"The relationship between educational and scientific regulatory interventions and socio-economic development in military conflict-affected countries: A Sustainable Development Goals perspective"

AUTHORS	Dariusz Krawczyk (iD)
	Nadiia Artyukhova (iD)
	Dmytro Svynarenko (R)
	Anna Vorontsova (iD) (R)
	Artem Artyukhov (iD) (R)
	Robert Rehak (iD) (R)
	Tetiana Vasylieva (iD) (R)

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
43	2	8

Dariusz Krawczyk, Ph.D., Department of Applied Social Sciences, Faculty of Organization and Management, Silesian University of Technology, Poland.

Nadiia Artyukhova, Ph.D., Associate Professor, University of Economics in Bratislava, Slovakia; Department of Marketing, Sumy State University, Ukraine.

Dmytro Svynarenko, Ph.D., Associate Professor, Educational and Methodological Department of Educational Quality Assurance and Accreditation, University of Customs and Finance, Ukraine.

Anna Vorontsova, Ph.D., Associate Professor, Department of International Economic Relations, Sumy State University, Ukraine.

Artem Artyukhov, DSc, Associate Professor, Senior Researcher, Department of Marketing, Sumy State University, Ukraine; University of Economics in Bratislava, Slovakia.

Róbert Rehák, Ph.D., Associate Professor, Faculty of Commerce, University of Economics in Bratislava, Slovakia.

Tetiana Vasylieva, Dr., Prof., Department of Financial Technologies and Entrepreneurship, Sumy State University, Ukraine. (Corresponding author)

Dariusz Krawczyk (Poland), **Nadiia Artyukhova** (Slovakia, Ukraine),
Dmytro Svynarenko (Ukraine), **Anna Vorontsova** (Ukraine),
Artem Artyukhov (Ukraine, Slovakia), **Robert Rehak** (Slovakia), **Tetiana Vasylieva** (Ukraine)

THE RELATIONSHIP BETWEEN EDUCATIONAL AND SCIENTIFIC REGULATORY INTERVENTIONS AND SOCIO-ECONOMIC DEVELOPMENT IN MILITARY CONFLICT-AFFECTED COUNTRIES: A SUSTAINABLE DEVELOPMENT GOALS PERSPECTIVE

Abstract

This study investigates the structural relationships between educational and scientific regulatory interventions and socio-economic development in countries affected by armed conflict and political instability, using the framework of Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation and Infrastructure). Rather than focusing on regulatory interventions in a narrow administrative sense, SDG 4 is conceptualized as a reflection of national efforts to improve access to and quality of education, including institutional reforms, policy initiatives, and capacity-building measures in post-conflict settings. The analysis covers 16 countries affected by conflict and instability across Eastern Europe, including Ukraine; the Balkans (Albania, Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, Slovenia); the Middle East (Israel, Jordan, Lebanon, Syrian Arab Republic, Turkey); and the South Caucasus (Armenia, Azerbaijan, Georgia), using data from 2011 to 2020. Employing multivariate confirmatory factor analysis (CFA), the study reveals statistically significant and conceptually meaningful covariances between the selected SDGs. The strongest relationship is observed between SDG 8 and SDG 9, underscoring the interdependence of economic growth, industrial development, and innovation. Moderate but significant correlations between SDG 4 and both SDG 8 and SDG 9 highlight the foundational role of education in enabling socio-economic recovery and technological advancement. Key indicators such as primary school completion, secondary and tertiary enrollment, employment in industry and services, and high-tech value-added production serve as measurable proxies for these dynamics. The findings emphasize the importance of aligning education policy with broader development strategies to support resilience and sustainable growth in fragile contexts.

Keywords	education, science, regulatory interventions, state, fair work, economic growth, innovation, Sustainable Development Goals (SDGs)
JEL Classification	Q01, I25, I28

INTRODUCTION

Russia's full-scale invasion of Ukraine, along with earlier conflicts in the Balkans, the Middle East, and the Caucasus, has highlighted the urgent need for resilient education systems and targeted scientific reforms capable of supporting recovery, stabilization, and long-term development. In this context, the term regulatory interventions refers

not only to formal legislative acts but also to a broader range of measures aimed at reforming, modernizing, and adapting the educational and scientific sectors to the realities of post-conflict environments.

A key reference point for assessing the effectiveness of such interventions is Sustainable Development Goal 4 (SDG 4), which reflects the commitment to ensuring equitable access to quality education, high standards of learning, and lifelong development. The indicators used to evaluate this goal capture both the levels of educational participation across different stages and the structural characteristics of the educational environment. Together, these aspects help assess the accessibility and quality of education, its inclusiveness, and the system's capacity to respond to social challenges, which is particularly relevant in the context of post-conflict recovery.

At the same time, understanding the broader impact of educational and scientific change on societal development requires consideration of not only educational outcomes but also the economic and infrastructural processes that unfold in parallel. These dimensions are reflected in Sustainable Development Goal 8 (SDG 8), which focuses on decent work and economic growth, and SDG 9, which addresses industrialization, innovation, and infrastructure. These areas are critically important for countries that have experienced armed conflict, as the recovery of the economy, labor market, and innovation potential is an integral part of sustainable development strategies.

Thus, this study aims to explore potential interconnections between regulatory interventions in education and science and key aspects of socio-economic development. This approach helps to better understand which institutional mechanisms may contribute to achieving sustainable development goals in the context of post-conflict transformation and long-term growth.

1. LITERATURE REVIEW

Educational and scientific regulatory interventions are increasingly seen as critical factors in overcoming socio-economic challenges, especially in times of crisis, war and post-crisis recovery. In this context, universities, research institutions, and public policy form a complex system of interaction that can influence the sustainable development of society. According to Petrushenko et al. (2023), Russia's full-scale war against Ukraine has highlighted the need for active involvement of educational institutions in solving social problems, in particular in the areas of integration, resilience, and recovery. In particular, Kichurchak et al. (2024) used synthetic control to study the transformations in higher education in Ukraine during the war, showing its strategic importance for social sustainability.

The ongoing military conflicts, particularly the war in Ukraine, have significantly accelerated the transformation of education systems, especially through the forced and rapid integration of digital technologies. Scholars such as Sułkowski et al. (2024), González-Zamar et al. (2020), and Zhao and Zhou (2024) note that integration of digital

technologies into learning processes has significantly changed the functioning of educational institutions. These changes have contributed to increasing the accessibility of knowledge and creating conditions for a more inclusive educational environment (Ogunleye et al., 2023; Gkrimpizi et al., 2023). These developments have laid the foundation for new models of higher education governance, especially in conflict-affected countries like Ukraine (Kuzheliev et al., 2023).

In parallel, a growing body of literature explores the role of education in achieving the Sustainable Development Goals (SDGs) (Gallardo-Vázquez et al., 2024; Makarenko et al., 2023; Noguera-Méndez et al., 2024), particularly SDG 4 (quality education), SDG 8 (decent work and economic growth), and SDG 9 (industry, innovation, and infrastructure). The implementation of ESG (Environmental, Social, and Governance) principles in education is also gaining traction, contributing to the development of socially responsible and environmentally conscious professionals (Kubalek et al., 2024; Pruchnicki et al., 2023). This opens up prospects for integrating sustainability principles not only at the level of educational programs but also in

university management. The introduction of the concepts of ethical leadership, empathy, social responsibility, and environmental awareness contributes to the development of a new generation of managers and professionals focused on a sustainable future (Pruchnicki et al., 2023; Dadkhah et al., 2024). The relationship between technological innovation, intellectual capital, and the implementation of the SDGs is also being studied (Prieto-Gutierrez et al., 2023; Dallakyan et al., 2025).

Other studies focus on the role of education in promoting gender equality and empowering younger generations, particularly Generation Z (Kozová et al., 2024; Bhowmik, 2023). Equal access to education is viewed as a critical factor in reducing social inequality and enhancing economic participation. In this context, financial literacy and entrepreneurship education are also gaining attention as drivers of socio-economic growth (Didenko et al., 2023; Kuzior et al., 2022; Kuzior et al., 2024; Lacmanović & Škare, 2024; Jurgelevičius & Raišienė, 2025). In particular, support for women's entrepreneurship is defined as an effective means of economic mobilization and innovative development (Hossain et al., 2023). Educational programs can shape entrepreneurial thinking, which is especially important for young people (Kaouache et al., 2024). In this context, the concept of individual entrepreneurial orientation plays a key role in the development of intentions to start a business.

A number of studies focus on the need for government intervention in shaping education policy, which allows for the formation of competitive educational systems and stimulates economic growth through the development of human capital (Djamal et al., 2023; Pozovna et al., 2023). At the same time, optimal financing of higher education becomes important as one of the most effective mechanisms to support the country's development (Hara, 2023; Yu et al., 2023, 2024; Abuselidze, 2022). In the field of leadership and management training, more and more researchers are focusing on the need to develop competencies, in particular in the areas of biosecurity, cybersecurity and public administration (Ninassi & Burrell, 2023; Burrell et al., 2024; Pruchnicki et al., 2023). Investments in leadership development are seen as a factor in improving the effectiveness of both public and corporate governance.

The literature also points to the growing importance of university–industry collaboration as a means of enhancing the economic impact of education, reducing informal employment, and promoting innovation (Samoilikova et al., 2023a, 2023b). University social responsibility is another emerging theme, with institutions increasingly engaging in community development and promoting civic values, including tax culture and ethical leadership (Ahmad et al., 2024).

In general, the literature review shows the multi-dimensional impact of educational and scientific interventions on socio-economic development. However, much of the research is fragmented and focuses on specific aspects, such as digitalization, gender equality, or entrepreneurship. At the same time, a comprehensive approach to analyzing these interventions in the context of their cause-and-effect relationships and impact on the Sustainable Development Goals remains insufficiently studied.

In view of the identified gaps in the scientific landscape, the purpose of this article is to study the existing links between educational and scientific regulatory interventions and socio-economic development through the prism of the Sustainable Development Goals.

2. METHODOLOGY

For this study, data were collected from the World Bank's Sustainable Development Goals database for the period from 2011 to 2020, which is available in the public domain. The data include indicators of educational and scientific regulatory interventions and socio-economic development presented through the prism of SDGs 4-8-9 (Table 1) for the Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, Slovenia) and the Middle East (Israel, Jordan, Lebanon, Syrian Arab Republic, Turkey), some Caucasian countries (Armenia, Azerbaijan, Georgia) and Ukraine. These countries are united by a history of political conflicts and wars that have had serious consequences for economic stability, infrastructure, education systems, and the general well-being of their populations. These events have necessitated the intro-

duction of regulatory interventions and recovery strategies aimed at ensuring sustainable development and improving socio-economic conditions. Therefore, although the dataset ends in 2020, it captures a critical period of post-conflict transformation and institutional adaptation in most of the selected countries. In the case of Ukraine, the data reflect the prelude to full-scale war, including the impacts of the 2014 conflict and early reform efforts. As such, the study provides a valuable baseline for understanding pre-war and post-conflict dynamics, offering insights for future recovery strategies aligned with the SDG framework.

The list of indicators was selected based on the availability of statistical data for the analyzed countries for the period of analysis, by selecting the most relevant indicators using Principal Component Analysis, excluding multicollinearity. The selected indicators were normalized using Z-scores, which allowed for their standardization by subtracting the mean and dividing by the standard deviation for each indicator. This ensured that different indicators could be compared with each other, regardless of their original units or range.

To achieve this goal, the study uses confirmatory factor analysis (CFA), which is a statistical technique used to test the statistical relationships between observed variables and latent constructs. CFA allows us to assess how well the structural and measurement models meet theoretical expectations (Brown, 2006).

As a result of the specification of the number of latent variables, the relevant three SDGs were selected:

- *SDG4* as a manifestation of the country's educational and scientific regulatory interventions;

- *SDG8* (decent work and economic growth) as a manifestation of the country's socio-economic development;

- *SDG9* (industry, innovation and infrastructure) as a manifestation of the country's socio-economic development.

A number of real-world indicators were selected as their explicit relationships with the respective observed variables, as presented in Table 1. To check the adequacy of the model, the threshold values of such statistical indicators are used; the traditional goodness-of-fit index $\chi2$ is not used in this paper due to numerous criticisms of its adequacy (Hu & Bentler, 1999; Satorra & Bentler,

Table 1. Characteristics of the input parameters of the study

Variables	Units of measurement	Symbol
SDG4 as a manifestation of the country's educational and scientific regulatory interventions		
Adolescents out of school	% of lower secondary school age	sdg4_1
Children out of school, primary	amount	sdg4_2
Over-age students, primary	% of enrollment	sdg4_3
Primary completion rate, total	% of relevant age group	sdg4_4
Pupil-teacher ratio, primary	rate	sdg4_5
School enrollment, secondary (gross)	Gender parity index (GPI)	sdg4_6
School enrollment, tertiary (gross)	GPI	sdg4_7
SDG8 (decent work and economic growth) as a manifestation of the country's socio-economic development		
Employment in agriculture	% of total employment	sdg8_1
Employment in industry	% of total employment	sdg8_2
Employment in services	% of total employment	sdg8_3
GDP per capita growth	annual %	sdg8_4
Services, value added per worker	constant 2015 US$	sdg8_5
Share of youth not in education, employment or training, total	% of youth population	sdg8_6
Unemployment, total	% of total labor force	sdg8_7
SDG9 (industry, innovation and infrastructure) as a manifestation of the country's socio-economic development		
Air transport, freight	million ton-km	sdg9_1
CO2 emissions	kg per 2017 PPP $ of GDP	sdg9_2
Medium and high-tech manufacturing value added	% manufacturing value added	sdg9_3
Research and development expenditure	% of GDP	sdg9_4

2010). Instead, other indicators such as comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), as well as Akaike information criterion (AIC) and Bayesian information criterion (BIC) statistics, which provide a more comprehensive assessment of the model's fit to the data, are used to assess the model's adequacy.

The paper uses standardized indicators to interpret existing relationships, measured in units of standard deviation. Accordingly, the standardized coefficients for this model can be interpreted as correlation coefficients between the indicator and the latent variable, since each indicator measures only one factor.

All calculations in this paper were performed using the STATA/SE 18.0 software package and its modules.

3. RESULTS

To empirically investigate the relationship between educational and scientific regulatory interventions and socio-economic development in conflict-affected countries a confirmatory factor analysis (CFA) was conducted. The first stage of the analysis focused on SDG4, which serves as a latent construct representing the impact of regulatory efforts in the education and science sectors.

This construct was operationalized through seven observed indicators that reflect various dimensions of educational access, equity, and system performance (*sdg4_1 – sdg4_7*). Together, these indicators provide a measurable framework for assessing how well national education systems respond to structural challenges, particularly in post-conflict contexts.

The visual representation of CFA model for SDG 4 is presented below (Figure 1).

Based on the estimation of the model parameters, the following results were obtained (Table 2), which are satisfactory in terms of the model's adequacy. The variables *sdg4_2* and *sdg4_3* are not statistically significant for this sample of countries, affected by political instability and armed conflict, indicating that there is no clear link between children out of primary school and over-primary age students and SDG 4. The rest of the observed variables are statistically significant; the most significant for the latent variable SDG 4 are *sdg4_4* (primary completion rate), *sdg4_6* (secondary school enrollment), *sdg4_7* (tertiary school enrollment). These findings suggest that the ability to ensure continuity of education beyond the primary level is a more stable and reliable indicator of educational system performance, even in challenging contexts. These results highlight the importance of focusing regulatory interventions on strengthening secondary and tertiary education pathways, particularly in post-conflict recovery strategies. The residual variances or variations are moderate.

Similarly to the previous step, the single-factor CFA models were analyzed to identify structural relationships within SDG 8 and SDG 9, which are manifestations of the country's socio-economic development. A summary of the results is pre-
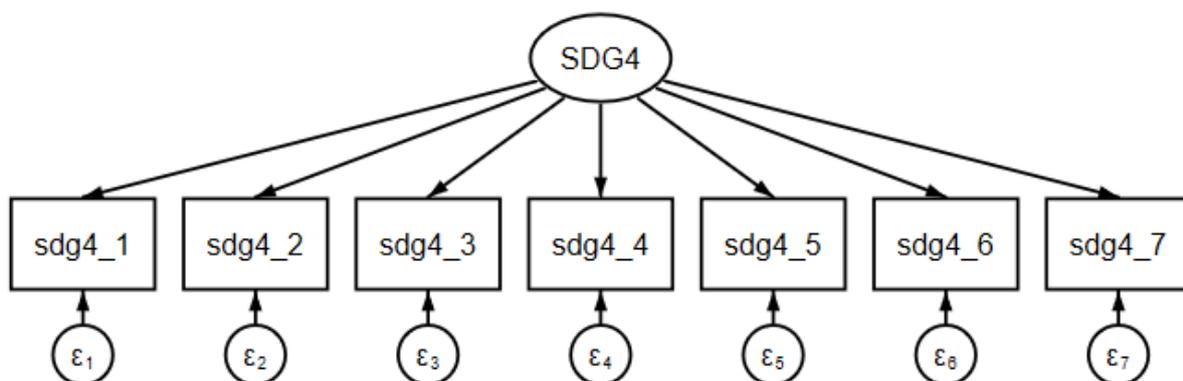

Figure 1. Single-factor CFA model for identifying structural explicit relationships within the SDG 4 as a manifestation of educational and scientific regulatory interventions

Table 2. Results of univariate CFA to identify structural explicit relationships within SDG 4 as a manifestation of educational and scientific regulatory interventions

Variables	Coefficient	OIM std. err.	z	P>|z|	[95% conf. interval]	
SDG4 → sdg4_1	0.178	0.085	2.110	0.035*	0.013	0.344
_cons	−0.356	0.082	−4.370	0.000*	−0.516	−0.196
SDG4 → sdg4_2	0.101	0.089	1.140	0.255	−0.073	0.275
_cons	−0.174	0.080	−2.180	0.029*	−0.330	−0.017
SDG4 → sdg4_3	−0.062	0.091	−0.680	0.495	−0.240	0.116
_cons	−0.406	0.082	−4.940	0.000*	−0.567	−0.245
SDG4 → sdg4_4	0.849	0.047	17.990	0.000*	0.756	0.941
_cons	−0.587	0.086	−6.860	0.000*	−0.755	−0.419
SDG4 → sdg4_5	0.236	0.085	2.780	0.005*	0.070	0.403
_cons	−0.952	0.095	−9.990	0.000*	−1.139	−0.766
SDG4 → sdg4_6	0.799	0.049	16.220	0.000*	0.703	0.896
_cons	−0.743	0.089	−8.320	0.000*	−0.918	−0.568
SDG4 → sdg4_7	0.708	0.050	14.180	0.000*	0.610	0.805
_cons	−0.657	0.087	−7.540	0.000*	−0.828	−0.487
var(e.sdg4_1)	0.468	0.030	0.911	1.029		
var(e.sdg4_2)	0.390	0.018	0.955	1.026		
var(e.sdg4_3)	0.396	0.011	0.974	1.018		
var(e.sdg4_4)	0.280	0.080	0.160	0.490		
var(e.sdg4_5)	0.444	0.040	0.869	1.026		
var(e.sdg4_6)	0.361	0.079	0.235	0.554		
var(e.sdg4_7)	0.499	0.071	0.378	0.659		
var(SDG4)	1.000	.	.	.		

Note: RMSEA = 0.081, CFI = 0.858, TLI = 0.871, where * – significance of the indicator at the 5% level.

sented in Tables 3 and 4 and led to the exclusion of certain indicators from the model. In particular, variables that were not statistically significant were excluded: *sdg8_1* (level of employment in agriculture), *sdg8_6* (unemployment rate), and *sdg9_4* (research and development expenditure), which prevented the model from converging.

The latent construct of SDG8 is mostly driven by factors *sdg8_2* (employment rate in industry) and *sdg8_3* (employment rate in services), as employ-ment rates in industry and services are among the most critical indicators of economic growth and improving living standards. It is also worth noting that the service sector is one of the largest employ-ers in the selected countries and covers a wide range of activities, from financial services and insurance to tourism, healthcare, education and other profes-sional services. In many of the analyzed countries, particularly those undergoing recovery or transition, these sectors serve as anchors of economic activity and are often the first to rebound.

Table 3. Results of single-factor CFA for identifying structural explicit relationships within SDG 8

Variables	Coefficient	OIM std. err.	z	P>|z|	[95%	conf. interval]
SDG8 → sdg8_1	0.076	0.078	0.970	0.333	−0.078	0.229
_cons	−0.136	0.079	−1.710	0.087	−0.291	0.020
SDG8 → sdg8_2	0.699	0.053	13.240	0.000*	0.002	0.595
_cons	−0.259	0.080	−3.220	0.001*	−0.416	−0.101
SDG8 → sdg8_3	0.996	0.052	19.010	0.000*	0.098	1.893
_cons	−0.285	0.081	−3.530	0.000*	−0.443	−0.127
SDG8 → sdg8_4	0.290	0.078	3.710	0.000*	0.043	0.437
_cons	−0.002	0.079	−0.030	0.980	−0.157	0.153
SDG8 → sdg8_5	0.557	0.063	8.860	0.000*	0.081	0.834
_cons	−0.204	0.080	−2.550	0.011	−0.360	−0.047
SDG8 → sdg8_6	0.103	0.080	1.300	0.194	−0.053	0.260
_cons	0.000	0.079	0.000	1.000	−0.155	0.155

Note: RMSEA = 0.078, CFI = 0.758, TLI = 0.796, where * – significance of the indicator at the 5% level.

Table 4. Results of the univariate CFA to identify structural explicit relationships within SDG9

Variables	Coefficient	OIM std. err.	z	P>|z|	[95%	conf. interval]
SDG9 → sdg9_1	0.244	0.092	2.640	0.008*	0.063	0.425
_cons	−0.049	0.079	−0.620	0.537	−0.204	0.106
SDG9 → sdg9_2	0.650	0.153	4.240	0.000*	0.349	0.951
_cons	−0.199	0.080	−2.490	0.013*	−0.355	−0.042
SDG9 → sdg9_3	0.782	0.179	4.370	0.000*	0.432	1.133
_cons	−0.234	0.080	−2.920	0.004*	−0.391	−0.077
var(e.sdg9_1)	0.941	0.045	0.856	1.033		
var(e.sdg9_2)	0.577	0.200	0.293	1.137		
var(e.sdg9_3)	0.388	0.280	0.095	1.594		
var(SDG9)|	1.000	.	.	.		

Note: RMSEA = 0.094, CFI = 0.798, TLI = 0.832, where * – significance of the indicator at the 5% level.

For SDG 9, the most significant links are with *sdg9_2* (amount of CO_2 emissions) and *sdg9_3* (medium and high-tech manufacturing value added), as these indicators reflect key aspects of the environmental sustainability of industrialization and innovation, especially in contexts of recovery and reconstruction.

The next step is to build a multivariate CFA, which involves identifying the links between educational and scientific regulatory interventions and socio-economic development through the lens of the SDGs. Visually, this can be represented as follows (Figure 2), which includes the relationship of three latent variables: *SDG4*, *SDG8* and *SDG9*.

The empirical results of the multivariate CFA are presented in Table 5, which also satisfy the model's adequacy criteria.
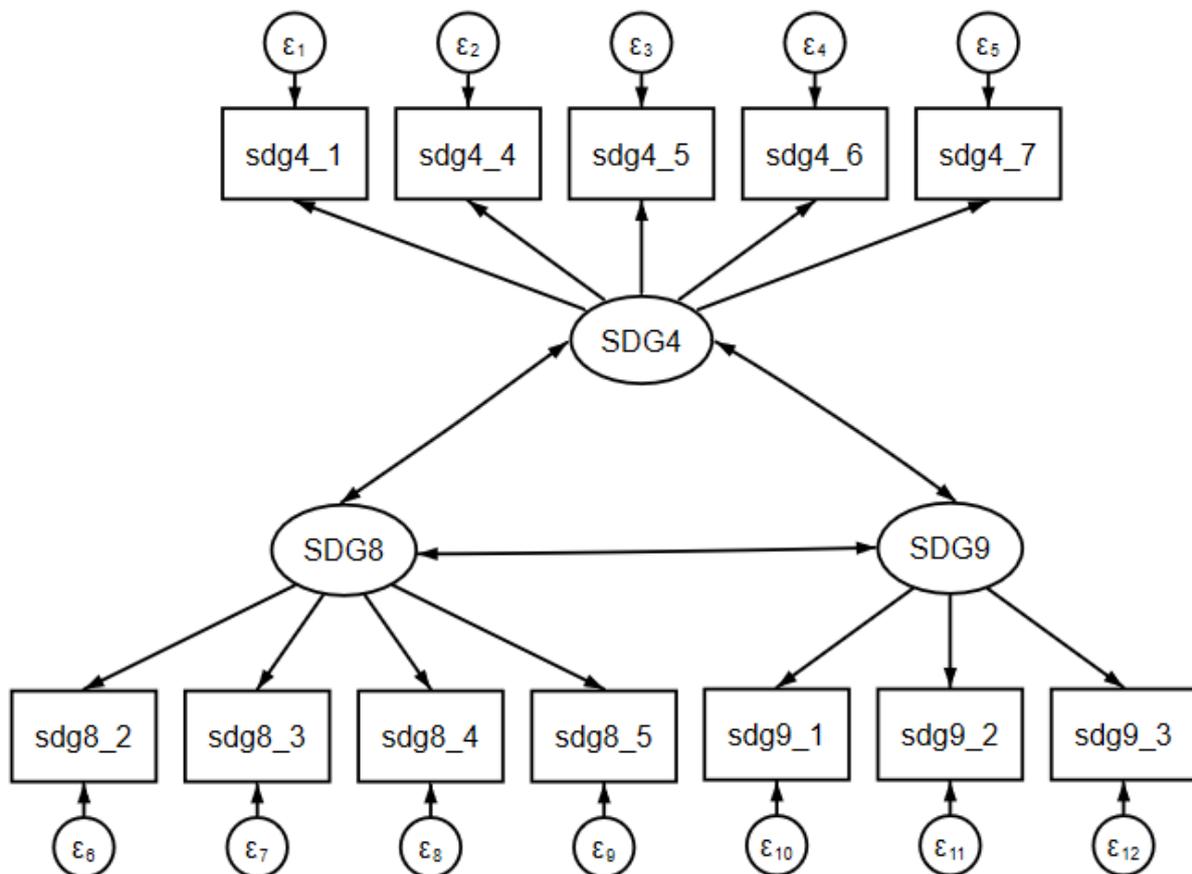

Figure 2. Multivariate CFA model for identifying structural relationships between educational and scientific regulatory interventions and socio-economic development through the lens of the SDGs

Table 5. Covariance relationships between educational and scientific regulatory interventions and socio-economic development through the lens of the SDGs

Variables	Coefficient	OIM std. err.	z	P>|z|	[95%	conf. interval]
cov(SDG4,SDG8)	0.223	0.093	2.400	0.016*	0.041	0.404
cov(SDG4,SDG9)	0.279	0.102	2.730	0.006*	0.079	0.480
cov(SDG8,SDG9)	0.927	0.067	16.840	0.000*	0.996	1.258

Note: *RMSEA* = 0.059, *CFI* = 0.881, *TLI* = 0.835, where * – significance of the indicator at the 5% level.

The obtained covariances between the latent constructs indicate positive statistically significant relationships between them, with a stronger relationship between *SDG8* and *SDG9*, which naturally highlights the close correlation between economic growth, industrialization, and innovation. As for *SDG4*, although the correlation is more moderate, it still emphasizes that quality education is the basis for economic development and technological progress. Educational and scientific regulatory interventions that ensure the formation of a high level of knowledge and skills contribute to the creation of a skilled workforce that can work effectively in the industrial and service sectors, as well as introduce and use the latest technologies. In turn, the successful development of the economy and industry provides resources for further improvement of educational programs and infrastructure.

These interconnections are particularly relevant for countries facing or recovering from armed conflict, such as Ukraine. In such contexts, the reinforcement of education (SDG 4) becomes a strategic foundation for rebuilding human capital, which in turn supports the revitalization of economic (SDG 8) and industrial (SDG 9) capacities.

The observed covariances thus not only confirm theoretical linkages between the goals but also reflect the practical necessity of integrated development strategies in crisis-affected regions.

To confirm the obtained results, one of the variants of goodness-of-fit statistics tests was used, which assesses how much of the variance of each endogenous variable is explained by the model; the results are presented in Table 6. The coefficients of determination and correlation confirm the relevance of individual variables within the latent constructs. The overall R^2 for the model is 0.970, which indicates that the model explains the variance of the endogenous variables well.

To identify a more precise relationship between educational and scientific regulatory interventions and socio-economic development through the prism of the SDGs, a structural model with a measurement component was additionally built, which provides for more specific regression relationships between latent variables. The results are presented in Table 7.

Among the structural constructs, weak statistically significant relationships were found between

Table 6. Results of estimating the variance of the model variables

Dependent variables	Variance			R-squared	mc
	Fitted	Predicted	Residual		
sdg4_1	0.733	0.022	0.712	0.030	0.172
sdg4_4	22.327	16.880	5.447	0.756	0.870
sdg4_5	7.165	0.495	6.670	0.069	0.263
sdg4_6	303.540	184.812	118.728	0.609	0.780
sdg4_7	33.034	16.093	16.941	0.487	0.698
sdg8_2	2.242	1.432	0.811	0.639	0.799
sdg8_3	3.309	2.165	1.144	0.654	0.809
sdg8_4	0.982	0.100	0.882	0.102	0.319
sdg8_5	1.079	0.454	0.625	0.421	0.648
sdg9_1	0.876	0.000	0.876	0.000	0.001
sdg9_2	1.580	0.396	1.184	0.250	0.500
sdg9_3	1.328	0.787	0.542	0.592	0.770
Overall				0.970	

Table 7. Results of multivariate CFA to identify structural latent relationships within SDG4– SDG8–SDG9

Variables	Coefficient	OIM std. err.	z	P>|z|	[95%	conf. interval]
SDG4 → SDG8	0.182	0.090	2.010	0.044*	0.005	0.359
SDG4 → SDG9	−0.092	0.238	−0.380	0.701	−0.558	0.375
var(e.SDG8)	0.967	0.033	0.904	1.034		
var(e.SDG9)	0.992	0.044	0.910	1.081		
var(SDG4)	1.000	.	.	.		

Note: RMSEA = 0.063, CFI = 0.792, TLI = 0.747.

SDG4 and *SDG8*, while no relationships were found for *SDG9*. This indicates that improving the quality of education contributes to economic growth and the creation of decent jobs in these regions. Additional modification indices were used to test the paths and covariates that could be added to the model to improve the fit, and it was found that there are still more specific relationships between *SDG4* and *SDG9* (Table 8).

The weak link between SDG 4 and SDG 8 may reflect the delayed or indirect impact of educational improvements on labor market outcomes in countries affected by instability or conflict. In such contexts, even when education systems function relatively well, structural barriers, such as economic disruption, displacement, or institutional fragility, can limit the immediate translation of educational gains into employment.

The absence of a direct relationship between SDG 4 and SDG 9 in the initial model may also be explained by the disruption of innovation ecosystems in countries like Ukraine and Syria, where scientific and industrial capacities have been significantly affected. However, the identification of additional paths between these constructs through modification indices suggests that education still plays a foundational role in supporting innovation and industrial recovery, albeit through more complex or context-dependent mechanisms.

Potential linkages between *SDG4* and *SDG9* include high primary education completion rates (*sdg4_4*), which can have a positive impact on technological development and industrialization by providing basic educational training. Increased secondary education enrolment (*sdg4_5*) contributes to the preparation of a skilled workforce for the technology and innovation sectors of the economy. Higher enrolment rates in tertiary education (*sdg4_7*) can contribute to the development of innovation and high-tech industries. Additional links to *SDG8* include increased employment in industry (*sdg8_2*) and services (*sdg8_3*), as well as increased value added per worker in services (*sdg8_5*), which indicates economic development and increased productivity.

4. DISCUSSION

The empirical findings confirm and elaborate on the key points presented in the literature review, in particular in the context of the interaction between the Sustainable Development Goals (SDGs) focused on education (SDG 4), economic growth (SDG 8), and innovation (SDG 9). The study found

Table 8. Indices of modification of the multivariate CFA model to identify structural relationships within *SDG4– SDG8–SDG9*

Variables	MI	df	P>MI	EPC	Standard EPC
SDG9					
sdg4_4	14.127	1.000	0.000	−0.030	−0.773
sdg4_5	26.904	1.000	0.000	−0.028	−0.425
sdg4_6	5.890	1.000	0.020	0.004	0.377
sdg4_7	11.462	1.000	0.000	0.013	0.415
sdg8_2	23.835	1.000	0.000	−0.161	−1.347
sdg8_3	9.531	1.000	0.000	0.098	1.003
sdg8_5	9.236	1.000	0.000	0.066	0.383

moderate but statistically significant associations between education and science regulatory interventions (SDG 4) and socio-economic development (SDG 8, SDG 9), which is consistent with the concept of synergies proposed by Bennich et al. (2023), where SDG 4 is seen as a multiplier of positive impact on the other goals.

The relationship between SDG 4 and SDG 8 is consistent with the findings of Cling et al. (2020), who confirmed the significance of the impact of education on the economy based on PCA for European countries. A similar positive relationship between SDG 4, SDG 8, and SDG 9 was also reported by Fonseca et al. (2020) in a global analysis for 193 UN member states.

The study confirmed that the most important SDG 4 indicators are primary education completion rates (sdg4_4), secondary education enrolment (sdg4_6), and tertiary education enrolment (sdg4_7), which form the basis for economic growth and technological progress.

At the same time, as noted by Bennich et al. (2023) and Anderson et al. (2022), SDG 8 and SDG 9 are characterized not only by mutual reinforcement but also by potential trade-offs, which is also reflected in our results. The insignificant or statistically insignificant direct relationship between SDG4 and SDG9 (coefficient -0.092) is only found at the level of specific indicators through modification indices, which allows us to interpret the SDG4-SDG9 interaction as an intra-linkage of the level of indicators, not just target constructs. This confirms the recommendation of Bennich et al. (2023) that it is necessary to analyze not only external but also internal linkages between the SDGs at the indicator level.

Thus, in contrast to previous studies that have focused mainly on correlational or comparative approaches (Cling et al., 2020; Fonseca et al., 2020), the current study contributes to the identification of explicit and latent causal relationships based on structural factor modelling. It confirms that investments in education, in particular in basic and secondary education, are critical not only for the formation of human capital but also for increasing productivity, developing industrial sectors, and introducing innovations.

Furthermore, the results are in line with the findings of Kichurchak et al. (2024) and Petrushenko et al. (2023), who emphasize the strategic importance of education in countries devastated by war and political conflict as a precondition for recovery and long-term development. The impact of SDG4 on SDG8 that we have shown is of particular practical importance in this context.

To summarize, this study shows that even a moderate but statistically significant interaction between SDGs 4, 8, and 9 can be a powerful tool for strategic planning of sustainable development policies. It should be based on the integration of education, economic, and innovation indicators, as also emphasized by Dadkhah et al. (2024), Gallardo-Vázquez et al. (2024), and Noguera-Méndez et al. (2024). The structural approach presented in this study allows us to go beyond the formal comparison of goals and move on to analyze the mechanisms of influence at the inter- and intra-goal levels.

CONCLUSION

This paper aimed to investigate the structural explicit and latent causal links between educational and scientific regulatory interventions and socio-economic development through the lens of the Sustainable Development Goals (SDGs), in particular SDG 4 (quality education), SDG 8 (decent work and economic growth), and SDG 9 (industry, innovation and infrastructure), in 16 countries affected by military operations and politic al conflicts, including the Balkan region, the Caucasus, the Middle East, and Ukraine. In this study, regulatory interventions are conceptualized specifically in relation to SDG 4, which reflects institutional efforts to improve access to and quality of education in post-conflict settings. SDG 8 and SDG 9, meanwhile, are used to capture broader socio-economic outcomes that may be influenced by improvements in education and science.

The results confirm that education, particularly completion of primary and access to secondary and tertiary levels, is a foundational driver of educational system performance in countries, affected by political instability and armed conflict. However, the strength and clarity of these relationships vary depending on the stability and resilience of national systems. In the context of socio-economic development, the most influential indicators are employment in industry and services, the value added by high-tech manufacturing, and CO_2 emissions, which together reflecting the dual imperative of economic productivity and environmental responsibility in shaping sustainable growth trajectories.

Multivariate confirmatory factor analysis confirm the existence of statistically significant and conceptually meaningful relationships between educational and scientific regulatory interventions (SDG4) and key dimensions of socio-economic development (SDG8 and SDG9) in conflict-affected countries. While the strongest correlation was observed between SDG8 and SDG9, highlighting the close interdependence of economic growth, industrialization, and innovation, the moderate but significant covariances between SDG4 and both SDG8 and SDG9 emphasize the foundational role of education in enabling these processes. The findings suggest that policy strategies should not treat education, economy, and innovation as separate domains. Instead, integrated approaches are needed, where educational and scientific regulatory interventions are explicitly aligned with economic and industrial recovery goals.

Among the limitations are the limited timeframe (until 2020) and the availability of statistical data for individual countries, which influenced the choice of indicators. In addition, CFA models do not take into account dynamic changes or external shocks, such as ongoing military operations or new political decisions. Despite these limitations, the study provides a valuable analytical basis for designing recovery-oriented development strategies. In particular, it highlights the need for targeted support to education systems in conflict-affected countries, not only as a humanitarian priority but as a prerequisite for rebuilding economic and technological capacity. The findings should be viewed as a foundation for further research and policy development that explicitly addresses the realities of ongoing crises, especially the war in Ukraine, and their long-term impact on sustainable development.

AUTHOR CONTRIBUTIONS

Conceptualization: Dariusz Krawczyk, Nadiia Artyukhova, Dmytro Svynarenko, Anna Vorontsova, Artem Artyukhov, Robert Rehak, Tetiana Vasylieva.
Data curation: Nadiia Artyukhova.
Formal analysis: Nadiia Artyukhova.
Funding acquisition: Dariusz Krawczyk.
Investigation: Nadiia Artyukhova, Anna Vorontsova.
Methodology: Nadiia Artyukhova.
Project administration: Artem Artyukhov.
Resources: Dariusz Krawczyk.
Software: Nadiia Artyukhova.
Supervision: Tetiana Vasylieva.
Validation: Nadiia Artyukhova, Robert Rehak.
Visualization: Nadiia Artyukhova, Dmytro Svynarenko.
Writing – original draft: Dariusz Krawczyk, Nadiia Artyukhova, Dmytro Svynarenko, Anna Vorontsova, Artem Artyukhov, Robert Rehak, Tetiana Vasylieva.
Writing – review & editing: Dariusz Krawczyk, Nadiia Artyukhova, Dmytro Svynarenko, Anna Vorontsova, Artem Artyukhov, Robert Rehak, Tetiana Vasylieva.

ACKNOWLEDGMENTS AND RESEARCH FUNDING

REFERENCES

1. Abuselidze, G. (2022). Financing Higher Education: New Challenges, Incentives and Opportunities. *IOP Conference Series: Earth and Environmental Science, 1026,* 012066. https://doi.org/10.1088/1755-1315/1026/1/012066

2. Ahmad, J., Saad, S., Krishnan, M., Stancu, A., & Mogoș, O. (2024). Exploring the University Social Responsibility Initiatives and Sustainable Development in Malaysia: A Carroll Model Approach. *European Journal of Interdisciplinary Studies, 16*(1), 71-90. https://doi.org/10.24818/ejis.2024.06

3. Anderson, C. C., Denich, M., Warchold, A., Kropp, J. P., & Pradhan, P. (2022). A systems model of SDG target influence on the 2030 Agenda for Sustainable Development. *Sustainability Science, 17,* 1459-1472. https://doi.org/10.1007/s11625-021-01040-8

4. Bennich, T., Persson, Å., Beaussart, R., Allen, C., & Malekpour, S. (2023). Recurring patterns of SDG interlinkages and how they can advance the 2030 Agenda. *One Earth, 6*(11), 1465-1476. https://doi.org/10.1016/j.oneear.2023.10.008

5. Bhowmik, D. (2023). Gender Inequality in Higher Education and Research. *Business Ethics and Leadership, 7*(3), 108-119. https://doi.org/10.61093/bel.7(3).108-119.2023

6. Brown, T. A. (2006). *Confirmatory factor analysis for applied research.* Guilford Press.

7. Burrell, D.N., Wansi, T., Mathis, V.B., Ninassi, C., Brian Hollar, B., Yang, J., England, C., Eulberg, J., & Ryerson, J. (2024). The Master of Business Administration (MBA) Advantage for Police Chiefs: A Case for Studying Business for Law Enforcement Leadership. *SocioEconomic Challenges, 8*(1), 253-268. https://doi.org/10.61093/sec.8(1).253-268.2024

8. Cling, J.-P., Eghbal-Teherani, S., Orzoni, M., & Plateau, C. (2020). The interlinkages between the SDG indicators and the differentiation between EU countries: It is (mainly) the economy! *Statistical Journal of the IAOS, 36*(2), 455-470. https://doi.org/10.3233/SJI-190507

9. Dadkhah, M., Nedungadi, P., Raman, R., & Dávid, L. D. (2024). Emerging and disruptive technologies and the sustainable development goals: A state of art and research agenda. Equilibrium. *Quarterly Journal of Economics and Economic Policy, 19*(1), 13-21. https://doi.org/10.24136/eq.2985

10. Dallakyan, S., Makaryan, A., Isanians, V., Mkrtchyan, H., Sargsyan, H., Tovmasyan, G., & Bilan, S. (2025). Policy priorities for improving Global Innovation Index score and innovative performance in upper-middle-income countries: Implications for Armenia. *Problems and Perspectives in Management, 23*(1), 569-583. https://doi.org/10.21511/ppm.23(1).2025.43

11. Didenko, I., Petrenko, K. & Pudlo, T. (2023). The role of financial literacy in ensuring financial inclusion of the population. *Financial Markets, Institutions and Risks, 7*(2), 72-79. https://doi.org/10.21272/fmir.7(2).72-79.2023

12. Djamal, D., Fariou, C. & Brahim, L. (2023). Effect of Human Capital on Economic Growth in South Africa: an ARDL Approach. *Financial Markets, Institutions and Risks, 7*(4), 1-13. https://doi.org/10.61093/fmir.7(4).1-13.2023

13. Fonseca, L. M., Domingues, J. P., & Dima, A. M. (2020). Mapping the Sustainable Development Goals Relationships. *Sustainability, 12*(8), 3359. https://doi.org/10.3390/su12083359

14. Gallardo-Vázquez, D., Severino-González, P., Tunjo-Buitrago, E., Sarmiento-Peralta, G., & Romero-Argueta, J. (2024). Empathy and solidarity as a bridge between sustainable development goals and strategic management of higher education institutions. *Oeconomia Copernicana, 15*(3), 925-956. https://doi.org/10.24136/oc.2975

15. Gkrimpizi, T., Peristeras, V., & Magnisalis, I. (2023). Classification of barriers to digital transformation in higher education institutions: Systematic literature review. *Education Sciences, 13*(7), 746. https://doi.org/10.3390/educsci13070746

16. González-Zamar, M. D., Abad-Segura, E., López-Meneses, E., & Gómez-Galán, J. (2020). Managing ICT for sustainable education: Research analysis in the context of higher education. *Sustainability, 12*(19), 8254. https://doi.org/10.3390/su12198254

17. Hara, M. (2023). Educational reform for middle-income trap under digitalization: Culprits, challenges, and strategies in the Philippines. *SocioEconomic Challenges, 7*(3), 200-218. https://doi.org/10.61093/sec.7(3).200-218.2023

18. Hossain, S., Islam, M. S., Kundu, S., Faruq, O., & Hossen, M. A. (2023). Women Participation in Entrepreneurial Activities in the

Post COVID-19 Pandemic: Empirical Evidence from SMEs Sector. *Health Economics and Management Review, 4*(1), 1-10. https://doi.org/10.21272/hem.2023.1-01

19. Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1-55. https://doi.org/10.1080/10705519909540118

20. Jurgelevičius, A., & Raišienė, A.G. (2025). University entrepreneurial ecosystems: Start-up founders 'perspectives on critical factors for student start-up success. *Economics and Sociology, 18*(2), 221-245. https://doi.org/10.14254/2071-789X.2025/18-2/12

21. Kaouache, D. E., Amara, C., Chatter, C., & Kaouache, A. (2024). The Effect of Individual Entrepreneurial Orientation on Entrepreneurial Intention Among University Students. *Business Ethics and Leadership, 8*(2), 63-75. https://doi.org/10.61093/bel.8(2).63-75.2024

22. Kichurchak, M., Paslavska, I., Hrynkevych, O., Mishchuk, H., & Bilan, Y. (2024). Examining Tertiary Education Amid the War in Ukraine: A Synthetic Control Approach. *European Journal of Interdisciplinary Studies, 16*(2), 95-115. https://doi.org/10.24818/ejis.2024.13

23. Kozová, K., Grenčíková, A., & Habánik, J. (2024). Building a sustainable future: Gender, education & workforce needs of Gen Z. *Economics & Sociology, 17*(2), 209-223. https://doi.org/10.14254/2071-789x.2024/17-2/10

24. Kubalek, J., Erben, E., & Kudej, M. (2024). Impact of the environmental ESG pillar on firm sustainability: Empirical research in the V4 countries. *Journal of International Studies, 17*(3), 148-163. https://doi.org/10.14254/2071-8330.2024/17-3/8

25. Kuzheliev, M., Zherlitsyn, D., Nechyporenko, A., Lutkovska, S., & Mazur, H. (2023). Distance learning as a tool for enhancing university academic management processes during the war. *Problems and Perspectives in Management, 21*(2), 23-30. https://doi.org/10.21511/ppm.21(2-si).2023.04

26. Kuzior, A., Didenko, I., Vorontsova, A., Lyeonov, S., & Brožek, P. (2022). Managing educational determinants of financial inclusion as a key factor of sustainable development: logit-probit modeling. *Polish Journal of Management Studies, 26*(2), 265-279. https://doi.org/10.17512/pjms.2022.26.2.16

27. Kuzior, A., Samoilikova, A., Valúch, M., & Bácsné Bába, E. (2024). Impact of university-industry R&D collaboration on innovation transfer and startup performance. *Journal of International Studies, 17*(3), 164-181. https://doi.org/10.14254/2071-8330.2024/17-3/9

28. Lacmanović, S., & Škare, M. (2024). The comparative analysis of B Corp Impact Report results in higher education organizations. *Journal of International Studies, 17*(4), 255-277. https://doi.org/10.14254/2071-8330.2024/17-4/15

29. Makarenko, I., Bilan, Y., Streimikiene, D., & Rybina, L. (2023). Investments support for Sustainable Development Goal 7: Research gaps in the context of post-COVID-19 recovery. *Investment Management and Financial Innovations, 20*(1), 151-173. https://doi.org/10.21511/imfi.20(1).2023.14

30. Ninassi, C. J., & Burrell, D. N. (2023). Teaching business leadership skills to professionals in healthcare cybersecurity, biodefense and biotechnology through experiential learning methods. *Health Economics and Management Review, 4*(3), 82-94. https://doi.org/10.61093/hem.2023.3-07

31. Noguera-Méndez, P., Molera, L., & Semitiel-García, M. (2024). Integrating sustainability in the economics curriculum: Challenges and impact on future decision-makers. *Oeconomia Copernicana, 15*(3), 871-923. https://doi.org/10.24136/oc.3084

32. Ogunleye, J. K., Afolabi, C. S., Ajayi, S. O., & Omotayo, V. A. (2023). Virtual Learning as an Impetus for Business Education Programme in the Midst of COVID-19 in Nigeria. *Health Economics and Management Review, 4*(2), 83-89. https://doi.org/10.21272/hem.2023.2-08

33. Petrushenko, Y., Vorontsova, A., Dorczak, R., & Vasylieva, T. (2023). The third mission of the university in the context of war and post-war recovery. *Problems and Perspectives in Management, 21*(2), 67-79. https://doi.org/10.21511/ppm.21(2-si).2023.09

34. Pozovna, I., Arhipov, S., & Kuzior, A. (2023). Determinants of Leadership in Higher Education in European Countries. *Business Ethics and Leadership, 7*(4), 210-224. https://doi.org/10.61093/bel.7(4).210-224.2023

35. Prieto-Gutierrez, J.-J, Segado-Boj, F., & Da Silva França, F. (2023). Artificial intelligence in social science: A study based on bibliometrics analysis. *Human Technology, 19*(2), 149-162. https://doi.org/10.14254/1795-6889.2023.19-2.1

36. Pruchnicki W., Smal, T., & Tomaszycki, M. (2023). Shaping leadership at the Military University of Land Forces in Wroclaw – recommendations for improving the process. *Administratie si Management Public, 40,* 95-112. https://doi.org/10.24818/amp/2023.40-06

37. Samoilikova, A., Korpysa, J., Vasylieva, T., & Filep, B. (2023b). Business – education collaboration in R&D investment: Analysis of development gaps and critical points using MAR-splines. *Journal of international studies, 16*(2), 57-71. https://doi.org/10.14254/2071-8330.2023/16-2/3

38. Samoilikova, A., Kuryłowicz, M., Lyeonov, S., & Vasa, L. (2023a). University-industry collaboration in R&D to reduce the informal economy and strengthen sustainable development. *Economics & Sociology, 16*(3), 339-353. https://doi.org/10.14254/2071-789x.2023/16-3/18

39. Satorra, A., & Bentler, P. M. (2010). Ensuring positiveness of the scale chi-square test statistic. *Psychometrika, 75,* 243-248.

https://doi.org/10.1007/s11336-009-9135-y

40. Sułkowski, Łukasz, Kolasińska-Morawska, K., Brzozowska, M., Morawski, P., & Seliga, R. (2024). Application of e-learning platforms by higher education institutions during the COVID-19 pandemic: The Polish perspective. *Human Technology, 20*(3), 446-467. https://doi.org/10.14254/1795-6889.2024.20-3.2

41. Yu, Y., Ruoxi, L., Tingting, Y., & Xinxin, W. (2023). Convergence and Disparities in Higher Education Fiscal Expenditures in China: A Regional Perspective. *Financial Markets, Institutions and Risks, 7*(3), 31-47. https://doi.org/10.61093/fmir.7(3).31-47.2023

42. Yu, Y., Xinxin, W., Ruoxi, L., & Tingting, Y. (2024). The Influence of Regional Socioeconomic Features On the Distribution of Financial Resources For Higher Education. *SocioEconomic Challenges, 8*(1), 269-285. https://doi.org/10.61093/sec.8(1).269-285.2024

43. Zhao, B., & Zhou, J. (2024). Research hotspots and trends in digitalization in higher education: A bibliometric analysis. *Heliyon, 10*(21), e39806. https://doi.org/10.1016/j.heliyon.2024.e39806