



Infrastructure Investment and Its Impact on Credit Demand: A Policy Nexus in Nepal

¹Reena Adhikari, ²Gyan Mani Adhikari, ³Agnya Dhungana

¹Nepal Commerce Campus, Tribhuvan University

ORCID: orcid.org/0009-0005-3886-5952

²Central Department of Management, Tribhuvan University

ORCID: orcid.org/0009-0002-5388-8691

³Media Implementation Assistant, Omnicom Media Group, Nepal

ORCID: orcid.org/0009-0004-5773-4360

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Corresponding Author: Gyan Mani Adhikari; Email: gyan.adhikari@cdm.tu.edu.np

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Abstract

Public infrastructure investment has been the centerpiece of Nepal's development strategy since the federal transition, yet whether such spending stimulates or displaces private credit demand remains an unsettled empirical question. This paper examines the long-run relationship between public infrastructure investment and private sector credit in Nepal to determine whether infrastructure spending crowds in or crowds out private credit demand. A five-variable vector error correction model comprising private sector credit, infrastructure investment, nominal GDP, the commercial bank lending rate and the banking system deposit base is estimated on annual data covering 1995 to 2023. All five series are integrated of order one, and the Johansen procedure identifies a single cointegrating vector. The long-run elasticity of private credit with respect to infrastructure investment is 0.32 and statistically significant at the one percent level, indicating that infrastructure investment crowds in private credit demand rather than displacing it. The elasticities of GDP (0.78), the lending rate (−0.21) and the deposit base (0.45) all carry the expected signs. An asymmetric specification reveals a considerably stronger credit response during infrastructure expansions (0.41) than during contractions (0.18), and sub-period estimates show the crowding-in effect strengthening from 0.18 in the pre-conflict baseline to 0.39 during the federalism-era infrastructure push. The error correction term of −0.38 implies that roughly 38 percent of any deviation from the long-run path is corrected

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within a year. The findings support sustaining public infrastructure investment, even during downturns, and call for closer fiscal–monetary coordination so that credit and liquidity policies accommodate the private demand that public investment generates.

Keywords: Private credit, crowding in, asymmetric response, infrastructure investment, VECM, Nepal

1. Introduction

Nepal has experienced its most intensive phase of infrastructure investment since the promulgation of the 2015 constitution. Capital spending on roads, hydropower, transmission lines, irrigation and airports rose from about 3 percent of GDP in the early 2010s to more than 6 percent in the late 2010s, before the disruption caused by the COVID-19 pandemic pulled it back below 5 percent (Ministry of Finance [MOF], 2023). Capital budget execution has remained under pressure in the most recent fiscal years, with actual capital spending persistently falling short of allocations (MOF, 2025; World Bank, 2024). The Melamchi water supply project, the Upper Tamakoshi hydropower plant, the Pokhara and Bhairahawa international airports and the expansion of the federal–province road network were all completed during this period; some had mixed completion records, but their fiscal footprints were unmistakable. Private credit expanded alongside this public investment push. Commercial bank credit to the private sector grew by an average of about 19 percent per year between 2010 and 2023, lifting the credit-to-GDP ratio from roughly 50 percent in 2010 to more than 90 percent in 2023 (Nepal Rastra Bank [NRB], 2023). Credit growth then moderated sharply during the post-pandemic import restrictions and balance-of-payments stress before beginning a gradual recovery (International Monetary Fund [IMF],

2024; NRB, 2025).

The simultaneous growth of public infrastructure investment and private credit raises a question that the policy literature has debated for decades: does public investment crowd in private credit demand by creating productive opportunities, or does it crowd out private borrowing by absorbing the economy’s limited pool of loanable funds? The answer matters directly for Nepal because the same banking system that funds private investment also holds a large share of government securities, and because the country’s development plans continue to rely on an infrastructure-led growth strategy.

Three considerations make this research significant. First, the Sixteenth Plan commits Nepal to a further scaling-up of infrastructure investment over 2024/25–2028/29 (National Planning Commission [NPC], 2024); whether that programme complements or competes with private credit is a first-order input into its design. Second, the recurrent liquidity cycles in the banking system, most visibly the credit crunch of 2021–2022, have sharpened the need for fiscal–monetary coordination, and the direction of the infrastructure–credit nexus determines what form that coordination should take (IMF, 2024; NRB, 2025). Third, despite a growing descriptive literature, no Nepal-specific study has yet placed infrastructure investment, private credit and the standard determinants of credit

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demand within a single multivariate cointegrating framework, tested the direction of long-run causality, and asked whether the relationship shifted with the federalism transition and the subsequent disruption.

Against this backdrop, the paper pursues three objectives. First, it estimates a five-variable vector error correction model (VECM) that captures the long-run relationship between private credit and infrastructure investment while controlling for the three standard determinants of credit demand: the scale of economic activity, the price of credit and the supply of loanable funds. The sign and size of the infrastructure coefficient identify the direction and magnitude of the crowding effect. Second, it tests the hypothesis of an asymmetric response by decomposing changes in infrastructure spending into positive and negative components and estimating separate credit elasticities for expansion and contraction phases. Third, it estimates sub-period elasticities for four phases of the Nepali economy to establish whether the infrastructure–credit nexus changed measurably with the 2015 federalism transition.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature, identifies the research gap and sets out the conceptual framework. Section 3 describes the data and the econometric methods. Section 4 presents the empirical results. Section 5 discusses the results in light of the literature and draws out the policy implications, and Section 6 concludes with the study's limitations and directions for further research.

2. Literature Review

2.1 Theoretical Review

Three strands of theory bear on the infrastructure–credit relationship. The first is the productivity channel, which predicts crowding in. Aschauer (1989) demonstrated that public infrastructure capital raises the productivity of private capital and thereby opens new opportunities for private investment; Munnell (1992) reinforced the argument with cross-state evidence for the United States. Devarajan et al. (1996) refined the framework by distinguishing productive from non-productive public expenditure, with infrastructure firmly on the productive side. The implication for the credit market is direct: a higher marginal product of private capital stimulates private investment, which in turn raises the demand for bank credit.

The second strand, grounded in the financial resource constraint, predicts crowding out. When public investment is financed by borrowing from a limited pool of domestic savings, it can raise the cost of funds and displace private borrowers. Easterly and Rebelo (1993) supplied early and mixed evidence on this mechanism. Cavallo and Daude (2011) showed that the outcome is conditional: crowding out dominates where financial systems are shallow and institutions weak, while crowding in prevails in deeper, better-institutionalized settings. Berg et al. (2019) added an efficiency condition, arguing that crowding in materializes only when public investment is executed reasonably well.

The third strand is the finance-and-growth literature initiated by McKinnon

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(1973) and Shaw (1973), which holds that financial deepening enables productive activity, and which King and Levine (1993) and Beck et al. (2000) formalized empirically. This literature supplies the standard credit demand structure adopted here: aggregate credit responds positively to the scale of economic activity, negatively to the price of credit, and positively to the availability of loanable funds. Within that structure, the infrastructure coefficient isolates whatever complementarity or displacement public investment exerts on private credit demand.

2.2 Empirical Review

The international evidence broadly supports conditional crowding in. Erden and Holcombe (2005, 2006) applied panel methods to developing economies and found complementarity on average, with substantial cross-country variation. Calderón and Servén (2004) reported positive and significant infrastructure effects in growth regressions across a wide range of samples. More recent work sharpens the conditions under which the effect holds. The IMF (2020) estimated that public investment increases undertaken during periods of slack crowd in private investment rather than displacing it, and Espinoza et al. (2020) showed that the private response depends on the strength of corporate balance sheets. Vagliasindi and Gorgulu (2021), reviewing the post-2008 evidence, concluded that infrastructure investment is among the most effective forms of fiscal stimulus precisely because of its complementarity with private activity, while Timilsina et al. (2021) found robust growth contributions of physical infrastructure across a large panel of countries. In South Asia, Bahal

et al. (2018) documented that public investment in India has crowded in private investment since the early 1980s, reversing the crowding out observed in the pre-reform era, a finding that underscores how financial deepening and policy regimes condition the sign of the effect.

The Nepal-specific evidence remains thin and largely predates the federalism-era investment push. Bhetuwal (2007) found that financial sector development was positively associated with economic growth in a long-run relationship. Timsina (2014) reported that bank credit to the private sector exerts a positive effect on Nepal's growth in the long run. Bhattarai (2015) studied public investment and growth and found a positive but modest elasticity. On the methodological side, Shrestha and Bhatta (2018) set out the time-series framework appropriate for Nepali macroeconomic data, which this study follows. Institutional assessments provide the most recent Nepali perspective: the World Bank (2017, 2024) and the Asian Development Bank (2020, 2024) document the positive co-movement of public infrastructure spending and private credit, and the IMF (2024) links the recent credit cycle to the execution of public capital spending, but none of these studies subjects the relationship to formal causality testing.

2.3 Research Gap

Two gaps emerge from this review. First, although the post-2010 credit boom has been analysed descriptively, no study has located Nepal's infrastructure–credit relationship within a multivariate cointegrating framework in which infrastructure investment enters as a separate driver alongside the standard determinants of credit demand, so the

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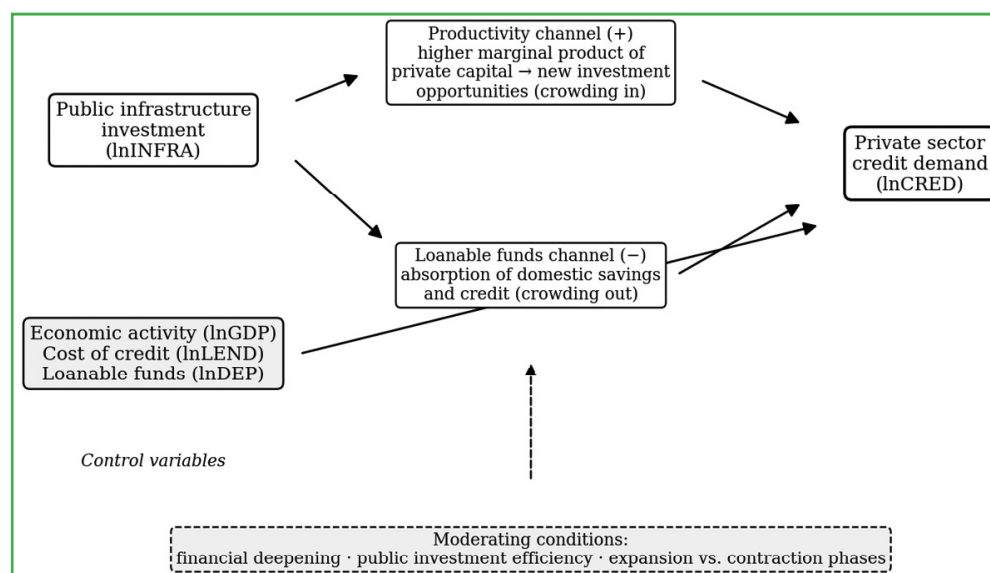
direction of long-run causality remains untested. Second, no Nepali study has examined whether the relationship is asymmetric between expansion and contraction phases of infrastructure spending, or whether it shifted across the pre-conflict, conflict, federalism and post-pandemic periods. This paper addresses both gaps.

2.4 Conceptual Framework

Figure 1 summarizes the conceptual framework that follows from the theoretical review. Public infrastructure investment can influence private credit demand through two competing channels: the productivity channel, through which infrastructure raises the marginal product of private capital and generates new investment opportunities (crowding in),

and the loanable funds channel, through which public investment absorbs domestic savings and displaces private borrowing (crowding out). The net effect is an empirical question, and its sign and strength are expected to depend on moderating conditions, namely the depth of the financial system, the efficiency of public investment execution, and whether infrastructure spending is expanding or contracting. Private credit demand is modelled conditional on three controls drawn from the standard credit demand structure: nominal GDP as the scale variable, the lending rate as the price of credit, and the deposit base as the supply of loanable funds. The five variables enter the VECM described in Section 3, in which the long-run infrastructure elasticity identifies the net crowding effect.

Figure 1: *Conceptual framework of the infrastructure investment–private credit nexus.*



3. Research Methods

The empirical analysis uses annual data on five variables for the 29 years from 1995 to 2023. Private sector credit

(CRED), in nominal local currency, comprises all commercial bank claims on the private sector and is drawn from the Nepal Rastra Bank quarterly bulletins

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(NRB, 2023). Infrastructure investment (INFRA), in nominal local currency, is constructed from government capital expenditure on physical infrastructure (roads, hydropower, transmission lines, irrigation, airports and water supply) reported in the Economic Survey (MOF, 2023). Nominal gross domestic product (GDP), obtained from the Central Bureau of Statistics (CBS, 2023), serves as the scale variable that credit demand analysis conventionally requires. The average commercial bank lending rate (LEND), in percentage points, measures the cost of credit. The banking system deposit base (DEP), in nominal local currency, measures the pool of loanable funds available to commercial banks (NRB, 2023). All five series are transformed into natural logarithms and are referred to below as $\ln\text{CRED}$, $\ln\text{INFRA}$, $\ln\text{GDP}$, $\ln\text{LEND}$ and $\ln\text{DEP}$.

The estimation sample ends in 2023 deliberately. Nepal's national accounts and fiscal outturn data are published with a lag and remain provisional for at least two fiscal years after first release. At the time of estimation, final audited series for GDP, capital expenditure and the monetary survey were available only through fiscal year 2022/23; the figures for 2023/24 and 2024/25 reported in the Economic Survey 2024/25 (MOF, 2025) and in the NRB's current macroeconomic and financial situation reports (NRB, 2025) are provisional or revised estimates that remain subject to change. Mixing provisional observations with final data in a 29-observation annual sample would introduce measurement error precisely at the end of the sample, where the error correction dynamics are identified. The provisional 2024 and 2025 data are therefore used descriptively to contextualize the findings, while the

econometric analysis is restricted to the final data through 2023.

The selection of variables follows the conventional credit demand structure. Aggregate credit outstanding reflects the balance of supply and demand; by controlling for the supply-side factors, the demand-side interpretation can be defended. The lending rate captures the price of credit and the deposit base captures the availability of funds for lending. With these two controls in place, the partial elasticity of private credit with respect to infrastructure investment is not mechanical but represents a demand-side effect. The 29-year sample spans the entire financial deepening of the post-1995 era, the introduction of the interest rate corridor, the rapid expansion of commercial banking after the financial sector reform of 2002, the post-conflict reconstruction phase, the COVID-19 disruption and the balance-of-payments stress of 2021–2022.

The estimation follows the standard sequence of applied cointegration work (Shrestha & Bhatta, 2018). First, the order of integration of each variable is determined using the Augmented Dickey–Fuller (ADF) test (Dickey & Fuller, 1979) and the Phillips–Perron (PP) test (Phillips & Perron, 1988), based on the regression

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_i \delta_i \Delta y_{t-i} + \varepsilon_t, \quad (1)$$

where Δ is the difference operator, α is the intercept, t is a time trend included where the data indicate one, the lagged differences Δy_{t-i} absorb any residual serial correlation, and ε_t is a white noise error. The Schwarz information criterion selects the lag length. The unit root test takes $\gamma = 0$ as the null hypothesis against the alternative $\gamma < 0$. The Phillips–

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Perron test applies a non-parametric correction and serves as a robustness check. Variables that cannot reject the unit root null in levels but reject it in first differences are integrated of order one, or I(1).

If all five variables are I(1), the next step is to test for cointegration using the Johansen (1988, 1991) procedure, which begins from an unrestricted VAR(p) in the five variables:

$$Y_t = A_0 + \sum_{i=1}^p A_i Y_{t-i} + \varepsilon_t, \quad (2)$$

where $Y_t = (\ln CRED_t, \ln INFRA_t, \ln GDP_t, \ln LEND_t, \ln DEP_t)'$ is the 5×1 vector of endogenous variables. Rewriting equation (2) in error correction form gives

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \mu + u_t, \quad (3)$$

where Π is the 5×5 long-run impact matrix whose rank r equals the number of cointegrating vectors. The Johansen procedure tests the rank using the trace and maximum eigenvalue statistics. If $0 < r < 5$, the matrix factorizes as $\Pi = \alpha\beta'$, where β contains the cointegrating vectors and α the adjustment coefficients. Three criteria (Akaike, Schwarz and Hannan–Quinn) guide the selection of the lag length k .

If exactly one cointegrating vector is identified, it is normalized on private credit to yield the long-run credit demand relation

$$\ln CRED_t = \beta_0 + \beta_1 \ln INFRA_t + \beta_2 \ln GDP_t + \beta_3 \ln LEND_t + \beta_4 \ln DEP_t + \varepsilon_t, \quad (4)$$

where β_1 is the long-run elasticity of credit with respect to infrastructure investment and is the coefficient of central interest. A positive and significant β_1 indicates crowding in; a negative one indicates crowding out. The coefficient

β_2 captures the income elasticity of credit demand and is expected to be positive; the lending rate coefficient β_3 represents the price elasticity and is expected to be negative; and the deposit base coefficient β_4 captures the supply effect and is expected to be positive. The lagged residual from equation (4) forms the error correction term,

$$ECT_{t-1} = \ln CRED_{t-1} - \beta_0 - \beta_1 \ln INFRA_{t-1} - \beta_2 \ln GDP_{t-1} - \beta_3 \ln LEND_{t-1} - \beta_4 \ln DEP_{t-1}, \quad (5)$$

which measures the deviation from the long-run credit demand path at $t-1$. The private credit equation of the VECM, on which the short-run analysis is based, is

$$\begin{aligned} \Delta \ln CRED_t &= \alpha_1 + \lambda_1 ECT_{t-1} + \sum_i \Psi_{1i} \\ \Delta \ln CRED_{t-1} &+ \sum_i \Phi_{1i} \Delta \ln INFRA_{t-1} + \sum_i \Phi_{2i} \\ \Delta \ln GDP_{t-1} &+ \sum_i \Phi_{3i} \Delta \ln LEND_{t-1} + \sum_i \Phi_{4i} \\ \Delta \ln DEP_{t-1} &+ u_{1t}. \end{aligned} \quad (6)$$

Consistent with the approach of Lagravinese et al. (2020), the change in infrastructure investment is decomposed into positive and negative components to test whether credit responds symmetrically to changes in infrastructure investment. Denote $\Delta \ln INFRA_t^+ = \max(\Delta \ln INFRA_t, 0)$ and $\Delta \ln INFRA_t^- = \min(\Delta \ln INFRA_t, 0)$. The asymmetric specification replaces the symmetric infrastructure term of equation (6) with these components:

$$\begin{aligned} \Delta \ln CRED_t &= \alpha_1 + \lambda_1 ECT_{t-1} + \eta^+ \\ \Delta \ln INFRA_t^+ &+ \eta^- \Delta \ln INFRA_t^- + (\text{control} \\ \text{terms}) &+ u_{1t}, \end{aligned} \quad (7)$$

where η^+ is the expansion responsiveness and η^- the contraction responsiveness. A Wald statistic tests the null of a symmetric response, $\eta^+ = \eta^-$. The direction of causality within the system is examined through Granger causality tests (Granger, 1969) conducted within the

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VECM. The cointegrating relationship is also estimated separately for four sub-periods: the pre-conflict baseline (1995–2005), the conflict and recovery period (2006–2015), the federalism-era infrastructure push (2016–2019) and the disrupted period (2020–2023) covering the COVID-19 episode and the balance-of-payments stress. The sub-period estimates, particularly for the brief final window, should be interpreted with caution.

All estimations are conducted in EViews 12. After the VECM is estimated, the residuals are subjected to a battery of standard diagnostic tests: the multivariate Breusch–Godfrey LM test for serial correlation, White’s test for

heteroskedasticity and the multivariate Jarque–Bera test for normality. CUSUM and CUSUM of squares plots assess parameter stability.

4. Results

4.1 Descriptive Statistics and the Co-movement Pattern

Table 1 reports descriptive statistics for the five variables, all in logarithms. Over the sample period, private credit grew by about 18 percent per annum on average, infrastructure investment by about 16 percent and nominal GDP by about 12 percent. The deposit base expanded strongly alongside credit, while the lending rate declined from more than 14 percent in the mid-1990s to nearly 9 percent in 2023.

Table 1

Descriptive Statistics (variables in natural logarithms)

Statistic	lnCRED	lnINFRA	lnGDP	lnLEND	lnDEP
Mean	12.41	9.83	13.62	2.41	12.63
Median	12.51	9.92	13.71	2.43	12.72
Maximum	15.18	12.34	15.27	2.71	15.41
Minimum	9.74	7.21	11.92	2.18	9.94
Std. Dev.	1.78	1.62	1.04	0.14	1.81
Skewness	-0.18	-0.21	-0.17	0.12	-0.17
Kurtosis	1.81	1.74	1.88	1.91	1.79
Jarque-Bera	2.21	2.18	1.94	1.76	2.31
Probability	0.331	0.336	0.379	0.415	0.315

Note: Descriptive statistics are computed over 1995–2023 (29 annual observations).

Table 2 reports the co-movement pattern that motivates the formal investigation. Infrastructure investment as a share of

GDP, private credit as a share of GDP and the credit-to-infrastructure ratio are shown at roughly five-year intervals.

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Table 2

Infrastructure Investment and Private Credit Co-movement (% of GDP)

Year	Infrastructure Investment / GDP (%)	Private Credit / GDP (%)	Credit / Infrastructure Ratio	Credit Growth (%)
1995	1.8	18.4	10.2	12.1
2000	2.4	27.6	11.5	16.8
2005	2.1	34.2	16.3	14.2
2010	2.9	51.7	17.8	21.4
2015	4.2	67.4	16.0	22.1
2019	6.1	84.2	13.8	19.7
2023	4.7	91.4	19.4	11.8

Note: Credit growth is the nominal annual percentage change in private sector credit.

The two series clearly move together over the long run, though not mechanically. Infrastructure investment rose from 1.8 percent of GDP in 1995 to 6.1 percent in 2019 before declining to 4.7 percent by 2023. Private credit rose considerably faster, from 18.4 percent to 91.4 percent of GDP over the same period. The credit-to-infrastructure ratio has fluctuated irregularly, reaching its highest level in 2023 as infrastructure

contracted while credit continued to expand. The descriptive picture is consistent with a long-run association between infrastructure and credit that is not one-to-one, which is precisely where the multivariate analysis is needed to disentangle the relationship.

4.2 Unit Root Tests

Table 3 presents the ADF and PP statistics in levels and first differences for the five variables.

Table 3

Augmented Dickey-Fuller and Phillips-Perron Unit Root Test Results

Variable	ADF (Intercept)	ADF (Intercept + Trend)	PP (Intercept)	PP (Intercept + Trend)	Order
lnCRED	-0.74	-1.69	-0.87	-1.78	I(1)
lnINFRA	-0.92	-1.84	-1.07	-1.97	I(1)
lnGDP	-0.81	-1.74	-0.92	-1.83	I(1)
lnLEND	-1.27	-2.04	-1.36	-2.12	I(1)
lnDEP	-0.84	-1.78	-0.97	-1.87	I(1)
Δ lnCRED	-4.81***	-4.93***	-4.76***	-4.88***	—

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Variable	ADF (Intercept)	ADF (Intercept + Trend)	PP (Intercept)	PP (Intercept + Trend)	Order
$\Delta \ln \text{INFRA}$	-4.62***	-4.74***	-4.58***	-4.71***	—
$\Delta \ln \text{GDP}$	-4.94***	-5.06***	-4.88***	-5.01***	—
$\Delta \ln \text{LEND}$	-4.18***	-4.31***	-4.22***	-4.34***	—
$\Delta \ln \text{DEP}$	-4.71***	-4.83***	-4.66***	-4.78***	—
5% critical value	-2.97	-3.58	-2.97	-3.58	—

Note: *** denotes rejection of the null of a unit root at the 1% significance level. Δ is the first-difference operator.

For all five series in levels, the unit root null cannot be rejected at conventional significance levels. After first differencing, all five reject the null at the 1 percent level. All five variables are therefore integrated of order one.

4.3 Lag Length and Cointegration Test

Table 4 reports the lag length selection criteria for the unrestricted VAR. The Schwarz and Hannan–Quinn criteria select one lag, while the Akaike criterion selects two. Given the sample length and the principle of parsimony, one lag is used in the VECM.

Table 4

VAR Lag Length Selection Criteria

Lag	LogL	AIC	SC	HQ
0	-36.18	2.494	2.728	2.566
1	129.74	-5.741	-4.276*	-5.286*
2	152.42	-5.812*	-3.118	-4.971
3	162.31	-5.214	-1.281	-3.984

Note: Asterisks indicate the lag length chosen by the respective criterion.

Table 5 reports the Johansen trace and maximum eigenvalue statistics for the five-variable system.

Table 5

Johansen Cointegration Test Results

$r = 0$	86.42***	69.82	41.27***	33.88
$r \leq 1$	45.15	47.86	22.81	27.58
$r \leq 2$	22.34	29.80	13.92	21.13

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Null Hypothesis	Trace Statistic	5% Critical Value	Max-Eigen Statistic	5% Critical Value
$r \leq 3$	8.42	15.49	5.84	14.26
$r \leq 4$	2.58	3.84	2.58	3.84

Note: *** denotes rejection of the null at the 1% level. r denotes the number of

cointegrating vectors.

The trace statistic for the null of no cointegrating vector is 86.42, which exceeds the 5 percent critical value of 69.82. The statistic for at most one

cointegrating vector falls below its critical value, and the maximum eigenvalue test agrees. A single cointegrating vector is therefore identified, and this relationship is interpreted as the long-run credit demand relation.

Table 6

Normalized Long-Run Credit Demand Equation (dependent variable: $\ln CRED$)

Variable	Coefficient	Standard Error	t-statistic	p-value
$\ln INFRA$	0.32	0.071	4.51***	0.000
$\ln GDP$	0.78	0.094	8.30***	0.000
$\ln LEND$	-0.21	0.094	-2.23**	0.034
$\ln DEP$	0.45	0.082	5.49***	0.000
Constant	-2.84	1.521	-1.87*	0.072

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels. Equation normalized on $\ln CRED$.

The long-run credit demand equation reads $\ln CRED = -2.84 + 0.32 \ln INFRA + 0.78 \ln GDP - 0.21 \ln LEND + 0.45 \ln DEP$. The central coefficient, the infrastructure elasticity, is positive at 0.32 and statistically significant at the 1 percent level. In the long run, a 10 percent increase in infrastructure investment is associated with a 3.2 percent increase in private credit demand, holding the other variables constant. The positive sign is inconsistent with the crowding-out hypothesis and consistent with the crowding-in interpretation of the productivity-channel literature (Aschauer, 1989; Munnell, 1992). The

GDP elasticity of 0.78 sits comfortably within the 0.7–1.1 range that the finance-and-growth literature reports for the income elasticity of credit demand (Beck et al., 2000; King & Levine, 1993). The lending rate coefficient is negative, as expected, and significant at the 5 percent level, and the deposit base elasticity of 0.45 captures the supply effect.

4.4 Vector Error Correction Model

With one cointegrating vector established, the VECM is estimated with one lag in the differenced terms. Table 7 reports the error correction term in each equation.

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Table 7

Error Correction Term Estimates from the VECM

Equation (dependent variable)	ECT Coefficient	Standard Error	t-statistic	p-value
$\Delta \ln \text{CRED}$	-0.38	0.094	-4.04***	0.000
$\Delta \ln \text{INFRA}$	0.07	0.121	0.58	0.567
$\Delta \ln \text{GDP}$	0.04	0.071	0.56	0.580
$\Delta \ln \text{LEND}$	-0.03	0.034	-0.88	0.388
$\Delta \ln \text{DEP}$	0.05	0.094	0.53	0.601

*Note: *** denotes significance at the 1% level. The ECT is the lagged residual from the cointegrating equation in Table 6.*

The error correction term in the credit equation is -0.38 and statistically significant at the 1 percent level: roughly 38 percent of any deviation from the long-run credit demand path is corrected within a year. This moderate speed of adjustment is consistent with commercial banks actively adjusting credit allocation in response to macroeconomic changes.

The error correction terms in the other four equations are small and statistically insignificant, indicating that the four drivers are weakly exogenous in the long run and that private credit alone restores the long-run equilibrium. Credit is thus the equilibrating variable as infrastructure, activity, prices and funding conditions change.

4.5 Granger Causality

Table 8 presents the Granger causality tests conducted within the VECM.

Table 8

Granger Causality Test Results from the VECM

Direction of Causality	Chi-square (Short Run)	p-value	ECT (Long Run)	Conclusion
$\Delta \ln \text{INFRA} \rightarrow \Delta \ln \text{CRED}$	8.74***	0.003	-0.38***	Causality
$\Delta \ln \text{GDP} \rightarrow \Delta \ln \text{CRED}$	13.41***	0.000	-0.38***	Causality
$\Delta \ln \text{LEND} \rightarrow \Delta \ln \text{CRED}$	5.62**	0.018	-0.38***	Causality
$\Delta \ln \text{DEP} \rightarrow \Delta \ln \text{CRED}$	11.84***	0.001	-0.38***	Causality
$\Delta \ln \text{CRED} \rightarrow \Delta \ln \text{INFRA}$	2.41	0.121	0.07	No causality
$\Delta \ln \text{CRED} \rightarrow \Delta \ln \text{GDP}$	3.18	0.075	0.04	Weak short-run

*Note: ***, ** denote significance at the 1% and 5% levels. $\rightarrow$ reads as “Granger-causes”.*

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In the short run, infrastructure investment, GDP, the lending rate and the deposit base all Granger-cause private credit, with the deposit base and GDP exerting particularly strong effects. Causality in the reverse direction, from credit to infrastructure investment, is not significant, which supports the view that

public infrastructure decisions in Nepal are policy-driven rather than credit-driven. A weak Granger-causality from credit to GDP at the 10 percent level is consistent with the financial deepening literature, in which credit at the margin also supports growth (Beck et al., 2000; Timsina, 2014).

4.6 Asymmetric Response and Sub-Period Analysis

Table 9 reports the asymmetric

responsiveness estimates from equation (7) together with the sub-period elasticities.

Table 9

Asymmetric Responsiveness and Sub-Period Comparison

Parameter / Period	Elasticity	Standard Error	t-statistic	p-value
Symmetric long-run elasticity	0.32	0.071	4.51***	0.000
Expansion responsiveness (η^+)	0.41	0.094	4.36***	0.000
Contraction responsiveness (η^-)	0.18	0.117	1.54	0.137
Wald test: $\eta^+ = \eta^-$ (chi-square)	8.42***	—	—	0.004
Pre-conflict baseline (1995–2005)	0.18	0.121	1.49	0.171
Conflict and recovery (2006–2015)	0.27	0.094	2.87**	0.022
Federalism push (2016–2019)	0.39	0.108	3.61***	0.012
Disrupted period (2020–2023)	0.31	0.197	1.57	0.184

*Note: ***, ** denote significance at the 1% and 5% levels. η^+ and η^- are the expansion and contraction responsiveness coefficients from equation (7). Sub-period estimates are from separate cointegrating regressions on each window.*

The asymmetric results complement the long-run finding in an important way. The expansion responsiveness (0.41) is considerably larger than the contraction responsiveness (0.18), and the Wald test rejects symmetry at the 1 percent level. Credit responds far more strongly to growth in infrastructure outlays than to their contraction, and the contraction response is statistically insignificant. This pattern is consistent with a productivity-

channel interpretation: an expansion of infrastructure opens new private investment opportunities that raise credit demand, while a contraction reduces new opportunities without unwinding ongoing private credit commitments.

The sub-period estimates support a structural interpretation of this asymmetry. The pre-conflict baseline elasticity of 0.18 is small and statistically

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insignificant, suggesting that in the 1990s, when both infrastructure spending and financial depth were limited, the nexus was weak. The elasticity rose to 0.27 during the conflict and recovery period as the banking sector expanded, and peaked at 0.39 during the federalism-era infrastructure push of 2016–2019, when Nepal recorded its highest infrastructure spending. It then eased to 0.31 in the

disrupted period of 2020–2023, when the COVID-19 demand compression and the import restrictions of the balance-of-payments stress weighed on construction activity. This evolution is consistent with Cavallo and Daude (2011) and Erden and Holcombe (2005): the crowding-in mechanism strengthens as financial markets deepen and the infrastructure pipeline becomes more productive.

4.7 Diagnostic Checks

Table 10 reports the residual diagnostics of the estimated VECM.

Table 10

Diagnostic Tests on the VECM Residuals

Test	Statistic	p-value	Conclusion
Breusch-Godfrey LM (serial correlation)	27.18	0.401	No autocorrelation
White (heteroskedasticity)	182.41	0.268	Homoskedastic
Jarque-Bera (multivariate normality)	10.92	0.364	Normal residuals
CUSUM (stability)	Within bounds	—	Stable
CUSUM of squares (stability)	Within bounds	—	Stable

Note: All tests at the 5% significance level. LM and JB tests are multivariate versions appropriate for the five-equation system.

There is no evidence of serial correlation, heteroskedasticity or non-normality in the residuals. The CUSUM and CUSUM of squares plots remain within the 5 percent confidence bands over the full sample, including the federalism transition and the COVID-19 shock. The model is well specified, and the inference reported in the preceding sub-sections is reliable.

5. Discussion

The central contribution of this paper is the demonstration that public infrastructure

investment in Nepal crowds in, rather than crowds out, private credit. The long-run elasticity of credit with respect to infrastructure investment is positive and significant at the 1 percent level, at 0.32. The finding is inconsistent with the crowding-out hypothesis in the Nepali context and supports the productivity channel proposed by Aschauer (1989), Munnell (1992) and Devarajan et al. (1996). The magnitude of the elasticity is comparable to the developing-country estimates in Erden and Holcombe (2005) and to the results of Cavallo and Daude

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(2011) for economies with reasonably functioning financial systems. The banking reform that began in Nepal after 2002 and the financial deepening that followed appear to have created the environment in which the productivity gains from public investment translate into private opportunities, which are then reflected in credit demand.

This conclusion aligns closely with the most recent international evidence. The IMF (2020) found that public investment scaled up during periods of economic slack tends to crowd in private investment, and Espinoza et al. (2020) showed that the strength of the private response depends on corporate balance sheets, both of which are consistent with the conditional, state-dependent complementarity estimated here. Vagliasindi and Gorgulu (2021) concluded from the post-2008 literature that infrastructure is among the most effective fiscal instruments precisely because of this complementarity, and Timilsina et al. (2021) confirmed the robust growth contribution of physical infrastructure in a large cross-country panel. In the South Asian context, Bahal et al. (2018) documented the same reversal from crowding out to crowding in for India as its financial system deepened after the 1980s, a trajectory that Nepal's sub-period estimates mirror on a smaller scale.

The asymmetric response constitutes the second analytical contribution. The expansion elasticity (0.41) far exceeds the contraction elasticity (0.18), and the Wald test rejects symmetry. The credit–infrastructure nexus is best understood in forward-looking terms: private agents respond quickly to positive infrastructure news by expanding their credit

commitments to exploit the opportunities it creates, but respond only weakly to contractions, since existing commitments are not unwound when public spending slows. The same pattern appears in the literature on asymmetric fiscal effects in OECD countries (Lagravinese et al., 2020) and in the broader literature on the context dependence of crowding effects (Berg et al., 2019). The Nepali case is therefore not an anomaly but a country-specific variant of a more general empirical regularity.

The sub-period results corroborate this structural reading, and the most recent Nepali evidence reinforces it. Crowding in was weak in the 1990s, when both infrastructure and finance were scarce, strengthened through the recovery phase as the banking sector grew, and peaked during the federalism-era push of 2016–2019, exactly as the conditional crowding-in literature predicts (Beck et al., 2000; King & Levine, 1993). The elasticity eased in 2020–2023, when the COVID-19 episode and the balance-of-payments stress compressed both infrastructure activity and private investment. The subsequent record fits the same mechanism: the IMF (2024) links Nepal's post-2022 credit slowdown in part to weak public capital spending execution, and the World Bank (2024) documents that capital budget under-execution has remained a binding constraint on the recovery. Both observations are what the estimated asymmetry would predict when the infrastructure pipeline stalls.

Several policy implications follow. First, the crowding-in result indicates that public infrastructure investment in Nepal need not come at the expense of private credit; increases in infrastructure

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investment tend to be accompanied by, rather than offset by, increases in private credit and private investment, particularly in expansionary phases. This productive complementarity, foretold by the Aschauer–Munnell tradition, supports the infrastructure-led growth strategy that successive plans, most recently the Sixteenth Plan (NPC, 2024), have adopted. Second, the asymmetry implies that infrastructure investment should be protected rather than sacrificed in downturns: when public capital formation contracts, the muted credit response means private capital formation is unlikely to fill the gap, worsening the net impact on aggregate activity. Third, the time-varying sub-period elasticities show that crowding in is conditional on financial sector depth and public investment efficiency, in line with Cavallo and Daude (2011) and Berg et al. (2019); persistent capital budget under-execution therefore erodes the very complementarity on which the strategy depends (World Bank, 2024). Finally, the results argue for explicit fiscal–monetary coordination: since infrastructure expansion raises private credit demand, the central bank’s liquidity management and macroprudential settings should anticipate that demand rather than react to it, a lesson underlined by the 2021–2022 credit crunch (NRB, 2025).

6. Conclusion

The evidence assembled in this paper supports a clear conclusion: in Nepal, public infrastructure investment and private credit are long-run complements, not competitors. The concern that an ambitious public investment programme would drain the pool of loanable funds and squeeze private borrowers finds no support in three decades of data;

instead, infrastructure spending has systematically generated the private investment opportunities that show up as additional credit demand, and it is credit, rather than the public investment programme, that adjusts to restore the long-run equilibrium. The complementarity is conditional and has grown stronger as Nepal’s financial system has deepened and its project pipeline has matured, and it operates far more powerfully when infrastructure spending is expanding than when it is contracting.

For policy, the conclusion is equally direct. The post-federalism infrastructure push has been productive at the macro-financial level: it has been supported by, and has in turn stimulated, private credit demand. Sustaining this complementarity requires continued financial sector development, improved efficiency in public investment execution, and, given the asymmetry, the protection of public capital formation during downturns, when the crowding-in gains would otherwise be forgone. It also requires fiscal and monetary authorities to coordinate, so that liquidity and credit policies accommodate the private demand that the public investment programme itself creates.

The study has limitations that define the scope for further research. The infrastructure series aggregates transport, energy, water and digital investment, and the credit aggregate combines working capital, term and consumer lending, although these components may exhibit different complementarities; disaggregation along both dimensions would sharpen the policy implications. The 29 annual observations are sufficient for the five-variable VECM but cannot

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capture higher-frequency dynamics, and the sub-period windows, especially 2020–2023, are short, so those estimates should be read as indicative. The sample also ends in 2023, since later fiscal and national accounts data remained provisional at the time of estimation. Future research could extend the sample once the 2024–2026 data are finalized, move to quarterly frequency,

apply nonlinear ARDL or threshold cointegration techniques, merge the aggregate series with project-level credit disbursement data to exploit cross-bank and cross-sector variation, and determine the timing of regime shifts endogenously through structural break tests rather than imposing it from the macroeconomic narrative.

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