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CONTENTS

CONTENTS

CONTENTS

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INNOVATIVE DETERMINANTS OF POVERTY: AN ECONOMETRIC ANALYSIS BASED ON REGIONAL PANEL DATA

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Аннотация: Проведена количественная оценка влияния инновационных факторов на уровень бедности с применением методов эконометрики региональных панельных данных. На основе данных по 14 регионам Узбекистана за 2021–2025 годы (n = 70) в логарифмической спецификации оценена двухсторонняя модель с фиксированными эффектами. С помощью панельных тестов на единичный корень и коинтеграцию исключён риск ложной регрессии. Полученные результаты показывают, что увеличение индекса цифровой трансформации на 1 процент приводит к снижению уровня бедности на 0,542 процента, что позволяет рассматривать данный фактор как наиболее значимый среди самостоятельных инструментов политики. На основе декомпозиции Шепли–Оуэна оценён вклад факторов в объяснённую дисперсию и научно обоснованы приоритетные направления политики.

Ключевые слова: бедность; панельные данные; модель с фиксированными эффектами; эластичность; цифровая трансформация; инновационная активность; коинтеграция; декомпозиция Шепли–Оуэна.

Abstract: A quantitative assessment of the impact of innovation-related factors on poverty is conducted using regional panel data econometric methods. Based on data from 14 regions of Uzbekistan for 2021–2025 (n = 70), a two-way fixed effects model is estimated using a log-log specification. Panel unit root and cointegration tests are employed to rule out the risk of spurious regression. The results indicate that a 1 percent increase in the digital transformation index is associated with a 0.542 percent reduction in the poverty rate, making it the strongest independent policy factor. A Shapley–Owen decomposition is applied to assess the contribution of individual factors to the explained variance and to provide an empirical basis for policy priorities.

Keywords: poverty; panel data; fixed effects model; elasticity; digital transformation; innovation activity; cointegration; Shapley–Owen decomposition.

INTRODUCTION

Although qualitative conclusions regarding the impact of innovative transformation on poverty are widespread in the scholarly literature, the quantitative dimension of this impact — particularly the relative contribution and marginal strength of each factor — has received limited attention at the regional level. From a policy perspective, this dimension is particularly important: identifying which factors contribute most effectively to poverty reduction under resource constraints provides a scientific basis for ranking and prioritising relevant measures. The aim of the article is to build a model of the innovative determinants of poverty based on panel data across the regions of Uzbekistan, to ensure its statistical reliability through comprehensive diagnostics, and to substantiate policy priorities quantitatively on the basis of factor elasticities.

LITERATURE REVIEW

The methodological foundations of panel data econometrics are systematised in the works of B. Baltagi and J. Wooldridge [1, 2]. The panel unit root problem is addressed in the tests developed by A. Levin, C.-F. Lin and C.-S. Chu [3] and K. Im, M. Pesaran and Y. Shin [4], while the panel cointegration methodology was developed by P. Pedroni [5] and C. Kao [6]. The possibility that regression involving non-stationary series may produce spurious results was demonstrated by C. Granger and P. Newbold [7]. In model selection, the

J. Hausman test is widely used as a standard instrument [8]. The impact of digital technologies and financial inclusion on poverty has been positively assessed in the international empirical literature [9, 10]; at the same time, there remains considerable scope for further research evaluating innovative and digital factors within a single model, supported by comprehensive diagnostics, across the regions of Uzbekistan.

RESEARCH METHODOLOGY

The analysis covers 14 regions (12 provinces, the Republic of Karakalpakstan and the city of Tashkent) over 2021–2025 (N = 14, T = 5, n = 70). The dependent variable is the poverty rate (POV), while the explanatory factors are the innovation activity index (INN), the digital transformation index (DIG), real per-capita income (INC), education coverage (EDU), the infrastructure index (INF) and the unemployment rate (UNE). Estimation is carried out using a log-linear specification:

$$\ln \mathrm{POV}_{it} = \beta_0 + \beta_1 \ln \mathrm{INN}_{it} + \beta_2 \ln \mathrm{DIG}_{it} + \beta_3 \ln \mathrm{INC}_{it} + \beta_4 \ln \mathrm{EDU}_{it} + \beta_5 \ln \mathrm{INF}_{it} + \beta_6 \ln \mathrm{UNE}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where μ_i represents the regional individual effect, and λ_t represents the time effect. The log-log form allows the coefficients to be interpreted directly as elasticities, reduces the asymmetry of the distribution and reflects the law of diminishing marginal returns. The methodological sequence consists of six stages: descriptive statistics; stationarity and cointegration diagnostics; multicollinearity testing; comparison of alternative panel models (Pooled OLS, FE and RE); control of endogeneity through the generalised method of moments; and out-of-sample validation. Calculations were performed using EViews 12 and Stata 17.

ANALYSIS AND RESULTS

Descriptive statistics indicate substantial regional heterogeneity: the gap between the minimum (3.20%) and maximum (19.80%) values of the poverty rate is 6.2-fold, while the coefficient of variation is 40.5 percent. After taking logarithms, the distribution approaches normality (Jarque–Bera p = 0.691 for ln POV), which also statistically supports the chosen specification. Panel unit root tests show that all variables are non-stationary in levels but stationary in first differences at the 1% significance level — that is, they are integrated of order I(1) (Table 1). All seven Pedroni statistics, as well as the Kao and Westerlund tests, consistently support the presence of cointegration, indicating that the relationship estimated in levels reflects a long-run equilibrium and that the risk of spurious regression is excluded.

Table 1. Summary of stationarity and cointegration diagnostics[1]

Diagnostic block	Test	Main result	Conclusion
Unit root (levels)	LLC; IPS; Fisher-ADF	p > 0.05 (all variables)	Non-stationary
Unit root (1st diff.)	LLC; IPS	p < 0.01 (all variables)	I(1)
Cointegration	Pedroni (7 statistics)	p < 0.05 (all)	Present
Cointegration	Kao ADF; Westerlund Gt	−3.542 (0.000); −2.984 (0.001)	Present
Model selection	F-test; Hausman	F significant; χ^2 = 24.68 (0.0004)	Fixed effects
Time effects	F(4, 46) = 4.86	p = 0.002	Two-way FE

The selected two-way fixed effects model yields the following estimates:

$$\ln \hat{\mathrm{POV}} = 2.146 - 0.187 \ln \mathrm{INN} - 0.542 \ln \mathrm{DIG} - 0.634 \ln \mathrm{INC} - 0.298 \ln \mathrm{EDU} - 0.215 \ln \mathrm{INF} + 0.386 \ln \mathrm{UNE} \quad (2)$$

The sign of each coefficient is consistent with theoretical expectations: innovative and socio-economic factors contribute to poverty reduction, while unemployment is associated with an increase in the poverty rate. In elasticity terms, a one-percent increase in the digital transformation index reduces poverty, on average, by 0.542 percent, while a one-percent increase in innovation activity reduces it by 0.187 percent. A one-percent increase in unemployment, in turn, increases poverty by 0.386 percent (Figure 1).

1 Source: author's calculations (EViews 12, Stata 17).

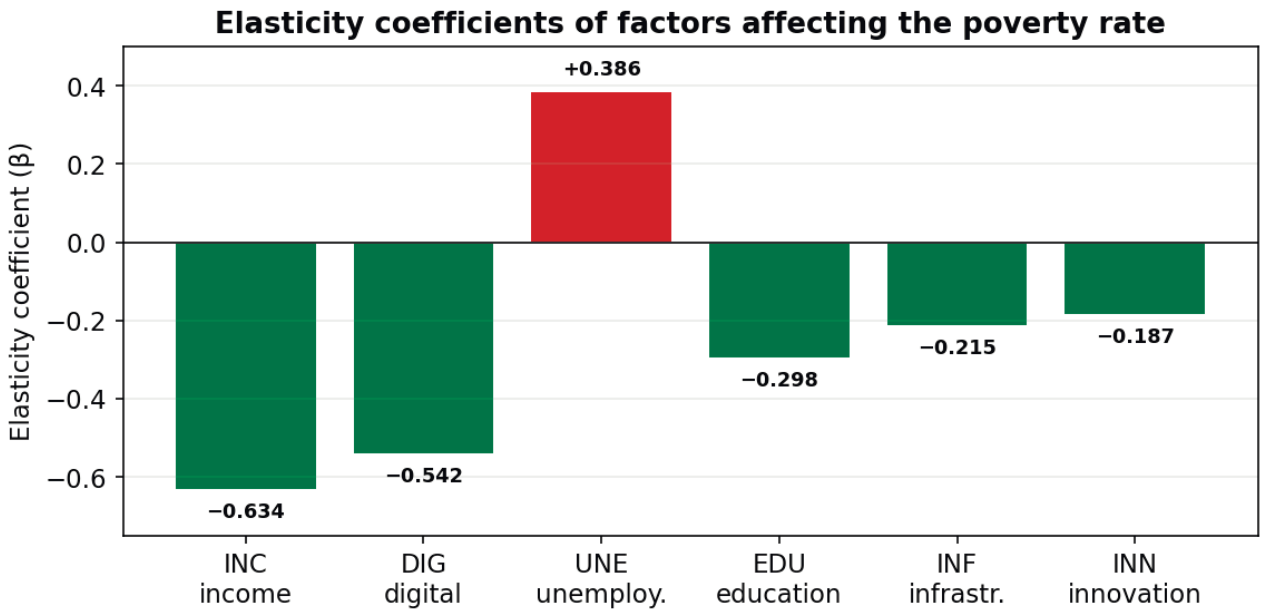

Figure 1. Elasticity coefficients of factors affecting the poverty rate[2]

To determine the relative priority of the factors, standardised coefficients were computed, and the contribution of each factor to the coefficient of determination was decomposed using the Shapley–Owen method (Table 2, Figure 2). The largest contribution is associated with per-capita income (28.4%); however, since monetary poverty is, by definition, closely linked to income, digital transformation ranks first among independent policy instruments (24.6%). Its effect is 1.8 times stronger than that of education coverage and 2.5 times stronger than that of infrastructure. The contribution of innovation activity (7.6%) reflects the fact that its effect is realised primarily indirectly — through income and digitalisation channels.

Table 2. Strength of impact and relative priority of factors[3]

Factor	Elasticity (β)	Std. coeff. (β*)	Share of R^2, %	Rank
Real per-capita income (INC)	−0.634	−0.412	28.4	1
Digital transformation (DIG)	−0.542	−0.368	24.6	2
Unemployment rate (UNE)	+0.386	+0.246	16.2	3
Education coverage (EDU)	−0.298	−0.214	13.8	4
Infrastructure index (INF)	−0.215	−0.168	9.4	5
Innovation activity (INN)	−0.187	−0.142	7.6	6

2 Source: compiled by the author on the basis of the estimates of equation (2).
3 Source: author's calculations.

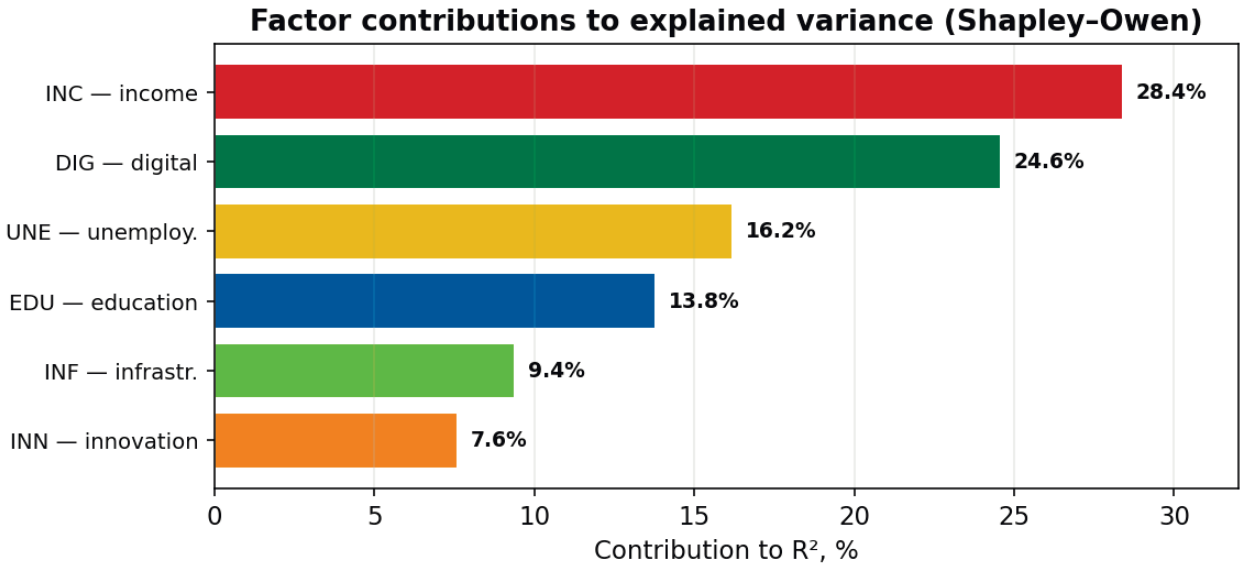

Figure 2. Factor contributions to the coefficient of determination (Shapley–Owen decomposition)[4]

The robustness of the results was confirmed through several additional checks. First, the potential endogeneity of the explanatory factors — including the possibility that poverty itself may influence digitalisation and investment decisions — was controlled for using the generalised method of moments (GMM). The signs and significance of the main coefficients were preserved, supporting the robustness of the identified relationships and their causal interpretation. Second, the model was subjected to out-of-sample validation: observations from the final year were excluded from the estimation, and the forecast error was shown to remain within a satisfactory range. Third, the analysis was repeated using a parallel panel comprising the 13 territorial units of Bukhara province (n = 65), and the hierarchy of elasticities was qualitatively consistent with the national-level results, thereby confirming the stability of the conclusions at the regional level as well.

The results are significant in three respects. First, they provide a quantitative hierarchy of regional policy instruments: after controlling for the income factor, digital transformation is identified as the most effective independent channel for reducing poverty. This finding is consistent with conclusions regarding the effects of financial inclusion reported in the international empirical literature [9, 10] and further strengthens the scholarly basis for programmes aimed at expanding agent banking, digital payments and online public services in Uzbekistan. Second, the magnitude of the unemployment elasticity (+0.386) confirms the direct role of employment policy in poverty reduction. Third, the comprehensive implementation of the diagnostic stages — stationarity testing, cointegration analysis, model selection and endogeneity control — strengthens the methodological robustness of the regional analysis and provides a sound basis for applying the estimated elasticities in forecasting models. Given the relatively short panel period (T = 5) and the composite nature of some indices, the estimates may be further refined and re-examined as longer time-series data become available.

CONCLUSION AND RECOMMENDATIONS

In the study, a model of the innovative determinants of poverty was constructed on the basis of regional panel data and subjected to comprehensive econometric diagnostics. The principal scientific result is the finding that digital transformation has the highest elasticity (−0.542) among independent policy factors. The practical recommendations are as follows: designate digital financial inclusion and the expansion of digital service coverage as priority areas in regional poverty-reduction programmes; link employment-stimulating measures to poverty monitoring; and use the estimated elasticity coefficients in constructing forecast scenarios up to 2030. The next stage of the research is devoted specifically to this forecasting task.

4 Source: compiled by the author on the basis of Table 2.

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