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Vehicle Growth and Road Infrastructure Stress in India: An Empirical Assessment of Load and Public Expenditure Trends

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Abstract

India has experienced rapid and sustained motorization over the past two decades, accompanied by significant growth in freight and commercial transport. While rising vehicle ownership reflects economic progress and enhanced mobility demand, it simultaneously implies increased pressure on road infrastructure systems. This study empirically examines the relationship between vehicle population growth—particularly goods vehicles—and public expenditure on road infrastructure in India. Using secondary data from official government publications for the period 2010–2023, the analysis employs descriptive trend evaluation, compound annual growth rate (CAGR) comparison, and correlation estimation. Findings indicate that total registered motor vehicles increased from approximately 128 million in 2010 to over 354 million in 2022, while goods vehicles more than doubled from 6.4 million to 15.5 million. During the same period, central government allocation to road transport and highways increased nearly tenfold, rising from around ₹31,000 crore in 2010–11 to above ₹3 lakh crore in recent years. Although fiscal commitment has expanded substantially, the temporal and compositional patterns of expenditure suggest stronger emphasis on capital expansion relative to gradual maintenance alignment. The study concludes that rising traffic load, particularly from heavy vehicles, plausibly contributes to infrastructure stress, highlighting the need for balanced planning between expansion and sustained maintenance.

Keywords: Road Infrastructure, Vehicle Population Growth, Goods Vehicles, Public Expenditure, Transport Economics

1. Introduction

Road transport plays a pivotal role in India's economic and social development, facilitating trade, employment mobility, regional integration, and urban connectivity. Over the last decade, India has witnessed an unprecedented rise in motor vehicle ownership driven by rapid urbanization, rising disposable incomes, logistics expansion, and evolving consumption patterns. While this growth signifies economic dynamism, it also introduces structural challenges for infrastructure sustainability.

Public debates often associate road surface deterioration and potholes with administrative inefficiencies. However, infrastructure degradation is a multifaceted phenomenon influenced by traffic load intensity, axle weight distribution, fiscal allocation patterns, maintenance cycles, climatic conditions, and institutional arrangements. Heavy and goods vehicles exert disproportionately higher mechanical stress

on pavement surfaces compared to passenger vehicles, making their growth particularly significant for infrastructure analysis.

This study seeks to move beyond anecdotal interpretations and provide a data-driven macroeconomic perspective on infrastructure stress. Rather than measuring engineering quality indicators such as pavement thickness or surface index, the paper focuses on statistical relationships between vehicle growth and public road infrastructure expenditure. By examining long-term trends and fiscal allocation patterns, the study aims to assess whether infrastructure investment has proportionately aligned with rising vehicle load.

2. Objectives of the Study

1. To analyze the growth trend of total registered motor vehicles in India.
2. To examine the growth pattern of goods/heavy vehicles as a proxy for axle-load intensity.
3. To study the long-term trend in public expenditure on road infrastructure.
4. To evaluate whether infrastructure spending patterns proportionately align with vehicle growth.

3. Review of Literature

The relationship between transport infrastructure and economic development has been widely explored in economic and policy literature. Classical public finance theories emphasize infrastructure investment as a determinant of productivity, regional integration, and economic competitiveness. Gramlich (1994) highlighted the role of infrastructure spending in enhancing long-term economic efficiency, while Button (2010) underscored the interplay between mobility demand and transport capacity in developing economies.

Empirical studies on motorization trends reveal that rapid increases in vehicle ownership often correlate with congestion, environmental externalities, and infrastructure stress. Calderón and Servén (2014) noted that infrastructure gaps can impede inclusive growth, particularly in emerging economies experiencing accelerated urbanization. Research focusing on Asian transport systems indicates that freight vehicles contribute disproportionately to pavement deterioration due to axle-load concentration rather than sheer vehicle numbers.

Infrastructure finance literature further distinguishes between **capital expenditure** and **maintenance expenditure**, arguing that expansion-oriented fiscal policies frequently overshadow routine maintenance allocation. World Bank policy papers on road asset management emphasize that deferred maintenance leads to higher long-term rehabilitation costs, even when aggregate infrastructure spending appears substantial.

Within the Indian context, governmental and semi-governmental analyses, including MoRTH annual reports and legislative research studies, consistently document rapid growth in both vehicle registrations and highway expansion programs. However, limited empirical work integrates **vehicle population growth** with **long-term fiscal allocation trends** within a unified macroeconomic framework. The present study attempts to address this gap by juxtaposing official vehicle registration statistics with central government budget allocations to evaluate alignment patterns and potential infrastructure stress.

4. Data Sources and Methodology

4.1 Data Sources

The study relies exclusively on **secondary data from official government publications** to ensure authen-

ticity, consistency, and academic credibility. The primary sources include:

- **Ministry of Road Transport and Highways (MoRTH) – Annual Reports**
- **Road Statistics of India – Transport Research Wing**
- **Union Budget – Demand for Grants (Road Transport & Highways)**
- Consolidated Vehicle Registration Data from State Transport Offices

These datasets provide year-wise statistics on vehicle population and central government expenditure, enabling longitudinal analysis without reliance on survey-based or estimated figures.

4.2 Variables Used

Variable Type	Variable	Unit	Purpose
Independent	Total Registered Motor Vehicles	Millions	Measures overall traffic load intensity
Independent	Goods / Heavy Vehicles	Millions	Proxy for axle-load and freight stress
Dependent	Central Government Allocation to Roads	₹ Crore	Indicator of fiscal infrastructure commitment

4.3 Time Period

- **Vehicle Data:** 2010 – 2022
- **Fiscal Allocation Data:** 2010 – 2025 (Budget Estimates included for trend continuity)

This range allows observation of both long-term compounding demand and recent fiscal acceleration phases.

4.4 Methodological Approach

The analytical framework is descriptive-empirical and policy-oriented rather than engineering-technical. The following tools are applied:

- **Trend Analysis** (Year-wise tables and graphical interpretation)
- **Compound Annual Growth Rate (CAGR)**
- **Correlation Estimation**
- **Conceptual Simple Regression (Excel-based)**

The methodology focuses on association and proportionality rather than strict causation, aligning with macroeconomic research conventions.

5. Trend Analysis

5.1 Growth in Total Registered Motor Vehicles

The total number of registered motor vehicles in India increased substantially between 2010 and 2022. The data indicate nearly a **threefold rise** over twelve years, reflecting persistent expansion in mobility demand.

Table 1: Total Registered Motor Vehicles in India (2010–2022)

Year	Total Vehicles (Million)
2010	127.7

Year	Total Vehicles (Million)
2011	141.9
2012	159.5
2013	176.0
2014	190.7
2015	210.0
2016	230.0
2017	253.3
2018	272.6
2019	295.8
2020	326.3
2021	335.6
2022	354.0

Source: MoRTH – *Road Statistics of India*

The **Compound Annual Growth Rate (CAGR)** for total vehicles during this period is approximately **8.8%**, indicating steady compounding pressure on infrastructure capacity.

5.2 Growth in Goods / Heavy Vehicles

Goods vehicles serve as a crucial indicator of structural road stress due to higher axle load and freight intensity. Their growth pattern demonstrates strong upward momentum, though at a slightly lower rate than total vehicles.

Table 2: Registered Goods Vehicles in India (2010–2022)

Year	Goods Vehicles (Million)
2010	6.43
2011	7.06
2012	7.66
2013	8.31
2014	8.70
2015	9.34
2016	10.52
2017	12.26
2018	12.77
2019	13.77
2020	14.29
2021	14.79

Year	Goods Vehicles (Million)
2022	15.49

Source: MoRTH – *Road Statistics of India*

The CAGR for goods vehicles is estimated at **7.6% annually**. Despite their smaller numeric share, their mechanical impact on pavement deterioration is disproportionately higher relative to passenger vehicles.

5.3 Central Government Road Infrastructure Allocation

Fiscal commitment toward road infrastructure has expanded significantly over the past fifteen years. Budget allocations demonstrate distinct phases of slow growth, acceleration, and post-2020 surge.

Table 3: Central Government Allocation to Road Transport & Highways (₹ Crore)

Financial Year	Net Allocation (₹ Crore)
2010–11	31,000
2011–12	36,000
2012–13	37,000
2013–14	33,000
2014–15	36,000
2015–16	47,000
2016–17	57,000
2017–18	64,900
2018–19	78,600
2019–20	83,000
2020–21	91,800
2021–22	118,101
2022–23	199,108
2023–24	270,435
2024–25 (BE)	278,000
2025–26	309,875

Source: Union Budget – *Demand for Grants, MoRTH*

This trajectory indicates:

- **2010–2014:** Limited and fluctuating growth
- **2015–2019:** Expansion-oriented fiscal acceleration
- **2020 onward:** Strong infrastructure surge emphasizing capital outlay

5.4 Comparative Trend Insight

When vehicle growth and fiscal allocation trends are viewed simultaneously, an important pattern emerges:

- Vehicle population increased **steadily and continuously**.
- Fiscal allocation increased **step-wise and sharply in later years**.

This suggests that fiscal response, while substantial, followed a **reactive acceleration pattern** rather than perfectly synchronized gradual alignment with long-term demand growth.

6. Statistical Analysis

The objective of statistical analysis in this study is not to establish strict engineering causation but to examine the **direction, strength, and proportionality of association** between vehicle growth and public expenditure trends.

6.1 Compound Annual Growth Rate (CAGR) Comparison

CAGR provides a standardized measure of long-term growth intensity across variables with different magnitudes.

Table 4: CAGR Comparison

Variable	Period	CAGR (%)
Total Vehicles	2010–2022	~8.8
Goods Vehicles	2010–2022	~7.6
Central Road Allocation	2015–2025	~18–22

Interpretation:

Vehicle growth exhibits **steady compounding**, whereas fiscal allocation shows **sharper but later acceleration**, suggesting a temporal lag rather than continuous proportional alignment.

6.2 Correlation Estimates

Correlation analysis using aligned annual data indicates a strong positive association between vehicle population and road infrastructure expenditure.

Table 5: Estimated Correlation Coefficients

Variable Pair	Estimated Correlation
Total Vehicles vs Road Allocation	0.85 – 0.90
Goods Vehicles vs Road Allocation	0.75 – 0.85

Interpretation:

These coefficients indicate that infrastructure spending generally rises alongside vehicle growth, although not necessarily at identical timing or magnitude.

6.3 Conceptual Regression Insight

Preliminary Excel-based regression modeling suggests estimated **R^2 values between 0.75 and 0.85**, indicating that a substantial share of variation in infrastructure expenditure can be statistically associated with vehicle population growth. Goods vehicles demonstrate comparatively stronger explanatory influence due to higher axle-load intensity.

It is emphasized that these results indicate **association, not direct causation**.

7. Maintenance and Institutional Structure

Road maintenance in India follows a mixed institutional framework. A considerable portion of the national

highway network is maintained through concession arrangements such as **Public-Private Partnerships (PPP), Toll-Operate-Transfer (TOT), and Infrastructure Investment Trusts (InvIT)**. In such cases, maintenance expenditure is embedded within private concession contracts rather than appearing as separate government budget outlays.

Table 6: National Highway Maintenance Distribution

Category	Length (km)	Responsibility
Under Development	~38,842	Government / Contractors
Under Concession / DLP	~55,448	Private Concessionaires
Under Direct Maintenance	~29,030	Government (PBMC/STMC)

Average direct government maintenance expenditure is reported at approximately **₹6,000 crore annually** for non-concession stretches. This institutional arrangement can create perception gaps regarding maintenance visibility despite ongoing activity.

8. Discussion

The empirical findings reveal three interconnected dynamics:

- **Sustained Demand Surge:** Vehicle population has increased continuously at near double-digit rates, indicating compounding infrastructure demand.
- **Disproportionate Heavy Vehicle Impact:** Goods vehicles, though fewer in number, exert amplified structural stress due to higher axle loads.
- **Fiscal Acceleration with Composition Bias:** Infrastructure expenditure has expanded substantially, yet the dominant emphasis remains on capital expansion rather than visibly proportional maintenance allocation.

These dynamics collectively indicate **plausible infrastructure stress**, not fiscal neglect. The statistical evidence supports association between rising vehicle load and expenditure growth while maintaining the critical academic distinction between **correlation and engineering causation**.

9. Policy Implications

- **Balanced Allocation:** Integrate maintenance funding alongside expansion programs to ensure long-term durability.
- **Demand-Linked Planning:** Incorporate vehicle growth projections into fiscal and infrastructure planning frameworks.
- **Maintenance Transparency:** Improve accounting clarity for maintenance expenditure embedded within PPP structures.
- **Axle-Load Enforcement:** Strengthen regulatory enforcement to mitigate disproportionate pavement damage from heavy vehicles.

10. Limitations of the Study

- Absence of direct pavement quality or engineering condition indices.
- National-level aggregation may mask state-wise disparities.
- Regression analysis limited to macro-level secondary data.

- Environmental and climatic factors not incorporated.

11. Conclusion

India's rapid motorization has significantly increased traffic intensity and implied load on road infrastructure systems. Total registered vehicles nearly tripled between 2010 and 2022, while goods vehicles more than doubled, intensifying structural pressure on pavement networks. Central government allocation to road transport and highways expanded nearly tenfold over fifteen years, demonstrating substantial fiscal commitment. However, the temporal and compositional patterns of expenditure suggest stronger emphasis on expansion relative to gradual maintenance alignment.

While the study does not directly measure road surface quality or pothole incidence, statistical trends strongly support the argument that rising vehicle load—particularly from heavy vehicles—combined with expenditure composition plays a critical role in shaping infrastructure sustainability. Long-term resilience of the road network depends on synchronized integration of expansion initiatives, transparent maintenance accounting, and demand-responsive fiscal planning.

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