Highways and Growth : A Causal Analysis for India

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Abstract

The paper investigated the relationship between the growth of highways and economic growth. We tested for mutual causality between the growth of road networks (which were functionally divided as state highways and national highways) and growth in investment and GDP. We employed time series data set containing observations of growth in road route kilometres by type for India over the period from 1972 - 2016 to fit a vector autoregressive model with exogenous variable describing the growth in road networks, GDP, and gross capital formation. We also checked if the establishment of National Highway Authority of India (NHAI) had any significant impact on the economy. The results indicated the existence of bidirectional causality between growth in GDP and growth in national highways and a unidirectional causality was seen from growth in national highways to growth in gross capital formation. Additionally, it was observed that the growth in state highways led to subsequent growth in national highways as well. The NHDP programme had a significant impact on the expansion of national highways, but no causal influence could be empirically identified on GDP and gross capital formation.

Keywords : **causality, agglomeration, network externalities, roadways, human-capital, crowding out**

JEL Classification : O18, O47, R41

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The demand for transportation infrastructure is highly derived in nature. Its demand arises to connect people and places. The extent to which transport is demanded depends on the state of economic activity. Improved transportation services enlarge markets and profitability. Access to market and ideas open up the channels of growth and development. Richer economies perform better due to their better transportation infrastructure than the poorer ones. Various macroeconomic models establish that transport infrastructure leads to cost reductions and output augmentation (Aschauer, 1989, 1990 ; Mera, 1973 ; Munnell, 1990 ; Nadiri & Mamuneas, 1998).

Better access to the retail outlets by firms, also households commuting for work, shopping, or leisure affect the total output. Overall, transport infrastructure paves way for competition, innovation, spatial agglomeration, scale economies, and greater efficiencies leading to the restructuring of the economy. A sustained improvement in transport infrastructure leads to endogenous growth effects, thereby expanding the economic effects of transport infrastructure even more (Lakshmanan & Anderson, 2007). With lowered travel cost and time, firms can reach out to localities and regions. As a consequence, greater focus on specialization will generate gains from trade and productivity. Moreover, transport investment is a determinant of city size and urban form (Fujita, Krugman, & Venables, 1999). The availability of transport infrastructure determines the land use and also enhances the

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implicit value of land. The significance of costs of transport, market access, and increasing returns taken together will determine the extent of agglomeration economies (Vikerman, 2008).

Roadways are now a major mode of transportation. Since the era of motorization, roadways travel has become more popular. The inherent advantages to roadways travel such as convenience, adaptability, and flexibility make roads preferable. Roads are indeed the arteries for the economy. Roads link producers to markets, labour pool to jobs, students to educational hubs, and the sick to hospitals. Looking at the wider economic benefits of roadways, it is justifiable that roadways generate spillovers, specifically network externalities. Each network connects to other networks, thereby enhancing accessibility by connecting places.

Highways and other transportation infrastructure are considered as the source of economic growth (Owen, 1959), so it is intuitive in the case of highways that it indeed has an impact on the health of the economy. Highways are often planned in locations where growth in the future is projected. Therefore, economic growth causes highways and vice-versa (Boarnet, 1997). To add to it, they channel the forward and backward linkages, like many new towns develop along the routes of highways. Apart from drawing workers, they open opportunities along their spread. Hence, highways serve as the economic backbone of a country. In this paper, we check if enhanced highways have given substantial gains to economic growth in India over time. We have functionally distinguished between national highways and state highways. We also check if the expansion of highways impacts the investment growth in India.

Economic Consequences of Roadways Infrastructure

The literature on highway investment is distributed as per the neoclassical growth theory, growth pole theory, and location theories. In neoclassical theory, infrastructure such as a highway network is an input in the production function (Eberts, 1990). It acts to improve the overall productivity. Growth pole theory is helpful for a policy maker for the decision of investment of resources across regions. It forecasts the impact of such investments on population change (Thiel, 1962). This theory recognizes the role of highway investment as just a catalyst in the growth process. For the location theory, highway investment is a necessary condition for local economic growth. This is because highways facilitate the flow of goods, services, people, and ideas (Vickerman, 1991).

The economic consequences of highways can be varied. It can lead to employment changes. Highways can affect employment through growth or decline of the economy. Secondly, improved highways generate additional opportunities within commutable distance, saving travel time and costs. Finally, employment is also created along the expansion routes of highways where new establishments arise - like an eating junction or retail malls.

Distributional effect of roads is that it gives rise to more cities along with accessibility. Cities being the engines of growth also get a flow of productive capital and an effective labour pool gets drawn towards them with the expansion of roads. Better roads lead to market integration and reduction in trade costs. This can tame price volatility and reallocate resources as per the comparative advantage of regions. Competition among firms is strengthened, and firms can better capture the gains from increasing returns. Roads make factors largely mobile, facilitating human capital investments. Also, there is indeed a greater scope of sharing, learning, and matching economies. These intangible benefits sow the seeds of ideas and innovation.

Several studies have considered well laid-out road networks as a pre-requisite for socioeconomic transformation. Highway infrastructure improvements in the form of new roads or expansion and upgradation of existing roads reduce transportation costs by reducing distance to be covered and enhancing capacity, thereby decreasing congestion along existing routes (Lakshmanan, 2011). He further added that new highways spur economic activities by generating new demands. There are strong arguments in favour of expansion of roads. Scholars believe that highway construction is accompanied by economic growth, reduction in traffic congestion, and better travel safety (Chi, 2010 ; Moore & Thorsnes, 1994). Shepherd and Wilson (2007) used gravity model simulations to suggest that road upgradation can increase trade by almost 50%. Infrastructure facilities, including highways and road networks, facilitate economic activity and help in attracting FDI. Madam (2014) observed significant variation in FDI distribution across Indian states. Similar results were also obtained by Kumar, Dhingra, and Saihjpal (2012) for developing countries of Asia by using the exploratory factor analysis technique.

Highways influence distribution population and social organization (Wisenbaker, 1973). Better the employment opportunities, better the socioeconomic status. Highways affect the occupational distribution of localities, changing the social structure. It also gives people easy access to several social institutions like schools, hospital, banks, etc., and cultural opportunities as well (Boarnet & Chalermpong, 2001). Also, with better accessibility, people do not prefer to stay in city centres but rather amidst remote natural areas.

Indian Roadways and the National Highways Development Project

India's transport sector is indispensably a road - dominated one (Ministry of Finance, 2015). The road sector has taken up the modal share of railways in both passenger and freight transportation. It has been growing since the beginning of 1980s and is likely to continue as well. India has the second largest road network in the world, about 54.8 lakh kilometres. Of the total road network, the length of national highways is 1,14,158 km and that of state highways is 1,61,487 km as in March 2017 (Ministry of Finance, 2018) ; 90% of total passenger traffic and 67% of freight traffic is carried by road transport. The transport sector contributes 5% to the gross value added (GVA). The contribution of road transport to GVA was 3.3% (Ministry of Road Transport and Highways, 2016). Roadways play a dominant role in India's transport network. The highway network density in India is 0.66 km of roads per square kilometre of land. This is similar to the figures for United States (0.65) and much higher than that of China (0.16) and Brazil (0.20) (The World Bank, 2014).

Road transport comprises of road infrastructure, motor vehicles, and road transport services. The primary infrastructure for road transport is roads. Roadways are divided as national highways, state highways, district roads, rural roads, urban roads, and project roads. The medium and long distance inter-city passenger and freight

Table 1. Progress of the NHDP

Phases	Total Length in Km	Length Completed till December 2017(in km)
Phase I		
Golden Quadrilateral, North South-East West corridors, Port connectivity & others	7,522	7,521
Phase II		
24/6 laning of North-South East-West Corridors, others	6,647	6,593
Phase III		
Upgradation, 4/6 laning	12,125	7,962
Phase IV		
2 laning with paved shoulders	20,000	8,285
Phase V		
6 laning of GQ and High Density Corridor	6500	2,643
Phase VI		
Expressways	1000	NIL
Phase VII		
Ring roads, bypass, flyovers, and other structures	700 km of ring roads/bypass + flyovers	24

Source: Ministry of Finance (2018)

traffic is facilitated by national highways, and state highways carry traffic along major centres within the states (National Highway Authority of India, 2016). Except national highways, roads fall under the jurisdiction of the respective State governments. Also, certain selected roads in different states are given assistance from the Central Road Fund (CRF) under the Inter State Connectivity and Economic Importance (ISC&EI) scheme.

To enhance connectivity, the government undertook the largest highway project called the National Highways Development Project (NHDP) in 1995. It was created under the promulgation of National Highways Authority of India (NHAI) Act of 1988. The Parliament passed the NHAI Act to ensure a central authority to maintain, manage, and develop the National Highways of India. The projects under NHAI are divided into seven phases as depicted in the Table 1.

Apart from the ambitious NHDP, there have been several other programs like Special Accelerated Road Development for North-Eastern Region (SARDP-NE), National Highway Interconnectivity Improvement Programme (NHIIP), Bharatmala Programme, and the Setu Bharatam Programme. All these programmes are indeed the recognition of the need for roads and also show the contribution of roads to the world's third largest economy (in purchasing power parity terms).

Literature Review

Research about transportation has long recognized its role for economic and social prosperity. This has also been validated by empirical tests (Brueckner & Fansler, 1983). There have been several studies analyzing the impact of specific sectors in the transportation network. The role of transport infrastructure is very dominant for the regional economic growth process (Aschauer, 1990).

Aschauer (1990) conducted a study of 48 states of U.S over 1960 - 1985. Using least squares, he stated that the growth of per capita income is related to highway capacity and quality of pavement. Aschauer also found that both rural and urban roads are significant determinants of economic growth, the effects of rural roads being larger.

Voss and Chi (2006) found a causal relationship running from expansion of highways to population growth for U.S., but no significant effect emerged from population change to expansion of highways. It was observed that highway infrastructure supported the growth trends that were underway when the expansion of highways began.

Jiwattanakulpaisarn, Noland, Graham, and Polak (2009) estimated a dynamic panel model in vector autoregressive framework to check the causal relationship of highways and employment for U.S. over 1984 - 1997. Employment growth was temporally influenced by annual growth in highway stock within the same state and also other states. Weber (2012) analyzed the inter-state highway system of the U.S. using a GIS data set since 1947. He found that no correlation existed between change in accessibility and population change.

Gibbons (2010) analyzed micro longitudinal data set for Britain from 1998 to 2003 and concluded that transport improvement led to sustained productivity gains. The effect of higher accessibility, though found to be insignificant on employment, but it enhanced total factor productivity of firms. Gibbons, Lyytikäinen, Overman, and Sanchis - Guarner (2012) found a 3% rise in local employment associated with a 10% rise in improvement in accessibility induced by transportation. They also found evidence for higher output, improvements in labour productivity, and higher wages among existing firms. They made a detailed geographic scale study using GIS technique on Britain over the period from 1998 - 2007.

Duranton (2015) used theoretical modelling to examine the impact of highways on level and composition of trade in USA. He concluded that weight of trade decreased faster than value of trade with highway distance among cities. Cities specialize in the export of heavy goods with the rise in within city highways. A 10% rise in city highway stock raises weight in exports by 5%. He also reported a major impediment to trade in road distance between cities. The elasticity measure of the effect of roads within cities on cities' exports was 0.20 by OLS and 0.50 by IV.

Datta (2011), while studying the Golden Quadrilateral Programme on Indian highways, noted that the programme enabled firms to make productive choices. Firms along the Golden Quadrilateral route held lesser input inventories after the highway developed than previously. He also reported that firms along the improved highway route did not report transportation as an obstacle to the process of production.

Banerjee, Duflo, and Qian (2012) stated a moderately positive causal effect of transportation network on per capita GDP across sectors. But no such effect was found for per capita GDP growth. They developed a theoretical model for China during the two decades after China opened up to trade and market reforms to investigate transport infrastructure's role during its high GDP growth period.

Pradhan and Bagchi (2013) used the vector error correction model to check the effect of transport infrastructure in India over 1990 - 2010. They found bidirectional causality between roads and capital formation.

Tripathi and Gautam (2010) investigated a long-run relationship between road transport and macroeconomic variables like output, gross private capital formation, and employment for India over the period from 1971 - 2007. They also checked their causal relationship using vector autoregressive model (VAR). They found a long - term impact from road network dynamic externalities of knowledge spillovers with GDP and gross private capital formation. Interestingly, they also reported that the length of national highways had a negative impact on employment and also on output. According to the authors, it also crowded out private investment.

Iacono and Levinson (2016) employed a panel data study for Minnesota over the period from 1988 to 2007. They found that bidirectional causality ran between local road network and population. No evidence of causality could be found between networks and local employment.

Martincus, Carballo, and Cusolito (2017) tested the impact of roads in a developing country like Peru over 2003 - 2010. They found a significant and positive implication on export of firms and also their job growth due to transportation improvement with new roads deepening the foreign market penetration.

From the literature, we indeed see the importance of highways. The growth variables that we decide from the literature are investment and output of the economy on a whole. Moreover, there has been no stress on the impact on NHAI policy programmes, specifically NHDP, while checking for the impact of highways in India. Our paper is an attempt to fill this gap in the literature.

Methods and Data

In this section, we shall brief about the ways we go ahead with this study. We shall discuss the tools we used for the empirical analysis of this paper. To capture the interface between growth and highways, the present paper uses data on highway route length in kilometres. Furthermore, we segregate highways as state highways and national highways. GDP is taken as the proxy for economic growth, and gross capital formation is chosen as a proxy for investment. The data pertains to India. Data are in annual, and for the current study, were taken in growth terms for the period from 1972 - 2016. The annual data comes from World Development Indicators reported by the World Bank and Centre for Monitoring Indian Economy Pvt. Ltd (Economic Outlook) database. The data were further converted to growth forms using the formula given in equation (1).

(1) Hypotheses : In order to examine an empirical relationship between the growth of highways and economic growth & the state of investment in an economy, we formulated the following hypotheses :

➥ **H1 :** GDP grows in response to growth of the national highway network as the increased accessibility to labour markets and suppliers improves the relative attractiveness of an economy.

➥ **H2 :** National and state highways are complementary to each other. Growth in national highways is followed by growth of state highways and vice versa.

➥ **H3 :** National highway networks grow in response to growth in GDP as new employers need to draw on a larger labour pool, and networks serving existing employment centres become more heavily burdened.

➯ **H4:** The establishment of NHAI in 1988 has affected growth of national highways, state highways, gross domestic product, and gross capital formation in the economy.

(2) Empirical Specification : All the variables are in the form of annual time series data spanning from 1971 - 2016. In order to proceed with the model, we convert them to their respective growth forms (1972-2016) using the formula depicted in the equation (1) :

$$\text{Growth in } X_t = (X_t - X_{t-1})/X_{t-1} \qquad (1)$$

The variable taken to study economic growth is gross domestic product (GDP). The role of highways cannot be studied by ignoring the role of investment, for which we chose to include gross capital formation as a variable. Next, highways were functionally divided as state highways and national highways. We further incorporated an interaction dummy (growth in national highway × the NHDP dummy [1]) to test the impact of the NHDP programme (1995).

Macroeconomic variables do contain stochastic trends, so before proceeding to the tools, the basic stationary property of these time series variables were checked. We used Augmented Dickey - Fuller (ADF), Dickey - Fuller (DF), and Phillips - Peron (PP) tests on all the variables individually to check the presence of unit root. The results are stated in the Table 2.

Table 2. Unit Root Test at Level

With Trend and Intercept			
Variables	**ADF**	**DF**	**PP**
GGDP	-8.067260***(9)	-7.255876***	-9.675162***
GGCF	-7.563597***(9)	-7.307171***	-7.646468***
GNH	-5.921631***(9)	-4.336992***	-5.922653***
GSH	-12.98097***(9)	-1.054295	-14.03835***

Note: GGDP- Growth in gross domestic product, GGCF- Growth in gross capital formation, GNH- growth in national highways, GSH- growth in state highways.

The above values are of *t* - statistics. Numbers in parenthesis () are lag length based on the optimum lag selection criterion. The critical values for unit root tests at 1%, 5%, and 10% levels are -4.243644, -3.544284, and -3.204699 (with trend and intercept), respectively.

* denotes significance at the 10% level ; ** denotes significance at the 5% level ; *** denotes significance at the 1% level.

To investigate the impact of highways as a determinant of growth and also to examine the role of NHDP, we start with a simple single equation model, where we check for the significance of growth on national highways and state highways on gross domestic product using ordinary least squares (OLS) as in equation (2) :

$$GGDP_t = \alpha_1 + \alpha_2 GP_t + \alpha_3 GGCF_t + \alpha_4 GSH_t + \alpha_5 GNH_t + \alpha_6 ID\_GNH_t + e_t \qquad (2)$$

We make use of several specifications reported as three separate equations in Table 3. In equation (1), we just check for the highways and interaction dummy only. Then in equation (2), we only restrict our model with all the variables except the dummy. Finally, in equation (3), we take all the variables and the interaction dummy.In all these cases, GGDP is taken as the independent variable.

Due to apparent endogeneity of infrastructure towards growth, the empirical research encounters reverse causality by taking such variables. To test for such causality among the variables, we checked for Granger causality test at level as the variables are stationary at level. The results are reported in the Table 4.

[1] The NHDP dummy takes the value 1 for post 1995 periods and 0 otherwise.

Table 3. Results of OLS Estimation

Variables	Equation I	Equation II	Equation III
C	0.055927***	0.045713***	0.045376***
GGCF	-	0.147427***	0.141547***
GNH	-0.623693***	0.009358	-0.628699***
GSH	0.130426*	0.009095	0.169040**
ID_GNH	0.734505***	-	0.701625***
R - Squared	0.812118	0.23348	0.410825
Adjusted *R* - Squared	0.802953	0.177251	0.351908
F - statistic	88.61114***	4.159754**	6.972891***
Durbin-Watson Statistic	2.347996	1.854343	2.082965

Note: Above variables are in their growth forms. GGDP is the dependent variable.

* denotes significance at the 10% level ; ** denotes significance at the 5% level ; *** denotes significance at the 1% level.

Table 4. Granger Causality Test

Null Hypothesis	*F* - Statistic
GGCF $\nRightarrow$ GGDP	0.50395
GGDP $\nRightarrow$ GGCF	0.08484
GNH $\nRightarrow$ GGDP	0.58905
GGDP $\nRightarrow$ GNH	0.62846
GSH $\nRightarrow$ GGDP	0.80389
GGDP $\nRightarrow$ GSH	0.52085
ID_GNH $\nRightarrow$ GGDP	1.10043
GGDP $\nRightarrow$ ID_NH	0.47763
GNH $\nRightarrow$ GGCF	3.57204**
GGCF $\nRightarrow$ GNH	0.55709
GSH $\nRightarrow$ GGCF	0.63697
GGCF $\nRightarrow$ GSH	1.50881
ID_GNH $\nRightarrow$ GGCF	3.77680***
GGCF $\nRightarrow$ ID_NH	0.44808
GSH $\nRightarrow$ GNH	2.05054*
GNH $\nRightarrow$ GSH	0.53789
ID_GNH $\nRightarrow$ GNH	0.53408
GNH $\nRightarrow$ ID_GNH	0.32984
ID_GNH $\nRightarrow$ GSH	0.53304
GSH $\nRightarrow$ ID_GNH	3.28833**

Note: The notation $\nRightarrow$ stands for does not Granger cause.

The pair-wise Granger causality test is done in lag 6. The total number of observations is 39.

* denotes significance at the 10% level ; ** denotes significance at the 5% level ; *** denotes significance at the 1% level.

Then, to proceed with the investigation of causal relationships as hypothesized, we use the VAR model. The use of VAR model is very conditional on the stationarity property of the time series variable. The stability condition required for VAR is met when the variables are stationary at level. The following VAR model is used in our study and the results are furnished in the Table 5.

$$GGDP_t = \alpha_0 + \sum_{i=1}^{p}\alpha_{1i}\, GGDP_{t-i} + \sum_{j=1}^{p}\alpha_{2j} GGCF_{t-j} + \sum_{k=1}^{p}\alpha_{3k} GNH_{t-k} + \sum_{l=1}^{p}\alpha_{4l}\, GSH_{t-1} + \sum_{m=1}^{p}\alpha_{5m}\, ID\_GNH_{t-m} + \zeta_{1t} \quad (3)$$

$$GGCF_t = \beta_0 + \sum_{i=1}^{p}\beta_{1i}\, GGDP_{t-i} + \sum_{j=1}^{p}\beta_{2j}\, GGCF_{t-j} + \sum_{k=1}^{p}\beta_{3k}\, GNH_{t-k} + \sum_{l=1}^{p}\beta_{4l}\, GSH_{t-1} + \sum_{m=1}^{p}\beta_{5m}\, ID\_GNH_{t-m} + \zeta_{2t} \quad (4)$$

$$GNH_t = \lambda_0 + \sum_{i=1}^{p}\lambda_{1i}\, GGDP_{t-i} + \sum_{j=1}^{p}\lambda_{2j}\, GGCF_{t-j} + \sum_{k=1}^{p}\lambda_{3k}\, GNH_{t-k} + \sum_{l=1}^{p}\lambda_{4l}\, GSH_{t-1} + \sum_{m=1}^{p}\lambda_{5m}\, ID\_GNH_{t-m} + \zeta_{3t} \quad (5)$$

$$GSH_t = \mu_0 + \sum_{i=1}^{p}\mu_{1i}\, GGDP_{t-i} + \sum_{j=1}^{p}\mu_{2j}\, GGCF_{t-j} + \sum_{k=1}^{p}\mu_{3k}\, GNH_{t-k} + \sum_{l=1}^{p}\mu_{4l}\, GSH_{t-1} + \sum_{m=1}^{p}\mu_{5m}\, ID\_GNH_{t-m} + \zeta_{4t} \quad (6)$$

The LR - statistic test for the significance of dummy is done as per the following equation :

$$LR = (T- m)\ (\ln\Sigma_r - \ln\Sigma_u) - \chi^2\ (q)$$

Table 5. Results of VAR Model (Unrestricted with Interaction Dummy)

Dependent Variable	GGDP	GGCF	GNH	GSH
GGDP (-1)	0.204719	-0.970493	0.040815	0.082231
GGDP (-2)	-0.492875	0.220671	-0.448123***	-0.426077
GGDP (-3)	0.953707**	1.257669	-0.141588	0.105577
GGDP (-4)	-0.457049	-0.743894	-0.001025	-0.094738
GGDP (-5)	0.263499	-0.444991	-0.012327	0.562881
GGDP (-6)	0.128327	0.527752	0.125059**	0.008401
GGCF (-1)	-0.048519	0.065862	-0.030376	0.097230
GGCF (-2)	0.138454	0.134340	0.054882	0.202007
GGCF (-3)	-0.222777*	-0.690468**	0.048896	-0.077040
GGCF (-4)	0.066723	0.119750	0.002210	0.001550
GGCF (-5)	0.134732	0.492675*	0.028716	-0.140592
GGCF (-6)	-0.077243	-0.416200	-0.004659	0.102057
GNH (-1)	0.032046	-0.085849	-0.002551	-0.202515
GNH (-2)	-0.180202	-0.664979**	0.013308	-0.034776
GNH (-3)	0.014185	0.589402	-0.079585**	0.174069
GNH (-4)	0.048711	0.151594	0.041409	-0.193793
GNH (-5)	-0.198750	0.041973	-0.060123	-0.214870
GNH (-6)	0.272326*	0.993003**	-0.003647	0.012645
GSH (-1)	-0.076979	0.690559	0.023171	-0.235954
GSH (-2)	0.040327	0.020013	0.135088**	-0.202278
GSH (-3)	-0.372799	-0.841950	-0.046082	0.161655
GSH (-4)	-0.015601	0.273469	-0.081832	-0.040956
GSH (-5)	0.032808	0.797406	-0.075386	-0.352865
GSH (-6)	-0.25329**	-0.426766	0.032053	-0.165291
ID_GNH	-0.000813	0.309177	1.024020***	-0.174415
C	0.039088	0.068815	0.024020***	0.023461

Note: The above - mentioned variables are in their growth forms. The dependent variables are given horizontally. The above values are the coefficients of the VAR model.

* denotes significance at the 10% level ; ** denotes significance at the 5% level ; *** denotes significance at the 1% level.

where,
m is the number of parameters in each equation of the unrestricted VAR plus constant,
T is the number of observations,
q is the number of dummies multiplied by the number of equations,
Σ is the determinant of the residual covariance matrices.

Here, the null hypothesis is no interaction dummy of NHDP on growth in national highways :

LR stat = $(T\text{-}m)$*[ln{sigma_var_restricted} - ln{sigma_var_unrestricted}] = (39 - 26)* [ln(1.15E-13) - ln(2.36E-15)] = 50.52151662
$T = 39$
$m = 4*6 + 1 + 1 = 24 + 2 = 26$
$D.F = 1*4 = 4$
$\chi^2(4)$ tabulated at 5% is 9.45.

Table 6. Diagnostic Test of VECM Residual

Diagnostic Test	*d.f*	Test Statistic	*p*-value
Serial Correlation LM Tests	39	16.66701	0.4075
Jarque Bera	8	1.968058	0.9820

The Table 6 highlights the diagnostic tests used to check the stability of the model. For serial correlation, LM test is used. To check the normality condition, Jarque-Bera statistic is used. In the following section, we shall interpret the outcome of these rigorous tests.

Empirical Results

The present analysis is an attempt to empirically examine the causality of highways and economic growth. The econometric tests started with test of stationarity of our variables which are taken in their growth forms. Unit-root test is supposed to give us insights about the stochastic trends. We made use of ADF, DF, and PP tests with trend and intercept. We tested stationarity at level in Table 2. Using p -values of 0.01, 0.05, and 0.10, all the series did not accept the null hypothesis of a unit root. So we find the variables to be stationary at level.

Without the stationarity condition being satisfied, ordinary least squares would give spurious results. Here, since all our variables under study are indeed stationary as accorded by at least one of the three tests, we can advertently run OLS. In the first equation, growth in GDP is a function of two variables - growth in national highways and growth in state highways. Along with that, an interaction dummy is taken to show the impact of NHDP of national highway expansion post 1995. Interestingly, we see that the coefficient of the growth of national highways is negative and statistically significant. However, the expansion of state highways positively influences growth in GDP. Also, the NHDP expansion of national highways has a positive and significant influence on GDP growth. Next, we incorporate GGCF variable in our equations (2) and (3), but we eliminate the interaction dummy from equation (2) and then apply OLS to both the equations. As expected, GGCF positively and significantly influences GDP. No significant results of GNH and GSH are found on GGDP with the removal of the interaction dummy from equation (2) ; whereas, in equation (3), we see that GGDP is positively and significantly influenced by the GGCF, GSH, and ID_GNH. However, GNH negatively influences GGDP. The inclusion of the interaction dummy makes all the coefficients significant. The government has been pro-active in developing national highways after implementing the National Highway Development Programme in 1995. Therefore, the inclusion of the dummy is justified.

When all the variables are stationary and hence integrated of order zero, we make use of the Granger causality test. We see unidirectional causality from the growth of national highways to growth in gross capital formation (GNH ≥ GGCF), growth in national highways due to NHDP to growth in GGCF (ID_GNH ≥ GGCF), growth in state highways to growth in national highways (GSH ≥ GNH), and the growth in state highways to growth in national highways due to NHDP (GSH ≥ ID_GNH).

Due to identifiable endogeneity among the variables, we checked the causality relation in a VAR model. According to the lag selection criteria (The lag selection criteria for the model are shown in the Table 7), the maximum lag that should be taken is 0 as per the final prediction error (FPE), Schwarz's information criterion (SC), and Hannan - Quinn information criterion (HQ). It should be 2 as per sequential modified LR test statistic (each test at the 5% level). However, with the leverage of our discretion, we made use of 6 lags instead as per the Akaike Information Criterion (AIC). This is because for roads, the impact of such an infrastructure stock is better studied over a higher lag of periods.

To know if the direction of causality is in line with our hypothesis, the VAR was applied. Interpreting the results from Table 5, we find that growth in gross capital formation, growth in national highways, and a growth in state highways lead to a growth in GDP over the years. Moreover, growth in national highways also leads to a growth in gross capital formation. Growth in GDP, growth in state highways, and the NHDP programme manifest a growth in national highways. Just as the past growth in GDP at lag 3 has an influence on the present growth in GDP, likewise, with lag 3 and lag 5, gross capital formation influences present growth of gross capital formation. In the same way, past growth of national highways at lag 3 influences its present growth. The LR statistics computed

Figure 1. Impulse Response Function

Response to Chole Sky one S.D. Innovations ± 2 S.E

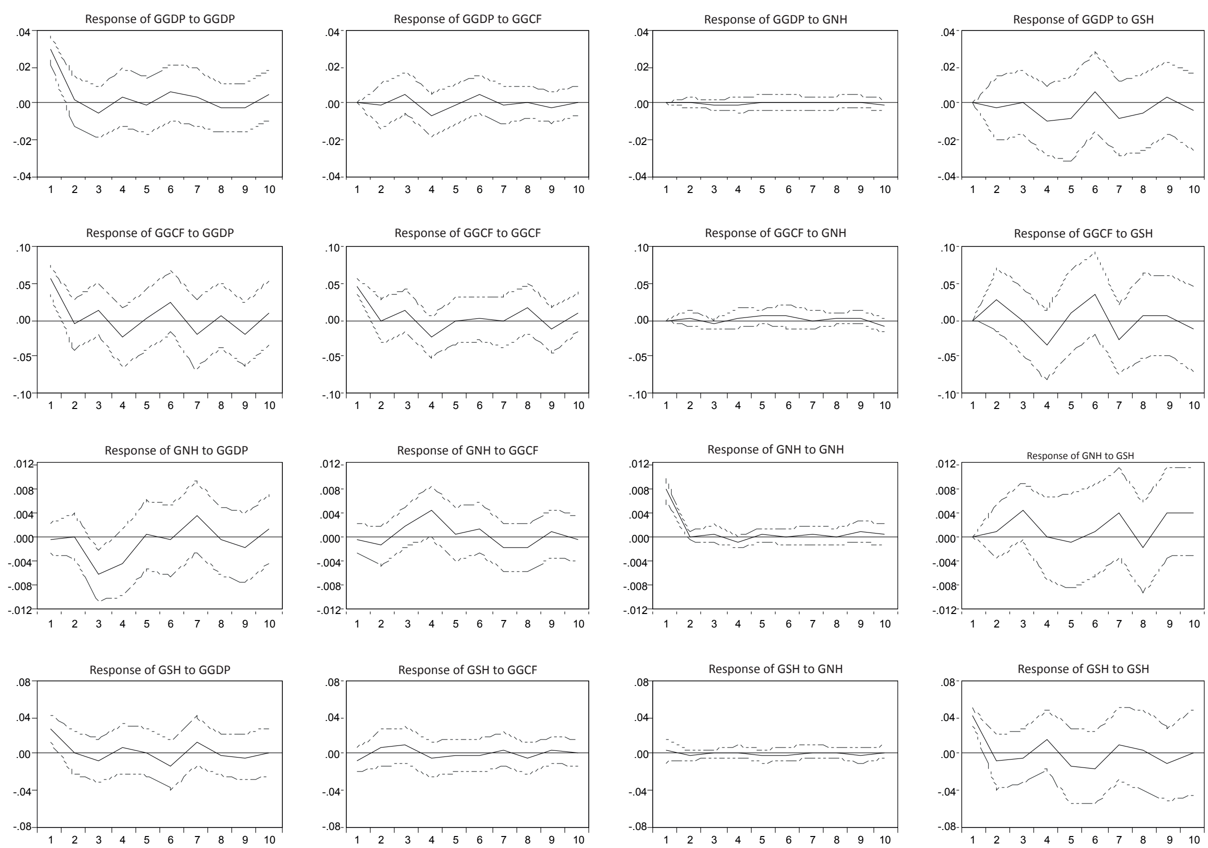

Table 7. Lag Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: GGDP, GGCF, GNH, GSH
Exogenous variables: C ID_GNH

Lag	LogL	LR	FPE	AIC	SC	HQ
0	325.1010	NA	1.02e-12*	-16.26159	-15.92035*	-16.13915*
1	331.5152	10.85481	1.68e-12	-15.77001	-14.74628	-15.40270
2	354.7745	34.59077*	1.20e-12	-16.14228	-14.43606	-15.53011
3	373.6557	24.20673	1.13e-12	-16.29004	-13.90133	-15.43299
4	381.7718	8.740342	2.00e-12	-15.88573	-12.81454	-14.78382
5	408.4789	23.28314	1.56e-12	-16.43482	-12.68114	-15.08803
6	435.4260	17.96472	1.47e-12	-16.99621*	-12.56004	-15.40455

Note : * indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level).
FPE: Final prediction error ; AIC: Akaike information criterion ; SC: Schwarz information criterion ;
HQ: Hannan-Quinn information criterion

value is higher than the $\chi^2(4)$ tabulated at the 5% level. Therefore, we reject the null hypothesis and hence our inclusion of the interaction dummy is justified.

To give a graphical picture and to further verify the results, we depict the generalized impulse response functions. The impact or response of other variables, when one standard deviation shock is given to one endogenous variable, is traced in the graph in the Figure 1. These figures confirm the existence of causality as found in the VAR model.

To further show the fit of the VAR, we conduct serial correlation test and test of normality. From Table 6, we see that there is no serial correlation and also the residual is normally distributed. So our VAR model passes all the diagnostic tests, except heteroskedasticity. Since we intend to see the causal relationship among the variables and do not intend to forecast the future trends, the presence of heteroskedasticity would not invalidate our results.

Discussion and Conclusion

The importance of infrastructure is indeed much studied in literature. A focus on roadways and its improvement programme is a worthwhile effort with consistent results. The empirical analysis of roadways gives us varied results. The hypothesis H1 - GDP grows in response to growth of the national highway network as the increased accessibility to labour markets and suppliers improves the relative attractiveness of an economy is established. Along with it, H3 that national highway networks grow in response to growth in GDP, as new employers need to draw on a larger labour pool and networks serving existing employment centres become more heavily burdened, is also established. We find that the growth in state highways leads to a growth in national highways, but a complementary relationship between them could not be identified as suggested by H2. This is because under the NHDP, many state highways were given the rank of national highways. Therefore, our empirical results may be the outcome of such a policy change. This interpretation also justifies our growth in the state highway variable unidirectionally causing the interaction dummy.

The NHDP programme's impact on gross domestic product, national highway expansion, and gross capital formation is identified as in H4. With infrastructure projects, the investment climate of an economy improves. However, it is the national highways rather than state highways, which have a significant causal relationship with gross capital formation. The results from our VAR model are consistent with Granger's causality test results.

The OLS model that we started with makes our analysis a bit difficult to substantiate. The coefficient of growth in national highways is negative and significant in equation (3), with GDP growth being the dependent variable. Such negative relationship was also reported in literature by Tripathi and Gautam (2010). The interpretation on this can be varied. Public capital may crowd out private capital, having a negative impact on growth. Or the policy of "development by excess" is the strategy for national highways development in India.

Research and Policy Implications

From the results, we see that the coefficient of the growth of national highways is negative and statistically significant. This stands against the general assumption of infrastructure having a positive effect on growth. Furthermore, it calls for identifying other factors and forces which are necessary to harness the positive effects of any infrastructure development endeavour. The policy implication drawn from this result is that any disjointed effort at infrastructure expansion may not yield the desired outcomes. Government needs to integrate infrastructure development programmes with several other projects aimed at enhancing the quality of human capital, increasing the efficiency of markets, and so on. The results reveal that expansion of national highways under the NHDP has a positive and significant influence on GDP growth. This can be considered as an indication of the growth generating potential of ongoing projects like National Highway Interconnectivity Improvement Programme (NHIIP), Bharatmala Programme, and the Setu Bharatam Programme.

Limitations of the Study and Scope for Further Research

The present work studies the relationship between GDP, GCF, national highways, and state highways. However, it does not include variables to represent market efficiency and human capital, which could have an important bearing on the process of accentuating economic growth via improved highway networks. Future research could try to find out the importance of highways on several socioeconomic variables. Employment level and population dimensions may be explored to find their association with expansion of road networks. Impact of highways on intraregional trade, flow of foreign direct investment (FDI), etc. may also be studied. The nexus between expansion of roadway networks and environment could be explored. A more intensive study could consider several other road networks like project roads, other urban roads, service roads, etc. in addition to national highways and state highways. The present study uses time series data at the national level ; future research could use data at the state level. A panel data study may also be pursued in the future.

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