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International scientific and technical cooperation of Ukraine in the postwar period

Abstract

The purpose of the article is to investigate the prospects of development of international scientific and technical cooperation of Ukraine after the war. The article presents the state of international scientific and technical cooperation of Ukraine in the prewar period. *Methodology.* The study is based on the comparison of data of the state bodies of Ukraine, intergovernmental economic organizations, opinions of international and Ukrainian experts, etc. The results of the study showed that Ukraine has positive prospects for the development of international scientific and technological cooperation. Numerous examples of foreign science and technology assistance during the war and initiatives to restore Ukraine after the war are illustrated. Foreign universities and various organizations provide significant support to Ukrainian students, researchers and professors who were forced to leave Ukraine as a result of the war. Many international companies in various industries offer technological support during the war and are willing to invest in the reconstruction of Ukraine in the postwar period. *Practical implications.* This article may be useful for the formation of the strategy of post-war reconstruction of Ukraine. Understanding the prospects for the development of international scientific and technical cooperation in Ukraine will allow to properly regulate the state policy. It will help to determine which areas of international cooperation should be given more attention, taking into account the assistance already provided by Ukraine's foreign partners. The article *will be useful* for companies that want to help Ukraine with their services or technology. It will help foreign partners understand what areas they should focus on when supporting Ukraine. *Value/originality.* The article is valuable for the people, the government and the world in understanding the prospects of Ukraine in international scientific and technical cooperation. The originality lies in the systematization of a large amount of knowledge and information on the topic. A comparison is made of the pre-war situation, the changes that are already visible, and the prospects. All this provides a holistic unique picture for a complete analysis of international scientific and technological cooperation in Ukraine.

Keywords

Ukraine, international cooperation, science, technology, education, reconstruction

JEL: F53, H52, I25



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1 Introduction

Scientific and technological cooperation in the modern world is a prerequisite for achieving a high competitive position. The formation of a new technological base determines the pace of development of world countries and their ability to develop their own potential and economic opportunities. It is the formation of a new technological platform that may become an opportunity for Ukraine to recover from the war. Russia's war against Ukraine is inflicting terrible losses every day, both on our

economy and directly on every Ukrainian. In the first six weeks of the war, Ukraine's total economic losses exceeded \$500 billion. The government estimates that in the long term, this figure could grow to \$1 trillion, five times the GDP of 2021. According to experts, GDP may fall by 30-50% in 2022 alone, but the heaviest losses for Ukraine are human casualties. According to the UN, 12.1 million Ukrainians fled their homes in nearly two months of war. Five million of them were outside the country. It is known that human capital is an important factor in the development of the economy of any

state. Therefore, one can only imagine the devastating losses inflicted on Ukraine by the aggressor country: the unused labor potential of people who died through the fault of the occupiers; an increase in the number of maimed people resulting in full or partial disability, which will entail an increase in government spending on maintaining these people; downtime of industries, businesses due to forced relocation of people and problems with logistics, etc.

International scientific and technical cooperation of Ukraine, perhaps, can be called a priority at the moment, because it is an integral part of consideration of the prospects of post-war Ukraine. International scientific and technical cooperation is a form of international economic relations and is a system of economic relations at the interface of science, technology, production, services and trade and exists on the basis of common, predetermined and agreed intentions, enshrined in international economic treaties.

In general, restructuring the economy, which requires rapid renewal and recovery, is an important task for a country that has suffered significant damage to its production infrastructure, the fastest option may be to change the technological basis of economic development.

2 Pre-war period

By February 24, 2022 Ukraine is rapidly developing international scientific and technological cooperation. For effective integration of Ukraine into the European research space, the Ministry of Education and Science of Ukraine together with a wide range of stakeholders has prepared a Roadmap, sectoral academies, leading universities, international and public organizations. The document was approved by the decision of the board of the MESU on March 22, 2018. One of the main priorities was the integration of Ukraine into the European research space. This was facilitated by bilateral international cooperation with EU member states, with the countries of the Eastern Partnership, participation in the EU Framework Program for Research and Innovation "Horizon 2020".

Specifically, since 2014, 446 tenders for 117 Ukrainian organizations participating in Horizon 2020 have provided funding of €17.232 million for 90 projects, 9 of which were coordinated by Ukrainian organizations (Roadmap for Ukraine's, 2022). Ukrainian universities and research institutions actively participated in bilateral scientific and technical cooperation within the framework of intergovernmental agreements. The number of bilateral cooperation projects in 2017 doubled compared to 2016.

Ukraine also participated in the Euratom Research and Training Program, the EUREKA International European Science and Technology Innovation

Program, the NATO Science for Peace Program, etc. Ukrainian research organizations and universities cooperated with international organizations and foundations, including the European Organization for Nuclear Research (CERN), the Ukrainian Science and Technology Center (STCU), the Antarctic Research Committee (SCAR), etc. (Roadmap for Ukraine's, 2022).

The scientific field is one of the most globalized, and information about the results of scientific research was disseminated and was available to Ukrainian scientists. In 2017, the Ministry provided access to the most popular Web of Science and Scopus resources in the scientific world, which became not only the basis for scientific publications and editions, but also information platforms with many additional useful analytical services. It is important to note that institutions did not just get access to scientometric resources. Both publishers – Elsevier (Scopus) and Clarivate Analytics (Web of Science) – at the request of the ministry agreed to hold seminars and trainings on increasing the publication activity of scientists, writing high-quality scientific articles, searching for scientific publications, and planning scientific careers in Kyiv and the regions. Separately, these companies were to work on streamlining the profiles of Ukrainian higher education institutions and research institutes, which would increase their rankings and visibility on the world scientific map.

According to the Organization for Economic Cooperation and Development (OECD), the percentage of scientific publications with international cooperation in 2007 was the highest – 23.9%. But since 2017, Ukraine shows an increase in this indicator from 18.7%, in 2018 – 18.9%, in 2019 – 19.3%, and up to 20% in 2020. These are good results, because they show a positive trend – an increase in the share of publications with the cooperation of Ukrainian and foreign researchers (Percentage of..., 2022).

However, according to the indicator "International joint inventions, % of the total number of patent applications (PCT)" Ukraine has been regressive since 2015. In 2014 this indicator was 23.4%; in 2015 – 32.9%; in 2016 – 25.1%; in 2017 – 22.9%; and in 2018 – 16%. This means that the share of patents issued jointly with foreign inventors from the total number of Ukrainian patents issued annually decreases over the years. But the highest value for the whole period of demonstration of the indicator is 62.5% in 1992 (International co-invention, 2022).

The reason for the existence in 1992 of patents jointly with foreign inventors, as more than half of all patents issued in that year shows the value of the indicator "Number of patents (PCT)". In 1992, this indicator was 5.9 and further from the graph of this indicator shows a rapid increase in the number of patents (PCT), so in 2014 the value of the indicator

was 122.3; 2015 – 135.2; 2016 – 124.1; 2017 – 129; 2018 – 172.3.

This shows that the absolute values of the number of all patents increased, but the share of patents with the participation of foreign inventors became less. It should be noted that despite the general trend of increase in the number of patents, the share of patents with the participation of the international community is decreasing (PCT patents, 2022).

Ukraine ranked 207th in the world in the number of citations of scientific articles per scientist. At the same time, by the number of total citations of scientific articles of scientists Ukraine ranks much higher – 54th. In general, it can be noted that Ukrainian scientists produce a significant amount of scientific results, but the international progress is only at the initial stage with a simultaneous reduction in the number of scientists, for example, only from 2015–2018, that is, we now have the number of scientists, per 1 million population, equal to 1.45 thousand people. From 2013 to 2020, the number of young scientists in Ukraine decreased from 2,984 to 1,625, i.e., almost twofold. The salaries of both academic and university scientists are 30-40% lower than the average salary in the country (14.3 thousand UAH). This indicates a slight decrease in the potential of Ukrainian science (Yak maie..., 2022), (Figure 1).

All this is a consequence of the fact that in previous periods the state did not provide sufficient financial income in the field of science and technology: low salaries for researchers and scientists led to a decrease in motivation to work, "brain drain". Science is a powerful engine of progress, so it cannot be neglected. In the field of international cooperation, one cannot say that the results have been much better, but a positive trend is evident.

3 During & after the war

After the full-scale Russian invasion of Ukraine in international cooperation in science and technology, despite the negative consequences of the aggressor country's actions: the breaking of many scientific ties, loss of data, stopping research projects, some scientists were forced to leave the country, but there are still huge positive changes. On April 29, 2022 the Government approved the draft law "On Termination of the Agreement between the Government of Ukraine and the Government of the Russian Federation on Scientific and Technical Cooperation". The bill proposes to completely suspend cooperation between ministries of education, research institutions, scientific organizations and societies, higher educational institutions and enterprises, etc. Monitoring was carried out to deprive Russian and Belarusian scientists of their foreign membership titles in the National Academy of Sciences of Ukraine and sectoral academies of sciences, as well as the termination of Ukrainian scientists' membership in the academies of sciences of Russia and Belarus.

Scholars and graduate students have announced the opening of a fellowship program from Penn State University in partnership with the Ukrainian Embassy in the United States, which welcomes Ukrainian scholars and graduate students who have been forced to leave their place as a result of or to avoid the negative consequences of Russian aggression against Ukraine.

Order of the Ministry of Education and Science of 28.04.2022 No. 395 "On Financing Joint Ukrainian-Chinese Research Projects in 2022" on financing of 15 joint Ukrainian-Chinese research projects by the Ministry of Education and Science in the amount of 140 thousand UAH each (Overview of ..., 2022).

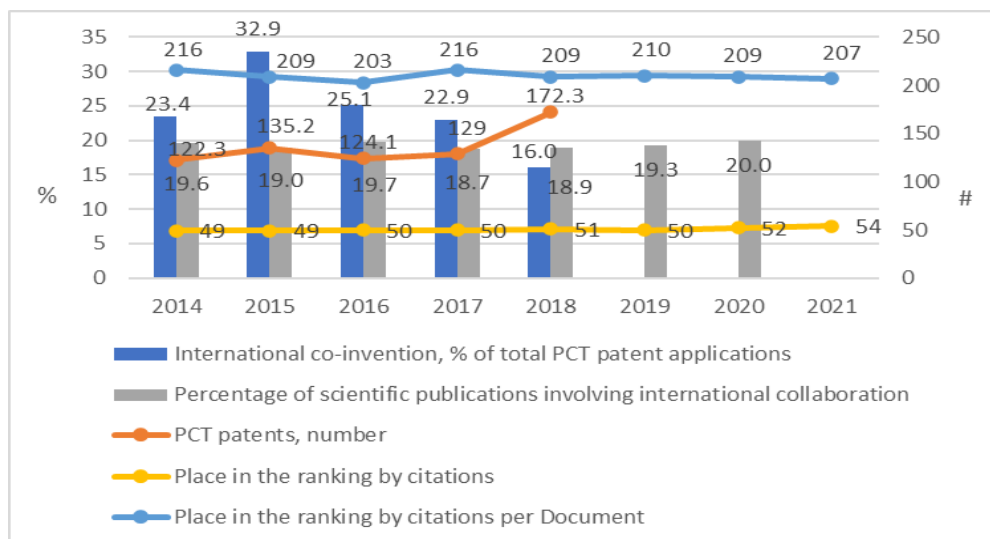


FIGURE 1 Pre-war indicators of scientific and technological cooperation of Ukraine
 Source: compound by authors from *stip.oecd.org* & *scimagojr.com*

A large number of foreign universities condemn the war Russia is waging against Ukraine and are directing their efforts to provide various forms of assistance to our country and its citizens, both informational and material. Many foreign universities stand in solidarity with Ukraine and stop their academic cooperation with the universities of the aggressor country. The AACSB Business School Development Association, together with the BGA Business School Alumni Association, the AMBA Program Association, and the EFMD Global Network of Business Schools, will not recognize diplomas issued by Russian universities.

Numerous institutions of higher education abroad offer support to Ukrainian students, scholars, researchers, and teachers who have been forcefully displaced. Opportunities are provided to enter foreign universities or to continue higher education abroad on the basis of scholarships or grants for students. Scholars and researchers are also given the opportunity to continue their work on a grant basis. Teachers have the opportunity to continue teaching at foreign universities. Leading European universities such as Oxford University, Cambridge University, ETH Zurich, WU (Vienna University of Economics and Business) and others – provide these opportunities to Ukrainians.

Dozens of foreign universities have said they are willing to ease admission conditions and provide additional places and scholarships for applicants from Ukraine. In order to coordinate the accession process, a number of leading Ukrainian universities (Kyiv School of Economics, Catholic University, SET University, Ukraine Global Scholars and others) together with the government launched the Ukrainian Global University initiative. The Ukrainian Global University is a broad network of educational institutions that work together to rebuild Ukraine by supporting Ukrainian schoolchildren, students, scholars and teachers through scholarships and graduate programs. This non-profit initiative aims to overcome the devastating effects of the war and to attract world best practices to build a new Ukraine that will be a proud member of the free states of the world. UGU's partners include Stanford, the University of Pittsburgh, the University of Toronto, the University of Paris (Pantheon-Sorbonne) and more than thirty universities in Canada, Germany, the United States, Italy and other countries. Upon completion of their studies or research, participants in this initiative should return to Ukraine to apply the valuable knowledge gained at the world's leading universities to rebuild our nation and further its prosperity.

Despite all the above-mentioned good gestures of foreign Ukrainian partners, this mass forced emigration may have even worse consequences for Ukrainian science. The Ukrainian scientific community may face a very serious brain drain, which

will make the task of post-war reconstruction even more difficult.

The question of the post-war reconstruction of Ukraine is currently being raised. The authorities have already begun to prepare a plan according to which Ukraine will be restored. Leading domestic and international experts, public figures, scientists, and politicians are to be involved. Thus, a group of independent international and domestic experts presented their vision of the plan for the reconstruction of Ukraine. The authors of this study note that it is based on the experience of post-war reconstruction (Marshall Plan, German unification, reconstruction of Iraq, Afghanistan) and the experience of recovery from natural disasters (T. Becker, B. Eichengreen..., 2022). In particular, this work highlights the successive stages of the reconstruction of Ukraine.

The issue of international cooperation in science and technology is illustrated in the third stage of recovery, "The basis for long-term growth". This stage is supposed to consider the basis of Ukraine's successful prosperity in the long term. Namely, the attraction of foreign capital and technology for the radical modernization of our country. At this stage of reconstruction, the authors point out, it is necessary to use international assistance to create favorable conditions (including the prospect of accession to the EU), Ukraine can become an attractive destination for FDI. This process can be accelerated by policies stimulating FDI inflows. Incentives for FDI should be based on an understanding of the difficulty of finding investors in a broken economy, which could include subsidies, guarantees, subsidized investment insurance, and so on.

Today, many companies from developed countries want to provide free aid for the future reconstruction of Ukraine; this aid needs to be formalized now. It is necessary to begin as soon as possible to involve companies in signing such aid, while Ukraine is on the front pages of the world media, the state should try to fix these promises of aid. Not only engineering or architectural companies, but also IT companies can provide software and equipment to restore public administration services. For example, Starlink Internet terminals, which provide access to the SpaceX satellite Internet, are already supplied. Thus, Internet connectivity is provided for critical facilities: military, government, and also for those regions of Ukraine that have lost Internet connectivity due to the invasion of the occupants.

Among the industries on which international cooperation with Ukraine for the development of our state is already focused today is the construction industry. According to the Ministry of Entrepreneurship of Denmark, the first batch of construction equipment for cleaning and reconstruction has already been formed and will be delivered to Ukraine in the near future. Specifically, 35 pieces of

equipment will include excavators, road rollers, wheel loaders, fractional screeners, trucks, dump trucks and heavy equipment trailers that will be sent to help the devastated cities of Ukraine (Danish..., 2022).

The Czech company ICE, which has begun production of concrete anti-tank barriers for the Ukrainian army, made on a special 3D printer, is also providing support. The company is also considering the possibility of providing Ukraine with printers that would allow these barriers to be made on site. It is also reported that this equipment could be used in the future to build houses after the war (Czech firm..., 2022).

The official web portal of the Ukrainian parliament says that the basic principles on which the reconstruction plan will be based will include the development of the domestic military-industrial complex, not only the purchase of weapons, but also production, including the transfer of military technology. This will make it possible to set up production as quickly as possible in a wide range, from small arms to air defense. At the same time, military technology will become a driver of development for civilian sectors of the economy (The Budget Committee..., 2022).

Sygnis S.A., 3YourMind and Prusa Research, based in Poland, Germany and the Czech Republic, are also involved in 3-D printers, helping Ukraine to manufacture protective equipment, harnesses, periscopes, drones and transmitting these 3-D printers directly. To date, the initiative has already created 10,000 parts and items for Ukraine (Czech firm 20, 2022; Entrepreneurs in Poland..., 2022).

There is also help from the IT industry, with Google security teams working to protect Ukrainian users and government institutions from DDoS attacks, which have targeted the Foreign Ministry, the Interior Ministry and Liveuamap, a service that helps people find information, among others. The Ukrainian News Service is among more than 150 websites in the country that are currently protected by Project Shield, Google's free service for news, human rights and election monitoring (Web3..., 2022).

The next area to consider in international cooperation is the electric power industry. Since 2017, Ukraine's national grid operator Ukrenergo has been trying to sever ties with the Russian energy system and instead synchronize its networks with the European Network of Transmission System Operators for Electricity (ENTSO-E). After the Russian invasion on February 24, Ukrenergo applied to ENTSO-E for emergency synchronization with the continental European power system. As early as April 26, Ukraine received observer member status with ENTSO-E (Ukraine..., 2022). Estonia also sent various components and components for power lines to the Ukrainian Ministry of Energy to

help Ukraine rebuild its destroyed infrastructure (Estonia..., 2022).

Rebuilding a country requires a permanent, reliable record of land registries, property rights, births, and other official documents that help establish who owns what and is entitled to what. Ukraine is one of the first countries to use blockchain technology for land registries and other government documents.

The significant influx of refugees, including many students, researchers, and other white-collar workers, from Ukraine to the EU and recovery provides an opportunity to establish long-term research and development (R&D) ties. European educational programs (such as Erasmus or the European Research Council) could be expanded to include Ukraine and provide (financial) opportunities for Ukrainians to study abroad and then return home. The relationships with foreign universities that will be established during the war are likely to persist for a long time. Therefore, they will need to be successfully used and improved to improve the quality of faculty and administrative staff at Ukrainian universities, the global education of Ukrainian students, and the flow of knowledge (people may not be physically present in Ukraine, but working on Ukrainian projects). Higher education in Ukraine needs consolidation to concentrate resources at the leading institutions that can provide the best research and student services.

4 Conclusions

In conclusion, it should be noted that Russia's war against Ukraine is undoubtedly taking a huge toll on all sectors of the economy. Ties are being severed, including scientific cooperation. Numerous students, graduate students, researchers, researchers, and professors are being forced to suspend their activities. Particularly in areas that were significantly damaged by shelling and where it was impossible to continue research, scientific work, there was loss of data, research projects were halted, etc. Many of the results of intellectual work were damaged or lost to debris or other circumstances, much of the infrastructure was damaged or destroyed. That is why the issue of international scientific and technical cooperation and the development of new formats of interaction for rapid economic recovery becomes relevant. Increased international support, on the one hand, is aimed at creating a positive trend towards gradual consolidation, but on the other hand, it contributes to the outflow of highly qualified personnel and the intellectual potential of the nation. Educators, students and researchers are supported with scholarships, grants, jobs and opportunities to continue their research. This opportunity is given to return to Ukraine, after receiving those valuable knowledge and achievements at leading

foreign universities, and rebuilding our state with their help. Many foreign companies want to provide gratuitous assistance in the future reconstruction of Ukraine. These are not only engineering or architectural companies, but also IT companies that can provide software and equipment to restore public administrative services. Even the use of 3-D printers and blockchain technology is suggested.

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