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FINANCIAL AND DIGITAL FACTORS OF INNOVATIVE OUTPUT IN UZBEKISTAN'S SOCIAL SECTOR: ECONOMETRIC EVIDENCE FOR 2007–2025

Kholmuratov Jakhongir Salimbek ugli
Peter the Great St. Petersburg Polytechnic University,
Tashkent state university of economics

Abstract. This study examines the relationship between financial, investment, and digital factors and innovative output in Uzbekistan's social sector during 2007–2025. The empirical framework considers the volume of innovative products and services as the dependent variable and innovation financing, government social expenditure, non-budgetary investment, management digitalization, and digital-platform implementation as explanatory variables. A log-linear multiple regression model is specified and estimated using annual observations. The dissertation-based econometric results report a coefficient of determination of $R^2 = 0.9223$, indicating that the included variables jointly account for a substantial share of variation in innovative output. Innovation financing demonstrates the largest reported elasticity, while digital-platform implementation also exhibits a strong positive association. The overall model is statistically significant according to the reported F-test. For journal-level reproducibility, the study additionally emphasizes diagnostic procedures including multicollinearity testing, residual autocorrelation, heteroskedasticity, model specification, stationarity, and forecast-error measurement. A replication check indicates that some statistics obtained directly from the tabulated annual series require reconciliation with the reported EViews output before final submission. The findings underline a broader strategic implication: sustainable innovation in the social sector depends not only on higher public expenditure but on the interaction between dedicated innovation financing, digital infrastructure, management capacity, institutional quality, and effective deployment of digital platforms. The study provides a reproducible methodological framework for future regional and sector-level analyses.

Keywords: innovative output; social sector; innovation financing; digital transformation; digital platforms; econometric modelling; public expenditure; Uzbekistan.

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INTRODUCTION

Innovation is a central mechanism of long-term economic development. Schumpeterian theory associates development with innovation and creative destruction, while endogenous-growth approaches emphasize the accumulation of technological knowledge and human capital.

These theoretical arguments are particularly important for the social sector. Education contributes to human-capital accumulation. Healthcare affects labor productivity and economic participation. Social-protection institutions influence household resilience, poverty, and social stability. Digital public services reduce administrative transaction costs and can improve the targeting and accessibility of government support.

For emerging economies, the innovative development of these sectors therefore generates both direct and indirect economic effects.

Uzbekistan has experienced substantial transformation of its social sector during the last two decades. Financial resources increased, educational and healthcare infrastructure expanded, digital public services developed, and platform-based administration became increasingly important.

However, a key empirical question remains: Which financial and digital factors are most strongly associated with innovative output in the social sector?

Research gap. Previous studies frequently examine public financing, digital government, human capital, or innovation independently. Less attention has been paid to their simultaneous relationship with measurable innovative output in the social sector of Central Asian transition economies.

Research objective. The objective of this study is to estimate the relationship between innovative output and five major explanatory factors during 2007–2025.

Hypotheses

$$H_1: \beta_1 > 0$$

Innovation financing is positively associated with innovative output.

$$H_2: \beta_2 > 0$$

Government social expenditure is positively associated with innovative output.

$$H_3: \beta_3 > 0$$

Non-budgetary investment is positively associated with innovative output.

$$H_4: \beta_4 > 0$$

Management digitalization is positively associated with innovative output.

$$H_5: \beta_5 > 0$$

Digital-platform implementation is positively associated with innovative output.

LITERATURE REVIEW

Financial Inclusion, Fiscal Allocations, and Public Sector Modernization Scholars studying public finance and institutional economic growth demonstrate that financial deepening and targeted public resource distribution act as critical drivers of organizational and structural innovation in non-commercial sectors (Demirgüç-Kunt & Klapper, 2012). In transition economies, social infrastructure—including healthcare, higher education, and public administration—frequently operates under severe capital constraints. Empirical literature confirms that expanding state budgetary transfers, improving local fiscal sustainability, and increasing access to formal banking channels significantly reduce operational friction and enable capital investments in modern public delivery mechanisms. However, scholars caution that increased financial inflows yield diminishing returns unless paired with strong institutional absorptive capacity and performance-based budgetary governance. In the context of Uzbekistan's dynamic fiscal landscape (2007–2025), this highlights the necessity of evaluating whether expanding financial inputs directly convert into measurable social sector innovative outputs rather than passive operational expenditures.

Digital Infrastructure Adoption and Process-Oriented Innovation in Public Services Literature on the digital economy and administrative transformation highlights the transformative role of telecommunications expansion, broad internet penetration, and mobile technologies in public service efficiency (Goldfarb & Tucker, 2019). Scholars argue that while commercial sector innovation is traditionally quantified via patent filings and corporate R&D expenditures, social sector digital innovation primarily manifests as process optimization, e-governance integration, and user-centric digital delivery channels. Studies across developing and transition economies show that state-led digital initiatives act as exogenous technological shocks. These shocks lower administrative transaction costs, enhance transparency, and compel public entities to adopt digital operational models. Consequently, researchers stress that modeling digital factor inputs alongside financial variables is essential to isolate the precise technological contribution to social output productivity over multi-year observation windows.

Econometric Approaches to Structural Reforms and Non-Market Social Innovation Methodological researchers emphasize the distinct econometric challenges involved in evaluating innovative output within non-market and public economies. Unlike commercial industries, social innovations are predominantly organizational, institutional, and process-driven, making them imperfectly captured by traditional monetary output statistics alone. Furthermore, macro-econometric evaluations spanning extended reform periods must address structural breaks, common time trends, and potential multicollinearity between accelerating digital indicators and financial growth variables. Scholars advocate for dynamic econometric frameworks—such as Autoregressive Distributed Lag (ARDL) bounds testing (Pesaran et al., 2001) or Vector Autoregressions (VAR)—to disentangle long-run structural trends from true policy-driven innovation. Applying these robust quantitative methods allows researchers to systematically verify the empirical linkages between financial and digital factors and the innovative capacity of the social sector.

RESEARCH METHODOLOGY

2.1. Data

The dataset contains $n = 19$ annual observations covering $t = 2007, \dots, 2025$.

Variable	Definition
Y_t	Volume of innovative products/services in the social sector
X_{1t}	Volume of innovation financing
X_{2t}	Government expenditure on the social sector
X_{3t}	Non-budgetary investment indicator reported in the dataset
X_{4t}	Level of management digitalization
X_{5t}	Level of digital-platform implementation

2.2. Growth indicators

$$g_t = [(X_t - X_{(t-1)}) / X_{(t-1)}] \times 100 \quad (1)$$

$$G = X_T / X_0 \quad (2)$$

$$CAGR = (X_T / X_0)^{(1/T)} - 1 \quad (3)$$

2.3. Correlation analysis

$$r_{xy} = \Sigma[(x_t - \bar{x})(y_t - \bar{y})] / \sqrt{\{\Sigma(x_t - \bar{x})^2 \cdot \Sigma(y_t - \bar{y})^2\}} \quad (4)$$

The coefficient satisfies $-1 \leq r_{xy} \leq 1$. A positive coefficient indicates a direct relationship, whereas a negative coefficient indicates an inverse relationship.

2.4. Econometric model

$$\ln Y_t = \beta_0 + \beta_1 \ln X_{1t} + \beta_2 \ln X_{2t} + \beta_3 \ln X_{3t} + \beta_4 \ln X_{4t} + \beta_5 \ln X_{5t} + \varepsilon_t \quad (5)$$

Because the specification is log-linear, the coefficients can be interpreted as elasticities. For example:

$$\beta_1 = \partial \ln Y / \partial \ln X_1 \quad (6)$$

Therefore, a 1% change in X_1 is associated with approximately a $\beta_1\%$ change in Y , ceteris paribus.

2.5. Ordinary Least Squares estimator

$$\beta = (X'X)^{-1}X'y \quad (7)$$

$$\hat{\varepsilon} = y - X\hat{\beta} \quad (8)$$

$$RSS = \Sigma(t=1 \text{ to } n) \hat{\varepsilon}_t^2 \quad (9)$$

2.6. Coefficient of determination

$$R^2 = 1 - [\Sigma(Y_t - \hat{Y}_t)^2 / \Sigma(Y_t - \bar{Y})^2] \quad (10)$$

$$R^2 = 1 - (1 - R^2)[(n - 1)/(n - k - 1)] \quad (11)$$

In this study, $n = 19$ and $k = 5$.

2.7. Student t-test

$$t_j = \beta_j / SE(\beta_j) \quad (12)$$

The null hypothesis is $H_0: \beta_j = 0$, against $H_1: \beta_j \neq 0$. At the 5% significance level, $p_j < 0.05$ is normally interpreted as statistical significance.

2.8. Overall Fisher F-test

$$F = (R^2 / k) / [(1 - R^2) / (n - k - 1)] \quad (13)$$

The null hypothesis is $H_0: \beta_1 = \beta_2 = \dots = \beta_k = 0$. If $\text{Prob}(F) < 0.05$, the model is jointly statistically significant.

2.9. Multicollinearity diagnostics

$$\text{VIF}_j = 1 / (1 - R_j^2) \quad (14)$$

where R_j^2 is obtained from a regression of explanatory variable X_j on all other explanatory variables. Common diagnostic interpretation is $\text{VIF} < 5$ as relatively low multicollinearity, $5 \leq \text{VIF} < 10$ as potentially problematic, and $\text{VIF} \geq 10$ as evidence of serious multicollinearity requiring additional attention.

2.10. Durbin–Watson statistic

$$\text{DW} = \sum_{t=2}^n (\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2 / \sum_{t=1}^n \hat{\varepsilon}_t^2 \quad (15)$$

The statistic generally ranges between 0 and 4, and a value around 2 is consistent with the absence of first-order residual autocorrelation.

2.11. Mean Absolute Percentage Error

$$\text{MAPE} = (100/n) \sum_{t=1}^n |(Y_t - \hat{Y}_t) / Y_t| \quad (16)$$

Smaller MAPE values indicate a closer fit between actual and fitted observations.

2.12. Stationarity testing

$$\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{i=1}^p \delta_i \Delta y_{t-i} + \varepsilon_t \quad (17)$$

The Augmented Dickey–Fuller test evaluates $H_0: \gamma = 0$ (unit root) against $H_1: \gamma < 0$ (stationarity). If the variables are non-stationary in levels but stationary in first differences, cointegration analysis or alternative time-series specifications should be considered.

3. analysis and Results

3.1. Descriptive dynamics

Innovative output increased from UZS 11,547.2 billion in 2007 to UZS 68,321.5 billion in 2025.

$$G_Y = 68,321.5 / 11,547.2 \approx 5.92 \quad (18)$$

Innovation financing increased from approximately UZS 5,028.6 billion to UZS 10,020.4 billion. Digital-platform implementation increased from 31.7% to 68.7%. The period also contains important structural shocks, especially the COVID-19 period, during which social expenditure increased while innovative output experienced temporary volatility.

3.2. Dissertation-reported econometric specification

The econometric output reported in the dissertation gives the following coefficient structure:

$$\ln Y = 3.732594 + 1.275379 \ln X_1 + 0.150891 \ln X_2 + 0.151629 \ln X_3 + 0.047467 \ln X_4 + 0.607612 \ln X_5 \quad (19)$$

$$R^2 = 0.922286 \quad (20)$$

$$R^2 = 0.892395 \quad (21)$$

$$F = 30.85583 \quad (22)$$

$$\text{Prob}(F) = 0.000001 \quad (23)$$

The model therefore demonstrates high overall explanatory power according to the reported results.

3.3. Economic interpretation of reported elasticities

The largest reported coefficient is $\beta_1 = 1.275379$. Therefore:

$$\Delta Y / Y \approx 1.275379 \times \Delta X_1 / X_1 \quad (24)$$

A 1% increase in innovation financing is associated with an approximately 1.275% increase in innovative output, *ceteris paribus*.

$$\beta_5 = 0.607612 \quad (25)$$

$$1\% \uparrow X_5 \Rightarrow 0.608\% \uparrow Y \quad (26)$$

$$\beta_2 = 0.150891 \quad (27)$$

$$1\% \uparrow X_2 \Rightarrow 0.151\% \uparrow Y \quad (28)$$

$$\beta_3 = 0.151629 \quad (29)$$

$$\beta_4 = 0.047467 \quad (30)$$

Variable	Coefficient	Interpretation of 1% increase
Innovation financing (X_1)	1.275379	$\approx 1.275\%$ increase in Y
Government social expenditure (X_2)	0.150891	$\approx 0.151\%$ increase in Y
Non-budgetary investment (X_3)	0.151629	$\approx 0.152\%$ increase in Y
Management digitalization (X_4)	0.047467	$\approx 0.047\%$ increase in Y
Digital-platform implementation (X_5)	0.607612	$\approx 0.608\%$ increase in Y

DISCUSSION

4.1. Innovation financing

The reported elasticity of innovation financing is greater than one. This implies that innovation-specific financing is more strongly associated with innovative output than general social expenditure. The distinction is economically plausible because general expenditure finances salaries, infrastructure maintenance, transfers, routine administration, and current service provision, while innovation financing is more directly oriented toward technological modernization, digital systems, experimentation, research, and organizational transformation.

4.2. Digital-platform implementation

Digital-platform implementation also demonstrates a substantial reported elasticity. Platforms create network effects because they connect citizens, government agencies, service providers, databases, payment systems, and identification systems. The economic value of a digital platform therefore arises not only from automation but from integration.

$$\text{Digital infrastructure} + \text{Interoperability} + \text{Data} + \text{Human capabilities} \rightarrow \text{Innovative services} \quad (31)$$

4.3. Public expenditure

The smaller coefficient of general government expenditure does not mean that social expenditure is unimportant. Instead, it implies that innovation depends on the structure and productivity of expenditure, not simply its volume. This supports the transition toward results-based budgeting.

$$RE_i = \Delta \text{Outcome}_i / \Delta \text{Expenditure}_i \quad (32)$$

4.4. Public-private and non-budgetary financing

Alternative financing can reduce pressure on the public budget and support modernization. However, PPP effectiveness is not equivalent to private financing alone. Its effect depends on contract quality, risk allocation, competition, monitoring, and social outcomes.

$$PPP_E = f(\text{contract quality, risk allocation, competition, monitoring, social outcomes}) \quad (33)$$

4.5. Methodological robustness

The high reported R^2 should not by itself be interpreted as proof of a causal model. With trending annual data, high R^2 may partly result from common trends. Consequently, a journal-quality time-series analysis should combine OLS with unit-root tests, VIF diagnostics, residual tests, heteroskedasticity tests, cointegration analysis where relevant, structural-break tests, and robustness specifications. This is especially important because the sample contains only $n = 19$ observations.

4.6. Limitations

The first limitation is sample size. With five explanatory variables and 19 observations:

$$df_residual = n - k - 1 = 19 - 5 - 1 = 13 \quad (34)$$

Therefore, coefficient estimates may be sensitive to individual observations. The second limitation is the potential presence of common time trends. The third limitation is the possibility of multicollinearity among financial and digital-development variables. The fourth limitation concerns the measurement of social innovation. Many social innovations are organizational rather than technological and therefore may be imperfectly captured by monetary innovative-output statistics. The fifth limitation is the need to reconcile the original annual dataset with the final EViews output before journal submission.

CONCLUSION AND SUGGESTIONS

This study examines the financial and digital factors associated with innovative output in Uzbekistan's social sector during 2007–2025. The dissertation-based results indicate that the selected variables jointly explain a substantial proportion of changes in innovative output.

Innovation financing demonstrates the largest reported elasticity, while digital-platform implementation is the second most influential factor in the reported specification.

The findings support an integrated strategic interpretation in which innovation financing, digital platforms, institutional capacity, human capital, and effective governance jointly shape innovative social-sector output.

The principal policy implication is that higher social expenditure alone is insufficient. Sustainable innovation requires targeted financing, interoperable digital infrastructure, diversified investment mechanisms, effective public management, qualified personnel, and continuous measurement of final social outcomes.

From a methodological perspective, future research should extend the analysis using regional panel data.

Innovation Financing + Digital Platforms + Institutional Capacity + Human Capital + Effective Governance
→ Innovative Social-Sector Output (35)

$$\ln Y_{it} = \alpha + \beta_1 \ln X_{1,it} + \beta_2 \ln X_{2,it} + \beta_3 \ln X_{3,it} + \beta_4 \ln X_{4,it} + \beta_5 \ln X_{5,it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (36)$$

where i denotes region, t denotes year, μ_i denotes region-specific effects, and λ_t denotes time-specific effects. Such an extension would considerably strengthen causal identification and the international publication potential of the research.

The annual statistical series used in the study are based on official statistical information and the dataset compiled in the underlying dissertation research. For publication, the final reconciled dataset and econometric output should be retained as supplementary material or made available from the corresponding author in accordance with the selected journal's data policy.

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