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Article

Prospects for Forecasting and Econometric Assessment of Performance Indicators of Higher Education Service Delivery in The Khorezm Region

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Abstract: This paper analyses the developmental processes higher education services in the Khorezm region and measurable trends via econometric forecasting. Despite that rapid change, these structural patterns that is the volumes of service produced, the capacity of institutions and their regional competitiveness are known little about especially as they relate to the growing body of non-state institutions. With ARMA and ARMAX models, we predict the reported variables such as education services, the share of regional services, student enrollment, and faculty numbers. That is what thought before they ran the numbers, which show that service volumes will grow but growth rates will steadily decrease as the market reaches saturation. The proportion of national service delivered in the region is set to fall gradually before increasing again after 2027. Moderate growth in student numbers will be followed by even stronger growth of faculty — partly relieving current staffing shortages. Taken together these results indicate both advancement and ongoing structural deficiencies, like pretty lousy student-to-faculty ratios. These projections offer a realistic foundation for regional planning, enabling policymakers and university leaders to proactively identify resource requirements and to formulate plans for sustainable higher education development.

Keywords: Khorezm region, education, higher education, service, higher education services, efficiency, indicator, econometric assessment, forecasting, prospects

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1. Introduction

The development of educational services-particularly the reform of the education system, the expansion of access through strengthening the role of private entrepreneurship in the sector, and the introduction of market principles-has been carried out on a large scale in recent years. In particular, great attention is being given to deepening reforms in higher education, identifying priority areas, and creating an education system focused on training specialists equipped with modern knowledge and strong moral and ethical values. Efforts are also being made to elevate the process of preparing highly qualified personnel with independent thinking to a new qualitative level. Special emphasis is placed on the modernization of higher education and the development of social sectors and the economy based on advanced educational technologies.

As a result, there has been an increase in the number of non-state educational institutions in the field of higher education, which has contributed to a proportional rise in enrollment levels. Since "the Uzbekistan – 2030" Strategy sets the goal of raising the share of young people enrolled in higher education to at least 50 percent [1], this justifies the need for substantial work in this direction. Based on this, we will examine the calculation of forecast values for a number of indicators that reflect changes in higher education and the development of educational services in the Khorezm region-the focus of our study.

2. Materials and Methods

It is a quantitative research design and the design is based on time series for key indicators of higher education service delivery in the Khorezm region during 2010 to 2024. The data starts with cleaning and standardizing regional quantitative records on service volumes, students, and faculty so that they are comparable across years. The research specifications and adequacies are verified by z statistics, corresponding confidence levels and goodness of fit; thereby implies underpinning trends and short-term behaviour through suitable ARMA and ARMAX models. Testing for parameter significance and stability is carried out for each model with only those models that meet the reliability benchmark of greater than 99 percent being used to make forecasts. Model-fitting of the most appropriate models enables forecast values for 2025–2030; thus, the study can project change both in total service volume and also share of national educational services and student population changes and in faculty growth for the region. This approach has the benefit of offering a transparent view of trends in structural change to the UK system of higher education, and by relating trends across indicators, the methodology can explain how tensions between capacity, demand, and staffing pressures will play out over the next few years.

3. Results and Discussion

A considerable number of studies have been conducted on the econometric assessment and forecasting of performance indicators in higher education service delivery. In particular, some works examine approaches to determining university performance indicators and forecasting the sales volume of paid educational services using econometric regression models [2]. Other studies focus on developing econometric models related to students' academic activities. That is, reliable econometric models are created to evaluate student performance as a criterion of education quality, and factors influencing academic outcomes, attendance, and student attrition from universities are examined [3].

A number of additional studies conclude that significant changes are taking place in higher education and that new trends are emerging. On this basis, relevant research focuses on analyzing models that describe processes occurring directly within the education system [4]. It is also emphasized that effective financial management plays an important role in ensuring the sustainability and strategic development of higher education institutions. In this context, a quantitative tool is proposed that integrates econometric forecasting using ARIMA with financial management at universities in Uzbekistan, enabling improved accuracy in budget planning [5]. Another study analyzes the economic diagnostics of assessing the quality of higher education and proposes modeling methods for economic diagnostics aimed at evaluating the quality of higher education [6].

Based on the above, several models were considered to calculate the forecast values of the volume of educational services in the Khorezm region, from which the most reliable one was selected:

$$TX_t = -250{,}94 + 1{,}90 * TX_{t-1} - 0{,}99TX_{t-2} - \varepsilon_{t-1} + 73{,}47 * t$$

Here: TX – the volume of educational services provided in the Khorezm region, in billion sums; t – represents the trend and starts from the year 2010.

As can be seen from the presented results, the z-statistics for each coefficient meet the required criteria, meaning their values are either less than –1.96 or greater than 1.96. The

probability values provided to assess their significance are below 0.05 in all cases, which confirms a reliability level of over 99 percent (Table 1).

Table 1

Results of the selected model for calculating the forecast values of the volume of educational services in the Khorezm region

Model 33: ARMAX, using observations 2010-2024 (T = 15)

Dependent variable: TX

Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
Constant	−250.945	86.5810	−2.898	0.0038	***
phi_1	1.89829	0.0540016	35.15	<0.0001	***
phi_2	−0.988207	0.0147728	−66.89	<0.0001	***
theta_1	−1.00000	0.210257	−4.756	<0.0001	***
Time	73.4753	15.1731	4.842	<0.0001	***

Mean dependent var	257.6867	S.D. dependent var	274.0782
Mean of innovations	−0.531859	S.D. of innovations	26.80499
R-squared	0.989762	Adjusted R-squared	0.986970
Log-likelihood	−74.49870	Akaike criterion	160.9974
Schwarz criterion	165.2457	Hannan-Quinn	160.9522

		Real	*Imaginary*	*Modulus*	*Frequency*
AR					
	Root 1	0.9605	-0.2990	1.0059	-0.0480
	Root 2	0.9605	0.2990	1.0059	0.0480
MA					
	Root 1	1.0000	0.0000	1.0000	0.0000

The near-unity of the coefficient of determination demonstrates that the model's form and the factors included in it have correctly selected. Based on the results of the analysis presented, forecast values for 2025–2030 were calculated based on the proposed model (Table 2).

Table 2. Projected values for the volume of education services in the Khorezm region

For 95% confidence intervals, z(0.025) = 1.96

Years	**Educational services**	**Growth rate**	**Standard error**	**95% confidence interval**
2025	1031,97	116,6	26,805	(979,430, 1084,50)
2026	1168,52	113,2	36,0319	(1097,90, 1239,14)
2027	1289	110,3	40,8374	(1208,96, 1369,04)
2028	1389,39	107,8	42,7636	(1305,58, 1473,21)
2029	1467,49	105,6	43,0662	(1383,09, 1551,90)
2030	1523,16	103,8	43,1615	(1438,57, 1607,76)

The forecast results, based on the model developed taking into account existing trends, indicate that in the region the volume of services in the education sector will initially have high growth rates, i.e. it is expected to increase by 16.6 per cent in 2025 compared to the previous year. This indicator is observed to decrease to 3.8 per cent by 2030. Overall, the volume of services in the education sector is expected to reach 1,523.16 billion sums in 2030, representing a 1.72-fold increase compared with 2024.

Given that the volume of educational services is expected to grow sharply in the following years owing to the increase in the number of non-state educational institutions, high growth rates have been secured, and this is to be regarded as a natural consequence

of market saturation [7]. If we take this into account, the proposed forecast results can be considered reliable.

To clarify the level of development of educational services in the region, the share of the volume of educational services in the Khorezm region in the national volume was calculated, and on this basis, forecast values were developed for subsequent years. For this purpose, the following model variant was chosen as the most suitable option:

$$TX_t = 3{,}15 + 1{,}74 * TXS_{t-1} - 0{,}97 * TXS_{t-2} - 1{,}95 * \varepsilon_{t-1} + 0{,}99 * \varepsilon_{t-2}$$

Here: TXS – the share of educational services provided in Khorezm region the national total (in percentage).

The results of the criteria required to establish the adequacy of the model are presented: z- statistic for each coefficient satisfies the requirements, and the probability for all cases is less than 0.01, which confirms the reliability level of more than 99% [8]. However, the coefficient of determination is 0.79, which means that the model factors explain 79% of the variation in the dependent variable (Table 3).

Table 3

Results of the selected model for calculating the forecast values of the share of education services provided in the Khorezm region in the total education services provided at the national level

Model 18: ARMA, using observations 2010-2024 (T = 15)

Dependent variable: TXS

Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
Const	3.14997	0.0225995	139.4	<0.0001	***
phi_1	1.73651	0.0495159	35.07	<0.0001	***
phi_2	−0.970115	0.0373481	−25.97	<0.0001	***
theta_1	−1.94628	0.329187	−5.912	<0.0001	***
theta_2	0.999999	0.328137	3.048	0.0023	***

Mean dependent var	3.132021	S.D. dependent var	0.377241
Mean of innovations	−0.046975	S.D. of innovations	0.194806
R-squared	0.787807	Adjusted R-squared	0.729936
Log-likelihood	−0.420406	Akaike criterion	12.84081
Schwarz criterion	17.08911	Hannan-Quinn	12.79556

		Real	*Imaginary*	*Modulus*	*Frequency*
AR					
	Root 1	0.8950	-0.4794	1.0153	-0.0783
	Root 2	0.8950	0.4794	1.0153	0.0783
MA					
	Root 1	0.9731	-0.2302	1.0000	-0.0370
	Root 2	0.9731	0.2302	1.0000	0.0370

Considering the variability and instability of the data over the period studied, this result can be considered quite high [9]. The MAPE (mean absolute percentage error) value of 5.3 indicates that the model is reliable for calculating forecast values. As a result, the predicted values generated based on the model took the following form (Table 4).

Table 4

Forecast values of the share of the volume of education services provided in the Khorezm region in the total education services provided at the national level.

For 95% confidence intervals, z(0.025) = 1.96

Years	**The share of educational services**	**Difference from the previous year**	**Standard error**	**95% confidence interval**
2025	2,7	-0,06	0,19481	(2,32406, 3,08769)

2026	2,7	-0,01	0,19905	(2,30252, 3,08276)
2027	2,8	0,09	0,20943	(2,37615, 3,19712)
2028	3,0	0,18	0,22195	(2,52769, 3,39771)
2029	3,2	0,21	0,2311	(2,72430, 3,63020)
2030	3,4	0,20	0,23463	(2,91915, 3,83888)

The share of educational services in the Khorezm region has declined over the past two years and amounted to 2.8% in 2024, whereas in 2022 this figure was 3.6%, meaning it decreased by 0.8 percentage points over two years. Despite changes in the absolute value, a decline in the relative indicator is observed. In other words, the region's level of development id lagging behind that of other regions..

The forecast results show that in 2025 the region's share will amount to 2.7%, indicating a continued downward trend [10]. However, according to the forecast, the share will begin to increase starting from 2027 and will reach 3.4% by 2030. At the same time, this figure remains 0.3 percentage points lower than the maximum value observed during the analyzed period, which was 3.7%. The analysis indicates that in the coming years not only quantitative but also qualitative changes can be expected.

It is necessary to cite the changes in higher education as a significant source of changes in educational services, namely, namely the increase in the number and performance of non-state higher educational institutions, which directly affect the volume of educational services in the region. Therefore, forecast values of key indicators reflecting changes in the higher education system were calculated [11]. Taking into account the fact that the performance of universities is measured directly by the number of students, the following optimal version of the model was chosen to calculate forecast values taking into account existing trends:

$$TS_t = 1{,}89 * TS_{t-1} - 0{,}98 * TS_{t-2} - 0{,}99 * \varepsilon_{t-1} + 3{,}25 * t$$

Here: TS – the number of students studying at higher education institutions in Khorezm region (in thousands);

To justify the reliability of the proposed model and the influence of factors, the coefficients were calculated, all of which meet the necessary criteria (Table 5). Therefore, a comparative analysis of their values was not considered necessary.

Table 5

Results of the selected model for calculating forecast values of the number of students at higher education institutions in the Khorezm region.

Model 15: ARMAX, using observations 2010-2024 (T = 15)

Dependent variable: ST

Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
phi_1	1.89473	0.0416014	45.54	<0.0001	***
phi_2	−0.986160	0.0150301	−65.61	<0.0001	***
theta_1	−0.999999	0.301637	−3.315	0.0009	***
Time	3.25444	0.488820	6.658	<0.0001	***

Mean dependent var	20.50667	S.D. dependent var	17.90911
Mean of innovations	−0.418761	S.D. of innovations	1.942243
R-squared	0.989017	Adjusted R-squared	0.986021
Log-likelihood	−34.97802	Akaike criterion	79.95603
Schwarz criterion	83.49629	Hannan-Quinn	79.91832

		Real	*Imaginary*	*Modulus*	*Frequency*
AR					
	Root 1	0.9607	-0.3019	1.0070	-0.0485
	Root 2	0.9607	0.3019	1.0070	0.0485
MA					

	Root 1	1.0000	0.0000	1.0000	0.0000

The results of these criteria confirm the reliability of the proposed model and indicate that it can be used to calculate scientifically meaningful forecast indicators [12]. The forecast values calculated using the model are presented as follows (Table 6).

Table 6

Predicted values for the number of students studying at higher education institutions in the Khorezm region

For 95% confidence intervals, z(0.025) = 1.96

Years	Number of students	Growth rate	Standard error	95% confidence interval
2025	67,67	111,67	1,94224	(63,8661, 71,4796)
2026	73,27	108,27	2,60619	(68,1583, 78,3744)
2027	77,19	105,35	2,94773	(71,4098, 82,9647)
2028	79,40	102,86	3,08085	(73,3594, 85,4361)
2029	80,02	100,78	3,09947	(73,9420, 86,0917)
2030	79,31	99,11	3,10881	(73,2145, 85,4008)

According to the forecast data, the number of students enrolled in higher education institutions will continue to grow and will reach its peak of 80.02 thousand people by 2029. In 2030, a slight decrease of 0.89% is expected compared to the previous year, bringing the figure to 79.31 thousand students. In other words, while enrollment continues to expand, the growth rate is gradually declining. Overall, by 2030 the number of students in higher education institutions will increase 1.31 times compared to 2024, which can be considered a positive outcome.

However, it should be noted that the growth in the number of students requires a proportional increase in academic and teaching staff. As a result, relevant challenges may arise in the coming years [13]. According to calculations based on available statistics, in the 2010-2011 academic year there were on average 14 students per lecturer, whereas in the 2024-2025 academic year this figure reached 29.1-nearly doubling. Consequently, universities are compelled to compensate for the shortage of teachers through external sources. With the continued increase in the number of higher education institutions and students, the relevance of this issue will only intensify.

Given the significance and urgency of this problem, forecast values for the number of academic and teaching staff in higher education institutions of the Khorezm region were calculated [14]. In developing the forecast, several model options were comparatively analyzed, and the most reliable model was selected along with its corresponding forecast values. The model is as follows::

$$(1 - L)PR_t = -71{,}78 - 0{,}99 * \varepsilon_{t-1} + 20{,}35 * t$$

Here: PR – the number of professors and lecturers working in higher educational institutions of the Khorezm region (number of people).

The criteria and results confirming the reliability of the model are presented in Table 7. All indicators meet the required standards: the z-statistics confirm the adequacy of each coefficient, and the coefficient of determination demonstrates the correctness of the factor selection and model form.

Table 7

Results of the model selected to calculate the forecast values of the number of faculty members working in higher education institutions in the Khorezm region

Model 17: ARMAX, using observations 2011-2024 (T = 14)

Dependent variable: (1-L) PR

Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
Const	−71.7759	15.2431	−4.709	<0.0001	***
theta_1	−0.999995	0.221759	−4.509	<0.0001	***
Time	20.3471	1.74927	11.63	<0.0001	***

Mean dependent var	103.9286	S.D. dependent var	117.7177
Mean of innovations	2.976010	S.D. of innovations	56.17680
R-squared	0.986071	Adjusted R-squared	0.984910
Log-likelihood	−77.61819	Akaike criterion	163.2364
Schwarz criterion	165.7926	Hannan-Quinn	162.9998

		Real	*Imaginary*	*Modulus*	*Frequency*
MA					
	Root 1	1.0000	0.0000	1.0000	0.0000

Using this model, forecast values for the number of faculty members working in higher education institutions in the Khorezm region were developed through 2030 (Table 8).

According to the forecast, the number of faculty members in the region's higher education institutions will continue to grow steadily in the coming years. At the same time, the growth rate of teaching staff remains higher than the rate of increase in the number of students, which creates an opportunity to partially mitigate the problem of faculty shortages in the near future.

The growth rate of faculty numbers ranges from 11.9% to 10.5%, with an average rate of 10.9%. As a result, by 2030 the number of faculty members in higher education institutions in the region will reach 3,883 people. This represents a 1.86-fold increase compared to the number of faculty in the 2024–2025 academic year.

Table 8

Forecast values for the number of professors and teachers working in higher educationainstitutions in the Khorezm region.

For 95% confidence intervals, z(0.025) = 1.96

Years	**Number of professors and lecturers**	**Growth rate**	**Standard error**	**95% confidence interval**
2025	2309	110,9	56,1768	(2199,09, 2419,30)
2026	2583	111,9	56,1768	(2473,22, 2693,43)
2027	2878	111,4	56,1768	(2767,69, 2987,90)
2028	3193	110,9	56,1768	(3082,51, 3302,72)
2029	3528	110,5	56,1768	(3417,68, 3637,89)
2030	3883	110,1	56,1768	(3773,19, 3993,40)

Using the forecast values for the number of students enrolled in higher education institutions and the number of active faculty members, the issue of assessing staffing levels in the coming years and developing corresponding forecast values was examined. Since under current conditions an average of 29 students fall per faculty member-almost twice the required standard-we will consider how this issue will evolve during the forecast period (Figure 1).

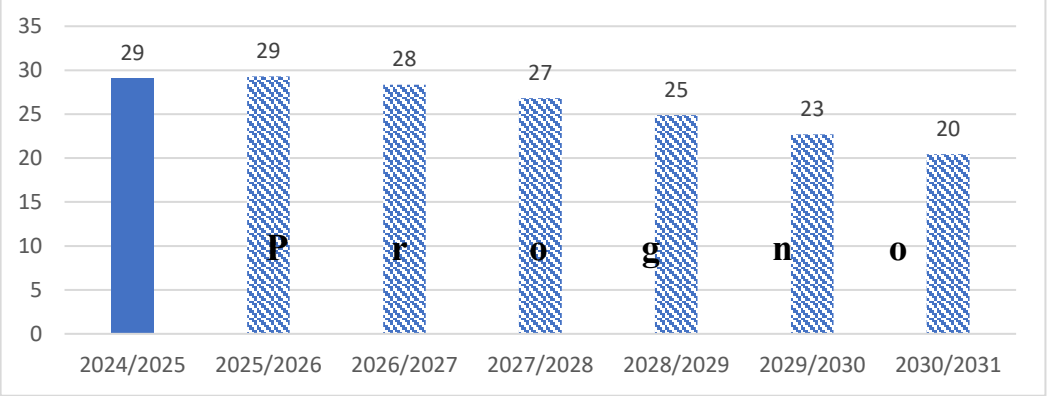

Figure 1. Average number of students per one professor-teacher in higher educational institutions of the Khorezm region (number of people)

According to the forecast results, higher education institutions in the region are expected to see a decline in the average number of students per faculty member-from the current 29 students to 20 students [15]. However, even in this case, the indicator remains significantly higher than the required standard. In other words, although the issue will not be fully resolved, its severity will decrease compared to the current situation.

4. Conclusion

The developed forecasts indicate that while the growth rate of the volume of educational services in the region is declining, the region's share in the total volume of educational services nationwide continues to increase. This is explained by the saturation of the educational services market at the national level. At the same time, the number of students in higher education institutions will show a tendency toward slowing growth in the coming years, which supports the findings presented above. The currently pressing issue of faculty staffing will also improve partially. In our view, in the coming years the growth rates of educational services, as well as student numbers in higher education institutions-driven by the sharp expansion of private educational institutions-will stabilize, ensuring long-term stability.

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