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Scientific Reboot After the War

White Paper

March 2023

Project: Science at Risk

scienceatrisk.org



The project is supported by Press, Education and
Culture Department of the US Embassy in Ukraine

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Summary

This analysis contains a forecast of the development of science in Ukraine till 2033 taking into account the change of the situation during 2022 and all the risks and uncertainties caused by the russian invasion of Ukraine. The analytical team working on this report includes scientists from the NASU, university professors and independent researchers that represent different spheres of knowledge and have different scientific experience, from masters to doctors of sciences.

They offer a number of practical steps to reboot the system of scientific research in Ukraine that can be applied fully or partially in 2023–2024, among them:

1. Strengthening the role and quality of competitive grant financing of science.
2. Systemic development of international collaboration.
3. Improvement of management in the system of national science academies.
4. Ensuring autonomy and academic freedom for universities and their research departments.
5. Development of criteria and methods of evaluation of scientific work in every sphere.
6. Creation and maintenance of a cluster of security studies.
7. Decolonization of research.
8. Battling corruption and academic dishonesty in the academic system.
9. Evaluation of the damage caused by the russian aggression.
10. Activation of engagement of the public and businesses with the academic system.

Despite the full reboot of science is possible only after the end of the hot phase of the war, it has to be prepared in advance.

Introduction

After the war, Ukraine will face a lot of challenges, the need to reboot the scientific system in the country being one of them.

The war has left a noticeable mark on the Ukrainian scientific sphere. The main consequences are:

Loss of scientists: the war has led to the loss of many scientists who were either forced to leave the country or died because of the war. This reduces the scientific potential of Ukraine and leads to the loss of valuable knowledge and experience.

Destruction of the infrastructure: the war has led to the destruction of the scientific infrastructure (laboratories, scientific centers and other facilities). This reduces the possibilities of doing scientific research and leads to delays in the development of new technologies.

Decrease in funding: the war has led to decreased scientific research funding in Ukraine. Lack of funding became the reason for insufficient provision of resources for the scientific sphere, which were needed to do research.

Decrease of international collaboration: the war has decreased possibilities of international cooperation in science, as scientists can travel less and therefore are restricted in their communication with foreign colleagues.

In these difficult circumstances, a great effort is needed to support and develop science in Ukraine.

Lack of important knowledge often costs us more than funding relevant research in time. The countries that rank among the richest in the world invest at least 2% of their GDP into research and development¹. Lack of qualified professionals leads to more losses than it costs to teach qualified scientific and pedagogical personnel, both practitioners and theorists. Scientific advances are the key requirement for the sustainable development of society. We should form and maintain the view of science as an important resource in the modern world that affects public wealth and well-being and is the key to the post-war rebuilding of the economy.

1 <https://data.worldbank.org/country/UA>

This analysis contains a forecast of the development of science in Ukraine till 2033 taking into account the change of the situation during 2022 and all the risks and uncertainties caused by the russian invasion of Ukraine.

The document is created for the officials who can influence state policies connected to the scientific, technological and pedagogical sphere, research and personnel training. International and foreign organizations that are currently undertaking or are planning to undertake any scientific collaboration with Ukraine, managers of scientific organizations, institutions and universities, researchers and pedagogues are also the target audience.

Research methodology

An expert group was formed to prepare this document based on competition. It includes scientists who work in the academic system, higher education, and independent researchers; they represent different branches of knowledge and have either a Ph. D. or a Doctor of Sciences.

The group has analyzed the sources, including analytical documents of international institutions, Ukrainian governmental and Ukrainian scientific institutions, publications in international peer-reviewed journals and academic publications of the group members.

The focus-group method was used to form a general vision of the development of Ukrainian science till 2033 and a more detailed vision for 2023–2024; possible scenarios of development were outlined. The focus group was balanced by age, gender and workplace of the scientists.

To clarify a number of issues, experts were inquired about their experience in international collaboration, getting basic or grant funding, management of scientific institutions and personnel training, which wasn't reflected in enough detail in the available sources.

Based on the established facts and possible scenarios, complex practical solutions are proposed.

Current state of science in Ukraine

The state of Ukrainian science was dire enough even before the full-scale russian invasion in 2022. Statistical data shows a decline in the number of researchers² with, at the same time, the number of scientific positions only formally staying largely the same; many other researchers were working part-time. The decline in the funding of science is a long-term tendency. International experts mark the relatively low innovation potential of the Ukrainian economy, low spending on *R&D* in the state and private sectors as one of the reasons (*GERD*, general national spending on *R&D*)³ — 0.41% of GDP in 2020. Local advances and even leadership in separate spheres were combined with stagnation and imitation of scientific work in others. General evaluation of the state of Ukrainian science has to be combined with evaluations in separate branches; they have to be made by expert communities. In separate branches, it was possible to form a consensus about the acceptability and importance of the international scientific indices. Other professional communities, including in humanities, are in favor of creating national indices; some authors believe that quantitative evaluation methods, including international publications only may be detrimental to their branches. Objective evaluation of the work results of these communities has to be made with the involvement of independent international experts⁴.

In 2022, a group of security risks appeared that are directly connected to the russian aggression. These are violence against Ukrainian citizens, forced migration, occupation of territories. They also include hindering education and scientific work through destruction of the research infrastructure, shelling, and technological challenges.

Nonetheless, most of the problems created by the full-scale russian aggression in 2022 only aggravate the existing problems.

In 2022, the brain drain problem deepened, with scientists and youth emigrating on a bigger scale instead of engaging with the Ukrainian academic system. We consider the data about the Ukrainian population declining by 6.7 million people in 2022 and the forecast of its decline by 24–33% in the consequence of the war to be reliable⁵. Ella Libanova, director of the NASU Institute for Demography and Social Sciences, estimates that considering current tendencies of emigration and return the population may decline to 27–28 million (pessimistic forecast) or to 35 million

(optimistic forecast)⁶. British demographers propose similar estimates⁷. According to the data from the Ministry of Education and Science at the beginning of 2023, 500 thousand Ukrainian school students are studying abroad⁸. The most optimistic estimates show that up to 90% of the emigrants will come back; but expressed desire to return may differ from the actual behavior. Two years are enough of a term to adapt socially to a new place. Also, Ukraine currently shows growth in objective poverty (from 40% to 67%), and scientists aren't the exception⁹. A return to a poor country from a richer one (Poland, Germany etc.) isn't a rational decision in many cases. A more realistic estimate, therefore, is the return of 30–40% of the migrants.

An opinion poll conducted among a representative sample of researchers shows that around 15% of the respondents are abroad; but 38% more have changed their place of residence inside the country and now have restricted access to the needed equipment and materials¹⁰.

We can estimate only approximately the loss of the scientific potential due to emigration, internal displacement and decline of the real income of the population because of the war. Some of the scientists who can't proceed with their work in Ukraine because of the objective circumstances keep their work connections and plan to come back under more favorable conditions. The other part will probably integrate into new professional environments and adapt to new life circumstances. Therefore, maintenance and reinforcement of connections with the migrants, their practical involvement in collaboration and creation of the right conditions for the return of a part of the scientists are needed.

The general aging of the scientific personnel¹¹, and a connection gap between the generations of scientists are also of notice. Ageism is still prominent in personnel policies. In many cases, the work capabilities of a person are evaluated and rewarded by age, not by actual achievements. Social security has become a privilege for a narrow group of people, independent of how much of a contribution they keep making to research and (or) personnel training. Competitions for job positions, promotions and dismissals are often held in a non-transparent way. In many institutions, there is a superfluous personnel turnover rate, when the employees are fired before reaching the age of their optimal productivity, and this is combined with the absence of rotation of the managers on the level of a rector (director), who usually occupy the same position for more than 10 years.

A significant disbalance in personnel training still exists; in some popular professions, there are much more graduates than the national economy

needs. Not all of the universities have the required personnel potential to fulfill their plans for the number of bachelor and master graduates. In other professions, there is an insufficient number of students to cover all needs of the job market. Keeping up with the decline of the number of students, the number of professors declines as well («the money follows the student» concept). It creates a risk of a decline for whole branches; situations are possible where local demand for qualified specialists will be met only with the involvement of international professionals. The disbalance in personnel training is the consequence of a lack of strategic planning, and insufficient contact of the universities with employers and school graduates.

For instance, law training is provided by around 200 universities in Ukraine. Only 59 of those have made it into the independent rating of education quality in the sphere; the rest didn't meet the criteria of the rating. Among other things, their graduates can't pass the bare minimum of the universal professional test¹². Thus, we have a number of people who formally have diplomas but aren't actually able to do the job. We should note that the community of law professionals is better organized than others in Ukraine; they were able to take responsibility and make an independent knowledge evaluation. This kind of data is absent in other branches.

Another serious complex of problems is the insufficient involvement of university professors and master-level students in research projects. The professors often have such a load of pedagogical work that it doesn't leave them any free time to do research, regularly improve their qualification and update the contents of their courses. The demands of scientific work for professors who are physically overloaded often lead to imitation of such work and to academic dishonesty. At the same time, researchers and practitioners who could take part in personnel training for their branches meet with unnecessary formal obstacles, and, as a consequence of this, don't pass their relevant experience to students and postgraduates.

Plagiarism and other types of academic dishonesty are widespread practices, especially in some scientific branches. More finger-pointing at someone to blame or a replacement of individual corrupt officials with others while keeping the same practices of bribery doesn't solve any problems. Arbitrary punishment for plagiarism in circumstances where plagiarism is a common practice also won't be productive. The bribes are given in circumstances where lawful solutions are problematic. Science work is imitated in circumstances where there are no possibilities or motivation to do real research²¹. Information campaigns against individual officials

are a good way to draw attention to the problems but are insufficient to solve them.

The problem in many branches of humanities and social sciences is still a major orientation on the russian discourse, lack of understanding of the current state of scientific knowledge in the world and insufficient acquaintance with fundamental sources that are often known to the community through inaccurate russian retellings. The Moscow-centered worldview of some scientists, with their connections oriented only on russia, has brought direct damage to Ukraine, financial as well.

All in all, the return to the state of affairs of 2021 is neither a possible nor a desirable result. To break negative tendencies present in Ukrainian science before the full-scale invasion and aggravated by it, it's necessary to make real changes with the participation of all the stakeholders. Among them are the Ministry of Education and Science and other central government institutions that have specialized research institutes and universities in their subordination. The research is undertaken by the institutions of the NASU (*National Academy of Sciences of Ukraine*) and specialized academies, research departments of universities, and private institutions. In 2018, creating the National Research Fund of Ukraine, responsible for competitive grant funding of the projects, was an important innovation. A detailed overview of the state stakeholders and their functions is present in this document¹⁰. Other stakeholders are businesses that often lack productive contacts with science, professional associations and NGOs. A separate analysis is needed of the anti-development interest groups that locally benefit from the status quo and are interested rather in imitation of reforms than in real change. The same research was done based on Polish material¹³.

Best international practices to apply to Ukrainian science

1. **Identify strategic priorities on the national level**, like it was done in the Netherlands (9 priority directions) or in Ireland (18 priority directions). Priorities have to correspond to the needs of the national economy and personnel potential in each of the directions¹⁴. According to the defined international priorities, the universities should be specialized. One university should gather the best personnel in one of the chosen directions of scientific and pedagogical work. There should be a limited number of such directions in each university.

In Ukraine, the priorities are set by the law of 2011, designed by the government of Azarov, the pro-russian prime minister under Yanukovich, with amendments from 2021 and 2022. Even after shortening the list, there are 48 priorities, which practically means there are no defined priorities at all¹⁵.

The data from the international audit shows that Ukraine is highly specialized in physics, astronomy, material science and chemistry. It's also moderately specialized in technical sciences, mathematics and Earth sciences. There is growth in the indices of computer sciences, chemical technologies and energy industry. According to other evaluations, Ukraine has already reached leadership in computer sciences¹⁶. The list is not final and not complete. It can be supplemented with a list of branches where there has been a significant growth in indices during the last 5 years, and where there is potential to reach the average world level.

After defining the extant potential in every branch, an analysis should be made of the reasons that hinder the development of the branches that haven't reached the median level by international standards. These can be a lack of funding, equipment, knowledge of foreign languages, or productive international contacts.

2. **Internationalization through academic mobility during studying and systemic work with the scientific diaspora.** Being formally a part of the Bologna Process, Ukraine doesn't fully apply one of its key principles: mobility, intensive personnel exchange. Such exchange should mean, for instance, that a student gets their bachelor's and master's degree in two different universities, and the Ph.D. in a third one. This way, a typical master has connections in at least two universities, and a Ph.D. has connections in three universities. If these universities are located in different countries, there are many professionals with international connections.

Of course, mobility between universities, cities, or states depends on the individual interest of the students and researchers; it's a right, not an obligation. There are also modern communication technologies that let us maintain efficient academic connections online.

It should become common practice, not an exception, that a student goes abroad to study and then comes back to Ukraine. At the same time, certain directions of studies in Ukraine can become interesting to international students. For this to happen, a large part of the courses have to be in English or other popular world languages. For obvious reasons connected to the war, russian language loses its role in international communications; studies in russian should not be encouraged in any way, except for preparation of certain narrow professionals.

The scientific diaspora should be an asset, a link that connects Ukrainian science with world science. The potential of Ukrainian scientists who work abroad, their connections in professional communities, can work for the benefit of Ukraine and internationalization of its science. At the same time, in the relationship with the diasporas, we should also understand what we can offer them. Is this just moral satisfaction, the feeling that you are useful to your country, or are these material benefits, or maybe conditions to do research and train personnel in Ukraine^{16 17}?

3. **A revision and broadening of the functions of universities** according to the models of functioning of the best world universities. In Ukraine, universities mostly play only a part in passing knowledge from professors to students.

First of all, the research function has to be fulfilled, for instance, by ensuring that students take part in scientific work starting from master's level. This way, knowledge isn't only passed from older people to younger, it is regularly updated to the current state of world science.

Universities, academies and other higher education institutions with the like status have to play an important part in the development of professional communities. In many cases, university professors form the core of a professional community; everyone who does research or practical scientific work in a certain branch forms the periphery. A professional who goes to work in the private sector of the economy isn't considered lost; they can take part in the pedagogical work, for example, by training personnel for the jobs in their business. This way, both the professors have an additional motivation to teach well, and the students have motivation to compete for better rating; the best students of the course get additional chances to work at better positions.

The social function that can be fulfilled by a university is also lacking in Ukraine; universities can be centers of attraction for local communities of the cities, centers of cultural life, professional training courses and places for studying during the whole lifetime for the locals. The presence of a university is an important way to attract youth into the city, part of which will stay and go to work, thus improving the state of the local economy and demographic situation^{17 18}. Of course, fulfillment of the research and social function by the university in practice is largely defined by the presence of adequate personnel and material resources there; these strategies have to be approved at the local level with the involvement of the local stakeholders first of all.

4. **Battling sexism and ageism.** Among the people in the research sector in general there is an approximate gender balance; but starting from the level of the Doctors of Sciences, there is a noticeable disbalance on behalf of men. It gets even more disbalanced on the level of Academicians of the NASU, directors of institutions and rectors of universities. A workgroup typical for Ukraine will include both men and women; but the chair will more likely be a man.

In spite of there being laws about the special status of young scientists as PhDs before 35 and Doctors of Sciences before 40, the scientific personnel in the country doesn't get younger. According to the recommendations of the UN on battling ageism, this practice is considered discriminatory. It also isn't connected to the results of the scientific work of young scientists. Is there any rational sense to treat differently people who work on the dissertation at the age of 33 and 43? It should be noted that persons of retirement age can proceed to actively work in science if they have a possibility and desire to do so; their work should also be evaluated by the result and not by the date of birth.

The notion that there is an optimal career path that is the same for everyone and strictly determined by age is detrimental to the personnel policy and doesn't correspond to modern realities. So called young teams or, on the contrary, teams made up only of «veterans», usually produce worse results than the groups balanced by age and gender of the participants¹⁹.

Recommendations

1. Strengthening the role and quality of competitive grant financing of science.

- Ensure the broadening of the role of the National Research Foundation of Ukraine, guarantee its funding.
- Minimize conflict of interest in the distribution of research grants, involve professionals in project evaluation; they should have proper qualifications for such evaluation and include independent international experts.
- Revise the methods of holding grant competitions by the Ministry of Education and Science, the NASU and the specialized academies. Ensure independent professional expertise, competitiveness and transparency of such competitions.
- Growth of grant funding should be achieved by attracting additional funds. Basic financing of scientific institutions from the state budget should grow or at least stay at the current level.
- Identify priority directions of research with the active involvement of professional communities based on the needs of the national economy and taking into account factors connected to the russian aggression. The number of directions should be less than the current 48, and the list should be formed through a rational and transparent procedure. Provide financial instruments for funding the research in these priority directions accordingly.

2. Systemic development of international collaboration.

- **Strengthen international collaboration** by taking part in research programs, *Horizon Europe* in particular. It is doubtful that any complete list of such programs can be formed. Priority should be given to collaboration with the strategic partners of Ukraine; collaboration with russian institutions should be out of the question. Collaboration with any organizations or people who support russian aggression should also be avoided.

- Encourage publications by Ukrainian scientists in collaboration with international colleagues. Such publications usually get higher citation indices and broaden the visibility of Ukrainian science in the world.
- Encourage individual and collective membership in international professional societies.
- **Activate interaction with the scientific diaspora.** Move from the perception of the emigration of scientists abroad as a brain drain to looking at it as a possibility to develop systemic collaboration and use the intellectual potential of the migrants. Ukrainian scientists should not only expect help from the diaspora, but also spread information, take part in the research started by their colleagues etc.
- **Start and broaden support programs for the scientists that are in Ukraine or come back to Ukraine.** A large part of extant international programs envisages that the researchers move abroad, which in many cases is not possible because of martial law or private circumstances, and in perspective aggravates the brain drain. Involve international professionals in work in Ukraine. Part of such programs can include collaboration online.

3. Improvement of management in the system of national science academies.

- **The NASU and the specialized academies** should make an **independent audit of the research institutions** with the participation of international experts. The structure of the specialized academies should be changed to correspond to the structure of the NASU institutions to optimize their interaction.
- Academic institutions should communicate their achievements more actively, interact more actively with businesses and local communities, and take part in personnel training for their branches both in collaboration with universities and by themselves.
- Introduce the reform of the management system; forego the rigid vertical structure in favor of horizontal interaction of the research departments. Strengthen the role of professional communities in the institutions.
- In personnel policy, introduce diversity; in particular, maintain age and gender balance according to the best international practices.

4. Ensuring autonomy and academic freedom for universities and their research departments.

- Change the rigid vertical structure of management to a more balanced one that would encourage horizontal interaction between all of the participants of the process. Increase the visibility of scientific groups and individual researchers.
- Professionals with the appropriate competencies should control the quality of the research in universities. The status of a research university should be given based on the results of work during the last 5 years, and not automatically, and it should be possible to rescind it if the university doesn't meet the requirements.
- Universities should move from fulfilling mostly educational functions to joining them with research and active participation in the life of society. In particular, they should encourage the formation of professional associations, and interact more with businesses and local communities. But research and social functions should be fulfilled taking into account extant personnel and material resources.

5. Development of criteria and methods of evaluation of scientific work in every sphere.

- The number of publications in international peer-reviewed journals and citation indices is an important criterion, but they ignore the quality of the publications. There are known methods of artificial increase of these indices. A number of Ukrainian professional communities consider evaluation by the H-index realistic. But other communities consider it irrelevant to their work and detrimental to their branch. The criteria for quality evaluation are proposed in³. Possibilities for application of international citation indices and qualitative methods on the example of psychology are considered in¹⁹. Thus, the criteria for quality evaluation of the work should be clarified, partially changed, and probably decided on separately for every branch of knowledge.

6. Create and maintain a cluster of security studies,

organize and maintain productive collaboration of the governmental bodies with professional communities. Create and support independent research groups that study practical issues connected to russian aggression and national security²⁰.

7. Decolonization of research.

- Part of the scientists in humanities and social sciences should join the cluster of security studies rather than identify with the aggressor and propagate capitulation.
- Join forces with the Baltic countries, Poland and Czech Republic for exchange of knowledge and joint work.
- Propagate Ukrainian studies and decolonization of the discourse about Ukraine in the world.

8. Battle corruption and academic dishonesty in the scientific system.

- Do interdisciplinary research to find out what management practices facilitate corruption, plagiarism and other forms of academic dishonesty.
- Make changes to the law that would create real conditions for punishment for academic dishonesty.

9. Evaluate the damage caused by the russian aggression

- in material resources and the damage to the personnel potential of Ukrainian science; describe systematically the critical vulnerabilities that should be liquidated first of all.
- Help internally displaced persons return to studying, research and teaching.
- Renew and maintain connections with migrants.
- **Do research on the migrant communities** from Ukraine with the involvement of partners in corresponding countries, and develop recommendations for their support and possible return.
- Develop rehabilitation programs for persons who suffered because of the russian aggression, including those illegally deported to russia. We should secure our people as well as we can, and not just territories.

10. After the end of the hot phase of the war, do a census using internationally recognized methods.

The last census in Ukraine was held in 2001; its data is obviously outdated, and the evaluations of the size and composition of the population with indirect methods have a significant measurement error. A lack of relevant and reliable data leads to errors and abuse of social policies. The lack of data also makes the job of social scientists who work with numerical data more difficult. It decreases the accuracy and prognostic value of public opinion polls. The authorities get inaccurate feedback on their managerial decisions.

11. Activation of engagement of the public and businesses with the scientific system.

- In academia, there's still a suspicious outlook on private business, and there's a lack of motivation to work with private orders. Researchers who went to work in the private sector could keep their connections in academia, and facilitate mutual understanding and productive collaboration between business and research groups. Investment into national developments instead of buying ready solutions from foreign manufacturers could become a rule and not an exception. But we should note that economic liberty is a condition for active investment in commercial developments.
- Create and support quality popular science content in Ukrainian; if there's a lack of it, people will turn to dubious sources including pseudoscience. Professionals who are able to produce popular science content should be encouraged to do it, and their texts and media products should be promoted among the target audience. It is possible to push pseudoscience out of academia. But outside of academia and universities, a prohibition like this is impossible to maintain for technical reasons; besides that, it contradicts freedom of expression. The scientists should actively create and promote content that would gain more trust to science among the general population and would facilitate growth in public authority for science.

Conclusion

By fulfilling the recommendations described in this document, we will be able to stabilize the situation and also help scientists make their contribution to the victory. We lack data about the end of the hot phase of the war; but we can begin to fulfill a large part of the recommendations before the end of it. It's important to have a clear vision and strategy regarding our future after the victory. But we also have to understand what risks we are avoiding when we resist the aggressor and work most actively on those things **that can be done in these two years (2023–2024)**.

Because of the demographic and migration crisis and also of the security threats connected to the russian aggression, our hope for the development of science is limited to intensive factors. First of all, we have to concentrate on **securing the extant scientific potential**, optimization of the interaction between the researchers that are in Ukraine and abroad, and also on optimization of specifics of doing research, working on technologies and training personnel during the war.

Internationalization of the scientific environment, **deepening international collaboration** that involves international grant funding but isn't limited to it, is an important direction of work. Research projects that concentrate on making Ukraine more stable in war conditions and security projects are of utmost import.

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