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Original Research Article

Impact of Public Transport Infrastructure Investment on Economic Growth in Nepal

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Abstract
This paper assesses the relationship between public transport infrastructure investment and economic growth in Nepal using time series data. The study uses Vector Error Correction Model (VECM) to study the short and long run relationship between public transport infrastructure investment and economic growth in Nepal during the period from 1974-2019. The study finds that in the short-run, there is an initial negative impact of public transport infrastructure investment on economic growth, which attenuates over time and eventually transitions to a positive effect. The study concludes that while challenges persist, strategic investments in public transport infrastructure remain a cornerstone for Nepal's journey towards sustained economic growth, prosperity, and inclusive growth.

Introduction

Public transport infrastructure investment is crucial for economic growth, especially in developing countries like Nepal, as it enhances productive capacity, supports economic development, diversifies the economy, and expands the export base. According to endogenous growth theory, investment in public infrastructure improves labor productivity, national output, and private sector profitability by reducing production costs and boosting investment (Dhungel, 2020).

There are two major opposing theories in economics regarding the relationship between government expenditure and economic growth. The Keynesian macroeconomic theory posits that increased government expenditure boosts aggregate demand, leading to higher economic growth. In contrast, Wagnerian theory argues that higher national income results in more government expenditure, which tends to be less efficient (Dandan, 2011). Classical economists like J. B. Say, Alfred Marshall, and A. C. Pigou advocated for a balanced budget, minimal government expenditure, and 'laissez-faire'—believing the economy functions better under market forces than state control (Shapiro, 2001). However, J. M. Keynes emphasized increasing government budgets during depressions to boost consumption and overall economic growth (Ackley, 2007).

Prior to 1951, there was no formal government expenditure on transport infrastructure in Nepal. During the Rana regime (1847-1951), their main intention was to keep the people out of the scenes of the country's fiscal position. After the political changes in 1951, government expenditure on transport infrastructure was allocated in every fiscal year (Khanal, 1988). In a speech delivered on July 13, 1990, Minister of Finance presented a government expenditure with four major objectives: to direct development programs by eliminating existing anomalies and by making them more realistic and productive, as well as overseeing their consistency indirectly benefiting deprived community; to rationalize the role of private sector and facilities provided by the government; to minimize increasing hardship faced by common people; and to start a process of repaying the accumulated financial liabilities of the government. Government expenditure has been increasing tremendously mainly after the restoration of democracy in 1991 and the adoption of liberalization policy in 1992 but public investment expenditure is still very low. It is clear from the budget of fiscal year 2023/24. In the fiscal year 2023/24, the estimated public investment expenditure was about 27 percent of the total budget (MOF, 2023). However, the expected GDP growth was only around 2 percent. According to Shrestha (2004), "Decades of Nepalese planning exercise and development efforts with increasing government expenditure has been the question for its contribution to economic growth. For this reason, public infrastructure investment and its contribution to economic growth is necessary to study."

The impact of public transport infrastructure investment on economic growth in developing countries constitutes an increasingly controversial issue. It has also been the subject of much attention in recent academic research and policy debates. Therefore, it is necessary to examine the impact of public transport infrastructure investment policy in economic growth in order to formulate appropriate public investment policy in developing countries like Nepal. Although, the government of every country invests on public infrastructure with the objective of overall development of the nation, there is a debate on the impact of public infrastructure investment. The role and size of government expenditure have always been in debate. Although neoclassical economists argue for a small role of the government in economic affairs, some roles of the government cannot be ignored in economic activities. There are some public goods like physical infrastructure, and semi-public goods like education and health, in which we expect the significant role of the government. Private sectors do not generally enter these sectors because of externality, long gestation period and need of huge investment. But private production requires directly or indirectly these public goods. Hence, the impact of public investment on growth has been the subject of much attention in recent academic research and policy debates (Agenor, 2007).

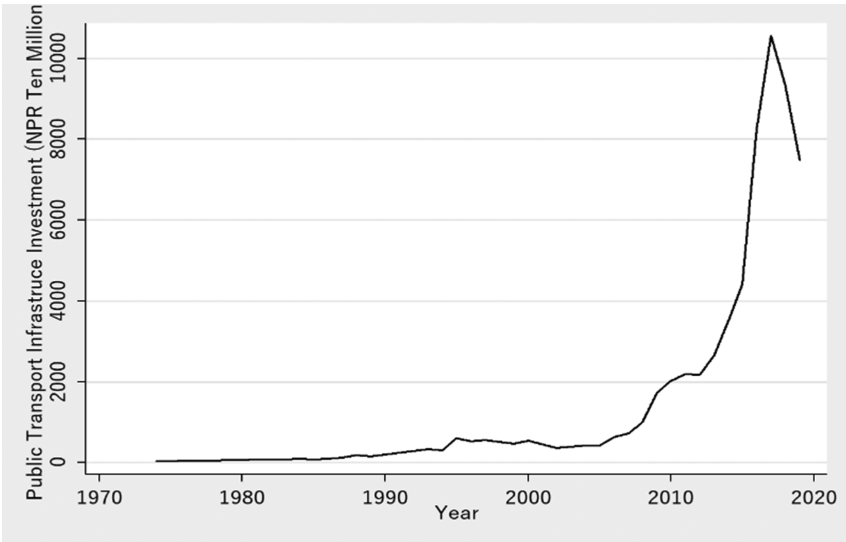

Figure 1: *Public Transport Infrastructure Investment in Nepal*
Source: NRB Database, 2020

Figure 1 illustrates the trend of public transport infrastructure investment in Nepal from 1974 to 2019, measured in NPR Ten Million. Over this period, the public transport infrastructure investment has seen a clear upward trajectory with a particularly sharp increase observed from the mid-2000s. Up until mid-2000s, public transport infrastructure investment in Nepal remained relatively low and stable. However, from the mid-2000s, there was a noticeable increase, marking the beginning of an exponential growth phase. This growth continues steadily through the 2010s, reflecting the impact of favorable economic conditions and possibly the implementation of supportive policies.

We can see that public financing for its transportation infrastructure program is critical to the Nepalese economy. There is a high cost, both financial and national, to infrastructure capital development. Therefore, the government should choose a project wisely which is more conducive to the economic growth of the country. This paper consists of five sections. The second section consists of review of literature. The third section consists of data, variable description and methodology. The fourth section consists of empirical results and discussion. The final section concludes this paper.

Review of Literature

Public transportation infrastructure investment has historically been linked to economic growth. Early studies, such as Smith's (1990) seminal work, examined the economic impact of public transportation projects dating back to the mid-20th century. Utilizing historical data and case studies, Smith demonstrated the potential of well-planned transportation investments to stimulate economic activity, reduce congestion, and enhance urban accessibility. However, Smith's study lacked rigorous quantitative methodologies prevalent in modern research.

Johnson's (2002) study embraced a more comprehensive approach by incorporating econometric techniques. Analyzing panel data across American cities, Johnson employed fixed-effects models to investigate the relationship between transportation infrastructure investment and economic growth. His findings reaffirmed the positive correlation between well-executed transportation projects and local economic development. However, Johnson's research was challenged for its potential failure to address endogeneity concerns arising from omitted variables.

Shrestha (2009) investigated the role of composition of public expenditure, particularly the expenditure on physical infrastructure, on economic growth in Nepal from the time series perspective based on the endogenous growth model. The impact of public expenditure on economic growth has been found to be positive. Hence, he concludes that low economic growth in Nepal in recent years could be attributed to low government expenditure on infrastructure and he suggest that Nepal can go for more investment in infrastructure by external borrowing at least for the medium term.

Thompson et al. (2010) embarked on an ambitious cross-sectional analysis of metropolitan areas. Their research integrated a diverse set of indicators, including accessibility measures and employment data, to ascertain the influence of public transportation projects on local economies. Thompson et al.'s findings unveiled spatially heterogeneous effects, where cities with well-integrated transit systems experienced notable employment growth, while others exhibited more modest outcomes. This emphasized the importance of considering regional dynamics in assessing transportation's economic impact.

Kharel (2012) developed a macroeconomic forecasting model focusing on fiscal policy and economic growth in Nepal. The empirical evidence suggested that fiscal policy, particularly governments' capital expenditure affects economic growth positively and also crowds-in private investment. Positive effect of fiscal policy to economic growth and crowd-out effect of public investment to private investment are the main findings of his study.

Anderson and Lee (2015) focused on transit-oriented development (TOD) as a mechanism to amplify economic growth. Their study employed a mixed-methods approach, combining quantitative analyses of land values and employment changes with qualitative assessments of development patterns around transit hubs. Anderson and Lee's results underscored the potential of strategic public transportation investments in fostering urban revitalization and spurring business activity. However, they acknowledged the challenges of capturing causality in complex urban environments.

Jones and Smith (2018) examined how investments in public transportation infrastructure drive economic growth. Using an input-output modeling framework, they identified the direct and indirect economic impacts across industries, highlighting multiplier effects within urban economies. Building on this, Green et al. (2021) analyzed the policy implications of such investments, focusing on urban congestion and environmental sustainability. Their comparative study of cities with different investment levels showed that improved public transportation can reduce traffic congestion and enhance air quality, supporting both economic and environmental goals.

Ghosh and Dinda (2019) empirically examined the relationship between transport infrastructure and economic growth in India for the period 1990–2017. Authors have applied multivariate dynamic models to estimate the relationship between economic growth and different modes of transport infrastructure namely road, rail and air transports in the vector error correction model framework. The results reveal that road and air transports have significant positive contribution to economic growth in the long-run while rail transport is insignificant.

Dhungel (2020) examined the relationship between infrastructure development and economic growth in Nepal during the study period 1994-2018. To investigate the casual relationship between infrastructure development and the economic growth, he employed Engel-Granger cointegration test and Error Correction Mechanism (ECM) model. The results showed a cointegration and a stable relationship between gross domestic product and infrastructure variables—such as total length of road, percentage of economically active population, percentage of tertiary education enrollment, and gross capital formation. This study has its implication for policymakers to raise economic growth through infrastructure development.

Rodriguez and Martinez (2021) examined the synergistic relationship between public transportation infrastructure investment, air quality improvement, and economic growth within urban environments. Concentrating on Latin American cities, they utilized a panel vector autoregression (VAR) model to capture the dynamic interactions between transportation, air quality, and economic indicators. The study revealed a positive feedback loop: public transportation investment led to enhanced air quality, which in turn promoted economic growth by fostering a healthier workforce and reducing healthcare costs. This study demonstrated the potential for sustainable development through well-planned transportation investments.

Martinez and Singh (2022) investigated the spillover effects of public transportation infrastructure investment on neighboring regions. Focusing on European cities, they employed a spatial autoregressive model to capture inter-regional interactions. The study demonstrated that transportation investments in one region had positive externalities on neighboring regions, leading to a "multiplier effect" on economic growth. This suggested that well-planned transportation projects could trigger a chain reaction of growth, benefiting not only the investing region but also its surroundings.

Zhang and Cheng (2023) investigated the relationship between transport infrastructure development and economic growth in the UK from different time spans. They applied Vector Error Correction Model (VECM) to investigate both long-run and short-run relationships between transport infrastructure development and economic growth from 1970 to 2017 in the UK. Empirical results suggest that transportation infrastructure has a long-run promotive effect on economic development. However, in the short run, this effect turns out to be significantly negative.

Most studies on public transport infrastructure investment and economic growth focus on high- and middle-income countries, with few addressing low-income countries like Nepal. The experiences of wealthier nations cannot be generalized to Nepal, which has lower levels of human capital, physical infrastructure, and R&D investment. This study aims to fill this gap by examining the relationship between public transport infrastructure investment and economic growth in Nepal.

Data, Variable Description and Methodology

This section includes data, variable description and methodology.

Data

The study utilizes public transport infrastructure expenditure, GDP, capital and population data from the NRB and the World Bank Database. Table 1 provides a detailed summary statistics of the data employed in the study. The time-series data covers the period of 1974 to 2019, with all the variables being recorded annually.

Variables and Descriptive Statistics

We have used the following variables to study the relationship between public transport infrastructure investment and economic growth in Nepal.

The variable "lntransport" denotes the natural log of public transport infrastructure expenditure in NPR (ten million) in a given year. This data is sourced from the Nepal Rastra Bank's data repository. "lngdp" represents the natural log of the gross domestic product of Nepal, measured in constant 2015 USD and extracted from the World Bank Database. Since economic growth also depends on various other factors, we also incorporate a set of control variables to avoid the issue of omitted variable bias. The control variables are selected according to the Cobb-Douglas production function. The control variables are the natural log of total population, denoted by "lnpopu" and sourced from the World Bank Database, and "lncapital" which is the natural log of the overall gross fixed capital, sourced from the Nepal Rastra Bank's data repository. We take natural logarithm of the variables in order to reduce the volatility and to transform the relationship between the variables into elastic analysis which helps us to interpret our regression coefficients as elasticities.

Table 1: *Summary Statistics*

Variable	Mean	Std. Dev.	Min	Max
lntransport	5.98	1.61	3.51	9.26
lngdp	22.44	0.96	20.92	24.25
lncapital	3.13	0.29	2.17	3.72
lnpopu	16.88	0.23	16.42	17.17

Source: Author's calculation

The following table describes the correlation among the variables used in this study.

Table 2: *Correlation Matrix*

	lntransport	lngdp	lncapital	lnpopu
lntransport	1.0000			
lngdp	0.9756	1.0000		
lncapital	0.8906	0.8926	1.0000	
lnpopu	0.9176	0.9211	0.8703	1.0000

Source: Author's calculation

A strong positive correlation is observed between the public transport infrastructure investment and the GDP. We also see that there is a strong positive correlation between the GDP and the overall gross fixed capital, and the population. This information will aid us in conducting lateral analysis and estimations.

Methodology

This study aims to model the relationship between public transport infrastructure investment and economic growth in Nepal using either the Vector Autoregressive (VAR) model or the Vector Error Correction Model (VECM), depending on the results of stationarity and cointegration tests. Specifically, we will use the Augmented Dickey-Fuller (ADF) test to assess stationarity and the Johansen test to evaluate cointegration among the variables.

There are two potential scenarios based on the testing outcomes:

i. VAR Model: If the variables do not exhibit integration of the same order, we will employ the VAR model. In this case, we will model the stable variables after differencing. The VAR(p) model with k variables can be expressed as follows:

$$Y_t = \mu + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + \epsilon_t$$

Here,

$$Y_{t-i} = \begin{cases} Y_{1t-i} \\ \vdots \\ Y_{kt-i} \end{cases}, i = 1, \ldots, p$$

where Y_t is a vector of endogenous variables with k dimensions, p is the lag order, and T represents the total number of observations. A_j is a k*k coefficient matrix, and ϵ_t is a k-dimensional random disturbance vector that can be contemporaneously correlated but is uncorrelated with its lagged values and the right-hand side variables of the model.

ii. VECM Model: If the series are found to be cointegrated, the VECM is deemed more appropriate. The VECM captures both the long-run equilibrium relationship and short-run dynamics between public transport infrastructure investment and economic growth. The VECM for the four series can be expressed as:

$$\Delta Y_t = \Pi Y_{t-1} + \Phi_1 \Delta Y_{t-1} + \cdots + \Phi_p \Delta Y_{t-p} + \epsilon_t$$

The key difference between the VAR and VECM models lies in the inclusion of the cointegration term ΠY_{t-1} on the right-hand side, which accounts for the long-run equilibrium relationship.
Following the model estimation, we will conduct several post-estimation analyses, including the Granger causality test, variance decomposition analysis, and impulse response function analysis, to further understand the dynamics between the variables.

Empirical Results and Discussion

This section includes stationary test, Lag Length Selection Based on VAR and cointegration test.

Stationarity Test

This study employs the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests to assess the stationarity of variables. The ADF test tests the null hypothesis of a unit root, indicating non-stationarity, whereas the KPSS test examines the null hypothesis of stationarity. Thus, rejecting the null hypothesis in the ADF test and accepting it in the KPSS test indicates that the series is stationary.

In conducting empirical tests on the original series, this research incorporates both intercept and trend terms. Conversely, when analyzing differenced series, only the intercept term is considered. The stationary test results shown in Table 3 indicates that lntransport and lngdp are non-stationary, lncapital is stationary while lnpopu is ambiguous due to mixed results (stationary by ADF, non-stationary by KPSS). Then we take first-order differencing and conducts the test again. We find that all the differenced variables except Dlnpopu are stationary with at least an I(1) process. Hence, we can conduct the cointegration test to verify whether there exists a long-term equilibrium relation. Since the mixed stationarity results for lnpopu create some ambiguity, we later see that there is a presence of cointegration with other I(1) variables which suggests that lnpopu might behave similarly to an I(1) process in the context of our system.

Table 3: *ADF and KPSS Test*

Panel A: ADF Test				
Original Series	lntransport	lngdp	lncapital	lnpopu
t-Statistic	0.18	0.62	-3.00***	-8.52***
Prob.	0.97	0.99	0.03	0.00
First-order Difference	Dlntransport	Dlngdp	Dlncapital	Dlnpopu
t-statstic	-6.63***	-6.91***	-9.91***	-0.53
Prob.	0.00	0.00	0.00	0.89
Panel B: KPSS Test				
Original Series	lntransport	lngdp	lncapital	lnpopu

Statistic	0.43***	0.86***	0.15	1.11***
1% critical value	0.216			
First-order difference	Dlntransport	Dlngdp	Dlncapital	Dlnpopu
Statistic	0.06	0.08	0.08	0.06
1% critical value	0.739			

***denotes rejection of the null hypothesis at the 1% significance level. D denotes first-order difference.

Lag Length Selection Based on VAR

We now use the lag length exclusion test to choose the optimal lag order. From the Table 4 we see that the AIC value is the lowest for the 4th order lag. Hence, the suggested lag length in four. This means that for VECM, the lag length should be 3. Building from this, we set the lag length to be 3 for the cointegration test.

Table 4: *Selection-order Criteria*

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	11.00				8.4e-06	-0.33	-0.27	-0.16
1	294.23	566.45	16	0.00	2.5e-11	-13.05	-12.75	-12.23
2	357.89	127.31	16	0.00	2.7e-12	-15.32	-14.78	-13.83
3	381.11	46.45	16	0.00	2.0e-12	-15.67	-14.88	-13.52
4	398.18	34.14	16	0.05	2.1e-12	-15.78*	-14.69	-12.90

Source: Author's Calculation

Cointegration Test

After being sure about the lag length, we run the Johansen cointegration test to determine whether there is a long run relationship between our variables. Table 5 gives evidence of the fact that there is an existence of at least 1 cointegrating relationship between our variables suggesting a stable long run equilibrium relationship.

Table 5: *Johansen Tests for Cointegration*

Maximum Rank	Parms	LL	Eigenvalue	Trace Statistics	5% CV
0	36	360.54		57.06	47.21
1	43	376.48	0.52	25.17*	29.68
2	48	384.32	0.30	9.48	15.41
3	51	388.33	0.17	1.48	3.76
4	52	389.07	0.03		

Source: Author's Calculation

Due to a long-run equilibrium relationship, estimating a VECM model is appropriate. We will analyze the short-term dynamic relationship based on VECM and test the causality relation based on the Granger causality test.

Table 6: *Long-term Cointegration Relationship*

Lngdp	Lntransport	lncapital	lnpopu
1.00	-0.14**	-1.58**	-0.72**

**Statistically significant at 5% level

Table 6 gives the long term cointegration relationship among our variables of interest. The estimates indicate that public transport infrastructure expenditure has a positive effect on economy in the long run, with a coefficient estimate of 0.14, which is consistent with the literature we have reviewed above. We see that the effect of log gross capital formation has even bigger and significant effect in the economy on the long run. Similarly, population growth also seems to be beneficial for Nepal's economy in the long run.

Estimating VECM Based on the established long-run cointegration, we measure the relationship between public transport infrastructure investment and economic growth in both the long and the short run. Table 7 reports the estimates of our VECM model.

Table 7: *VECM Estimates*

VARIABLES	$\Delta lngdp_t$	$\Delta lntransport_t$	$\Delta lncapital_t$	$\Delta lnpopu_t$
Cointegration	-0.218*	0.687*	0.382***	0.00347**
	(0.121)	(0.404)	(0.148)	(0.00145)
$\Delta lngdp_{t-1}$	0.0250	-0.837	-0.668***	-0.000628
	(0.202)	(0.672)	(0.246)	(0.00241)
$\Delta lngdp_{t-2}$	-0.0643	-0.673	-0.0589	-0.00234
	(0.187)	(0.622)	(0.228)	(0.00223)
$\Delta lngdp_{t-3}$	0.135**	-1.009*	-0.125	-0.00157
	(0.01)	(0.537)	(0.196)	(0.00192)
$\Delta lntransport_{t-1}$	0.0220	0.00402	0.337***	9.90e-05
	(0.0607)	(0.202)	(0.0739)	(0.000723)
$\Delta lntransport_{t-2}$	0.00803	0.404	0.0204	0.00197*
	(0.0847)	(0.282)	(0.103)	(0.00101)
$\Delta lntransport_{t-3}$	-0.0737**	0.281	-0.0210	0.000125
	(0.024)	(0.250)	(0.0915)	(0.000896)
$\Delta lncapital_{t-1}$	-0.0516	0.590	-0.0441	0.00105
	(0.157)	(0.523)	(0.192)	(0.00187)
$\Delta lncapital_{t-2}$	0.0420	0.000845	0.153	0.000115
	(0.132)	(0.441)	(0.161)	(0.00158)
$\Delta lncapital_{t-3}$	0.124	0.245	0.122	0.000603
	(0.0947)	(0.315)	(0.115)	(0.00113)
$\Delta lnpopu_{t-1}$	-8.792	33.43	-53.71***	1.995***
	(16.05)	(53.43)	(19.56)	(0.191)
$\Delta lnpopu_{t-2}$	22.16	-160.5*	86.23**	-1.607***
	(27.74)	(92.33)	(33.79)	(0.331)
$\Delta lnpopu_{t-3}$	-22.23	139.4**	-23.26	0.695***
	(18.07)	(60.13)	(22.01)	(0.215)
Constant	0.182***	0.0877	-0.0536	-0.000946
	(0.0628)	(0.209)	(0.0764)	(0.000748)
Observations	42	42	42	42

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

We find that the estimated coefficient for the long-run cointegration relationship is -0.218, which is statistically significant at 10% level. It indicates that the convergence speed of the short-run connection to long-run equilibrium is 21.8 per cent, which suggests that the short-term dynamic relationship between public investment in transportation infrastructure and economic economy adjusts to the long-term at a moderately faster rate. From the table, we can see that the effect of public investment in transport infrastructure remains insignificant in lagged year one and two. However, we see that there is a negative significant short-term impact of public transport infrastructure investment on economic growth which shows that the significant short-term impact of the transport infrastructure investment in Nepali economy is evident only after 3 years. This implies that large transport infrastructure projects are often expensive and fail to deliver the promised benefits in the short term. Hence, we can say that public investment on transport infrastructure in Nepal has a significant and positive impact on the economic growth while the short run impact tends to be significantly negative.

Granger Causality Test

I now examine the granger effects of public investment on transport infrastructure, gross capital formation and population on economic growth. The results show that the public investment on transport infrastructure and gross capital formation is the granger cause of economic growth while population is not. When I analyze the granger effects of economic growth, population and gross capital formation on public investment on transport infrastructure, we see that all of these variables are the granger causes of transportation infrastructure.

Table 8: *Granger Causality Test*

H_0	Chi-Statistic	Prob.
lntransport Does Not Granger Cause lngdp	4.66*	0.021
lncapital Does Not Granger Cause lngdp	2.03	0.44
Lnpopulation Does Not Granger Cause lngdp	0.76	0.99
Lngdp does Not Granger Cause lntransport	7.6***	0.00
Lncapital does not granger cause lntransport	14.32***	0.00
lnpopulation Does Not Granger Cause lntransport	5.4***	0.00
lngdp Does Not Granger Cause lncapital	0.23	0.16
Lntransport does not granger cause lncapital	4.55	0.77
Lnpopulation does not granger cause lncapital	2.33	0.34
Lngdp does not granger cause lnpopulation	1.86	0.75
Lntransport does not granger cause lnpopulation	5.77	0.55
Lncapital does not granger cause lnpopulation	0.71	0.32

*Statistically significant at 10% level, ***statistically significant at 1% level

When we analyze the granger effects of economic growth, population and gross capital formation on public investment on transport infrastructure, we see that all of these variables are the granger causes of transportation infrastructure.

Conclusion

Using the Vector Error Correction Model (VECM), we study the short and long run relationship between public transport infrastructure investment and economic growth in Nepal during the period from 1974-2019. We find that in the short-run, there is an initial negative impact of public transport infrastructure investment on economic growth, which attenuates over time and eventually transitions to a positive effect. This pattern suggests that while large-scale infrastructure projects may initially pose challenges such as high costs and delayed benefits, they ultimately contribute significantly to economic expansion and productivity enhancement.

Furthermore, the Granger causality tests confirm that public transport infrastructure investment and gross capital formation Granger cause economic growth, highlighting their pivotal roles in driving economic prosperity in Nepal. These findings align with international literature on infrastructure economics, emphasizing the importance of well-targeted public investment policies in fostering sustainable economic growth. In policy terms, the study recommends that Nepalese policymakers prioritize continued investment in transport infrastructure, ensuring that projects are efficiently planned, implemented, and monitored to maximize their developmental impact. Additionally, integrating public and private sector efforts could further enhance infrastructure development outcomes, addressing both short-term economic challenges and long-term growth objectives.

Nevertheless, future research should explore additional dimensions such as the environmental and social impacts of transport infrastructure investments in Nepal, as well as conduct comparative studies with other developing nations facing similar economic and infrastructural challenges. Such endeavors will provide a comprehensive understanding of the broader implications of infrastructure investments on economic development and societal well-being. In conclusion, while challenges persist, strategic investments in public transport infrastructure remain a cornerstone for Nepal's journey towards sustained economic growth, prosperity, and inclusive growth.

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