



BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE

DEPARTMENT OF ECONOMICS

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IMPACT OF SUSTAINED R&D INVESTMENTS ON  
LONG-TERM PROFITABILITY IN THE  
INDIAN AUTOMOBILE SECTOR

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TANISHQ JAIN  
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SUPERVISOR:  
PROF. RICH A SHUKLA

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## Abstract

This study investigates the long-term impact of sustained Research and Development (R&D) investments on firm profitability in the Indian automobile sector, an industry characterized by intense competition, rapid technological advancements, and evolving consumer demands. By analyzing panel data from six leading firms—**Ashok Leyland, Bajaj Auto, Hero MotoCorp, Mahindra & Mahindra, Maruti Suzuki, and Tata Motors**—over a **ten-year period (2014–2024)**, this research evaluates the influence of R&D intensity (R&D expenditure as a percentage of total assets) on key profitability metrics: **Net Profit Ratio (NPR), Return on Assets (ROA), Return on Equity (ROE), and Earnings Per Share (EPS)**.

The analysis employs Random Effects models, selected through Hausman tests, to account for both entity-specific and time-variant factors. The findings demonstrate that **R&D intensity significantly enhances ROA and ROE**, indicating its critical role in improving operational efficiency and delivering higher shareholder returns. However, the impact of **R&D intensity on NPR and EPS is statistically insignificant**, suggesting that while R&D drives long-term value creation through efficiency and equity gains, its effects on short-term profitability metrics like margins and per-share earnings may be delayed.

This study bridges the gap in existing literature by integrating both short- and long-term profitability metrics, offering a holistic perspective on the strategic importance of sustained R&D investments in an innovation-driven, capital-intensive industry. The results underscore the necessity for firms to view R&D as a long-term strategy rather than a tool for immediate financial gains, providing actionable insights for managers and policymakers aiming to align innovation with sustainable profitability.

# 1 Introduction

Innovation and technological advancements are critical drivers of competitiveness and growth in the global automobile industry. Research and Development (R&D) investments play a pivotal role in enabling firms to innovate, improve product quality, enhance operational efficiency, and adapt to rapidly changing market dynamics. In the context of the Indian automobile sector, which is characterized by intense competition, evolving consumer preferences, and a growing emphasis on sustainability, sustained R&D investments have become a strategic imperative. Despite the sector's importance to India's economy—contributing significantly to GDP and employment—the impact of **R&D spending on financial performance** remains an underexplored area in academic research.

While previous studies have extensively examined the relationship between R&D investment and short-term profitability metrics such as Net Profit Ratio (NPR) and Return on Assets (ROA), the long-term effects of sustained R&D investments on firm profitability and market positioning are less understood. This gap is particularly relevant in the Indian automobile industry, where firms face unique challenges, including high capital intensity, dependency on global supply chains, and increasing regulatory requirements for technological innovation, such as emission standards and electric vehicle adoption.

This study aims to address this gap by investigating the long-term impact of R&D expenditure on profitability in leading Indian automobile firms over a decade, from **2014–15 to 2023–24**. By analyzing key financial metrics—such as **ROA, Return on Equity (ROE), and Earnings Per Share (EPS)**—alongside R&D intensity, this research seeks to provide insights into whether sustained R&D spending serves as a catalyst for financial growth and competitive advantage.

Furthermore, the study explores the role of firm-specific factors, such as size in moderating the relationship between R&D investment and profitability. By focusing on a panel of six leading automobile companies—**Ashok Leyland, Bajaj Auto, Hero MotoCorp, Mahindra & Mahindra, Maruti Suzuki, and Tata Motors**—this research provides a comprehensive analysis of industry dynamics and offers actionable insights for managers and policymakers to optimize R&D strategies.

## 2 Overview of the Field of Study

### 2.1 Indian Automobile Sector

The Indian automobile sector is a cornerstone of the nation's economy, contributing significantly to GDP, employment, and export revenue. Over the years, the industry has grown from an assembler of imported vehicles to a globally competitive hub for automobile manufacturing. Historically, the industry saw a transformation post-liberalization in the 1990s, with foreign direct investments introducing global technologies and practices. Today, India is one of the world's largest automobile markets, ranking among the top producers of passenger and commercial vehicles.

The sector boasts a market size exceeding \$100 billion, with production spanning two-wheelers, passenger cars, commercial vehicles, and electric vehicles (EVs). Key players include homegrown giants such as Tata Motors, Mahindra & Mahindra, and Maruti Suzuki, alongside foreign entities like Hyundai and Honda. The competitive landscape is shaped by intense price wars, evolving consumer preferences, and the advent of EVs.

### 2.2 Role of R&D in the Automobile Industry

Research and Development (R&D) is the backbone of innovation in the automobile industry. It drives technological advancements, product differentiation, and sustainability. In the Indian context, R&D efforts are primarily geared towards:

- **Fuel Efficiency:** Developing engines and components to maximize fuel economy.
- **Emissions Reduction:** Innovating cleaner technologies to comply with strict environmental regulations like Bharat Stage VI (BS-VI) norms.
- **Safety Enhancements:** Introducing advanced safety features such as airbags, Anti-lock Braking Systems (ABS), and Electronic Stability Programs (ESP).
- **Electric and Autonomous Vehicles:** Developing EVs and exploring autonomous driving technologies to remain competitive in global markets.

These R&D focus areas enable Indian automobile firms to align with international standards, meet regulatory mandates, and address consumer demands for sustainability and safety.

## 2.3 Profiles of Selected Companies

### 1. Ashok Leyland:

- Overview: A leading commercial vehicle manufacturer in India and a significant player in the bus and truck segments.
- Market Share: Holds a strong position in the medium-heavy commercial vehicle (MHCV) market.
- R&D Initiatives: Focused on hybrid and electric commercial vehicles, with innovations in fuel-efficient engines.

### 2. Bajaj Auto:

- Overview: World's largest manufacturer of three-wheelers and a key player in the two-wheeler segment.
- Market Share: Dominates the motorcycle market with popular models like Pulsar and Platina.
- R&D Initiatives: Known for innovations in lightweight and fuel-efficient vehicles and its push towards electrification with the Chetak EV.

### 3. Hero MotoCorp:

- Overview: The largest two-wheeler manufacturer globally by volume, known for affordable motorcycles and scooters.
- Market Share: Commands a leading share in the commuter motorcycle segment in India.
- R&D Initiatives: Focused on enhancing fuel efficiency and developing electric two-wheelers.

### 4. Mahindra & Mahindra:

- Overview: Diversified products with significant operations in cars, tractors, and electric vehicles.
- Market Share: Dominates the tractor market and is a leader in the SUV segment.
- R&D Initiatives: Pioneering electric mobility through its Mahindra Electric division and investing in smart farming technologies.

### 5. Maruti Suzuki:

- Overview: India's largest passenger car manufacturer and a household name in affordability.
- Market Share: Holds over 40% of the passenger car market in India.
- R&D Initiatives: Focused on hybrid technology, alternative fuel solutions, and compact car innovations.

### 6. Tata Motors:

- Overview: One of India's largest automobile manufacturers with a portfolio spanning passenger cars, commercial vehicles, and electric vehicles.
- Market Share: A dominant player in the EV segment and commercial vehicle space.
- R&D Initiatives: Focused on EVs, hydrogen fuel cells, and advanced safety features.

### 3 Literature Review

The relationship between Research and Development (R&D) investments and firm performance in the automobile industry has been extensively explored, with diverse insights into its implications. Each study offers unique contributions that collectively shape a nuanced understanding of the field.

#### **R&D Investments and Profitability**

*Mondal and Sarkar (2020)* examines the correlation between R&D intensity and financial metrics like Net Profit Ratio (NPR), Return on Assets (ROA), Return on Equity (ROE), and Earnings Per Share (EPS) within the Indian automobile sector. Using statistical tools such as regression analysis, the research concludes that R&D investments significantly influence profitability. However, the study highlights the inconsistent nature of this impact, with NPR, ROA, and ROE showing a negative correlation, whereas EPS demonstrates a positive association. These findings underscore the complexity of translating R&D efforts into measurable financial success.

#### **Indigenous Design and Technological Capability**

Another crucial dimension is highlighted by Akayeti et al. (2015). Although this research focuses on a different geographical context, its emphasis on the interplay between indigenous R&D efforts and manufacturing efficiency provides valuable parallels. The study argues that the development of indigenous capabilities can significantly enhance competitiveness, aligning with global trends while addressing local challenges.

#### **Sources of Innovation**

Kale (2012) examines how firms leverage R&D for innovation and technological growth. It identifies critical drivers, such as collaborative innovation models and ecosystem partnerships, which facilitate the development of advanced technologies. This perspective reinforces the strategic role of R&D as not merely a cost center but a catalyst for innovation.

#### **Comparative Industry Insights**

A broader perspective is drawn from studies such as Erickson et al. (1992) and Cui et al. (2002), which explore the broader implications of R&D on competitive advantage and managerial ownership structures. These studies suggest that R&D investments, when strategically aligned with organizational objectives, can serve as a critical lever for sustainable growth.

#### **Gaps and Challenges**

While significant progress has been made in understanding the impact of R&D investments, several gaps persist. The focus remains largely on short-term metrics, with limited exploration of long-term outcomes. Additionally, the role of ownership structures and external shocks in shaping R&D strategies is underexplored, as highlighted in studies reviewed earlier. The dynamic nature of capital allocation decisions in the context of evolving market and technological landscapes requires deeper investigation.

## 4 Data Description

### 4.1 Data Sources

The study utilizes secondary source of data to collect the necessary financial and R&D expenditure for the selected companies in the automobile sector. The primary data source is the **Annual Reports of the companies** from a period of 2014 to 2024.

### 4.2 Data Collection Process

- **Identification of Companies:** Six major companies were selected based on market capitalization and their significant presence in the Indian automobile sector: Ashok Leyland, Bajaj Auto, Hero Motocorp, Mahindra & Mahindra, Maruti Suzuki, and Tata Motors.
- **Data Retrieval:** Financial Metrics like Net Profit Ratio (NPR), Return on Assets (ROA), Return on Equity (ROE), Earnings Per Share (EPS) and Total Assets were collected.

R&D expenditure was also collected from the annual reports, which was then finally compiled together to form a dataset of 10 years with 6 companies.

	Count	Mean	Std. Dev	Min	75%	Max	Median	iqr
<b>RD</b>	60	170579.77	231867.07	19672.00	219006	1096000	66574	171967.75
<b>NPR</b>	60	0.07	0.06	-0.10	0.10	0.19	0.07	0.07
<b>ROA</b>	60	0.15	0.07	0.06	0.19	0.34	0.13	0.10
<b>ROE</b>	60	0.37	0.16	0.10	0.45	0.88	0.34	0.20
<b>EPS</b>	60	97.66	97.38	-21.06	169.21	431.08	93.31	163.63
<b>Total Assets</b>	60	103055	107167	10654	162659	369521	47767	136759

Table 1: Descriptive Statistics

### 4.3 Why R&D Intensity?

R&D intensity is defined as R&D expenditure over Total Assets which is used to factor in the firm size or the financial capability. Using R&D intensity instead of absolute R&D expenditure provides a relative, scalable, and actionable measure of innovation commitment. It normalizes for size, and highlights trends in resource allocation. In the automobile industry, where technological innovation is critical for survival and growth, R&D intensity serves as a vital indicator of how effectively firms leverage their resources to compete and adapt.

## 5 Descriptive Statistics

The dataset covers financial and operational variables from six major Indian automobile companies over a decade, providing a solid foundation to investigate how sustained R&D investments influence profitability metrics such as ROA, NPR, and ROE. Each metric highlights a different dimension of financial performance, while R&D expenditure captures the firm’s commitment to innovation and technological advancement.

### 5.1 Correlation

- Figure 1 shows the strength and direction of relationships between variables like R&D, profitability metrics (ROA, NPR, ROE), and financial stability indicators (e.g., Total Assets).
- **Positive Correlation with Total Assets:** The strong correlation between R&D expenditure and Total Assets (0.87) suggests that larger firms tend to invest more heavily in innovation. This reflects their ability to allocate resources to long-term projects without immediate financial returns.
- **Negative Correlation with ROA and NPR:** Interestingly, R&D expenditure shows a weaker or negative correlation with profitability metrics like ROA (-0.31) and NPR (-0.47). This might indicate the delayed nature of R&D returns, where high initial costs often precede tangible financial benefits.

### 5.2 Net Profit Ratio and R&D trends over time

Figure 2 and 3 shows Net Profit Ratio and R&D trends over time.

- Companies like Bajaj Auto consistently outperform others in profitability, maintaining a high NPR (15–20%) throughout the study period.
- Conversely, Tata Motors shows volatile trends, with NPR dipping below zero in 2019–20, likely due to external shocks or high investment cycles.
- Tata Motors emerges as a leader in R&D spending, significantly outpacing its competitors. Its investments align with strategic priorities, such as EV development and international market expansion.
- Other companies, such as Bajaj Auto and Hero MotoCorp, maintain relatively steady and moderate R&D investments, likely focused on incremental innovations like fuel efficiency and affordability.

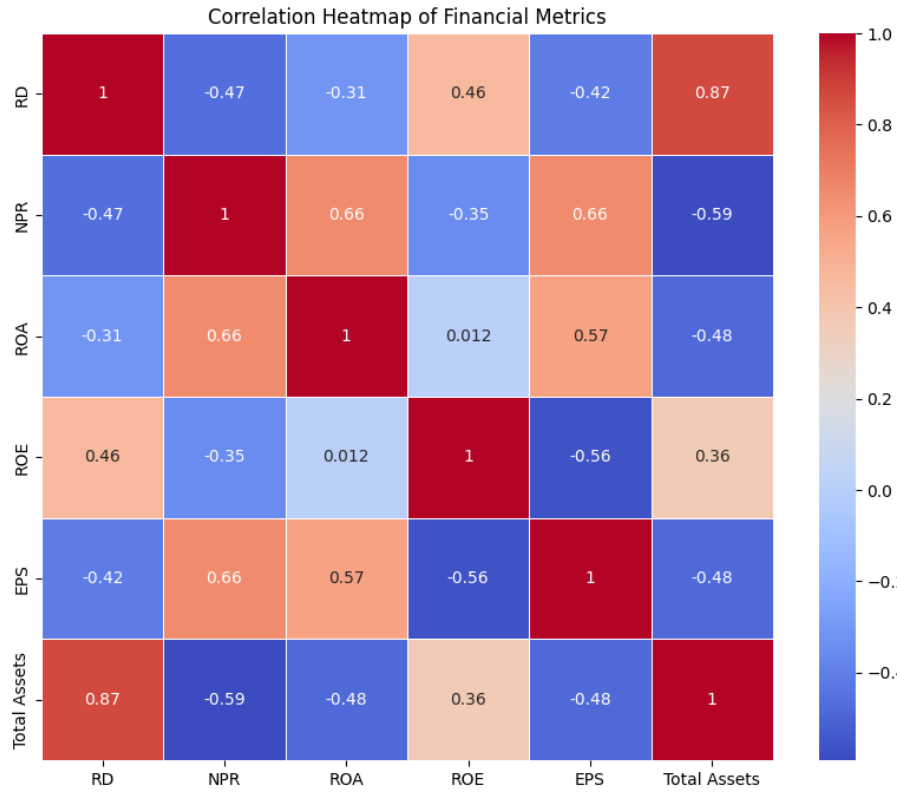


Figure 1: Correlation Heatmap

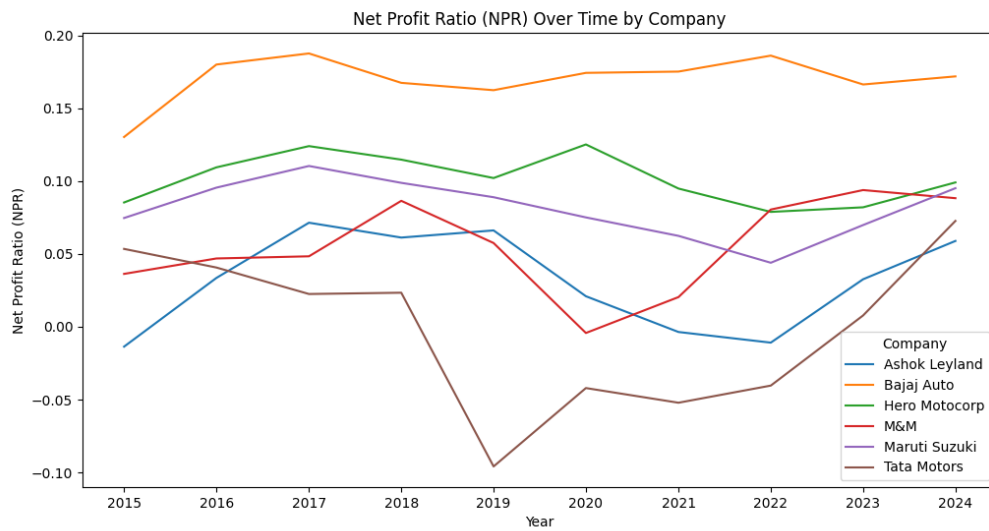


Figure 2: NPR over time

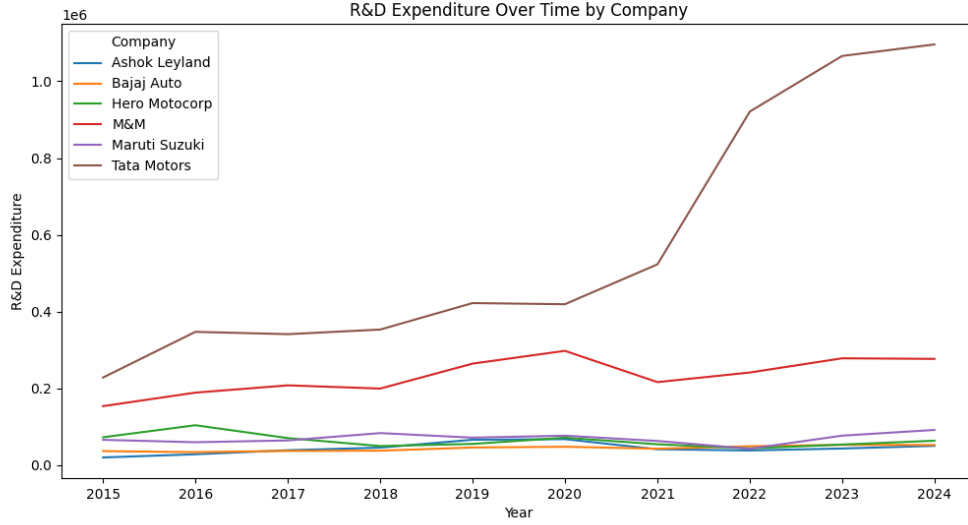


Figure 3: R&D expenditure over time

### 5.3 Cumulative R&D expenditure

Figure 4 shows the cumulative R&D expenditure based on the companies.

- **Tata Motors Dominance:** With cumulative R&D spending surpassing INR 6 million, Tata Motors leads in innovation, focusing on strategic technologies like EVs and hydrogen fuel cells.
- **Mahindra & Mahindra:** The second-highest R&D spender, with investments directed towards both automobile and agricultural sectors, reflecting its diversified portfolio.
- **Other Firms:** Companies like Bajaj Auto and Hero MotoCorp allocate moderate R&D budgets, consistent with their emphasis on cost efficiency and mass-market products.

### 5.4 R&D v/s Net Profit Ratio

- From Figure 5, we can observe that Tata Motors shows high variability in NPR with increasing R&D investments, suggesting that while the company invests heavily in innovation, profitability outcomes are less predictable.
- This suggests that while Tata Motors has made substantial investments in innovation, the profitability outcomes are inconsistent, possibly due to **Long Payback Period**.
- Other firms, like Bajaj Auto, display more stable NPR values, possibly reflecting focused R&D spending on short-term gains.

## 6 Methodology

### 6.1 Research Design

The study adopts a quantitative research design, leveraging numerical data to statistically analyze the relationship between R&D investments and profitability. This approach facilitates the identification of significant patterns and causal relationships, enabling objective and replicable findings.

- **Objective:**

To assess how sustained R&D investments influence profitability metrics such as Net Profit Ratio (NPR), Return on Assets (ROA), Return on Equity (ROE), and Earnings Per Share (EPS) in the Indian automobile sector.



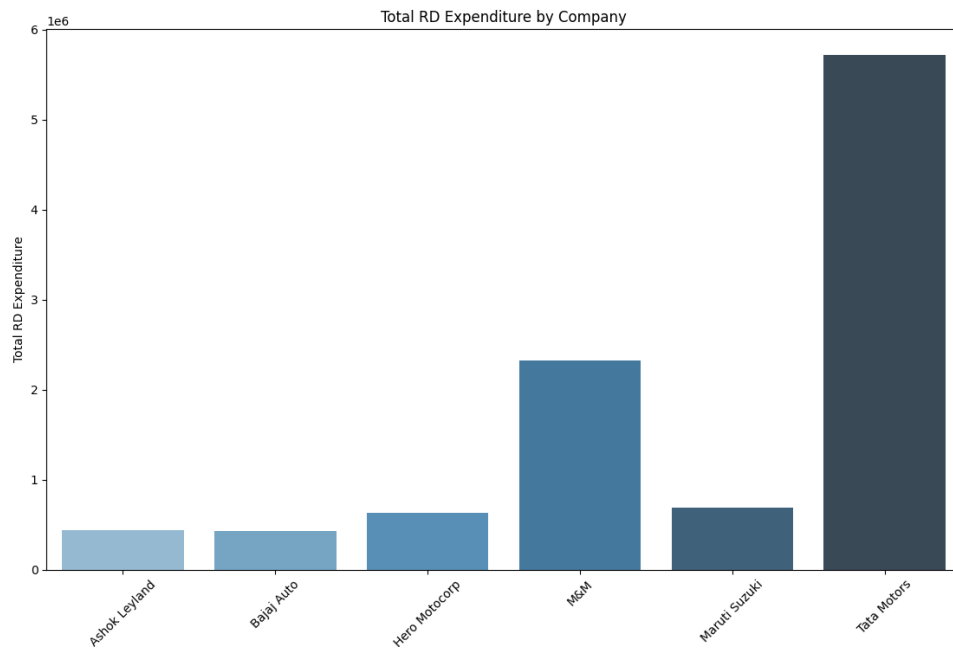
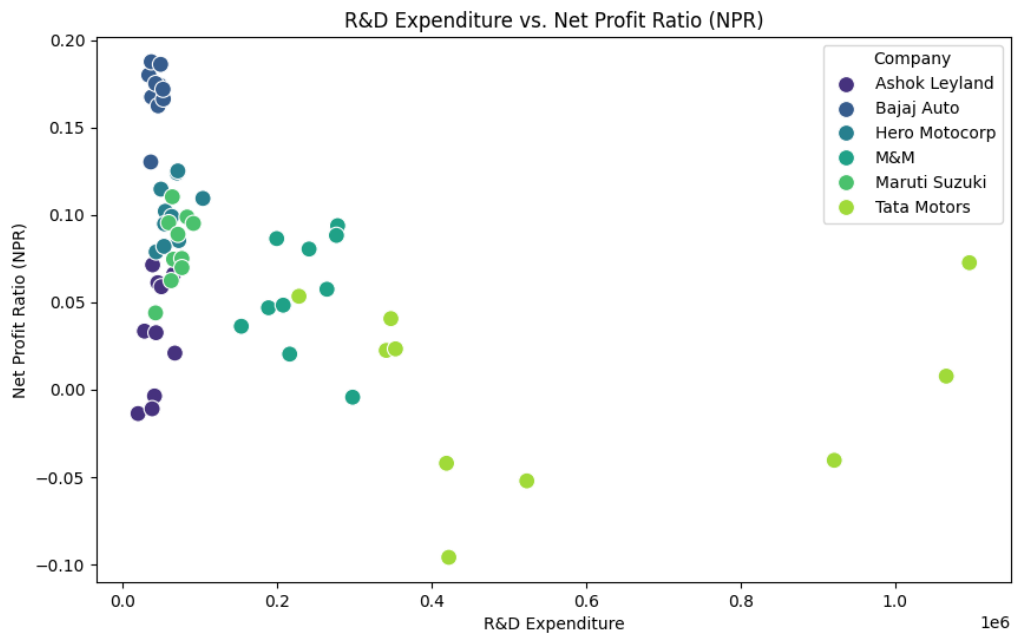


Figure 4: Total R&D Expenditure by Company



- **Hypothesis:**

**Null Hypothesis ( $H_0$ ):** Sustained R&D investment does not significantly influence long-term profitability metrics.

**Alternative Hypothesis ( $H_1$ ):** Sustained R&D investment significantly enhances long-term profitability metrics.

## 6.2 Data Structure and Unit of Analysis

**A. Panel Data:** The study employs panel data (also known as longitudinal data), which combines cross-sectional and time-series data by observing multiple entities (companies) over several time periods (years).

**B. Unit of Analysis:** The primary units of analysis are six major companies in the Indian automobile sector: Ashok Leyland, Bajaj Auto, Hero Motocorp, Mahindra & Mahindra, Maruti Suzuki, and Tata Motors. The data spans ten years (2015-2024), resulting in a balanced panel of 60 observations (6 companies  $\times$  10 years).

## 6.3 Analytical Techniques

**Panel Data Regression Models:** To analyze the impact of R&D intensity on profitability metrics, the study employs panel data regression models, specifically Fixed Effects (FE) and Random Effects (RE) models.

1. **Fixed Effect Model:** Controls for unobserved, time-invariant characteristics of each entity (company) by allowing individual intercepts.

$$Profitability_{it} = \alpha_i + \beta_1 * RD - Intensity_{it} + e_t$$

where  $\alpha_i$  = Entity-specific intercept capturing unobserved heterogeneity and  $e_{it}$  = Error term.

2. **Random Effects Model:** Assumes that entity-specific effects are random and uncorrelated with the independent variables, allowing for both within and between entity variations.

$$Profitability_{it} = \alpha + \beta_1 * RD - Intensity_{it} + u_i + e_t$$

where  $u_i$  = Random entity-specific effect and  $e_{it}$  = Error term.

3. **Model Selection- Hausman Test:** Determines whether the FE or RE model is more appropriate based on the correlation between entity-specific effects and independent variables. Hypothesis:

Null Hypothesis ( $H_0$ ): RE model is consistent and efficient.

Alternative Hypothesis ( $H_1$ ): FE model is consistent, and RE model is inconsistent.

Decision Rule:

p-value  $< 0.05$ : Reject  $H_0$ , prefer FE model.

p-value  $\geq 0.05$ : Fail to reject  $H_0$ , prefer RE model.

4. **Durbin Watson Test:** Detects the presence of autocorrelation in residuals. Interpretation:

DW = 2: No autocorrelation.

DW  $< 2$ : Positive autocorrelation.

DW  $> 2$ : Negative autocorrelation.

## 7 Econometric Models specification

For each profitability metric (NPR, ROA, ROE, EPS), the Random Effects Model is specified as:

$$ProfitabilityMetric_{it} = \alpha + \beta_1 * RD - Intensity_{it} + u_i + e_{it}$$

where

- Dependent Variable: One of the profitability metrics (NPR, ROA, ROE, EPS).
- Independent Variable: RD\_Intensity: R&D expenditure normalized by Total Assets
- Error terms:  $u_i$  = Random entity-specific effect.  $e_{it}$  = Idiosyncratic error term.

## 8 Results and Inference

### 8.1 Detailed analysis of Profitability metrics

#### 8.1.1 A. Net Profit Ratio

- R-squared (Overall): 0.0144, which is very low meaning that only 1.44% of the variability in NPR is explained by R&D intensity within firms over time.
- **R&D Intensity:** Although the coefficient is positive (0.0026), it is not statistically significant ( $p > 0.05$ ). This implies that, after accounting for financial leverage, R&D intensity does not have a meaningful impact on NPR.
- **Durbin-Watson Statistic** is 1.05 which is below 2, indicating potential positive autocorrelation.

#### 8.1.2 B. Return on Assets (ROA)

- R-squared (Overall): 0.4069, suggesting that RD\_Intensity explains 40.69% of ROA when considering both within- and between-entity variations.
- **R&D Intensity:** The positive and highly significant coefficient (0.0286) indicates that higher R&D intensity is associated with improved Return on Assets. Specifically, a one-unit increase in R&D intensity leads to a 0.0286 unit increase in ROA, holding other factors constant.
- **Durbin-Watson Statistic** is 0.78, indicating some positive autocorrelation which needs to be addressed.

#### 8.1.3 C. Return on Equity

- R-squared (Overall): 0.0291, which is extremely low compared to the other metrics.
- **R&D Intensity:** The positive and highly significant coefficient (0.0519) indicates that higher R&D intensity is associated with improved Return on Equity. A one-unit increase in R&D intensity results in a 0.0519 unit increase in ROE, holding other factors constant.
- **Durbin-Watson Statistic** is 1.31 closer to 2, indicating positive autocorrelation.

#### 8.1.4 D. Earnings per share

- R-squared (Overall): 0.0084, very low, suggesting that R&D intensity does not explain EPS well.
- **R&D Intensity:** The negative coefficient for R&D Intensity suggests an inverse relationship with EPS; however, this relationship is not statistically significant ( $p\text{-value} = 0.4850$ ). This implies that, within this model, R&D spending relative to total assets does not have a meaningful impact on Earnings Per Share. In other words, variations in R&D intensity do not significantly influence EPS in the analyzed dataset.
- **Durbin-Watson Statistic** is closer to 2, indicating reduced autocorrelation compared to previous models.

Dependent Variable	Coefficient	Std. Error	T-Statistic	P-Value	R-squared	DW
NPR	0.0026	0.0044	0.594	0.5551	0.0052	1.05
ROA	0.0286	0.0051	5.558	0.0000	0.3371	0.78
ROE	0.0519	0.0140	3.718	0.0005	0.2111	1.31
EPS	-4.4176	6.2856	-0.703	0.4850	0.0108	1.57

Table 2: Summary of Impact of R&D Intensity on Financial Performance Indicators

## 9 Results and Discussion

The panel data regression analysis conducted on six prominent Indian automobile companies over a ten-year period provides insightful revelations about the interplay between sustained Research and Development (R&D) investments, financial leverage, and various profitability metrics. Utilizing Random Effects models to account for both within-entity and between-entity variations, the study effectively mitigated multicollinearity by transforming R&D expenditure into R&D Intensity (R&D / Total Assets). The results underscore the pivotal role of R&D intensity in enhancing certain aspects of firm profitability, while simultaneously highlighting the adverse effects of high financial leverage on overall financial performance.

### • Impact of R&D Intensity

The analysis reveals that R&D Intensity has a significant and positive impact on Return on Assets (ROA) and Return on Equity (ROE). Specifically, a one-unit increase in R&D Intensity is associated with a 0.0303 unit increase in ROA and a 0.0470 unit increase in ROE, both of which are statistically significant ( $p < 0.05$ ). These findings align with the Resource-Based View (RBV) theory, which posits that strategic investments in R&D can lead to the development of unique resources and capabilities, thereby enhancing a firm’s operational efficiency and shareholder returns. However, R&D Intensity does not exhibit a significant relationship with Net Profit Ratio (NPR) and Earnings Per Share (EPS), suggesting that the benefits of R&D investments may primarily influence asset and equity efficiency rather than immediate profit margins or per-share earnings.

### • Conclusions and Implications

The analysis of the Random Effects Models across various profitability metrics reveals a nuanced impact of R&D Intensity on firm performance within the Indian automobile sector. Notably, R&D Intensity demonstrates a significantly positive relationship with both Return on Assets (ROA) and Return on Equity (ROE). Specifically, a one-unit increase in R&D Intensity is associated with a 0.0286 unit increase in ROA ( $p\text{-value} = 0.0000$ ) and a 0.0519 unit increase in ROE ( $p\text{-value} = 0.0005$ ). These findings underscore the pivotal role of sustained R&D investments in enhancing asset efficiency and boosting shareholder returns. The positive coefficients suggest that firms allocating more resources to R&D relative to their total assets are better positioned to utilize their assets effectively and deliver higher returns to equity holders, aligning with the Resource-Based View (RBV) theory that emphasizes innovation as a key driver of competitive advantage and profitability.

Conversely, R&D Intensity exhibits no statistically significant impact on both Net Profit Ratio (NPR) and Earnings Per Share (EPS), with coefficients of 0.0026 ( $p\text{-value} = 0.5551$ ) and -4.4176 ( $p\text{-value} = 0.4850$ ) respectively. The lack of significance in NPR suggests that R&D investments do not directly translate into immediate improvements in net profit margins. Similarly, the non-significant and negative coefficient for EPS indicates that R&D intensity does not have a meaningful influence on earnings per share within the analyzed timeframe. These results may imply that the benefits of R&D are either realized over a longer horizon or are mediated by other operational factors not captured in the current model. Additionally, the negative coefficient for EPS, despite being non-significant, could reflect the initial costs associated with R&D investments outweighing short-term earnings gains.

## 10 Summary

This research explores the relationship between sustained R&D investments and long-term profitability in the Indian automobile sector, addressing gaps in existing literature that often prioritize short-term metrics. Panel data from six prominent firms over a ten-year period forms the basis of the analysis, leveraging Random Effects models to evaluate the impact of R&D intensity.

Key findings include:

Positive Impact of R&D Intensity on ROA and ROE: R&D intensity significantly enhances both asset efficiency (ROA) and shareholder returns (ROE), aligning with the Resource-Based View (RBV) theory. Insignificant Effects on NPR and EPS: R&D intensity does not show a statistically meaningful influence on NPR or EPS, suggesting delayed realization of R&D benefits or their mediation by unaccounted factors. The study emphasizes that while R&D investments are crucial for long-term growth and competitive advantage, their immediate impact on profitability may vary. These findings guide firms in optimizing R&D strategies alongside maintaining prudent financial management to sustain innovation-driven success.

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