Tertiary Sector Economics

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CROSS-CORRELATION ANALYSIS OF DYNAMIC INTERDEPENDENCIES BETWEEN SOCIO-ECONOMIC DEVELOPMENT AND THE DEMAND FOR HIGHER EDUCATION IN UKRAINE

Abstract

The paper identifies time lags and provides a quantitative assessment of the interrelationships between key socio-economic indicators and the dynamics of enrollment in higher education institutions. The methodological framework is

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based on cross-correlation time series analysis using distributed lags, which made it possible to determine the delayed effects of demographic and economic factors on educational processes. The study revealed a delayed correlation between birth rates and the number of students, with a time lag of 16–18 years, as well as an inverse relationship between the unemployment rate among individuals with higher education and the number of applicants. A negative impact of high lending rates on the demand for higher education was identified, alongside a positive effect of the growth of vulnerable employment, which stimulates the pursuit of education. The practical significance of the study lies in the potential use of the obtained results for forecasting educational needs, improving public funding mechanisms, optimizing the network of higher education institutions, and developing an integrated «education–economy–security» strategy in the context of Ukraine's European integration.

Key Words:

Problem Statement and Literature Review

The modern world is characterized by rapid technological change, global imbalances, and intensifying competition. Under these conditions, economic growth and sustainable development of any country largely depend on the efficiency of its human capital, innovative activity, and ability to adapt to new challenges. Higher education, as an institution for the formation of knowledge, skills, and competencies, plays a key role in this process by ensuring the training of qualified professionals, generating new knowledge and innovations, and contributing to social progress.

The successful functioning and development of domestic enterprises, as well as the enhancement of their competitiveness in the global market, directly depend on the level of scientific and technological progress and the introduction of advanced technologies. Higher education institutions are not only centers of learning but also research institutions that generate new knowledge, develop innovative solutions, and facilitate their commercialization.

For Ukraine, a country that is presently at war and facing the destruction of its economic and social potential while at the same time pursuing full European integration, understanding and strengthening the connection between higher education and economic development is of crucial importance. The war has caused significant demographic shifts and intensified migration processes, particularly the outflow of qualified professionals abroad. This poses a serious threat to Ukraine's future economic development. Higher education must adapt to these challenges by developing effective mechanisms for retaining talented youth, attracting foreign students, and encouraging the return of Ukrainian professionals after completing their studies abroad.

The dynamics of student admissions serve as an important indicator of the state of the education system, reflecting broader socio-economic processes within the country. In Ukraine, which is currently facing demographic challenges, economic instability, and the consequences of large-scale military aggression, understanding the factors that influence young people's decisions to pursue higher education becomes particularly relevant.

The **purpose of this study** is to identify and quantitatively assess the dynamic interdependencies between socio-economic development and the demand for higher education in Ukraine using the methodology of cross-correlation time-series analysis. To achieve this goal, the research compares the rates of change in key demographic, economic, and educational indicators; determines the time lags between socio-economic stimuli and the response of the higher education system; and outlines how the obtained results can be applied to improve the country's educational and socio-economic policies.

The modern theory of human capital, the foundation of which was established in the works of T. Schultz (1961) and G. Becker (1975), provides the methodological basis for analyzing the relationship between education and economic growth, particularly within the framework of empirical research. Within this paradigm, education is viewed as a strategic investment in human capital that enhances labor productivity, innovation capacity, and economic competitiveness. Human capital, in turn, is considered one of the key determinants of long-term economic growth, as well as a driving force of technological progress and structural transformations in the national economy (Teixeira & Queirós, 2016; Leoni, 2025; Dao & Khuc, 2023).

Higher education serves as one of the key factors of socio-economic development, as it closely interacts with the economy at all stages of the educational

process – from the formation of human capital to the implementation of innovative solutions in the production sphere. In most countries of the world, it is regarded as a strategic instrument for enhancing individual economic productivity, achieving higher financial rewards, and ensuring social mobility (Abu-Saad, 2016). The higher education system plays a particularly important role in countries seeking to modernize their economies by shifting from resource-based or traditional models to innovation-driven, knowledge- and technology-oriented ones (Etzkowitz et al., 2022). In this context, the transformation of higher education becomes not only a demand of the times but also a prerequisite for national development. The experience of countries that have implemented deep reforms in higher education demonstrates its role as a catalyst for economic restructuring and technological progress (Azman et al., 2014; Olo et al., 2021).

Modern economies largely depend on the availability of a sufficient number of highly skilled workers who form the foundation for innovative development, increased productivity, and competitiveness. Individuals with higher levels of education enjoy significant advantages in the labor market, including better employment conditions, higher incomes, and more stable career trajectories (OECD, 2024). These advantages, combined with broader opportunities for acquiring new knowledge and developing skills, serve as important motivational factors for most citizens of OECD countries in pursuing higher education (OECD, 2023, pp. 359-369).

The dynamics of student enrollment represent an important indicator of the state of the education system and reflect the socio-economic processes in the country. The analysis of factors influencing enrollment dynamics in higher education institutions is a subject of active research in the field of economics. Decisions regarding admission to higher education are significantly influenced by demographic, economic, and socio-cultural factors. The demographic factor serves as a basic indicator of enrollment volume; specifically, the number of young people aged 17–24 determines the potential number of applicants (Bound & Turner, 2007). Studies by the Organisation for Economic Co-operation and Development show a direct relationship between past fluctuations in birth rates and future student numbers (OECD, 2023). However, in many countries experiencing demographic decline, a compensatory increase in the share of youth aspiring to obtain higher education is observed, indicating the influence of other factors.

Economic factors have a significant impact on the demand for higher education, primarily through household income levels, which directly affect affordability. According to Heller (1997), households with higher incomes have not only greater financial capacity to fund education but also a stronger interest in making long-term investments in human capital. McMahon (2009) notes that higher family income levels correlate with a greater likelihood of obtaining higher education. However, reduced access to finance or rising tuition costs often lead to lower enrollment levels, particularly among socially vulnerable groups (Dynarski, 2002). The cost of credit resources and the availability of student loan programs represent another important indicator. Low-interest student loan programs significantly

increase access to higher education, especially for students from low- and mid-dle-income families. In the United States and the European Union, the system of educational loans is well developed, and therefore, the availability and interest rates of student loans are crucial factors (Olcott, 2022; McGreal & Olcott, 2022). In Ukraine, the system of educational lending remains at an early stage of devel-opment, and most students depend on family income or state funding. Conse-quently, Ukrainian demand for higher education is more sensitive to fluctuations in household income and less sensitive to loan costs.

The unemployment rate also exerts a dual effect on the demand for higher education. On the one hand, high unemployment reduces motivation for studying due to uncertainty regarding graduates' employment prospects. On the other hand, during crisis periods (particularly in 2008-2009), an increase in enrollment was recorded, as education was seen as a means of avoiding temporary unem-ployment and improving qualifications (Callender & Jackson, 2005; Marginson, 2016).

Social factors, such as the prestige and quality of education, accessibility (Lishchynskyy & Lyzun, 2024), and migration processes, also have a substantial impact on decisions to pursue higher education. For Ukraine, after 2022, migra-tion and security factors have become decisive.

Thus, higher education serves as a key factor in shaping the intellectual po-tential of the nation, contributing to the socio-economic development of the state, enhancing its competitiveness on the global stage, and promoting active integra-tion into global economic and educational processes.

Methodology

For the empirical study, we hypothesize that the dynamics of the number of persons admitted to higher education depend not only on demographic indicators but also on a number of other economic and social factors (such as household in-come levels, the cost of credit resources, and the unemployment rate).

To test this hypothesis, a cross-correlation analysis was applied (in particu-lar, distributed lag analysis tools), which makes it possible to assess dependen-cies between time series while accounting for their shifts relative to each other by a given number of lags. This approach allows the estimation of delayed effects of the independent variable on the dependent variable over time (Jabeen et al., 2015; Lishchynskyy et al., 2025; Yankovyi et al., 2022).
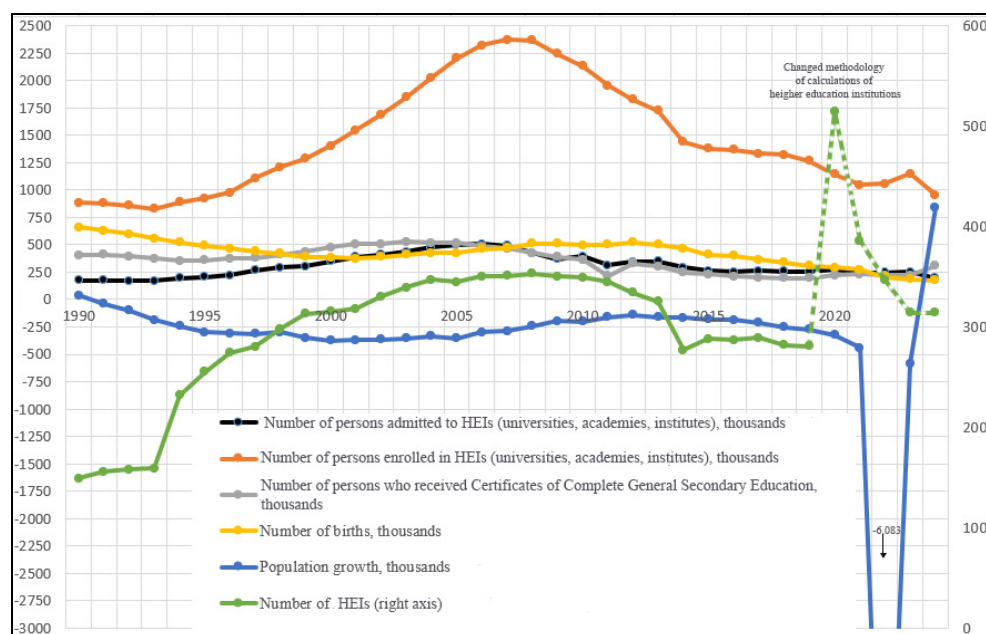
The cross-correlation analysis was conducted on time series reflecting the dynamics of quantitative characteristics of higher education in Ukraine and se-lected demographic indicators: Number of Persons Admitted to Higher Education

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Institutions (NPASHEI); Number of Persons Enrolled in Higher Education Institutions (NPHEI); Number of Institutions of Higher Education (NIHE); Number of Persons who Received Certificates of Complete General Secondary Education (NPCCGSE); Number of Children Born (NCB); Population Growth (PG); and Share of Young People aged 15-19 (SYP).

Among these variables, the first two are of key importance for quantifying the state of higher education, while the others are used as independent variables (predictors). A graphical representation of a portion of these time series is shown in Figure 1.

Figure 1

Dynamics of quantitative indicators of higher education and demographic trends in Ukraine, 1990–2024

Source: compiled by the authors based on data from the State Statistics Service of Ukraine (n.d.).

It should be noted that until 2019, the reports of the State Statistics Service of Ukraine («Institutions of Higher Education», Form No. 2–3 NK) included only universities, academies, and institutes that had the III–IV levels of accreditation, state or private registration in the Unified State Electronic Database on Education (EDEBO), and submitted statistical reports to the State Statistics Service. Starting from 2020, the State Statistics Service changed the methodology for counting higher education institutions in accordance with the Law of Ukraine «On Education» (Verkhovna Rada of Ukraine, 2017) and the new classifier of educational institutions.

Accordingly, institutions of the II level of accreditation (colleges and technical schools), which had previously been officially classified as «institutions of professional pre-higher education» and recorded separately, were included in the report as part of the «higher education institutions» category following the reform. This led to a formal increase in the number of higher education institutions from 281 to 515, although the actual number continued to decline. The trend toward significant optimization of the number of HEIs in Ukraine persisted throughout 2021–2024, eventually leading to the alignment of time series calculated under both methodological approaches.

The outbreak of Russian military aggression significantly affected all socio-economic indicators of Ukraine, including the development of higher education. In 2022, the population decreased by more than 6 million people, primarily due to emigration (while in 2024 an increase of more than 837 thousand people was recorded). However, this population decrease and territorial losses resulting from hostilities were not as dramatic in their effect on educational dynamics, which can be explained by the relocation of universities and the partial preservation of their student contingents. These periods of anomalous data fluctuations were excluded from the empirical analysis.

A visual analysis of the time series indicates that for the vast majority of variable pairs, the relationship is not contemporaneous but delayed. Therefore, for the identified pairs of time series, the distributed lag analysis algorithm was applied. Since time lags most frequently manifest in socio-economic processes (Hryhorkiv, 2016), in our study greater attention was given to positive lags. One of the main tasks of the research was to determine the magnitude of the lag between the stimulus (the value of an independent variable) and the effect (the corresponding value of the dependent variable). Determining the length of such lags for the quantitative characteristics of higher education in Ukraine is important and useful for planning and forecasting management decisions in the field of higher education.

In addition to demographic factors, the motivation of the population to obtain higher education can also be influenced by economic predictors (Tabassum & Akhter, 2020). The analysis covered a number of factors such as government expenditure on education, unemployment rate, unemployment among individuals with higher education, vulnerable employment rate, and credit interest rate.

A general overview of all indicators used in the study is presented in Table 1.

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Table 1

Overview of indicators used for the analysis

Indicator	Unit of Measurement	Symbol	Data Source
Number of persons admitted to higher education institutions	thousands of persons	*NPASHEI*	State Statistics Service of Ukraine
Number of students enrolled in higher education institutions	thousands of persons	*NPHEI*	State Statistics Service of Ukraine
Number of higher education institutions	units	*NIHE*	State Statistics Service of Ukraine
Number of persons who received Certificates of Complete General Secondary Education	thousands of persons	*NPCCGSE*	State Statistics Service of Ukraine
Number of births	thousands of persons	*NCB*	State Statistics Service of Ukraine
Population growth	thousands of persons	*PG*	State Statistics Service of Ukraine
Share of young people aged 15-19 in the total population	% of total population	*SYP*	State Statistics Service of Ukraine
Government expenditure on education, total	% of GDP	*GEE*	World Bank
Unemployment, total	% of total labor force	*UT*	International Labour Organization
Unemployment among persons with higher education	% of total labor force with higher education	*UAE*	International Labour Organization
Vulnerable employment, total	% of total employment	*VET*	International Labour Organization
Lending interest rate	%	*LIR*	World Bank

Combining social and economic indicators within a unified analytical model makes it possible to gain a deeper understanding of the multifactor nature of the higher education system in Ukraine. This approach enables not only the identification of time lags between demographic processes, household income dynamics, unemployment, and educational activity, but also the detection of their delayed effects on the number of admitted students and the overall size of the student body. A comprehensive consideration of these interrelations provides a foundation for more accurate forecasting of educational development, the formation of effective public financing policies, and the alignment of educational supply with the needs of the economy and demographic reproduction trends. Therefore, the integration of social and economic factors into the systemic analysis of higher education opens new opportunities for enhancing its adaptability, efficiency, and strategic contribution to the sustainable development of the country.

Research Results

For most pairs of time series, the relationship is not contemporaneous but delayed. Accordingly, the distributed lag analysis algorithm was applied to the identified pairs of time series, and the results are presented in Figure 2. It should be noted that for the period 1990-2019, this dependence was even more pronounced ($R^2 = 0.982$ for the number of persons admitted to higher education institutions and $R^2 = 0.944$ for the number of students enrolled in higher education institutions).

According to the results of the cross-correlation analysis, the following regularities can be identified:
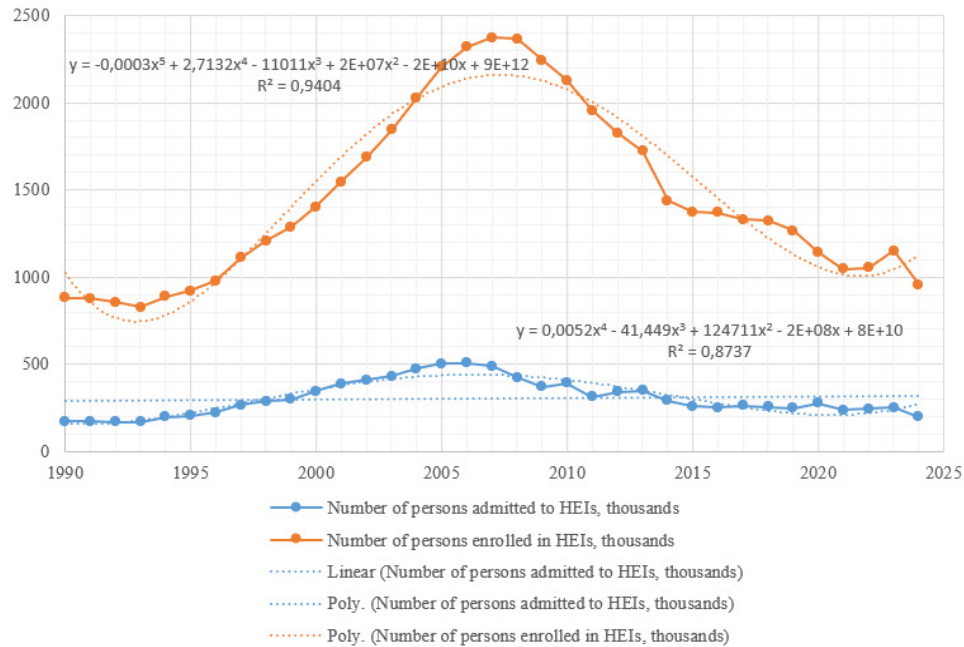
(i) The number of secondary school graduates in a given year naturally correlates with the number of students admitted to higher education institutions in the same year ($r = 0.562$), and the effect of this factor persists over the following years (see Table 2).

(ii) The number of births in Ukraine shows the highest level of statistically significant correlation ($r = 0.919-0.928$) with the number of students admitted to higher education institutions, with a positive time lag of $τ = 16-18$ years (Table 3).

(iii) The share of young people, both male and female, aged 15–19 as a percentage of the total population of Ukraine positively correlates with the number of matriculated students already at $τ = 0$, reaching its maximum at $τ = 3$. At the same time, the number of young men shows a slightly higher correlation with the dependent variable.

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Figure 2

**Distributed lag analysis of the number of persons admitted to and the number
of persons enrolled in higher education institutions in Ukraine, 1990-2024**

Source: calculated by the authors based on data from the State Statistics Service of
Ukraine (n.d.).

Table 2

**Results of the cross-correlation analysis between the number
of secondary school graduates and the number of persons admitted
to higher education institutions**

Dependent variable – NPASHEI; Independent variable – NPCCGSE

Lag	Cross-correlation	t	p-value
0	0.562	3.85	0.0005
1	0.626	4.47	0.0001
2	0.669	4.93	0.0001
3	0.710	5.44	<0.0001
4	0.716	5.43	<0.0001

5	0.675	4.76	0.0001
6	0.581	3.64	0.0012
7	0.460	2.59	0.0158
8	0.289	1.48	0.1517
9	0.084	0.41	0.689
10	-0.083	0.39	0.699

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (n.d.).

Table 3

Results of the cross-correlation analysis of the number of children born and the number of persons admitted to higher education institutions
Dependent variable – *NPASHEI*; Independent variable – *NCB*

Lag	Cross-correlation	t	p-value
0	-0.213	1.20	0.2409
1	-0.268	1.53	0.1377
2	-0.319	1.84	0.0755
3	-0.417	2.48	0.0198
4	-0.479	2.88	0.0075
5	-0.541	3.34	0.0025
6	-0.538	3.25	0.0032
7	-0.470	2.67	0.0133
8	-0.349	1.83	0.0801
9	-0.187	0.92	0.3695
10	0.040	0.19	0.8527
11	0.257	1.22	0.2368
12	0.456	2.29	0.0328
13	0.620	3.44	0.0027
14	0.759	4.95	0.0001
15	0.857	6.84	<0.0001
16	0.919	9.33	<0.0001
17	0.928	9.67	<0.0001
18	0.928	9.34	<0.0001

Source: calculated by the authors based on data from the State Statistics Service of Ukraine (n.d.).

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In addition to demographic factors, the study also examined the influence of economic factors on the population's motivation to obtain higher education. As noted in the methodological section, the analysis included the following indicators: Government expenditure on education, total (% of GDP); Households and NPISHs final consumption expenditure (constant 2015 US$); Unemployment with advanced education (% of total labor force with advanced education); Unemployment, total (% of total labor force) (modeled ILO estimate); and Vulnerable employment, total (% of total employment) (modeled ILO estimate) (World Bank, n.d.).

Among these time series, correlations were found both without a time shift and with a one-period positive lag ($\tau = 1$) with the time series UAE – Unemployment among persons with higher education (Table 4). In other words, a high unemployment rate among the population with higher education serves as a negative signal for potential university entrants. This explains why significant negative cross-correlation coefficients are observed for lags $\tau = 0$ and 1 ($r = -0.730$ and -0.752, respectively).

Table 4

Results of the cross-correlation analysis between the unemployment rate among persons with higher education and the number of admitted students
Dependent variable – *NPASHEI*; Independent variable – *UAE*

Lag	Cross-correlation	t	p-value
0	-0.730	3.20	0.0108
1	-0.752	3.22	0.0108
2	-0.370	1.05	0.3272
3	-0.642	0.16	0.8799
4	-0.233	0.53	0.6157
5	-0.100	0.20	0.8545

Source: calculated by the authors.

At the same time, the overall unemployment rate positively correlates with the number of university entrants ($r = 0.437-0.605$), though with a certain delay (lag from 1 to 7 years). It is evident that for many entrants, 5–6 years of study at higher education institutions serve as a form of employment guarantee during youth and as a potential pathway to future labor market integration (Table 5).

Table 5

**Results of the cross-correlation analysis between total unemployment
and the number of admitted students**
Dependent variable – *NPASHEI*; Independent variable – *UT*

Lag	Cross-correlation	t	p-value
0	0.339	1.94	0.0620
1	0.437	2.57	0.0159
2	0.521	3.17	0.0038
3	0.581	3.64	0.0012
4	0.605	3.80	0.0008
5	0.591	3.59	0.0015
6	0.535	3.04	0.0059
7	0.412	2.19	0.0455
8	0.268	1.27	0.2169

Source: calculated by the authors.

The number of entrants to higher education institutions in Ukraine is naturally influenced by the mechanisms of student financing available in a given year. The main forms of financing higher education are state-funded (publicly financed) education and contract-based (tuition) education paid by individuals or legal entities. It should be noted that a significant share of students pay tuition fees at their own expense, including through bank loans. Therefore, it is reasonable to assume that the lending interest rate may be one of the factors influencing motivation and ability to obtain higher education. Cross-correlation analysis confirms this hypothesis: as shown by the data in Table 6, the lending interest rate correlates negatively with the number of entrants in the same year ($r = -0.510$).

Table 6

**Results of the cross-correlation analysis between the lending interest rate
and the number of admitted students**
Dependent variable – *NPASHEI*; Independent variable – *LIR*

Lag	Cross-correlation	t	p-value
0	-0.510	3.24	0.0029
1	-0.449	2.70	0.0114
2	-0.378	2.16	0.0394
3	-0.266	1.43	0.1637

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4	-0.133	0.69	0.4984
5	-0.005	0.03	0.9798
6	0.152	0.75	0.4584
7	0.320	1.62	0.1190

Source: calculated by the authors.

The indicator of vulnerable employment reflects the share of workers employed under unstable conditions as a percentage of total employment in the country. Vulnerable employment refers to forms of work characterized by precarious conditions, limited social protection, and high income insecurity. This category typically includes individuals working without formal contracts, with irregular earnings, or with limited labor rights and guarantees. Such workers usually receive low wages and lack the ability to defend their rights in the event of conflict with employers or job loss. In Ukraine, the level of vulnerable employment did not exceed 10% in the 1990s, but began to increase in the early 2000s, reaching 18.2% in 2011 and later stabilizing at 15–17%. The results of the cross-correlation analysis are presented in Table 7.

Table 7

**Results of the cross-correlation analysis between the level
of vulnerable employment and the number of admitted students**
Dependent variable – *NPASHEI*; independent variable – *VET*

Lag	Cross-correlation	t	p-value
-7	0.768	5.62	<0.0001
-6	0.832	7.22	<0.0001
-5	0.841	7.61	<0.0001
-4	0.812	6.96	<0.0001
-3	0.768	6.11	<0.0001
-2	0.677	4.79	0.0001
-1	0.601	3.98	0.0004
0	0.496	3.07	0.0046
1	0.346	1.95	0.0611
2	0.153	0.80	0.4293
3	-0.063	0.32	0.7498
4	-0.273	1.42	0.1677
5	-0.470	2.60	0.0154

Source: calculated by the authors.

As can be seen, an increase in vulnerable employment motivates young people to pursue higher education. Hence, the correlation coefficient for a time lag of $\tau = 0$ is positive and statistically significant. The high positive cross-correlation values for negative time lags $\tau = -5$ and -6 (*0.841* and *0.832*) reflect an unfavorable situation in the labor market for university graduates – a substantial share of them join the ranks of workers with vulnerable employment. One of the reasons for this phenomenon is the mismatch between the number of licensed student places in certain fields of study and the number of actual job opportunities in the labor market.

The results of the study demonstrate the need for a coherent and strategically coordinated policy that links higher education reform with demographic recovery and long-term economic development. To make higher education a genuine driver of national resilience and modernization, the following policy directions are recommended:

1. Integrate the higher education system into national security and post-war recovery strategies. In the context of war and reconstruction, higher education should be regarded as a key factor in restoring human capital and strengthening national resilience. Legislative and financial instruments should link university funding to the development of Ukraine's innovation, defense, and regional capacities.

2. Introduce a demographic and educational forecasting system based on evidence. The identified delayed correlation between birth rates and student enrollment ($\tau = 16$–18 years) underscores the need for an integrated demographic–educational monitoring system. This would enable forecasting of future needs for educational places, teaching staff, and scholarship funds in accordance with demographic cycles and regional labor market structures.

3. Reform financing mechanisms and enhance educational equity. Considering the sensitivity of educational demand to household income levels, state policy should promote sustainable student financing instruments — such as low-interest educational loans, deferred payment mechanisms, and targeted scholarships for vulnerable groups. This would reduce educational inequality and mitigate youth outmigration.

4. Strengthen alignment between higher education and labor market dynamics. The strong correlation between unemployment and educational demand calls for flexible educational programs incorporating dual learning systems, internships, and partnerships with strategic industries – digital technologies, renewable energy, defense engineering, and logistics.

5. Rationalize the institutional network of higher education institutions. The increase in the number of institutions after 2019 reflects methodological changes rather than structural growth. The government should continue optimizing the HEI

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network based on performance, regional needs, and specialization, supporting mergers that enhance research capacity and international visibility.

6. Institutionalize the role of universities in regional development. Higher education institutions should become centers of regional innovation ecosystems and local labor market development. Their funding should be linked to smart specialization strategies, regional sustainable development programs, and European integration initiatives.

Thus, Ukraine's higher education system must transition from the role of a knowledge provider to that of a driver of economic modernization, demographic stabilization, and geopolitical resilience. The proposed policy measures form the foundation for an integrated «education–economy–security» model, which will define the success of Ukraine's sustainable recovery and progress toward the European higher education area.

Conclusions

The results of the study have shown that the higher education system of Ukraine is not only a social institution but also a key component of the economic reproduction of human capital. Its functioning is directly correlated with demographic trends, the structure of the labor market, and the dynamics of macroeconomic development. It has been established that there exists a delayed dependence between the birth rate and the number of entrants to higher education institutions, with a time lag of approximately 16–18 years. This finding underlines the necessity of long-term forecasting of educational needs within the framework of demographic policy.

The analysis demonstrated that the number of students in the higher education system has a stable inverse correlation with the unemployment rate, indicating its compensatory role during periods of economic instability. Higher education serves as a mechanism for adapting young people to changing labor market conditions and as a reserve for fostering entrepreneurial and innovative activity. At the same time, the financial sensitivity of the system — in particular, the dependence of educational accessibility on household income levels — reveals the risk of increasing educational inequality and highlights the need for reforming financing mechanisms.

Under wartime and post-war recovery conditions, the role of universities is significantly enhanced. They should become not only centers for professional training but also active actors in innovation, economic transformation, and regional development. Higher education has the potential to serve as a key instrument for economic modernization, the strengthening of human capital, the en-

hancement of technological security, and Ukraine's integration into the European educational and research space.

The study confirms that effective interaction between the higher education system and economic development is possible only through a comprehensive approach to educational policy – combining it with demographic forecasting, reform of financial mechanisms, strengthening the institutional capacity of universities, and deepening their connection with the real sector of the economy.

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References

Abu-Saad, I. (2016). Access to higher education and its socio-economic impact among Bedouin Arabs in Southern Israel. *International Journal of Educational Research*, *76*, 96-103. https://doi.org/10.1016/j.ijer.2015.06.001

Azman, N., Sirat, M., & Ahmad, A. R. (2014). Higher education, learning regions and the Malaysian transformation policies. *Higher Education Policy*, *27*, 301–321. https://doi.org/10.1057/hep.2013.26

Becker, G. S. (1975). *Human capital: A theoretical and empirical analysis, with special reference to education*. National Bureau of Economic Research.

Bound, J., & Turner, S. (2007). Cohort crowding: How resources affect collegiate attainment. *Journal of Public Economics*, *91*(5-6), 877–899. https://doi.org/10.1016/j.jpubeco.2006.07.006

Callender, C., & Jackson, J. (2005). Does the fear of debt deter students from higher education? *Journal of Social Policy, 34*(4), 509–540. https://doi.org/10.1017/S004727940500913X

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Dao, T. B. T., & Khuc, V. Q. (2023). The Impact of openness on human capital: A study of countries by the level of development. *Economies*, *11*(7), Article 175. https://doi.org/10.3390/economies11070175

Dynarski, S. (2002). *The consequences of merit aid* (Working Paper 9400). National Bureau of Economic Research. https://doi.org/10.3386/w9400

Etzkowitz, H., Dzisah, J., & Clouser, M. (2022). Shaping the entrepreneurial university: Two experiments and a proposal for innovation in higher education. *Industry and Higher Education*, *36*(1), 3-12. https://doi.org/10.1177/0950422221993421

Heller, D. E. (1997). Student price response in higher education: An update to Leslie and Brinkman. *The Journal of Higher Education*, *68*(6), 624–659. https://doi.org/10.2307/2959966

Hryhorkiv, M. (2016). Time lags in the dynamic economic model [in Ukrainian]. *Visnyk Chernivetskoho Torhovelno-Ekonomichnoho Instytutu. Ekonomichni Nauky*, (1), 242-251. http://nbuv.gov.ua/UJRN/Vchtei_2016_1_29

Jabeen, L., Iqbal, N., Haider N., & Ibal, S. (2015). Cross correlation analysis of reward & punishment on students learning behavior. *International Letters of Social and Humanistic Sciences*, *59*, 61–64. https://d-nb.info/1191596907/34

Leoni, S. (2025). A historical review of the role of education: From human capital to human capabilities. *Review of Political Economy*, *37*(1), 227–244. https://doi.org/10.1080/09538259.2023.2245233

Lishchynskyy, I. & Lyzun, M. (2024). Pattern of European regional creativity: Exploring endogenous sustainability. *ECONOMICS*, *12*(3), 397-407. https://doi.org/10.2478/eoik-2024-0030

Lishchynskyy, I., Krysovatyy, A., Desyatnyuk, O., Bogacki, S., & Lyzun, M. (2025). Quantitative measurement of glocalization to assess endogenous and exogenous parameters of regional sustainability. *Sustainability*, *17*(17), Article 7584. https://doi.org/10.3390/su17177584

Marginson, S. (2016). The worldwide trend to high participation higher education: Dynamics of social stratification in inclusive systems. *Higher Education*, *72*, 413–434. https://doi.org/10.1007/s10734-016-0016-x

McGreal, R., & Olcott, D., Jr. (2022). A strategic reset: Micro-credentials for higher education leaders. *Smart Learning Environments*, (9), Article 9. https://doi.org/10.1186/s40561-022-00190-1

McMahon, W. W. (2009). *Higher learning, greater good: The private and social benefits of higher education*. Johns Hopkins University Press.

OECD. (2023). *Education at a Glance 2023: OECD Indicators*. OECD Publishing. https://doi.org/10.1787/e13bef63-en

OECD. (2024). *Education at a Glance 2024: OECD Indicators*. OECD Publishing. https://doi.org/10.1787/c00cad36-en

Olcott, D., Jr. (2022). Micro-credentials: A catalyst for strategic reset and change in U.S. higher education. *American Journal of Distance Education*, *36*(1), 19–35. https://doi.org/10.1080/08923647.2021.1997537

Olo, D., Correia, L., & Rego, C. (2021). Higher education institutions and development: Missions, models, and challenges. *Journal of Social Studies Education Research, 12*(2), 1-25. https://www.learntechlib.org/p/219851/

Schultz, T. W. (1961). Investment in human capital. *American Economic Review*, *51*(1), 1–17.

State Statistics Service of Ukraine. (n.d.). *Network and activities of educational institutions* [Online database]. https://stat.gov.ua

Tabassum, R., & Akhter, N. (2020). Effect of demographic factors on academic performance of university students. *Journal of Research & Reflections in Education*, *14*(1), 64-80. https://ue.edu.pk/jrre/articles/Article14-5.pdf

Teixeira, A. A. C., & Queirós, A. S. S. (2016). Economic growth, human capital and structural change: A dynamic panel data analysis. *Research Policy*, *45*(8), 1636–1648. https://doi.org/10.1016/j.respol.2016.04.006

Verkhovna Rada of Ukraine. (2017, September 5). *Law on education* (No. 2145-VIII) [in Ukrainian]. https://zakon.rada.gov.ua/laws/show/2145-19#Text

World Bank. (n.d.). *World Bank Open Data* [Online database]. World Bank Group. https://data.worldbank.org/

Yankovyi, O., Kozak, Y., Lyzun, M., Lishchynskyy, I., Savelyev, Y., & Kuryliak, V. (2022). Investment decision based on analysis of mathematical interrelation between criteria IRR, MIRR, PI. *Financial and Credit Activity: Problems of Theory and Practice*, *5*(46), 171–181. https://doi.org/10.55643/fcaptp.5.46.2022.3857