Marketing and Management of Innovations
Issue 2, 2022

sciendo

ISSN 2227-6718 (on-line)
ISSN 2218-4511 (print)

https://doi.org/10.21272/mmi.2022.2-20

JEL Classification: Q01, O3, M2, I2

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«BUSINESS-EDUCATION-SCIENCE» COOPETITION AND INNOVATION TRANSFER FOR SUSTAINABLE DEVELOPMENT

Abstract. *Today «business-education-science» coopetition is an innovative approach to achieving sustainable development goals on different levels of economy and in various spheres of human life. In particular, there is great potential in the context of the fourth, eighth, and ninth sustainable development goals. That is why the article aims to analyze key trends and empirically prove and formalize the impact of «business-education-science» coopetition on sustainable development. The key directions of multidisciplinary study on «business-education-science» coopetition for sustainable development are determined by bibliometric analysis of 6035 documents for 38 years using the Scopus database tools and VOSviewer software. The obtained results allowed to form 7 clusters of multidisciplinary studies on this issue. A comparative analysis of Ukraine and the top 10 countries' levels of sustainable development, innovation development, and business-education competition were conducted. Besides a dynamic analysis of sustainable and innovation development in Ukraine, a dynamic analysis of business and education coopetition in Ukraine, Finland, Denmark, and Sweden was made for 2012-2021. The sample from the top 10 countries in the Sustainable Development Rating in 2021 (Finland, Denmark, Sweden, Norway, Austria, Germany, France, Switzerland, Ireland, and Estonia) are formed for 10 past years (2012-2021) to investigate the relationship between the level of «business – education – science» coopetition and the level of sustainable development, in particular the scores of University-Industry Collaboration Indicator and Sustainable Development Index. The Shapiro-Wilk test for normal data and Pearson / Spearman correlation analysis was used at the first stage of empirical confirmation of the hypothesis about the impact of «business – education – science» coopetition on sustainable development. In the second stage, the regression model of system dynamic panel-data estimation (The Arellano–Bover / Blundell–Bond model) is built to formalize and determine this impact. Then Arellano-Bond test for zero autocorrelation in first-differenced errors is made to show that there is no present evidence that the model is misspecified. It is proved that if the level of «business – education – science» coopetition (on the example of the score of the University-Industry Collaboration Indicator) increases by 1%, the level of sustainable development (in particular, the score of the Sustainable Development Index) will increase on 0,04% too. The obtained results could be useful for business, education, science institutions, and governance for further research and strengthening sustainable and innovation development levels.*

Keywords: business and education coopetition, innovation development, innovation transfer, partnership, R&D, research and development, science, SDG, sustainable development, university-industry collaboration.

Cite as: Samoilikova, A., Zhylinska, O., Pal, Z., & Kuttor, D. (2022). «Business-Education-Science» Coopetition and Innovation Transfer for Sustainable Development. *Marketing and Management of Innovations*, 2, 220–230. http://doi.org/10.21272/mmi.2022.2-20

Received: 13 April 2022 **Accepted:** 21 June 2022 **Published:** 30 June 2022

Introduction. One of today's mainstreams is achieving sustainable development goals that are important for every country and nation, economy and business structure, institutions and organization, family and person, and humanity in general. On this road, «business-education-science» coopetition and innovation transfers are significant drivers and sources of potential competitive advantages and socioeconomic effects. Besides, the fourth sustainable development goal proclaims the course to quality education and lifelong learning. The eighth sustainable development goal advocates sustainable and inclusive economic growth, entrepreneurship, and innovation. And the ninth sustainable development goal follows sustainable and inclusive industrialization and innovation, scientific research, upgrading industry technological capabilities, expanding access to information and communication technologies, promoting an increase in the spending on research and development, and the number of scientific workers (UNDESA, 2021). Achieving all these targets requires close coopetition of business, education and science, and rapid innovation transfer. At the same time, not all countries in the world demonstrate a sufficient level of both sustainable and innovative development. For example, Ukraine ranked only 37th among the 163 countries (the 36th place in the previous year) according to the Sustainable Development Index (Sachs, 2022), and 49th place among the 132 countries (the 45th place in the previous year) according to the Global Innovation Index (WIPO, 2021).

That is why the research aims to analyse key trends and empirically prove and formalize the impact of «business-education-science» coopetition on sustainable development.

Literature Review. The issue of «business-education-science» coopetition for sustainable development is enough new in science. It is proved by a small number of publications indexing in the Scopus database (only six ones in 2013-2021 from the search «business, and education and science and *coopetition*» on article title, abstract, keywords). But many aspects of this multidisciplinary study are not new. That is why the search by the Scopus database tools on article title, abstract, and keywords should include not only the above request, but the following: «coopetition and business, and science, and sustainable and development» or «coopetition, and business, and education, and sustainable and development» or «education, and business, and sustainable and development» or «business, and science, and sustainable and development» or «university, and business, and collaboration, and sustainable and development», or «education, and business, and partnership, and sustainable and development» etc. A formed sample of found articles consists of 6035 documents for thirty-eight years (1984-2021) (Figure 1).

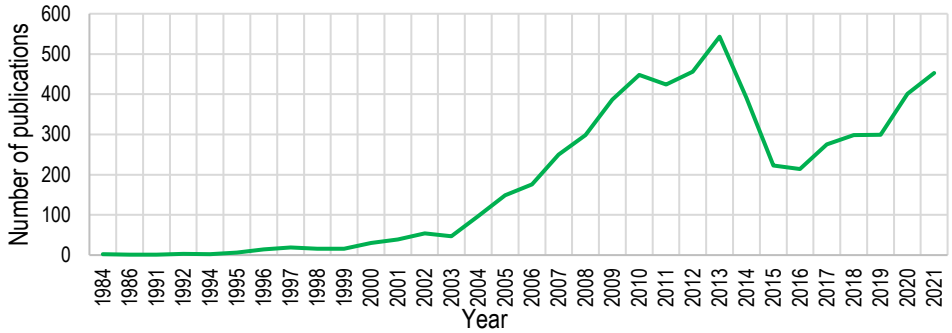

Figure 1. The dynamic of publishing articles on «business-education-science» coopetition and innovation transfer for sustainable development

Sources: developed by the authors using Scopus database tools and Excel software.

At the same time, nearly 60% of articles on «business-education-science» coopetition and innovation transfer for sustainable development were published and indexed in the Scopus database only in the last ten years (2012-2021). Thus the «business-education-science» coopetition for sustainable development is especially relevant nowadays.

A graph generally shows a positive dynamic of publishing articles on this research issue. Still, in 2014-2016 it was negatively caused by recession (rising dollar value, weakening in emerging markets, a drop in oil and other commodities price, a sharp down in business investment, etc.). Also, there were military actions in Ukraine and economic decrease, a Brazilian economic crisis, and other global challenges. But from 2017 trend was changed, and it is still positive. In order to visualize key directions of multidisciplinary study on «business-education-science» coopetition for sustainable development, the bibliometric analysis was conducted using VOSviewer software. A minimum number of occurrences of a keyword was set at 20, and 616 keywords were selected. Figure 2 shows the results of the bibliometric analysis.

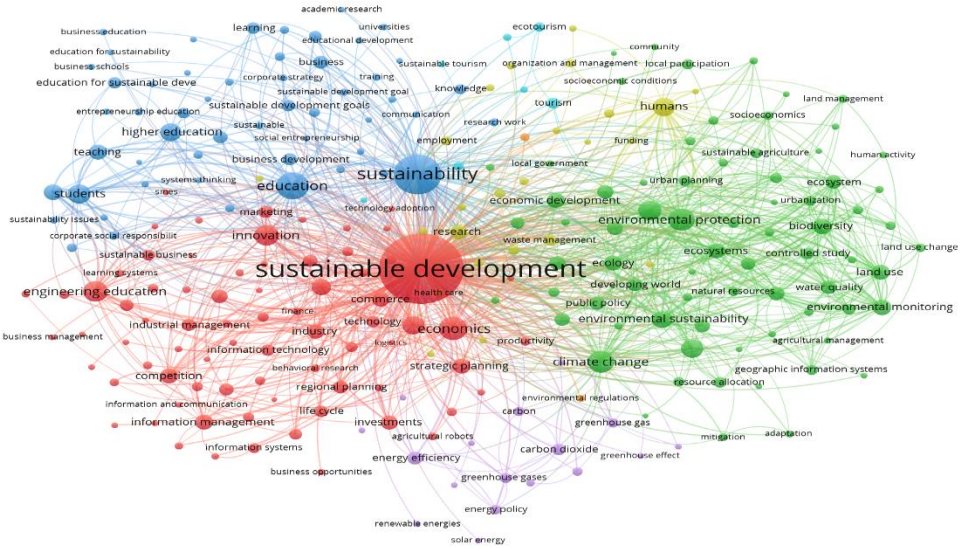

Figure 2. The key directions of multidisciplinary study on «business-education-science» coopetition for sustainable development based on bibliometric analysis results

Sources: developed by the authors using VOSviewer software.

There are seven clusters of multidisciplinary study on «business-education-science» coopetition for sustainable development as follows:

– cluster 1 (red colour): sustainable development, sustainable business, project management, business management and strategy, competitiveness, finance, investment, digital transformation, e-learning, artificial intelligence, informational science, ICT, technology and knowledge transfer, open innovation, research and development, behavioural research, industry 4.0, industrial research;

– cluster 2 (green colour): environmental sustainability, environmental economics, ecosystem management and services, economic growth, risk assessment, socioeconomics, ecology, environmental protection, land, water and forest management, resource management, mitigation, adaptation, urban development, participatory approach, consumer and local participation;

– cluster 3 (blue colour): higher education and institutions, university sector, academic research, education for sustainability, business education, entrepreneurship education, environmental education,

engineering, social entrepreneurship, curriculum development, educational development, leadership, collaboration, corporate social responsibility;

– cluster 4 (yellow colour): globalization, international cooperation, organizational and program management, governance, environmental health, public health, healthcare, humans, waste management, biotechnologies, nanotechnologies;

– cluster 5 (purple colour): energy management, energy efficiency, renewable energy, housing, greenhouse effect;

– cluster 6 (light blue colour): quality of life, consumption behaviour, ecotourism development, sustainable tourism;

– cluster 7 (orange colour): environmental engineering and environmental regulations.

It should be noted that the problems of achieving sustainable development goals connected with education and innovation, technology and knowledge transfer, research integrity, education transformation in the context of socioeconomic development strategic management, and post-COVID-19 recovery were investigated by Makarenko et al. (2021), Matos and Kasztelnik (2021), Artyukhov et al. (2021), Petrushenko et al. (2020), etc. Antonyuk et al. (2021), Novikov (2021), Tenytska and Palienko (2021), and Kaya (2021). The scholars paid special attention to the direction of sustainable business and environmental economics, including financial, fiscal, business, and entrepreneurial transformation and development, caused by modern challenges and the SDG agenda. The important aspects of digital transformation in business and education, ICT and national security, and sustainability were described by Novikov (2021), Skrynnyk (2021), Lopez et al. (2019), etc. Other scholars proposed new solutions in environmental protection, ecology, environmental education, and health care (Kyrychenko et al., 2021, Onopriienko et al., 2021, Pimonenko et al., 2021).

This list of scientific achievements is not exhaustive, but the issue of cooperation «business-education-science» and assessment of its impact on sustainable development remains poorly understood. It determines the relevance of the chosen area of research in this article.

Methodology and research methods. The key directions of multidisciplinary study on «business-education-science» coopetition for sustainable development were determined by bibliometric analysis using the Scopus database tools, Excel, and VOSviewer software. A comparative analysis of Ukraine and the top 10 countries' levels of sustainable development, innovation development, and business-education competition were also conducted. Besides a dynamic analysis of sustainable and innovation development in Ukraine, dynamic analysis of business and education coopetition in Ukraine, Finland, Denmark, and Sweden were made for 2012-2021.

The sample from the top 10 countries in the Sustainable Development Rating in 2021 (Finland, Denmark, Sweden, Norway, Austria, Germany, France, Switzerland, Ireland, and Estonia) was formed for ten past years (2012-2021) to investigate the relationship between the level of «business – education – science» coopetition and the level of sustainable development, in particular the scores of University-Industry Collaboration Indicator and Sustainable Development Index.

The Shapiro-Wilk test for normal data and Pearson/Spearman correlation analysis was used at the first stage of empirical confirmation of the hypothesis about the impact of «business – education – science» coopetition on sustainable development. In the second stage, the regression model of system dynamic panel-data estimation (The Arellano–Bover/Blundell–Bond model) was built to formalize and determine this impact. Then Arellano-Bond test for zero autocorrelation in first-differenced errors was made to show that there is no present evidence that the model is misspecified.

Results. According to Sustainable Development Index 2022, Ukraine had taken 37th place in the general ranking. Figure 3 demonstrates the comparative analysis of Ukraine and the top 10 countries' levels of sustainable development.

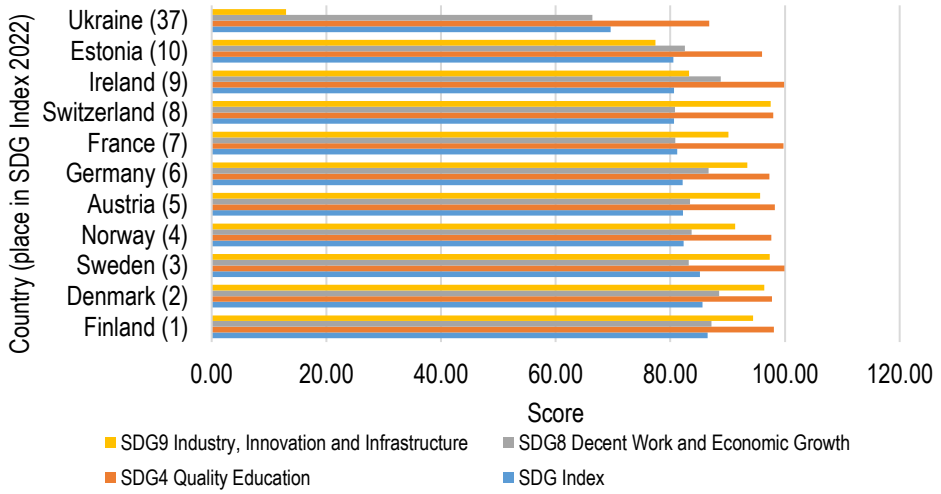

Figure 3. The results of a comparative analysis of Ukraine and the top 10 countries' levels of sustainable development

Sources: developed by the authors based on (The SDG Database, 2022).

There is a significant lag behind the leading countries, which is worrying, especially concerning the indicator of achieving the 9th sustainable development goal. This goal is mostly connected with innovation development. Figure 4 visualizes the dynamic analysis of both sustainable and innovative development in Ukraine from 2012 to 2021.

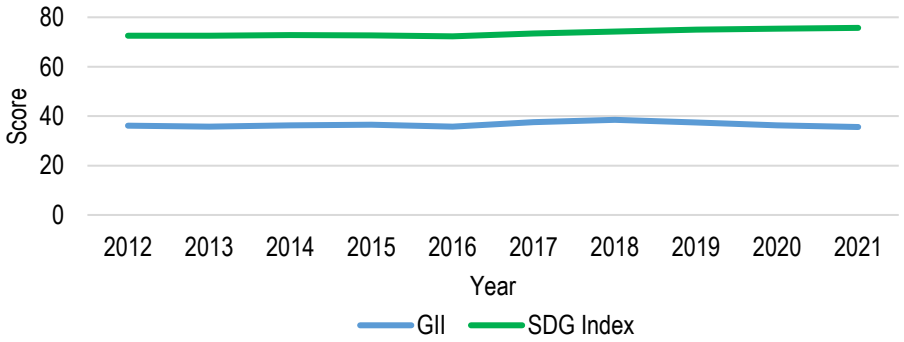

Figure 4. The results of dynamic analysis of sustainable and innovation development in Ukraine for 2012-2021

Sources: developed by the authors based on (GII, n.d.).

The trends of sustainable and innovative development in Ukraine are similar. So, it is important to encourage innovation development to strengthen the level of sustainable development.

Figure 5 presents the results of a comparative analysis of Ukraine and the top 10 countries' levels of innovation development and business-education competition.

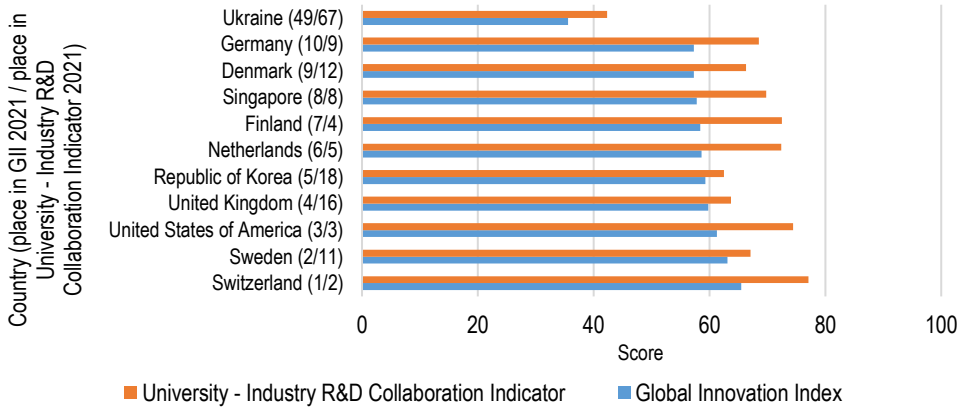

Figure 5. The results of the comparative analysis of Ukraine and the top 10 countries' levels of innovation development and business-education coopetition

Sources: developed by the authors based on (GII, n.d.).

Ukraine lags behind both in the overall level of innovation development and in the studied indicator of business and education cooperation. A comparison in dynamic is given in Figure 6, where Ukraine is compared with Finland, Denmark, and Sweden, which are the top 3 countries in sustainable development.

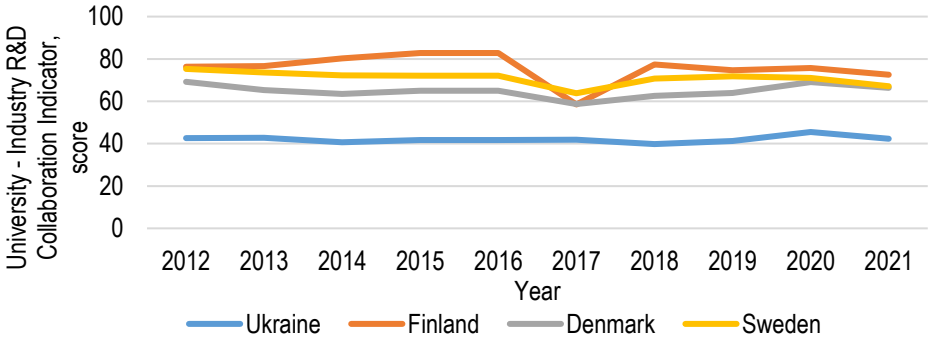

Figure 6. The results of dynamic analysis of business and education coopetition in Ukraine, Finland, Denmark, and Sweden for 2012-2021

Sources: developed by the authors based on (GII, n.d.).

To investigate the relationship between the level of "business – education – science" coopetition and the level of sustainable development, in particular, the scores of the University-Industry Collaboration Indicator and Sustainable Development Index, the sample from the top 10 countries in the Sustainable Development Rating in 2021 (Finland, Denmark, Sweden, Norway, Austria, Germany, France, Switzerland, Ireland, and Estonia) was formed for ten past years (2012-2021). Table 1 presents the results of the Shapiro-Wilk test for normal data and Pearson / Spearman correlation analysis.

The direction of the relationship between the level of «business – education – science» coopetition and the level of sustainable development is direct in five countries. Besides, it is indirect in five countries too. The strength of this relationship is statistically significant – very high in two countries, high in four countries, and average in four countries too. Thus, in order to formalize and determine the impact of

«business – education – science» coopetition on the sustainable development (based on the scores of the University-Industry Collaboration Indicator and Sustainable Development Index), this study built the model of system dynamic panel-data estimation (Anderson and Hsiao, 1981; Arellano and Bond, 1991).

Table 1. The results of the Shapiro-Wilk test for normal data and Pearson/Spearman correlation analysis

Country	Prob>z	r	t	direction	strength
Austria	0.83375**	-0.7179	3	indirect	high
Denmark	0.19452**	-0.8354	2	indirect	high
Estonia	0.04053*	-0.9190	0	indirect	very high
Finland	0.80953**	0.4872	2	direct	average
France	0.34037**	0.3087	0	direct	average
Germany	0.09814**	0.9281	2	direct	very high
Ireland	0.74973**	0.4254	3	direct	average
Norway	0.05056**	-0.7012	0	indirect	high
Sweden	0.85170**	0.3953	1	direct	average
Switzerland	0.50157**	-0.7221	0	indirect	high

*Note: * – there are no normal data (Prob>z is less than 0,05), and the method of Spearman correlation is used; ** – there are normal data (Prob>z is more than 0,05), and the method of Pearson correlation is used; r – the maximum value of correlation coefficient during investigating period; t – time lag of the most statistically significant correlation coefficient.*

Sources: developed by the authors using STATA software.

The Arellano–Bover / Blundell–Bond system estimator fits a linear dynamic panel-data model where the unobserved panel-level effects are correlated with the lags of the dependent variable. This method assumes that there is no autocorrelation in the idiosyncratic errors and requires that the panel-level effects be uncorrelated with the first difference of the first observation of the dependent variable (Arellano and Bover, 1995; Blundell and Bond, 1998). The number of lags of the dependent variable (the score of Sustainable Development Index) to be included in the model is one (the default). For the endogenous variable (the score of the University-Industry Collaboration Indicator), the maximum number of lags is set at the level of two (the default). The one-step estimator is calculated, and robust standard errors are used (the Arellano–Bond robust VCE estimator). Natural logarithms of model variables were generated to obtain adequate results. Table 2 presents the results of the impact assessment of the «business – education – science» coopetition on sustainable development.

Table 2. The results of impact assessment of «business – education – science» coopetition on the sustainable development based on the system dynamic panel-data model

lnSDG		Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
lnSDG							
	L1	.9151929	.0469308	19.50	0.000*	.8232101	1.007176
lnUI_RD							
	--	-.0313457	.016714	-1.88	0.061	-.0641045	.0014131
	L1.	.0426966	.0207195	2.06	0.039*	.0020871	.0833061
	L2.	-.0019866	.011256	-0.18	0.860	-.024048	.0200747
_cons		.336381	.2068685	1.63	0.004*	-.0690738	.7418359
Wald chi2(4) = 490.29			Prob > chi2 = 0.0000				

*Note: lnSDG – natural logarithm of the score of Sustainable Development Index; lnUI_RD – natural logarithm of the score of University-Industry Collaboration Indicator; L1, L2 – time lags; cons – constant; Coef. – estimates of regression model coefficients; Std.Err. – standard errors, standard deviations; z – criteria of z-statistics; P – p-value, level of significance; [95% Conf. Interval] – confidence interval; * – p-value of researching indicators is less than 5 %, they are statistically significate.*

Sources: developed by the authors using STATA software.

The level of model significance (Prob > chi2 = 0.0000), and the p-value of model variables marked with * (less than 5 %) prove the model adequacy. Also, the Arellano-Bond test for zero autocorrelation in first-differenced errors shows no evidence that the model is misspecified (STATA) (Table 2).

Table 3. The results of the Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	z	Prob > z
1	-2.3118	0.0208
2	1.3822	0.1669

H0: no autocorrelation

Sources: calculated by the authors using STATA software.

The system dynamic panel-data model of impact assessment of «business – education – science» coopetition on the sustainable development is the following:

$$\ln SDG = 0,34 + 0,92 \ln SDG_{t-1} + 0,04 \ln UI\_RD_{t-1} \quad (1)$$

This means that if the level of «business – education – science» coopetition (the example of the score of the University-Industry Collaboration Indicator) increases by 1%, the level of sustainable development (in particular, the score of the Sustainable Development Index) will increase on 0,04% too.

Conclusions. It is proved that the issue of «business-education-science» coopetition for sustainable development is especially actual nowadays. Nearly 60% of articles on «business-education-science» coopetition and innovation transfer for sustainable development were published and indexed in the Scopus database only in the last 10 years (2012-2021). There is a positive dynamic in publishing articles on this research issue. Still, in 2014-2016 it was negatively caused by recession (rising dollar value, weakening in emerging markets, a drop in oil and other commodities price, a sharp down in business investment, etc.). Also, there were military actions in Ukraine and economic decrease, Russian financial crisis, Brazilian economic crisis, and other global challenges. But from 2017 trend was changed, and it is still positive.

The key directions of multidisciplinary study on «business-education-science» coopetition for sustainable development were determined by bibliometric analysis of 6035 documents for 38 years using the Scopus database tools and VOSviewer software. The obtained results allowed to form 7 clusters of multidisciplinary studies on this issue:

1) Sustainable development, sustainable business, project management, business management and strategy, competitiveness, finance, investment, digital transformation, e-learning, artificial intelligence, informational science, ICT, technology and knowledge transfer, open innovation, research and development, behavioural research, industry 4.0, industrial research;
2) Environmental sustainability, environmental economics, ecosystem management and services, economic growth, risk assessment, socioeconomics, ecology, environmental protection, land, water and forest management, resource management, mitigation, adaptation, urban development, participatory approach, consumer and local participation;
3) Higher education and institutions, university sector, academic research, education for sustainability, business education, entrepreneurship education, environmental education, engineering, social entrepreneurship, curriculum development, educational development, leadership, collaboration, corporate social responsibility;
4) Globalization, international cooperation, organizational and program management, governance, environmental health, public health, healthcare, humans, waste management, biotechnologies, nanotechnologies;

5) Energy management, energy efficiency, renewable energy, housing, greenhouse effect;
6) Quality of life, consumption behaviour, ecotourism development, sustainable tourism;
7) Environmental engineering and environmental regulations.

The comparative analysis of Ukraine and the top 10 countries' levels of sustainable development showed a significant lag behind the leading countries, which is worrying, especially concerning the indicator of achieving the 9th sustainable development goal, which is mostly connected with innovation development. The trends of sustainable and innovative development in Ukraine are similar. So, it is important to encourage innovation development to strengthen the level of sustainable development.

A correlation and regression analysis were conducted to investigate the relationship between the level of «business – education – science» coopetition and the level of sustainable development, in particular the scores of the University-Industry Collaboration Indicator and Sustainable Development Index, based on the sample from top 10 countries in the Sustainable Development Rating in 2021 for 10 past years (2012-2021). The regression model of system dynamic panel-data estimation (The Arellano–Bover/Blundell–Bond model) was built to formalize and determine this impact. Then Arellano-Bond test for zero autocorrelation in first-differenced errors was made to show that there is no present evidence that the model is misspecified.

It was proved that if the level of «business – education – science» coopetition (on the example of the score of University-Industry Collaboration Indicator) increases by 1%, the level of sustainable development (in particular, the score of Sustainable Development Index) will increase on 0,04% too.

The obtained results will be useful for business, education, science institutions, and governance for further research and strengthening sustainable and innovation development levels.

Author Contributions: conceptualization, A. S., and O. Z.; methodology, A. S., D. K. and O. Z.; software, A. S.; validation, A. S., Z. P. and O. Z.; formal analysis, A. S.; investigation, A. S., Z. P. and O. Z.; resources, D. K., H. L., A. S.; data curation, A. S., D. K. and O. Z.; writing-original draft preparation, A. S., Z. P., D. K. and O. Z.; writing-review and editing, H. L., A. S., D. K. and O. Z.; visualization, A. S., Z. P.; supervision, O. Z.; project administration, A. S.

Funding: This research was funded by the Ministry of Education and Science of Ukraine and performed the results of the projects «Business-Education-Science Coopetition: Institutional and Economic Models of Innovation Transfer for National Security and Sustainable Development» (№ 0122U000772) and «Cognitive Model of Innovations' Commercialization in the Conditions of Industry 4.0: Intellectual Capital Protection, Marketing and Communications» (№ 0122U000780).

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Коопетиція «бізнес-освіта-наука» та трансфер інновацій для сталого розвитку

Сьогодні співробітництво «бізнес-освіта-наука» – це інноваційний підхід у досягненні цілей сталого розвитку на різних рівнях економіки та в різних сферах людського життя. Зокрема, великий потенціал існує в контексті четвертої, восьмої та дев'ятої цілей сталого розвитку. Метою статті є аналіз ключових тенденцій, емпіричне підтвердження та формалізація впливу коопетиції «бізнес-освіта-наука» на сталий розвиток. Ключові напрямки міждисциплінарних досліджень коопетиції «бізнес-освіта-наука» для сталого розвитку визначені шляхом бібліометричного аналізу 6035 документів за 38 років із застосуванням засобів баз даних Scopus та програмного забезпечення VOSviewer. Отримані результати дозволили сформувати 7 кластерів міждисциплінарних досліджень з цього питання. Також проведено порівняльний аналіз України та топ-10 країн за рівнем сталого розвитку, інноваційного розвитку та співробітництва бізнесу й освіти. Крім того, проведено динамічний аналіз сталого та інноваційного розвитку в Україні, динамічний аналіз співпраці бізнесу та освіти в Україні, Фінляндії, Данії та Швеції за 2012-2021 роки. Вибірка з 10 країн-лідерів у рейтингу сталого розвитку у 2021 році (Фінляндія, Данія, Швеція, Норвегія, Австрія, Німеччина, Франція, Швейцарія, Ірландія та Естонія) була сформована за 10 останніх років (2012-2021) для дослідження взаємозв'язків між рівнем коопетиції «бізнес – освіта – наука» та рівнем сталого розвитку, зокрема оцінками Індикатора співпраці університетів і промисловості та Індексу сталого розвитку. На першому етапі, для емпіричного підтвердження гіпотези про вплив коопетиції «бізнес – освіта – наука» на сталий розвиток, застосовано тест Шапіро-Вілка для нормальних

даних та відповідно кореляційний аналіз Пірсона/Спірмена. На другому етапі, для формалізації та визначення цього впливу, побудовано регресійну модель системної динамічної оцінки панельних даних (модель Ареллано–Бовера/Блунделла–Бонда). У дослідженні застосовано тест Ареллано-Бонда на нульову автокореляцію в помилках із першим диференціюванням, щоб показати відсутність неправильно визначеної моделі. За результатами дослідження доведено, що якщо рівень коопетиції «бізнес – освіта – наука» (на прикладі оцінки Індикатора співробітництва університетів і промисловості) збільшується на 1%, то рівень сталого розвитку (зокрема, оцінка за Індексом сталого розвитку) також зросте на 0,04%. Отримані результати мають практичну цінність та можуть бути корисними для бізнесу, освіти, науки та управління для подальших досліджень та підвищення рівня сталого та інноваційного розвитку.

Ключові слова: дослідження та розробки, інноваційний розвиток, коопетиція бізнесу та освіти, наука, НДДКР, партнерство, співпраця університету та промисловості, сталий розвиток, трансфер інновацій.