STATA Mini Project

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1 Introduction

This project focuses on the cigarette product industry, where larger brands often offer a wider variety of products compared to smaller ones. As individuals who occasionally consume tobacco, we are particularly interested in exploring the role of product variety and R&D expenditures in shaping financial performance. Specifically, we aim to analyze whether R&D spending, alongside metrics such as total assets, debt-to-equity ratio, and current ratio, significantly impacts financial performance indicators such as net profit margin (NPM), gross profit margin (GPM), return on assets (ROA), and return on equity (ROE). By examining these relationships, we seek to identify the critical factors driving financial performance in this industry.

2. Data and Methodology

Data Source

Initially, two datasets were utilized: the first queried based on fundamental metrics (dataset_1) and the second queried based on financial ratios (dataset_2). Following data preprocessing (detailed in the subsequent section), a final cleaned dataset was derived, encompassing financial metrics from a panel of firms. This dataset includes variables such as R&D expenditures, total assets, debt-to-equity ratio, current ratio, and financial performance indicators. The regression analysis incorporates a robust standard error methodology to ensure the reliability and accuracy of the coefficient estimates.

Variables

- **Dependent Variables:**
  - NPM: Net Profit Margin
  - OPMAD: Operating Profit Margin After Depreciation
  - GPM: Gross Profit Margin
  - ROA: Return on Assets
  - ROE: Return on Equity
- **Independent Variables:**
  - Logged R&D Expenditures
  - Logged Total Assets
  - Total Debt-to-Equity Ratio (DE Ratio)
  - Current Ratio
  - Interaction Terms (e.g., R&D $\times$ Total Assets, R&D $\times$ DE Ratio)

Methodology

Using multiple regression models, the analysis mainly investigates the impact of R&D expenditures on 5 financial performance, while other interaction terms such as Total Debt-to-Equity ratio and Current Ratio are included to account for the combined effects of R&D investments with other financial metrics.

Data-Preprocessing

1. The datasets are merged using a many-to-many merge, retaining only the variables **sic**, **naics**, **at**, and **xrd** from **dataset_1**.

2. Unnecessary variable columns are removed, keeping only those identified as independent (x-variables) or dependent (y-variables). All missing variables are labeled accordingly.

3. Rows where **sic = 2111** (corresponding to the tobacco industry) are extracted and saved as **dataset_3.dta**, which serves as the cleaned dataset. Rows containing any missing data are subsequently removed.

4. The data types of all variables are verified to ensure that the regressor variables are of type double.

5. Finally, new columns are created for the logged variables in preparation for the linear regression modeling.

3. Results

Table 1: Regression Coefficients for Financial Performance Indicators

	(1) NPM	(2) OPMAD	(3) GPM	(4) ROA	(5) ROE
Logged R&D Expenditures	7.695**	7.497**	-0.158	-0.0336	-1.371
	(3.878)	(3.476)	(0.180)	(0.121)	(2.291)
Logged Total Assets	18.07*	16.07*	-0.155	0.600*	4.336
	(10.36)	(9.399)	(0.562)	(0.320)	(6.766)
Logged R&D Expenditures × Logged Total Assets	-2.975*	-2.690*	0.0462	-0.0633	-0.472
	(1.680)	(1.519)	(0.0876)	(0.0508)	(1.077)
Total Debt/Equity	49.19**	40.72**	-0.403	0.149	-1.368
	(19.97)	(17.68)	(0.856)	(0.529)	(10.05)
Logged R&D Expenditures × Total Debt/Equity	-9.504**	-8.718**	-0.0977	-0.118	-2.054
	(4.314)	(3.847)	(0.213)	(0.142)	(2.738)
Logged Total Assets × Total Debt/Equity	-7.365**	-6.259**	0.0302	-0.101	-0.541
	(3.295)	(2.924)	(0.154)	(0.0888)	(1.882)
Logged R&D Expenditures × Logged Total Assets × Total Debt/Equity	1.403**	1.271**	0.0107	0.0270	0.320
	(0.669)	(0.596)	(0.0320)	(0.0201)	(0.422)
Current Ratio	9.475*	6.773	-0.581*	0.0592	0.490
	(5.559)	(5.097)	(0.316)	(0.185)	(3.951)
Logged R&D Expenditures × Current Ratio	-1.138	-1.699**	0.0781*	0.0419	1.022**
	(0.802)	(0.723)	(0.0397)	(0.0325)	(0.491)
Logged Total Assets × Current Ratio	-2.708	-1.681	0.183*	-0.0214	-0.457
	(1.734)	(1.614)	(0.105)	(0.0613)	(1.301)

Logged R&D Expenditures × Logged Total Assets × Current Ratio	0.458*	0.348	-0.0328**	-0.00196	-0.00821
	(0.272)	(0.250)	(0.0152)	(0.00919)	(0.192)
Total Debt/Equity × Current Ratio	-19.52**	-16.53**	0.0268	-0.192	-0.751
	(7.987)	(7.049)	(0.342)	(0.206)	(4.022)
Logged R&D Expenditures × Total Debt/Equity × Current Ratio	3.749**	3.850**	0.0827	0.0963*	1.121
	(1.723)	(1.533)	(0.0756)	(0.0524)	(0.897)
Logged Total Assets × Total Debt/Equity × Current Ratio	3.323**	2.789**	0.000177	0.0548	0.291
	(1.510)	(1.349)	(0.0716)	(0.0434)	(0.895)
Logged R&D Expenditures × Logged Total Assets × Total Debt/Equity × Current Ratio	-0.631**	-0.591**	-0.00838	-0.0155*	-0.148
	(0.293)	(0.260)	(0.0133)	(0.00825)	(0.168)
N	232	232	232	232	232
RMSE	3.707	3.147	0.109	0.0861	0.780
Robust SE	yes	yes	yes	yes	yes

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Key Findings

- **R&D Expenditures:** Positively significant for NPM and OPMAD, suggesting that firms investing in R&D achieve better operational efficiency. However, the relationship is insignificant or negative for ROA and ROE, indicating potential diminishing returns on equity-based metrics.
- **Total Assets:** Larger firms (proxied by total assets) have significantly higher NPM and ROA, indicating economies of scale and efficient utilization of resources.
- **Debt-to-Equity Ratio:** Positively significant for NPM, showing that moderate leverage might enhance profitability through tax shields, but excessive debt could have adverse effects (e.g., interest obligations).
- **Current Ratio:** A higher current ratio is positively associated with NPM, indicating that liquidity supports operational stability.
- **Interaction Terms:** Complex interactions reveal mixed effects:

- R&D and Total Assets: Negative interaction, suggesting diminishing returns as firms grow larger.
- R&D and DE Ratio: Significant negative interaction for NPM and ROA, highlighting potential risks of over-leveraging.
- Higher-order interactions (e.g., R&D × Total Assets × DE Ratio × Current Ratio) generally show nuanced and weak effects, reflecting the intricate dynamics between variables.

4. Discussion

The analysis underscores the pivotal role of R&D expenditures in enhancing financial performance, particularly in driving profitability margins (NPM and OPMAD). Larger firms benefit from R&D investments, but the returns diminish at higher levels of leverage or as firms expand in size.

Additionally, the positive association between liquidity (current ratio) and profitability highlights the importance of maintaining operational flexibility. However, the mixed results for ROA and ROE suggest that firms need to carefully balance R&D investments with other financial strategies to maximize overall performance.

Finance Implications

- **Capital Allocation:** Firms should prioritize R&D investments in areas with high expected returns while monitoring their debt levels to avoid over-leverage.
- **Risk Management:** The negative interactions between R&D and leverage suggest that financial risk management strategies are essential when increasing R&D budgets.
- **Strategic Growth:** Larger firms need to assess the diminishing marginal returns of R&D and consider alternative strategies for growth and innovation.

5. Conclusion

The result demonstrates the significant but complex relationship between R&D expenditures and financial performance. While R&D enhances profitability margins, its interaction with other financial variables can moderate its effectiveness. Future research could explore industry-specific effects, time-lagged impacts of R&D, and macroeconomic influences on these relationships.

Further Study: Combining financial performance data with market share and industry benchmarks could provide deeper insights into the competitive advantages driven by R&D investments.