallest share is allocated to sectoral science. In 2021, the structure of expenditures was 71%, 22.1%, and 6.9%, respectively. In 2023, the funding allocated for R&D in HEIs and research institutions of dual subordination (MESU and NASU) decreased by 15% due to the war, compared to the planned amounts approved in January 2022 [161; 162].

In relative figures (as a percentage of GDP), the share of R&D expenditures in 1997-2020 fell from 1.19% to 0.41% [163]. This is the lowest figure compared to the EU countries, where Romania (0.47%) [164] and some other countries lag in terms of science funding. Ukraine is often compared to Poland, which had a worse starting position in 1997 than Ukraine, but by 2011 it caught up with Ukraine and by 2020 had reached a level of R&D expenditure of 1.39% of GDP [165]. It should be noted that this growth was accompanied by active development of industrial and business sectors of the economy.

The legislation currently in force provides for an increase in science funding to 3% of GDP by 2025 (of which 1% is public spending and 2% is private sector spending) [115]. Given the complicated military and political situation in the country, the recovery plan for Education and Science [41] envisaged only 0.6% of public spending on R&D by December 2025, with the total spending at 1% of GDP. Reaching the target 3% of total R&D expenditures is scheduled for 2032 [42]. This approach raises certain concerns: In 2023, the European Council of Doctoral Candidates and Junior Researchers (Eurodoc) highlighted that Ukraine may lose an entire generation of scientists if it does not change the financial conditions for young scientists [166].

Funding for Ukrainian science and innovation is based on the priorities set by the state [167; 168]. This applies to both basic and competitive funding. According to experts, setting priorities enables the implementation of the principle of justification for public expenditures on R&D and is a powerful tool for stimulating the development of certain fields of science. However, the problem is that these areas are not sufficiently distinguished in terms of funding compared to others. Moreover, these priorities should be set and work proactively (to give an example, a scientist-entrepreneur refers to the state's disinterest in innovative developments in military tech two or three years before the war), not ex post factum. The issue of approaches to setting priorities by the state is debatable. Experts refer to the German Research Community (DFG, Deutsche Forschungsgemeinschaft) [169] as an example, which develops competition-based priority programmes, while independent international experts assess their priority.

In July 2018, the principles of science and innovation funding were expanded from

[8] Calculated by the authors based on the Consumer Price Index data for 2010–2020: State Statistics Service of Ukraine (2023). Statistical information. *https://www.ukrstat.gov.ua/*

exclusively administrative and distribution to competitive ones with the establishment of the National Research Foundation of Ukraine. In 2020–2021, the Foundation held 5 competitions [170]. As a result of the full-scale Russian aggression in 2022, the NRFU did not receive funds to continue funding projects, including those that won the 2020–2021 competitions. The state budget planned to allocate UAH 833.8 million for the Foundation's activities in 2022 and UAH 504.8 million in 2023. [171; 172]. Funding for 2023 is estimated at UAH 466.835 million. [173]. Compared to 2021, when the amount of funding for the Foundation's activities was UAH 732.8 million, the reduction of this amount in 2023 is a nominal reduction by 31%, while the real reduction (adjusted for inflation) is over 50%[9]. In 2022, NRFU launched a fundraising campaign to attract extra-budgetary funds [174].

At the commercialisation stage, grant funding opportunities for the commercialisation of innovations are provided by the Innovation Development Fund (known as the Ukrainian Startup Fund). The activities of the Innovation Development Fund were financed mainly from the state budget of Ukraine. In 2022, UAH 50 million was allocated for the Fund's activities; in 2023, the Fund switched to the funding from international donor organisations, including the EU. Between July 2019 and July 2023, the Fund provided support to 352 startups for a total of USD 8.2 million [175]. The Fund is currently competing for EUR 20 million in funding from the European Innovation Council as part of the Seeds of Bravery project, which will last for two years [176].

The problem with the current financial model is that it does not actually provide resources for the stage of improving the TRL of a product to a level that is ready for commercialisation. This process often requires substantial capital investment, especially in deep tech, including the construction of test benches or product prototypes. So at this stage, as the startups are only able to raise funds from foreign investors, they migrate to other tax jurisdictions.

The Horizon Europe programme, established by the European Union, provides support for innovative projects throughout their life cycle, from idea to market. It consists of three pillars [177]: Excellent Science (support for research projects, training of doctoral students and academic exchanges); The Global Challenges and European Industrial Competitiveness (support for research related to societal issues and strengthening technological and industrial capacity through clusters); The Innovative Europe (creating a market for innovation through the European Innovation Council). During the war, Ukraine's opportunities to participate in grant funding programmes from the EU and other countries expanded. However, Ukraine has not yet established its own sustainable system of support for knowledge-intensive innovation projects, which hinders the integration of the research and innovation systems.

On 2 February 2023, the European Commission announced that it would open a research office in Kyiv. This was preceded by the decision made in 2022 for Ukraine to join Horizon Europe, the EU's main research and innovation funding scheme. As of October 2023, Ukrainian scientists participated in 103 Horizon Europe projects with funding of EUR 22.24 million (compared to 49 projects in January 2023, with funding of USD 13.9 million) [178]. The Association Agreement grants the Ukrainian researchers the same status as the EU researchers, also enabling them to manage projects [179].

Analysing the situation around financial support for science and innovation in Ukraine, the experts interviewed for the study supported the need to increase state funding,

[9] Calculated by the authors based on the Consumer Price Index in January–December 2022 and January–July 2023.

while stressing the need to change approaches to setting R&D and innovation priorities. In their opinion, at the first stages of recovery, the first areas to receive funding should be defence, medical and environmental R&D, as well as R&D of strategic importance. According to several experts, funding for applied science should be provided on a competitive (tender) basis. "The state, business and society should become customers of science" (Nadiya Bihun, Deputy Minister of Economy of Ukraine).

It has been noted by experts that the system for receiving and managing foreign grant funding in Ukraine still creates barriers. They pointed out such factors as bureaucratisation of procedures related to the movement of funds, lack of awareness among the HEI management staff regarding the requirements and responsibilities in the implementation of international projects. Certain measures to simplify financial procedures were implemented by MESU as early as August 2022 [180].

During the focus group, scientists also suggested an approach whereby basic funding should be provided to individual research teams on a competitive basis rather than the entire research institution, with monitoring of the team's performance indicators and the results of its research work. However, this mechanism is difficult to implement and requires revision of legislation.

International experience of other funding tools for research and innovation activities

Innovation procurements

To finance and develop knowledge-intensive innovations in Ukraine, there is a promising instrument of public procurement of innovative products which was actively used in the US and the UK during the war and post-war periods. In the EU innovation procurements, the state acts as the first active consumer of a knowledge-intensive innovative product of public importance.

The prevalence of this tool in European countries is demonstrated by the share of innovation procurements in the total public procurement in the EU countries — as of 2020, it ranged between 2% and 13%. The leaders are Finland, Norway, the Netherlands, Switzerland, the United Kingdom, France, Sweden, Denmark, Belgium, and Austria, which allocate 10% of all procurement to innovation [181; 182]. On average across the EU, the largest areas of procurement are public services (35%), health and social services (21%), and public transport (10%). The European Commission has developed a new paradigm for combining public procurement and the innovation ecosystem [183] in the context of the new European innovation agenda [131]. To engage startups in public procurements, a special procedure has been developed and support introduced in the form of innovation procurement brokers [184].

To implement this tool, the Ukrainian public procurement system should be reformed in terms of assessing corruption risks and developing a mechanism for such procurement. The current legislation imposes administrative liability for violations of budget legislation and criminal liability for misuse of budget funds, this risk being increased for civil servants who may procure innovations. So this instrument requires certain legislative coordination, as well as additional mechanisms and measures to enhance its efficiency.

Crowdfunding

The crowdfunding tool is a public call for money from the general public and is a popular source of funding for entrepreneurial, artistic, and social projects [185]. It is also an alternative source of R&D support in developed countries. Currently, many Western universities are actively encouraging their researchers to conduct crowdfunding campaigns.

For example, after several unsuccessful attempts to obtain traditional funding to sequence the Gila monster genome (Heloderma

suspectum), scientists at the University of Arizona turned to crowdfunding. Thanks to the support of 173 individual donors, they raised enough money to decode the genome of this poisonous lizard [186].

There are at least several potential advantages of crowdfunding: increasing the total amount of resources available to a researcher; partial compensation for limited budgets of scientific institutions; assistance in obtaining funding for young researchers who face challenges in obtaining it through traditional channels, or due to their inexperience; greater involvement of society in the "scientific process"; and indirect popularisation of science [187].

That said, crowdfunding is not intended to replace traditional funding sources, but rather to supplement them. Most crowdfunded research projects are small, with an average funding of USD 3,500 per project [186].

Crowdfunding is considered as non-refundable financial aid under national legislation, which entails tax consequences. However, this funding tool can help finance projects that would not have been funded under other circumstances, as they address niche problems. The best legal form for a research institution to attract such funding is a non-profit organization or a charity.

Grant and charitable support

This type of research funding can be singled out among others, as the attraction of sponsors for R&D relies on both individual and corporate contributions, contributions from organisations (including international ones), and these contributions can reach sizable levels.

This is quite common in US universities and research centres. For example, the laboratory of Prof. Michael Snyder [188], one of the most cited geneticists in the world, officially accepts funds to support its research.

Unlike crowdfunding, grants enable organisations and philanthropists to provide more powerful incentives for certain areas of research. At the same time, a certain level of financial stability and favourable economic conditions in the country are required for science donors to emerge.

Therefore, in the first stages of post-war recovery, it is possible to support the integration of RIS and R&D and innovation by changing the funding model and introducing new tools that are common in Western countries as fundraising tools to support projects of research teams, scientific institutions, universities, and other institutions engaged in R&D.

SECTION 3. HOW TO TRANSFORM THE RESEARCH AND INNOVATION SYSTEM. PROPOSALS AND RECOMMENDATIONS

The transformation of the RIS should be complementary to the changes that will facilitate the development of the future Ukraine, the model of which will be presented in the final post-war recovery plan. To this end, urgent measures should be taken as early as now, during the war. Given the multiple challenges and problems faced by Ukrainian science, it is simply impossible to solve them all at once. Therefore, this paper focuses on systemic solutions that can be implemented in the short term and that will launch the process of further transformation of Ukrainian RIS in the future.

1. Bring the legislation governing scientific, technical and innovation activities in line with internationally accepted terminology.

Methodology, notions and concepts harmonised with the international, and in particular the European, scientific environment should be enshrined in the current legislation. They are already actively used in partnerships with EU funds, cooperation of research teams in international projects, and in documents related to integration into the European Research Area.

Terms such as research and innovation system, research and innovation policy, knowledge transfer, deep tech, boundary organisation, researcher, etc. are increasingly practiced during communication in science and education. Failure to clearly understand them hinders, to a certain point, the drafting of policies aimed at developing science and innovation and usage of European opportunities in Ukraine. The TRL, MRL (Market Readiness Level), IRL (Investment Readiness Level) and BRL (Business Readiness Level) systems should be introduced into the regulatory framework and practice to improve integration as part of international scientific cooperation.

The national statistical methodology should be aligned with the European one [189] regarding sample observations of innovation activities of enterprises to ensure better comparability, and national legislation should be harmonised

with the statistical methodology (for example, there is no definition of "researcher" in the Law of Ukraine On Scientific and Technical Activities but it is used by the state statistics authorities).

The first steps taken by MESU to obtain a licence in 2023 to translate and publish OECD works in science, technology and innovation spheres — the Oslo Manual 2018, the Frascati Manual 2015 and the OECD Patent Statistics Manual [190] — are the beginning of a movement in this direction, which should be encouraged for subsequent practical implementation of these documents.

2. Introduce EU practices into the process of shaping public policy pursuant to evidence-based and science-based principles

To actively engage scientists in post-war recovery, it is necessary to change the principles of policy development in Ukraine and harmonise them with EU rules and principles. In particular, the "innovation principle" which requires any policy development to take into account the impact on innovation should be introduced into lawmaking practice.

Ukraine has a unique chance to use the period of preparation for EU accession to make significant progress in refining its policy-making approaches. This includes providing better access to scientific expert examination, expanding ways to engage scientists, researchers, and experts in advisory roles, and developing "boundary organisations" [191] to connect government policymakers with the scientific community and strengthen the analytical capacity of state institutions.

At that, the principle of transparency in the policy-making process should be observed. This requires documenting all steps in data collection and interpretation, as well as ensuring effective communication between stakeholders. Legal, financial, and other constraints should also be taken into account.

To ensure effective communication between policy makers and experts, the following measures are suggested:

1. The CMU needs to introduce positions of deputy ministers for science and innovation (knowledge transfer) in each ministry to support post-war recovery and modernisation. They will be responsible for engaging scientists to provide scientific and analytical support for policies and will be part of the Administrative Committee of the National Council for Science and Technology for horizontal coordination. These positions may be temporary during the first years of post-war recovery until the practice of engaging scientific expertise becomes regular, including as a result of European integration processes.
2. Government bodies, including local authorities at regional and community levels, should establish departments comprising trained professionals who understand scientific research methodology and possess knowledge management tools.
3. Simultaneously, training and advanced training of specialists in scientific and analytical support of the policy-making process should be carried out at state level through the implementation of appropriate state and regional programmes and the development of relevant training programmes for specialists in the higher education system. Emphasis should be placed on training specialists in research and analysis methodology and complex system science.
4. MESU, or the leading civil society organisations engaged by it, should create a centralised knowledge base by subject area (in the form of a portal), to contain a database of information sources and a repository of developed analytical documents, a list of think tanks and research centres, and a forum for sharing practices, discussions and debates. Posting materials on the portal regarding the results of completed projects under grant programmes is also recommended, along

with applications prepared for participation in competitions (Annex C).

5. Introduce the institution of "knowledge brokers'' (boundary organisations). These organisations could act as intermediaries between academic institutions and the government and serve as integrators in forming teams of representatives from different subject areas to conduct interdisciplinary research to inform policy making.
6. Improve the system of interaction between the state and subjects of scientific and technical activities which can provide scientific expertise for lawmaking. Expand the list of knowledge fields in the Law of Ukraine On Lawmaking where scientific results should be taken into account when drafting regulatory legal acts in the relevant area (Social and Behavioural Sciences, Governance and Administration, Transport, Culture and Arts, etc.).
7. Improve the mechanism for engaging and funding analytical activities of experts in science, as well as funding scientific and analytical research commissioned by the government. This should be done in the area of simplifying procedures and ensuring the possibility of paying for the activities of engaged experts, both individuals and organisations, also known as "knowledge brokers".

The implementation of these recommendations requires organisational changes and institutional development of scientific institutions, including large-scale introduction of knowledge management and project management tools in their activities. The funding sources could include Digital Europe funds and projects of various donor agencies that promote digitalisation. It would also be advisable to include this proposal as a draft Recovery Plan for funding under Ukraine Facility.

3. Develop the institutional capacity of regions for innovative growth and their recovery on the basis of smart specialisation

To benefit from smart specialisation, local executive authorities lack the competencies to engage businesses and the public in the development of the region's innovations, facilitative institutions, and functional innovation ecosystems.

To increase institutional capacity, local executive authorities could implement projects to create regional innovation hubs, similar to the model piloted by UANIPIO, by attracting funds from local budgets, international donor funding, grants or investments. Professional facilitation institutions can be formed within such an ecosystem to help achieve the goals of regional development strategies and smart specialisation.

The implementation of smart specialisation strategies and the innovative development of regions on the whole is impossible without a digital component (such as artificial intelligence, high-performance computing, cybersecurity and digital skills). Small and medium-sized enterprises need to achieve their digital transformation by introducing new innovative production processes, new business models and upgraded innovative products. As a powerful policy tool, European Digital Innovation Hubs[10] will support the introduction of regional innovation strategies and contribute to regional economic recovery. The transition to Industry 4.0–5.0 requires scaling up this instrument and solving the problem of state co-financing of such centres under the Digital Europe programme.

4. Design an effective model of multi-channel financing to support knowledge-intensive innovative products throughout their life cycle.

[10] How to become a digital innovation hub. Take part in webinars hosted by European colleagues / Ministry of Digital Transformation of Ukraine. Government portal: official webpage. 10 October 2023. URL: *https://www.kmu.gov.ua/news/yak-staty-tsyfrovym-innovatsiinym-khabom-doluchaitesia-do-vebinariv-vid-ievropeiskykh-koleh*

Along with the existing sources of funding — budget funds in the form of basic and competitive funding, Horizon Europe — the state may receive dedicated loans from international institutions such as the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), and other. Research teams can use crowdfunding for small projects.

The concept of a model for supporting research, development and innovation throughout their entire life cycle should be developed by an interagency working group, with further implementation of measures to ensure the conditions for its functioning. The working group should include representatives of MESU, the Ministry of Economy of Ukraine, the Verkhovna Rada Committee on Education, Science and Innovation, the Ministry of Finance of Ukraine, the Ministry of Digital Transformation of Ukraine, and the Scientific Committee.

Along with this, the introduction of multi-channel financial support requires amendments to the current legislation in the context of increasing autonomy in the use of grants from donor organisations in compliance with the conditions specified in grant agreements. To ensure long-term development and sustainability of the RIS, the government, the NBU, and the VRU should also work systematically to create an effective capital market in Ukraine. Affordable bank loans and a stock market will provide alternatives for funding research and innovation projects and prevent the export of intellectual property abroad.

5. Introduce the practice of public innovation procurements for post-war recovery purposes.

It is necessary to implement the general recommendations on the implementation of the public procurement of innovations, as outlined in the Analytical Report "Procurement of Innovations in Ukraine. Public Consultation" [192]. Under current Ukrainian legislation, including anti-corruption laws, decision makers may face certain negative consequences. Therefore, the Verkhovna Rada of Ukraine should align the Law of Ukraine On Public Procurement with EU standards and the Law of Ukraine On Combating Corruption, highlight the specifics of public officials' responsibility in procuring innovations among regular procurements, define mechanisms and establish appropriate legal support for high-risk procurement — specific contracts, establishment of innovation divisions of state agencies tasked with selecting and testing innovative developments.

To improve the instrument's effectiveness, it is advisable to implement the following initiatives.

5.1. Localisation of public innovation procurements

State institutions and local executive authorities have the opportunity to purchase innovative products developed in Ukraine, based on the principle "developed and made in Ukraine", according to their needs. The list of these products can be formed based on strategic documents for post-war recovery.

To effectively implement this instrument, the VRU needs to amend the Law of Ukraine On Public Procurement to align it with EU legislation [193]. Furthermore, it is imperative to establish regulations for sustainable investment, akin to the EU taxonomy [194]. These regulations would enable the screening and prevention of the importation of obsolete and environmentally harmful technologies during the procurement process, giving preference to domestic developments that meet the said requirements.

According to this mechanism, only the absence of domestic analogues or a local component will justify purchasing foreign technology. This will also support the life cycle of a knowledge-intensive innovation at the stages most risky for business (marketing).

5.2. Development of a system to procure public innovations from startups (methodological support)

Initiatives to introduce innovative public procurement should be accompanied by the development of mechanisms to engage knowledge-intensive startups in public procurement as suppliers. When purchasing an innovative solution, it is recommended to draw on the experience and paradigm of interaction between the state and innovative enterprises (SMEs, start-ups) proposed in the EU. To implement this initiative, institutional support from the Ministry of Economy of Ukraine is advisable to facilitate and mediate the relations of purchase and sale of innovative products, including an institution of innovation brokers.

5.3. Development of an innovation procurement culture

This initiative envisages the development of a model of innovation procurement in Ukraine, considering the suggestions and caveats mentioned above. Simultaneously, it is necessary to develop the competencies of public officials involved in the innovation procurement process. This includes studying the European experience of innovation procurement, training specialists who will be involved in procurement on both the state (buyer) and RIS (seller) sides, gradually accelerating procurement by all departments, increasing the propensity to take appropriate risks, and implementing innovations more effectively to achieve state goals. In addition, committees on sectoral areas of innovation, including scientists and business experts, should be set up to facilitate and justify procurement.

The implementation of this initiative should be entrusted to higher education institutions that train specialists for the public sector and centres for the professional development of public officials.

6. Implement a pilot project to create a special legal and tax space for innovative companies in Ukraine and academic startups.

For academic start-ups that result from R&D and are located in start-up ecosystems of universities and research institutions, it is recommended to establish a special tax regime. This regime should take into account the peculiarities of the production cycle at such enterprises and be similar to the conditions offered to residents of Diia.City [195].

The necessary changes regarding tax benefits will require amendments to be made by the Verkhovna Rada to the Tax Code of Ukraine and related regulations. Given that Diia. City has introduced elements of English law and investment mechanisms common to foreign venture investors, the same system could be introduced for knowledge-intensive innovative companies and academic startups. This will enhance the confidence of both domestic and foreign investors, who are a crucial source of funding for innovative startups during the post-war recovery period, in Ukrainian startups. Additionally, it will assist startups in overcoming administrative obstacles when implementing projects with lengthy research cycles.

7. Establish an ecosystem to support research institutions and HEIs in their interaction with users of R&D results.

The capacity of the RIS should be strengthened by the necessary institutions to promote science and its achievements, commercialise research and development results, and establish communication between science, business, government, and civil society. This is a large-scale issue that needs to be addressed during post-war recovery through the activities of the government, the Verkhovna Rada, NASU, sectoral academies of sciences, universities, and other relevant institutions.

The tasks to be solved include the following:

1. separation of, and provision for, the development of management functions in science through the training of research management specialists and research project administrators, grant application specialists and innovation managers. Such specialists can be trained using the approaches of the European Association of Research Managers and Administrators [196];
2. develop the competencies of scientists in technology transfer and commercialisation of innovations both through the establishment of Technology and Innovation Support Centres (already underway under the initiatives of UANIPIO, HEIs and SIs) and by raising awareness among scientists regarding the opportunities these centres can provide for developers;
3. ensure the introduction of new interdisciplinary educational programmes for training specialists in the commercialisation of research results and innovation management in priority research areas (through the development and implementation of a national programme);
4. legislatively enable scientific institutions and higher education institutions to include communications and marketing specialists or units in their staffing lists. This specifically applies to institutions engaged in applied research and development, which are intended for implementation in various sectors of the economy and in the state;
5. at the initiative of MESU, implement a pilot project to introduce outsourcing services (innovation management, commercialisation of innovations, mentoring of academic startups, marketing, preparation of grant applications, advising on financial issues of grantees, and more) for HEIs and research institutions.

Implementation of these initiatives will require amendments to the current legislation of Ukraine, such as Laws of Ukraine On Education, On Higher Education, On Scientific and Technical Activities, the Budget Code of Ukraine and a number of bylaws, upon submission from MESU and other authorities.

8. Establish a unified systematic register (database) of domestic scientific developments in the areas and priorities of post-war recovery to ensure their further commercialisation.

The recommendation includes conducting an inventory of existing databases on Ukrainian scientific developments (UKRISTEI, NASU, sectoral national academies of science, patent databases, data on supported domestic and international projects) and their analysis and distribution by recovery priorities.

This will enable the development of a unified system of national scientific achievements that is comprehensible to both the government and businesses, and can be effectively utilised to address the challenges of post-war recovery. Additionally, groups of experts should be formed based on information about researchers and projects in relevant areas, and these groups should be engaged by the government in the development of a post-war recovery plan and scientific support for its implementation.

MESU, NASU, and the Ministry of Digital Transformation of Ukraine may be jointly entrusted with the implementation of this recommendation.

9. Improve the institutional framework for technology transfer and support for the full life cycle of innovation

9.1. Improving the current model of operation for science and technology parks

To ensure conditions for the development of science and technology parks in Ukraine for the purposes of removing the gaps in institutional support for the development of innovations in the middle stages of their life cycle (between

TRL 4 and TRL 7). Namely, amendments should be made to regulatory documents, in particular to the Law of Ukraine On Science Parks, regarding the lease of premises of HEIs and SIs by science parks (to allow science parks to rent vacant premises of HEIs and SIs on privileged terms), facilitating the attraction of the required number of employees in the field of scientific, technical and innovation activities and expanding the operational activities of such parks.

9.2. Adopting the Draft Law of Ukraine On Innovation Parks

The Verkhovna Rada of Ukraine shall adopt Draft Law of Ukraine No.7658 On Innovation Parks of 11 August 2022. Thanks to their wide range of functions enshrined in law, innovation parks will help to address issues such as attracting investment in innovative projects, supporting knowledge-intensive start-ups, facilitating the commercialisation of research results, and introducing innovative products. Another advantage of innovation parks is the possibility to have a scientific, technological, industrial park or innovation cluster and/or other elements of innovation infrastructure in their structure. They are able to expand the capabilities of science and innovation parks, transforming them into high-tech enterprises. The importance of participation in the Horizon Europe programme in the area of Excellence Hubs should be considered when adopting the draft Law of Ukraine On Innovation Parks.

9.3. Promoting successful practices of Ukrainian spin-offs

MESU, UANIPIO, NASU and other agents of academic, scientific, technical, and innovation activities should expand their information and awareness-raising activities on the mechanisms of establishing spin-offs (based on success stories in Ukraine). This can be achieved through specialised seminars, conferences, and forums, to which representatives of Ukrainian spin-offs should be invited.

9.4. Simplifying the mechanism for transferring intellectual property rights

MESU should initiate amendments to the current legislation, specifically, the Laws of Ukraine On Scientific and Technical Activities and On State Regulation of Activities in the Area of Technology Transfer to facilitate the transfer of intellectual property rights from research institutions or HEIs with budgetary status to spin-off companies created by them. The amendments should take into account the interests of private investors as owners of financial resources to support scientific, technical and innovation activities.

REFERENCES

1. Roadmap for the integration of Ukraine's research and innovation system into the European Research Area / Ministry of Education and Science of Ukraine. 10 February 2021. [In Ukrainian] URL: *https://mon.gov.ua/storage/app/uploads/public/602/e67/2f0/602e672f0d6a3587992264.pdf*
2. Ukraine's Answers to the EU Questionnaire on the Application for Membership. Part II Volume 5 Chapters XXII-XXV. May, 2022. URL: *https://eu-ua.kmu.gov.ua/wp-content/uploads/vol_5._ch.xxii-xxv.pdf*
3. The European Science and Innovation System: S4D4C European Science Diplomacy Course. 2021. URL: *https://www.s4d4c.eu/lessons/4-3-the-european-science-system/*
4. Position Statement "Towards strengthened research and innovation systems across Europe" / Science Europe. 2022. DOI: 10.5281/zenodo.7303455.
5. Amanatidou E. Germany: Country Report – ERA-LEARN: enabling systematic interaction with the P2P community. 2022. URL: *https://www.era-learn.eu/documents/country_report_germany*
6. Research and Innovation System. Research.fi. 2022. URL: *https://research.fi/en/science-innovation-policy/research-innovation-system*
7. Science Europe Strategy Plan 2021-2026 / Science Europe. June, 2021. DOI: 10.5281/zenodo.4911426
8. Tzifakis N. Post-Conflict Economic Reconstruction, Encyclopedia Princetoniensis. 2023. URL: *https://pesd.princeton.edu/node/586*
9. Recovery of Ukraine: Principles and Policies / Editors: Yu. Horodnichenko, I. Solohub, B. Weder di Mauro / Paris Report. Centre for economic policy research. 2022. 507 pages. [In Ukrainian] URL: *https://cepr.org/system/files/2022-12/reconstruction%20book_Ukrainian_0.pdf*
10. Runswick-Cole I. Life After War: Changing Perceptions Of Post-Conflict Rehabilitation. The Organization for World Peace . August 5, 2017. URL: *https://theowp.org/reports/life-after-war-changing-perceptions-of-post-conflict-rehabilitation/*
11. Post-war Reconstruction of Economy: Case Studies / KPMG-Ukraine. 2022. 70 p. URL: *https://assets.kpmg.com/content/dam/kpmg/ua/pdf/2023/01/post-war-reconstruction-of-economy-en.pdf*

12. Ukraine Relief and Reconstruction: Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: COM(2022) 233 final. 18.05.2022. URL: *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0233*
13. Relief, Recovery and Resilient Reconstruction: Supporting Ukraine's Immediate and Medium-Term Economic Needs. Informal approach paper by World Bank Group staff. Ministerial Roundtable for Support to Ukraine at IMF-World Bank Spring Meetings. 2022. 28 p. URL: *https://documents1.worldbank.org/curated/en/099608405122216371/pdf/IDU08c704e400de7a048930b8330494a329ab3ca.pdf*
14. Koczan Z., Chupilkin M. The economics of post-war recoveries and reconstructions. VOX. eu CEPR, 22 November 2022. URL: *https://cepr.org/voxeu/columns/economics-post-war-recoveries-and-reconstructions*
15. Research personnel and number of organisations. State Statistics Service of Ukraine. 2023. [In Ukrainian] URL: *https://ukrstat.gov.ua/operativ/operativ2005/ni/ind_rik/ind_u/2002.html*
16. Statistic year book of Ukraine 2020 / Editor: I.E. Verner. Kyiv, State Statistics Service of Ukraine. 2021. 453 pages. [In Ukrainian] URL: *https://ukrstat.gov.ua/druk/publicat/kat_u/2021/zb/11/Yearbook_2020.pdf*
17. Gaind N., Leverpool L.War shattered Ukrainian science — its rebirth is now taking shape. Nature. 22 June 2023. URL: *https://www.nature.com/articles/d41586-023-02031-8*
18. Gaind N., Abbott A., Witze A., Gibney E., Tollefson J., Aisling I., Van Noorden R. Seven ways the war in Ukraine is changing global science. Nature. 20 July 2022. URL: *https://www.nature.com/articles/d41586-022-01960-0*
19. Working groups. National Council for the Recovery of Ukraine from the War. Government portal. 2022. [In Ukrainian] URL: *https://www.kmu.gov.ua/diyalnist/nacionalna-rada-z-vidnovlennya-ukrayini-vid-naslidkiv-vijni/robochi-grupi*
20. Ukraine Recovery Plan. Online platform. 2023. URL: *https://recovery.gov.ua/*
21. The plan for the rapid recovery of Ukraine will provide for the prompt reconstruction of the social infrastructure destroyed by the Russian aggressor—Kyrylo Tymoshenko / President of Ukraine. Official presidential office online. 12 July 2022. URL: *https://www.president.gov.ua/news/plan-shvidkogo-vidnovlennya-ukrayini-peredbachatime-operativ-76433*
22. Ukraine Relief and Reconstruction / European Commission. July 2022. URL: *https://www.eeas.europa.eu/sites/default/files/documents/Factsheet_Ukraine_Relief_and_Reconstruction.pdf.pdf*
23. Becker T., Eichengreen B., Gorodnichenko Y., Guriev S., Johnson S., Mylovanov T., Rogoff K., Weder di Mauro B. A Blueprint for the Reconstruction of Ukraine. CEPR Press. 8 April 2022. URL: *https://cepr.org/system/files/2022-06/BlueprintReconstructionUkraine.pdf*
24. Ganster R., Kirkegaard J., Kleine-Brockhoff T., Stokes B. Designing Ukraine's Recovery in the Spirit of the Marshall Plan: Principles, Architecture, Financing, Accountability: Recommendations for Donor Countries September 2022. Washington, GMF. 44 p. URL: *https://www.gmfus.org/sites/default/files/2022-09/Designing%20Ukraine%E2%80%99s%20Recovery%20in%20the%20Spirit%20of%20the%20Marshall%20Plan_0.pdf*
25. Resilience, Recovery and Reconstruction 2023-2026. Council of Europe Action Plan for Ukraine / Council of Europe. 1452nd meeting, 14 December 2022. URL: *https://search.coe.int/cm/Pages/result_details.aspx?ObjectId=0900001680a96440*
26. Svyrydenko Yu. The world will see Ukraine that has ambition. Ekonomichna Pravda. 19 JUNE 2023. [In Ukrainian] URL: *https://www.epravda.com.ua/columns/2023/06/19/701238/*
27. Proposal for a Regulation of the European Parliament and of the Council on establishing the Ukrainian Facility / European Commission, COM(2023) 338 final. Brussels, 20.6.2023. URL: *https://neighbourhood-enlargement.ec.europa.eu/system/files/2023-06/*

COM_2023_338_1_EN_ACT_part1_v6.pdf

28. A New Ukraine Facility. Recovery, Reconstruction, Modernisation of Ukraine / European Commission. 2023. URL: *https://neighbourhood-enlargement.ec.europa.eu/system/files/2023-06/Ukraine-facility-11.pdf*
29. Green post-war recovery of Ukraine: Vision and Models. Analytical memo / Resource & Analysis Center "Society and Environment". August 2022. 32 pages. [In Ukrainian] URL: *https://www.rac.org.ua/uploads/content/658/files/zelene-vidnovlennyafinal.pdf*
30. Recovery and reconstruction of Ukraine's post-war economy. Academic report / National Academy of Science of Ukraine, State Institution "Institute of Economy and Forecasting of NASU". K., 2022. 305 pages. [In Ukrainian] URL: *http://ief.org.ua/wp-content/uploads/2022/12/Vidnovlennja-ta-reconstrukcsja-povojennoji-economiky.pdf*
31. Ukraine's Post-war Recovery Should Be Green / Ukrainian National Platform of the Eastern Partnership Civil Society Forum. 9 December 2022. 6 pages. [In Ukrainian] URL: *http://eap-csf.org.ua/wp-content/uploads/2022/12/Position-paper_UNP_2022_ua.pdf*
32. Study of Post-War Reconstruction Initiatives / ISAR Ednannia, Kyiv International Institute of Sociology. 2023. [In Ukrainian] URL: *https://ednannia.ua/images/Master_version_UKR_Rebuilding.pdf*
33. Ukraine's financing needs in 2023 and beyond: Multi-agency Donor Coordination Platform for Ukraine meets in Brussels. EU Neighbours East. September 27, 2023. URL: *https://euneighbourseast.eu/news/latest-news/ukraines-financing-needs-in-2023-and-beyond-multi-agency-donor-coordination-platform-for-ukraine-meets-in-brussels/*
34. Rudolph J., Eisen N. Donors Should Get Businesses to Invest in Ukraine by Committing to Muscular Reform Coordination. Alliance for Securing Democracy. May 22, 2023. URL: *https://securingdemocracy.gmfus.org/donors-ukraine-investment/*
35. Bedratenko O. Ukraine Well-Positioned for Post-War Recovery, Supporters Say. VOA. April 27, 2023. URL: *https://www.voanews.com/a/ukraine-well-positioned-for-post-war-recovery-despite-vast-destruction-supporters-say/7067764.html*
36. O'Driscoll D. Good Practice in Post-Conflict Reconstruction. University of Manchester. 02 November 2018. URL: *https://assets.publishing.service.gov.uk/media/5c6bdb23ed915d4a343cb9dd/494_Good_Practice_in_Post-Conflict_Reconstruction.pdf*
37. Manufacturing, value added (% of GDP) / The World Bank. 2023. URL: *https://data.worldbank.org/indicator/NV.IND.MANF.ZS*
38. Post-Conflict Economic Recovery: Enabling Local Ingenuity. UNDP. 2008. URL: *https://www.undp.org/sites/g/files/zskgke326/files/migration/tr/Post_Conflict_Economic_Recovery_Report.pdf*
39. On Sustainable Development Goals until 2030: Decree No.722/2019 of the President of Ukraine of 30 September 2019. [In Ukrainian] URL: *https://www.president.gov.ua/documents/7222019-29825*
40. On approval of the Regulations of the Cabinet of Ministers of Ukraine. CMU Resolution No.950 of 18 July 2007. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/950-2007-%D0%BF#Text*
41. Education and Science Recovery Plan (draft as of 03 August 2022) / Ministry of Education and Science of Ukraine 2022. [In Ukrainian] URL: *https://mon.gov.ua/storage/app/media/gromadske-obgovorennya/2022/08/19/HO.proyekt.Planu.vidnovl.Osv.i.nauky-19.08.2022.pdf*
42. Policy Briefs on Ukraine's Recovery / Ukraine Recovery Conference, 4-5 July 2022, Lugano, Switzerland. URL: *https://www.easybusiness.in.ua/media/ukraine-recovery-conference-2022-policy-brief/*
43. Radosevic S. Technology upgrading for economic growth of Ukraine: Policy Note. 2020. URL:

https://uploads-ssl.webflow.com/621f88db25fbf24758792dd8/64905e6c41ecae83932e62bb_Technology_upgrading_for_economic_growth_of_Ukraine_Radosevic_UCL.pdf
44. ERAC Report on the role of Research and Innovation in Ukraine's Recovery /Council of the European Union. Brussels, 2 June 2023. URL: https://data.consilium.europa.eu/doc/document/ST-10034-2023-INIT/en/pdf
45. Shatz H.J., Tarini G., Ries C.P., Dobbins J. Reconstructing Ukraine: Creating a Freer, More Prosperous, and Secure Future / RAND Corporation. 2023. URL: https://www.rand.org/content/dam/rand/pubs/research_reports/RRA2200/RRA2200-1/RAND_RRA2200-1.pdf
46. Holynska K., Balagna J., Marcinek K.The Trade-Offs of Ukraine's Recovery. Fighting for the Future / RAND Corporation. 2023. URL: https://www.rand.org/content/dam/rand/pubs/research_reports/RRA2300/RRA2370-1/RAND_RRA2370-1.pdf
47. Data and resources / International Organization for Migration (IOM). 2023. URL: https://ukraine.iom.int/uk/dani-ta-resursy
48. Experts to discuss how Ukraine could return refugees from abroad. Ukrinform. 10 August 2023. [In Ukrainian] URL: https://www.ukrinform.ua/rubric-society/3746791-eksperti-obgovorat-ak-ukraini-povernuti-bizenciv-zza-kordonu.html
49. Vinokurov Ya. Three million Ukrainians might not return home after war. What awaits economy? Ekonomichna Pravda. 11 September 2023. [In Ukrainian] URL: https://www.epravda.com.ua/publications/2023/09/11/704143/
50. Koshkina S. Ella Libanova: "Hopefully there would still be 30 million of us by 2035". LB.ua. 21 August 2023. [In Ukrainian] URL: https://lb.ua/news/2023/08/21/570946_ella_libanova_day_bozhe_shchob_2035.html
51. Birthrate in Ukraine declined by 28% during the war — Askionova. Ukrainske Radio. 11 September 2023. URL: http://www.nrcu.gov.ua/news.html?newsID=102216
52. Russian army is particularly zealous about destroying Ukrainian forests. Range and consequences. FreeДом. 15 September 2023. [In Ukrainian] URL: https://uatv.ua/uk/rosijska-armiya-z-osoblyvym-zavzyattyam-znyshhuye-ukrayinski-lisy-masshtaby-i-naslidky-video/
53. Total direct damages to the Ukrainian infrastructure caused by the war exceeded $150 billion, as of June 2023 / KSE. 2 August 2023. [In Ukrainian] URL: https://kse.ua/ua/about-the-school/news/zagalna-suma-pryamih-zbitkiv-zavdana-infrastrukturi-ukrayini-cherez-viynu-za-pidsumkami-chervnya-2023-roku-perevishhila-150-mlrd/
54. Goto R., Guerrero A.P.S., Speranza M., Fung D., Paul C., Skokauskas N. War is a public health emergency. The Lancet. 2022. Vol. 399, Issue 10332, P1302. DOI: https://doi.org/10.1016/S0140-6736(22)00479-2
55. Benjamine D. War and Public Health. Healthy Generations. 2007. Vol. 7, Issue 3. URL: https://mch.umn.edu/wp-content/uploads/2015/09/hg_april07.pdf
56. PTSD and chronic illnesses exacerbation. How the war will affect the Ukrainians' health. Slovo I Dilo. 1 November 2022. [In Ukrainian] URL: https://www.slovoidilo.ua/2022/11/01/infografika/suspilstvo/ptsr-ta-zahostrennya-xronichnyx-xvorob-yak-vijna-vplyne-zdorovya-ukrayincziv
57. Ukraine: First Review under the Extended Arrangement under the Extended Fund Facility – Press Release; Staff Report; Staff Statement; and Statement by the Executive Director for Ukraine / IMF Country Reports 23/248. July 2023. URL: https://doi.org/10.5089/9798400247224.002
58. Foreign direct investment, net (BoP, current US$) – Poland / The World Bank. 2023. URL: https://data.worldbank.org/indicator/BN.KLT.DINV.CD?locations=PL
59. Sluggish Growth, Rising Risks: Europe and Central Asia Economic Update. / World Bank Group. Fall 2023. 86 p. URL: https://bit.ly/ECA_EU_October_2023
60. Total damages to Ukrainian infrastructure caused by the war exceeded $150 billion –

KSE. Ukrinform. 03 August 2023. [In Ukrainian] URL: *https://www.ukrinform.ua/rubric-economy/3743725-zagalna-suma-zbitkiv-infrastrukturi-ukraini-vid-vijni-perevisila-150-milardiv-kse.html*

61. Howard J. The Latest Data on Confidence in Institutions (2023). Exploding Topics. January 13, 2023. URL: *https://explodingtopics.com/blog/trust-in-institutions#confidence-in-governments*
62. Cunha M. de C. Institutional Foundations of Trust: Sociolegal Perspectives. In Bachmann R., Zaheer A. (ed.). Handbook of trust research. Northampton, MA: Edward Elger, 2006. URL: *https://www.redalyc.org/journal/3509/350972599010/html/*
63. Corruption in Ukraine 2021: Understanding, Perception, Prevalence. Report based on population and business poll. K. 2021. [In Ukrainian] URL: *https://nazk.gov.ua/wp-content/uploads/2022/07/100948829996671044nacp_report_info_sapiens_2021_ukr_final_.pdf*
64. Industry (including construction), value added (% of GDP) – Ukraine / The World Bank. 2023. URL: *https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=UA*
65. High-technology exports (% of manufactured exports) – Ukraine / The World Bank. 2023. URL: *https://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS?end=2021&locations=UA&start=2011&view=chart*
66. Capital investments by types of economic activities in 2010–2022 / State Statistics Service of Ukraine. 2023. [In Ukrainian] URL: *https://www.ukrstat.gov.ua/operativ/operativ2021/ibd/kin/kin_rik/k_ed_10-21.xlsx*
67. Introducing innovations at industrial enterprises / State Statistics Service of Ukraine. 2023. [In Ukrainian] URL: *https://www.ukrstat.gov.ua/operativ/operativ2021/ni/vpr_ipp/vpr_ipp_20ue.xlsx*
68. Community Reintegration Forum was held in Zaporizhzhia / Zhytomyr Regional State Administration. Official website. 25 September 2023. [In Ukrainian] URL: *https://oda.zht.gov.ua/news/u-zaporizhzhi-vidbuvsya-forum-reintegratsiyi-gromad/*
69. Laschenko O. Reintegration of occupied Donbas in Ukraine: how long and at what price? Radio Svoboda. 05 November 2021. [In Ukrainian] URL: *https://www.radiosvoboda.org/a/reintehratsiya-donbas-ukrayina-rosiya/31548104.html*
70. Recovery and reconstruction of Ukraine / European Commission. 2023. URL: *https://eu-solidarity-ukraine.ec.europa.eu/eu-assistance-ukraine/recovery-and-reconstruction-ukraine_en*
71. Hordiichuk D. Ukraine presented a $750 billion recovery plan: what post-war recovery will look like. Ekonomichna Pravda. 4 July 2022. [In Ukrainian] URL: *https://www.epravda.com.ua/news/2022/07/4/688833/*
72. Ukraine Recovery Conference 21-22 June 2023, London, UK. URL: *https://ua.urc-international.com/urc-2023-info*
73. UAScience.Reload Project to support Ukrainian scientists. 2022. URL: *https://www.uascience-reload.org/wp-content/uploads/2022/07/UAS.R-Presentation-100-Days-Ukrainian-June-2022.pdf*
74. Zabaznova N., Yarmolovska A. Lviv scientists developed a hemostatic agent for Ukrainian military. Suspilne Novyny. 25 October 2022. [In Ukrainian] URL: *https://suspilne.media/302594-u-lvovi-rozrobili-krovospinnij-preparat-dla-ukrainskih-vijskovih*
75. Zaimenko N.V. Protection and restoration of soils in post-war period. Official Bulletin of the National Academy of Sciences of Ukraine. 2023. #5, p. 54-56. [In Ukrainian] URL: *https://visnyk-nanu.org.ua/ojs/index.php/v/article/view/3075/3091*
76. Lavryniuk L. Hardware bionic prosthetics from Ukraine. How Esper Bionics startup is preparing to provide roboarms of the future to Ukrainians. DOU. 24 August 2022. [In Ukrainian] URL: *https://dou.ua/lenta/interviews/bionic-prostheses-esper-bionics-for-ukrainians/*

77. Roboneer. Official website. 2023. URL: *https://roboneers.net/#about-us*
78. McMillion M. LinkedIn post. 10 October, 2023. URL: *https://www.linkedin.com/posts/activity-7116079587683377152-rk08?utm_source=share&utm_medium=member_desktop*
79. On approval of Strategy for the Development of Innovation Sphere Activities until 2030. CMU Order No.526-p of 10 July 2019. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/526-2019-%D1%80#Text*
80. Global Innovation Index 2022: Ukraine / WIPO. 2023. URL: *https://www.wipo.int/edocs/pubdocs/en/wipo_pub_2000_2022/ua.pdf*
81. On approval of an action plan for 2021–2023 to implement the Strategy for the Development of Innovation Sphere Activities until 2030. CMU Order No.1687-p of 09 December 2021. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/1687-2021-%D1%80#Text*
82. Vision of the future of education and science of Ukraine / Ministry of Education and Science of Ukraine. 2023. [In Ukrainian] URL: *https://mon.gov.ua/ua/viziya*
83. Oleksenko R.I., Ortina H.V. Shaping the innovation policy of the real sector of economy as a special area of development of Ukraine. Ekonomika I Suspilstvo. 2018. Issue #18. p. 173-180. [In Ukrainian] URL: *https://economyandsociety.in.ua/journals/18_ukr/24.pdf*
84. Ukrainian inventions that changed the world. UkraineNOW. 2023. URL: *https://ukraine.ua/invest-trade/ukrainian-inventions-that-changed-the-world/*
85. SmartNanotubes. Official web-page. 2023. URL: *https://smart-nanotubes.com/about-us/*
86. Firefly Aerospace.Official web-page. 2023. URl: *https://fireflyspace.com/*
87. Sila. Official web-page. 2023. URL: *https://www.silanano.com/*
88. Top Ukrainian unicorn companies. UCLUSTER. 2021. URL: *https://ucluster.org/shkola-startapiv/top-ukrainski-edynorogy/*
89. International Property Rights Index 2022: Ukraine / Property Rights Alliance. URL: *https://www.internationalpropertyrightsindex.org/country/ukraine*
90. Several matters of state attestation of scientific institutions. Order No.1008 of the Ministry of Education and Science of Ukraine of 17 September 2018. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/z1504-18#n19*
91. On approval of the Procedure of State Attestation of Scientific Institutions and Higher Education Institutions in the Part of Their Conduction of Academic (Scientific and Technical) Activities. Resolution No.540 of the Cabinet of Ministers of Ukraine of 19 July 2017. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/540-2017-%D0%BF#Text*
92. Shulikin D. Science Parks: When Do We Stop Putting Spokes in the Wheel? Svit newspaper, #33-34, September 2021. [In Ukrainian] URL: *https://svit.kpi.ua/2021/09/13/наукові-парки-чи-не-вийняти-палиці-з-ко/*
93. Perminova S.O., Chuprina M.O. Development of national innovative ecosystem in the context of interaction between science entities and businesses. Ekonomika ta suspilstvo, issue #38, 2022. [In Ukrainian] URL: *https://ela.kpi.ua/bitstream/123456789/48345/1/Development%20_of_the_national*
94. Several matters of drafting regional development strategies and action plans for their implementation and monitoring. CMU Resolution No.816 of 4 August 2023. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/816-2023-%D0%BF#Text*
95. Danylyshyn B. Structural reforms capable of changing Ukraine. Ekonomichna Pravda. 31 May 2022. [In Ukrainian] URL: *https://www.epravda.com.ua/columns/2022/05/31/687649/*
96. Input-Output table for Ukraine 2010 in main prices / State Statistics Service of Ukraine. 2012. [In Ukrainian] URL: *https://www.ukrstat.gov.ua/druk/publicat/kat_u/2012/05_2012/zb_tv_os_2010.zip*
97. Input-Output table for Ukraine 2019 in main prices / State Statistics Service of Ukraine. 2021. URL: *https://www.ukrstat.gov.ua/druk/publicat/kat_u/2021/zb/05/zb_tvv_2019.zip*

98. Input-Output-Tabelle (Revision 2019) – Inländische Produktion (Herstellungspreise): Deutschland, Jahre 2020. URL: Destatis. Genesis-Online. URL: *https://www-genesis.destatis.de/genesis/online?operation=abruftabelleBearbeiten&levelindex=1&levelid=1698170442212&auswahloperation=abruftabelleAuspraegungAuswaehlen&auswahlverzeichnis=ordnungsstruktur&auswahlziel=werteabruf&code=81511-0004&auswahltext=&werteabruf=Werteabruf#abreadcrumb*
99. Information on the National Academy of Sciences of Ukraine (as of 01 January 2023) / National Academy of Sciences of Ukraine. 2023. [In Ukrainian] URL: *https://www.nas.gov.ua/UA/About/Pages/information.aspx*
100. Tereschenko H.M., Londar L.P. Formation and usage of special monetary fund by higher education institutions in Ukraine. Education Analytics of Ukraine. 2020. #1 (8). p. 36-49. [In Ukrainian] URL: *https://science.iea.gov.ua/wp-content/uploads/2020/06/3_Tereshchenko_18_2020_36_49.pdf*
101. Bobrovska O.Yu. Organizational and management issues in preservation, development, and quality improvement of scientific potential of the country. Aspects of Public Governance. 2018. Book 6. ## 1-2. [In Ukrainian] URL: *https://aspects.org.ua/index.php/journal/article/download/374/369/*
102. Danylyshyn B. What problems does Ukrainian science have today? Glavkom. 20 May 2019. [In Ukrainian] URL: *https://glavcom.ua/columns/b_danilishyn/yaki-problemi-sogodni-maje-ukrajinska-nauka-594957.html*
103. Oleksiuk B. Optimisation of science sphere management. Foreign case studies and recommendations for Ukraine. 2019. Ukrainian Centre for European Policy NGO. URL: *https://ucep.org.ua/wp-content/uploads/2020/08/nauka_survey_UPD_FINAL.pdf*
104. Better Regulation Guidelines / European Commission. Commission Staff Working Document. SWD(2021) 305 final. Brussels, 3.11.2021. URL: *https://commission.europa.eu/system/files/2021-11/swd2021_305_en.pdf*
105. On the establishment of Expert Council for Preparation of Generalising Tax Advice at the Ministry of Finance of Ukraine. Order No.948 of the Ministry of Finance of Ukraine of 20 November 2017. [In Ukrainian] URL: *https://zakon.rada.gov.ua/rada/show/v0948201-17#Text*
106. Members of the Science Expert Council at the State Environmental Inspectorate of Ukraine. Approved by Order No.128 of the State Environmental Inspectorate of Ukraine of 19 September 2022. [In Ukrainian] URL: *https://www.dei.gov.ua/files/1663592870910272/%D0%A1%D0%BA%D0%BB%D0%B0%D0%B4%20%D0%B7%20%D0%BC%D0%B0%D1%80%D0%BA%D1%83%D0%B2%D0%B0%D0%BD%D0%BD%D1%8F%D0%BC%20.pdf*
107. On Committees of the Verkhovna Rada of Ukraine. Law of Ukraine No.116/95-BP of 04 April 1995. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/116/95-%E2%F0#Text*
108. On the Research Service of the Verkhovna Rada of Ukraine. Order No.438 of the Chairperson of the Verkhovna Rada of Ukraine of 11 August 2022. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/438/22-%D1%80%D0%B3#Text*
109. National Institute for Strategic Studies: About Us. Official website. 2023. URL: *https://niss.gov.ua/pro-instytut*
110. Central Research Institute of the Armed Forces of Ukraine / Wikipedia. URL: *https://uk.wikipedia.org/wiki/Центральний_науково-дослідний_інститут_Збройних_Сил_України*
111. Kyiv Scientific Research Institute of Forensic Expertise. Official webpage 2023. URL: *https://kndise.gov.ua/*
112. State Scientific Research Institute of the Ministry of Internal Affairs of Ukraine. Official webpage. 2023. URL: *https://dndi.mvs.gov.ua/*
113. Research Institute for Fiscal Policy of the State Tax University. Official webpage. 2023. [In

Ukrainian] URL: *https://dpu.edu.ua/ndi-fp*
114. Ukrainian Institute of Scientific and Technical Expertise and Information. Official webpage. 2023. URL: *http://www.uintei.kiev.ua/*
115. On Scientific and Technical Activities. Law of Ukraine No.848-VIII of 26 November 2015. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/848-19#Text*
116. Better regulation toolbox / European Commission. July 2023. URL: *https://commission.europa.eu/document/download/9c8d2189-8abd-4f29-84e9-abc843cc68e0_en?filename=BR%20toolbox%20-%20Jul%202023%20-%20FINAL.pdf*
117. On Lawmaking. Law of Ukraine No.3354-IX of 24 August 2023. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/3354-20#Text*
118. White paper as a public policy document. Policy Brief. Kyiv. European Information Research Centre. 2016. 4 pages. [In Ukrainian] URL: *https://infocenter.rada.gov.ua/uploads/documents/28870.pdf*
119. Ukraine, European Commission, and UNO to cooperate to reach SDGs through innovation and technology. Derzhzovnishinform State Enterprise. 09 March 2021. [In Ukrainian] URL: *https://dzi.gov.ua/press-centre/news/ukrayina-yevrokomisiya-ta-oon-spivpratsyuvatymut-dlya-dosyagnennya-tsilej-stalogo-rozvytku-za-dopomogoyu-innovatsij-ta-tehnologij/*
120. Number of employees involved in scientific research and development, by staff category, 2010-2020 / State Statistics Service of Ukraine. 2023. [In Ukrainian] URL: *https://www.ukrstat.gov.ua/operativ/operativ2021/ni/rik/kpzvndrkp_10_20_ue.xlsx*
121. Number of employees involved in scientific research and development, with an academic degree, 2010-2020 / State Statistics Service of Ukraine. 2023. [In Ukrainian] URL: *https://www.ukrstat.gov.ua/operativ/operativ2021/ni/rik/kpzvndrns_10_20_ue.xlsx*
122. Academic, scientific and technical activity in Ukraine in 2022. Scientific and analytical report / Ukrainian Institute of Scientific and Technical Expertise and Information. 2023. Kyiv. [In UKrainian] URL: *https://mon.gov.ua/storage/app/media/nauka/2023/07/25/Nauk-analit.dopov.Naukova.ta.nauk-tekhn.diyaln.v.Ukr.2022-25.07.2023.pdf*
123. Research Infrastructures in the European Research Area: A report by the ESF Member Organisation Forum on Research Infrastructures / European Science Foundation (ESF). March 2013. URL: *https://portal.meril.eu/meril/downloadFile?uuid=55ed930b-2898-4916-8c29-95370bde4b5e&name=mof_research_infrastructures.pdf*
124. Junior Academy of Sciences of Ukraine. Official webpage. 2023. URL: *https://man.gov.ua/about*
125. Science for Policy in Europe Conference "Building better science for policy ecosystems", 10-11 October 2023 / European Commission. 2023. URL: *https://science-for-policy-europe-conference.blumm.it/s4p-conference*
126. Edmonton Tech Wednesdays. Eventbrite. 2023. URL: *https://www.eventbrite.ca/e/edmonton-tech-wednesdays-tickets-662082084337*
127. Business representatives survey regarding innovation activities and relevant needs in R&D. Final report. / Ministry of Education and Science of Ukraine. 2020. 56 pages. [In Ukrainian] URL: *https://mon.gov.ua/storage/app/media/innovatsii-transfer-tehnologiy/2020/08/28.08/opituvannya-28-08-2020.pdf*
128. Open Innovation Platform OIP / Ukrainian Institute of Scientific and Technical Expertise and Information. 2023. [In Ukrainian] URL: *http://technology.ukrintei.ua/*
129. Science2Business / Ministry of Education and Science of Ukraine. 2023. URL: *https://s2b.nauka.gov.ua/about*
130. Nazovni.Tech. Official webpage. Ministry of Foreign Affairs of Ukraine. 2023. URL: *https://nazovni.tech/*
131. The New European Innovation Agenda / European Commission. 2023. URL: *https://*

research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/new-european-innovation-agenda_en#what-is-the-new-european-innovation-agenda

132. Regional Innovation Valleys calls for proposals are now open. European Innovation Council and SMEs Executive Agency (EISMEA). European Commission. 2023. URL: *https://eismea.ec.europa.eu/news/regional-innovation-valleys-calls-proposals-are-now-open-2023-05-17_en*
133. Excellence Hubs. European Research Executive Agency. European Commission. 2023. URL: *https://rea.ec.europa.eu/funding-and-grants/horizon-europe-widening-participation-and-spreading-excellence/excellence-hubs_en*
134. COST: About COST. Official web-page. 2023. URL: *https://www.cost.eu/about/cost-mission/*
135. Enterprise Europe Network Ukraine. Official webpage. 2023. URL: *http://eenukraine.com/uk*
136. SoftServe announced lecturer selection for the Education Grant project. National University Yuri Kondratyuk Poltava Polytechnic. 15 July 2021. [In Ukrainian] URL: *https://nupp.edu.ua/news/kompaniya-softserve-ogolosila-vidbir-vikladachiv-do-proektu-osvitni-granti.html*
137. "Horizon Europe: Grant Opportunities for Educators. Scientists are invited to participate in an online meeting. National University Yuri Kondratyuk Poltava Polytechnic. 14 February 2023. [In Ukrainian] URL: *https://nupp.edu.ua/news/programa-gorizont-evropa-naukovtsiv-zaproshuyut-vzyati-uchast-v-onlayn-zustrichi.html*
138. SoftServe Sustainability Report 2022. URL: *https://www.softserveinc.com/files/csr/softserve-corporate-social-responsibility-report-2022.pdf*
139. BioUkraine: US-Ukraine Foundation Biotech Initiative. Official webpage. 2023. URL: *https://bioukraine.org/*
140. Bohdan Hawrylyshyn Family Foundation. Official webpage. 2023. URL: *https://bhfamily.org/*
141. Fedir Shpyg Foundation. Official webpage. 2023. URL: *https://shpyg.foundation/*
142. Zavtra.UA. Scholarship Programme from Viktor Pinchuk Foundation. Official webpage. 2023. URL: *https://zavtra.in.ua/*
143. Korelova N. Law to enhance intellectual property rights protection entered into force. Details. LIGA ZAKON. 30 May 2023. [In Ukrainian] URL: *https://jurliga.ligazakon.net/news/219894_nabuv-chinnost-zakon-shchodo-posilennya-zakhistu-prav-ntelektualno-vlasnost-shcho-vstanovleno*
144. Intellectual property. Agreement Pulse: Monitoring of Measures Taken to Implement the Association Agreement. 2023. [In Ukrainian] URL: *https://pulse.kmu.gov.ua/ua/direction/intelektualna-vlasnist*
145. Pysarenko T.V., Kvasha T.K., Musina L.A., Paladchenko O.F., Molchanova I.V. State of innovative activities and measures taken in top priority areas of innovation during 2012-2021. Kyiv. UKRISTEI. 2023. [In Ukrainian] URL: *http://www.uintei.kiev.ua/sites/default/files/az_stan_innovaciynoyi_diyalnostiyi_2012-2021.pdf*
146. Anhel E. Innovations during wartime not relevant? Based on the results of New Monthly Survey of Enterprises, #NRES. 2023. [In Ukrainian] URL: *http://www.ier.com.ua/files/Projects/2023/TDF/NRES_Innovations_Anhel_22.05.2023.pdf*
147. Information and analytical memo on the impact of technology transfer on the financial status of enterprises, institutions, and organizations in 2021 / Ministry of Education and Science of Ukraine. 2023. [In Ukrainian] URL: *https://mon.gov.ua/storage/app/media/nauka/2022/Transefer.tekhnolohiy.2022/16.08.2022/Zvit.vplyv.na.finstan.u.2021.rotsi.sayt.MON-16.08.22.pdf*

148. Promising Scientific and Technical Developments of the National Academy of Science of Ukraine. Reference Book (2017, 2019, 2022) / National Academy of Science of Ukraine. 2023. [In Ukrainian] URL: *https://www.nas.gov.ua/RDOutput/UA/book2017/Pages/default.aspx*
149. Russian Aggression in Ukraine: How Do Ukrainian Startups Survive. Report / Polish-Ukrainian Startup Bridge. 2023. URL: *https://res2.weblium.site/res/5dc7e00190601300222 4f90e/64e08ece2c620c000e69ef44*
150. Dudko V., Neseniuk A. Over two dozen Ukrainian funds have only lost one startup during the great war. Forbes surveyed most active investors whether to expect for a new contract boom. Forbes. 07 July 2023. [In Ukrainian] URL: *https://forbes.ua/innovations/za-chas-velikoi-viyni-mayzhe-dva-desyatki-ukrainskikh-fondiv-vtratili-lishe-odin-startap-forbes-opitav-nayaktivnishikh-investoriv-chi-varto-teper-chekati-bumu-novikh-ugod-07072023-14666*
151. Ukraine: Hands-on support to recover and rebuild the Ukrainian innovation community / Startup Wise Guys. 2023. URL: *https://startupwiseguys.com/location/ukraine/*
152. DealBook of Ukraine. 2022 edition / AVentures. 2023. URL: *https://drive.google.com/file/d/11EsiNxGdSWQSgH8-v_UmaeC22qZlftas/view*
153. Open Innovation Laboratory / Kyiv Academic University. 2023. URL: *https://kau.org.ua/labinno*
154. Sikorsky Challenge Innovation System / National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Official webpage. URL: *https://kpi.ua/ecoino*
155. IP&I Hub—new tools to unleash the inventor potential. – Mykola Pototsky at StartUp—way to success / IP Office (Ukrainian National Office for Intellectual Property and Innovations). 25 September 2023. URL: *https://nipo.gov.ua/pototskyi-pro-ip-i-hub-startup-way-to-success/?fbclid=IwAR0oOkFNLJnfgBmqdP20glf0o2qkv2L3PMjQ16BypydPcHKRGZhRDjn-xHs*
156. *TISC. Official webpage. 2023. URL: https://tisc.nipo.gov.ua/index.html*
157. Information for ASFIMIR users / Ukrainian Institute of Scientific and Technical Expertise and Information. 2023. [In Ukrainian] URL: *http://www.uintei.kiev.ua/transfer/store/index.html*
158. UKRISTEI signed the Memorandum of Cooperation with UANIPIO / Ukrainian Institute of Scientific and Technical Expertise and Information. 2023. [In Ukrainian] URL: *http://www.uintei.kiev.ua/news/ukrintei-pidpysav-memorandum-pro-spivpracyu-z-ukrnoivi*
159. Invention activities at scientific institutions / Edited by Yu.M. Kapitsa; team of authors: Yu.M. Kapitsa. T.H. Kossko, D.S. Makhnovskyi, I.I. Khomenko, N.I. Aralova, M.P. Turov: Academic and practical literature publishing, Kyiv: Logos, 2021. 455 pages. [In Ukrainian] URL: *https://ipr.nas.gov.ua/wp-content/uploads/2021/01/Vynakhidnytska_Diialnist_v_Naukovykh_Ustanovakh_2021.pdf*
160. Measuring the Science and Engineering Enterprise. Priorities for the Division of Science Resources Studies. National Research Council. 2000. 160 p. URL: *https://nap.nationalacademies.org/read/9775/chapter/1#ii*
161. On the amount of funding for basic and applied research and scientific and technical (experimental) developments carried out by higher education institutions and scientific institutions subordinate to the Ministry of Education and Science of Ukraine, and financial support for scientific facilities of national importance for 2023 under KPKVK classifier 2201040 for expenditure and local budget crediting: Order No.20 of the Ministry of Education and Science of Ukraine of 11 January 2023. [In Ukrainian] URL: *https://zakon.rada.gov.ua/rada/show/v0020729-23#Text*
162. On the amount of funding for scientific research and development and financial support for scientific facilities of national importance for 2022, under KPKVK classifier 2201040 for expenditure and local budget crediting: Order No.50 of the Ministry of Education and Science

of Ukraine of 21 February 2022. [In Ukrainian] URL: *https://mon.gov.ua/storage/app/uploads/public/61f/166/8d1/61f1668d132a9236334134.pdf*

163. Research and development expenditure (% of GDP) – Ukraine / The World Bank. 2023. URL: *https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=UA&view=chart*
164. Research and development expenditure (% of GDP) – Romania / The World Bank. 2023. URL: *https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=RO&view=chart*
165. Research and development expenditure (% of GDP) – Poland / The World Bank. 2023. URL: *https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=PL&view=chart*
166. Magee R. Young researchers in Ukraine say they are struggling financially. Research Professional News. 24 Jul 2023. URL: *https://www.researchprofessionalnews.com/rr-news-europe-other-nations-2023-7-young-researchers-in-ukraine-say-they-are-struggling-financially/*
167. On top priority areas for the development of science and technology. Law of Ukraine No.2623-III of 11 July 2001. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/2623-14#Text*
168. On top priority areas of innovation activity: Law of Ukraine No.3715-VI of 08 September 2011. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/3715-17#Text*
169. Deutsche Forschungsgemeinschaft (DFG). Official webpage. 2023. URL: *https://www.dfg.de/en/dfg_profile/about_the_dfg/what_is_the_dfg/index.html*
170. NRFU reports. 2023. [In Ukrainian] URL: *https://nrfu.org.ua/about-us/zvity-nfdu_1/*
171. On the State Budget of Ukraine for 2022. Law o Ukraine No.1928-IX of 02 December 2021. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/1928-20#Text*
172. On the State Budget of Ukraine for 2023. Law of Ukraine No.2710-IX of 03 November 2022. [In Ukrainian] URL: *https://zakon.rada.gov.ua/laws/show/2710-20#Text*
173. Verkhovna Rada approved the state budget of Ukraine for 2023 / National Research Foundation of Ukraine. 2023. [In Ukrainian] URL: *https://nrfu.org.ua/news/verhovna-rada-uhvalyla-derzhavnyj-byudzhet-ukrayiny-na-2023-rik/*
174. Fundraising Strategy of the National Research Foundation of Ukraine for 2022-2024. [In Ukrainian] URL: *https://nrfu.org.ua/wp-content/uploads/2022/08/strategiya_fandrezyng_stysla_versiya-1.pdf*
175. 4 years of Foundation operations: key results / USF. 11 July 2023. [In Ukrainian] URL: *https://usf.com.ua/4-roki-diyalnosti-usf/*
176. Dziuba O. Kartashov, Chairman of Startup Foundation: “We are going to renew the $25,000–$50,000 investment programme”. Dev.ua. 10 August 2023. [In Ukrainian] URL: *https://dev.ua/news/holova-fondu-startapiv-kartashov-zaraz-my-vidnovymo-prohramu-z-investytsii-v-25-000-50-000#comments*
177. The Horizon Europe structure / Bavarian Research Alliance. 2023. URL: *https://www.bayfor.org/en/eu-funding/horizon-europe/structure.html*
178. R&I Country Profile. Participation in Programmes. 2023. URL: *https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/1213b8cd-3ebe-4730-b0f5-fa4e326df2e2/sheet/d23bba31-e385-4cc0-975e-a67059972142/state/analysis*
179. Nature: Recovery of Ukrainian science cannot wait. Where do we start? / EuroOsvita. 22 February 2023. [In Ukrainian] URL: *https://euroosvita.net/index.php/?category=1&id=7786*
180. Financial procedure for Horizon Europe and Erasmus+ project coordinators simplified / Ministry of Education and Science of Ukraine. 2022. [In Ukrainian] URL: *https://mon.gov.ua/ua/news/sprosheno-finansovi-proceduri-dlya-koordinatoriv-proyektiv-program-gorizont-yevropa-ta-erazmus*
181. Austria Country Profile. The Strategic Use of Public Procurement for Innovation in the Digital Economy. Smart # 2016/0040 / European Commission. 2016. URL: *https://ec.europa.*

eu/newsroom/dae/document.cfm?doc_id=70289

182. Benchmarking of innovation procurement investments and policy frameworks across Europe / European Commission. 2023. URL: *https://digital-strategy.ec.europa.eu/en/library/benchmarking-innovation-procurement-investments-and-policy-frameworks-across-europe*
183. Scale Up with the Public Sector. A brochure for start-ups / European Commission. 2023. URL: *https://ec.europa.eu/docsroom/documents/54276/attachments/1/translations/en/renditions/native*
184. Public Procurement of Innovation: how do start-ups fit in. A brochure for public buyers / European Commission. 2023. URL: *https://ec.europa.eu/docsroom/documents/54254/attachments/1/translations/en/renditions/native*
185. Agrawal A.K., Catalini C., Goldfarb A. Some simple economics of crowdfunding In: Lerner J, Stern S, editors. Innovation Policy and the Economy. 14: National Bureau of Economic Research. 2014. pp. 63–97
186. Wilson M.A. Crowdfunding science. Genome Biol. 2019. Vol. 20. DOI: 10.1186/s13059-019-1864-3
187. Sauermann H., Franzoni C., Shafi K. Crowdfunding scientific research: Descriptive insights and correlates of funding success. PLoS One. 2019. Vol. 14(1). DOI: *https://doi.org/10.1371/journal.pone.0208384*
188. Welcome to the Snyder Lab / Stanford Medicine. 2023. URL: *https://med.stanford.edu/snyderlab.html*
189. Science, Technology and Innovation. Information on Data / Eurostat. 2023. URL: *https://ec.europa.eu/eurostat/web/science-technology-innovation/information-data#Available%20breakdowns*
190. OECD bodies and standards / Ministry of Education and Science of Ukraine. 2023. URL: *https://mon.gov.ua/ua/nauka/yevrointegraciya/standarti-ta-proyekti-oesr/organi-ta-standarti-oesr*
191. Supporting and connecting policymaking in the Member States with scientific research. Communication Staff Working Document. SWD(2022) 346 final / European Commission. Brussels, 25.10.2022. URL: *https://knowledge4policy.ec.europa.eu/sites/default/files/SWD_2022_346_final.PDF*
192. Innovation procurements in Ukraine. Public consultation. Analytical report / Committee of the Verkhovna Rada of Ukraine. Kyiv. 2021. 17 pages. [In Ukrainian] URL: *https://ag.com.ua/upload/0050784001623748846.pdf*
193. Guidance on Innovation Procurement. Commission Notice. C(2021) 4320 final / European Commission. Brussels, 18.6.2021. URL: *https://ec.europa.eu/docsroom/documents/45975/attachments/1/translations/en/renditions/native*
194. FAQ: What is the EU Taxonomy and how will it work in practice? / European Commission. 2021. URL: *https://finance.ec.europa.eu/system/files/2021-04/sustainable-finance-taxonomy-faq_en.pdf*
195. Diia.City. Official webpage. 2023. URL: *https://city.diia.gov.ua/*
196. European Association of Research Managers and Administrators (EARMA). Official webpage. 2023. URL: *https://earma.org/about*

ANNEX A. Expert Interview Questions

1. Type of organization you represent:
    a) Central government body
    b) Verkhovna Rada of Ukraine
    c) Business entity
    d) Research institution
    e) Higher education institution
    f) Local government body
    g) Other

2. Your position in the organization:
    a) Director/CEO
    b) CEO's Advisor
    c) Deputy Director
    d) Member of parliament
    e) Department/unit manager
    f) Specialist/Researcher
    g) Other

3. Education/academic degree:
    a) Higher
    b) Candidate of sciences
    c) PhD
    d) Other (provide your answer).

4. In your opinion, what influences the efficiency of scientific activity? Rate them by degree of importance:
    a) Availability of modern equipment/ infrastructure for research
    b) Knowledge of foreign languages by researchers
    c) Remuneration (salary) of a researcher/ scientist
    d) Usage of modern methods of research management
    e) Internal motivation scientists to work
    f) Research culture level in the organization (academic integrity, academic freedom, research methodology, and more)
    g) Atmosphere in the research team, organizational culture
    h) Involvement of research teams in international cooperation
    i) Scientific personnel training system

5. Is there anything that should be changed to make a researcher's work in Ukraine prestigious? What do you think should be changed?

6. Do you think the following phenomena are common for the Ukrainian science:
    a) using official powers, position or related opportunities to obtain unlawful benefits for oneself or other persons;
    b) using state or municipal property in

private interests;

c) a person receiving gifts in connection with the performance of activities related to the performance of state functions from a person subordinate to such recipient;

d) conflict of interest (inducing subordinates in any way to make decisions, commit actions or omissions in favour of their private interests or private interests of third parties);

e) violation of ethical behaviour rules;

f) a person illegally discloses or otherwise uses for his/her own benefit information that became known to the person in connection with the performance of official duties.

7. What key instruments do you think should be used to fund science in Ukraine?

a) Direct budget funding of research institutions and HEIs

b) Competitive budget funding

c) Public contracts

d) Donor funds from foreign and international organisations

e) Funds of enterprises and organisations (provision of scientific services)

f) Investments (venture capital, state investments)

g) Grant programmes

h) Other (provide your answer)

8. In your opinion, what place does science have in Ukraine today?

9. Do you need to contact scientific/educational institutions or scientists in the course of your professional activities (for instance, during performance of your official duties)? If so, how often and with what questions do you contact them? If you have such interaction, how effective do you think it is?

10. If you have personal experience of research, please describe it. What was positive and negative about it? Is this experience useful in your further activities?

11. How effective is the personal development system for scientists in Ukraine? What needs to be done to improve it?

12. Does the State need to set priorities for the development of science and technology? If so, what should be the basis for these priorities? Who should formulate a request for these priorities?

13. What should be changed in the research and innovation system to improve its efficiency?

14. What changes are needed in the mechanism of science management at the state/national level? Please explain.

15. What tasks do you see for science in the post-war recovery of Ukraine?

16. Should scientific activity result in an innovation and a product? What does science lack for this today?

17. How would you describe the state of innovation in Ukraine, specifically knowledge-intensive innovation?

18. What form of partnership between science and business can be established?

19. What kind of science specialists will be most in demand for post-war recovery?

20. Which countries' experience, if you know any, should be used for the development of science in Ukraine?

21. Are you familiar with the problems in the functioning of the research infrastructure during the full-scale war and before it?

22. How do you feel about the idea of establishing and developing a network of national sectoral research infrastructure centres at the leading HEIs/SIs with access to them based on best practices?

23. What recommendations do you have to improve the system of research infrastructures?

In particular, regarding the legal framework that regulates its formation and use?

24. Are you familiar with international programmes that support the development of research infrastructure? What are the prospects for research and cooperation with other countries in the context of restoring research infrastructures? How do you plan to interact with international organisations, foundations, and foreign universities to receive aid and support in the process of restoring research infrastructure?

ANNEX B

The development of strategic and programme documents in Ukraine is regulated by special legislative acts.

The CMU Regulations contain requirements for the content and structure of the CMU programme and planning documents (see Table A.1).

Table A.1. Types of documents developed by the Cabinet of Ministers of Ukraine

Programme documents	Planning documents
The Programme of Activities of the Cabinet of Ministers (outlines the strategy of the Government)	Medium-term action plan of the Government (for three years))
Development strategies for the relevant areas (defines the course of policymaking and implementation in the relevant areas for the medium or long term)	Government Priority Action Plan (for no more than one year)
State targeted programmes	

According to the information from the Secretariat of the Cabinet of Ministers provided at Inquiry No. 1/10-2-91-2023[11], of 16 March 2023, "the issue of development and implementation of programme (strategic) documents is regulated, inter alia, by the Laws of Ukraine On State Targeted Programmes, On State Forecasting and Development of Programmes for Economic and Social Development of Ukraine, Article 11 of the Law of Ukraine On the Cabinet of Ministers of Ukraine and paragraphs 5, 51, 56–58 of the Regulations of the Cabinet of Ministers of Ukraine approved by Resolution No.950 of the Cabinet of Ministers of 18 July 2007 (as amended) intended to regulate issues in certain areas of state policy".

At the same time, no hierarchical subordination between documents is actually established.

For example, the following hierarchy of programme documents is used in the information sector: Doctrine → Concept → Strategy → Programme → Plan (see document of National Institute for Strategic Studies[12]).

Another hierarchy of documents used quite often is Concept → Strategy → Programme→ Plan or Concept → Plan or Strategy → Plan[13].

Most strategic documents are approved by resolutions and orders of the Cabinet of Ministers of Ukraine.

There are strategic documents adopted by laws of the Verkhovna Rada, in particular, the Law of Ukraine On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine until 2030, the Law of Ukraine On the National Informatisation Programme, the Law

[11] Letter No.7713/0/2-23 of Deputy State Secretary of the Cabinet of Ministers of Ukraine of 31 March 2023. [In Ukrainian] URL: *https://dostup.pravda.com.ua/request/109904/response/374667/attach/3/.pdf?cookie_passthrough=1*

[12] Structure of Public Policy Guiding Documents in the Information Sphere: Urgent Problems and Regulation Ways. Briefing note. 04.10.2011. [In Ukrainian] URL: *https://niss.gov.ua/doslidzhennya/informaciyni-strategii/struktura-kerivnikh-dokumentiv-derzhavnoi-politiki-v*

[13] For example, there are several documents in the area of gender equality, such as the Concept of Communication in the Area of Gender Equality, the State Strategy for Ensuring Equal Rights and Opportunities for Women and Men until 2030, the Strategy for Implementing Gender Equality in Education until 2030, the State Social Programme for Preventing and Combating Domestic and Gender-based Violence until 2025, and action plans for their implementation.

of Ukraine On the State Programme of Aviation Security for Civil Aviation. A considerable number of strategic documents are adopted by the NSDC and approved by decrees of the President of Ukraine (National Security Strategy of Ukraine, Biosafety and Biological Protection Strategy, Cybersecurity Strategy of Ukraine, Communication Strategy on Ukraine's Euro-Atlantic Integration until 2025, and more.) Accordingly, their development as a draft law is carried out pursuant to the Rules of Procedure of the Verkhovna Rada.

The Law of Ukraine On State Forecasting and Development of Programmes for Economic and Social Development of Ukraine contains provisions on the use of principles correlated with the EU concept of evidence in forecasting and strategy-making, namely the following principles:

- objectivity—forecast and programme documents for economic and social development are prepared on the basis of data from state statistics bodies, CEBs that shape and implement public policy in economic and social development, other central and local executive authorities, local governments, and report data from official publications of the National Bank of Ukraine);
- scientific approach — development of forecasting and programme documents for economic and social development on a scientific basis, continuous improvement of methodology and use of global experience in forecasting and developing economic and social development programmes.

Forecasting should be based on powerful analytics. The composition of the analysis elements, as regulated by this law, enables consideration of forecasting documents as a basis for white papers in line with the European approach. The law also stipulates the need to introduce modern technologies for forecasting socio-economic processes into practice.

ANNEX C. Information on relevant international projects involving Ukrainian HEIs and SIs to be published in a centralised knowledge base (on the portal)

##	Name of project	Programme / Competition	Link to project description	Participants from Ukraine	Possible areas of introduction
Food industry, agriculture, water resources, natural ecosystems					
1.	FUSILLI Fostering the Urban food System Transformation through Innovative Living Labs Implementation	Horizon 2020 *CE-FNR-07-2020 – FOOD 2030 – Empowering cities as agents of food system transformation*	*https://cordis.europa.eu/project/id/101000717*	V. N. Karazin Kharkiv National University, KHARKIVSKA MISKA RADA	Food industry, smart and carbon-neutral cities
2.	RoBUTCHER A Robust, Flexible and Scalable Cognitive Robotics Platform	Horizon 2020 *ICT-10-2019-2020 – Robotics Core Technology*	*https://cordis.europa.eu/project/id/871631*	LLC SIKLUM	Information and communication technologies, artificial intelligence, robotic technologies
3.	MyToolBox	Horizon 2020 *SFS-13-2015 – Biological contamination of crops and the food chain*	*https://cordis.europa.eu/project/id/678012*	AGRO LV LIMITED	Food industry
4.	ClieNFarms Climate Neutral Farms	Horizon 2020 *LC-GD-6-1-2020 – Testing and demonstrating systemic innovations in support of the Farm-to-Fork Strategy*	*https://cordis.europa.eu/project/id/101036822*	LIMITED LIABILITY COMPANY NESTLE UKRAINE	European Green Deal
5.	AGROinLOG Demonstration of innovative integrated biomass logistics centres for the Agro-industry sector in Europe	Horizon 2020 *RUR-08-2016 – Demonstration of integrated logistics centres for food and non-food applications*	*https://cordis.europa.eu/project/id/727961*	ASSOCIATION UKRAINIAN AGRIBUSINESSCLUB	Використання біомаси
6.	InnoVar Next generation variety testing for improved cropping on European farmland	Horizon 2020 *SFS-29-2018 – Innovations in plant variety testing*	*https://cordis.europa.eu/project/id/818144*	LIMITED LIABILITY COMPANY AGROSCOPEINTERNATIONAL	New plant sorts, adaptation to climate change, biotechnologies, AI

##	Name of project	Programme / Competition	Link to project description	Participants from Ukraine	Possible areas of introduction
7.	IMBIO Innovative Manure Biofertilizers	Horizon 2020 *SMEInst-07-2016-2017 – Stimulating the innovation potential of SMEs for sustainable and competitive agriculture, forestry, agri-food and bio-based sectors*	*https://cordis.europa.eu/project/id/807017*	LIMITED LIABILITY COMPANY INTEGRO-SD	Biotechnologies, fertilizer production, organic production
8.	MAGIC Marginal lands for Growing Industrial Crops: Turning a burden into an opportunity	Horizon 2020 *RUR-07-2016 – Resource-efficient and profitable industrial crops on marginal land*	*https://cordis.europa.eu/project/id/727698*	INSTITUTE OF BIOENERGY CROPS AND SUGAR BEET NATIONAL ACADEMY OF AGRARIAN SCIENCES OF UKRAINE	Industrial plant sorts, bioeconomics, bioenergy, land restoration
9.	RURACTIVE Empowering rural communities to act for change	Horizon Europe *HORIZON-CL6-2022-COMMUNITIES-02-01-two-stage – Smart solutions for smart rural communities: empowering rural communities and smart villages to innovate for societal change*	*https://cordis.europa.eu/project/id/101084377*	FORZA AGENCY FOR SUSTAINABLE DEVELOPMENT OF THE CARPATHIAN REGION NONPROFIT ORGANIZATION	Development of countryside and community areas, digital and green transformation
10.	UP_running Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal	Horizon 2020 *LCE-14-2015 – Market uptake of existing and emerging sustainable bioenergy*	*https://cordis.europa.eu/project/id/691748*	NAUKOVO-TEHNICHNII CENTAR BIOMASA LLC, ASSOCIATION UKRAINIAN AGRIBUSINESSCLUB	Biomass utilizing, bioenergy, forestry
11.	ROSEWOOD4.0 EU NETWORK OF REGIONS ON SUSTAINABLE WOOD MOBILISATION READY FOR DIGITALISATION	Horizon 2020 *RUR-15-2018-2019-2020 – Thematic networks compiling knowledge ready for practice*	*https://cordis.europa.eu/project/id/862681*	FORZA AGENCY FOR SUSTAINABLE DEVELOPMENT OF THE CARPATHIAN REGION NONPROFIT ORGANIZATION	Value added chains for wood production, forest management, IT
12.	OTTERS Social Transformation for Water Stewardship through Scaling Up Citizen Science	Horizon Europe *HORIZON-MISS-2021-OCEAN-05-03 – Piloting citizen science in marine and freshwater domains*	*https://cordis.europa.eu/project/id/101094041*	ODESKIY NACIONALNIY UNIVERSITET IMENI I.I. MECHNIKOVA	Water ecosystems, sustainable water consumption, data management, citizen science

##	Name of project	Programme / Competition	Link to project description	Participants from Ukraine	Possible areas of introduction
13.	AGROSUS Agroecological strategies for sustainable weed management in key European crops	Horizon Europe *HORIZON-CL6-2022-FARM2FORK-02-01-two-stage – Agroecological approaches for sustainable weed management*	*https://cordis.europa.eu/project/id/101084084*	POLISSIA NATIONAL UNIVERSITY	Sustainable agriculture, agroecology, methods and instruments of plant protection in various natural and climatic zones
Technologies and equipment, new materials, medical and environmental product design					
14.	DiCoMI Directional Composites through Manufacturing Innovation	Horizon 2020 *MSCA-RISE-2017 – Research and Innovation Staff Exchange*	*https://cordis.europa.eu/project/id/778068*	NATIONAL AEROSPACE UNIVERSITY KHARKIV AVIATION INSTITUTE NAMED BY N ZUKOVSKIY, LIMITED LIABILITY COMPANY CARBOLINE	New materials
15.	ENGIMA Engineering of Nanostructures with Giant Magneto-Piezoelectric and Multicaloric Functionalities	Horizon 2020 *MSCA-RISE-2017 – Research and Innovation Staff Exchange*	*https://cordis.europa.eu/project/id/778072*	NANOTECHCENTER LLC	New materials, electronics
16.	MELON Memristive and multiferroic materials for emergent logic units in nanoelectronics	Horizon 2020 *MSCA-RISE-2019 – Research and Innovation Staff Exchange*	*https://cordis.europa.eu/project/id/872631*	NANOTECHCENTER LLC	New materials, electronics
17.	SOMPATY Spectral Optimization: From Mathematics to Physics and Advanced Technology	Horizon 2020 *MSCA-RISE-2019 – Research and Innovation Staff Exchange*	*https://cordis.europa.eu/project/id/873071*	INSTITUTE OF MATHEMATICS OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE	New materials, electronics
18.	IMAGE Innovative Optical/ Quasioptical Technologies and Nano Engineering of Anisotropic Materials for Creating Active Cells with Substantially Improved Energy Efficiency	Horizon 2020 *MSCA-RISE-2017 – Research and Innovation Staff Exchange*	*https://cordis.europa.eu/project/id/778156*	LVIV POLYTECHNIC NATIONAL UNIVERSITY, SCIENTIFIC RESEARCH COMPANY ELECTRON-CARAT BRANCH OF PRIVATE JOINT STOCK COMPANY CONCERN-ELECTRON, PRIVATE ENTERPRISE SOFTPARTNERS	New materials

##	Name of project	Programme / Competition	Link to project description	Participants from Ukraine	Possible areas of introduction
19.	TeraHertz Novel Technologies and Materials for TeraHertz Radiation Control	Horizon Europe *HORIZON-MSCA-2021-SE-01-01 – MSCA Staff Exchanges 2021*	*https://cordis.europa.eu/project/id/101086493*	LVIV POLYTECHNIC NATIONAL UNIVERSITY, SCIENTIFIC RESEARCH COMPANY ELECTRON-CARAT BRANCH OF PRIVATE JOINT STOCK COMPANY CONCERN-ELECTRON, PRIVATE ENTERPRISE SOFTPARTNERS	New materials
20.	TWISMA Twinning with ISMA to develop innovative calorimeters for high energy physics based upon advanced scintillation materials	Horizon Europe *HORIZON-WIDERA-2021 – ACCESS-03-01 – Twinning*	*https://cordis.europa.eu/project/id/101078960*	SCIENTIFIC CENTRE FOR AEROSPACE RESEARCH OF THE EARTH OF THE INSTITUTE OF GEOLOGICAL SCIENCES OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE, LIMITED LIABILITY COMPANY ECOMM CO	Quantum technologies, energy
21.	BIONANOSENS Deeping collaboration on novel biomolecular electronics based on “smart” nanomaterials	Horizon 2020 *WIDESPREAD-05-2020 – Twinning*	*https://cordis.europa.eu/project/id/951887*	INSTYTUT MOLEKULYARNOI BIOLOGII I GENETYKY NAN UKRAINY	Biotechnologies, sensors, ecology, food industry, medical sphere

!!!