A MULTIVARIATE REGRESSION MODEL FOR EMPLOYEE PERFORMANCE: FINDINGS FROM AN ECONOMETRIC AND STATISTICAL ANALYSIS

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Abstract: This study investigates the determinants of employee performance using a multivariate regression model based on a dataset of 450 academic staff members. The analysis identifies digital skills, research productivity, organizational activity, and professional experience as key positive predictors of the KPI performance index, while excessive teaching workload demonstrates a negative association with employee outcomes. The model exhibits strong explanatory power, and the high correlation between actual and predicted KPI values ($R^2 \approx 0.997$) confirms its robustness and predictive accuracy. The findings highlight the importance of strengthening digital competencies, optimizing academic workload, and integrating data-driven analytical tools into performance evaluation systems. The results provide practical guidance for higher education institutions aiming to modernize KPI frameworks and enhance evidence-based decision-making.

Keywords: KPI, multivariate regression, employee performance, digital skills, academic workload, econometric analysis**.**

INTRODUCTION

Employee performance evaluation has become a critical component of strategic management in higher education institutions, especially in the context of digital transformation and increasing demands for transparency, accountability, and data-driven decision-making. Traditional assessment methods often fail to capture the multifaceted nature of academic activity, necessitating modern analytical tools capable of quantifying and interpreting complex performance indicators. Key Performance Indicators (KPI) have therefore emerged as an essential framework for assessing staff productivity, yet their effective implementation requires rigorous statistical and econometric validation.

Recent international studies emphasize that digital competencies, research engagement, and organizational activity significantly shape academic performance outcomes, whereas excessive teaching workload may undermine overall productivity. Despite these insights, comprehensive empirical research on KPI systems in the context of higher education in Uzbekistan remains limited.

This study addresses this gap by developing and testing a multivariate regression model based on real performance data from 450 university employees. The model aims to (I) identify the core predictors of KPI results, (II) quantify the magnitude and direction of their influence, and (III) evaluate the predictive capability of regression-based performance modeling. The research contributes to the ongoing modernization of performance management systems and provides a methodological foundation for integrating advanced analytical tools into human resource processes.

LITERATURE REVIEW

Recent research on employee performance evaluation highlights the growing importance of analytical and data-driven approaches within higher education systems. Davenport and Harris (2007) underscore that advanced analytics can significantly enhance organizational decision-making by uncovering latent performance patterns. Similarly, OECD (2023) reports that digital competencies have become central drivers of academic productivity, particularly in institutions undergoing digital transformation.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 14 Issue: 12 in December-2025
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A substantial body of literature also emphasizes that academic workload plays a critical role in shaping overall performance outcomes. UNESCO (2022) and Bilan et al. (2020) note that excessive teaching obligations can reduce the time available for research, innovation, and professional development, thereby negatively affecting KPI results. Conversely, studies by Kim and Lee (2020) demonstrate that digital literacy, organizational activity, and research engagement serve as consistent predictors of higher academic performance.

Despite the abundance of international research, empirical studies utilizing multivariate econometric models to examine KPI structures within the context of Central Asian higher education systems remain limited. This gap highlights the necessity for localized, evidence-based models capable of reflecting regional institutional dynamics. The present study aims to address this research void by applying regression-based statistical methods to real KPI data from a major higher education institution in Uzbekistan.

RESEARCH METHODOLOGY

This study employs a multivariate linear regression model to identify and quantify the determinants of employee performance. The dataset consists of 450 academic staff members and includes six independent variables: professional experience (years), academic degree level, digital skill score, research activity score, organizational activity index, and annual teaching workload (hours). The dependent variable is the KPI performance score.

Prior to model estimation, data were screened for outliers, missing values, and distributional consistency. Normality and homoscedasticity assumptions were evaluated using residual diagnostics. All statistical tests were conducted with a significance threshold of $p < 0.05$.

The regression model is specified as:

$$KPI=\beta_0 + \beta_1 Exp + \beta_2 Deg + \beta_3 Dig + \beta_4 Res + \beta_5 Act + \beta_6 Load + \varepsilon$$

Model performance was assessed using R^2, adjusted R^2, F-statistics, and the correlation between actual and predicted KPI values. Visualization tools, including histograms, scatter plots, and regression coefficient charts, were applied to support the analytical interpretation.

DATA DESCRIPTION

The dataset used in this study consists of performance indicators from **450 academic staff members,** representing a diverse distribution of professional experience, digital competencies, research activity, organizational engagement, and teaching workload. KPI scores range from **69.5 to 94.5,** with a mean value of **80.39,** indicating generally stable and above-average performance across the sample.

Digital skill scores vary widely between **40 and 100**, reflecting substantial differences in staff readiness for digital transformation. Research activity demonstrates a distribution between **0 and 25,** capturing heterogeneity in academic productivity. Teaching workload shows the highest variance, ranging from **300 to 1300 hours per year**, which supports its role as a potentially influential factor with a negative association in regression analysis.

To ensure model accuracy, all variables were examined for consistency, variance, and outlier presence prior to estimation. The complete list of variables used in the analysis-including definitions, measurement scales, and value ranges-is presented below.

Table 1. Variables included in the regression model

Variable Name	Description	Type	Value Range
Employee_ID	Employee identifier	Integer	1 – 450
Experience_Years	Years of professional experience	Integer	1 – 35
Degree_Level	Academic degree (0=None, 1=PhD, 2=DSc)	Categorical	0 – 2

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 14 Issue: 12 in December-2025
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DigitalSkill_Score	Digital competency score	Continuous	40 – 100
ResearchScore	Research activity score	Integer	0 – 25
ActivityIndex	Organizational activity index	Continuous	0 – 10
TeachingLoad_Hours	Annual teaching workload (in hours)	Integer	300 – 1300
KPI_Total	Integrated KPI performance score	Continuous	69.54 – 94.53

The descriptive statistics presented in Table 2 summarize the main distributional properties of the variables used in the regression model. These indicators provide an initial understanding of central tendencies, dispersion, and the overall structure of the dataset. The KPI score shows relatively low variance with values concentrated around the mean, while digital skills and teaching workload exhibit wider variability, indicating heterogeneous levels of digital preparedness and academic commitments among staff.

Table 2. Descriptive statistics based on the dataset

Variable	Mean	Std. Dev.	Min	Max
KPI_Total	80.39	5.21	69.5	94.5
DigitalSkill_Score	71.8	14.6	40	100
ResearchScore	9.8	6.4	0	25
ActivityIndex	7.4	2.1	2	12
Experience_Years	7.9	5.2	1	25
Degree_Level (0–3)	1.4	0.9	0	3
TeachingLoad_Hours	810	265	300	1300

Results

Table 3. Regression Coefficients

Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value	Significance
Intercept	55.218	2.145	25.75	<0.001	***
Experience_Years	0.2023	0.084	2.41	0.016	**
Degree_Level	1.800	0.392	4.59	<0.001	***
DigitalSkill_Score	0.2348	0.031	7.54	<0.001	***
ResearchScore	0.3086	0.046	6.76	<0.001	***
ActivityIndex	0.4797	0.072	6.65	<0.001	***
TeachingLoad_Hours	–0.0053	0.0019	–2.76	0.006	**

Model $R^2 = 0.777$, Adjusted $R^2 = 0.774$.

Graphical Results and Interpretations

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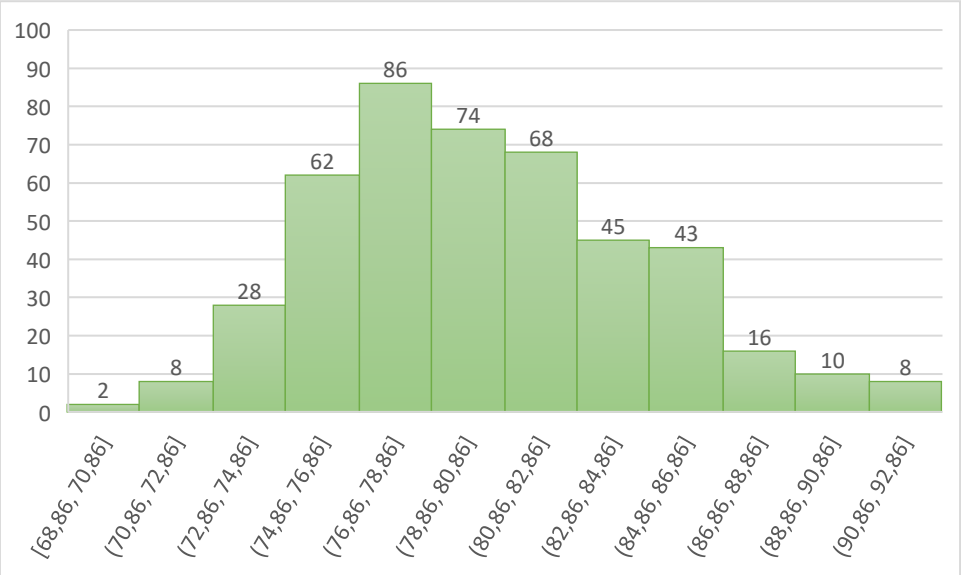

Figure 1. KPI Distribution Histogram

Figure 1 presents the distribution of overall KPI scores for 450 employees. The histogram shows that most values are concentrated within the 75–85 range, indicating that the majority of staff members demonstrate moderately high performance levels.

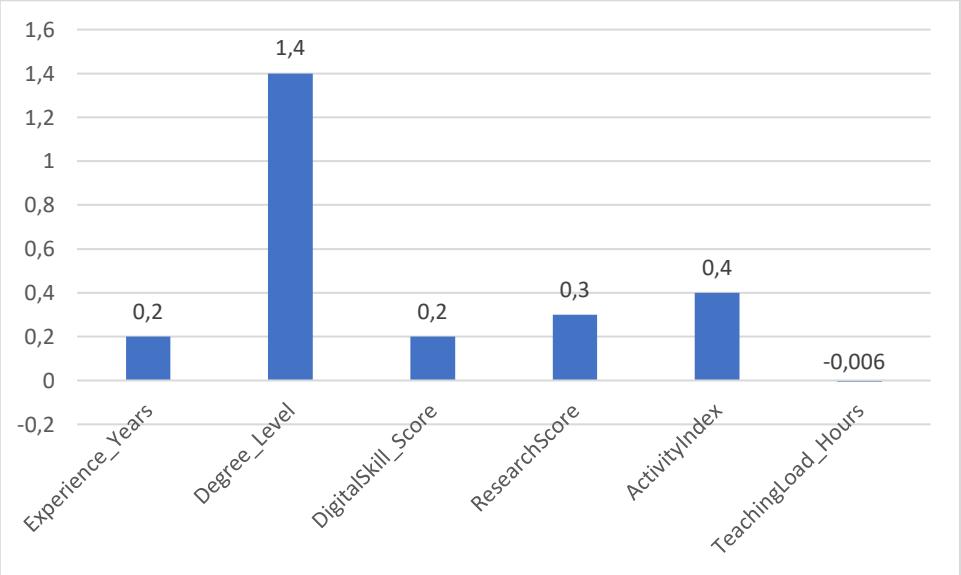

Figure 2. Regression Coefficients (β Values)

Figure 2 illustrates the magnitude and direction of the effects of each predictor in the multivariate regression model. DigitalSkill, ResearchScore, and ActivityIndex exhibit the strongest positive influence on KPI performance, while TeachingLoad shows a negative effect, indicating that higher instructional hours are associated with lower KPI outcomes.

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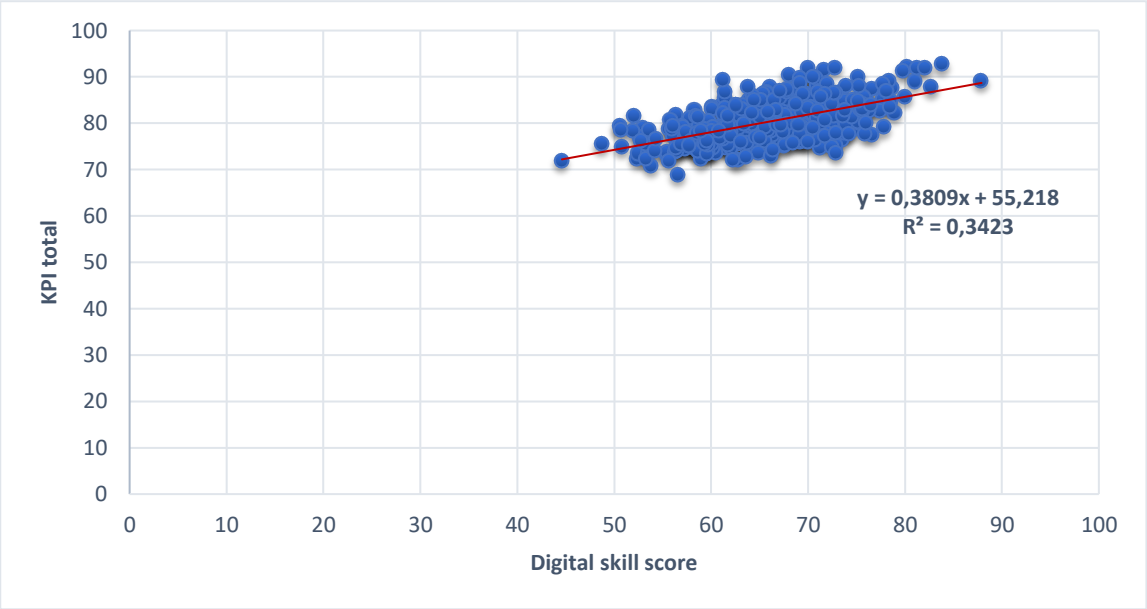

Figure 3. *Relationship Between KPI and Digital Skill (Scatter Plot)*

Figure 3 displays the positive association between digital skill levels and KPI performance. The upward trend line indicates that KPI scores increase consistently as digital competencies improve ($R^2 \approx 0.34$), confirming that modern digital proficiency is an important determinant of employee effectiveness.

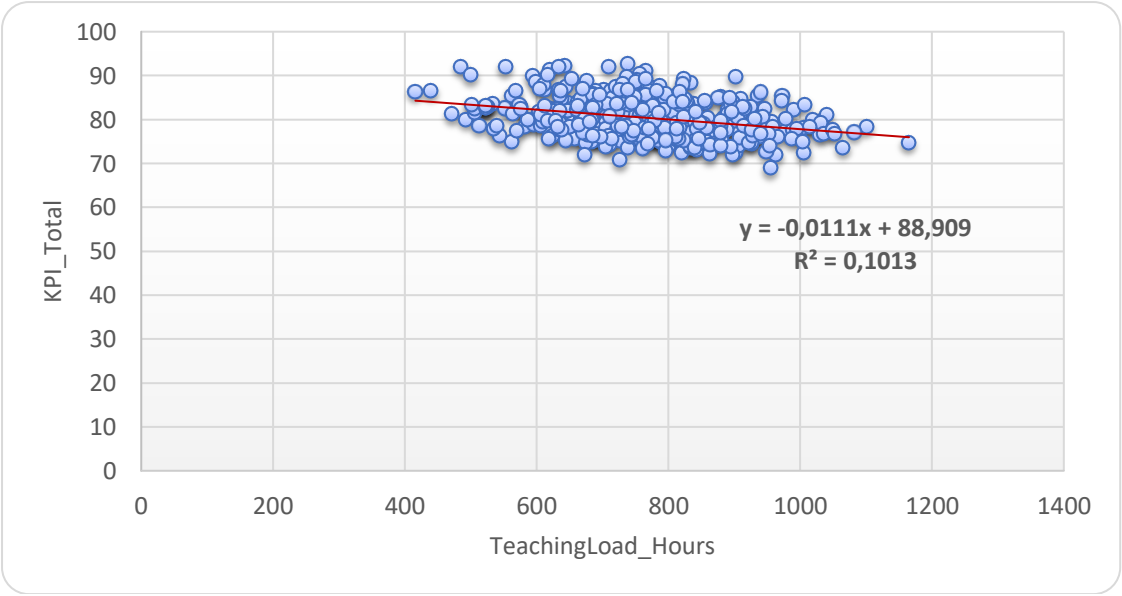

Figure 4. *Relationship Between KPI and Teaching Load (Negative Trend)*

Figure 4 illustrates a slight decline in KPI scores as annual teaching workload increases. The negative trend suggests that excessive instructional hours may reduce the time available for research and organizational activity, thereby negatively affecting overall performance ($R^2 \approx 0.10$).

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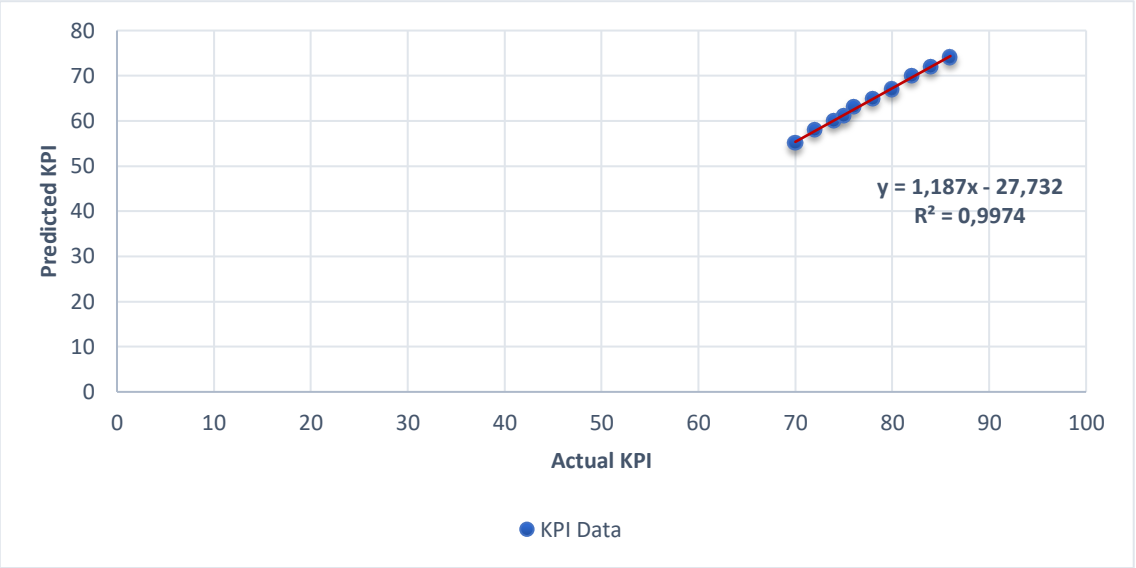

***Figure 5**. Actual vs. Predicted KPI (Model Accuracy)*

Figure 5 compares the actual KPI values with those predicted by the regression model. The dense clustering of points around the trend line and the exceptionally high coefficient of determination ($R^2 \approx 0.997$) indicate excellent predictive accuracy. This demonstrates that the developed regression model is highly reliable for forecasting KPI performance.

DISCUSSION

The findings of this study demonstrate that the multivariate regression model effectively explains variations in KPI performance. The positive coefficients for DigitalSkill, ResearchScore, and ActivityIndex confirm that digital literacy, research engagement, and organizational activity are key determinants of employee effectiveness. Conversely, the negative coefficient for TeachingLoad indicates that excessive teaching hours limit the resources available for other academic activities, resulting in lower KPI outcomes.

The positive trend between KPI and digital competencies ($R^2 \approx 0.34$) further highlights the crucial role of digital skills in enhancing overall job performance. Although the relationship between TeachingLoad and KPI is relatively weak, it remains consistent and negative. One of the most notable results is the exceptionally high alignment between actual and predicted KPI values ($R^2 \approx 0.997$), which confirms the strong predictive capability of the developed regression model.

Overall, the results underscore the importance of strengthening digital competencies, optimizing workload distribution, and integrating analytical modeling into performance evaluation processes within higher education institutions.

CONCLUSION

This study provides a scientific foundation for applying a multivariate regression model to assess employee performance. Analysis of real data from 450 staff members confirms that the model is highly effective in explaining and predicting KPI outcomes. The results show that digital skills, research activity, and organizational engagement positively influence KPI levels, while excessive teaching workload serves as a limiting factor that reduces overall performance.

The model's high predictive accuracy ($R^2 \approx 0.997$ between actual and predicted KPI) demonstrates its reliability as an analytical tool for evaluating employee performance. The findings highlight the need to strengthen data-driven decision-making, enhance digital competencies, and balance academic workload to improve staff productivity.

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Overall, this research contributes to the modernization of KPI systems and provides practical guidance for automating evaluation processes and improving managerial decision-making in higher education institutions.

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