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MODELS OF INTERACTION BETWEEN ECONOMIC DEVELOPMENT AND HIGHER EDUCATION *

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Abstract. Modern trends in the country's economic development indicate an increasing influence of the higher education system on the dynamics of economic indicators. The article is devoted to analyzing and modeling the mutual influence of the country's economic development and the higher education system (HES) in the context of achieving sustainable development goals, taking into account differences in external conditions and opportunities. The main attention is paid to identifying the key indicators and patterns that shape the interaction of the national economy and the higher education system, as well as the development of economic and mathematical models that assess such interaction. A conceptual model of the interaction of HES and the level of development of the national economy has been developed, and a set of research hypotheses has been formed. Based on the dynamic analysis of a set of indices, retrospective trends in the development of economic and educational processes have been studied, and portraits of the development of Slovakia and Ukraine have been constructed. Factors reflecting the relationship between the development of the country's economic and educational systems have been identified; the lag structure and fractal nature of their mutual influence have been proven based on model experiments. The following mathematical tools were used: Granger Causality test - to determine the mutual influence and lags of such influence between the indicators of the national economy and HES; Lagged models are used to determine the relationships between factors; VAR models, impulse response, and dispersion analyses are used to study the degree of strategic interaction and assess the mutual influence of economic development and the HES. The obtained results form the basis for developing government approaches to developing, retaining, and attracting talent for long-term sustainable development and enhancing the country's competitiveness.

Keywords: economic development; higher education system; impact; interaction; index; model; Granger test

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1. Introduction

The current stage of civilization's development is characterized by key transformations caused by the large-scale and rapid implementation of technological innovations in all areas of society and the economy. Under these conditions, the landscape of all organizations' activities is changing significantly, requiring a rethinking of their operating paradigms, the establishment of new patterns and rules for organizational management, the

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development of new approaches, methods, and tools for conducting business, and the establishment of new relationships with clients and key stakeholders. Higher education is at the center of these transformations, as it is a necessary condition for creating a more equitable, sustainable, and prosperous future for countries and civilization as a whole. The attractiveness of higher education is steadily increasing. According to UNESCO, the number of students studying in higher education institutions worldwide in 2025 is expected to reach a record 264 million, 25 million more than in 2020, and more than double the 2000 figure. According to OECD data, the number of people with higher education has doubled over the period (2000–2024) and reached 41% of the total population (OECD, n.d.).

As experts from the OECD's Centre for Educational Research and Innovation (CERI) (OECD, 2025) note, the future of higher education is determined by the combination of economic, social, demographic, and technological changes characteristic of the 21st century. Global crises and geopolitical tensions, particularly those triggered by military conflicts, have sparked significant processes of international migration and altered the structure of public spending in many countries. In turn, this has created ambiguous trends in economic growth, social security, democratic participation, and the implementation of technological and environmental innovations, significantly complicating the current and future educational landscape, much like a domino effect. In this context, higher education institutions face the following challenges: learning in an AI-driven world; education on a fragile planet; mind the gaps: inequality, fragmentation, and polarization.

A special place in this list is occupied by the study of the new mutual influence of higher education on the economic development of countries, which corresponds, on the one hand, to the new role of education in strengthening peace and solidarity, and on the other hand, actualizes the need for resistance and resilience of higher education to the challenges of the development of civilization.

2. Literature review

The mutual influence of a country's economic development and higher education is a complex, multifaceted process and is the focus of contemporary scientific and practical research. Economic stability and national development have a direct impact on the quality, accessibility, and attractiveness of higher education, shaping its financial base, student support tools, and opportunities for innovation in the educational process. In turn, the higher education system develops qualified human capital, which facilitates the implementation of the latest scientific research and technological innovations in all types of economic activity, enhances the state's readiness to achieve sustainable development goals, transition to new technological paradigms, and improve societal well-being. It is precisely this interaction that creates a new foundation for a country's competitiveness in the globalized world.

Many scientists (Danyliuk et al., 2021; Ahmadova et al., 2025; Abo-Khalil, 2024; Bucata, Popescu & Tileaga, 2022; Rayevnyeva et al., 2023) believe that the country's stable economic development, supported by long-term investments in educational systems, active development of innovative potential, and gradual modernization of the information infrastructure, creates all the necessary conditions for the transition to an economy based on knowledge and high technology. This approach contributes to strengthening the country's competitiveness in the global market, ensures sustainable growth of human capital, and stimulates the implementation of intelligent digital innovations in various areas of activity of both the country, society, and the higher education system.

Over the past decade, the higher education system has undergone a transformation, with universities becoming increasingly innovative and open to technological changes and the digitalization of socio-economic processes in society. According to scientists (Kraus et al., 2021; Kamath, 2025; Rayevnyeva et al., 2024; Apdillah et al., 2022; Yashchyk et al., 2021; Ketoeva et al., 2025; Xu et al., 2025; Mabungela et al., 2025) at the current stage of digital development, there is a need to rethink the interaction between the higher education system and the labor market. The higher education system must meet the current and future needs of the market, offering programs that graduate specialists with relevant skills and knowledge, while the labor market, in the process of active interaction with universities, should adjust demand and influence the formation of competencies of future specialists, depending on the current and prospective situation in the economy.

Leading global institutions, such as UNESCO, are defining the new role of higher education. Stefania Giannini, UNESCO's Assistant Director-General for Education (UNESCO, 2025), notes: "The future of higher education is global, digital, and mobile. With millions more people pursuing degrees and alternative credentials, international cooperation on qualification recognition is more critical than ever to support mobility and safeguard trust in qualifications."

Raquel Bernal (2025), President of the University of the Andes, speaking at the World Economic Forum in Davos in 2025, noted that the education system, including higher education, faces specific challenges shaped by global demographic shifts, technological revolutions, and the urgent need to ensure equal access to education. The global higher education system is faced with the need to rethink the essence of education in four key perspectives: increasing flexibility, adaptability, and personalization; significantly increasing the influence of new technologies on the transformation of learning; the transition of the learning process from the "knowledge transfer" model to the "development of skills and thinking" model; increasing the importance of university research in solving global and local problems of societal and national development. All this requires a fundamental rethinking of university activities, the modernization of traditional universal approaches to education based on the priority of individual aspirations and career preferences of students. Achieving these goals requires innovative approaches to implementing modular programs, integrating certificates, transitioning to hybrid learning formats, creating digital platforms, and ensuring universities are prepared for the digitalization of their processes. Reengineering the educational process to develop key competencies of the future (critical thinking and creativity, collaboration and communication, ethical and global awareness), as well as a focus on ensuring equal access to education and its inclusiveness. In this context, the financial and institutional sustainability of education systems and individual universities is crucial and directly depends not only on the initiatives of the universities themselves but also on government financial support.

Kostetskyi, Kutsenko (2021), Alojail and Khan (2023), Alenezi (2023) believe that working with information is becoming one of the most essential skills in the modern world, and digital technologies and products are utilized in almost all sectors of the economy. The authors substantiate that the main areas of digital transformation of educational institutions should be the creation of a digital infrastructure, the formation of a sufficient level of digital skills of teachers, increasing the digital potential of educational institutions, the introduction of a digital component in academic programs, the use of digital educational resources, the development of a digital educational environment, the implementation of digital assessment systems.

The Global Talent Competitiveness Index 2023: What a Difference Ten Years Make What to Expect for the Next Decade (The GTCI report, n.d.) by Fontainebleau (UNESCO, 2025) examines the challenges of transforming future human capital to create new value and enhance talent competitiveness. The research focuses on the idea that competitive talent has a direct impact on a country's economic development. A key task for governments in the 21st century is to develop a set of adequate policies and practices that enable the country to create, attract, and expand the capabilities of its human capital, thereby contributing to productivity and prosperity. In this sense, the Global Talent Competitiveness Index (GTCI) is a crucial component of the talent management ecosystem.

Thus, a two-way interaction exists between a country's economic system and its SES, which is a phenomenon of a new stage in the development of civilization, based on the total digitalization of processes, the active implementation and use of artificial intelligence, the transformation of business and public ecosystems, changing resource priorities, and a focus on the importance of human development. All of this substantiates the relevance of studying the relationship between economic growth and SES, especially given the differences in socioeconomic opportunities and force majeure conditions for the development of individual countries.

3. Research objective and methodology

This article is devoted to analyzing and modeling the mutual influence of a country's economic development and its higher education system (HES) on achieving sustainable development goals, taking into account the varying opportunities conditioned by external conditions.

To achieve the research goal, the following are addressed:

1. Studying the characteristics and identifying objective trends in economic and educational processes, taking into account stable and force majeure circumstances, and constructing a portrait of the country's current state;
2. Justifying the dependent and independent influences between indicators of the economic and educational systems and constructing relationship diagrams;
3. Developing a set of models for forecasting the development of the economic system and HES;
4. Defining and modeling the relationship between HES and the country's economic system;
5. Assessing the strategic interaction between economic development and HES.

The solution to the stated problems is based on the proof of the following hypotheses:

1. The development of the country's economic system and higher education system is defined as readiness for the transformations of the 21st century and the implementation of information and communication innovations, as well as the creation of a favorable environment for their competitive development.
2. The interaction between the country's economic system and the higher education system has a lagged, fractal structure.
3. Managing the interaction between the economic and educational systems creates the preconditions for sustainable national development and the creation and attraction of talent to address strategic challenges.

Research methods encompass systems and conceptual approaches, as well as monographic and comparative analysis, index analysis, analysis of structural and logical relationships, econometric modeling, and visualization methods. The conceptual research model is presented in Figure 1.

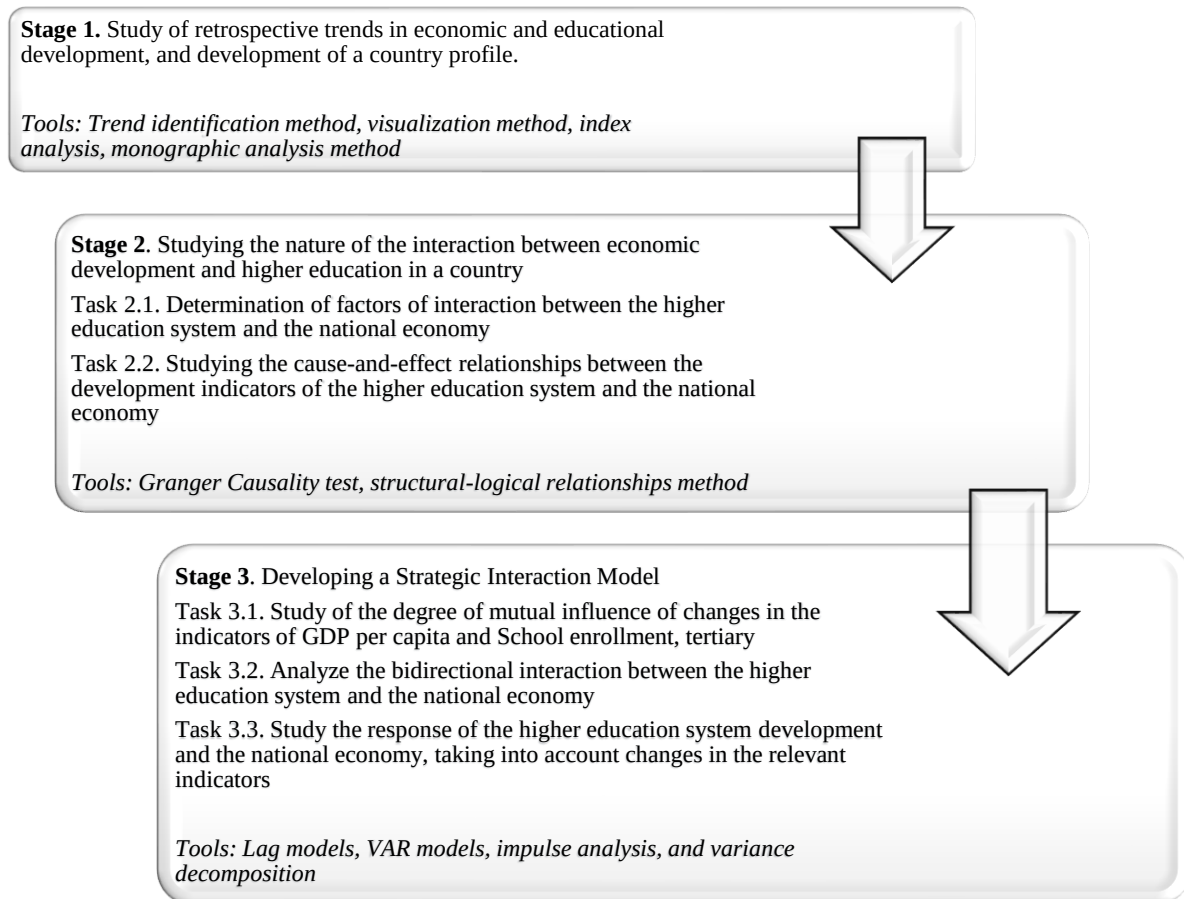


Figure 1. Conceptual research model

Source: compiled by the authors

To solve objective 1, international indices were used, namely: Human Development Index (HDI), Global Talent Competitiveness Index (GTCI), Global Innovation Index (GII), Digital Evolution Index (DEI), Fragile States Index (FSI), Education Index (EI).

The Human Development Index (HDI) is a comprehensive measure of human development. It was developed and published in 1990 by the United Nations Development Program in its Human Development Reports and includes three sets of indicators that assess the level of health, education, and economic well-being of a country's citizens (1) (Human Development Report, n.d.):

$$HDI = \langle \text{Life expectancy index}, \text{Education index}, \text{GNI index} \rangle \quad (1)$$

The HDI is calculated using the geometric mean of the three groups of indicators presented above. HDI values range from 0 to 1, allowing for a systematic assessment and ranking of countries based on their quality of life.

The Global Talent Competitiveness Index (GTCI) is a contemporary indicator for evaluating a country's capacity to attract and retain talent (The GTCI report, n.d.). This index was first published in 2013 by INSEAD and the Human Capital Leadership Institute in Singapore. The GTCI model is presented below (2):

$$HDI = \langle \text{Input}, \text{Output} \rangle \quad (2)$$

The GTCI is calculated as a simple arithmetic mean of the scores for each subsystem, with values ranging from 0 to 100, indicating that developed, high-income countries occupy the highest positions. The *Input sub-index* includes an assessment of the country's efforts to attract (Enable), select (Attract), develop (Grow) и and retain talented citizens (Retain); the *Output sub-index* assesses vocational and technical skills (VT Skills) and global knowledge skills (GK Skills). VT Skills analyze skills with a technical or vocational basis acquired through vocational or professional training and experience; GK Skills assess the creativity and problem-solving skills needed by knowledge workers in professional, managerial, or executive positions.

The Global Innovation Index (GII) was developed in 2007 by experts from INSEAD (France), with the support of the World Intellectual Property Organization (WIPO) and Cornell University (USA), among other participants. The Global Innovation Index comprises 80 different indicators covering the political situation, education system, infrastructure, and knowledge creation in each country (Global Innovation Index Report, n.d.). All GI indicators are divided into two groups of subindices: the Innovation Input subindex assesses the resources countries invest in innovation; the Innovation Output subindex evaluates the actual results of innovation activities (3).

$$GII = \frac{\text{Sub-index of innovation costs} + \text{Sub-index of innovation results}}{2} \quad (3)$$

This index enables us to examine the innovation performance of countries, identifying their strengths and weaknesses, and also to compare their levels of development.

The Digital Evolution Index (DEI) was first calculated in 2014 by Bhaskar Chakravorty, Christopher (Rusty) Tunnard, and Ravi Shankar at the Fletcher School of Law and Diplomacy at Tufts University, USA, in collaboration with Mastercard. The Digital Evolution Index is a tool for assessing the transformation of economies in developed and developing countries from traditional to digital. The DEI is calculated using 184 indicators that reflect the current state and pace of digitalization of a country's economy. These indicators are combined into clusters that reflect 35 aspects of digitalization, which are then grouped into 13 higher-order components and ultimately form four drivers of a country's digital development: supply conditions, demand conditions, the institutional environment, and innovation and change (Digital Evolution Index Report, n.d.) (4):

$$DEI = \langle 0,25 * \text{Supply} + 0,25 * \text{Demand} + 0,25 * \text{Institutional Environment} + 0,25 * \text{Innovation} \rangle \quad (4)$$

The results of the country's digital evolution assessment are scaled in the range [0÷100], where the highest score is given to countries with a high level of development of digital technologies, services, and citizen engagement.

The Fragile States Index (FSI) was developed in 2005 by the US-based Foundation for Peace and Foreign Policy magazine. It assesses the government's inability to maintain territorial integrity, as well as the country's demographic, political, and economic situation. The FSI is a crucial tool for not only identifying the challenges facing all states but also determining when these challenges exceed a state's ability to overcome them. The FSI comprises 12 indicators, grouped into four categories: cohesion, economic, political, and sociodemographic (Fragile States Index Report, n.d.) (5).

$$FSI = \sum \text{Cohesion} + \sum \text{Economic} + \sum \text{Political} + \sum \text{Social} \quad (5)$$

Each indicator in the group is assessed on a scale of [0÷10], where 10 is the highest level of instability.

The Education Index (EI) is a global index developed by the United Nations Development Program, measuring literacy and education coverage (UNDP, n.d.). The EI is calculated as the adult literacy index and the gross enrollment index and includes key aspects such as education coverage, the quality of educational programs, the accessibility of academic institutions, and the literacy rate of the population (6).

Education Index = $(0,75 * \text{Mean Years of Schooling Index}) + (0,25 * \text{Expected Years of Schooling Index})$ (6)

The obtained calculation results are standardized as numerical values on a scale from 0 (minimum) to 1 (maximum).

To solve objectives 2-4, the following mathematical tools were used in the study:

Granger causality test — this is a statistical test that determines whether one time series helps predict another. There are two stationary time series, X_t and Y_t . Classical Granger tests whether adding lags X_{t-i} to the forecasting model improves the forecasting of Y_t compared to a model using only lags Y_{t-j} . This test uses the hypothesis H_0 : lags X do not cause changes in Y , that is, the coefficients $\beta_1 = \beta_2 = \dots = \beta_m = 0$ in the model (Stiglitiz, 1974).

$$Y_t = \alpha_0 + \sum (\alpha_j Y_{t-j}) + \sum (\beta_i X_{t-i}) + \varepsilon_t$$

If hypothesis H_0 is rejected, then factor X is the cause of the change in factor Y .

The Granger causality test has the following assumptions: 1) the time series must be stationary; 2) the lag structure must be correctly specified; 3) the model must be linear, and the model residuals must not have autocorrelation.

The limitations of the test are as follows:

The test establishes mathematical causality, whereas there may be no economic meaning in causality; therefore, it is essential to consider economic meanings when testing multiple indicators for causality.

there may be a hidden factor or common driver (spurious causality) that will jointly influence all factors in the aggregate. Therefore, its influence will limit the investigation of the causality of other factors.

The more complex the system, the less appropriate its decomposition into local systems is, particularly when studying the interaction of individual factors in pairs.

VAR models. The model has the following formal form (7)

$$\begin{aligned} X_{1,t} &= a_{10} + a_{11}X_{1,t-1} + \dots + a_{1p}X_{1,t-p} + \dots + b_{1p}X_{n,t-p} \\ X_{2,t} &= a_{20} + a_{21}X_{1,t-1} + \dots + a_{2p}X_{1,t-p} + \dots + b_{2p}X_{n,t-p} \\ &\dots \\ X_{n,t} &= a_{n0} + a_{n1}X_{1,t-1} + \dots + a_{np}X_{1,t-p} + \dots + b_{np}X_{n,t-p} \end{aligned} \quad (7)$$

where n – the number of variables; p – optimal lag of the VAR model.

The VAR model is based on the following assumptions: 1) all variables in the model are endogenous, that is, they act as a result of the influence of other factors in the model system; 2) time series must be stationary or reduced to stationarity; 3) model errors ε_t are uncorrelated with previous values of the regressors; 4) the choice of lags must be mathematically justified (Jeff E. Biddle, 2021).

This class of models offers significant advantages when modeling interactions between systems, namely:

it allows for modeling dynamic relationships between multiple time series;

it does not require pre-definition of exogenous variables, as exogenous variables in turn become endogenous;

it is used for forecasting, impulse response analysis, shock assessment, and variance decomposition, which allows one to determine the influence of certain factors on the outcome factor.

4. Results and recommendations

Stage 1. Study of retrospective trends in economic and educational development, and development of a country profile. The 21st century is a period of globalization and digitalization, the development of new knowledge, change, and large-scale innovative progress, encompassing virtually all aspects of society and national life. This large-scale transformation poses a crucial challenge for the state: it is necessary not only to retain existing talent within the country, creating favorable conditions for their development and activity, but also to actively attract new, highly qualified specialists. All this will strengthen the state's resilience to the challenges of the 21st century through the widespread adoption of innovation, flexibility to adapt to new opportunities in the global economy, trends in scientific and technological progress, and a new understanding of the role of human capital and skilled labor in the country's socioeconomic development.

To analyze the created opportunities and the environment for innovative societal development, the study constructed a portrait of the country's development. A set of international indices was used as a toolkit, enabling a systematic assessment of the country's socioeconomic status, education level, security, and capacity to implement various innovations and transition to a new technological paradigm. The results of the analysis will

help formulate several areas for further interaction between the country's economy and educational environment to retain human resources under normal and unforeseen development conditions.

Figure 2 presents the Education Index (EI) and the Global Talent Competitiveness Index (GTCI), which provide a comprehensive assessment of the development of the educational system and the degree to which society is realizing its individual potential. These indices help analyze the quality of education provided, professional development, and success in creating conditions for the realization of personal and professional talents, which, in turn, significantly impacts the social and economic development of a region or country as a whole.

The EI is an integrated indicator used to assess educational development in a country or region, allowing the current state of the education system to be measured and the problem areas requiring improvement to be identified. Furthermore, it plays an important role in shaping sustainable development strategies, as high-quality education, including higher education, is the foundation for social, economic, and scientific progress.

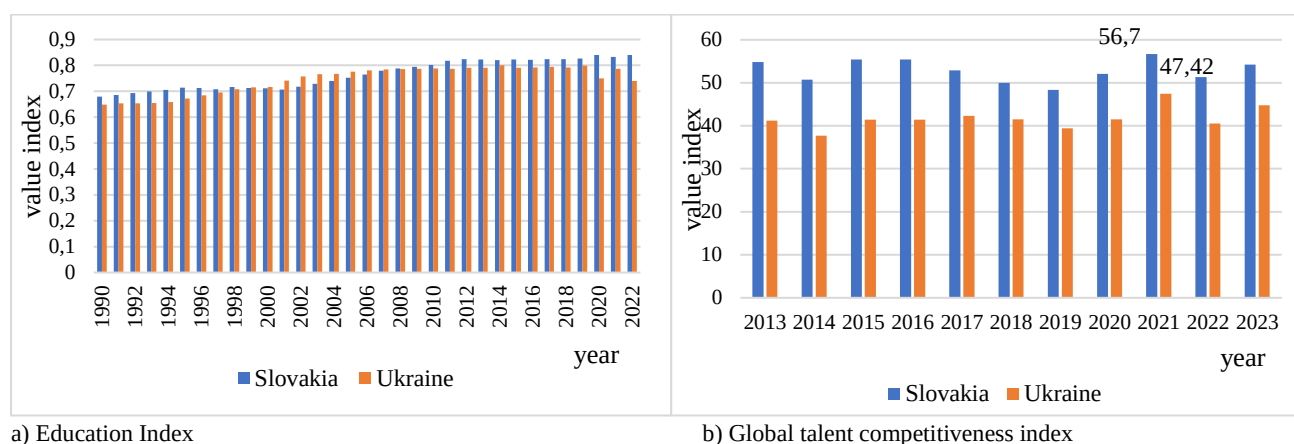


Figure 2. Dynamics Education Index и Global Talent Competitiveness Index
Source: compiled by authors based on GTCI report and UNDP

Figure 2 shows that for Slovakia and Ukraine, despite differences in their levels of economic development and state operating conditions (Slovakia – normal development conditions; Ukraine – force majeure military conditions), the education index has similarly high values (Ukraine – 0.65–0.8; Slovakia – 0.67–0.84), indicating the presence of an environment stimulating human capital development.

The education index in Ukraine for the period 1990–2022 demonstrates significant changes reflecting the various stages of the country's socio-economic development:

- 1990–2006 – a period of increasing numbers of educated people, indicating the level of accessibility and quality of education, as well as progress in the country's socio-economic development;
- 2007–2018 - a period of stable development despite transformations and challenges, namely the transition from an 11-year to a 12-year education system, which began in 2018 with the introduction of the New Ukrainian School concept, the strengthening of the role of the bachelor's degree as a foundation for higher education following the adoption of the Law on Higher Education in 2014 (Official portal of the Verkhovna Rada of Ukraine, 2014), and the need to optimize the structure of secondary and higher education, despite high levels of higher education enrollment;
- 2019–2022 - a period of development under force majeure conditions, characterized by a large-scale transition to online learning, the introduction of new educational technologies, and approaches to teaching, which became particularly relevant during COVID-19 and Russia's military aggression against Ukraine.

Regarding the development of education in Slovakia, it has demonstrated positive dynamics through reforms aimed at aligning with European standards, including the integration of higher education into the Bologna Process and improvements in the quality of education. Key changes included restructuring the secondary education system, developing public and private education, and emphasizing free higher education at public

universities for all applicants with a sufficient level of Slovak language proficiency. All of this contributed to an increase in the number of educated people in the country.

The dynamics of the Global Talent Competitiveness Index for Slovakia and Ukraine for the period 2013-2023 (Figure 2) show a unidirectional, nonlinear trend, driven by both the countries' strengthened positions on the international stage thanks to improved infrastructure and educational reforms, as well as the challenges they faced, such as the outflow of qualified specialists abroad or insufficient investment in professional development. An analysis of the index values suggests a middle-of-the-road position for these countries in the ranking, as index values for Slovakia fluctuate between 0.48 and 0.57 over the analyzed period, while for Ukraine, they range from 0.38 to 0.45. This demonstrates the need for government intervention: in the Input sub-index for Slovakia and Ukraine, it is about developing talented citizens (Grow); in the Output sub-index, it is about strengthening global knowledge skills for Slovakia; and for Ukraine, it is about strengthening global knowledge skills and vocational and technical skills. The highest index values for the analyzed countries correspond to 2021, the year of economic recovery after the global pandemic (Figure 2).

The Human Development Index (HDI) is an integrated indicator that assesses a country's attractiveness for highly educated people. By assessing a country's situation from three perspectives—long and healthy life, access to knowledge, and a decent standard of living—this indicator allows one to evaluate government efforts to preserve human capital for future economic development. Figure 3 shows the HDI trends for Slovakia and Ukraine.

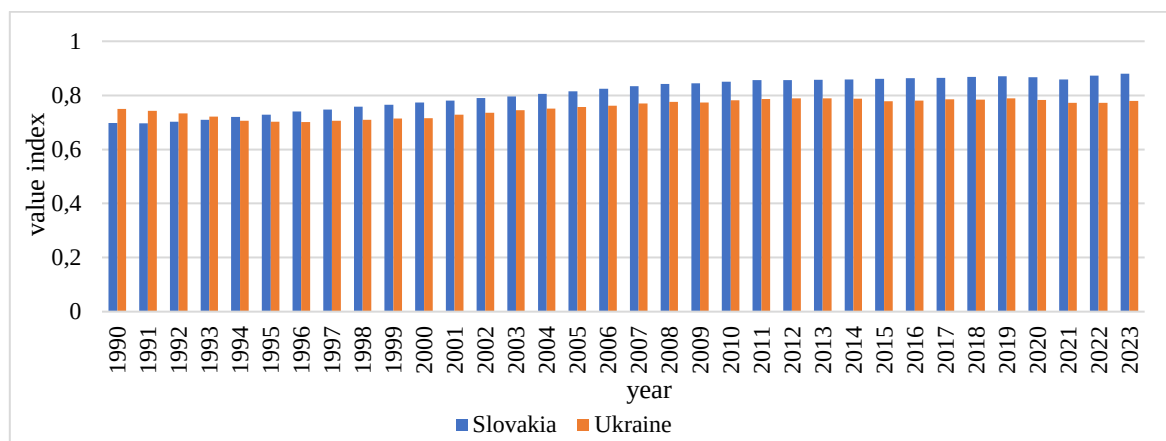


Figure 3. Dynamics Human Development Index by Slovakia and Ukraine

Source: compiled by authors based on Human Development Report

Figure 3 for Ukraine shows that from 2001 to 2014, there was a steady increase in the index, followed by a period of stagnation and a slight decline. Since 2020, the HDI has begun to decline, although this decline was not significant compared to global indicators. Ukraine's HDI dynamics for 1991-2023 can be roughly divided into three periods:

1991-2014 - a period of growth, meaning that during this period, the HDI increased from 0.71 to 0.77, reflecting the country's positive socioeconomic development;

2015-2019 - a period of stagnation, with the average HDI value being 0.78;

From 2020 to the present, the index has declined by 0.2 points due to declining life expectancy, per capita income, rising unemployment, and force majeure events such as COVID-19 and military action.

Although Ukraine still has an index value above the global average, the overall deterioration in the population's quality of life, economic decline, and rising public debt, problems in the real economy, funding constraints in higher education, and, most importantly, a significant loss of life security, make the country unattractive for human capital.

An analysis of Slovakia's HDI dynamics showed steady growth over the analyzed period, reflecting progress in improving the quality of life, increasing life expectancy, advancing education levels, and improving economic development. Thus, Slovakia demonstrates a high level of socioeconomic development, which is a positive signal for retaining and attracting talent.

The Digital Evolution Index (DEI) provides a national-level assessment of the current state of development and potential for digital technology adoption. It is an important tool for analyzing a country's competitiveness, identifying its strengths, and identifying areas requiring additional attention to ensure sustainable progress in the digital economy and human capital development. Figure 4 shows the DEI dynamics for Slovakia and Ukraine.

Slovakia's Digital Evolution Index analysis revealed rapid progress in the European Digital Competitiveness Index, improving its position by 18.55 points in 2023 compared to 2008. This reflects the country's commitment to digital transformation, which aligns with its national development strategy to ensure high-speed internet access by 2030 and support the diffusion of artificial intelligence across all sectors of the country.

Despite the force majeure conditions of 2022-2025, the Digital Evolution Index in Ukraine also demonstrates positive changes in the digital transformation process. Index values have increased by 23.43 points over 15 years, reflecting significant potential for further growth in digitalization thanks to digital literacy, access to technology, high-speed internet, and other factors.

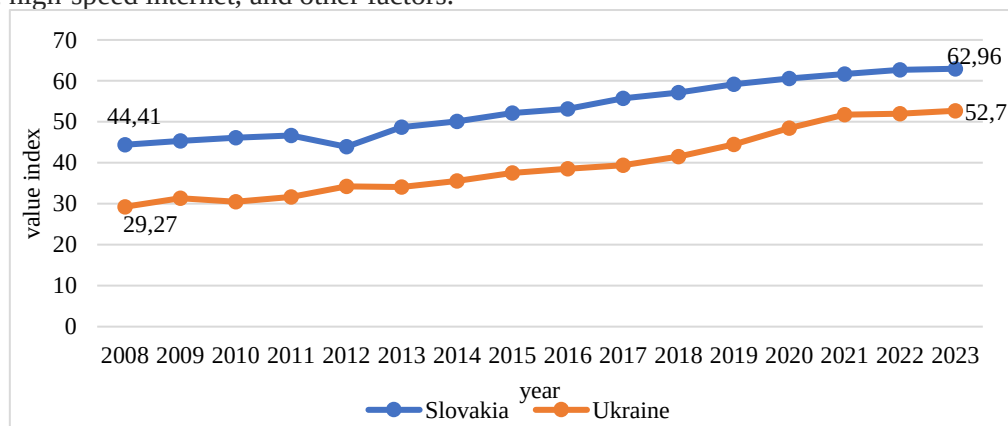


Figure 4. Dynamics Digital Evolution Index by Slovakia and Ukraine
Source: compiled by authors based on Digital Evolution Index Report

The sustainability of modern national development is characterized, on the one hand, by the need and opportunity to implement various innovations, and on the other, by strengthening political, economic, and social institutions. Therefore, the study used the Innovation Development Index and the State Fragility Index, whose dynamics are presented in Figure 5. The Innovation Development Index reflects the level of development and implementation of cutting-edge technologies and the contribution of innovation to economic and social development; the State Fragility Index assesses countries' vulnerability to various internal and external challenges, including political instability, economic difficulties, and social tensions. Both of these metrics serve as essential tools for analyzing state resilience and capacity, providing insight into a country's development dynamics.

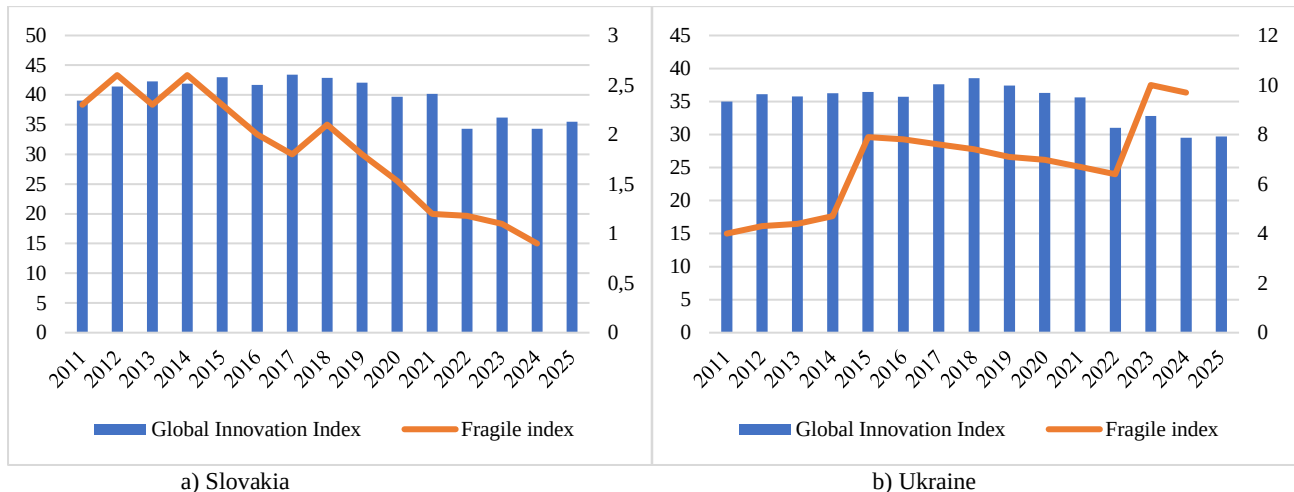


Figure 5. Dynamics Fragile index and Global Innovation Index by Slovakia and Ukraine
 Source: compiled by authors based on Fragile States Index Report and Global Innovation Index Report

An analysis of trends in the Innovation Development Index for Slovakia and Ukraine for 2011–2025 revealed similar nonlinear dynamics, with a characteristic decline in index values at the end of the analyzed period (Slovakia – 4.5 points; Ukraine – 5.3 points). The reasons for this decline were insufficient investment in research and development, low levels of technological infrastructure, patent activity, and the effectiveness of knowledge transfer. Focusing government efforts on improving this situation will accelerate the diffusion of innovations into the economy and society, facilitating adaptation to modern development trends.

Ukraine and Slovakia have opposed trends in their Fragile Index. Slovakia has strengthened its development sustainability since 2014 (Figure 5), as evidenced by a sharp 66 percent decline in its index. Ukraine has an opposite, upward trend in its index; over the analyzed period, its value increased 2.4-fold, reaching 9.7 points in 2024. However, since 2015, the country has seen a positive trend toward strengthening the state (a 1.5-point decrease in index values over the period 2015–2022), which was disrupted by Russia's military aggression (an increase in index values over the period 2022–2024 of 3.4 points).

Thus, the analyzed countries must continuously focus on improving their levels of innovative development, the quality of education, and socioeconomic development, which, in turn, will strengthen their competitiveness on the international stage and stimulate long-term growth. The socioeconomic and innovative development level in countries depends on the quality of education. By investing in education, states create the foundation for training qualified personnel and stimulating scientific potential, which, in turn, influences the formation of an innovative economy and increases its competitiveness.

The research that was conducted allowed for the construction of a portrait of the countries' socioeconomic development (Figure 6). Even though Slovakia and Ukraine have different levels of economic growth and are developing under different conditions (Slovakia – evolutionary development conditions; Ukraine – force majeure), their governments are making significant efforts to retain and attract talent as a driver of their future socioeconomic well-being.

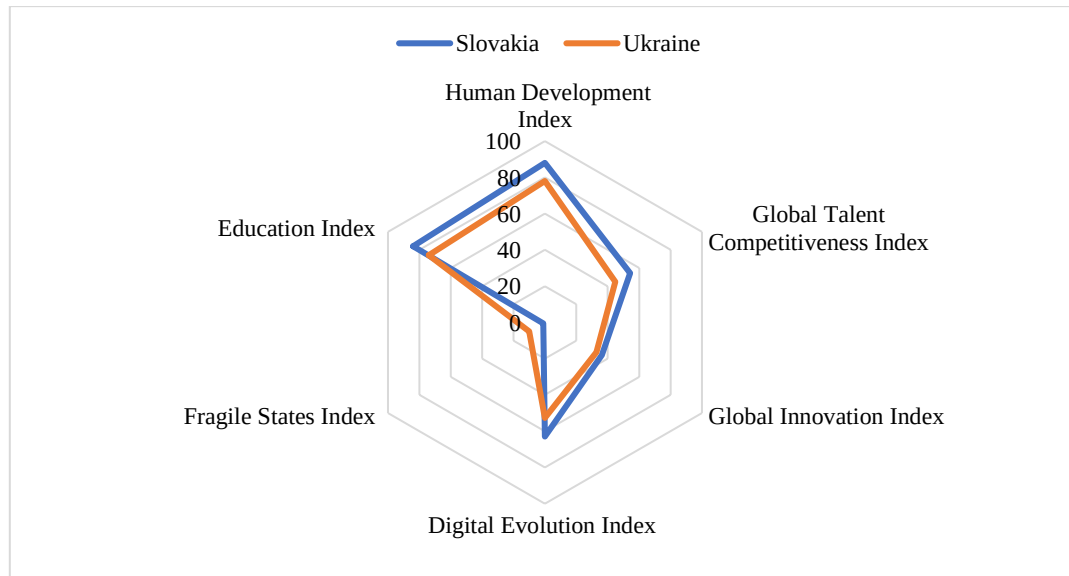


Figure 6. Portrait of the socio-economic development of countries, 2023

Source: compiled by the authors

The resulting portrait reflects the strengths and weaknesses of government efforts to create a favorable socioeconomic environment for development, attracting and retaining talent, which is essential for the new knowledge economy and developing drivers of the country's future competitiveness in global intellectualization and digitalization. Figure 6 shows that Slovakia ranks higher in all analyzed indices in 2023, suggesting the government's ongoing efforts to preserve human capital. Despite facing brutal force majeure circumstances, Ukraine strategically focuses on creating conditions for retaining and attracting talent. However, these efforts are significantly limited by the loss of the economically active population, particularly those with higher education, the decline in economic activity, and the resulting reduction in budget revenue due to Russia's military aggression.

Stage 2. Studying the nature of the interaction between economic development and higher education in a country

Task 2.1. Determination of factors of interaction between the higher education system and the national economy. The study of the content and analysis of the components of the HDI, GTCI, GII, DEI, FSI, and EI indices allowed us to form a list of indicators that will be used to identify the dependent and independent influence between the indicators of the economic and educational systems, and to build a set of structural and logical diagrams of their relationship. This list of indicators includes: 1) School enrollment, tertiary(% gross)- SE; 2) GDP per capita (current US\$)- GDP; 3) The level of attractiveness of the higher education system - Inter; 4) Global Talent Competitiveness Index - Talent; 5) The number of students who graduated from higher education institutions - Final; 6) The number of postgraduate students - PhD; 7) The index of expenditure on scientific research to GDP, % - RD_Spending; 8) The Cost of living Index - Cost; 9) The number of researchers - RD_People. The information space for solving the problem is formed by a dynamic series of these indicators for the period 1990-2024; the source of information was the databases GTCI report, World Bank, State Statistics Service of Ukraine, Eurostat database.

Task 2.2. Studying the cause-and-effect relationships between the development indicators of the higher education system and the national economy. The Granger Causality test was chosen as the mathematical tool for solving the problem. To confirm Hypothesis 2 regarding the existence of an interaction between the country's economic system and the SVO, the test was calculated for four lags to determine its lag and fractal structure. The test results for a one-year lag are presented in Table 1.

Table 1. Research on the causes and consequences of the interaction between the higher education system and the national economy

Null Hypothesis:		F-Statistic	Prob.
FINAL does not Granger Cause COST		6.66647	0.0148
GDP does not Granger Cause COST		12.3528	0.0014
COST does not Granger Cause INTER		4.16705	0.0498
PHD does not Granger Cause COST		4.45516	0.0430
COST does not Granger Cause TALENT		13.3521	0.0009
FINAL does not Granger Cause PHD		19.9955	0.0001
RD_PEOPLE does not Granger Cause FINAL		12.5580	0.0036
FINAL does not Granger Cause SE		8.64248	0.0062
TALENT does not Granger Cause FINAL		3.11361	0.0875
INTER does not Granger Cause GDP		3.71091	0.0633
GDP does not Granger Cause RD_PEOPLE		18.5655	0.0008
SE does not Granger Cause GDP		62.5552	6.E-09
GDP does not Granger Cause SE		4.59182	0.0401
GDP does not Granger Cause TALENT		4.16074	0.0500
RD_SPENDING does not Granger Cause INTER		9.38785	0.0059
SE does not Granger Cause INTER		8.49803	0.0065
INTER does not Granger Cause TALENT		15.3941	0.0005
SE does not Granger Cause PHD		5.15990	0.0302
RD_PEOPLE does not Granger Cause RD_SPENDING		7.32299	0.0180
RD_PEOPLE does not Granger Cause SE		7.86910	0.0149
RD_SPENDING does not Granger Cause SE		5.36992	0.0307
TALENT does not Granger Cause RD_SPENDING		4.19370	0.0533
TALENT does not Granger Cause SE		3.29108	0.0793
RD_SPENDING does not Granger Cause GDP		3.53229	0.0229

Source: compiled by the authors

The calculations presented in Table 1 enabled the construction of a system of dependent and independent influences between the analyzed indicators (Table 2).

Table 2. Granger test results for lag 1

Cause	Effect
The number of students who graduated from higher education	Cost of living
GDP per capita	
The number of postgraduate students	
The Cost of living Index	The level of attractiveness of the higher education system
The index of expenditure on scientific research to GDP	
School enrollment, tertiary	
The Cost of living Index	Global Talent Competitiveness Index
GDP per capita	
The level of attractiveness of the higher education system	
The number of students who graduated from higher education	The number of postgraduate students
School enrollment, tertiary	
Number of researchers	
Global Talent Competitiveness Index	The number of students who graduated from higher education
The level of attractiveness of the higher education system	
School enrollment, tertiary	
The index of expenditure on scientific research to GDP	GDP per capita
GDP per capita	
The number of students who graduated from higher education	
Number of researchers	School enrollment, tertiary
The index of expenditure on scientific research to GDP	
Global Talent Competitiveness Index	
GDP per capita	Number of researchers
Number of researchers	
Global Talent Competitiveness Index	
	The index of expenditure on scientific research to GDP

Source: compiled by the authors

These Tables 2 allow us to draw the following conclusions:

1. In the short term, a correlation is observed between the GDP per capita and school enrollment (tertiary) indicators. To suggest that, on the one hand, the higher the level of economic development, the more people desire higher education. On the other hand, the more people enroll in universities and, as a result, the proportion of the economically active population with higher education increases, the more GDP per capita increases.
2. Interestingly, the GDP per capita and school enrollment (tertiary) indicators are significantly influenced by the extent to which the state funds scientific research, that is, the state's scientific potential development.
3. With a one-year lag, the standard of living (Cost of Living) depends on the number of students who graduate from universities, economic development, and the number of people who want to pursue further research (the number of postgraduate students).
4. The attractiveness indicator of higher education depends on the Cost of Living, the research investment index, and the School Enrollment (tertiary). This indicates that the more a state invests in R&D and the better the living conditions of the country's population, the more people desire a high level of education.
5. The talent index, with a one-year lag, directly depends on the population's standard of living and economic development, as well as on the attractiveness of the higher education system. In our view, this reflects the creation of opportunities to improve the quality of a country's human capital while improving its socioeconomic development.
6. The number of researchers directly depends on the level of economic development; i.e., the higher the level of economic development, the greater the country's opportunities to stimulate scientific research, which serves as the basis for the country's innovative development.

Thus, the identified structural and logical relationships between the analyzed indicators allowed us to construct an interaction graph (Figure 7).

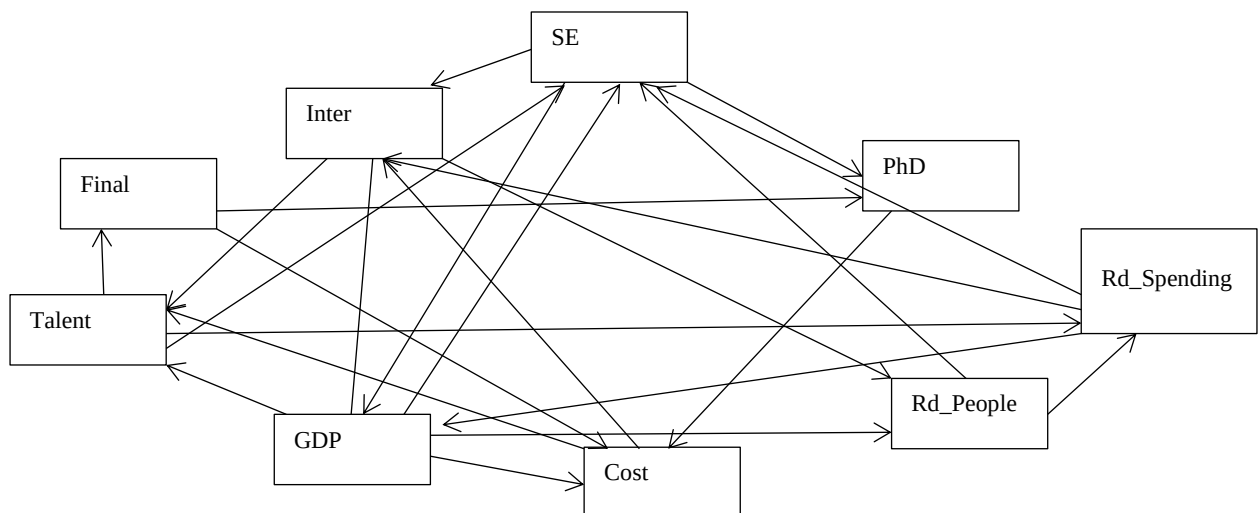


Figure 7. Graph of interaction and connection of indicators with lag 1

Source: compiled by the authors

To prove the stability of the relationships between the analyzed indicators, calculations were carried out for lags 2, 3. Table 3 presents the results of comparing the interaction for lags 1 and 2.

Based on the data in the table, the following general conclusions can be drawn:

1. At a short lag (lag 1), the national economy and the HES have a strong mutual influence, demonstrating the need to stimulate both economic development and the development of the HES to preserve, retain, and attract talent to create competitive advantages for the country's socioeconomic development. With an increasing lag (lag 2), the mutual influence intensifies, deepens, and extends to the scientific sector, increasing the number of researchers and graduate students.

Table 3. Comparative analysis of lags 1 and 2

Direction of influence	Lag 1 (p-value)	Lag 2 (p-value)	Conclusion
<i>SE → GDP</i>	6.E-09	1.E-08	A stable and extremely strong connection between higher education institutions and the national economy.
<i>GDP → SE</i>	0.0401	0.0004	The effect of economic growth, which leads to a more stable connection between the national economy and HES over time.
<i>PhD → GDP</i>	-	0.0105	The impact of the number of postgraduates on the national economy is manifested no earlier than after two years.
<i>GDP → Rd_people</i>	0.0008	0.0014	Stable causality is observed in both lags, which indicates a close connection between the national economy and the number of researchers.
<i>SE → PhD</i>	0.0302	0.0004	A strengthening of causality is observed, with a lag, the impact of higher education on the number of postgraduates increases.
<i>Final → SE</i>	0.0062	0.0118	For two lags, a constant, strong effect is observed.
<i>Rd_people → SE</i>	0.0149	0.0226	The involvement of researchers increases the educational level of the state, and this connection is constant in the lag structure.
<i>Rd_spendin → SE</i>	0.0307	0.0412	A stable dependence is observed.
<i>Rd_people → Rd_spendin</i>	0.0180	0.0021	As the lag increases, the effect increases, proving the strong influence of the number of researchers on funding research and development work.
<i>Rd_spendin → Inter</i>	0.0059	0.0672	With increasing lag, the effect of investment on HES attractiveness decreases.
<i>Inter → Rd_people</i>	-	0.0359	After two years, a new effect appears - the effect of HES attractiveness on the number of researchers.
<i>Inter → Talent</i>	0.0005	9.E-08	With lag 2, a close two-way relationship is observed between the number of people with higher education and the country's talent level.
<i>Talent → Inter</i>	-	0.0318	
<i>GDP → Cost</i>	0.0014	0.0024	A stable direct effect of economic growth on the quality of life of the population.
<i>Final → Cost</i>	0.0148	0.0488	Although causality is observed, it decreases over time.
<i>PhD → Cost</i>	0.0430	0.0590	The short-term effect (with lag 1) is more substantial than with lag 2.
<i>SE → Cost</i>	-	0.0280	The effect that appears over time: education affects the cost of living.
<i>Cost → Talent</i>	0.0009	0.0009	Absolutely stable relationship over time, i.e., the cost of living strongly affects the talent index.

Source: compiled by the authors

2. Over a one-year planning horizon, relationships in the scientific and educational sphere are more operational—investments in research and development influence the attractiveness of the higher education system, while for two years (lag 2), a structural, transitive causality emerges: educational attractiveness → researchers → expenditures → attractiveness of education;

3. At lag 2, systemic delayed effects are observed, while at lag 1, short-term reactions are characteristic.

These studies allowed us to construct a graph of the interrelationships between the indicators, shown in Figure 8. This figure presents the interactions between the analyzed indicators with different time lags. A key feature of this graph is the relationship between HES (school enrollment, tertiary) and national economic development (GDP per capita). As can be seen, the relationship is bidirectional across all study lags, confirming Hypothesis 1. However, the constructed graph can also be used to formulate public policies and management tactics for various areas of the country's development, as it reflects the cause-and-effect relationships between specific indicators. This, in turn, will help create a favorable environment for talent retention.

Stage 3. Developing a Strategic Interaction Model.

Task 3.1. Study of the degree of mutual influence of changes in the indicators of GDP per capita and School enrollment, tertiary. This study addresses this issue by constructing and analyzing lag models of the relationship

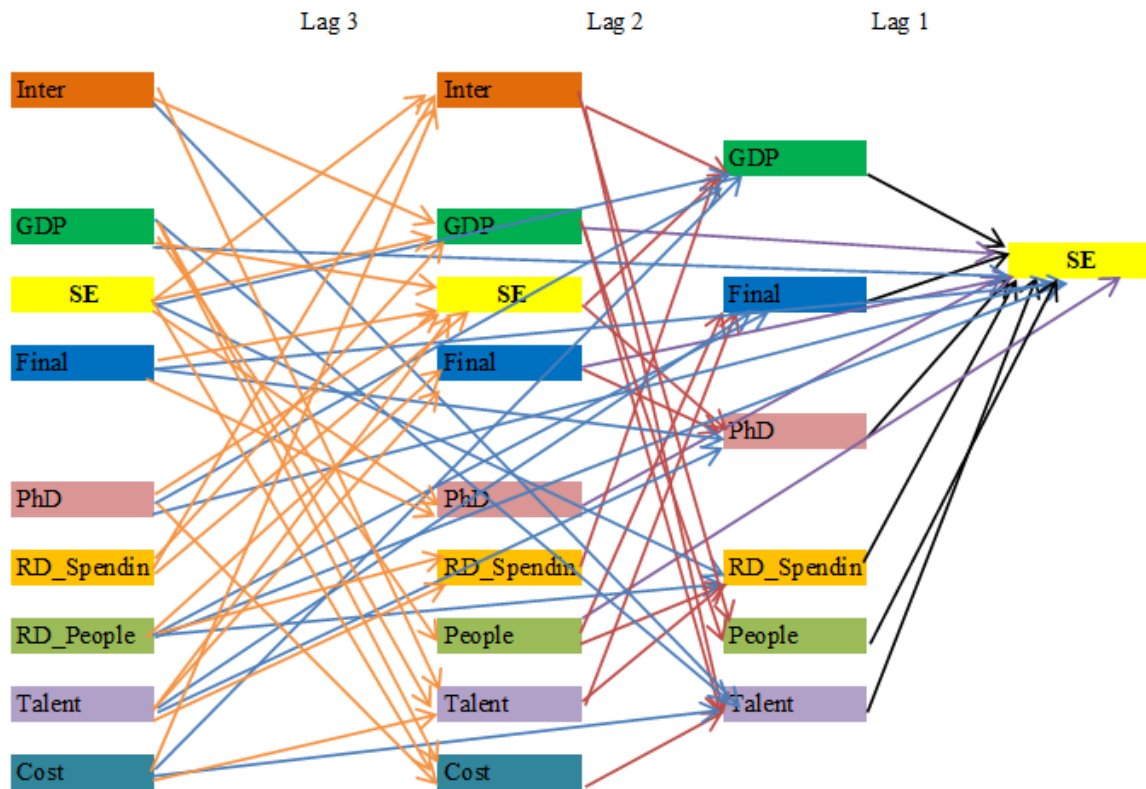


Figure 8. Graph of interactions between factors
Source: compiled by the authors

between the HES and the national economy. The data in Figure 8 and Table 3 were used to determine the lag lengths accurately.

Thus, to predict the dynamics of the School enrolment indicator, tertiary, the following model (8) was developed:

$$SE_t = C + a_1 SE_{t-1} + a_2 Final_{t-1} + a_3 GDP_{t-1} + a_4 GDP_{t-2} + a_5 Rd_Spending_{t-1} + a_6 Talent_{t-1} + a_7 PhD_{t-1} + a_8 RD_People_{t-1} \quad (8)$$

The results of calculating the model parameters and assessing its adequacy are presented in Table 4.

Table 4. Calculation of HES research model parameters

Variable	Coefficient	Prob.
SE(-1)	3.298960	0.0007
FINAL(-1)	-0.004447	0.0548
GDP(-1)	0.003864	0.0226
GDP(-2)	-0.007953	0.0137
RD_SPENDING(-1)	28.50564	0.5863
TALENT(-1)	0.397960	0.1530
PHD(-1)	-0.001322	0.2884
RD_PEOPLE(-1)	0.074970	0.1380
C	-230.4204	0.0179
R-squared	0.945422	75.48471

Source: compiled by the authors

As Table 4 shows, the last four factors have little impact on the development of HES and are therefore excluded from the model. Therefore, the calculation of the parameters and adequacy criteria for the modified model is presented in Table 5.

Table 5. Calculation of parameters of the modified HES research model

Variable	Coefficient	Prob.
FINAL(-1)	0.003206	0.0295
GDP(-1)	0.002311	0.0535
GDP(-2)	-0.006384	0.0122
C	5.939312	0.0373
R-squared	0.794991	

Source: compiled by the authors

Thus, the general model for forecasting HES depending on the factors influencing the national economy has the following form (9):

$$SE_t = 5.94 + 0.885288SE_{t-1} + 0.003206Final_{t-1} + 0.002311GDP_{t-1} - 0.006384GDP_{t-2} \quad (9)$$

The multiple correlation index is high, and this model can be used for further research.

Based on the data in Table 5, the following conclusions can be drawn:

- The high positive correlation between the development of the higher education system and its evolutionary patterns indicates that its development is inertial. This means that systemic changes occur gradually, and the effects of reforms manifest themselves over time.
- An increase in the number of university graduates in the preceding period contributes to the increased attractiveness of higher education among the country's population. A higher education multiplier effect is observed, meaning that the more people obtain higher education, the more young people are eager to enroll in universities.
- The positive impact of GDP per capita on the development of the HES indicates that economic growth increases the accessibility of higher education through improved economic conditions, living standards, and increased funding for the HES. At the same time, the negative impact with a lag of 2 reflects the saturation of educational demand and a shift in the population's focus to the labor market; that is, after an economic recovery, young people are more interested in employment than in further education. The multiple correlation index is high, and this model can be used for further research.

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- The positive impact of GDP per capita on the development of the HES indicates that economic growth increases the accessibility of higher education through improved economic conditions, living standards, and increased funding for the HES. At the same time, the negative impact with a lag of 2 reflects the saturation of educational demand and a shift in the population's focus to the labor market; that is, after an economic recovery, young people are more interested in employment than in further education. Let us construct a model of GDP per capita dependence on the influence of factors affecting the development of the higher education system.

The general form of the model is as follows (10):

$$GDP_t = C + a_1SE_{t-1} + a_2SE_{t-2} + a_3Inter_{t-1} + a_4PhD_{t-2} + a_5Rd_Spending_{t-1} + a_6Cost_{t-2} + a_7GDP_{t-1} \quad (10)$$

The calculation of the model parameters is presented in Table 6.

Table 6. Calculation of the parameters of the GDP per capita forecasting model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	0.476608	0.189181	2.519318	0.0221
SE(-1)	-56.96208	47.13262	-1.208549	0.0243
SE(-2)	47.46352	54.17284	0.876150	0.0302
INTER(-1)	1963.487	801.8640	2.448654	0.0255
RD_SPENDING(-1)	-2719.457	1339.723	-2.029866	0.0883
PHD(-2)	0.110329	0.065975	1.672281	0.1128
COST(-2)	-30.98912	10.93228	-2.834643	0.0114
C	-180.8092	1559.527	-0.115938	0.9091
R-squared	0.900984	Mean dependent var		2793.357

Source: compiled by the authors

Table 5 shows that the parameter for the factor—the number of graduate students—is not statistically significant, so we will conduct a series of experiments with the model to achieve significance for this parameter. The corresponding calculations are presented in Tables 7 and 8.

Table 7. Modification 1 of the GDP per capita forecasting model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	0.810524	0.164751	4.919692	0.0000
SE(-1)	64.73369	10.27252	6.301637	0.0000
SE(-2)	-53.06692	25.56788	-2.075530	0.0476
INTER(-1)	879.3275	627.7626	1.400732	0.1727
COST(-2)	-5.635777	8.979780	-0.627607	0.5355
C	-980.8288	685.9523	-1.429879	0.1642
R-squared	0.876711	Mean dependent var		2338.075

Source: compiled by the authors

Table 8. Modification 2 of GDP per capita forecasting models

Variable	Coefficient	Prob.
GDP(-1)	0.824842	0.0000
SE(-1)	66.69067	0.0000
SE(-2)	-60.85191	0.0103
INTER(-1)	868.5090	0.0177
C	-707.4897	0.1879
R-squared	0.886254	

Source: compiled by the authors

Thus, the modified model has the form (11):

$$GDP_t = -707.4897 + 66.691SE_{t-1} - 60.82191SE_{t-2} + 868.5090Inter_{t-1} + 0.821842GDP_{t-1} \quad (11)$$

The obtained results allow us to draw the following conclusions:

1. The economy has high inertia, as confirmed by the high impact of GDP per capita in the previous period.
2. A strong impact of the higher education system with a lag of 1 is observed. This means that expanding access to HES quickly translates into growth in human capital and labor productivity.
3. An adverse effect after two years may indicate labor market saturation and a mismatch between educational competencies and the needs of the national economy.
4. The high attractiveness of HES has positively impacted GDP per capita. The high reputation of education, openness, and the quality of education attract both national and international students, which strengthens the country's intellectual capital, attracts investment into the economy, and improves the competitiveness of the national economy.
5. Sustainable growth of the national economy should be based on the continued support of educational and institutional programs.

Thus, the research confirms Hypothesis 2: the indicators of the higher education system and the national economy have a strong, lagged interaction.

Task 3.2. Analysis of the bidirectional interaction between the higher education system and the national economy. To address this problem, the study developed a VAR model to determine the strength of the relationship between changes in the higher education system and the national economy. The first step is to test the stationarity of the time series, the results of which are presented in Table 9.

Table 9. Testing the stationarity of time series

	GDP per capita	School enrollment, tertiary
Probability value	0.0954	0.0031

Source: compiled by the authors

The obtained values indicate the analyzed series' stationarity, allowing us to construct a VAR model and calculate its parameters (Table 10).

Table 10. Calculation of VAR model parameters

	SE	GDP
SE(-1)	0.596416	63.45760
SE(-2)	1.197657	-41.39829
GDP(-1)	-0.001662	0.874182
GDP(-2)	-0.012785	-0.118280
C	-20.77729	-822.9796
R-squared	0.820303	0.867610
Akaike information criterion		22.89253

Source: compiled by the authors

To determine the strength of interaction between indicators, was calculated the variance decomposition (Table 11).

Table 11. Results of variance decomposition

Period	Decomposition SE		Decomposition GDP	
	SE	GDP	SE	GDP
1	100.0000	0.000000	30.91897	69.08103
2	99.59231	0.407694	38.10959	61.89041
3	91.15752	8.842475	44.97404	55.02596
4	81.24940	18.75060	78.79375	21.20625
5	73.75307	26.24693	77.57102	22.42898
6	64.58316	35.41684	73.49311	26.50689
7	59.44955	40.55045	64.92224	35.07776
8	54.01785	45.98215	59.48785	40.51215
9	51.01859	48.98141	53.21841	46.78159
10	52.67722	47.32278		

Source: compiled by the authors

The data in Table 11 allow us to draw the following conclusions:

- the impact of GDP per capita on school enrollment, tertiary

1. In the short term (1-2 years), changes in the attractiveness of higher education are explained by intrinsic factors—demographic trends, education policy, etc.—and starting in year 3, the influence of the country's level of economic development on the HES increases;

2. In the medium term (4-6 years), up to 35% of the variation in the HES is explained by changes in the national economy. This means that economic growth gradually translates into a stronger higher education system.

3. In the long term (over 6 years), rising well-being significantly impacts higher education's attractiveness, the creation of new university programs, and student mobility. Thus, approximately 47% of the HES variance is explained by economic development changes.

- The impact of school enrollment and tertiary education on GDP per capita

1. A study of the impact of HES on national economic growth revealed that, starting from the first period, 30.9% of the change in the national economy is explained by changes in HES, indicating that human capital immediately plays a significant role in the development of the national economy.

2. Over a planning horizon of 2-3 years, the impact of HES on the country's GDP increases to 45%, which

correlates with Lucas's theory of endogenous economic growth, where investment in education is the primary source of economic growth.

3. Over 4-6 years, the impact of HES on the economy reaches its maximum and amounts to 70-78%, indicating the peak of the educational effect on the country's economic development. Although this figure decreases to 50% in subsequent periods, it remains quite significant, demonstrating the ongoing impact of HES on socio-economic development.

Task 3.3. Study the response of the higher education system development and the national economy, taking into account changes in the relevant indicators

To solve this problem, impulse analysis was used based on the obtained VAR models (Figure 9).

Response to Cholesky One S.D. Innovations ± 2 S.E.

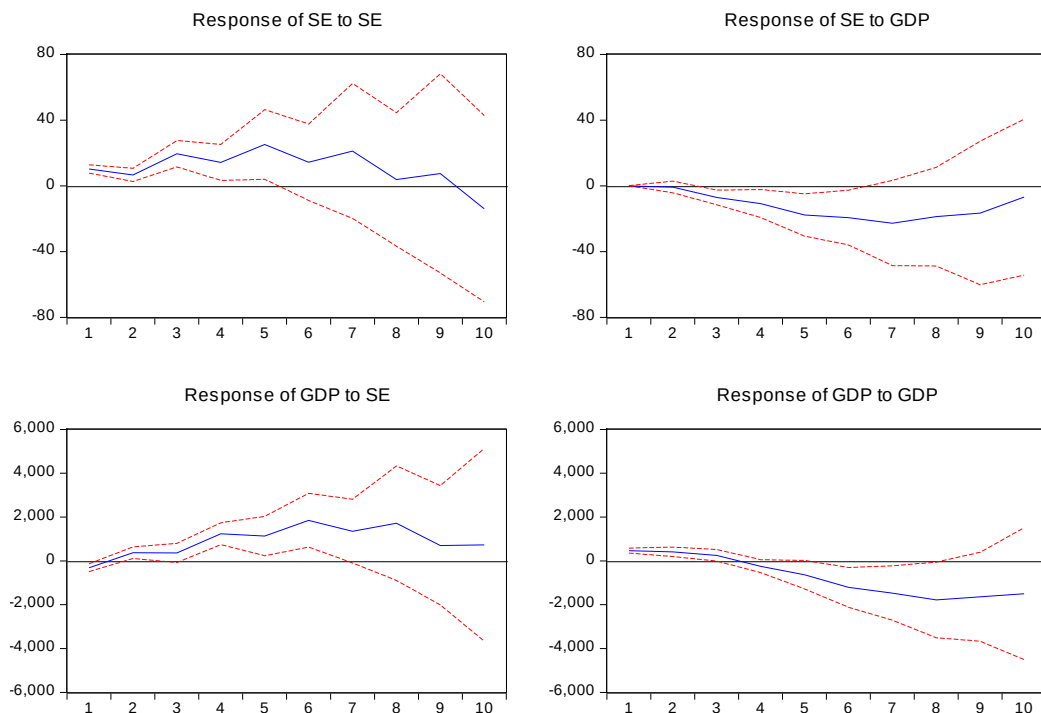


Figure 9. Impulse analysis of the interaction between the higher education system and the national economy

Source: compiled by the authors

An analysis of the results in Figure 9 yielded the following conclusions:

- A positive internal shock to the higher education system leads to growth in the system itself in subsequent periods. The positive response in the first 5 periods indicates the system's inertia. After period 8, this effect diminishes.
- The HES response to a positive shock to economic growth is initially insignificant, and starting in periods 3-4, the curve remains below 0, indicating that GDP stimulates the strengthening of the higher education system only with a lag, rather than immediately.
- During periods 1-6, the GDP response to changes in the HES is positive, promoting continued economic growth; subsequently, the impact stabilizes.
- A positive shock to economic development relative to itself causes a moderate short-term response, which declines to 0 over time, indicating the tendency of this impact to stabilize.

The results that were obtained confirm Hypothesis 3 of the study. Thus, the existence of a relationship and mutual influence between economic development and the development of the HES allows for the creation of a favorable environment for the development of the country's human capital, capable of solving new, complex problems of economic growth, which will ensure the possibility of transition to new technological paradigms and the achievement of sustainable development objectives.

Conclusions

1. An analysis of international indices, such as the Human Development Index (HDI), the Global Talent Competitiveness Index (GTCI), the Global Innovation Index (GII), the Digital Evolution Index (DEI), the Fragile States Index (FSI), and the Education Index (EI), provided a systematic understanding of the country's current status and potential in the context of 21st-century globalization and digitalization. Specifically, the study's findings demonstrate significant progress in education, essential for developing human capital capable of adapting to new technological challenges and stimulating innovative progress in the country. Furthermore, it was determined that, in the context of global transformations, the country must not only retain talent and create favorable conditions for its development but also actively attract new highly qualified personnel. A study of the country's historical trends confirms the need for strategic development of higher education, which will in turn enhance the country's economic growth. The integration of modern technologies, improving the quality of human capital, and active participation in international initiatives will become decisive factors for the country's successful adaptation to global changes and strengthening its position on the world stage.

2. The interaction between the higher education system and the national economy is diverse and time-dependent. The most stable relationships are observed between TER and GDP, research, and talent. These bidirectional relationships indicate a mutually reinforcing effect on the quality of education, the formation of highly educated human capital, and the country's economic development. Short-term effects (lags 1–2) dominate the interaction of indicators such as FINAL → PHD, indicating immediate dynamics of academic progress, while longer lags (3–4) strengthen relationships such as TALENT → FINAL and GDP → INTER, reflecting a delayed systemic impact.

3. Analysis of causal relationships using the Granger test confirms the evolutionary nature of the interaction between education and the economy, where short-term shocks develop into stable long-term dependencies, emphasizing the strategic role of education and innovation in supporting a country's economic development. 4. A model of the national economy's dependence on changes in the HES demonstrates that the higher education system is a key determinant of economic development. Its attractiveness catalyzes the influx of talent, investment, and scientific knowledge, directly stimulating the country's socioeconomic development. Enhancing the attractiveness of the higher education system has both short-term and long-term positive effects on national economic development, underscoring the need for continuous updates to educational programs, the introduction of pedagogical innovations, and new techniques and forms of interaction with students. The higher education system also exhibits a long-term self-reinforcing shock, demonstrating the HES self-organization effect and the constant response of higher education to new challenges in developing national economies and civilization.

Thus, this article analyzed the mutual influence and interaction of a country's strategic and national economic systems. Calculations using the Granger test revealed the existence of close local relationships between factors that also influence the country's economic development. Further research on this topic will aim to develop a comprehensive matrix of strategic interactions among all factors influencing talent development, retention, and attraction to the national economy.

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