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ORIGINAL ARTICLE

Road-based transport infrastructure and economic growth in Haryana: a causality analysis

Ranjan Aneja[1] · **N. K. Bishnoi**[2]

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Abstract

The present study was an attempt to examine the causal relationship between road infrastructure and economic growth in Haryana over the period of 2004–2018. This paper has used causality analysis to see whether road infrastructure induced the economic growth or economic growth prompted the road infrastructure or both stimulate each other. The study found that economic growth in Haryana, capital investment, and road infrastructure (particularly national highways) are mutually reinforcing. On the basis of the finding, it can be suggested that the achievement of higher growth through road infrastructure would be due to several direct and indirect benefits imparted to the economy. Therefore, the government should upscale and expand the road infrastructure in the state to retrieve further fruits in the form of better economic growth.

Keywords Economic growth · Causality analysis · Cointegration analysis · Road infrastructure · Haryana

Introduction

Physical infrastructure including roads, rail, ports, airports, electricity, and telecommunication etc. are necessary prerequisite for the faster development of an economy. If there is shortage in the basic infrastructure, it not only makes the living conditions difficult but also severely impacts the general economic activities of a modern economy. Inadequate infrastructure leads to higher cost of production and distribution for individual firms thereby rendering them uncompetitive in the global economic system. In other words, less than sufficient infrastructure pushes an economy down below its potential level. There is no surprise, the development of infrastructure is a

✉ Ranjan Aneja
ranjananeja@cuh.ac.in

[1] Department of Economics, Central University of Haryana, Mahendragarh, India

[2] Department of Economics, Guru Jambheswar University of Science and Technology, Hisar, India

primary goal for a developing country like India. In fact, infrastructure is regarded as the wheels of economic activities.

Infrastructure is defined as the public stock of social and economic overhead capital because of its huge potential for improving the quality of life and its large-scale impact on the aggregate economy as highlighted in the early works of development economists such as Rosenstein-Rodan (1943); Lewis (1955); Hirschman (1958); Myrdal (1958); Hansen (1965), and others.

Keeping in mind that infrastructure is directly related to economic growth, the government of India has also been taking several steps to improve the physical infrastructure in the country. As known, physical infrastructure, particularly the roads, ports, airports generates positive externality and therefore their social return outweighs their private return by a wide margin. It is obvious under such circumstances that in these activities private investment cannot be channeled without government support. That is the reason, the study finds government playing an active role in encouraging investment in physical infrastructure. The infrastructure sector in a developing country like India is also largely dominated by the government.

The infrastructure sector is divided into different groups such as EGW (Energy, Gas and Water supply), Railways & Communications, and Transportation other than Railways. In India, by the end of the 1980s, the public sector had almost fully contributed to the gross capital formation in different infrastructure groups. For example, in EGW the contribution of the public sector in GCF had gone up to 95% in 2016. In Railways and communication, it reached 100%. When it comes to transportation, the public sector's share in it appeared quite low about 47% only (GOI, Economic Survey 2018). In the 1980s, the public sector was considered to be important in it. After the 1990s, participation in the private sector also started increasing gradually. In 2005–06 the share of public sector had come down to 77% of GCF in EGW, 41% in Transportation, it was only Railways and communication GCF was 100%. (GOI, Economic Survey 2018). A system of good road networks is very important in developing the economic and promoting trade and social integration. Road infrastructure has become a base for bringing specialization in production and consumption at divergent regions. Many economists are of the view that to increase economic growth, it is necessary to have a good physical connectivity in urban and rural areas.

Having better transport connectivity is an essential component of the economic growth in any region. The road opens a region to the outside world and brings prosperity by providing the opportunity to the regions to specialize in activities it has comparative advantage and import other goods. Conceptually, road connectivity generates benefits broadly in two dimensions. Firstly, its work as a linkage between residents and employment opportunities, consumer and suppliers, and businesses to inputs. Secondly, it enhances the efficiency and productivity of existing inputs and further reduces the production/input cost (Pradhan and Bagchi 2013). The good road network also enables farmers to opt for new machines, chemical fertilizers, high quality seeds/ inputs to increase crop yield. Farmers are also encouraged to adopt new allied activity. Road connectivity enables to access basic services such as schools and medical facilities that may be helpful to improve quality of life of the people particularly in rural areas (Ramanathan 2001). The availability of good road

infrastructure increases efficiency and reduces costs of transportation. It would motivate private transport operators to provide transport services to the people.

The significance of transport and growth is well documented in the previous studies. There is varying observations/findings of the researches on the relationship between transport infrastructure and economic growth (Short and Kopp 2005). Some studies claim the bidirectional causality between both while some researchers have observed unidirectional causality from transport infrastructure to economic growth (Canning and Pedroni 2004). The importance of road infrastructure and its relationship has been well accepted by large numbers of researchers.

In the literature, the link between transport infrastructure and economic growth is either explored in terms of cost–benefit analysis or through macro-econometric modeling. In cost–benefit analysis methods, the feasibility and potential effect of the transport projects are measured by calculating their respective cost and potential benefits. In macro-econometric modeling, three methods are popular i.e., the production function approach, cost function approach, and causality analysis. (Aschauer 1989; Eisner 1991; Munnell 1992; Lynde and Richmond 1992; Morrison and Schwartz 1996; Nadiriv and Mamuneas 1996) Ramanathan 2001; Pradhan and Bagchi 2013).

Understanding such dependency between transport infrastructure and economic growth would be vital in the effective design and implementation of transport policies for an economy aspiring to grow. (Pradhan and Bagchi 2013). There are two possible hypotheses well documented in the literature i.e., infrastructure lead growth and economic growth lead infrastructure augmentation. The outcome of these hypotheses is far from being settled in the literature (Ramanathan 2001). Nag (2019) analyzes the contribution of road infrastructure development and other socio-economic factors that contributed to economic growth. To shed light on this issue, a fixed-effects panel linear regression analysis was conducted on data for 60 countries and demonstrated that the growth in road length per thousand population, per capita export, per capita education expenditure and physical capital stock per worker contributed positively to economic growth. This relationship between both has been reported as a unidirectional relationship, bi-directional relationship, or no causal relationship in literature. This controversial relationship exists due to differences in time period, regions and methodologies. Particularly for India, several studies have found a bi-directional relationship between road infrastructure and economic growth (Pardhan and Bagchi 2013; Raghuram and Babu 2001; Pardhan 2007; Sahoo and Das 2009; Mishra et al. 2013) while there are certain studies those found the unidirectional relationship between the both (Chakarborty and Guha 2009; Ghosh and Prabir 2005). Nenvath (2021) also established the uni-directional relationship from transport infrastructure to economic growth. Further, Ghosh and Dhinda (2022) examined the relationship between transport infrastructure and economic growth in India for the period 1990–2017 by using Multivariate dynamic models. The results revealed the uni-directional effect i.e., road and air transport have significant positive contribution to economic growth in the long-run while rail transport is insignificant.

Therefore, the present study aims to examine the causal relationship between road infrastructure and economic growth in Haryana over the period of 2004–2018. This

paper is an endeavor to assess the effectiveness of roads on accelerating the economic development in the state.

This study is organized in five sections including the present section of the introduction. "State of road transport infrastructure in Haryana" represents the state of road transport infrastructure in Haryana. "Data descriptions and methods" highlights the data description and methodology used in the present study. "Empirical findings and discussion" elaborate on the major finding and present the inferences of the analysis. Finally, "Conclusion" concludes the study.

State of road transport infrastructure in Haryana

India is a big country in size and is divided into 32 units called states in the country. Haryana is one of the relatively well-off states located in the north-western part of the country surrounding the national capital New Delhi from three sides. In terms of per capita income, Haryana is at the top of the major states in the country. The state has been an early adopter of high yield varieties of seeds and therefore agricultural of the state is fairly well developed. Similarly, the state took advantage of its strategic location being in close proximity of National capital Delhi and embarked upon the path of rapid industrialization since early 1980s when Maruti Udyog Ltd established its car production unit in Gurgaon. The setting of General Electric business process facility in late 1990s catapulted Gurgaon into a global hub of IT and ITES services. Presently, Gurgaon has become a world class business centre pulling up its hinterland through spillover effects of its economic activities. Faridabad, Panipat, Yamunanagar and Hisar are other prominent economic centres in the state. Recently, state government has declared to develop Hisar airport and its surrounding into an Economic Hub.

In the state, physical infrastructure particularly the roads are reasonably well developed. The state was amongst the few state in the country to have connected all its villages with all-weather road in early 1970s. In Haryana, 13 out of 22 districts fall under the National Capital Region. However, economic development is confined to Faridabad-Gurgaon and adjoining areas. Interestingly, the connectivity of the Faridabad-Gurgaon region with other parts of the state including its surrounding areas is not very good. To encourage the economic activities and promoting investment in other parts of the state connectivity through quality roads is a necessary prerequisite. At present, Haryana has a good network of roads from National Highways to village roads as depicted in table below (Table 1).

However, the roads in the state have not been able to facilitate industrial activities move into other parts of the state and the investment and business activity continues to be confined a Faridabad-Gurgaon pocket of the state. Over the last few years, in Haryana a number of Highways and other roads are improved and widened from two lane to four/six lane and therefore it is expected that economic activity would also follow the roads and travel into heart of the state. Table 2 shows that substantial amount of money is spent on construction and maintenance of roads in the state. The expenditure on state roads of different kinds is much more than expenditure on

Table 1 Road length in Haryana

Category	Total in numbers	Total length (upto 30.11.2020) KM
National highways	32	3011
State highways	31	1602
Major district roads	36	1337
Village roads	–	21,213
Total		**27,235**

Source: Public Works Department (B&R), Government of Haryana, India

national highways and it must have improved the regional and sub-regional connectivity in the state.

Data descriptions and methods

In this section, the methods applied and variable used in this study are described. The annual data on gross state domestic product (GSDP) in constant price of 2004–05 is used as a proxy for economic growth, TRL is Total road network length (km) to represent the road infrastructure (further divided in to national highway road length and other than national highway road length i.e., state highways). Later on, gross domestic capital formation (GCF) in 2004–05 prices is used as a proxy for increment in productive capacity. All variables are transformed into natural logarithms. Broadly to analyze the relationship between growth and road infrastructure the following model is used:

$$Y = f(\text{TRL}, \text{GCF}) \tag{1}$$

Table 2 Expenditure on State and National Highway (Haryana) (Rs. Crore)

State road	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17
1. Construction	775.5	882.6	1110.6	1549.7	1292.0	NA	1362.5
2. Bridges	36.7	4421.0	106.0	217.7	158.1	NA	176.2
3. Maintenance	390.7	302.1	468.7	597.9	522.0	NA	546.3
A: Total	1203.0	1228.9	1685.3	2365.2	1972.1	NA	2085.0
National highway							
1. Construction and bridges	183.9	94.9	79.6	50.1	61.8	NA	116.3
2. Maintenance	26.5	24.9	20.4	30.8	21.4	NA	35.5
B: Total	210.5	119.8	100.0	80.9	83.2	NA	151.9
Grand total (A + B)	1413.5	1348.7	1785.3	2446.1	2055.3		2236.9

Source: Statistical Abstract of Haryana, 2019–20

where Y is economic growth, TRL is the total Road length and GCF the gross domestic capital formation. The data employed for this research are annual and cover the period 2004–2018 obtained from Statistical Abstract of Haryana, Ministry of Road Transport, Haryana, and National Highway Authority of India.

In this study, Vector autoregression (VAR) based Granger causality test has been applied to see the relationship between economic growth and road infrastructure in Haryana. To apply this test, it is important to check the stationarity of time series involved. Most of the economic time series contain unit roots dominated by stochastic trends detectable by the method given by Nelson and Plosser (1982). A stochastic trend is determined by testing the presence of unit roots in time series data (Dritsaki and Dritsaki-Bargiota 2005; Elliot, Rothenberg and Stock 1996). The Augmented Dickey Fuller (ADF) test (Dickey and Fuller 1981) is used to test for detecting unit roots. ADF test is used to detect the nature of stationarity between the variables. This will indicate the presence of cointegration and causality, based on VAR and VECM representations. Engel and Granger (1987) showed that, if two variables are individually integrated of order one and cointegrated, and then a causal relationship may exist between them in at least one direction. Hence, it is necessary to also test for cointegration among the time series variables (Pardhan and Bagchi 2013).

$$\Delta Z = \alpha_1 + \alpha_2 t + \alpha_3 Z_{t-1} + \sum_{i=1}^{p} \beta i \Delta Z_{t-1} + \varepsilon_t \tag{2}$$

Table 3 shows the results of ADF tests. The table clearly indicates that the variables are stationary at first difference. Depending upon VAR and VECM representation, the presence of co-integration and causality can be ascertained with nature of stationarity.

If two variables are individually integrated of order one and co-integrated, then a causal relationship may exist between them in at least one direction (Engel and Granger 1987). Therefore, it becomes mandatory to check the co-integration among the variables. The co-integration test measures the long-run relationship between the time series variables. The hypothesis that tests this is the null of non-co-integration against an alternative that co-integration exists. This uses the Johansen (1988) maximum likelihood ratio test and based the trace statistics and the maximum eigenvalue statistics.

Therefore, the study proposes three models. In first model, the co-integration between GSDP, GFC and road length of the *national highway* in Haryana is examined. In second model the co-integration between GSDP, GFC and *Other than national highway* road length in Haryana is studied and existence of co-integration with total road length in Haryana was also investigated.

The null hypothesis of r co-integrating vectors is tested in above table against the alternative hypothesis of $r+1$ co-integrating vector. As we discussed earlier, depending upon the co-integration it would be determined that whether VAR to be used or VECM. For example, if the variables are stationary and not co-integrated, the following VAR model must be used:

Table 3 ADF-unit root tests

Variable	Constant	Constant with trend	Conclusion
Level			
GSDP	2.97	− 0.25	Non- Stationary
GCF	1.56	− 0.47	Non-stationary
NHRL	− 0.53	− 1.13	Non-stationary
ORL	− 0.27	− 1.29	Non-stationary
TRL	− 0.72	− 2.64	Non-stationary
First difference			
GSDP	− 4.47	− 6.07**	Stationary
GCF	− 5.85	− 6.86**	Stationary
NHRL	− 3.43	− 5.98**	Stationary
ORL	− 2.97	− 5.45*	Stationary
TRL	− 6.43	− 8.35*	Stationary

Where: *GSDP* gross state domestic product of Haryana, *GCF* gross capital formation, *TRL* total road length, *NHRL* national highway road length, *ORL* other than national highway road length

*Indicates statistically significant at 1%, **Indicates statistically significant at 5%

$$\mathrm{GSDPt} = \emptyset_0 + \sum_{j=1}^{P} \emptyset_{1i}\mathrm{GSDP}_{t-1} + \sum_{j=1}^{P} \emptyset_{2j}\mathrm{GCF}_{t-j} + \sum_{k=1}^{P} \emptyset_{3k}\mathrm{TRL}_{t-k} + \varepsilon_{1t} \quad (3)$$

$$\mathrm{GCFt} = \gamma_0 + \sum_{i=1}^{P} \gamma_{1i}\mathrm{GCF}_{t-1} + \sum_{j=1}^{P} \gamma_{2j}\mathrm{GSDP}_{t-j} + \sum_{k=1}^{P} \gamma_{3k}\mathrm{TRL}_{t-k} + \varepsilon_{2t} \quad (4)$$

$$\mathrm{TRLt} = \lambda_0 + \sum_{i=1}^{P} \lambda_{1i}\mathrm{TRL}_{t-1} + \sum_{j=1}^{P} \lambda_{2j}\mathrm{GCF}_{t-j} + \sum_{k=1}^{P} \lambda_{3k}\mathrm{GSDP}_{t-k} + \varepsilon_{3t} \quad (5)$$

In above equations, GSDP is used for Economic Growth, GCF used for Gross capital formation and TRL used for total road length as proxy to road infrastructure. As the above variables are co-integrated then VECM models would be applied on Eqs. 6, 7, 8.

$$\Delta\mathrm{GSDPt} = \emptyset_1 + \sum_{l=1}^{P} \alpha_{11,l}\Delta\mathrm{GSDP}_{t-1} + \sum_{l=1}^{P} \beta_{12,l}\Delta\mathrm{GCF}_{l-1} + \sum_{l=1}^{P} \emptyset_{13,l}\mathrm{TRL}_{t-i} + \delta_1\mathrm{EC}_{t-1} + \varepsilon_t \quad (6)$$

$$\Delta\mathrm{GCFt} = \emptyset_2 + \sum_{l=1}^{P} \alpha_{21,l}\Delta\mathrm{GCF}_{t-1} \sum_{l=1}^{P} \beta_{22,l}\Delta\mathrm{GSDP}_{l-1} + \sum_{l=1}^{P} \emptyset_{23,l}\mathrm{TRL}_{t-i} + \delta_2\mathrm{EC}_{t-1} + \varepsilon_t \quad (7)$$

Table 4 Results of co-integration tests

Model	H_0	Trace statistics	Max eigen value
Model-A	$r=0$	52.39*	23.65*
	$r\leq 1$	13.38*	9.95*
	$r\leq 2$	11.24	7.85
Model-B	$r=0$	48.66*	34.45*
	$r\leq 1$	7.78	7.37
	$r\leq 2$	1.65	1.55
Model-C	$r=0$	34.75*	31.37*
	$r\leq 1$	7.990	5.605
	$r\leq 2$	1.650	1.855

*Statistically significant at 5%, *r* is number of co-integrated vectors

$$\Delta \mathrm{TRLt} = \emptyset_3 + \sum_{l=1}^{P} \alpha_{31,l} \Delta \mathrm{TRL}_{t-1} + \sum_{l=1}^{P} \beta_{32,l} \Delta \mathrm{GCF}_{l-1} + \sum_{l=1}^{P} \emptyset_{33,l} \mathrm{GSDP}_{t-i} + \delta_3 \mathrm{EC}_{t-1} + \varepsilon_t \tag{8}$$

In above equations, EC represent the error corrections terms. This term represents the estimated residual from the co-integration regression.

Empirical findings and discussion

This empirical analysis of the study begins with the testing of stationarity of the time series variables as stationarity of the variables is a mandatory requirement before detecting the co-integration and causality among the variables. For the purpose, augmented Dickey Fuller test has been applied. The results of the test are given in Table 5. The table clearly reveals that none of the time series variable is stationary

Table 5 Causality analysis

Models	Dependent variable	ΔGSDP	ΔGCF	ΔNHRL	ΔORL	ΔTRL	ECM	Outcome
Model-A	ΔGSDP	–	6.05*	3.38*	–	–	− 2.15*	GSDP⇔GFC
	ΔGCF	5.28*	–	− 3.30*	–	–	− 3.54*	GSDP⇔NHRL
	ΔNHRL	3.72*	3.38*	–	–	–	− 2.45*	GFC⇔NHRL
Model-B	ΔGSDP	–	1.47	–	2.57**	–	2.88*	GSDP⇔GFC
	ΔGCF	3.11*	–	–	2.95	–	2.74**	GSDP⇒ORL
	ΔORL	0.76	− 0.65	–	–	–	1.35	GFC ⇒ORL
Model-C	ΔGSDP	–	5.13*	–	–	4.45*	2.84*	GSDP⇔GFC
	ΔGCF	4.95*	–	–	–	3.85*	2.88*	GSDP⇔TRL
	ΔTRL	2.85*	2.30*	–	–	–	2.84*	GFC⇔TRL

Where: *GSDP* gross state domestic product of Haryana, *GCF* gross capital formation, *TRL* total road length, *NHRL* national highway road length, *ORL* other than national highway road length

*Indicates statistically significant at 1%, **Indicates statistically significant at 5%

at level. It means the possibility of non-stationarity of time series variables cannot be rejected at level. Therefore, it becomes important to check the stationarity of time series variables at higher level of difference. Accordingly, the ADF test has been applied to check the stationarity at first difference (see Table 3). The Table 3 reveals that all the variables are stationary at first difference. Hence, the differences become stationary and consequently the related variables get characterized as integrated of order one, 1 (1).

By using Johanson's test on these integrated series of order one, co-integration relationship among the variables is measured and Table 4 depicts that all the time series variables (Road length, economic growth and capital investment) are related i.e., they are co-integrated. This indicates the long run relationship between the variables. Finding the variables co-integrated, it was decided to further examine the direction of causality between the variables. For the purpose, the VECM model has been established and the results of the VECM model are reported in Table 4.

The results of causality test (Model A, as shown in Table 5) confirm the existence of bidirectional causality between economic growth of the Haryana (GSDP) and gross capital formation; bidirectional causality between economic growth of the Haryana (GSDP) and National highways growth (NHRL); bidirectional causality between and National highways growth (NHRL) and gross capital formation.

This indicates that the economic growth, National highway road length growth and capital formation in Haryana are mutually reinforcing. Therefore, this finding justifies the both hypotheses i.e., infrastructure development leads to economic growth and growth in turn leads to infrastructure development in Haryana.

Further, the study finds the unidirectional relationship between economic growth and state highway growth; unidirectional growth from GCF to state highway growth (Model B, as shown in Table 5). This can be interpreted as that in Haryana over the study period 2004–2018, the economic growth and incremental investment create demand for new roads and subsequently *non-national highways roads (including state highways)* are constructed to meet the increase in demand of roads connecting to hinterland of the state. Further, the *non-national highways roads (including state highways)* do not stimulate economic growth in Haryana. In a sense, the sense of planning to attract economic activities in hinterland of Haryana, away from the national highways is missing in the development of *non-national highways roads (including state highways)*in Haryana. As result, despite Haryana achieving superlative economic growth, the hinterland of the state is bereft of modern economic activities and the economy continues to gravitate towards already developed few pockets in the state around the national highways.

Regarding the overall road infrastructure growth (measured as road-length), it was found that there is an existence of bidirectional causality between the variables. This again confirms the importance of National highways in Haryana and their contribution in economic growth of Haryana. (Model C, as shown in Table 5).

In nutshell, economic growth in Haryana, capital investment and road infrastructure (particularly national highways) are mutually reinforcing. These findings are in line with existing literature. The studies of (Pradhan 2007; Tripathi and Gautam 2010; Mishra et al. 2013; Sahoo and Das 2009) also confirm the similar type of relationship among the above variables. In a moderately developed economy like

Haryana that is situated at the outskirt of the national capital of the country investment in roads or increase in road length is attracting expansion of economic activities (industrial activities). Therefore, the road infrastructure is facilitating the industrial units and other economic activities as sound input. There is also a fact that being a rich economy, the per capita disposable income in the state is high and due to this there is increment in demand of better roads connectivity by the citizen of state. This further prompts to economic growth. Further, roads particularly national highways are increasing the revenue of the government in form of collection of toll taxes and other taxes.

On the basis of the finding it can suggested that the achievement of higher growth through road infrastructure would be due to several direct and indirect benefits imparted to the economy (Pardhan and Bagchi 2013). Therefore, the government should upscale and expand the road infrastructure in the state to retrieve the further fruits in form of better economic growth.

Conclusion

This study has examined the causal relationship between road infrastructure and economic growth in Haryana over the period of 2004–2018. The study is expected to be important for transport policy in India in general and for Haryana in particular. The authors used the causality analysis to see whether road infrastructure induced the economic growth or economic growth prompt the road infrastructure or both stimulate each other. The study found that economic growth in Haryana, capital investment and road infrastructure (particularly national highways) are mutually reinforcing. On the basis of the findings it can be suggested that the achievement of higher growth through road infrastructure would be due to several direct and indirect benefits imparted to the economy. Therefore, the government should upscale and expand the road infrastructure in the state to retrieve further fruits in form of better economic growth. The major limitation of this study is the availability of secondary data. This research can be further expanded by using more time-series data and also a comparative study be carried out between several states of India. One can also expand this study by including more variables such road density, public and private infrastructure investment etc.

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Declarations

Conflict of interest The authors declare that there is no conflict of interest.

Human participants or animals This article does not contain any studies with human participants or animals performed by any of the authors.

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