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PUBLIC-PRIVATE PARTNERSHIPS AND INFRASTRUCTURE INVESTMENT AS DRIVERS OF ECONOMIC GROWTH IN UZBEKISTAN: AN ECONOMETRIC ANALYSIS

ABSTRACT

Background: Public-private partnerships (PPPs) have emerged as a pivotal mechanism for financing infrastructure development in transition economies with constrained public budgets. Despite growing policy interest, the macroeconomic impact of PPP-driven infrastructure investment in Uzbekistan remains empirically underexplored.

Aim: This study examines the relationship between PPP-based infrastructure investment and GDP growth in Uzbekistan over the period 2000–2023, with a focus on the transport, energy, and water supply sectors.

Methods: We employ Ordinary Least Squares (OLS) regression, the Autoregressive Distributed Lag (ARDL) bounds-testing approach, and Granger causality tests using annual data sourced from the State Statistics Committee of Uzbekistan, the World Bank, and the Asian Development Bank.

Results: Empirical findings confirm that a 1% increase in PPP infrastructure investment as a share of GDP is associated with a 1.42–1.87% increase in real GDP in the long run. Transport and energy infrastructure demonstrate the strongest multiplier effects. Institutional quality and financial sector depth moderate the relationship.

Conclusion: Strengthening the PPP regulatory framework, expanding long-term financing instruments, and improving institutional capacity are critical enablers for sustaining infrastructure-driven economic growth in Uzbekistan. The proposed "5I Strategic Model" offers a coherent roadmap for policy implementation.

Keywords: public-private partnership; infrastructure investment; economic growth; GDP; Uzbekistan; ARDL; econometric analysis; 5I model; transition economy

JEL Classification: *H54, O18, E22, F21, P33*

1. INTRODUCTION

Infrastructure development occupies a central position in the economic transformation of emerging and transition economies. Transport networks, energy systems, water supply, and information-communication infrastructure form the material backbone of productivity, trade, and human capital accumulation. A growing body of empirical literature — originating with Aschauer's (1989) seminal contribution — confirms that public infrastructure investment generates substantial output multiplier effects, often exceeding those of other forms of public expenditure.

In Uzbekistan, rapid economic liberalization since 2017 has placed infrastructure modernization at the top of the national development agenda. The New Uzbekistan Development Strategy 2022–2026 sets explicit targets for infrastructure investment, privatization, and private sector engagement. However, chronic fiscal constraints limit the government's capacity to finance the infrastructure deficit through public expenditure alone. According to the Asian Development Bank (2023), Uzbekistan's infrastructure investment gap is estimated at approximately 3.2% of GDP annually — a shortfall that necessitates systematic mobilization of private capital.

Public-private partnerships (PPPs) represent a globally recognized mechanism for bridging this gap. By combining private financing, operational efficiency, and risk-sharing with public oversight and strategic direction, PPPs enable governments to deliver infrastructure services at scale without proportional expansion of public debt. Since the adoption of the Law on Public-

Private Partnerships in 2019 (Law No. ZRU-567), Uzbekistan has launched a portfolio of PPP projects encompassing thermal power generation, road construction, airport modernization, and urban water supply rehabilitation.

Yet despite growing policy momentum, the macroeconomic literature on PPP-infrastructure-growth linkages in Uzbekistan remains sparse. Existing studies either focus on individual project-level assessments (Berdiyorov, 2021; Jurayev, 2022) or rely on descriptive analysis without rigorous econometric estimation. To the best of our knowledge, no study has yet applied time-series econometric methods to quantify the aggregate impact of PPP-based infrastructure investment on GDP growth in Uzbekistan.

This paper addresses this gap through four specific contributions. First, we construct a comprehensive annual dataset of PPP infrastructure investment for Uzbekistan spanning 2000–2023. Second, we estimate the long-run elasticity of GDP with respect to infrastructure investment using ARDL bounds testing. Third, we disaggregate the analysis by infrastructure sector to identify where multiplier effects are strongest. Fourth, we propose the "5I Strategic Model" — a policy framework synthesizing our empirical findings into actionable recommendations for accelerating PPP development in Uzbekistan.

The remainder of the paper is organized as follows. Section 2 reviews the relevant theoretical and empirical literature. Section 3 describes data sources and research methods. Section 4 presents empirical results. Section 5 discusses policy implications. Section 6 concludes.

2. MATERIALS: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Infrastructure Investment and Economic Growth

The theoretical foundations linking infrastructure investment to economic growth draw on multiple strands of macroeconomic thought. The Harrod-Domar growth model posits that infrastructure expands the productive capacity of the economy by reducing transport costs, improving market integration, and enhancing capital productivity. Endogenous growth models (Romer, 1990; Lucas, 1988) formalize these externalities, treating public infrastructure as a component of the broad knowledge and human capital stock that sustains long-run growth.

Aschauer (1989) provided the first systematic empirical evidence that public capital — particularly core infrastructure — exhibits an output elasticity of 0.39–0.56 in the United States, substantially higher than private capital. Subsequent work by Calderón and Servén (2004), using a panel of 121 countries over 1960–2000, confirmed that infrastructure quantity and quality exert a statistically significant positive effect on GDP per capita growth while reducing income inequality.

More recent studies have refined these estimates. Bom and Ligthart (2014), in a meta-analysis of 578 estimates from 68 studies, find a corrected output elasticity of public capital of approximately 0.15, with transport infrastructure yielding the highest returns. IMF (2014) estimates suggest that in advanced economies, a 1 percentage point of GDP increase in infrastructure investment raises output by about 1.5% over four years, with larger effects in economies operating below potential.

2.2. Public-Private Partnerships: Theory and Evidence

The economic rationale for PPPs is grounded in transaction cost theory (Williamson, 1985) and incomplete contracts theory (Hart, 2003). PPPs allocate risk to the party best able to manage it: the private sector assumes construction and operational risk, while the public sector retains demand risk and political risk. When bundled correctly, this risk transfer improves efficiency relative to traditional public procurement (Grimsey and Lewis, 2007).

Empirical evidence on PPP outcomes is mixed but increasingly favorable. Hodge and Greve (2017) synthesize findings from 25 OECD countries and conclude that PPP projects deliver value for money when institutional quality is sufficiently high, contracts are well-designed, and competitive tendering is enforced. In developing and transition economies, Hwang et al. (2019) find that PPPs generate GDP growth effects of 0.8–1.3% for each 1% increase in PPP investment share, somewhat lower than in advanced economies due to weaker institutional environments.

For Central Asia, empirical work remains limited. Makhmudov (2020) examines Kazakhstan's "Nurly Zhol" infrastructure programme and finds that PPP-financed road projects reduced transport costs by 18% and increased regional trade by 12% over five years. Nazarov and Yusupov (2023) analyze PPP outcomes in the Uzbek energy sector and document a positive correlation between private investment in electricity generation and regional industrial output, though causality testing is not performed.

2.3. Research Gap

The foregoing review reveals three principal gaps in the existing literature: (i) the absence of aggregate, time-series econometric evidence on PPP-growth linkages in Uzbekistan; (ii) the lack of sector-disaggregated analysis that would inform prioritization among competing infrastructure needs; and (iii) insufficient attention to the institutional moderators of PPP effectiveness in the specific context of Uzbekistan's transition economy. This study directly addresses all three gaps.

3. METHODS

3.1. Data Sources and Variable Construction

Our empirical analysis employs annual data for Uzbekistan over the period 2000–2023, comprising 24 observations. Data are drawn from the following sources: (i) State Statistics Committee of Uzbekistan for GDP at constant 2015 prices, gross capital formation, and employment; (ii) World Bank World Development Indicators (WDI) for trade openness, inflation, population growth, and institutional indicators; (iii) Asian Development Bank Private Participation in Infrastructure (PPI) database for PPP project values; (iv) UNCTAD for foreign direct investment flows.

The core dependent variable is the annual growth rate of real GDP (GDPGR, %). The primary independent variable of interest is PPP infrastructure investment as a share of GDP (PPPGDP, %). We disaggregate total PPP investment into three sectoral components: transport (TRANS), energy (ENERGY), and water and sanitation (WATER). Control variables include trade openness (TRADE, % of GDP), inflation (INF, CPI-based), population growth (POPGR, %), and an institutional quality index (INST) derived from the World Governance Indicators.

3.2. Econometric Specification

We proceed in three stages. First, we test for unit roots using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to determine the order of integration of each variable. Second, given the presence of variables integrated of order I(0) and I(1), we apply the ARDL bounds-testing approach of Pesaran, Shin and Smith (2001) to estimate the long-run relationship between infrastructure investment and GDP growth. The ARDL error-correction model is specified as:

$$\Delta GDPGR_t = \alpha_0 + \Sigma_{i=1}^{p} \beta_i \Delta GDPGR_{t-i} + \Sigma_{j=0}^{g} \gamma_j \Delta PPPGDP_{t-j} + \Sigma_{k=0}^{r} \delta_k \Delta X_{t-k} + \lambda_1 GDPGR_{t-1} + \lambda_2 PPPGDP_{t-1} + \lambda_3 X_{t-1} + \varepsilon_t$$

where X is a vector of control variables, p, q, r are optimal lag lengths selected by the Akaike Information Criterion (AIC), and λ_1, λ_2, λ_3 are the long-run multipliers. The bounds test examines the null hypothesis of no long-run relationship (H_0: $\lambda_1 = \lambda_2 = \lambda_3 = 0$) against the alternative of cointegration.

Third, we conduct Granger causality tests within a VAR framework to determine the direction of causality between PPP investment and GDP growth, and perform robustness checks using OLS with Newey-West heteroskedasticity and autocorrelation consistent (HAC) standard errors.

3.3. Diagnostic Tests

Model diagnostics include the Breusch-Godfrey LM test for serial correlation, the ARCH test for heteroskedasticity, the Ramsey RESET test for functional form misspecification, and the Jarque-Bera test for normality of residuals. CUSUM and CUSUM-of-squares tests are applied to assess parameter stability over the sample period.

4. RESULTS

4.1. Descriptive Statistics and Trends

Table 1 presents summary statistics for the key variables. Over the sample period, Uzbekistan's real GDP grew at an average annual rate of 6.2%, with notable deceleration during 2008–2009 (global financial crisis) and 2020 (COVID-19 pandemic). PPP infrastructure investment as a share of GDP averaged 1.8%, rising from a negligible base of 0.3% in 2000 to a peak of 3.4% in 2022, reflecting the post-2019 regulatory impetus.

Table 1. Descriptive Statistics of Key Variables (Uzbekistan, 2000–2023)

Variable	Mean	Std. Dev.	Min	Max	Obs.
GDP Growth Rate (%)	6.21	2.84	1.70	9.00	24
PPP Investment (% GDP)	1.82	0.97	0.30	3.40	24
Transport Investment (% GDP)	0.74	0.43	0.10	1.62	24
Energy Investment (% GDP)	0.68	0.38	0.12	1.41	24
Trade Openness (% GDP)	58.3	9.12	41.2	76.8	24
Inflation (CPI, %)	11.4	7.32	8.80	27.3	24

Source: State Statistics Committee of Uzbekistan; World Bank WDI; ADB PPI Database. Author's calculations.

4.2. Unit Root and Cointegration Tests

ADF and PP unit root tests indicate that GDPGR, TRADE, and INF are stationary at levels I(0), while PPPGDP, TRANS, ENERGY, INST, and POPGR are integrated of order one I(1). The mixed order of integration validates the use of the ARDL bounds-testing approach.

The ARDL bounds test yields an F-statistic of 6.84, which exceeds the upper critical value of 5.61 at the 1% significance level (Pesaran et al., 2001), confirming the existence of a long-run cointegrating relationship between PPP infrastructure investment and GDP growth in Uzbekistan.

4.3. Long-Run and Short-Run Estimates

Table 2 reports the long-run ARDL coefficient estimates. The long-run coefficient on total PPP infrastructure investment (PPPGDP) is 1.64 ($p < 0.01$), indicating that a 1 percentage point increase in PPP investment as a share of GDP is associated with a 1.64 percentage point increase in the long-run GDP growth rate — an economically and statistically significant effect. Sectoral disaggregation reveals that transport infrastructure yields the highest multiplier ($\beta = 1.87$), followed by energy ($\beta = 1.42$) and water supply ($\beta = 0.98$).

Table 2. ARDL Long-Run Coefficient Estimates (Dependent Variable: GDP Growth Rate)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Total PPP Investment (% GDP)	1.642***	0.218	7.531	0.000
Transport Infrastructure	1.871***	0.241	7.763	0.000
Energy Infrastructure	1.421***	0.197	7.218	0.000
Water & Sanitation	0.982**	0.312	3.147	0.012
Trade Openness (% GDP)	0.048**	0.019	2.527	0.024
Institutional Quality Index	0.831***	0.214	3.882	0.002
Inflation (CPI, %)	-0.112***	0.031	-3.617	0.003

Error Correction Term (ECT)	-0.483***	0.094	-5.139	0.000

*Note: ***, ** denote significance at 1% and 5% levels respectively. ARDL(2,1,1,0,1) selected by AIC. Newey-West HAC standard errors.*

The error correction term (ECT = -0.483, $p < 0.01$) confirms the long-run equilibrium relationship. The coefficient implies that approximately 48.3% of any short-run deviation from the long-run equilibrium is corrected within one year — a moderately fast adjustment speed consistent with Uzbekistan's economic reform momentum.

The institutional quality index ($\beta = 0.831$, $p < 0.01$) emerges as a significant moderator: higher governance quality amplifies the growth impact of infrastructure investment. This finding aligns with Hwang et al. (2019) and suggests that Uzbekistan's institutional reforms since 2017 have materially enhanced the productive efficiency of PPP investments.

4.4. Granger Causality Results

Granger causality tests within a bivariate VAR(2) framework reveal bidirectional causality between PPP infrastructure investment and GDP growth at the 5% significance level. This feedback relationship is consistent with the hypothesis that economic growth itself stimulates demand for infrastructure — creating a virtuous cycle where PPP investment and growth reinforce each other over time.

4.5. Diagnostic Tests

All diagnostic tests confirm model adequacy. The Breusch-Godfrey LM test finds no evidence of serial correlation ($\chi^2 = 2.14$, $p = 0.34$). The ARCH test indicates no conditional heteroskedasticity ($F = 1.07$, $p = 0.32$). The Ramsey RESET test does not reject correct functional form ($F = 1.38$, $p = 0.26$). Jarque-Bera normality test confirms normally distributed residuals ($JB = 1.92$, $p = 0.38$). CUSUM tests indicate parameter stability throughout the sample period.

5. DISCUSSION

Our findings make several important contributions to the understanding of infrastructure-growth dynamics in Uzbekistan and Central Asian transition economies more broadly.

The estimated long-run elasticity of 1.64 falls within the range reported by Calderón and Servén (2004) for developing economies (1.3–2.1) and exceeds the IMF's (2014) benchmark for advanced economies (approximately 1.5). This suggests that Uzbekistan currently operates in a state of significant infrastructure underprovision, where the marginal return to infrastructure investment is particularly high — a finding that reinforces the strategic priority accorded to infrastructure in the 2022–2026 Development Strategy.

The sectoral heterogeneity in multiplier effects is economically meaningful. Transport infrastructure's higher multiplier (1.87) reflects Uzbekistan's role as a landlocked transit economy where connectivity improvements generate large trade cost reductions. The importance of transport is consistent with findings by Donaldson (2018) for railroads in colonial India and by Faber (2014) for China's highway network. Energy infrastructure's multiplier (1.42) reflects Uzbekistan's energy-intensive industrial base and the binding constraint that power supply unreliability has historically imposed on manufacturing output.

The significant positive coefficient on institutional quality (0.831) carries important policy implications. It implies that the observed acceleration in PPP activity post-2019 is not solely a function of regulatory reform — institutional quality improvements (transparency, contract enforcement, regulatory predictability) are necessary complements. This finding echoes Acemoglu and Johnson (2005), who demonstrate that the security of property rights is a fundamental determinant of long-run investment and growth outcomes.

The bidirectional Granger causality between PPP investment and GDP growth supports a virtuous cycle interpretation: growing incomes expand the fiscal space and private willingness to invest in infrastructure, which in turn sustains growth. However, this also implies a risk of vicious cycles in downturns, underscoring the importance of counter-cyclical public guarantees and minimum revenue mechanisms in PPP contracts — instruments that Uzbekistan's current legal framework does not yet fully accommodate.

5.1. The 5I Strategic Model

Drawing on our empirical findings and comparative international experience, we propose the "5I Strategic Model" as an integrated policy framework for accelerating PPP-driven infrastructure investment in Uzbekistan. The model comprises five mutually reinforcing pillars:

- Investment: Expand long-term infrastructure financing instruments, including infrastructure bonds, Islamic sukuk, and blended finance facilities co-financed with multilateral development banks (ADB, EBRD, World Bank IFC).
- Institution: Strengthen the PPP Agency with independent regulatory status, a dedicated PPP unit within the Ministry of Economy and Finance, and standardized contract templates aligned with international best practice.
- Infrastructure: Prioritize transport connectivity (road corridors, intermodal logistics hubs) and renewable energy (solar, wind) as the highest-multiplier sectors, while developing a pipeline of bankable projects with pre-feasibility studies publicly available.
- Innovation: Digitize the PPP project cycle through a national PPP portal (project registration, competitive tendering, performance monitoring), and integrate ESG (environmental, social, governance) metrics into project evaluation.
- Integration: Leverage regional connectivity initiatives (Trans-Caspian International Transport Route, BRI) to attract cross-border PPP investment, and harmonize PPP regulation with Central Asian regional standards.

Scenario projections suggest that full implementation of the 5I Model could raise PPP investment from the current 2.1% of GDP to 4.5–5.0% by 2030, generating cumulative additional GDP growth of 4.2–5.8 percentage points over the period — transformative in scale relative to Uzbekistan's current growth trajectory.

6. CONCLUSION

This study provides the first comprehensive econometric analysis of the relationship between public-private partnership infrastructure investment and economic growth in Uzbekistan. Using annual data for 2000–2023 and ARDL bounds-testing methodology, we establish a robust long-run cointegrating relationship, with a long-run elasticity of GDP growth with respect to PPP investment of 1.64. Transport infrastructure yields the highest multiplier effect (1.87), followed by energy (1.42) and water supply (0.98). Institutional quality significantly amplifies these effects.

These findings carry clear policy implications. Uzbekistan's post-2019 PPP regulatory reforms have laid a solid foundation, but realizing the full growth potential of infrastructure investment requires deepening institutional capacity, expanding long-term financing instruments, and embedding PPP development within a coherent strategic framework. The proposed 5I Strategic Model — encompassing Investment, Institution, Infrastructure, Innovation, and Integration — provides a structured roadmap for achieving this objective.

Several limitations of the current study should be acknowledged. The relatively short time series (24 observations) limits statistical power and precludes more granular econometric specifications. The PPP investment data rely on reported project values, which may not fully capture actual capital disbursements. Future research should incorporate sub-national panel data, extend the analysis to include social infrastructure (health, education), and apply synthetic control methods to evaluate the causal impact of specific landmark PPP projects.

Notwithstanding these limitations, this study makes an original and policy-relevant contribution to the economics of infrastructure development in transition economies, with direct applicability to Uzbekistan's ongoing reform agenda.

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