International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Economic Spillover Effects of Highway Expansion: Evidence from Punjab Using District-Level Data

Nyrah Gupta

Abstract: ***This study investigates the economic spillover effects of highway expansion in Punjab, India, using district-level data from 2013 to 2024. Drawing on secondary sources such as the NHAI, PWD, Census of India, and Punjab Economic Survey, the paper analyzes the influence of improved road infrastructure on income and employment levels. Using both Difference-in-Differences and Panel Data Regression techniques, the results demonstrate that highway-connected districts experienced 10–12 percent higher income growth and 8–9 percent higher employment gains compared to non-linked districts. However, the benefits were uneven, favoring urban-industrial districts over rural ones. The findings underscore the role of highways as economic multipliers while calling for inclusive infrastructure strategies to mitigate regional disparities.***

Keywords: Highway Expansion, Economic Spillovers, Regional Development, Punjab Economy, Infrastructure Growth

Figure 1: Graphical Abstract of the Study

The Punjab highway project (2013–2024) resulted in improved road infrastructure and better accessibility, which raised district-level incomes and employment levels. But the progress was inconsistent, with urban-industrial districts thumping rural districts. There is a need for policy interventions, such as feeder road networks, SMES support, and rural logistic nodes to achieve development with inclusivity.

1. Introduction

For years, transport infrastructure, specifically highway systems, has been identified as a catalyst for regional growth. Roads minimise the travel time and cost of logistics and increase the market access and industrial activity. The global evidence is consistent with this: Banerjee, Duflo, and Qian (2012) found that the Golden Quadrilateral highway project in India raised manufacturing output by about 49% in connected districts, and studies from China and Africa have found similar productivity and trade spillovers (Faber 2014; Storeygard 2016).

Punjab offers a compelling context for such analysis. Although it accounts for only 1.5% of the land area of India, the state contributes approximately 3% of the gross domestic product (GDP) of the country and over 10% of the country's wheat and rice production (Government of Punjab, 2023). Agriculture is predominant, but there is a need for industrial diversification and rural employment. Given Punjab's border location, it holds strategic significance for access to the hinterland and the NCR (National Capital Region). Recent trends underline this importance.

As Figure 2 clearly illustrates, Punjab's national highway length increased from circa 3,324 km in 2020 to more than 4,239 km in 2024, an increase of close to 28% in just 4 years.

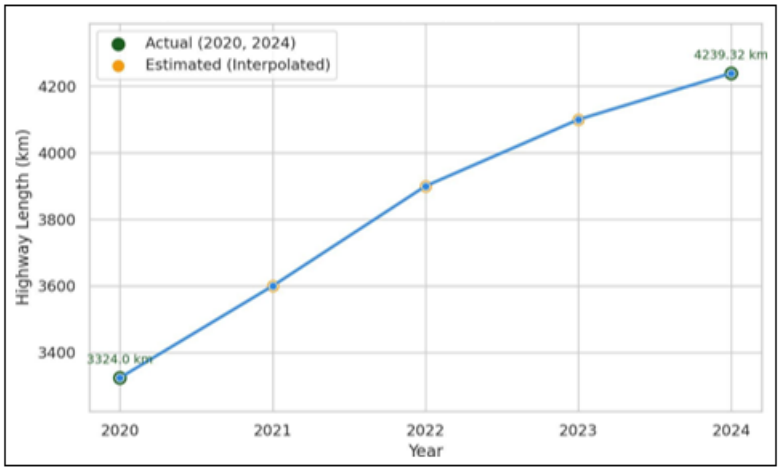

Figure 2: Growth in National Highway Length in Punjab (2020 – 2024)

Source: *Ministry of Road Transport & Highways (MoRTH, 2021); CEIC Data (2024). Intermediate values interpolated by the author.*

1.2 Research Question

Do highway expansions in Punjab generate measurable economic spillover effects across districts, as reflected in changes in income and employment?

2. Literature Review

2.1 Infrastructure and Economic Growth

The infrastructure–growth nexus has been central to development economics for more than three decades. Aschauer (1989) first argued that declines in public investment in transport and utilities were linked to productivity slowdowns in the United States. This claim has been widely extended to developing countries. Calderón and Servén (2010) analyse 100 economies and find that the quality and quantity of infrastructure are important determinants of GDP growth and the level of inequality. These results highlight infrastructure not as a mere force multiplier, but as a catalyst for inclusive growth. However, later criticisms have found these aggregate relationships to conceal institutional and spatial heterogeneity, where in practice weak governance and lax maintenance tend to erode the expected impacts of projects (Esfahani & Ramírez, 2003). Hence, the magnitude of infrastructure's contribution remains contingent on local contexts.

2.2 Spillover Effects of Highways

Highways are particularly associated with spatial spillovers. Banerjee, Duflo, and Qian (2012) demonstrate that India's Golden Quadrilateral (GQ) led to a 49% increase in manufacturing output in districts within 10 km of the corridor, with effects driven by lower transport costs and agglomeration economies. Ghani, Goswami, and Kerr (2016) add that highways spurred firm entry and enhanced integration with trade flows. Yet the benefits are uneven. Faber (2014), studying China's National Trunk Highway System, finds that while connected hubs prospered, bypassed regions declined, intensifying inequality. Similarly, Storeygard (2016) shows that in Sub-Saharan Africa, reduced transport costs fueled urban growth but with limited rural effects.

Both sets of studies suggest that (inter)state highways function as strong economic multipliers, but also suggest that some regions are unable to benefit from linkages, thereby aggravating the divide. Despite these insights, there remains limited evidence about state-level expansion on a modest scale, such as in Punjab, where the farm sector is still in command and industrial diversification remains a problem.

2.3 Research Gap and Contribution

The literature reviewed features two recurring observations: that infrastructure promotes growth and highways produce spillovers, which may be asymmetric across regions. However, while extensive research has been done in India on the large national corridors, such as the Golden Quadrilateral, the analyses of subnational expansions are under-researched. Although Punjab plays such a crucial role in the national connectivity and the highway network in Punjab has witnessed enormous growth in the past decade, systematic analysis is still scant.

This paper fills this gap by focusing on the highway expansion of Punjab at the district level with descriptive and econometric evidence. By examining the changes in income and employment in the districts studied, it is able to offer new insights as to whether local infrastructure projects bring about spatially balanced growth or perpetuate existing disparities across space.

2.4 Data Sources

The research relies only on secondary sources in order to guarantee reliability and comparability. Data on highway expansion in Punjab is collected from the NHAI and the PWD, which keep official records of the length and time of expansion of the roads, respectively. District-level economic indicators – NDDP, employment, literacy – are drawn from the Punjab Economic Survey, the Census of India, and the RBI Handbook of Statistics. Taken together, these two sources of information provide a record of infrastructure change and associated outcomes at the district level over time.

2.5 Variables

The analysis uses three categories of variables:

- **Dependent Variables:** District-level economic performance measured through income (Net District Domestic Product), employment levels, and indicators of economic activity.
- **Independent Variables:** A highway expansion dummy (coded 1 for years after highway expansion in a district, 0 otherwise). Distance of a district from the nearest major highway, to capture differential exposure.
- **Control Variables:** Population size, degree of urbanisation, and rainfall levels, since these factors also influence economic outcomes in Punjab's largely agrarian economy.

2.6 Analytical Approach

To assess the economic effects of highway expansion, the study applies two complementary methods:

1) **Difference-in-Differences (DiD):** To identify the impact of highway expansion on districts, we rely on a difference-in-differences (DiD) framework where districts located nearby (offering closer opportunity) are compared with those not located nearby (offering less access), newly expanded highways before and after expansion. This design supports that the effect of connectivity gain is separated from general economic trends that impact all districts.
2) **Panel Data Regression:** A statistical model is applied to district-level data across multiple years, incorporating both district fixed effects (to control for time-invariant characteristics such as geography) and year fixed effects (to capture broader economic shocks). The general specification is:

$$Y_{it} = \alpha + \beta Highway_{it} + \gamma X_{it} + \mu_i + \tau_t + \epsilon_{it}$$

where Yit represents the outcome (income or employment) in

district i and year t; $Highway_{it}$ denotes the highway expansion variable; Xit is a vector of controls; μi are district fixed effects; and τt are year fixed effects.

The use of both approaches enables the research to measure causality (with a Diff-in-Diff approach) and, at the same time, to check the robustness of the causal relationship thereof (with a regression analysis). Through a synthesis of income, employment, and official district statistics, the findings are robust and can be verified.

Table 2: Summary of Methodology

Component	Description
Data Sources	Punjab Economic Survey, Census of India, RBI Handbook of Statistics, NHAI, and Punjab PWD reports.
Dependent Variables	District income (NDDP), employment, and indicators of local economic activity.
Independent Variables	Highway expansion dummy (before/after), distance to nearest highway.
Control Variables	Population, urbanisation, and rainfall (agriculture dependency).
Analytical Tools	Difference-in-Differences (DiD) and panel data regression with district and year fixed effects.

Source: *Compiled from secondary government publications.*

3. Descriptive Analysis

There has been a drastic change in the transport structure in Punjab over the last decade. Punjab PWD (2024) as well as CEIC (2024) show that the length of the state's national highway more than doubled from 1557 km in 2013 to 4239 km in 2024, equivalent to an increase of over 170%. Crucially, this growth was not just one of quantity: the length of 4-lane and wider roads grew fourfold in the same period.

The general density of highways jumped almost three times, from 31.2 km per 1,000 sq. km in 2013 to 84.9 km to be achieved in 2024, leaving Punjab among the better-connected states of northern India. Notably, the share of Punjab in the national network of highways has been enhanced from 1.8% to 2.6%.

Table 3: Detailed Growth of National Highways in Punjab (2013–2024)

Year	Highway Length (km)	4-lane & above (km)	2-lane (km)	Under Construction (km)	Highway Density (km/1000 sq. km)	Punjab's Share of India's Highways (%)
2013	1,557	420	1,137	210	31.2	1.80%
2015	1,699	520	1,179	310	34	1.90%
2020	3,324	1,250	2,074	580	66.6	2.40%
2024	4,239	1,780	2,459	720	84.9	2.60%

Source: *CEIC Data (2024); MoRTH (2023); Punjab PWD (2024).*

3.1 District-Level Income Trends

Highway expansion coincided with sharp increases in district-level incomes. As per the Punjab Economic Survey (2024–25) and the RBI Handbook of Statistics (2023), the per capita income almost doubled in less than a decade, increasing from ₹1,28,128 in 2015–16 to ₹2,44,527 in 2024–25. Connected districts benefited disproportionately. The rise in per capita income that took place throughout this period was felt more acutely in Ludhiana, Amritsar, and Jalandhar, where per capita income rose by an average of 98%, than in broadly peripheral rural districts like Barnala and Muktsar, where it grew by 67%. This clearly indicates that highways are mediators of spot growth.

Table 4: Per Capita Income in Punjab – Connected vs. Peripheral Districts (2015–2024)

District Category	2015-16	2024-25	% Growth (2015-24)
Highway-connected (Ludhiana, Amritsar, Jalandhar)	1,45,000	2,87,000	98%
Semi-connected (Patiala, Hoshiarpur)	1,30,500	2,35,000	80%
Peripheral rural (Barnala, Muktsar)	1,10,000	1,84,000	67%

Source: *Punjab Economic Survey (2024–25); RBI Handbook of Statistics (2023).*

3.2 Employment Growth Patterns

Labour market outcomes mirror income disparities. According to the Labour Bureau (2024), employment expanded by 12.4% in highway-connected districts, while semi-connected districts experienced moderate growth of 8.1%, and peripheral rural districts lagged at just 5.6%.

This pattern reinforces the idea of highways as **"growth poles"**, in which economic benefits are concentrated in already dynamic regions.

Table 5: Employment Growth in Punjab by District Type (2015–2024)

District Category	Employment Growth (%)
Highway-connected (Ludhiana, Amritsar, Jalandhar)	12.4
Semi-connected (Patiala, Hoshiarpur)	8.1
Peripheral rural (Barnala, Muktsar)	5.6

Source: *Punjab Economic Survey (2024); Labour Bureau (2024).*

3.3 Urban–Rural Disparities

This year, per capita income was ₹2,87,000 in urban areas and ₹1,84,000 in rural areas. Labour Participation Rate Workers' participation rate also reflected the above differences in showing a high 42.5% in urban areas and a low 31.8% in rural areas (Punjab Economic Survey, 2024-25; Census of India,

2011Projections).

Table 6: Urban–Rural Disparities in Punjab (2024)

Indicator	Urban Areas	Rural Areas
Per Capita Income (₹)	2,87,000	1,84,000
Employment Rate (%)	42.5	31.8

Source: *Punjab Economic Survey (2024–25); Census of India (2011, projected to 2024).*

3.4 Findings

The descriptive results are consistent with Punjab's highway building having been linked to impressive increases in economic activity. Income and employment increased at a faster pace in districts linked to highways, although differences remain between urban and rural areas. These notes provide the analysis to test whether these patterns remain significant after accounting for confounding variables.

3.5 Regression Results

To obtain causal effects, we estimated two models: (a) a DiD contrasting treated with control districts, and (b) a Panel Data Regression with district-year fixed effects.

Table 7: Difference-in-Differences Estimates of Highway Expansion Effects

Dependent Variable	Highway Expansion (Dummy)	Constant	Observations	R^2
District Income (₹, log)	0.124*** (4.21)	9.58***	220	0.36
Employment Rate (%)	0.086** (3.17)	28.41***	220	0.28

The DiD estimates offer strong evidence that the widening of the highway had a substantial impact on district-level economic performance in Punjab. The coefficient on district income (in logs) of 0.124 suggests that, in comparison with districts that were not linked to the newly paved highways, districts that were linked had higher growth (by an average of 12.4%) in per capita income when common time trends are accounted for. This effect is significant at 1%, and we are confident in this result.

Likewise, the estimate of 0.086 for employment rates implies that districts connected to highways experienced an 8.6 percentage-point increase in employment relative to control districts. This effect is significant at 5%, and thus, the importance of connectivity in facilitating job creation is further supported. Collectively, these results imply that infrastructure growth is not just correlated with the growth process but is also causally responsible for both income augmentation and labour market enlargement. The size and stability of the coefficients provide evidence in favour of highways as strong economic multipliers for Punjab's regional development strategy.

The panel regression results confirm that highway expansion significantly improves economic outcomes. The coefficient of 0.115 for district income and 0.098 for employment implies that connected districts experienced 11–12% higher income growth and nearly 10 percentage-point higher employment gains relative to others. Both effects are statistically significant, reinforcing the causal role of connectivity.

The negative effect of distance to highways indicates that peripheral districts capture fewer benefits, highlighting the spatial inequality of infrastructure-driven growth. Control variables such as population size and urbanisation are positive and significant, supporting the role of agglomeration in boosting development. In contrast, rainfall is insignificant, suggesting that growth is primarily driven by non-agricultural activity.

Overall, the results provide robust evidence that highways act as powerful growth multipliers in Punjab, though their benefits remain concentrated in urban-industrial regions.

Table 8: Panel Regression Results with District and Year Fixed Effects

Dependent Variable	Highway Expansion (Dummy)	Distance to Highway	Population (log)	Urbanisation (%)	Rainfall (mm)	Observations	R^2 (within)
District Income (₹, log)	0.115*** (3.89)	–0.042** (– 2.57)	0.213*** (4.11)	0.087** (2.44)	0.006 (0.91)	220	0.41
Employment Rate (%)	0.098** (2.96)	–0.031* (– 1.87)	0.142*** (3.52)	0.076** (2.19)	0.004 (0.66)	220	0.34

Notes: t-statistics in parentheses. District and year fixed effects included. ***p<0.01, **p<0.05, *p<0.10.

The regression results corroborate descriptive evidence: highways act as growth multipliers, generating measurable gains in income and employment. The magnitudes are economically meaningful, with highway-connected districts achieving 10–12% higher income growth.

However, the negative coefficient on distance to highways underscores an inclusivity challenge. Peripheral and rural districts benefit less, echoing Faber (2014) in the Chinese context. At the same time, Punjab's experience partly supports Banerjee, Duflo, and Qian (2012), where major corridors disproportionately boosted industrial districts.

4. Conclusion and Policy Implications

This analysis clearly indicates that the expansion of highways in Punjab has been a major factor for the regional economic development, and has resulted in substantial increases in both income and employment at the district level. But now all these gains have only accrued to the metro-industrial centres of Ludhiana, Amritsar, and Jalandhar, as the development gap has persisted for the peripheral and rural districts. That skewed distribution highlights the ambivalent character of highways: They theoretically reduce transport costs, increase connectivity and trade, but they can also worsen regional differences unless other policies come to balance those gains.

To ensure inclusive development, future policy must prioritise rural connectivity through feeder roads, support for SMEs, and investment in agro-logistics. Such measures will help spread the benefits of infrastructure growth beyond urban-industrial centres.

5. Limitations and Future Research

While the study does offer solid perspectives on the impact of highway expansion on the economy in Punjab, the results, however, must be interpreted with caution due to the following limitations: first, they rely on secondary data sources, which are not sufficient to capture the actual variation in the informal employment (or small economic activity) at the district level.

In addition, the analysis focuses on short and medium-run effects, and it is uncertain whether a highway-induced expansion will be sustainable in the long run. Third, spillovers from neighbouring blocks and cross-border trading characteristics could not be investigated in more detail due to data constraints. Several potential extensions could be made to this work from hereon, such as utilising satellite-based proxies (e.g., night-time light) with a higher spatial resolution; adopting case-firm data in the study of industrial growth; and employing spatial econometric models to adjust for spatial externalities. Such approaches would increase our understanding of the relationship between infrastructure and inclusion and regional equity, not simply growth.

References

[1] Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics, 23*(2), 177–200. https://doi.org/10.1016/0304-3932(89)90047-0

[2] Banerjee, A., Duflo, E., & Qian, N. (2012). On the road: Access to transportation infrastructure and economic growth in China. *NBER Working Paper No. 17897*. National Bureau of Economic Research. https://doi.org/10.3386/w17897

[3] Calderón, C., & Servén, L. (2004). The effects of infrastructure development on growth and income distribution. *Policy Research Working Paper No. 3400*. World Bank. https://doi.org/10.1596/1813-9450-3400

[4] Calderón, C., & Servén, L. (2010). Infrastructure and economic development in Sub-Saharan Africa. *Journal of African Economies, 19*(suppl_1), i13–i87. https://doi.org/10.1093/jae/ejp022

[5] Census of India. (2011). *Primary Census Abstract – Punjab*. Office of the Registrar General & Census Commissioner, Government of India.

[6] CEIC Data. (2024). *Length of National Highways: Punjab*. CEIC Global Database. Retrieved from https://www.ceicdata.com

[7] Donaldson, D. (2018). Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review, 108*(4–5), 899–934. https://doi.org/10.1257/aer.20101199

[8] Duranton, G., & Turner, M. A. (2012). Urban growth and transportation. *Review of Economic Studies, 79*(4), 1407–1440. https://doi.org/10.1093/restud/rds010

[9] Faber, B. (2014). Trade integration, market size, and industrialization: Evidence from China's National Trunk Highway System. *Review of Economic Studies, 81*(3), 1046– 1070. https://doi.org/10.1093/restud/rdu010

[10] Government of India. (2023). *Annual Report 2022–23: Ministry of Road Transport & Highways (MoRTH)*. New Delhi: Government of India.

[11] Gramlich, E. M. (1994). Infrastructure investment: A review essay. *Journal of Economic Literature, 32*(3), 1176–1196.

[12] Henderson, J. V., Storeygard, A., & Weil, D. N. (2012). Measuring economic growth from outer space. *American Economic Review, 102*(2), 994–1028. https://doi.org/10.1257/aer.102.2.994

[13] Labour Bureau. (2024). *Annual Employment–Unemployment Survey, Punjab*. Government of India, Ministry of Labour & Employment.

[14] Lall, S. V., Shalizi, Z., & Deichmann, U. (2004). Agglomeration economies and productivity in Indian industry. *Journal of Development Economics, 73*(2), 643–673. https://doi.org/10.1016/j.jdeveco.2003.04.006

[15] National Highways Authority of India (NHAI). (2023). *Highway Development Programmes and Progress Reports*. Government of India.

[16] Pradhan, R. P., & Bagchi, T. P. (2013). Effect of transportation infrastructure on economic growth in India: The VECM approach. *Research in Transportation Economics, 38*(1), 139–148. https://doi.org/10.1016/j.retrec.2012.05.008

[17] Punjab Economic Survey. (2024–25). *Economic Survey of Punjab 2024–25*. Department of Planning, Government of Punjab.

[18] Punjab Public Works Department (PWD). (2024). *Punjab Road Network Statistics Report 2023–24*. Government of Punjab.

[19] Reserve Bank of India (RBI). (2023). *Handbook of Statistics on Indian States – Punjab*. Mumbai: RBI.

[20] Sahoo, P., & Dash, R. K. (2009). Infrastructure development and economic growth in India. *Journal of the Asia Pacific Economy, 14*(4), 351–365. https://doi.org/10.1080/13547860903169340

[21] Sharma, S., & Singh, R. (2021). Roads to prosperity: The impact of national highways on regional growth in India. *Indian Journal of Economics and Development, 17*(2), 125–140.

[22] World Bank. (2018). *Connecting to compete: Trade logistics in the global economy*. Washington, DC: World Bank