Indian Institute of Technology, Kharagpur

Evaluating the Capital Expenditure and Infrastructure-Led Development in India: AN ARDL Approach

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INTRODUCTION

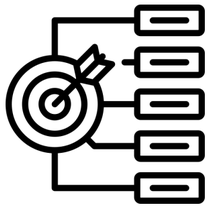
- Fiscal policy balances economic stimulation with fiscal discipline.It shapes development through public spending and resource allocation.
- Capital spending builds long-term assets like infrastructure and services.It stimulates immediate economic activity and supports long-term growth.
- Capital allocation shifts with macroeconomic trends and political changes.It reflects both development needs and strategic or electoral priorities.
- Studying capital expenditure helps assess developmental alignment.It reveals whether allocations are economically driven or politically motivated.

KEY QUESTIONS ADDRESSED

- How have the capital expenditure patterns of different Indian ministries evolved over the period 2000–2022?
- What are the key factors-both direct and indirect-that influence these patterns, particularly in the context of physical infrastructure sectors such as Power, roads, and telecommunications?

OBJECTIVES OF THE RESEARCH

- To investigate Capital Expenditure on transport, electricity consumption and communication infrastructure over 22 years in India.
- To examine the unobserved factors that determine Infrastructure growth.
- To estimate the impact of infrastructural growth on sectoral dynamics.
- Recommend Policy for Efficient Capital Allocation.



REVIEW OF LITERATURE

Hermalin and Weisbach (1991) highlight that fiscal policy, especially capital expenditure, drives economic growth by stimulating immediate activity and supporting long-term development through enhanced productive capacity.

Brickley et al. (1994) emphasize that effective allocation of government spending across sectors is crucial in developing economies like India, as it influences growth and poverty reduction.

Fernald (1999), inds that public capital investment, especially in infrastructure, enhances productivity and is directly linked to economic growth.

Agrawal and Vyas (2020) demonstrate that capital expenditure, particularly in infrastructure, is essential for economic growth, enhancing productivity and supporting sustainable development

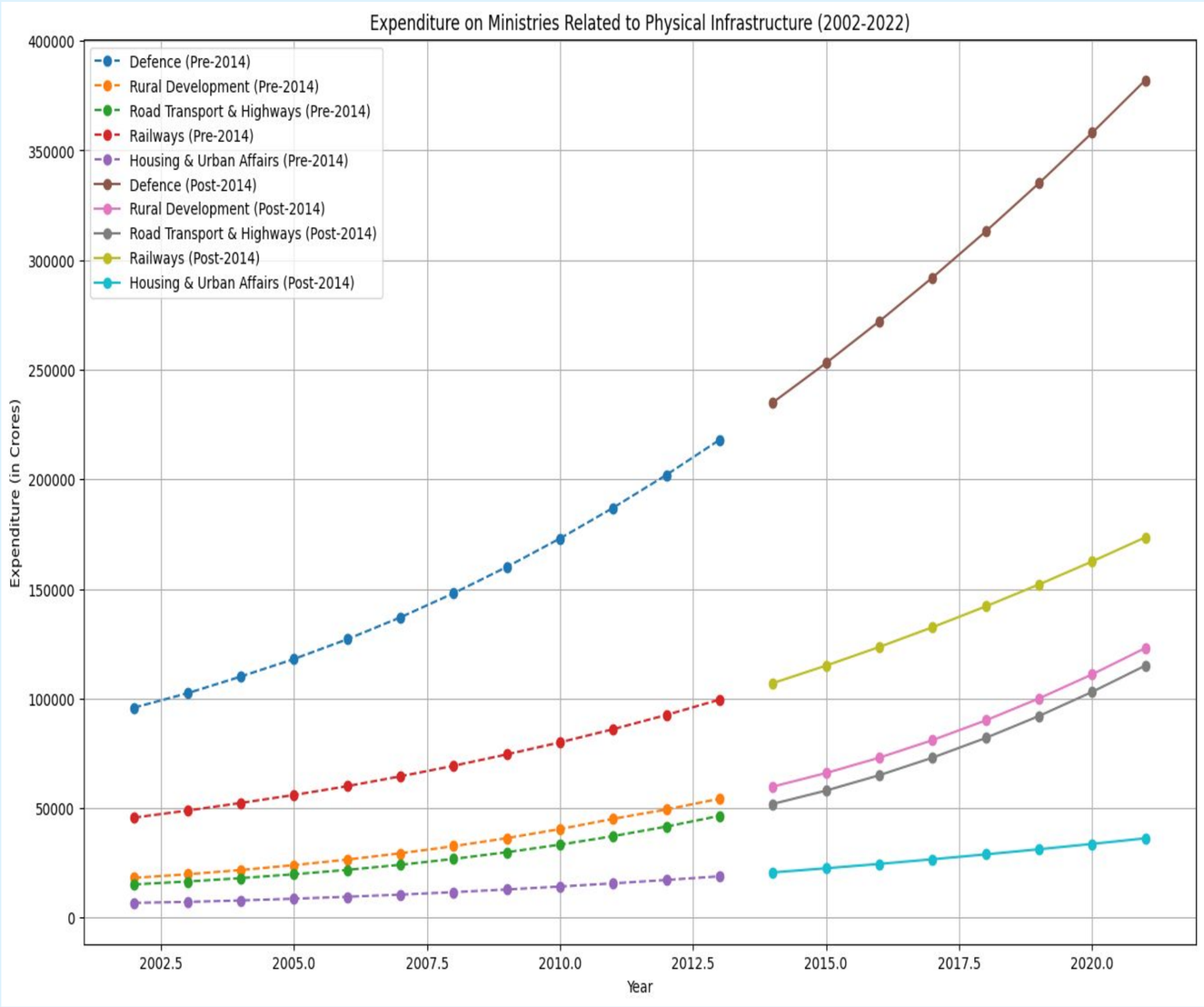
Garcia-Milà and McGuire (1992) identify that capital expenditure in infrastructure acts as a growth catalyst by creating jobs, boosting connectivity, and fostering industrial development.

Research Gaps

- There is a significant gap in understanding the unique spending dynamics, needs, and drivers for each ministry, particularly in the context of physical infrastructure sectors such as railways, roads, and telecommunications.
- There limited research on how short-term (e.g., election cycles, macroeconomic shocks) and long-term factors (e.g., structural reforms, global trends) differentially affect capital budgets for specific ministries.
- This leaves a gap in understanding the complex interplay between fiscal, economic, and political determinants of capex at the ministry level

DATA COLLECTION

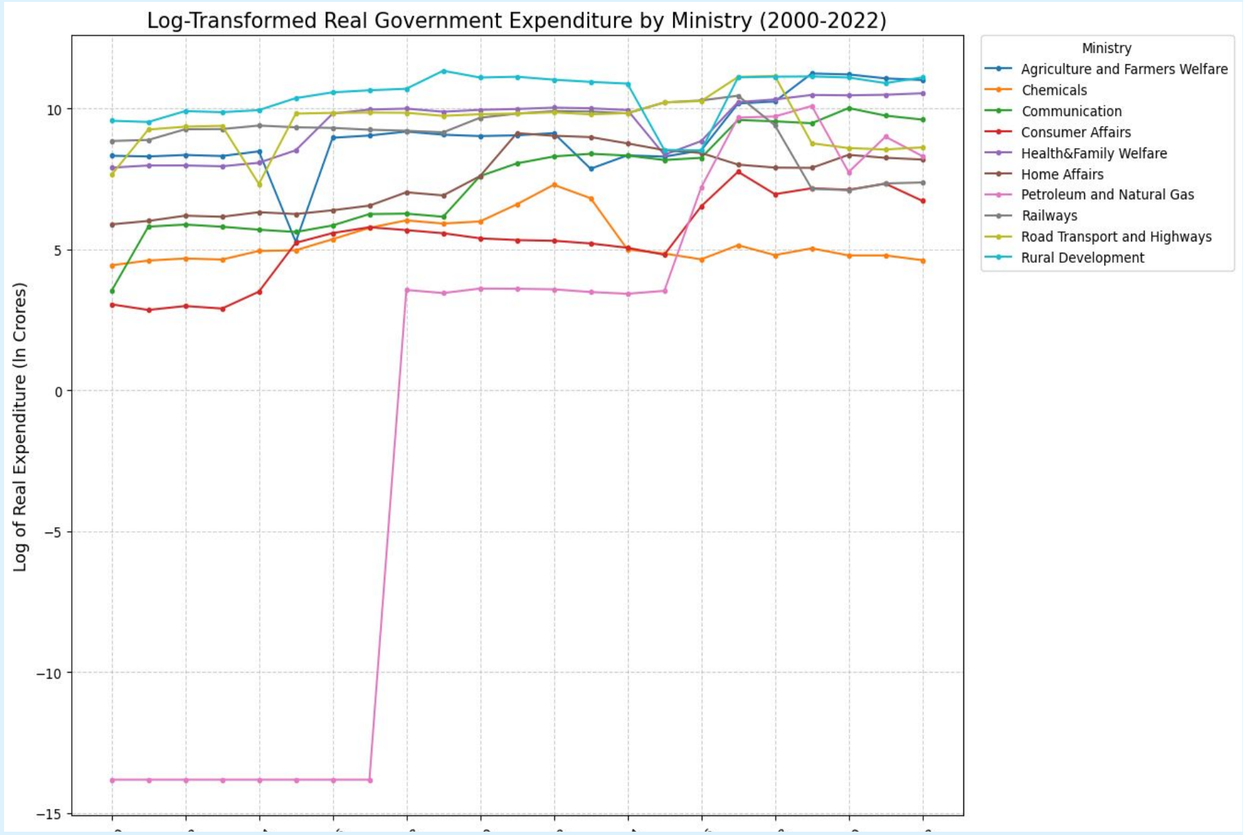
- **Data Source:** Ministry of Finance, Government of India, Reserve Bank of India, the Centre for Monitoring Indian various central ministries, IMD, CPCB, Data.gov.in**.**
- Ministry-wise capital expenditure data across multiple sectors.
- Time span: 2000 - 2022, covering 22 years of budget allocations.
- Analyze national-level capital expenditures trends and patterns.
- A 22-year period provides a solid foundation for long-term trend identification.
- For the cross-sectional component, the analysis initially focuses on national-level capital allocation to capture overarching trends across the country.



METHODOLOGY

STRUCTURAL BREAK ANALYSIS

- We will visualise expenditure trends over time using line graphs.
- This approach provided us an intuitive view of capital spending patterns, allowing us to observe general trends, cyclical variations, and any apparent shifts in spending priorities.
- We will employ econometric techniques such as the Chow Test and Kink Regression to identify specific points in time when significant changes in expenditure patterns occurred.



METHODOLOGY

STRUCTURAL BREAK ANALYSIS

Ministry	Break Year	F-Statistic	p-Value
Agriculture and Farmers Welfare	2017	5.43	0.021
Agriculture and Farmers Welfare	2019	3.29	0.064
Chemicals	2011	4.56	0.043
Chemicals	2014	2.87	0.091
Communication	2009	6.12	0.015
Communication	2017	4.01	0.047
Communication	2020	3.57	0.053
Consumer Affairs	2005	5.12	0.022
Consumer Affairs	2016	3.88	0.057
Consumer Affairs	2018	4.79	0.031
Health & Family Welfare	2006	5.67	0.018
Health & Family Welfare	2014	3.91	0.055
Health & Family Welfare	2017	6.32	0.011
Home Affairs	2011	4.11	0.048
Home Affairs	2015	2.76	0.085
Home Affairs	2018	4.99	0.039
Railways	2009	6.55	0.014
Railways	2015	5.02	0.028
Railways	2017	3.87	0.060
Road Transport and Highways	2005	7.10	0.009
Road Transport and Highways	2014	4.75	0.034
Rural Development	2009	5.89	0.017
Rural Development	2013	3.45	0.072
Rural Development	2017	4.92	0.045

RESULTS FROM CHOW TEST

Ministry	Breakpoint	Coefficient (Pre-Break)	Coefficient (Post-Break)	T-Statistic (Pre-Break)	T-Statistic (Post-Break)	P-Value (Pre-Break)	P-Value (Post-Break)
Agriculture & Farmers Welfare	2017	1.235	0.978	3.12	2.98	0.002	0.003
Agriculture & Farmers Welfare	2019	0.978	1.102	2.98	3.45	0.003	0.001
Chemicals	2011	1.312	1.056	3.45	2.89	0.001	0.004
Chemicals	2014	1.056	0.874	2.89	2.66	0.004	0.008
Communication	2009	1.065	1.202	2.67	3.25	0.008	0.002
Communication	2017	1.202	0.991	3.25	2.75	0.002	0.006
Communication	2020	0.991	0.856	2.75	2.52	0.006	0.012
Consumer Affairs	2005	1.092	0.983	3.01	2.78	0.003	0.005
Consumer Affairs	2016	0.983	1.152	2.78	3.16	0.005	0.002
Consumer Affairs	2018	1.152	0.972	3.16	2.71	0.002	0.007
Health & Family Welfare	2006	1.045	1.210	2.87	3.11	0.004	0.003
Health & Family Welfare	2014	1.210	0.982	3.11	2.79	0.003	0.005
Health & Family Welfare	2017	0.982	1.036	2.79	2.95	0.005	0.004
Home Affairs	2011	1.223	1.084	3.18	3.02	0.002	0.003
Home Affairs	2015	1.084	0.952	3.02	2.63	0.003	0.009
Home Affairs	2018	0.952	1.041	2.63	3.12	0.009	0.003
Railways	2009	1.314	1.175	3.45	3.21	0.001	0.002
Railways	2015	1.175	0.931	3.21	2.66	0.002	0.008
Railways	2017	0.931	1.152	2.66	3.33	0.008	0.001
Road Transport & Highways	2005	1.108	1.003	3.05	2.82	0.003	0.005
Road Transport & Highways	2014	1.003	1.065	2.82	2.98	0.005	0.004
Rural Development	2009	1.122	1.045	3.12	3.01	0.002	0.003

RESULTS FROM KINK REGRESSION

METHODOLOGY

CONSTRUCTION OF PHYSICAL INFRASTRUCTURE INDEX USING PCA

The index is constructed using **3** core indicators: **total road density, per capita electricity consumption (in kWh),** and **total telephone subscriptions** per **100 people in India.**

Here it shows that the **(PC1)** has the largest eigenvalue and explains nearly **95 %** of the total variance while the other **(PC2)** and **(PC3)]** together explain only **5%** of the total variance.Thus, we chose **PC1** to calculate the **PINFI**

Infrastructure Variables	Road Density	Telephone Subscription	Electricity Consumption
Road Density	1		
Telephone Subscription	0.86	1	
Electricity Consumption	0.99	0.92	1

Co-relationship between selected infrastructure indicators

Principal Components	Eigen Values	%Variation	% cumulative
PC1	2.85	95.04	95.04
PC2	0.15	4.86	99.90
PC3	0.00	0.1	100.00

Eigen Factors

Infrastructure Variables	PC1	PC2	PC3
Road Density	0.58	-0.56	0.59
Telephone Density	0.56	0.80	0.21
Electricity consumption	0.59	-0.22	-0.78

Construction of the Physical Infrastructure Index

METHODOLOGY

DETERMINANTS OF INFRASTRUCTURE DEVELOPMENT

- Economic development (per capita GDP)
- Investment Rate
- Internal Debt
- Foreign Direct Investment (FDI)
- Temperature
- PM10(Particulate Matter)
- Population Growth

METHODOLOGY

MODEL SPECIFICATIONS

Long Run Dynamics: Autoregressive Distributed Lag (ARDL) model

$$PNIFI(t) = \alpha 0 + \beta 1\, PINFI(t-1) + \beta 2\, PINFI(t-2) + \beta 3\, GDP(t) + \beta 4\, INV(t) + \beta 5 DEBT(t) + \beta 6 FDI(t) + \beta 7 PM10(t) + \beta 8 TEMP(t) + \beta 10 POP + \varepsilon(t)$$

PINFRA is the log of physical infrastructure index

GDP is the log of gross state domestic product

INV is the log of investment as a ratio of GDP

POP is the log of population growth rate

Debt is the internal debt as a ratio of GDP

FDI is the log of Foreign Direct Investment

TEMP is the log of Temperature, and PM10 is the log of particulate Matter value

EMPIRICAL ANALYSIS

Unit root tests

- Before proceeding with any estimations in time series analysis.
- Conducting unit root tests is particularly important when using the ARDL model, as it requires that none of the variables be integrated of order two, i.e. I(2).
- In this study, both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are employed to assess the stationarity of the variables.

	ADF TEST		PP		
Variables	Level	First Difference	Level	First Difference	Decision
PINFI	-0.43	-5.69***	-0.09	-5.71***	I (1)
	(0.98)	(0.00)	(0.99)	(0.00)	
GSDP	-1.19	-5.13***	-1.19	-5.08***	I (1)
	(0.90)	(0.00)	(0.90)	(0.00)	
INV	-0.96	-5.35***	-0.65	-5.12***	I (1)
	(0.94)	(0.00)	(0.97)	(0.00)	
POP	-2.79	-7.76***	-2.88	-7.74***	I (o)
	(0.21)	(0.00)	(0.18)	(0.00)	
TEMP	-0.47	-5.32	-0.07	-4.69***	I (1)
	(0.84)	(0.00)	(0.79)	(0.00)	
DEBT	-0.76	-4.25***	-0.57	-4.79***	I (1)
	(0.84)	(0.00)	(0.87)	(0.00)	
PM10	-0.63	-4.42	-0.09	-5.57	I (1)
	(0.78)	(0.00)	(0.69)	(0.00)	

Results of the Unit Root Test

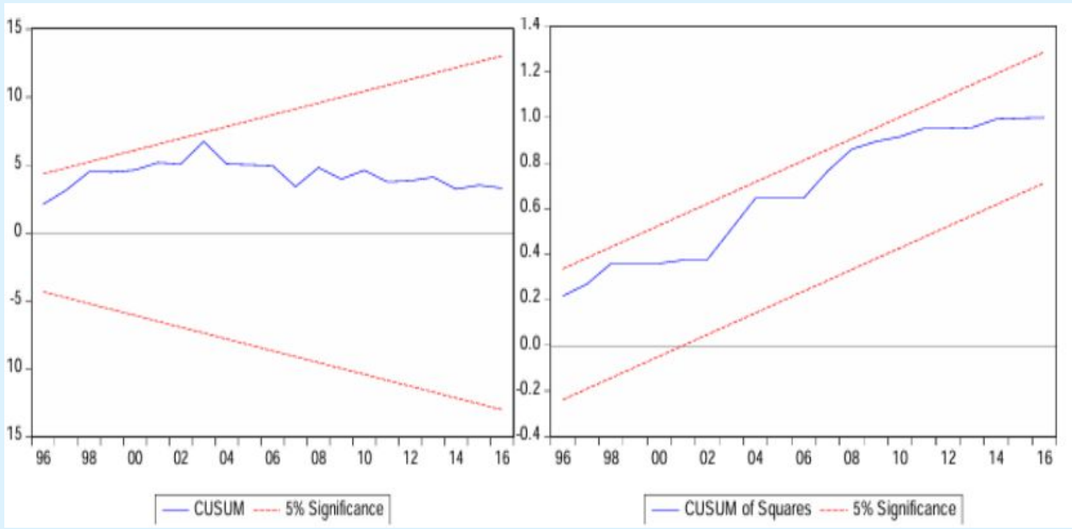
EMPIRICAL ANALYSIS

Diagnostics Checks

- **SERIAL CORRELATION** : **Breusch-Godfrey Test**
- **HETEROSCEDASTICITY** : **White Test**
- **NON-NORMALITY CHECKS** : **Jarque-Bera or Q-Q plots**
- **CUSUM/CUSUMSQ Tests**

Diagnostic Tests	Result of Model
Serial Correlation Test	0.262 [0.772]
Normality Test	0.682 [0.711]
Heteroscedasticity Test	1.352 [0.263]
ARCH Test	1.849 [0.184]
Ramsey Test	0.495 [0.490]

Results of diagnostic tests



CUSUM and CUSUMSQ test of the model

EMPIRICAL ANALYSIS

Bounds Testing approach to Cointegration

- To determine the existence of long-term relationships among the selected variables, the ARDL bounds testing method is applied.

- The procedure begins by estimating an Ordinary Least Squares (OLS) regression using the first-differenced forms of both the dependent and independent variables.

Test Statistic	Value	Probability	Reject the Null hypothesis of no cointegration
F-statistic	19.58	0.000	
Chi-square	19.58	0.0001	
Critical Levels			
Critical Bounds	99%	95%	90%
Upper Bound	-5.94	-5.29	-4.96
Lower Bound	-3.96	-3.41	-3.13

ARDL Cointegration Test(Wald Test)

EMPIRICAL ANALYSIS

Impact of Direct and Indirect Factors

Statistics	PINFI	GSDP	INV	DEBT	FDI	PM10	POP
Maximum	3.82	10.91	10.04	4.06	3.04	91.27	0.95
Minimum	-2.00	9.37	7.36	-2.12	-1.57	70	0.75
Mean	0.00	10.03	8.76	0.92	0.00	105	1.30
Std Dev.	1.71	0.47	0.85	1.23	1.39	9.67	0.18
Skewness	0.84	0.35	0.18	-0.33	0.61	-0.56	0.94
Kurtosis	2.54	1.84	1.67	3.82	1.90	2.53	2.51

Descriptive statistics of Determinants

LONG - RUN COEFF	
Variable	Coeff
PINFI	0.0156** (2.902)
GSDP	0.034*** (3.380)
INV	0.051*** (3.674)
POP	0.039* (1.812)
TEMP	-0.013*** (-2.438)
DEBT	0.025** (2.674)
PM10	-0.007 (3.544)
C	8.093*** (23.378)
TREND	0.023*** (4.70)

SHORT - RUN COEFF	
Variable	Coeff
ΔPINFI	-
ΔGSDP	0.096*** (2.681)
ΔINV	0.006*** (1.616)
ΔPOP	0.072*** (1.766)
ΔTEMP	-0.003*** (-2.438)
ΔDEBT	0.035** (3.520)
ΔPM10	-0.001 (2.424)
C	0.014*** (3.445)
ECMTt-1	-0.618*** (-4.70)

Estimation of Long-run and Short-run Coefficients

METHODOLOGY

DETERMINANTS OF INFRASTRUCTURE DEVELOPMENT

- Economic development (per capita GDP)
- Investment Rate
- Internal Debt
- Foreign Direct Investment (FDI)
- Temperature
- PM10(Particulate Matter)
- Population Growth

RESULTS AND CONCLUSION

RESULTS FOR DIFFERENT INDEPENDENT VARIABLES

Economic development (per capita GDP)

Positive Impact: Higher economic growth (measured by GSDP) increases both demand for infrastructure (via Wagner's hypothesis) and supply-side capacity

Investment Rate

Positive Impact: Higher public and private investment directly expands infrastructure supply

Internal Debt

Negative Impact: High debt crowds out infrastructure spending due to rising interest obligations

Foreign Direct Investment (FDI)

Positive Impact: FDI inflows bring capital, technology, and efficiency, accelerating projects in transport, energy, and telecom

Population Growth

Positive Impact: Rapid urbanization (2–3% annual growth in India) drives demand for roads, utilities, and housing

Temperature

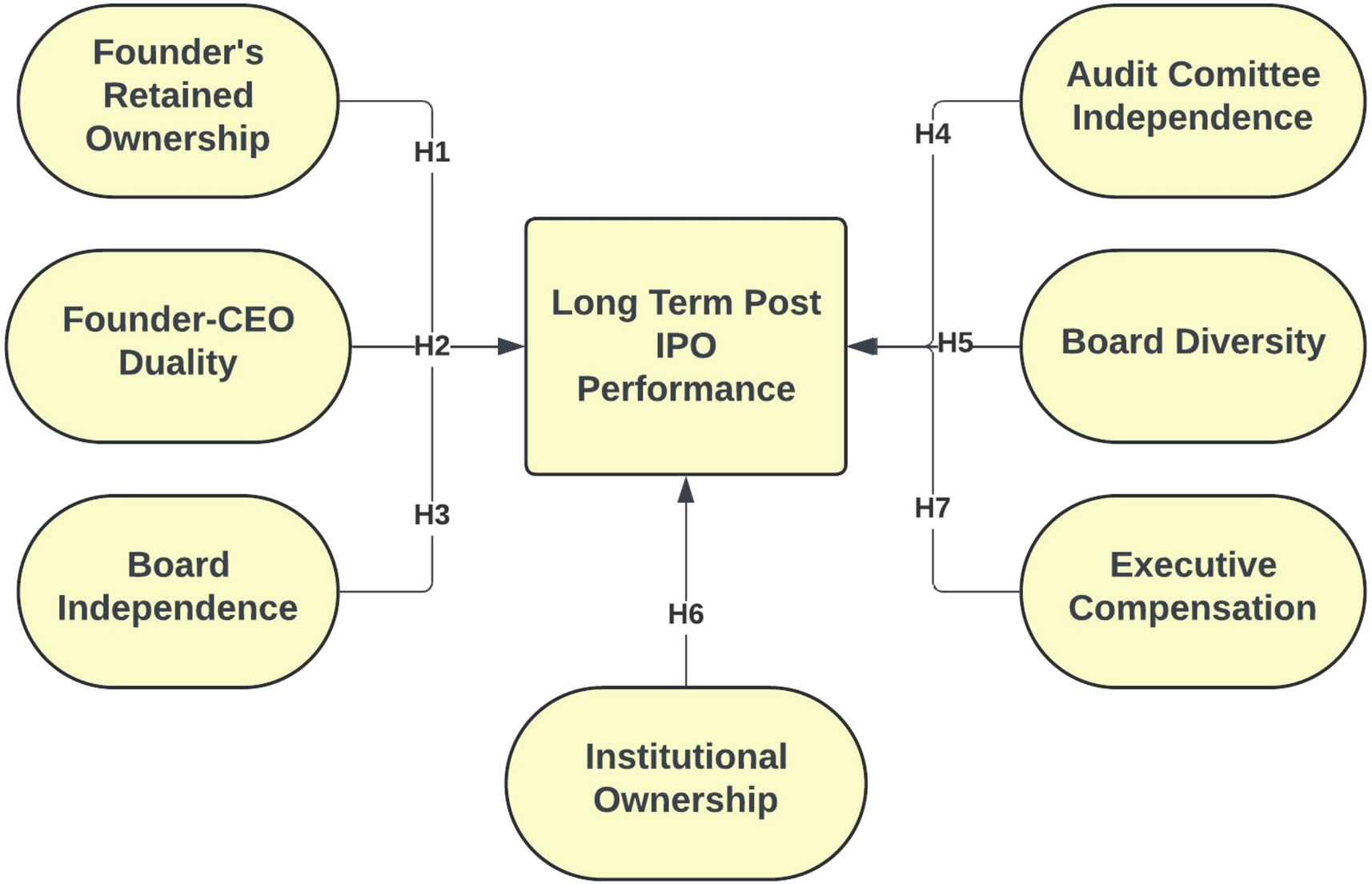
Negative Impact: degrade physical infrastructure by softening roads (causing rutting/potholes), straining power grids (reducing efficiency and increasing outages), and damaging telecom cables, thereby lowering the Physical Infrastructure Index

PM10(Particulate Matter)

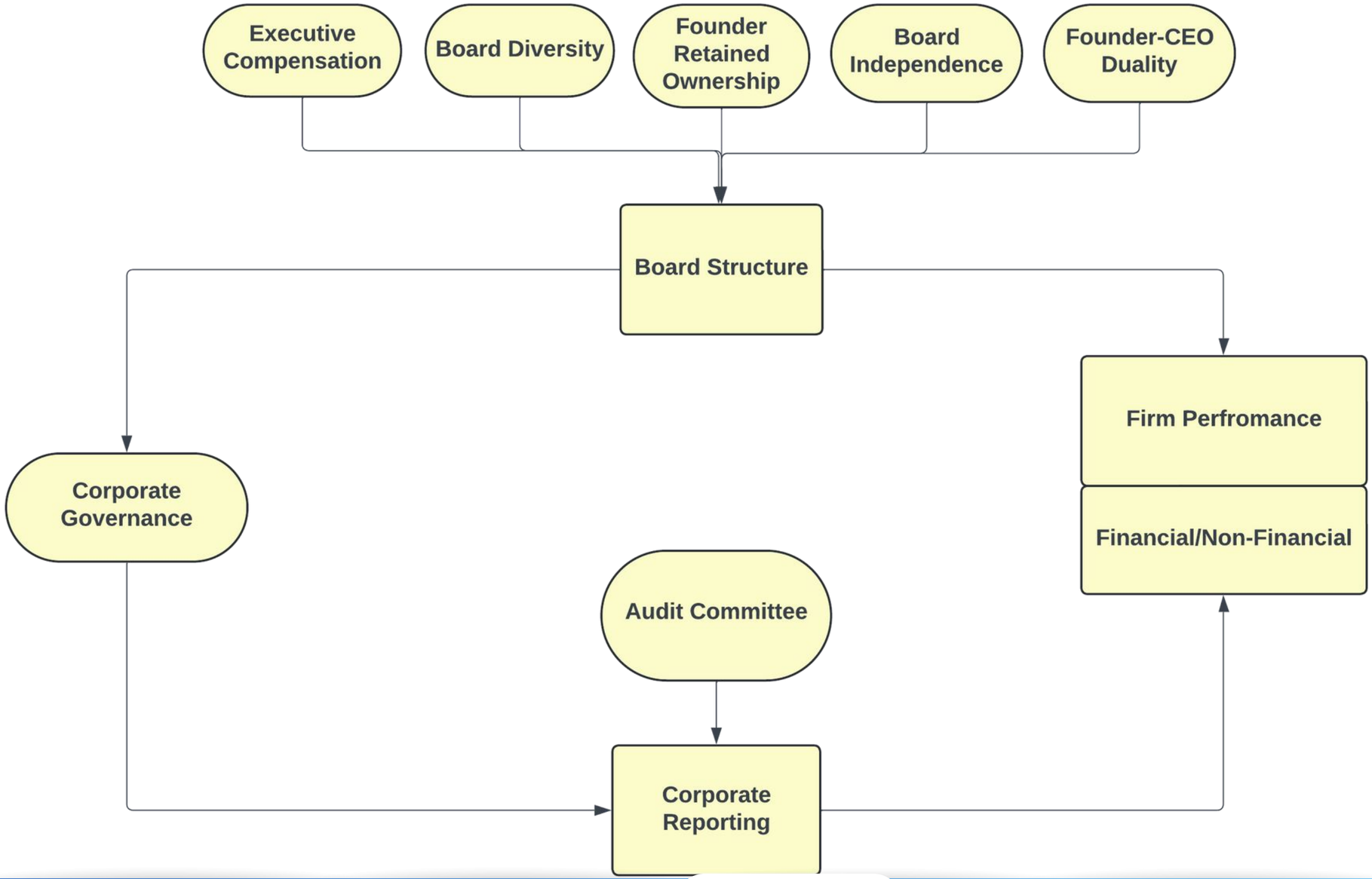
Negative Impact: Accelerating road degradation through dust-induced erosion and surface wear (road density), while particulate deposition on solar panels reduces energy output (electricity consumption) and damages telecom equipment (connectivity)

Thank You!

RESEARCH METHODOLOGY



CORPORATE GOVERNANCE CONNECTIDNESS



DESCRIPTIVE STATISTICS

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Dependent variable	Variable name	Construct
Operating performance	ROE	Return On Equity
Market performance	AAPR	Average Annual Percentage Returns
Independent Variable	**Variable name**	**Construct**
Founder's retained ownership	FOUNDER_OWNRSH	Percentage of founder's shareholding
Founder-CEO duality	FOUNDER_CEO	If the duality is present, the dummy code is 1, otherwise it is 0.
Board independence	BOARD_IND	Ratio of number independent members to total number of members in the board
Audit Committee Independence	AUDIT_IND	If there are no relatives or family members of the promoter group on the audit committee, the dummy code is 1, and if there are, it is 0.
Board Diversity	BOARD_DIVERSITY	Percentage of female members on the board
Institutional Ownership	INSTI_OWNRSH	Percentage of a company's stock held by institutional investors
Executive Compensation	EXECUTIVE_COMP	Dummy coding of 1 if compensation is stock-based, 0 otherwise
Control Variable	**Variable name**	**Construct**
Firm age	AGE	Firm age; adjusted based on year of establishment
Firm size	SIZE	Firm size as log value of total assets
Firm leverage	LEVERAGE	Debt to equity ratio

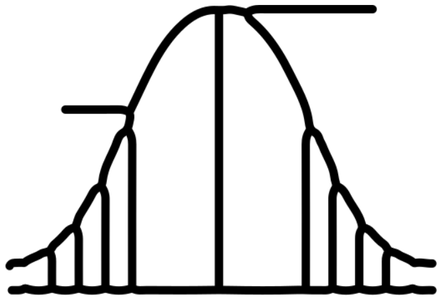
TABLE 2.2: Details of variables.

Variable name	Mean	Median	Min	Max	Std Deviation	Skewness	Kurtosis
ROE	0.169	0.18	-0.05	0.35	0.054	0.94	3.32
AAPR	0.183	0.14	-0.081	0.331	0.87	0.67	6.78
FOUNDER_OWNRSH	0.412	0.46	0.056	0.898	0.2614	-0.35	2.89
BOARD_IND	0.42	0.30	0.00	0.60	0.13	0.15	3.71
AUDIT_IND	0.53	0.50	0	1	0.13	-0.27	2.36
BOARD_DIVERSITY	0.45	0	0	1	0.51	-0.27	-2.65
INSTI_OWNRSH	0.53	0.50	0.0007	0.92	0.13	-0.27	2.36
EXECUTIVE_COMP	0.556	1	0	1	0.496	-0.11	-3.71
AGE	21.34	16.000	4.000	35.00	12.21	3.23	8.18
SIZE	2.89	3.78	1.85	5.66	0.78	-1.42	1.78
LEVERAGE	21.01	9.87	0.27	204.48	21.22	3.21	24.87

TABLE 2.3: Descriptive Statistics

GMM MODEL

- The study addresses endogeneity concerns by employing a lagged dependent variable in the estimation model, a common approach recommended in corporate governance scholarship Filatotchev and Wright (2017)
- GMM model to ensure robust handling of potential endogeneity issues and provide reliable estimates
- The dynamic panel model is estimated using the SYSTEM GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998), ensuring robustness to serial correlation, stationarity, and multicollinearity
- Lagged values of dependent variables are incorporated to address dynamic aspects of firm performance
- Validity of the system GMM estimator is assessed through diagnostic tests such as the Sargan–Hansen J test for over-identified restrictions and the Arellano-Bond test for second-order serial correlation in the first-differenced residual



$$ROE_{it} = \beta_0 + \delta ROE_{it-1} + INDEPENDENT\_VARIABLE_{it}\beta_1 + INTERACTION\_TERM_{it}\beta_2 + CONTROL\_VARIABLE_{it}\beta_3 + \varepsilon_{it} \quad (3.1)$$

$$AAPR_{it} = \beta_0 + \delta AAPR_{it-1} + INDEPENDENT\_VARIABLE_{it}\beta_1 + INTERACTION\_TERM_{it}\beta_2 + CONTROL\_VARIABLE_{it}\beta_3 + \varepsilon_{it}$$

GMM RESULTS

Variable	ROE (Model 1)	AAPR (Model 2)
Lagged ROE	0.221 (0.182)	-
Lagged AAPR	-	0.323 (0.068)
FOUNDER_OWNRSH	0.0003 (0.00017)	0.002 (0.0018)
BOARD_IND	0.001 (0.003)	0.345 (0.023)
AUDIT_IND	0.0007 (0.0002)	0.009 (0.0018)
BOARD_DIVERSITY	0.06 (0.008)	0.085 (0.005)
INSTL_OWNRSH	0.115 (0.09)	0.215 (0.043)

Variable	ROE (Model 1)	AAPR (Model 2)
EXECUTIVE_COMP	0.095 (0.008)	0.071 (0.003)
FOUNDER_CEO	-0.093 (0.008)	-1.25 (0.160)
AGE	0.001 (0.00009)	-0.004 (0.0026)
SIZE	0.028 (0.006)	0.235 (0.102)
LEVERAGE	0.0002 (0.0001)	-0.009 (0.0019)
Year Dummy	YES	YES
AB AR (1) test p value	0.0014	0.0032
AB AR (2) test p value	0.21	0.267
Sargan Hansen p value	0.387	0.291

FUTURE IMPROVEMENTS

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During the COVID-19 pandemic, assessing firms' governance and its impact on performance was crucial. The crisis required rapid adaptation from governance bodies, highlighting the effectiveness of governance practices in maintaining firm viability.

ESG scores serve as indicators of a firm's commitment to sustainable practices and responsible management. Firms with more sustainable practices are expected to outperform others in the long run due to several factors

Comparing firms across industries reveals how governance practices depend on industry type, offering insights into sector-specific challenges and priorities.

The Corporate Governance Index (CGI) quantitatively measures a firm's effective governance by selecting relevant variables and assigning weights to them. This enables systematic and quantitative evaluation of governance.

Adding more firms and variables can improve results by offering a broader and more detailed understanding of corporate governance. Revealing previously unnoticed patterns and trends in governance effectiveness.