RESEARCH AND DEVELOPMENT INTENSITY, CAPITAL EXPENDITURE INTENSITY, AND OPERATING PROFITABILITY: EVIDENCE FROM THE EUROPEAN AUTOMOTIVE INDUSTRY, 2005–2024

DOI: https://doi.org/10.53486/dri2026.69
UDC: [658.155:622.684]"2005/2024"(4)

Ibtihal AL-TAWEEL
Stefan cel Mare University of Suceava, 720229, Romania
ibtihal.taweel@usm.ro
ORCID: 0009-0004-0340-1587
Elena HLACIUC
Stefan cel Mare University of Suceava, 720229, Romania
elena.hlaciuc@usm.ro
ORCID: 0000-0003-0601-748X

Abstract: *This study examines whether research and development (R&D) intensity and capital expenditure (Capex) intensity are associated with operating profitability in the European automotive industry. Using firm-level data from the EU Industrial R&D Investment Scoreboard, the analysis covers an unbalanced panel of 852 firm-year observations from 153 European automotive firms over 2005–2024. Operating profitability is measured as operating profit relative to net sales, while R&D intensity and Capex intensity are calculated relative to net sales. The empirical strategy uses panel regression models with firm and year fixed effects, with standard errors clustered at the firm level. The results show that R&D intensity is negatively and significantly associated with contemporaneous operating profitability, suggesting that innovation-related expenditure may place short-term pressure on accounting performance. This relationship weakens after winsorizing extreme observations and does not persist in a one-year lagged specification, suggesting that the effect is mainly short-run. By contrast, Capex intensity shows a positive but statistically insignificant association with operating profitability in the preferred fixed-effects models. The findings indicate that R&D expenditure is more closely related to short-term accounting profitability than tangible capital investment; however, the negative coefficient should not be interpreted as evidence that R&D destroys value. Rather, it reflects short-term accounting pressure and the time lag between innovation expenditure and future returns, and the results should be interpreted cautiously due to sensitivity to outliers and timing effects.*

Keywords: *R&D intensity; capital expenditure; operating profitability; automotive industry; panel data; fixed effects.*

JEL: M41; G31; O32; L62.

Introduction

The European automotive industry is undergoing major technological transformation driven by electrification, digitalization, automation, stricter environmental regulation and changing consumer demand. The sector remains economically important for Europe, but its competitive position is increasingly challenged by new entrants, software-based differentiation and the transition from internal combustion engines to electrified powertrains (Cornet et al., 2023; Konrad and Stagl, 2018). These changes require firms to allocate substantial resources to both innovation-related investment and tangible capital investment.

Research and development (R&D) expenditure is central to automotive innovation, especially in areas such as electric vehicles, clean technologies, software, autonomous driving and safety systems. At the same time, capital expenditure (Capex) is necessary for plants, production capacity, equipment and the reconfiguration of manufacturing systems. Industry reports emphasize that high R&D spending, high Capex and regulatory costs can place pressure on profitability and pricing power in the automotive sector (Ferraris and Madlani, 2018).

This study asks whether R&D intensity and Capex intensity are associated differently with operating profitability in European automotive firms. The question is relevant because R&D may generate long-term competitiveness but reduce current accounting profit, while Capex may support production capacity but may not immediately improve operating margins. The paper contributes to applied financial accounting and corporate finance research by comparing the short-term profitability association of intangible innovation-related expenditure and tangible capital investment using firm-level panel data.

Literature Background and Hypotheses

Previous studies generally recognize innovation as an important driver of competitiveness and firm performance. Alt (2017), using evidence from the European automotive industry, reports that innovation indicators, including R&D intensity, are positively associated with return on assets. Ozer, Nazli and Yaniktepe (2019) also show that R&D expenditure in the automotive sector is related to sales and profitability measures, although the timing of these effects and the choice of performance indicators may influence the results.

From a theoretical perspective, the present study draws on the resource-based view of the firm. Barney (1991) argues that firm-specific resources and capabilities can support sustained competitive advantage when they are valuable, rare, difficult to imitate and effectively organized. In the context of automotive firms, technological knowledge, innovation capability, production assets and manufacturing capacity may therefore be viewed as strategic resources. However, their accounting effects may differ in the short run. R&D expenditure may reduce current profitability before innovation benefits are realized, while Capex may require time before new production capacity contributes to operating margins.

The short-term accounting effect of R&D can therefore differ from its long-term strategic value. Isik and Tasgin (2017) find that R&D costs can dampen profitability in manufacturing firms, suggesting that innovation expenditure may reduce current profit before benefits materialize. This view is particularly relevant for capital-intensive industries, where firms must continue investing in technology and product development even when immediate profitability is under pressure.

Capex has also been studied as a determinant of firm performance. Jaisinghani, Tandon and Batra (2018) examine the automobile industry and find a dynamic relationship between capital expenditure intensity and firm performance, highlighting the importance of appropriate investment levels. Aghion et al. (2012) show that environmental policy can redirect innovation in the auto industry toward cleaner technologies, while Rozendaal and Vollebergh (2024) provide further evidence that policy-induced innovation affects the direction of technological change in the car market. These studies suggest that R&D and Capex may both be important for competitiveness, but their short-term association with accounting profitability may differ.

Based on the reviewed literature, the study tests three hypotheses: H1: R&D intensity is significantly associated with operating profitability; H2: Capex intensity is significantly associated with operating profitability; and H3: the association between R&D intensity and operating profitability differs from the association between Capex intensity and operating profitability.

Research Methods Applied

The study uses firm-level data from the EU Industrial R&D Investment Scoreboard, published by the European Commission's Joint Research Centre (JRC). Hernandez et al. (2015) describe the Scoreboard as a source of economic and financial information on major corporate R&D investors and as a tool for monitoring corporate innovation activity. The analysis covers firms classified in the Automobiles & Parts sector over 2005–2024. Although the latest Scoreboard file used in this study is labelled 2025, the corresponding financial year is 2024; therefore, the empirical period ends in 2024.

The final baseline sample is an unbalanced panel of 852 firm-year observations from 153 European automotive firms. On average, each firm appears in the baseline sample for approximately 5.6 years,

reflecting the changing composition of Scoreboard firms over time. This unbalanced structure results from firm entry, exit, mergers, restructuring, changes in firm size and sector reclassification. Observations with missing values in the main regression variables and observations flagged for major validation issues are excluded from the baseline models.

Table 1. Variable definitions

Variable	Measurement	Role
Profitability	Operating profit / Net sales	Dependent variable
R&D intensity	R&D expenditure / Net sales	Main explanatory variable
Capex intensity	Capital expenditure / Net sales	Main explanatory variable
Firm size	Natural logarithm of net sales	Control variable

Source: Author's compilation based on EU Industrial R&D Investment Scoreboard data.

The baseline fixed-effects specification is:

$$\boldsymbol{Profitability_{it} = \beta 1\ RDIntensity_{it} + \beta 2\ CapexIntensity_{it} + \beta 3\ FirmSize_{it} + \alpha_i + \lambda_t + \varepsilon_{it}}$$

where i denotes the firm and t denotes the year. Firm fixed effects control for time-invariant firm characteristics, while year fixed effects control for common shocks affecting all firms in the same year. Firm size is measured as log net sales to reduce scale-related skewness and improve comparability across firms. Standard errors are clustered at the firm level to account for within-firm serial correlation. The models are estimated in R using the fixest package (Bergé, 2018).

Results and Discussions

Table 2 reports descriptive statistics for the main variables. The mean operating profitability is 5.06%, while the mean R&D intensity and Capex intensity are 6.14% and 5.16%, respectively. The wide range of profitability and R&D intensity indicates the presence of extreme observations, which motivates the use of robustness checks. Figure 1 visualizes this dispersion and shows that most observations cluster around moderate profitability levels, with a small number of extreme losses and gains.

Table 2. Descriptive statistics

Variable	Mean	SD	Min	Max
Profitability (%)	5.06	9.24	-78.80	80.92
R&D intensity (%)	6.14	8.31	0.16	99.81
Capex intensity (%)	5.16	3.61	0.00	28.65
Firm size	8.18	2.02	1.78	12.69

Source: Author's calculations based on EU Industrial R&D Investment Scoreboard data.

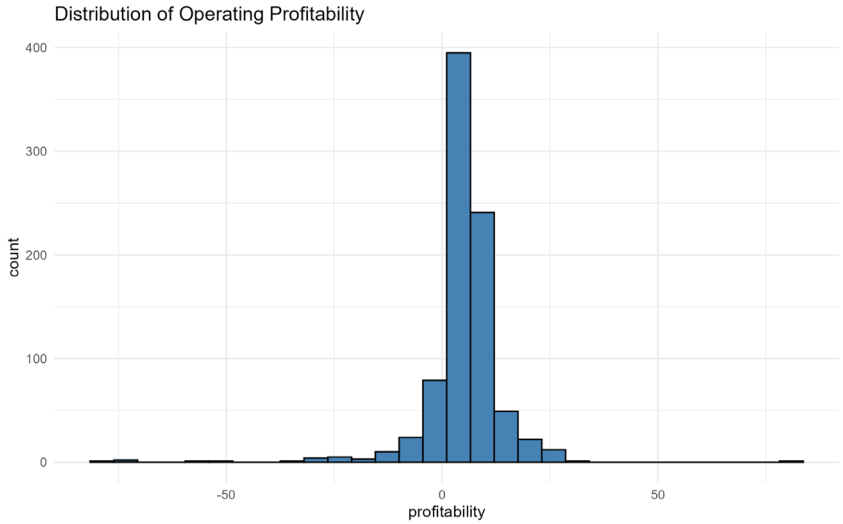

Figure 1. Distribution of operating profitability

Source: Author's calculations based on EU Industrial R&D Investment Scoreboard data.

The correlation matrix shows a negative correlation between R&D intensity and profitability (-0.301), while Capex intensity is positively but weakly correlated with profitability (0.186). The correlations among the explanatory variables are low, indicating no serious multicollinearity problem.

Table 3. Correlation matrix

Variable	Profitability	R&D intensity	Capex intensity	Firm size
Profitability	1.000	-0.301	0.186	0.190
R&D intensity	-0.301	1.000	-0.060	-0.283
Capex intensity	0.186	-0.060	1.000	0.157
Firm size	0.190	-0.283	0.157	1.000

Source: Author's calculations based on EU Industrial R&D Investment Scoreboard data.

Table 4 presents the baseline regression results. The preferred specification is the firm and year fixed-effects model, because it controls for both unobserved firm-specific characteristics and common time shocks. In this model, R&D intensity is negative and statistically significant. More specifically, a one-percentage-point increase in R&D intensity is associated with an approximately 1.4 percentage-point reduction in operating profitability, although this magnitude should be interpreted cautiously given the sensitivity to outliers. This finding should not be interpreted as evidence that R&D is harmful; rather, it suggests that innovation-related expenditure may place short-term pressure on accounting profitability before future benefits are realized.

Capex intensity is positive in the preferred model but statistically insignificant. Thus, the evidence does not support a robust short-term relationship between capital expenditure intensity and operating profitability once firm and year effects are controlled for. The difference between the pooled OLS and firm fixed-effects results suggests that the positive Capex-profitability relationship is stronger across firms than within firms over time. This may indicate that firms with structurally higher Capex intensity differ in scale, production systems or business models, while increases in Capex within the same firm do not immediately translate into higher operating profitability.

Table 4. Baseline regression results

Variable	Pooled OLS	Year FE	Firm + Year FE
R&D intensity	-0.296**	-0.313*	-1.398**
Capex intensity	0.398**	0.451*	0.148
Firm size	0.411**	0.336	-2.553
Observations	852	852	809
R^2	0.126	0.184	0.709
R^2 (within)	—	0.139	0.169
Year FE	No	Yes	Yes
Firm FE	No	No	Yes

*Source: Author's estimations. Clustered standard errors are used where applicable. Significance: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$. The reduction from 852 to 809 observations in the firm and year fixed-effects model reflects the removal of singleton fixed-effect observations by the estimator.*

Because the intensity variables are expressed in percentage terms, the coefficients should be interpreted as changes in operating profitability associated with a one-percentage-point change in investment intensity. The firm-size coefficient should be interpreted cautiously in firm fixed-effects models because much of the persistent size difference across firms is absorbed by firm fixed effects.

Robustness Checks and Discussion

Several robustness checks are conducted to assess whether the baseline findings are sensitive to outliers, timing effects, sample period, functional form, or alternative size measurement. Table 5 summarizes the main robustness models.

Table 5. Robustness regression results

Variable	Baseline FE	Winsorized FE	Lagged FE	2011–2024 FE	Log FE	Log Winsorized FE
R&D intensity	-1.398**	—	—	-1.051*	—	—
Capex intensity	0.148	—	—	0.071	—	—
R&D intensity (wins.)	—	-0.516+	—	—	—	—
Capex intensity (wins.)	—	0.179	—	—	—	—
R&D intensity (lag)	—	—	-0.137	—	—	—
Capex intensity (lag)	—	—	0.122	—	—	—
Log R&D intensity	—	—	—	—	-5.507*	—
Log Capex intensity	—	—	—	—	0.727	—
Log R&D intensity (wins.)	—	—	—	—	—	-3.451+
Log Capex intensity (wins.)	—	—	—	—	—	0.812
Observations	809	809	675	575	809	809
R^2 (within)	0.169	0.030	0.019	0.155	0.026	0.019

*Source: Author's estimations. All models include firm and year fixed effects with firm-clustered standard errors. Significance: + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$. An em dash (—) indicates that the variable is not included in that specification because an alternative transformation or lagged version is used.*

The winsorized specification shows that the R&D coefficient remains negative but becomes substantially smaller and only marginally significant (-0.516, $p < 0.10$), indicating sensitivity to extreme observations. The lower R^2 (within) in this specification suggests that outliers explain part of the within-firm variation in profitability. The one-year lagged model shows no significant coefficient for lagged R&D or lagged Capex, reducing but not eliminating concerns about timing and reverse causality. The 2011–2024 and log-transformed models confirm the negative R&D association, although the log winsorized model again shows weaker significance.

Additional robustness using an alternative firm-size proxy

To reduce the possibility that the results are driven by the use of net sales as the size control, an additional robustness specification replaces firm size, measured by log net sales, with an employee-based size proxy, measured as log(1 + employees). This check is useful because sales may be affected by price cycles, product mix, and temporary demand shocks, while employment captures a more operational dimension of firm scale. The use of an employee-based size proxy leaves the main conclusion unchanged: R&D intensity remains negative and statistically significant, Capex intensity remains positive but insignificant, and the employee-based size measure is not significant. This confirms that the negative R&D-profitability association is not an artefact of using sales as the denominator.

Table 6. Additional robustness using employee-based firm size

Variable	Employee-size FE
R&D intensity	-1.334** (0.518)
Capex intensity	0.162 (0.158)
Employee size	-0.439 (1.269)
Observations	844
Firm FE / Year FE	Yes / Yes

Source: Author's estimations. Employee size is measured as log(1 + employees). Clustered standard errors at the firm level are reported in parentheses. The observation count differs slightly because employee data are available for a different set of firm-year observations.

The results suggest that R&D intensity appears to be more consistently associated with short-term operating profitability than Capex intensity, although this association is negative and sensitive to outlier treatment. In the automotive industry, firms must continue investing in electrification, digitalization, automation, safety technologies and environmental innovation. These investments are strategically important but may not immediately translate into higher operating profitability. In addition, strong competition may force firms to sustain high R&D spending without immediate pricing power, further compressing short-term operating margins.

The Capex results are less robust. Although the coefficient is generally positive, it is not statistically significant in the preferred fixed-effects specifications. The different results for R&D and Capex may reflect the different accounting and operational timing of these expenditures. R&D is more directly reflected in current-period costs, whereas Capex is capitalized and its effect on profitability may appear gradually through depreciation, capacity utilization and production efficiency.

Limitations

This study has several limitations. First, the empirical analysis identifies associations rather than causal effects. Although firm and year fixed effects are used to reduce omitted-variable bias, the models do not fully address reverse causality between investment expenditure and profitability. Second, the sample is based on firms included in the EU Industrial R&D Investment Scoreboard, which mainly covers major R&D investors; therefore, the findings are more representative of relatively large and innovation-oriented automotive firms than of the entire European automotive industry. Third, the R&D result is partly sensitive to extreme observations, as shown by the weaker coefficient in the winsorized specifications. Some extreme observations appear to be driven by firms with very low net sales or unusually weak operating profit in specific years, which may amplify intensity ratios. In particular, the negative coefficient may be influenced by a small number of observations with unusually high R&D intensity and weak operating profitability. Finally, the models are limited by the variables available in the Scoreboard and do not fully control for financial structure indicators such as leverage, asset tangibility or liquidity.

Conclusions and Recommendations

This study examines whether R&D intensity and Capex intensity are associated with operating profitability in the European automotive industry over 2005–2024. Using an unbalanced panel of 852 firm-year observations from 153 firms, the study finds that R&D intensity is negatively associated with contemporaneous operating profitability in the preferred firm and year fixed-effects model. The relationship remains negative in the restricted 2011–2024 period and in the log-transformed model, but it weakens after winsorizing extreme values and does not remain significant in the one-year lagged specification. Taken together, the results indicate that the empirical contribution of the study lies not only in documenting the sign of the R&D coefficient, but also in showing how the interpretation changes across baseline, outlier-adjusted, lagged and alternative-size specifications.

Capex intensity shows no robust statistically significant association with operating profitability across the strongest specifications. Overall, R&D intensity appears to be more consistently associated with short-term operating profitability than Capex intensity, although this association is negative and sensitive to outlier treatment. The interpretation should therefore remain cautious: the results point to short-term accounting pressure from innovation-related expenditure, not to a definitive negative economic value of R&D. Future research may use longer lag structures, cumulative R&D capital measures, additional financial controls or instrumental-variable approaches to examine the long-term profitability effects of R&D investment.

References

1. Aghion, P., Dechezlepretre, A., Hemous, D., Martin, R. and Van Reenen, J., 2012. Carbon taxes, path dependency and directed technical change: evidence from the auto industry. NBER Working Paper No. 18596. Cambridge, MA: National Bureau of Economic Research.
2. Alt, P., 2017. Does innovation pay off in terms of firm performance? Evidence from the European automotive industry. Marble Research Papers, pp.145-165.
3. Barney, J., 1991. Firm resources and sustained competitive advantage. Journal of Management, 17(1), pp.99-120.
4. Bergé, L., 2018. Efficient estimation of maximum likelihood models with multiple fixed-effects: the R package FENmlm. CREA Discussion Papers.
5. Cornet, A., Heuss, R., Schaufuss, P. and Tschiesner, A., 2023. A road map for Europe's automotive industry. McKinsey & Company, August.
6. Ferraris, V. and Madlani, N., 2018. Industry Top Trends 2018: Autos. S&P Global Ratings.
7. Hernandez, H., Hervas, F., Tubke, A., Vezzani, A., Dosso, M., Amoroso, S., Grassano, N., Coad, A. and Gkotsis, P., 2015. The 2015 EU Industrial R&D Investment Scoreboard. Luxembourg: Publications Office of the European Union.
8. Isik, O. and Tasgin, U.F., 2017. Profitability and its determinants in Turkish manufacturing industry: evidence from a dynamic panel model. International Journal of Economics and Finance, 9(8), pp.66-75.
9. Jaisinghani, D., Tandon, D. and Batra, D.K., 2018. Capital expenditure and persistence of firm performance: an empirical study for the Indian automobiles industry. International Journal of Indian Culture and Business Management, 16(1), pp.39-56.
10. Konrad, K. and Stagl, S. eds., 2018. Competitiveness of the European automotive manufacturing industry. Berlin: Institute for Innovation and Technology.
11. Ozer, I.D., Nazli, E. and Yaniktepe, B., 2019. The impact investigation of R&D expenditure in automotive sector. Business & Management Studies: An International Journal, 7(3), pp.89-97.
12. Rozendaal, R. and Vollebergh, H., 2024. Policy-induced innovation in clean technologies: evidence from the car market. Working paper.