

Economic Development and Road Safety: Evidence from India

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ABSTRACT:

Road traffic crash is a major public health problem in India. Economic development influence road safety but few studies have assessed both the short- and long-run relation between economic performance and road safety. This paper studied the linkage between economic development and road traffic accidents, fatalities and injuries in India. The annual data related to gross domestic product per capita (GDP) and unemployment rate – for the level of economic development, and number of road traffic accidents, fatalities, and injuries – indicators of road safety. was used for the span of 28 years (1995–2022). The ARDL approach to cointegration was applied to estimate the short- and long-run effects of economic development on road safety. Results of the study showed that in the long-run, both accidents and fatalities decrease while injuries increase with GDP. In the short-run, fatalities decrease with GDP but the negative impact of GDP on injuries. Government, policymakers, road safety agencies, motorists and motorcyclists should invest in road infrastructure, enforcement of traffic regulations and safety measures that will reduce injuries.

KEYWORDS:

Short-term and Long-term coefficients, ARDL, Road Accidents, Economic Development.

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Introduction

Road traffic accidents continue to be a significant public health concern in contemporary society. The World Health Organization's Global Status Report on vehicle Safety 2023 reveals that over 1.19 million individuals perish each year as a result of vehicle accidents. Despite a small 5% global reduction since 2010, traffic injuries remain the primary cause of mortality for children and young adults aged 5 to 29 years. The

majority of these fatalities involve vulnerable populations, including walkers, cyclists, and motorcyclists, with low- and middle-income countries representing over 90% of all road traffic deaths. The paradox is that these countries own only a minor percentage of the world's motor cars, yet the likelihood of fatality in a road accident is almost threefold greater than in affluent nations. India exemplifies this dilemma distinctly. Notwithstanding swift economic advancement and enhanced connectivity, the nation persists in facing unacceptably elevated rates of road accidents and fatalities. In 2021, India documented almost 400,000 incidents, leading to more than 150,000 fatalities. Economic expansion and urbanisation have prompted increased motorisation; nevertheless, the concurrent rise in accidents underscores the necessity of ensuring that development is supported by sufficient infrastructure, efficient traffic management, and robust regulatory frameworks.

Economic development significantly impacts transportation infrastructure, traffic patterns, and road safety results. Increasing salaries promote higher ownership of private vehicles and exacerbate traffic congestion. In developed economies, continuous investment in infrastructure and regulatory enforcement has progressively lowered fatality rates; nevertheless, emerging nations frequently lack this institutional capacity. Consequently, they encounter an increase in traffic injuries during the initial phases of economic expansion. Numerous studies demonstrate that the correlation between economic development and road safety is neither linear nor consistent. Short-term economic expansion frequently correlates with more fatalities; but, as nations attain greater affluence, their capacity to enforce safety standards typically leads to a drop in such incidents. This pattern is commonly known as an inverted U-curve or Kuznets-type connection. In India, forecasts indicate that road fatalities may increase by almost 50% from 2015 to 2030 as the number of vehicles increases, underscoring the necessity for prompt legislative interventions.

The literature on economic development and road safety presents varied findings. A analysis of 49 studies indicates that roughly 69% discovered a positive short- or medium-term correlation between economic expansion and casualties, whereas 20% saw a negative correlation and 10% found no meaningful association. Unemployment frequently serves as a critical factor: in around 80% of studies, elevated unemployment was associated with increased casualties, but the nature of this correlation dif-

ferred. Numerous studies emphasise the inverted U-shaped relationship between per capita income and traffic deaths. Kopits and Cropper (2005) and Garg and Hyder (2006) both discovered that fatality rates escalate with increasing income until a maximum is attained, after which they commence to decrease. Additional case studies underscore this complexity. Akinyemi (2020) indicated that GDP expansion in Nigeria decreased mortality in the long term but increased injuries after a time lag. Tandrayen-Ragoobur (2024) demonstrated that accidents in Mauritius could diminish GDP by as much as 0.42% over the long term. Evidence from the OECD indicates nonlinear effects; Bayraktar (2024) discovered that health expenditure diminishes accident fatalities, whereas alcohol intake exacerbates them. In India, prior studies validated the Kuznets-type correlation, indicating that deaths rise during the initial phases of growth before either stabilising or decreasing.

Data and Methodology

This study examines the correlation between economic development and road safety in India utilising annual data from 1995 to 2022. Economic metrics comprise real GDP per capita (constant 2010 USD) and the unemployment rate, both sourced from the World Bank. Road safety results are assessed using accident, fatality, and injury statistics from the Ministry of Road Transport and Highways. All variables underwent log transformation for uniformity.

The methodology employs the Autoregressive Distributed Lag (ARDL) model, which is appropriate for small samples and for variables integrated of mixed orders (I(0) or I(1)). The analysis unfolds in three stages. The Dickey-Fuller GLS test was initially employed to evaluate stationarity, indicating that all variables achieved stationarity following first differencing. Secondly, ARDL bounds tests determined if the economic and safety variables exhibited long-term correlations. Third, error correction models (ECM) were estimated to elucidate short-run dynamics and the rate of adjustment.

Results and Discussion:

The findings demonstrate substantial evidence of cointegration among GDP, unemployment, and road safety indices, indicating that these variables exhibit synchronised movement over the long term. Specifically, GDP and unemployment had substantial favourable impacts on accidents.

A 1% increase in GDP resulted in a 0.72% rise in accidents, whereas a 1% increase in unemployment led to a 3.47% increase in accidents. Nonetheless, neither GDP nor unemployment exhibited statistically significant impacts on fatalities or injuries. In the short term, the error correction terms validated stable long-term associations, although the adjustment speeds differed: 25% for accidents, 11% for fatalities, and 15% for injuries. This suggests that abnormalities resulting from short-term shocks tend to rectify swiftly in the context of accidents, but more gradually for fatalities and injuries.

Table 1: Unit Root Test Results

Variable	Deterministic	level	First difference
Accidents	Individual intercept	-2.981	-4.507***
	Individual intercept and Trend	-3.603	-5.830***
Killed	Individual intercept	-2.981	-4.949***
	Individual intercept and Trend	-3.595	-4.839***
Inj	Individual intercept	-2.981	-4.856***
	Individual intercept and Trend	-3.603	-4.670***
GDP	Individual intercept	-2.981	-5.301***
	Individual intercept and Trend	-3.595	-5.187***
Unemp	Individual intercept	-2.986	-4.026***
	Individual intercept and Trend	-3.603	-5.593***

The rise in accidents along with GDP growth indicates multiple mechanisms. Increasing incomes accelerate motorisation, particularly of two-wheelers and commercial vehicles, which are significantly susceptible to accidents. Infrastructure development has lagged behind this increase, resulting in congestion and hazardous road conditions. Accelerated cars, hazardous behaviours, and increased alcohol consumption also contribute significantly. The beneficial impact of unemployment on accidents may arise from dependence on hazardous modes of transportation, elevated stress levels, or participation in informal transport sectors characterised by inferior safety standards. The lack of a significant GDP impact on deaths may suggest advancements in medical response, enhanced enforcement of safety regulations, or superior vehicle technology reducing acci-

dent severity.

Table 2: Results Bounds Cointegration

Dependent Variable	F-Statistics	P value	Decision
F(lnACC) I lnGDP, lnUNEMP	37.377	0.000	Co-integration
F(lnGDP) I lnACC, lnUNEMP	703.380	0.000	Co-integration
F(lnUNEMP) I lnACC, lnGDP	33.267	0.000	Co-integration
F(lnFAT) I lnGDP, lnUNEMP	407.916	0.000	Co-integration
F(lnGDP) I lnFAT, lnUNEMP	983.744	0.000	Co-integration
F(lnUNEMP) I lnFAT, lnGDP	25.595	0.000	Co-integration
F(lnINJ) I lnGDP, lnUNEMP	25.836	0.000	Co-integration
F(lnGDP) I lnINJ, lnUNEMP	700.458	0.000	Co-integration
F(lnUNEMP) I lnINJ, lnGDP	31.860	0.000	Co-integration

These findings align with international evidence. They endorse the inverted U-curve hypothesis, which posits that accidents increase during initial development but ultimately stabilise as nations attain greater income and more robust institutions. India seems to be in the ascending phase of this trajectory, where economic growth perpetuates road safety hazards. Comparisons with Botswana, Zambia, Nigeria, and OECD nations indicate analogous tendencies, although the speed and extent of effects vary by circumstance.

Table 3: Estimated long run coefficients

Variable	ACC Coef.	t-Statistics	P value	FAT Coef.	t-Statistics	P value	INJ Coef.	t-Statistics	P value
Constant	1.018	0.173	0.000	10.548	2.048	0.195	-5.498	-0.413	0.685
lnGDP	0.726	2.836	0.000	0.441	1.334	0.483	1.634	1.411	0.179
LnUNEMP	3.476	1.523	0.000	-1.125	-0.712	0.052	3.805	1.262	0.227

Table 4: Short Term Coefficients

Variables	ACC ARDL (3,2,2) Coefficient (Prob)	FAT ARDL (1,1,0)) Coefficient (Prob)	INJ ARDL (4,3,0) Coefficient (Prob)
$\Delta(\lnACC_{t-1})$	-0.378(0.268)		
$\Delta(\lnACC_{t-2})$	-0.6529(0.038)		

$\Delta(\ln\text{GDP})$	0.4708(0.133)		
$\Delta(\ln\text{GDP}_{t-1})$	0.7096(0.054)		
$\Delta(\ln\text{UNEMP})$	-0.3183(0.053)		
$\Delta(\ln\text{UNEMP}_{t-1})$	0.7765(0.075)		
ECt-1	-0.2508(0.145)		
R squared value	0.9573		
F Statistics	37.377		
DW Statistics	2.3648		
RSS	0.0073		
$\Delta(\ln\text{GDP})$		1.2686(0.000)	
$\Delta(\ln\text{UNEMP})$		0.1299(0.161)	
ECt-1		-0.1136(0.295)	
R squared value		0.9866	
F Statistics		407.916	
DW Statistics		-1.7756	
RSS		0.0252	
$\Delta(\ln\text{INJ}_{t-1})$			-0.612(0.037)
$\Delta(\ln\text{INJ}_{t-2})$			-0.3358(0.264)
$\Delta(\ln\text{INJ}_{t-3})$			-0.6032(0.028)
$\Delta(\ln\text{GDP})$			1.2619(0.001)
$\Delta(\ln\text{GDP}_{t-1})$			0.0042(0.993)
$\Delta(\ln\text{GDP}_{t-2})$			0.0290(0.177)
$\Delta(\ln\text{UNEMP})$			-0.5879(0.005)
ECt-1			-0.1545(0.772)
R squared value			0.9432
F Statistics			25.836
DW Statistics			1.7389
RSS			0.0360

Conclusion

This study illustrates that GDP and unemployment substantially elevate traffic accidents in India over the long term, although their impact on fatalities and injuries is less pronounced. The results indicate that eco-

conomic expansion enhances mobility but also increases dangers when infrastructure and regulation do not keep pace. The findings corroborate the idea of an inverted U-shaped correlation between wealth and road safety, indicating that India remains in the ascending part of the curve. Policy-makers must anticipate the road safety difficulties associated with growth and implement a proactive policy that integrates infrastructure, enforcement, health systems, and awareness. Road safety should be acknowledged not merely as a transportation and health issue but also as an essential element of sustainable economic development.

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Conflict of interest:

The Authors have no conflict of interest to declare that they are relevant to the content of this article.

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