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ANALYSIS OF THE RELATIONSHIP BETWEEN "BUSINESS-SCIENCE" COOPETITION AND INTELLECTUAL PROPERTY RECEIPTS

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Abstract*: The study actualizes the issue of cooperation between business and science on the way to the commercialization of innovations in modern conditions. A hypothesis is put forward regarding the relationship between the level of cooperation between industry and science (based on the University-Industry Research Collaboration indicator within the Global Innovation Index) and the income from intellectual property. Therefore, the article aims to confirm the existence and establish a cause-and-effect relationship between the level of cooperation between business and science and the amount of income from intellectual property. A bibliometric analysis is carried out at the first stage to confirm the hypothesis, and the main directions of interdisciplinary research related to this issue are highlighted. In the second stage, the research information base is formed based on the statistical data of the World Intellectual Property Organization for a sample of 10 countries - leaders according to the Global Innovation Index of 2022 for the last 10 years (2013-2022). In the third stage, a correlation analysis is carried out to confirm a relationship's existence and determine its statistical significance, nature and strength. At the fourth stage, a vector autoregression is constructed, based on the results of which Granger testing for cause-and-effect relationships is performed to determine the influence direction between the studied indicators. It is established that the level of cooperation between business and science is the cause and affects the amount of income from intellectual property in 6 of the 8 countries of the sample, in which the cause-and-effect relationship between the studied indicators was confirmed and established; the amount of income from intellectual property is the cause and affects the level of cooperation between business and science in 5 of the 8 countries of the sample, in which the cause-and-effect relationship between the studied indicators was confirmed. At the same time, in 3 out of 8 countries of the sample, in which the cause-and-effect relationship between the studied indicators was confirmed, a two-way influence was found. Accordingly, it is substantiated that the level of cooperation between business and science directly and positively affects the income from intellectual property. Therefore, the strengthening of collaboration between industry and science will contribute to the increase in the amount of income from intellectual property. In turn, the revenue volume from the intellectual property will also contribute to improving and developing cooperation between business and science. The obtained results can be helpful for scientists in further research in related scientific areas and for representatives of the business community, government officials and other persons interested in this issue.*

Keywords: business-science coopetition, causal relationships, Global Innovation Index, intellectual property income, research and development, research cooperation, university-industry research collaboration.

JEL Classification: M21, O32, O34.

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Introduction

Today, the cooperation of business and science is an important factor in innovative development, as evidenced by the methodology of the Global Innovation Index and the corresponding emphasis on the University-Industry Research Collaboration indicator in the structure of forming its overall assessment and rating position of the countries of the world (WIPO, 2020), as well as numerous analytical research (THE, 2020; OECD, 2019; Morisson & Pattinson, 2020) and scientific research in this context.

Lutchen, K. R. (2018) focuses on the changing model of interaction between business and science in the field of scientific research and development, taking into account the resulting benefits for participants, as well as the positive impact on economic growth in general. Collaboration between business and science is increasingly seen as a means of enhancing innovation through knowledge sharing (Ankrah & Al-Tabbaa, 2015). At the same time, universities and scientific institutions are traditionally considered to be responsible for fundamental scientific and pre-commercial research, while business and industry perform the main part of applied research and development in order to bring new products and processes to market. Accordingly, it is of great importance to ensure effective interaction, the speed of innovation transfer, overcoming the tension of the dual goals of knowledge appropriation and dissemination (Hall, 2004; Hall et al., 2003; Adams et al., 2001; Lee, 2000). The issue of attitude to intellectual property rights in this context is also controversial (Hall, 2004). Lace, N. & Rumbinaite, G. (2016) point to the difficulty of determining who owns the intellectual property created in joint projects as one of the key barriers to effective collaboration between science and business.

At the same time, despite the above, an important role in the direction of commercialization of innovations and receipt of income from intellectual property is assigned precisely to the cooperation of business and science. Therefore, the purpose of the article is to confirm the existence and establish a cause-and-effect relationship between the level of cooperation between business and science and the amount of income from intellectual property.

Literature Review

By conducting a bibliometric analysis, the dynamics of scientific interest in this issue were first analyzed based on the dynamics of indexing of publications on this issue in the Scopus scientometric database. The results of the analysis are shown in Figure 1.

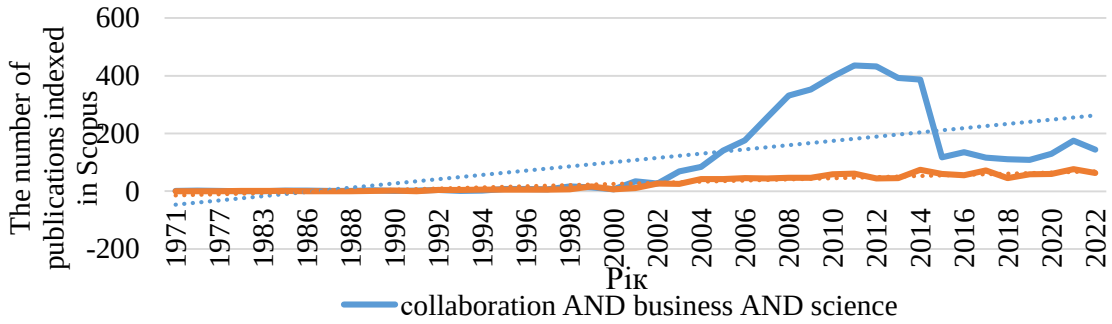

Figure 1. Dynamics of scientific interest in the relationship between the cooperation of business and science and the amount of income from the use of intellectual property

Source: constructed by the authors using the tools of the Scopus scientometric database

In general, the trend regarding the dynamics of publication activity is positive for both search queries ("collaboration AND business AND science" - 4,633 documents for more than 50 years - 1971-2022, and "intellectual AND property AND commercialization" - 1,175 papers for 40 years - 1982-2022); however,

scientific interest in the issue of cooperation between business and science is characterized by sharp changes - both ups and downs in the 2000s. It should also be noted that more than 80% of the publications on the issue of cooperation between business and science were published in the last 15 years from more than 50 studies. Similarly, more than 70% of publications on the commercialization of intellectual property were published in the previous 15 years out of 40 studies, which indicates the relevance of this scientific issue in general, particularly this study.

Based on the data samples formed above based on the specified search queries in the titles, abstracts and keywords of publications indexed by the Scopus scientometric database, a visualization map was built in the VosViewer software environment depicting clusters of interdisciplinary research related to this issue and their relationships between them (Figure 2).

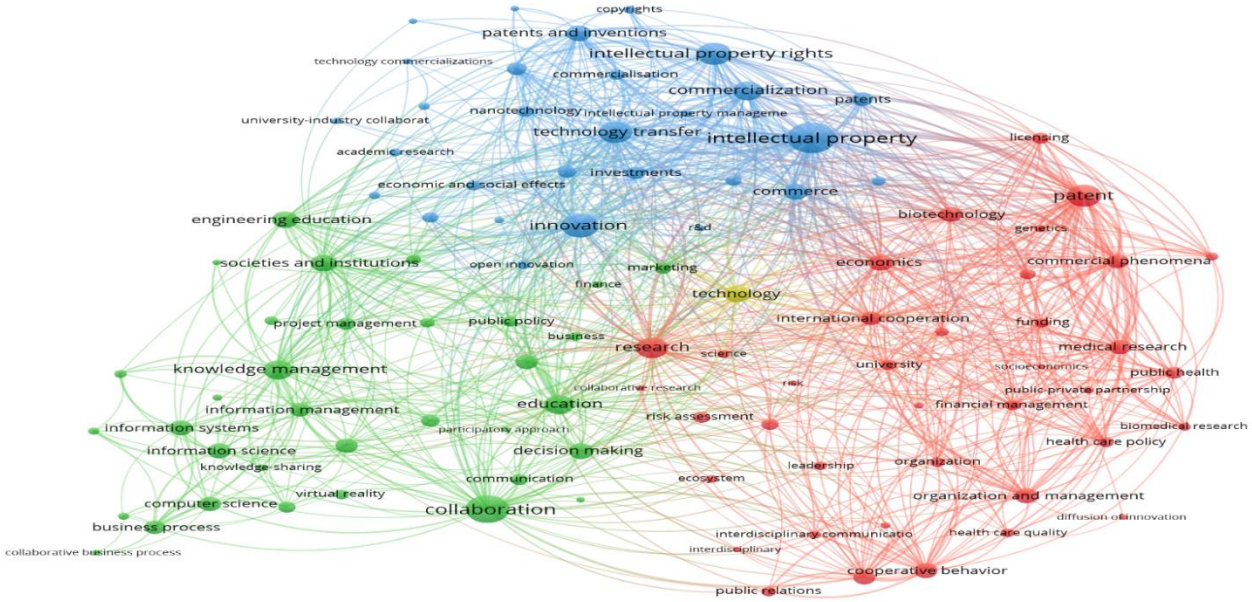

Figure 2. Visualization map of interdisciplinary research clusters and the relationships between them based on the search queries "collaboration AND business AND science" and "intellectual AND property AND commercialization"

Source: built by the authors using the tools of the Scopus scientometric database and the VosViewer software environment

The frequency of mention of specific keywords was set to 20, in connection with which 480 keywords were selected out of 331337 identified. After that, 112 keywords were selected based on the relevance of the research topic, displayed on the visualization map and grouped into four clusters:

1) blue cluster – intellectual property and innovation transfer, patents and inventions, copyright, intellectual property protection, commercialization, commerce, investments, legislation, economic and social effects, business and university cooperation, intelligent property management;

2) red cluster – research, knowledge, science, licensing, patents, organizational management, leadership, corporate behavior, public-private partnership, interdisciplinary communications, international cooperation, financing, risk assessment, economic research, medical research;

3) green cluster – cooperation and communications, public policy, business, business collaboration, decision-making, education, computer science, information systems, engineering education, knowledge management, project management, society and institutions, sustainable development;

4) yellow cluster – technologies, information technologies.

It follows from the above that the cooperation of business and science and the commercialization of intellectual property are most closely related to the medical, information and communication, engineering, and economic spheres, as well as sustainable development.

A visualization map by countries of scientific interest on this issue is shown in Figure 3.

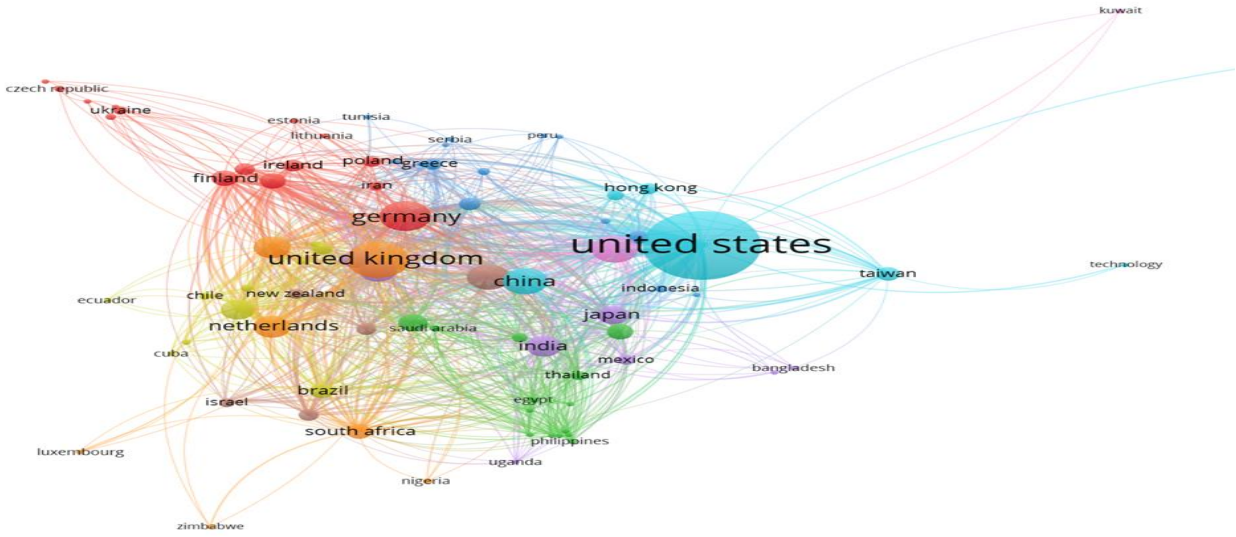

Figure 3. Analysis of scientific interest in the issue of cooperation between business and science and commercialization of intellectual property by country

Source: built by the authors using the tools of the Scopus scientometric database and the VosViewer software environment.

It is evident that the interest in this issue is taking place in many countries and is due, first of all, to the study of positive effects and the possibilities of their achievement in this area. The most significant scientific interest is characteristic of the United States of America, Great Britain, the Netherlands, Germany, Finland and others. Moreover, most countries are innovatively developed and occupy high positions in the Global Innovation Index.

In the example of cooperation between universities and industry in the USA, scientists consider both old models of interaction and the newest ones in their historical genesis, considering Bayh-Dole, etc. (Mowery et al., 1999; Mowery, 1999). Ivascu et al. (2016) investigated the model of cooperation between universities and industry under conditions of open innovation as a response of business companies to market demand to ensure successful collaboration between science and business.

Various aspects of cooperation between business and science and its effects were considered in works (Shvindina, 2017; Samoilikova et al., 2022; Koibichuk et al., 2022). Factors influencing the co-opetition of business and science were singled out by Ćudić et al. (2022), O'Dwyer et al. (2022), Awasthy et al. (2020), etc. Emphasis on the special promotion of partnerships between science and business in the era of digital pathology and artificial intelligence technologies is made in work (Pantanowitz et al., 2022).

Okamuro & Nishimura (2013) studied the impact of a university's intellectual property strategy on the productivity of university-industry research collaborations. He et al. (2021) analyzed the problem of asymmetry.

Methodology and research methods

The study puts forward a hypothesis regarding the relationship between the level of cooperation between business and science and the amount of income from intellectual property. In the first stage, a bibliometric analysis is carried out using Scopus database tools and VosViewer software to confirm it. The main directions (clusters) of interdisciplinary research related to this issue are identified. In the second stage, the research information base is formed based on the statistical data of the World Intellectual Property Organization for a sample of 10 countries - leaders according to the Global Innovation Index of 2022 for the last 10 years (2013-2022), taking into account

the overall rating assessment (WIPO, 2022) and in particular, estimates of University/Industry Research Collaboration (WIPO, n.d.b) and Intellectual Property Receipts, % of total trade (WIPO, n.d.a). In the third stage, a correlation analysis is carried out to confirm the existence of a relationship, its statistical significance, nature and strength. Based on the Shapiro-Wilk test (Shapiro & Wilk, 1965), the method of correlation analysis – Pearson (Pearson, 1896) or Spearman (Spearman, 1987) is determined. At the fourth stage, a vector autoregression is built, based on the results of which Granger's causality test is performed (Granger, 1969) to determine the direction of influence between the studied indicators using STATA software.

Results

To conduct a study to confirm the hypothesis about the existing relationship between the level of cooperation between business and science and the amount of income from intellectual property, a sample of 10 countries – leaders according to the Global Innovation Index of 2022 was formed, which included the following countries: 1) Switzerland; 2) USA; 3) Sweden; 4) Great Britain; 5) the Netherlands; 6) Republic of Korea; 7) Singapore; 8) Germany; 9) Finland; 10) Denmark (WIPO, 2022), for the last 10 years (2013-2022) according to indicators of cooperation between business and science (University/Industry Research Collaboration, estimate) and receipts from intellectual property, % of total trade (Intellectual Property Receipts, % Total Trade, estimate), which are indicators of the Global Innovation Index (WIPO, n.d.a, n.d.b).

To confirm the existence of a relationship, its statistical significance, nature and strength, a correlation analysis was conducted – the corresponding Pearson (Pearson, 1896) or Spearman (Spearman, 1987) correlation coefficients were calculated depending on the subordination of the data to the law of normal distribution, determined by the Shapiro test Wilk (Shapiro & Wilk, 1965). In the case of normal data distribution, the Pearson correlation coefficient was calculated (the result of the Shapiro-Wilk test is more significant than 0.05), and in the opposite case - Spearman's (the development of the Shapiro-Wilk test does not exceed 0.05). Time lags from 1 to 3 years was also considered. The summarized results are shown in Table 1.

Table 1. Results of confirming the existence of a relationship, determining its statistical significance, nature and strength

Country	Shapiro-Wilk test result	Results of correlation analysis			
		Correlation coefficient	Time lag	Nature of communication	Level of influence
Switzerland	0.55998	0.3776	2	direct / positive	average
USA	0.30395	0.6425	2	direct / positive	average
Sweden	0.23588	0.3108	1	direct / positive	low
United Kingdom	0.10641	-0.1940	–	inverted / negative	very low, not statistically significant
Netherlands	0.82113	0.7823	3	direct / positive	high
Republic of Korea	0.50683	0.7153	2	direct / positive	high
Singapore	0.07726	-0.7987	1	inverted / negative	high
Germany	0.00784*	-0.8571	–	inverted / negative	high
Finland	0.39784	0.3610	–	direct / positive	average
Denmark	0.35540	0.1829	1	direct / positive	very low, not statistically significant

*Note: * - data outside the normal distribution, Spearman's correlation coefficient is used.*
Source: Calculated by authors using STATA software based on (WIPO, n.d.a, n.d.b).

Correlation analysis shows that the relationship between indicators of cooperation between business and science and income from intellectual property is statistically significant in 8 out of 10 countries, including direct (positive)

in 6 of these 8 countries and inverse (negative) in 2 of these 8 countries. At the same time, in 7 out of 8 countries, the relationship is characterized by high or medium strength.

To find out directly the cause-and-effect relationships between indicators of cooperation between business and science and income from intellectual property, a vector autoregression was constructed, based on the results of which the Granger test is performed (Granger, 1969; Stata, n.d.), which determines causality and the direction of influence between the investigated indicators. The results of vector regression on the example of Switzerland are shown in Table 2.

Table 2. Results of vector autoregression on the example of Switzerland

Equation			R-sq	chi2	P>chi2	
IP			0.6114	12.58527	0.0135	
BS			0.7660	26.19207	0.0000	
IP	**Coef**	**Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**	
IP						
L1.	-.746069	.2958875	-2.52	0.012	-1.325998	-.1661402
L2.	-.4437012	.25869	-1.72	0.086	-.9507242	.0633219
BS						
L1.	-6.397302	2.310969	-2.77	0.006	-10.92672	-1.867885
L2.	6.360413	2.046931	3.11	0.002	2.348502	10.37232
_cons	212.8976	103.9476	2.05	0.041	9.164082	416.6311
BS						
IP						
L1.	.0160315	.0533423	0.30	0.764	-.0885176	.1205806
L2.	.0107796	.0466364	0.23	0.817	-.0806261	.1021852
BS						
L1.	1.179729	.4166196	2.83	0.005	.3631699	1.996289
L2.	-.3558714	.3690189	-0.96	0.335	-1.079135	.3673923
__cons	11.16048	18.73958	0.60	0.551	-25.56843	47.88939

Note: IP is an indicator of income from intellectual property; BS – an indicator of cooperation between business and science; R-sq – coefficient of determination; chi2 – chi-square criterion; P>chi2 – level of significance; Coef – regression model coefficient estimate; Std. Err. – standard deviations; z – z-criterion; P>|z| - level of significance; [95% Conf. Interval] – confidence interval.

Source: Calculated by the authors using STATA software based on (WIPO, n.d.a, n.d.b).

The results of the Granger test for Switzerland are shown in Table 3.

Table 3. Results of the Granger test on the example of Switzerland

.vargranger				
Granger causality Wald tests				
Equation	**Excluded**	**chi2**	**df**	**Prob>chi2**
IP	BS	9.6619	2	0.008
IP	ALL	9.6619	2	0.008
BS	IP	.11238	2	0.945
BS	ALL	.11238	2	0.945

Note: IP is an indicator of income from intellectual property; BS – an indicator of cooperation between business and science; chi2 – chi-square criterion; P>chi2 is the level of significance.

Source: Calculated by the authors using STATA software based on previous vector autoregression results.

The analysis of the results shows that the lag value of the indicator of co-opetition of business and science (BS) is the cause of the indicator of income from intellectual property (IP) and accordingly affects it, as indicated by the value of Prob > chi2 = 0.008, which does not exceed 0.05. On the other hand, there is no reverse effect (the lag value of the indicator of intellectual property income is not the cause and does not affect the indicator of cooperation between business and science), as evidenced by Prob > chi2 = 0.945, which exceeds 0.05.

Similar calculations were made for all sample countries and summarized in Table 4.

Table 4. Generalized result of the determination of cause and effect relationship and direction of influence

Country	Cause-and-effect relationships between indicators of cooperation between business and science (BS) and income from intellectual property (IP)
Switzerland	BS → IP
USA	BS ↔ IP
Sweden	BS ↔ IP
United Kingdom	not found
Netherlands	BS → IP
Republic of Korea	BS ← IP
Singapore	BS ↔ IP
Germany	BS → IP
Finland	BS ← IP
Denmark	not found

Source: Calculated by the authors using STATA software based on previous vector autoregression results.

As a result of regression analysis and the Granger test, the following causal relationships were established:

– the level of cooperation between business and science is the cause and affects the amount of income from intellectual property in 6 of the 8 countries of the sample, in which the cause-and-effect relationship between the studied indicators was confirmed and established;

– the amount of income from intellectual property is the cause and affects the level of co-operation between business and science in 5 of the 8 countries of the sample, in which a cause-and-effect relationship between the studied indicators was established;

– in 3 out of 8 countries of the sample, in which the cause-and-effect relationship between the studied indicators was confirmed, a two-way effect was found.

So, summarizing the results of correlation, regression analysis and the Granger test, we conclude that in most of the studied countries of the sample, which are leaders in innovative development, the level of co-opetition between business and science has a direct and positive effect on the volume of income from intellectual property, and, accordingly, the strengthening of co-opetition business and science will contribute to increasing the amount of income from intellectual property. In turn, the revenue volume from intellectual property will also improve and develop cooperation between business and science.

Conclusions

The article substantiates that in current conditions, business and science cooperation is essential in innovative development, particularly the receipt of income from intellectual property.

As a result of a bibliometric analysis of publications indexed by the Scopus scientometric database, it was established that more than 80% of works on the issue of cooperation between business and science were published in the last 15 years out of more than 50 years under investigation. Similarly, more than 70% of publications on the commercialization of intellectual property were published in the last 15 years out of the 40 studied years, confirming the relevance of this scientific issue. Also, with the help of the VosViewer tool, four clusters of interrelated interdisciplinary studies were identified on the above-mentioned issues: – 1st cluster – intellectual property and innovation transfer, patents and inventions, copyright, intellectual property protection, commercialization, commerce, investments, legislation, economic and social effects, business and university cooperation, intellectual property management; – 2nd cluster – research, knowledge, science, licensing, patents, organizational management, leadership, corporate behavior, public-private partnership, interdisciplinary communications, international cooperation, financing, risk assessment, economic research, medical research; – 3rd cluster – cooperation and communications, public policy, business, business collaboration, decision-making, education, computer science, information systems, engineering education, knowledge management, project management, society and institutions, sustainable development; - 4th cluster - technologies, information technologies. It is substantiated that the cooperation of business and science and the commercialization of intellectual property are most closely related to the medical, information and communication, engineering,

economic spheres, and sustainable development. It is also established that the most significant scientific interest is characteristic of the United States of America. Great Britain, the Netherlands, Germany, Finland and others, and most of these countries are innovatively developed and occupy high positions in the Global Innovation Index.

As a result of correlation and regression analysis (based on vector autoregression) and the Granger test, cause-and-effect relationships were established, namely: – the level of cooperation between business and science is the cause and affects the amount of income from intellectual property in 6 of the 8 countries of the sample, in which the cause-and-effect relationship between the investigated indicators was confirmed and established; – the amount of income from intellectual property is the cause and affects the level of cooperation between business and science in 5 of the 8 countries of the sample, in which a cause-and-effect relationship between the studied indicators was established; – in 3 out of 8 countries of the sample, in which the cause-and-effect relationship between the studied indicators was confirmed, a two-way effect was found.

In most of the studied countries of the sample, which are leaders in innovative development, the level of cooperation between business and science directly and positively affects the income from intellectual property. Accordingly, the strengthening of collaboration between industry and science will contribute to the increase in the amount of income from intellectual property. In turn, the revenue volume from intellectual property will also contribute to improving and developing cooperation between business and science.

The obtained results can be helpful both for scientists in further research in related scientific areas and representatives of the business community, government officials and other persons interested in this issue.

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