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INTERNATIONAL ACADEMIC COOPERATION: selected models and mechanisms

Tomasz Shapiro[1] and Viktoriia Yanovska[2]

[1] SGH Warsaw School of Economics, Warsaw, (Poland), tszapiro@sgh.waw.pl
[2] SGH Warsaw School of Economics, Warsaw, (Poland), State University of Infrastructure and Technologies, Kyiv (Ukraine), vyanov@sgh.waw.pl, v.yanovska@ukr.net

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GRAPHIC DESIGN

Anna Altuhova

Centre for Ukrainian Studies at the Warsaw School of Economics

Warsaw School of Economics

INTERNATIONAL ACADEMIC COOPERATION: PATTERNS AND MECHANISMS

Tomasz Szapiro, Warsaw School of Economics, Warsaw, (Poland).
Viktoriia Yanovska, SGH Warsaw School of Economics, Warsaw, (Poland),
State University of Infrastructure and Technologies, Kyiv (Ukraine).

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The aim of the study is to build a conceptual framework for international academic cooperation and to present recommendations for building a strategy for such cooperation. The identification of the desired principles of cooperation between partners with different potential uses the description of mechanisms that promote or constitute an obstacle to the integration of partners with different scientific potential, and in particular countries that are inferior to global standards in terms of the maturity of the science system. The study reviews the results of analyses of factors affecting effective international academic cooperation. On the basis of the results of this analysis, principles conducive to the integration processes of international academic cooperation treated as a complex, systemic process of knowledge and innovation production were proposed. An analysis of the economic aspects of the academic ecosystem has shown that academic goods are hybrid in nature, i.e. they have the characteristics of both public and private goods. The analysis of social aspects indicates open science, international cooperation, digital solutions and academic ethics as key directions for the development of academic ecosystems. Recommendations for institutional solutions and models of strengthening international academic cooperation and increasing the effectiveness of collaborative research should treat implementation in these directions as a priority.

1 Introduction

The main objective of the research is to answer questions about the choice of directions of transformation of the academic system in the process of global integration and innovative development of the economy. More precisely, the study attempts to present the generalization of effective experiments and the so-called good practices in international scientific cooperation. An additional objective is to create theoretical foundations for the construction of a procedure for supporting decision-makers, which can be used in recommendations for the choice of directions of scientific policy in the area of international scientific cooperation. In the next study, this analytical procedure will be presented in detail and illustrated with real data on international academic cooperation between Ukraine and its selected partners.

Outstanding achievements and organizational adjustments of the science and higher education system in Ukraine do not match the effects of world scientific leaders, which is a serious obstacle to scientific cooperation with Ukraine. The problem does not concern only Ukraine. Therefore, an important research task is to identify the desired general principles of cooperation between partners with different potential, based on the description of mechanisms that favor or constitute an obstacle to the integration of partners with less mature academic systems into the world community.

Science and education are part of national socio-economic ecosystems and should be analysed in such a broad context. However, socio-economic ecosystems are a difficult field for analysis because they are complex and open. The complexity of these systems is determined by the fact that they consist of a very large number of interrelated elements. They are also open systems, because their elements are also related to the external environment. The internal interdependence of systems and their surroundings is also a positive phenomenon, as it acts as a catalyst for technological, economic and social development, especially in the processes of social integration, cf. Rosenberg (1994).

Along with the development of information technologies in the context of the transition to the so-called *Fourth Industrial Revolution* (Industry 4.0), the concept of which generalizes the classic concept of the industrial revolution, the globalization of the world economy is progressing, cf. Davis and O'Halloran (2018). This process is accompanied by the integration of national socio-economic systems. The strengthening of the process of this integration observed since the mid-twentieth century proves that societies that make independent attempts to solve complex problems are less likely to succeed, cf. Lopez-Claros *et al*. (2020). In the conditions of globalization, economic growth, especially focused on innovation, social security and national defense, can be ensured by building institutions subordinated to the processes of international integration.

The process of global integration of social and economic systems is the subject of numerous scientific papers and expert opinions. World practice has developed a set of tools for building international integration bonds. The theoretical foundations of integration are considered in this study as a systemic social and political process (the construction of new political institutions that have a direct impact on state decisions). In this process, the authors consider scientific and non-scientific achievements, phases of integration theory (integration explanation, management analysis, construction), contexts of theoretical development, competing or complementary theoretical approaches, cf. Wiener *et al*. (2018).

Theoretical aspects of integration processes arise as a result of syntheses taking into account different conceptual perspectives and the results of various empirical research. As starting parameters for comparison, the study uses sets of innovation indicators, scientometric measures and measures of human capital flow presented in the literature. Comparisons of these indicators make it possible to formulate and verify research hypotheses and, on their basis, to shape strategies for international cooperation between universities and other scientific institutions.

As the main area of analysis, the study distinguishes global scientific cooperation and the development of joint academic institutions. Such a selection of topics results from the responsibility of universities for the development of national communities through innovative applications of scientific achievements. Good international cooperation in science is a necessary condition for the development of the socio-economic system.

After this Introduction, Chapter 2 characterizes international academic cooperation, taking into account the mechanisms affecting the development of innovation and cost-benefit analysis. Chapter 3 presents science as a process of producing the so-called academic goods. Chapter 4 presents science as a social value. In particular, the characteristics of open access and ethical issues are considered. The study closes with Final Remarks, Bibliography and Appendices.

2 International academic cooperation

In this chapter, in subsection 2.1, the forms and benefits of international academic cooperation are characterized, and then selected development trends in science and innovation (in subchapter 2.2.) and the directions of research of academic cooperation (in subchapter 2.3). The purpose of these considerations is to isolate the factors influencing the dynamics of this cooperation.

2.1 The international nature of science and innovation

Academic international cooperation leads to many benefits for its participants. In particular, such cooperation allows universities, research institutions and business organisations to access a wider pool of resources and knowledge at a lower cost, jointly solve complex problems and share R&D risks. International institutional and personal cooperation improves communication between scientists, increases the quality of research, increases the number of publications and thus contributes to scientific achievements, leads to synergistic effects of innovative development, supports positive trends of socio-economic changes. As a consequence, international cooperation in many countries is treated as a strategic goal of a policy aimed at functioning on a global scale. The internationalisation of national educational systems is becoming one of the key directions of scientific policy leading to their development and strengthening of scientific potential.

It should be emphasized that thanks to the dissemination of scientific results, the effects of innovative development are strengthened, which has a positive impact on economic growth processes. R&D, regardless of the sources of funding, contributes to strengthening the economy (by gradually increasing private sector productivity) and increasing the volume of production (due to an increase in overall demand for goods and services), cf. Reinsch *et al*. (2020). For example, the USA, the world leader in this area, spends on average more than $680 billion annually (in 2017–2021) on research activities, academic institutions, and the processes of shaping the cognitive abilities of talents to assimilate and use innovative ideas (about four times more than the entire Polish budget and almost twenty times more than the budget of Ukraine – author's note). Between 2008 and 2021, spending doubled (from $405 billion to $820 billion). In China, we are seeing a sharp increase in R&D spending (from $65 billion to dollars in 2008 to $430 billion in 2021, a 6.5-fold increase), cf. World Bank (2023), OECD (2024).[3] The

[3] Web address to World Bank https://data.worldbank.org/indicator/NY.GDP.PCAP.CD, OECD: https://www.oecd.org/en/data/datasets/science-technology-and-innovation-scoreboard.html, access date 22.08.2024

significant increase in funding resulted in a 3.4-fold increase in the number of Chinese scientific publications (the number of US publications increased by 35%), cf. SciVal (2024[4]), and led to China's dominant position in 23 of the 30 most popular research areas, cf. Sarpong *et al*. (2023).

The main forms of international cooperation are: exchange of researchers (including scholarships); seminars or other meetings; joint projects or networks (from sharing results to fully interactive partnerships with division of labour between participants); offering access to scientific equipment or sharing the costs of its use; long-term relationships between laboratories; participation in national programs as a foreign collaborator; the establishment of auxiliary laboratories in the partner country; and sponsorship or participation in national programs, cf. Georghiou (1998).

Within each form of international activity, an important element is the time of this activity and the level of expenditure related to this activity. By horizon, in the first approximation, activities can be grouped as short-term, moderately time-consuming, and long-term. Each group may be characterized by a high, moderate or low level of expenditure, cf. Table 2.1.

Selected forms of international cooperation

Group	Forms	Horizon	Inputs
Organization chart	Exchange of researchers Seminars and meetings Joint projects Partner networks	Multi-year Annual Several years Multi-year	High Low Moderate Moderate
Technical	Access to scientific equipment: ● Institutional cooperation ● Projects Creation of auxiliary laboratories in the country Long-term relationships between laboratories	 Multi-year Several years Multi-year Multi-year	 High Moderate High Low
Financial	Cost breakdown of projects Participation in national programs Sponsorship or participation in national programs	Several years Several years Several years	Low Moderate Moderate

Source: ed. On.

Table 2.1. *Forms of international academic cooperation are divided into three strongly differentiated groups, which is associated with a large diversity of the level, structure and funding horizon of scientific cooperation.*

The most durable and costly forms of cooperation concern forms of membership in groups that are organizationally and technically united. These include the creation of long-term partner networks, access to scientific equipment and the creation of laboratories. These forms

[4] Web address for SciVal https://www.scival.com/benchmarking/analyse, access date 22.08.2024

of cooperation require significant financial outlays, but can have a huge impact on the development of science, technology and innovation.

Budgetary forms of academic cooperation, such as cost sharing and participation in national programmes, are cheaper and usually have an average lead time. This underlines the importance of strategic planning and resource balancing for the successful implementation of international scientific cooperation.

2.2 Functional structure of ethnic capital

An important part of the expenditure on science and innovation is the cost of international cooperation in this area. The scale of these expenses is proven by the following examples. For example, the annual budget of the Polish National Agency for Academic Exchange exceeds PLN 212 million (2023), cf. NAWA (2023), for 2021-2027 the budget of the Erasmus+ programme is EUR 613 million (i.e. approx. EUR 2.5 billion, cf. Erasmus+ (2024), the amount of Horizon Europe co-financing – EUR 93.5 billion, cf. "Horizon Europe" (2024).[5] This creates a difficult situation for countries where research and development funding is limited. The lack of sufficient funding creates barriers that inhibit the processes of international cooperation in academic institutions. As a consequence, in countries where expenditure on international cooperation is low, the fear of threats from difficult civilizational and cultural problems is particularly strong, cf. Cerdeira *et al.* (2023). As a result, in such countries, the internationalisation process becomes a strategically important goal of science policy. Due to increasing global competition and rapid technological change, more and more countries regard science and technology cooperation as a key way to promote and maintain global competitiveness in innovation, per. Chen *et al.* (2019).

Economically developed countries have more resources to finance research and development. According to data for 2022, Gross domestic expenditure on R&D (GERD) in the United States amounts to 3.59 percent of GDP, in the United Kingdom – 2.90 percent of GDP, in Poland about 1.45 percent, in Poland and in Ukraine – only 0.33 percent of GDP, cf. OECD (2024).[6] Joint international scientific research increases the research potential and allows for the pooling of expenditures, which results in accelerating the process of creating knowledge

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[5] NAWA: https://nawa.gov.pl/images/users/629/BFK/PF-NAWA-na-rok-2023.pdf, Erasmus+: https://erasmus-plus.ec.europa.eu/news/results-2024-capacity-building-for-higher-education-call, Horizon Europe: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en, access date 22.08.2024

[6] OECD web address: https://www.oecd.org/en/data/datasets/science-technology-and-innovation-scoreboard.html,
access date 22.08.2024

important for socio-economic development. As a consequence, developed countries have an extensive and strong academic environment, which results in significant scientific and technological achievements. These countries are therefore constantly interested in increasing the internationalisation of academic activity.

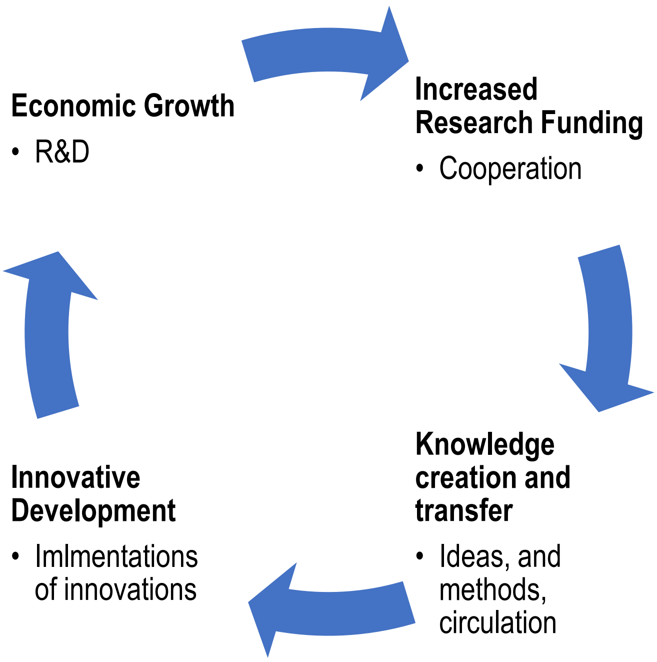
The scale of differences in R&D funding is the subject of scholars' interest, as reflected in the analytical literature, cf. m.in. Chen *et al*. (2019). It turns out m.in that in the United States, the amount of per capita R&D funding exceeds $2900, in the United Kingdom – $1400, while in Poland it is $320 and in Ukraine it is only $17 per capita, cf. World Bank (2023), OECD (2024).[7] Research reports show that in the case of industrialised countries, the differences in the level of international academic cooperation may be small. However, in the case of research centers from Eastern and Western Europe, the differences are already clear. Similarly high differences appear in the case of industrialized northern Italy and the developing south of Italy. Chen *et al*. point out directly that "*...the funding gap may be slightly less significant between industrialised countries, but it becomes more apparent when research collaborations now also cover the area between East and West, and between the industrialised North and the developing South...*", cf. Chen *et al*. (2019).[8]

Institutional and personal cooperation in basic and applied research, accompanied by the exchange of ideas and methodologies, becomes an important factor in the so-called knowledge transfer (circulation) (when research groups borrow ideas from external sources), see Grilisze (1998), cf. Figure 2.1. It is the transfer (circulation) of knowledge that determines the evolutionary nature of innovation, per. Reinsch *et al*. (2020) and, as a result, accelerates innovation processes. While investment in R&D, and innovation is important, it has far greater economic benefits than conventional capital, and it is also a spin-off and social benefit. Halla *et al*. (2009).

The importance of international cooperation in innovation development

[7] World Bank https://data.worldbank.org/indicator/NY.GDP.PCAP.CD web address, OECD: https://www.oecd.org/en/data/datasets/science-technology-and-innovation-scoreboard.html, access date 22.08.2024

[8] *Such differences may be slightly less significant between industrialized countries, but more pronounced when research collaboration now expands to that between East and West, and between the industrialised North and the developing South*



Source: ed. On.

Figure 2.1. *A diagram built on the concept of productivity (Griliches, 1998) and knowledge transfer (Reinsch et al., 2020) shows the importance of international cooperation.*

The calculation of benefits and costs associated with conducting research shows that the existing disparities in the financing of science may start a spiral increasing the scale of these disparities and, as a result, exclude less wealthy countries from participation in the global science system. The internationalization of science is both a way of doing it and a way to overcome the threat of marginalization of national scientific communities in the world of global science. Other management mechanisms require that the systemic method be described in science. Such a description is presented in the next Chapter 3.

3 Systemic learning

This chapter discusses the hybrid nature of the so-called academic goods and the problem of balancing public and private benefits in the context of international scientific cooperation. Subsection 3.2 models of functioning of the science system taking into account the international context. Section 3.3 justifies the importance of an integrated approach to the assessment of scientific potential as a key factor in achieving progress.

3.1 Science as an economic good – a process approach

Academic activity in many countries is an important segment of the economy and the term "great science" is used in the literature to describe it, cf. De Solla Price (1986). From an economic point of view, the results of activities in the academic ecosystem (science and higher education) are goods in the form of knowledge, ideas and innovations serving to meet people's needs through consumption. For the effects of academic activities, the term *academic goods was adopted in the study*. Economists analyze goods in relation to consumer access to goods and the possibility of competition of producers (in this case - we are talking about academic goods and scientific and educational institutions).

Most scholars agree with the opinion expressed that "...*scientific knowledge in its pure form is a classic public good*...", [9]cf. Dalrymple (2003). However, the analysis of the academic ecosystem from an economic point of view shows that academic good has the character of a service (we will further distinguish here *educational services* and *cognitive and applied knowledge*). A classic public good is a good to which every consumer has unlimited access, and the producers of this good do not have to compete with each other. The services offered by the science and higher education system do not have these properties. Institutions offering educational services from both the public and private sectors compete for the best-prepared candidates for studies and research. In addition, the costs of studies (even in the public sector, where there are no tuition fees[10]) may exclude you from using such an offer. Similarly, access to cognitive and scientific knowledge depends on one's financial status and perceptual abilities (e.g., education and ability to reach a level that allows for the perception of current knowledge).

Nor is academic good a private good, because although access depends on wealth, the effects of individual education are positive not only for consumers of academic services. In societies where the level of education is higher on average, the level of crime decreases (the

[9] Own translation, in the original: «*Scientific knowledge in its pure form is a classic public good*».
[10] In addition to tuition fees, the student bears, m.in other things, the costs of textbooks, and if he or she studies outside the place of residence – the costs of dormitory or renting accommodation.

sense of security of all citizens increases, not only those who bear the direct costs) and the rate of economic growth is higher (because a higher level of education leads to an increased ability to absorb technology, which in turn leads to an increase in total added value and increases the well-being of society, e.g. in the area of quality of health care services). The effects of the education of a part of the community (individuals who can afford it) benefit the whole society.

Since some academic services cannot be excluded from consumption, and the production and use of other goods is possible through the process of interaction and economic competition, the academic good is of *a hybrid* nature – some services are of a public good, others of a private, club or common resource, cf. Table 3.1.

Subecosystems (quadrants) and examples of academic good

	Exclude	Not excluded
Competitive	**Private goods** *Patents* *Corporate Research Results* *publications in closed access publishing houses* Private property and use for consideration	**The commons** *laboratories and other academic infrastructure facilities with limitations in the use of resources* exploitation within the potential of access to
Non-competitive	**Club goods** *Professional Associations Academic Services/Resources* *Results of special access studies (defense technology studies)* *access to academic resources through a paid subscription or subscription for a specific category of people* use within the framework of the right of access (paid / membership in a specific association)	**Public goods** *Public Research Results – Open Science* *open access to scientific resources (articles, periodicals, monographs, doctoral dissertations, reports, data sets)* State Property, Free Free Use

Source: ed. On.

Table 3.1. *The quadrants of academic good show the hybrid nature of the research ecosystem and development in an economic context.*

Access to publications presenting research results is associated with indirect costs (in the area of open science) or direct costs (in the traditional model). In the open learning model, the consumer (the reader of the publication) does not bear the costs – they are borne by a third party representing the public interest (authorities or public agencies). In the classic model, the costs are borne by the buyer of the publication.

Although the costs of access to publications in this case are borne by various entities, access (students) to publications in the open learning model makes the publication a public good, but for producers (authors and educational units) publications are private goods, access to which is paid for by the budget (open science model) or directly by the consumer. As these observations show, patent protection of manufacturers (scientists) means that their inventions and innovations are a private good, because you have to pay for the use of the patent. On the other hand, the results of research for special purposes (e.g. for the use of national defence or health care) are academic club goods, as only a limited group of beneficiaries have access to these results. On the other hand, laboratories and other academic infrastructure facilities, the functioning of which is inherently limited, are academic common resources. A hybrid set of academic services creates a complex socio-economic sub-system of the academic ecosystem. Ecosystems in the process of developing scientific and educational cooperation are becoming more and more complicated.

3.2 The process of producing academic good

Dalrymple (2003) considers the interactive four-step creative process of moving from academic ideas to academic goods. In the first stage, ideas and concepts are generated. At the second stage, based on the results of the research, there is a transition to the so-called pure knowledge, and then to applied knowledge. In the third stage, the acquired knowledge is enriched with an ownership element – the analysis is accompanied by an intellectual property perspective. In stage four, Dalrymple categorizes academic goods as public, public-private, and private goods. In this study, we treat these goods in more detail, due to their complex hybrid nature.

The process described by Dalrymple (2003) takes into account the difference between the public and private sectors resulting from the degree of satisfaction of social needs and the level of economic opportunities. Public investment ensures the widespread use of scientific ideas and avoids insufficient private investment, cf. Yin *et al*. (2022). In addition, the results of public-sector research are used by the private sector and vice versa, resulting in numerous forms of interaction. The private sector is characterized by greater economic efficiency than in the case of the public sector, but sometimes by social needs. This phenomenon leads to a hybrid form of functioning of academic institutions, based on the so-called *public-private partnership* (PPPs model[11]). The partnership of PPP is based on financing and multi-entity management.

The creation of academic benefits in the public-private partnership model is considered not only at the national level but also internationally (GPPPs model[12]), see Granados Moreno and Joly (2021). For economically developed countries, represented mainly by multinational corporations interested in developing target countries and future markets, public-private cooperation is becoming an effective tool for bringing together governments, businesses and research groups. Through international state-corporate consortia, research can bring academic goods in the form of new knowledge and innovation. In the Netherlands, the approach to jointly search for "...*innovative*

[11] *Public-Private Cooperation, PPC, Public-Private Partnership, PPP*
[12]Global Public-Private Partnership *(*GPPP *)*

solutions, creating efficient and sustainable business models, and promoting inclusive growth for small entrepreneurs and manufacturers..."[13] is called The Golden Triangle, *cf. Kempenaara* et al. (2017).

The concept of public-private cooperation focuses mainly on goods that have the characteristics of pure public and private goods at the same time. Van der Meer (2002) calls them *hybrid goods*. The public-private model of hybrid goods creation increases the efficiency of the system and the global volume of research achievements, cf. van der Meer (2002), but at the same time complicates the measurement of intellectual property, cf. Dalrymple (2003).

However, the hybrid nature of academic goods goes beyond the markets of public and private goods.

Club academic services and shared academic resources are also hybrid in nature when they benefit from co-funding from the private and public sectors, or even by organized communities. In particular, the partnership of organized academic communities with state bodies with ownership and control over material and technological resources (buildings, laboratories, digital platforms) creates an opportunity for the development of another new form of functioning of academic institutions, which is embodied in the concept of the so-called partnership in the management of the common resource (PCPs model[14]).

The PCPs model describes how to solve the general problems of a self-organizing socio-economic system, see Bollier and Helfrich (2019). The tool aims to create sustainable organisational structures for collective decisions on ownership and asset management, see Russell *et al*. (2023) and providing institutional support for the use of the common resources, Pera and Bussu (2024). As such, the PCPs model has the potential to be exploited in a sub-ecosystem of common academic goods. A similar model is possible in the case of raising capital from private business structures.

Hybrid financing of academic services (educational services, cognitive and applied knowledge) determines the combination of the characteristics of different types of services and therefore the identification of the so-called *quasi-categories* in the form of the so-called quasi-public, quasi-private, quasi-club and quasi-common academic resources. A good that has public-private characteristics and can arise as a result of public-private financing (PPP model, at the level of international cooperation – GPPPs model), depending on the predominance of certain features (limited fulfillment of the conditions of (non)exclusion and

[13] Own translation, in the original: «*...to identify innovative solutions, createefficient and sustainable business models and contributeto inclusive growth of small entrepreneurs and producers...*».
[14] *Public-Common Partnership* (*PCP)*

(non)competitiveness) becomes a quasi-public or quasi-private academic benefit. Thus, academic resources created as a public good, in the event that access to them is no longer open (it is made available for a fee), can only be considered a quasi-public academic good.

Academic services or academic resources created as part of the implementation of strategic directions of state policy become a quasi-private academic good when they are used by the private sector to obtain economic benefits. Similarly, a good whose use is financed by a third party (the state, private business, collective ownership organizations) can be considered a quasi-club academic good. A good created as a result of state and collective co-financing (PCP model) in the form of a partnership between state authorities and organized communities (including private business structures) is a quasi-common academic good.

Taking into account the quasi-categories and hybridity of academic goods, a general definition of hybrid goods can be given. More specifically, a hybrid academic good is a set of academic services whose process of creation and/or use by academia is co-financed by third parties (e.g. in partnership with state bodies, private companies and mixed-owned or dispersed-owned organisations).

3.3 Science as an economic good – a resultant approach

Measuring the potential and effectiveness of the process of creating academic goods must take into account many aspects of the development of science. The degree of development of science can be measured with the help of input and output parameters. The input parameters measuring the potential for the creation of academic goods include, m.in, financial outlays on research and higher education (measured by the level of expenditure and its amount per capita). Another input parameter is expenditure on the costs of academic infrastructure (fixed and investments) and the remuneration of academic staff, cf. Gilbert (1978). Bornmann et al. observe here that "*...science needs the economy in order to exist and function*...", cf. Bornmann *et al.* (2021). The output parameters describing the effectiveness of the academic ecosystem are, m.in, bibliometric data, such as the number of publications, patents, and citations, cf. Moravcsik (1973).

The overall upward trends in academic achievement, as measured by the number of scientific and technical publications, are exponential, which is confirmed in particular by scientometric data, cf. SciVal (1996–2022).[15] The exponential increase in the efficiency of the

[15] Web address for SciVal https://www.scival.com/benchmarking/analyse, access date 22.08.2024

academic ecosystem results from the increase in scientific potential[16]. Statistics on global R&D spending, cf. Statista (1996, 2022), [17]and the number of researchers in full-time equivalents, cf. World Bank (2000, 2018), [18]also show an increase in parameters in exponential progression, cf. normalized values (relative to minimum values) in Figure 3.1.

The intensity of the increase in the volume of financing of production processes and consumption of academic goods in the scientific ecosystem, and thus in the entire academic sector of the economy, significantly exceeds the growth rate of the workforce. The relevant gaps are systematically accumulating, narrowing the scientific potential in terms of quantity. At the same time, the increase in scientific achievements, exceeding the number of researchers, indicates an increase in academic productivity, and thus demonstrates positive trends in the aspect of global efficiency in the area of science and innovation.

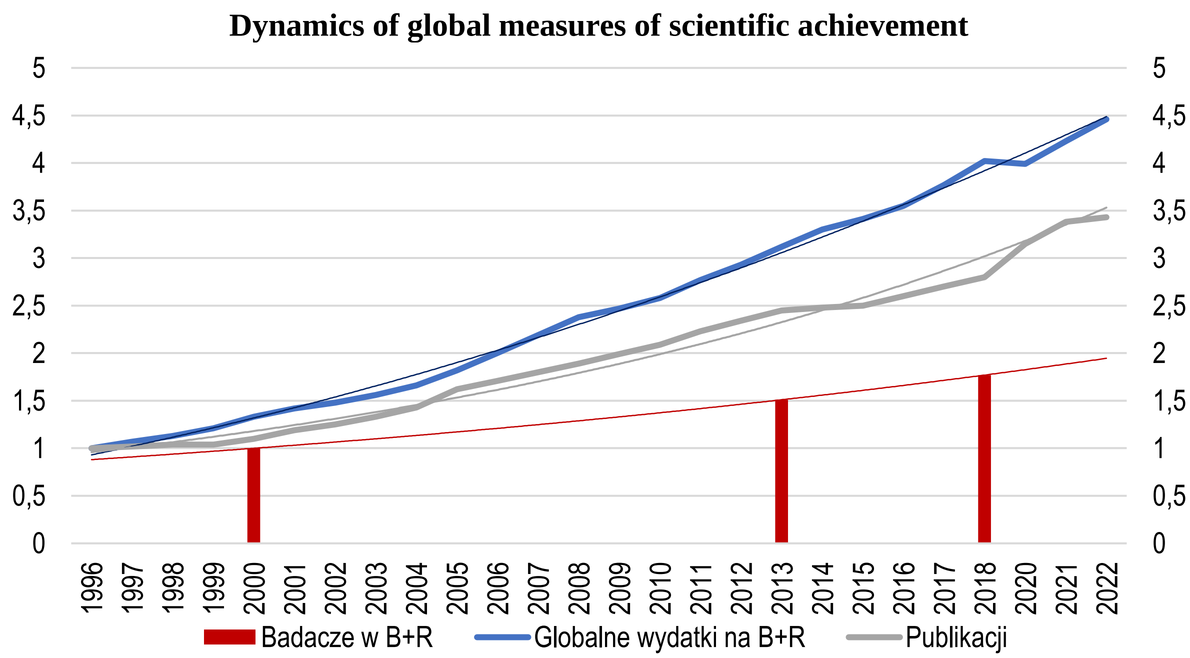


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Figure 3.1. *The number of scholars is growing slower than the level of publications, which in turn are growing slower than the level. This means that scientists are very productive, but the achievements are more costly.*

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[16] A simplified explanation for this results from the assumption that the increase in the number of publications is proportional to their number and each publication has the same development effect (generates the same number of subsequent publications).
[17] Statista web address: https://www.statista.com/statistics/1105959/total-research-and-development-spending-worldwide-ppp-usd/, access date 22.08.2024
[18] World Bank URL: https://databank.worldbank.org/source/world-development-indicators/Series/SP.POP.SCIE.RD.P6, access date 22.08.2024

De Solla Price (1986) points out that the exponential nature of the increase in scientific achievement results from the simplistic assumption that the rate of this growth is proportional to the number of scientists, which is correlated with population dynamics. In addition, the productivity of scientific activity is statistically related to national welfare.

Figure 3.2 shows the important relationship between scientific output and GDP. The figure shows the position of twelve countries (including Polish and Ukraine) comparing the scientific achievements according to SciVal data[19] with the gross domestic product accumulated in 2022.

Meanwhile, the factor of state policy in the area of science and innovation (the case of China) has a significant impact, which shifts the trend line and weakens the link between parameters. The share of publications obtained as a result of international cooperation in relation to the total scientific output is constantly growing, cf. Luukkonen et al. (1992). Figure 3.3 shows the normalised values (relative to the minimums) of global R&D expenditures, the level of international and sectoral cooperation according to SciVal data for the period 1996-2022.

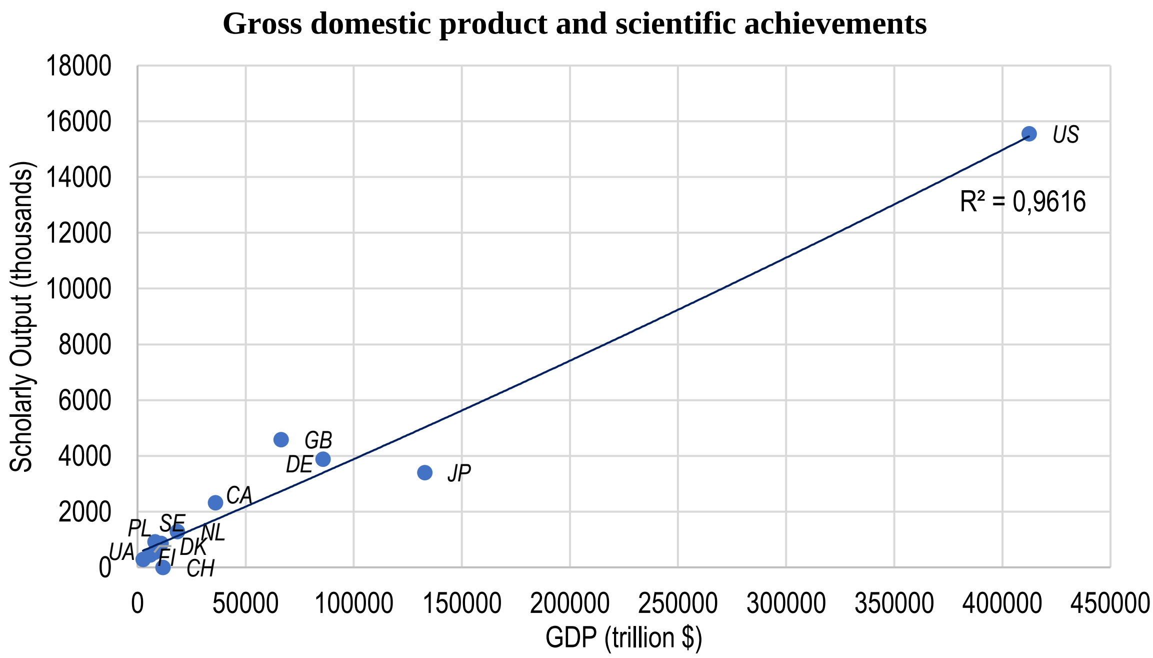

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Figure 3.2. *The number of scientific publications is higher in countries with a larger gross domestic product. Richer countries spend more on research and innovation, leading to greater academic goods.*

[19] Web address to SciVal https://www.scival.com/benchmarking/analyse, access date 23.08.2024

The dynamics of the indicators indicate stable tendencies to strengthen the importance and role of joint research of scientists between academic communities of different countries. As a result, there is a growing scientific interest in research on international academic cooperation.

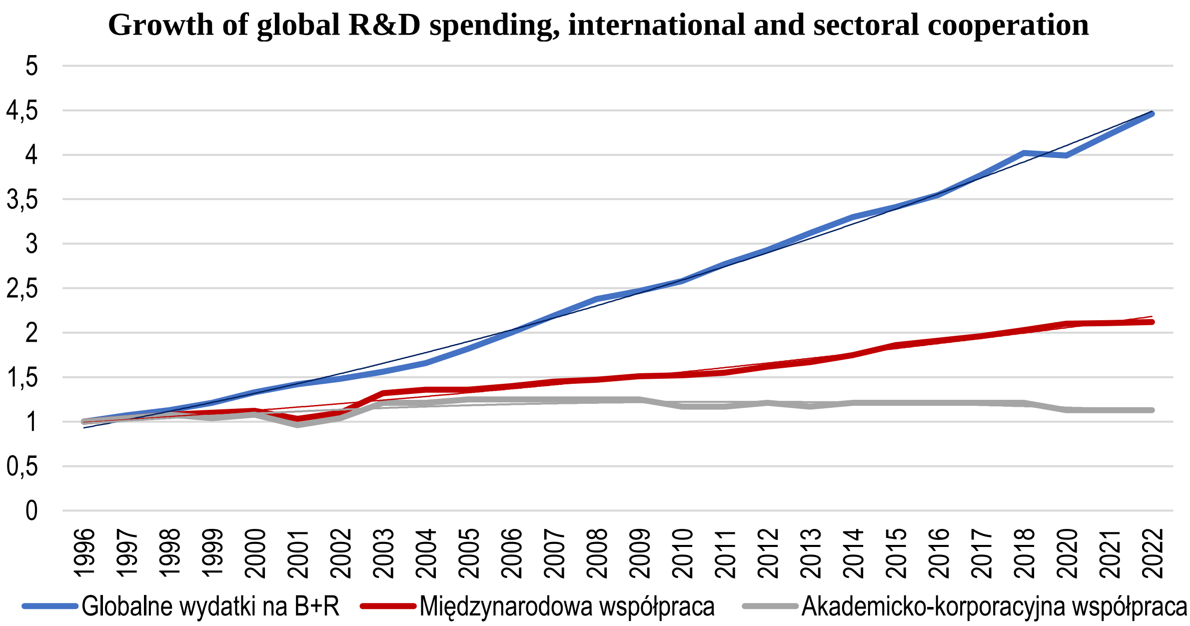

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Figure 3.3. *The level of international cooperation is growing slower than the level of global expenditures, but faster than the level of cooperation between the academic and corporate sectors.*

Figure 3.3 illustrates the low efficiency of expenditure on research and development, international and sectoral cooperation – the pace of incurring costs is much faster than the increase in the level of international cooperation, and relations with business remain at a constant level. This means that researchers are more willing to build and develop international academic networks than scientific and industrial clusters, and that the achievements resulting from the combination of global science, industry and other stakeholders become more expensive.

4 The Social Dimension of Academic Good

This chapter presents and analyzes the social dimension of academic goods, in particular describes the conflict between the social nature of scientific knowledge and private intellectual property. Contemporary challenges related to funding, ethics and productivity in the academic ecosystem (subsection 4.1) and mechanisms and challenges of international academic cooperation (subsection 4.2) are discussed.

4.1 The role of open access in the modern scientific community

As mentioned in Chapter 3, scientific activity can be treated as a four-phase process that includes the process of establishing the current state of knowledge, seeking the truth in the context of the needs of modernity, and shaping new knowledge. The main motives for practicing science are individual curiosity and the expected benefits of knowledge in satisfying social needs. This perspective can be supplemented with other motives (e.g. ambition, the desire to belong to a specific social group, the influence of social persuasion). The impact of such stimuli shapes the social dimension of science, as a result of which academic good takes on a social character. The social nature of science is related to the problem of social responsibility, which leads to the institutionalization of procedures, striving for effective organization of scientific activity and shaping the principles of academic culture.

Various concepts of the description of the social dimension of science have been presented in the scientific literature. The social dimension of academic good is considered without reference to the economics of goods. *Open science* in the literature means universal access to the results of scientific research. The basic assumption of the model in which science is financed publicly (i.e. from citizens' taxes) serves as a premise for justifying the need and requirement for the state to ensure universal access to research results (implemented e.g. through public libraries). This view leaves aside the differences in the financing of science from national budgets and private funds.

The communication of the results of contemporary scientific research takes place on a scale incomparable to that observed in the past, which results in an increase in the pace and scope of knowledge exchange, cf. De Solla Price (1986) and translates into an acceleration of the research process. The hybrid nature of scientific knowledge leads to a paradox resulting from the conflict between the social nature of scientific knowledge and the private intellectual property of the scientist associated with scientific discovery. The essence of this conflict results from the following fact. Private property leads to limited access to discoveries and their implementation, while the social nature of discoveries and knowledge requires them to be treated as a public good, and this means the requirement of open access to publications and the results of creative activity. Merton (1957) signals that the following dilemma arises here: either the product of scientific and technological activity will be widely available, or one must take into account the possibility of limiting this access, or in extreme cases losing it. The need to solve this dilemma in a situation of increasing the pace and scale of research leads to the question of the process of disclosing and communicating information about scientific results, in economics treated as the occurrence of the so-called *information asymmetry*. Perceiving information as an economic good is combined with considerations within *academic ethics*.

As David (1992) notes, the professional culture of the modern academic is different from that of the researcher concerned with the application and implementation of scientific results in industry. Industrial implementations, as well as industrial research conducted in a closed form, have specific standards for the disclosure and protection of the information obtained.

Academic institutions and scientific organizations have developed standards in the form of collective procedures that encourage and facilitate open communication and rapid verification of scientific claims. The level of adherence to these standards builds and reflects an academic reputation. This reputation plays a key role in the organization of scientific work and the creation of a system of material and moral rewards. As a result, the academic culture of open research takes on a social dimension, and the knowledge generated by open science becomes a public good. The sphere of applications and implementations has different norms in the information system, which require that the results obtained be treated as a private good.

Open science, i.e. open access to scientific knowledge, is created in an open scientific infrastructure, uses open scientific communication and makes research results available to social entities. Through inclusive dialogue with other knowledge systems, cf. UNESCO (2022), open science promotes the public sharing of scientific results as much as possible. Such sharing of research results leads to a long-term increase in the amount of academic information and multiplier effects in the process of accumulation of knowledge and benefits from its application. Creating a wide range of opportunities to learn about previous discoveries and scientific cooperation increase the potential of breakthrough research leading to an increase in the level of public welfare, cf. Partha and David (1994), Mukherjee and Stern (2009), Mirowski (2018).

Figure 4.1 shows that the change in the role of ecosystems in a perspective focused on mechanisms and forms of cooperation consists in moving from positioning scientific discoveries as a key factor of economic development, to building a science economy capable of meeting the needs of the market, and further to supporting the transparency of academic goods, and thus the complexity of the ownership structure in order to achieve synergistic effects of private-public partnership.

Research on the issues of international academic cooperation

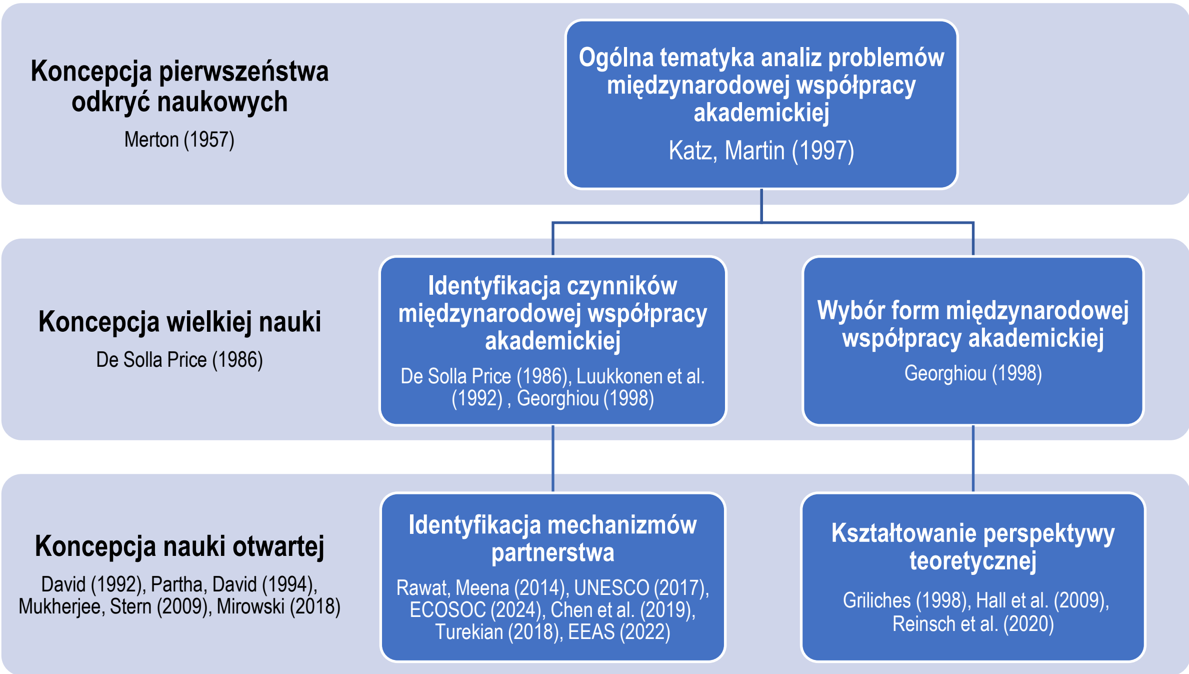

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Figure 4.1. *I divide the research on the conceptual structures of social science into the analysis of mechanisms and forms of cooperation (dark blue fields).*

Katz and Martin (1997) showed that the issues presented in the literature on collaborative research can be divided into several categories. They distinguish four groups of studies – studies that concern:

- methodology of multiple authorship measurement and research collaboration,
- factors conducive to the emergence of scientific cooperation,
- sources of cooperation,
- impact on the productivity of scientific activity and the impact of publications.

Chen *et al*. (2019) conclude that the research topics of scientific cooperation are changing slightly. Researchers are still interested in:

- stimulants,
- Effects
- measures of development,
- specific features of cooperation patterns,
- using social network analysis to assess S&T cooperation.

This paper focuses on two groups of issues concerning, respectively, the characteristics and mechanisms of scientific cooperation.

The study of the characteristics of international cooperation in science, technology and innovation[20] leads to a development analysis using measures of such research cooperation. The results of this analysis allow to indicate and justify the directions of partner selection and research topics, as well as to identify and compare differences between different countries and between different entities. An important area of research here is the analysis of the specific features of research cooperation networks, allowing for the development of an approach that rationally balances the potential costs and benefits of partners.

An important direction in the group of analyses concerning cooperation mechanisms is the study of factors and mechanisms specific to a given network of international scientific cooperation. This specificity is related to the effectiveness of scientific results, technology and innovation, and the promotion of knowledge transfer. The identification of the cause-and-effect relationship between international cooperation and the quality and effectiveness of the results of this cooperation allows us to recommend a multidimensional system for evaluating the future results of cooperation.

4.2 Mechanisms and challenges of international scientific cooperation

Attempts to explain the differences between countries in the areas of international co-authorship of publications, the functioning of scientific cooperation networks and models of global cooperation in scientific fields provide important information for scientific networking strategies. At the macro and mezzo level, social factors (geopolitical aspects, history, language, cultural traditions) are important. Economic factors and the level of development of scientific infrastructure, as well as the increase in the specialization of science, are also important here. The differences that occur allow us to distinguish a group of dominant and weaker countries. This approach will be used in the next study on the academic ecosystem of Ukraine, in which three groups of countries (reactive countries, ethnically determined countries, countries leading in science and innovation) were selected for comparison.

Scientific literature indicates that scientists from countries with low scientific achievements are looking for partners for cooperation, striving for complementarity in the use of resources. However, Luukkonen *et al*. (1992) indicate that the relationship between the size of scientific achievements and the rate of international cooperation is relatively weak.

[20] The acronym STI stands for *Science*, *Technology and Innovation*.

Georghiou (1998) explores global research collaboration between industrialized countries in the form of individual (non-formalized) collaboration between scientists, which he calls "bottom-up" collaboration. At the same time, Georghiou appreciates the importance of developing the functioning of institutional formalized mechanisms. The predominance and rapid progress of science in developed countries (USA, Japan, Korea, Australia, Canada) in key fields forces other countries to maintain the closest possible contact with them in the conditions of the competitive scientific environment of developed countries. In this situation, there are incentives for scientists to seek the benefits of additional knowledge available during contacts with high-class foreign specialists. Historical models of cooperation based on individual ties are gradually being replaced by the use of motivational incentives, which also affects bilateral relations between countries, cf. Georghiou (1998).

The scale, intensity and dynamics of international academic cooperation depend on a wide range of factors: cognitive, social, historical, geopolitical, economic, cf. Luukkonen *et al*. (1992). The fundamental importance of human capital should be emphasized here. The recommendations of the 2017 Conference on Education, Science and Culture organized by the United Nations stated that human resources are the basis for the development of research and experimentation and are necessary for the implementation and use of research results, cf. UNESCO (2017).

The literature notes the need to create mechanisms to support the development of the science system. As noted by Chen *et al*. (2019) Each country should have a stimulating environment in universities, with institutionalization of professional scientific structures and associations, with funding focused on basic and applied research and development, with the implementation of scientific policies that support and promote the development of research activities. The thesis is put forward that in order to achieve the goals of peace and universal prosperity, national political systems must ensure the development of international scientific relations, cf. UNESCO (2017). All this requires strengthening efforts to build an inclusive environment in the field of science, technology and innovation. Building an inclusive environment requires the development of a multilateral system for assessing the prospects for international cooperation. This requires a number of socio-economic and political and organizational decisions. To build a socio-economic base, it is necessary to develop digital infrastructure and skills, support investment in international public-private partnerships. Political-organisational support should include institutional and informal strengthening of research networks and cooperation between different actors, and political and organisational promotion of technology and knowledge transfer, cf. ECOSOC (2024).

At the same time, the researchers point to the spread of such a phenomenon as the growing social and political pressure on universities, cf. Dotti and Walczyk (2022). The emphasis on increasing the number of publications leads to unethical practices and the creation of many new journals, cf. Rawat and Meena (2014). Thus, the need for a balanced approach in the implementation of incentive mechanisms is emphasized, as well as the use of productive interaction between researchers and stakeholders as an effective strategy for joint and co-creative scientific work.

Against the background of political pressure in the conditions of widespread use of digital technologies, the idea of a constant increase in academic productivity measured only by quantitative measures – e.g. the level of publications, circulation and infrastructure measures – is questioned. Newport (2024) states that the increase in the number of digital devices reduces attention span and reflection and deteriorates the quality of scientific work, resulting in less disruptive to science despite increased publications and grant funding. As a result, we are dealing with the following paradox. On the one hand, the latest information and communication technologies are accelerating research, but on the other hand, there is an overload of the workforce. Newport also emphasizes that the time of reflection necessary to maintain sustained concentration, and thus the central element of scientific work, is in practice underestimated in the modern research environment and is not analyzed in measurable categories.

Scientific engagement in international cooperation to support broader goals, beyond scientific discovery, determines the need to leverage research experience and links to support priority foreign policy issues, see Turekian (2018). Scientific cooperation in international relations is being integrated and, entering the sphere of diplomacy, science acquires new social dimensions defined as diplomacy for science's sake, science for diplomacy's sake, and science for diplomacy, cf. EEAS (2022).

The analysis of the social dimension of academic benefits and the roles of open science in the context of international scientific cooperation and the challenges of the contemporary scientific community presented in this chapter (cf. Appendix) allows us to describe potential conditions in the process of choosing common directions of research in international academic cooperation (cf. Concluding Remarks).

5 Concluding Remarks

The most important results presented in the study are the following conclusions relating to. mechanisms and models, the implementation of which will contribute to strengthening international academic cooperation and increasing the effectiveness of scientific research:

- *Global virtual science platforms can greatly simplify international collaboration by enabling researchers, universities and companies to work together on projects and share knowledge in real time, reducing costs and increasing resource availability.*
- *Inclusive open science consortia that bring together researchers from different countries and sectors will provide access to cutting-edge developments and reduce differences between countries by creating mechanisms for knowledge and technology transfer.*
- *Public-private partnership models in science, which involve joint funding and commercialisation of research, can accelerate the deployment of research results in the real sector, stimulating innovation and increasing the competitiveness of economies.*
- *Digital science diplomacy hubs, which will act as platforms for collaboration between scientists, diplomats and policymakers, will help discuss global challenges and coordinate action at the international level, strengthening the role of science in policymaking.*
- *Mobility networks for young researchers can significantly improve their qualifications and develop global research networks by offering internships, exchanges and mentoring programmes in leading research centres.*
- *Mechanisms for the ethical certification of scientific projects that assess compliance with ethical standards will contribute to increasing transparency and preventing unethical practices in science.*
- *Support and integration of the scientific diaspora, through specialised platforms and funding for joint projects, will help to engage experienced researchers, maintain ties with home countries and expand international scientific networks, which will contribute to cultural and scientific* exchanges.

These mechanisms and models can create a more inclusive and effective system of international scientific cooperation that supports both the development of science and the solution of global challenges.

The study of the scientific context of global integration processes shows the multi-conceptual nature of the theory of international academic cooperation. The diversity of conceptual approaches to understanding, explaining and interpreting international academic cooperation on the one hand complicates the discussion, and on the other hand, allows to highlight the multiplicity of points of view and outline a wide set of conceptual frameworks, taking into account the possibility of identifying and analyzing the dominant trends and factors in the development of global cooperation. Summing up the available scientific contributions, we have tried to comprehensively reflect such a conceptual framework. This made it possible to form a systematic vision of the theoretical foundations and at the same time to guide scientific research. In our opinion, international academic cooperation is of key importance for strengthening scientific potential and stimulating innovative development, but unequal funding may limit its effectiveness. The initial features of international cooperation in the field of science, technology and innovation are conditioned by the hybrid nature of academic goods. This nature requires a comprehensive approach to management and investment. A balance between public and private interests should support the integration of scientific efforts and adapt practices to global challenges.

Contemporary research in the field of international academic cooperation is mainly based on theoretical assumptions concerning the social and economic aspects of scientific activity, and not on statistically representative samples. The requirement for representativeness can be reduced by focusing on smaller groups of countries and sampling the data, allowing for a more detailed analysis. Such analysis and review of statistical data will improve the reliability of the results.

An interesting direction of research is the mechanisms of science management in general, and international academic cooperation in particular in the process of knowledge creation and innovation in the situation of specific national research and higher education systems. In this process, it is crucial to separate the answer to the question of how international academic cooperation affects the effectiveness of research and what mechanisms of interaction between co-authors and in knowledge sharing are effective in this process.

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7 Annex: Selected results of analyses of scientific cooperation

Selected theoretical results of analyses of the contribution of science to the theory of scientific cooperation

Authors	Main result	Detailed results
1	2	3
Merton (1957)	The concept of the primacy of scientific discovery	Main theses: − primacy principle: priority of scientific discoveries is given to the first scientists (group of scientists) who proposed a theory and published scientific results; − The impersonality of scientific knowledge creates a paradox: the intellectual property of discoveries can only be protected through open publication containing a solution to the dilemma of "spread or lose"
De Solla Price (1986)	The concept of small and big science	Main theses: − the rule of thumb "80-90% out of 10-20%": 80-90% of all scientists who have ever lived are alive today, 80-90% of scientific work is created in one human lifetime, and 10-20% is previous experience; − The transition from small science (a set of theoretical results of individual or group efforts) to large science (large-scale academic projects) occurs gradually as a result of socio-economic and methodological changes and has significant social effects; − Science is growing exponentially, scientific power (scientific population (human capital) and number of publications) is growing by compound percentages and is a function of per capita wealth
David (1992), Partha and David (1994), Mukherjee and Stern (2009), Mirowski (2018)	The concept of closed and open learning	Main theses: − Unlike closed science (commercial research and development), open science (transparent and accessible knowledge that is shared) fosters accumulative production and maximizes long-term knowledge growth for groundbreaking research; − reputation plays a central role in the organization of scientific work; − In a reputation-based reward system, the principle of precedence is key
Katz and Martin (1997), Chen *et al*. (2019)	Division of topics for the study of problems of international academic cooperation	Research groups include: − methodology for measuring researcher cooperation; − determinants of shaping scientific cooperation; − sources of cooperation; − impact on research productivity and impact of publications; Study collaboration through social network analysis
De Solla Cena (1986), Luukkonen *et al.* (1992), Georghiou (1998)	Identifying the factors of international academic cooperation	The main factors include: − socio-economic factors; − development of scientific and mechanical infrastructure; − the growing specialization of science; − development of formalised institutional mechanisms; − human capital; − the size of the national wealth and population of the country
Georghiou (1998)	Selection of forms of international academic cooperation	Forms of international cooperation: − exchange of researchers (including scholarships); − seminars or other meetings; − joint projects or networks (from sharing results to interactive partnerships); − access to scientific equipment, division of the costs of its use; − long-term relationships between laboratories; − participation in the partner country's national programmes; − the establishment of auxiliary laboratories in the partner country; sponsorship or participation in national programs

1	2	3
Griliches (1998), in Hall *et al*. (2009), Reinsch *et al*. (2020)	Shaping the theoretical perspective	Theoretical principles of economic and social development: R&D → strengthening the economy; academic cooperation (institutional and personal cooperation in basic and applied research) → exchange of ideas and methods → the overflow (circulation) of knowledge → the evolutionary nature of innovation → economic growth
Rawat and Meena (2014), UNESCO (2017), ECOSOC (2024), Chen *et al*. (2019), Turkian (2018), EEAS (2022)	Identifying partnership mechanisms	Stimulating mechanisms: − stimulating environment in universities; − institutionalization of scientific professional structures and associations; − funding basic and applied research and development; − implementation of scientific policy supporting and promoting the development of research activities and the protection of intellectual property rights; − development of international scientific relations; − the use of a sustainable approach in the implementation of the stimulus mechanisms; − the use of digital technologies; − the development of science diplomacy

Source: ed. On.

Table. *In this paper, we build on the theoretical foundations of the large and open science concepts of De Soll Ceny (1986), David (1992), Partha and David (1994), Mukherjee and Stern (2009), Mirowski (2018), and use the mechanisms proposed by Rawat & Meena (2014), UNESCO (2017), Chen et al. (2019) (bold)*

8 Summaries

STRESZCZENIE

Celem niniejszego opracowania jest zbudowanie ogólnych ram pojęciowych dla badań w zakresie międzynarodowej współpracy akademickiej. Ważnym zadaniem badawczym jest określenie pożądanych zasad współpracy pomiędzy partnerami o różnym potencjale w oparciu o opis mechanizmów, które ułatwiają lub utrudniają integrację partnerów o mniej dojrzałych systemach akademickich ze społecznością globalną. W opracowaniu podsumowano przykłady wkładu nauki w teorię międzynarodowej współpracy akademickiej, która stała się podstawą do powstania podstaw metodologicznych do analizy akademickiego komponentu procesu integracji globalnej. Działalność akademicka jest przedstawiana jako złożony, systematyczny proces wytwarzania wiedzy, idei i innowacji. Teoretyczna analiza ekosystemu akademickiego z perspektywy ekonomicznej wykazała, że dobra akademickie mają charakter hybrydowy i mają cechy zarówno dóbr publicznych, jak i prywatnych. W wyniku przeprowadzonej analizy pod kątem społecznym wskazano kluczowe kierunki rozwoju ekosystemów akademickich: otwarta nauka, współpraca międzynarodowa, rozwiązania cyfrowe, etyka akademicka. Wnioski z analizy teoretycznej dostarczają kierunkowych rekomendacji dotyczących mechanizmów i modeli, których wdrożenie przyczyni się do zacieśnienia międzynarodowej współpracy akademickiej i zwiększenia efektywności badań naukowych.

АБСТРАКТ

Метою цього дослідження є побудова загальної концептуальної основи для досліджень у сфері міжнародного академічного співробітництва. Важливим дослідницьким завданням є визначення бажаних принципів співпраці між партнерами з різним потенціалом на основі опису механізмів, які сприяють або становлять перешкоду для інтеграції партнерів з менш зрілими академічними системами до світової спільноти. У дослідженні узагальнено приклади внеску науки в теорію міжнародної академічної співпраці, що стало основою для формування методологічних засад аналізу академічної складової глобального інтеграційного процесу. Академічна діяльність представлена як складний, системний процес виробництва знань, ідей та інновацій. Теоретичний аналіз академічної екосистеми з економічної точки зору показав, що академічні блага є гібридними за своєю природою та мають характеристики як суспільних, так і приватних благ. У результаті аналізу з соціальної точки зору було виділено ключові напрямки розвитку академічних екосистем: відкрита наука, міжнародна співпраця, цифрові рішення, академічна етика. Висновки з теоретичного аналізу дають напрямкові рекомендації щодо механізмів і моделей, впровадження яких сприятиме зміцненню міжнародної академічної співпраці та підвищенню ефективності наукових досліджень.