

Regression Analysis of Research & Development Expenditure and Annual Net Income: A Case Study of Apple Inc.

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Abstract: This article aims to investigate the effect of Research & Development Expenditure on Apple's net income. Data from 2010 to 2024, sourced from Statista.com, are analyzed to examine how strategic investments in R&D correlate with financial performance. The method of multiple linear regression is used to analyze the effect of Research & Development Expenditure on Apple's net income. The effect of advertising spending on Apple's net income is also considered. The findings indicate a statistically significant positive relationship, suggesting that R&D investments may play a critical role in driving revenue growth. Specifically, each additional billion dollars invested in R&D is associated with an approximate increase of 438 million dollars in revenue. These findings underscore the strategic importance of R&D investments in sustaining and enhancing Apple's competitive advantage and revenue growth. These insights provide valuable guidance for strategic planning and financial forecasting within the tech sector and beyond, advocating for sustained investment in innovation as a cornerstone of corporate growth strategies. Future studies are recommended to incorporate broader variables and more complex econometric models to deepen understanding of these dynamics.

Keywords: Research & development expenditure, multiple linear regression, prediction model.

1. Introduction

Research & Development spending is typically regarded as one of the key factors in driving firm income, simply because R&D can be viewed as an investment in future innovation, leading to potential increases in product offerings, efficiency, and market share. For instance, Economic theories have explained the connection between R&D expenditure and firm income. Endogenous growth theory holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth [1]. A resource-based view of the firm suggests that R&D provides firms with unique, inimitable resources leading to a competitive advantage [2]. Schumpeter's theory of creative destruction mentions that technological advancements, often driven by R&D, can radically shift market dynamics and lead to higher income for firms [3].

Apart from theoretical perspectives, mathematical studies have also measured the impact of R&D spending on firm income. Sridhar used a vector auto regression model of a panel of publicly listed U.S. high technology manufacturing firms [4]. Guo stated that increased R&D spending positively affects firm performance for product differentiation firms linearly using Linear regression with R&D intensity (R&D spending as a percentage of operating income) and its square term to test non-linearity

[5]. However, this study was limited to Chinese manufacturing firms, reducing generalizability to other regions or sectors. Yilmaz stated that higher R&D expenses were strongly correlated with increased turnover (a proxy for firm income) using linear regression on natural log-transformed data from 2007–2015 [6]. However, this study relied on historical data (up to 2015), which might not reflect current economic trends.

Arilica stated that public expenditure, including components potentially related to research, had a high positive correlation with economic growth in Pakistan using multiple linear regression using ordinary least squares (OLS) on time series data from 1982–2017 for Pakistan [7]. However, its limited sample size (Pakistan-specific) reduced its generalizability. Zou stated that government expenditure, potentially including research, positively affects economic growth in developing countries but negatively in developed ones, implying varying effects on national income by development stage using panel data analysis (not explicitly linear regression in the abstract) on 100 countries from 1970–2001 [8]. However, its extended time frame (1970–2001) might not accurately reflect modern economic dynamics. Piplica stated that R&D expenditure positively influences economic growth in the EU28, suggesting a beneficial effect on national income over the 2002–2012 period using multiple regression model using data from EU28 countries from 2002–2012, while the period ended in 2012, missing recent economic shifts [9].

Vurur stated that R&D expenditure has a one-way causal effect on operational profit in a Turkish pharmaceutical firm using Granger Causality Test on quarterly data from year 2005 to 2015 for a single firm listed on the Borsa Istanbul (BIST) [10]. However, it used Granger Causality rather than linear regression, testing directionality rather than magnitude of effect. In this article, multiple linear regression models are used to study the effect of Research & Development Expenditure on Apple's net income.

2. Methods

2.1. Data source

The data set used in this paper is fetched and organized from the [statista.com](https://www.statista.com) website, a reputable statistical database providing comprehensive and verified financial data. It was from 2010 to 2024. The original dataset about Apple Inc was extensive. This research selected 45 of them which are relatively complete and reliable.

2.2. Variable selection

The analysis focuses on 3 key variables which are: Annual Net Income (Y): Apple's annual net earnings, measured in billions of United States Dollar (USD), indicative of financial health. Research & Development Spending (X1): Annual R&D budget allocation, reflecting Apple's commitment to innovation, measured in billions of USD. Advertising Expenditure (X2): Annual spending on promotional activities, influencing consumer demand and brand strength, measured in billions of USD. A summary of the collected data is provided below in Table 1.

Table 1 summarizes Apple Inc.'s financial data from 2010 to 2024, highlighting net income, R&D spending, and advertising expenditures. Net income measures annual profitability after all expenses, indicating financial health. R&D spending shows Apple's yearly investment in innovation, reflecting strategic commitments to new product development and technological advancement. Advertising expenditures represent the budget for marketing activities aimed at boosting brand recognition and consumer demand. Overall, the table illustrates an upward trend in all three metrics, indicating that increased investments in R&D and advertising correlate positively with rising net income, underscoring their importance in Apple's overall growth strategy.

Table 1: List of data

Year	Net Income (in billions of USD)	R&D Spending (in billion USD)	Advertising Expenditures (in billion USD)
2024	93.74	31.37	3.262
2023	97	29.92	3.116
2022	99.8	26.25	3.137
2021	94.68	21.91	2.747
2020	57.41	18.75	2.490
2019	55.26	16.22	2.219
2018	59.53	14.24	1.947
2017	48.35	11.58	1.670
2016	45.69	10.05	1.502
2015	53.39	8.07	1.800
2014	39.51	6.04	1.499
2013	37.040	4.48	1.354
2012	41.73	3.38	1.020
2011	25.92	2.43	0.775
2010	14.01	1.78	0.691

2.3. Method introduction

The study uses a multiple linear regression model (a regression model that estimates the relationship between a quantitative dependent variable and two or more independent variables using a straight line.) to examine the impact of R&D expenditure on revenue. The regression equation is specified as:

$$y = \beta + \beta_1 x_1 + \beta_2 x_2 + \epsilon \quad (1)$$

Where y is the annual net income, x_1 is the R&D expenditure and x_2 is the advertising expenditure. β represents the y-intercept. β_1 and β_2 are the regression coefficients, indicating the change in net income for a one-unit change in R&D or advertising expenditure. And ϵ is the error term.

The model was estimated using the Ordinary Least Squares (minimizing the sum of the squares of the differences between the observed dependent variable, in this case, the annual net income of Apple Inc, in the input dataset and the output of the linear function of the independent variable, in this case, the Research & Development Expenditure). Graphical analysis which means scatter plots with fitted regression lines was also used to visualize the relationship.

3. Results and discussion

3.1. Descriptive statistics

After plotting the data on a graph with Annual Net Income (in billions of USD) on the y-axis and R&D Spending (in billion USD) on the x-axis, orange spots of estimated values and blue spots of actual values, figure 1 is obtained.

The figure 1 reveals a clear upward trend, suggesting a strong positive correlation between Apple's R&D spending and its net income. As R&D investment increases over the years, the actual net income also generally rises. The fitted regression line closely aligns with actual data points, indicating that R&D expenditures can reliably predict Apple's financial performance. The close proximity of the estimated values to the actual values demonstrates the accuracy of the regression model, validating the conclusion that increased investment in R&D significantly enhances Apple's profitability.

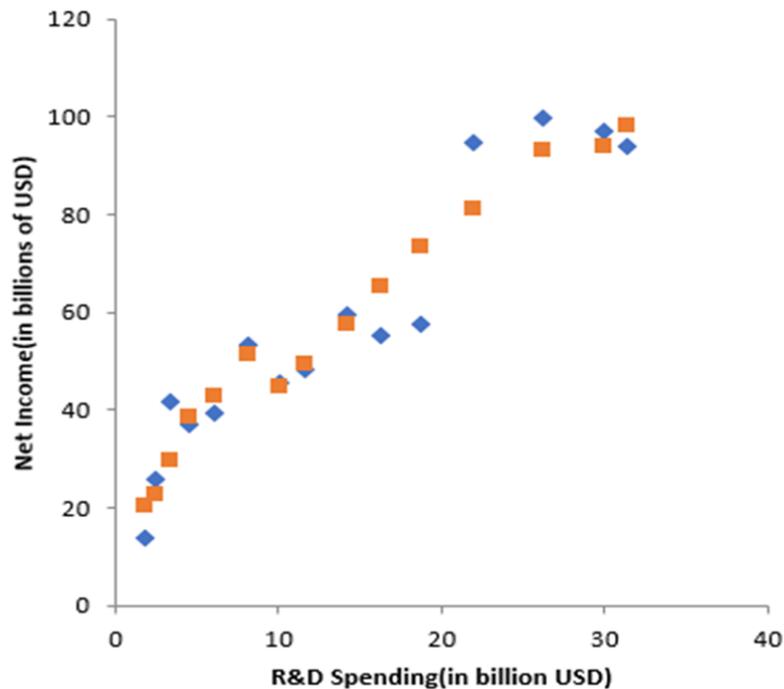


Figure 1: R&D spending (in billion USD) line fit plot

What’s more, figure 2 is obtained by plotting the data on a graph with Annual Net Income (in billions of USD) of y-axis and Advertising Spending (in billion USD) of x-axis, orange spots of estimated values and blue spots of actual values.

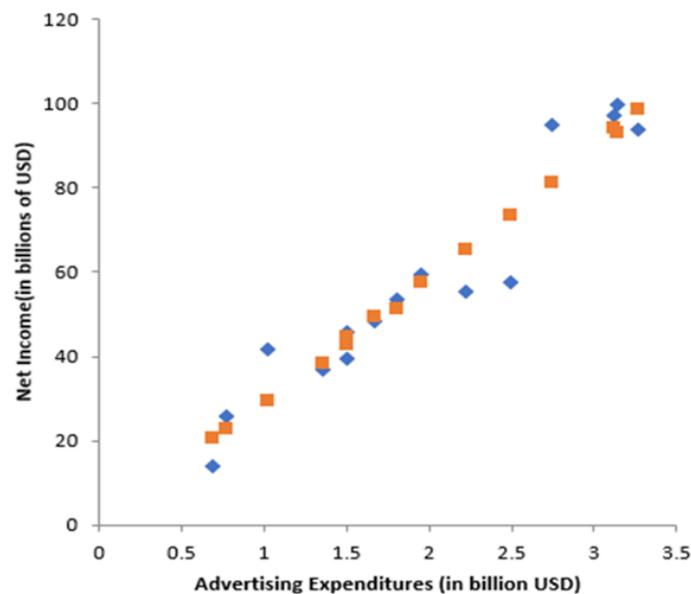


Figure 2: Advertising expenditures (in billion USD) line fit plot

The figure 2 also exhibits a distinct upward trend, indicating a robust positive relationship between advertising spending and net income. The consistent increase in net income alongside higher advertising spending emphasizes advertising’s critical role in enhancing Apple’s revenue. The fitted line closely matches actual data points, signifying a strong predictive capability of the regression

model. This alignment underscores the effectiveness of advertising investments in boosting Apple's brand strength, market presence, and financial performance.

3.2. Regression analysis

The regression output is summarized below in Table 2:

$$y = 2.240277 + 0.427859x_1 + 25.35549x_2 \quad (2)$$

Table 2: Linear regression results

Parameters	Coefficient	Std. Error	t-value	p-value
Intercept (β_0)	2.240	0.894	2.503	0.025
R&D Spending (β_1)	0.427	0.054	7.876	<0.001
Advertising Spending (β_2)	25.355	3.167	8.007	<0.001
R^2	0.917			
Adjusted R^2	0.903			
Correlation	0.957			

The results indicate that for every additional billion USD spent on R&D, Apple's annual revenue increases by approximately 0.438 billion USD (or 438 million USD), holding all else constant. The value of product-moment correlation coefficient is close to 1, suggesting a strong correlation among variables. The high R^2 and adjusted R^2 values indicate that over 90% of the variance in Apple's net income is explained by the model, emphasizing the strength and accuracy of the regression analysis (Table 2).

3.3. Implications for Apple

The findings of this study have important strategic implications for Apple, emphasizing the need for continued prioritization of innovation through robust investment in R&D. The strong correlation between Apple's R&D spending and increased net income indicates that sustained innovation efforts are crucial for maintaining and improving market leadership and financial performance. Apple should consider not only increasing its R&D budget but also strategically focusing its investment areas, such as emerging technologies, consumer electronics, and digital services, to maximize return on investment. Furthermore, Apple's successful integration of advertising strategies highlights the importance of synchronizing marketing efforts with innovation initiatives. This integrated approach can help Apple effectively communicate product innovations to consumers, thereby strengthening brand loyalty and expanding market reach. Finally, Apple can leverage these insights to inform stakeholders, reassuring investors and partners of the firm's strategic commitment to growth through calculated innovation and well-planned advertising campaigns.

3.4. Model limitations

Firstly, the model focuses solely on R&D and advertising expenditure, while other factors (e.g., SG&A, market conditions and employee structures) may also impact income. Secondly, the analysis relies on publicly reported figures, which might have discrepancies or rounding issues. Lastly, correlation identified through regression does not imply causation definitively, highlighting the necessity for further experimental or quasi-experimental approaches to establish direct causality.

4. Conclusion

The analysis robustly demonstrates that Research & Development (R&D) expenditures are critically influential in enhancing Apple Inc.'s annual net income, affirming theoretical perspectives that prioritize innovation as a primary driver of corporate growth. The regression model employed reveals that over 90% of the variability in Apple's net income can be explained by its expenditures in R&D and advertising, reflecting a high level of explanatory power and confidence in the accuracy of these findings.

Strategically, this study emphasizes the significance of ongoing investment in innovation, suggesting that R&D expenditure should continue to be a core component of Apple's financial and operational strategy. By quantifying the direct financial benefits of increased R&D spending, the analysis provides actionable insights for corporate executives and financial planners aiming to maximize returns on investment and strengthen competitive market positioning. Furthermore, the complementary role of advertising expenditure underscores the importance of integrated marketing and innovation strategies to achieve holistic corporate growth.

However, while this analysis offers compelling evidence regarding the financial benefits associated with increased R&D expenditure, the study acknowledges specific limitations, notably the exclusion of additional factors like market dynamics and administrative costs, which could also significantly impact net income. Additionally, as the findings are based on correlation, future research employing experimental or quasi-experimental methodologies could further clarify causality, enhancing the practical applicability of these insights.

To build upon the current findings, subsequent studies are encouraged to integrate a wider array of influencing variables and leverage advanced econometric techniques. Exploring longitudinal case studies across different sectors could further validate the generalizability of the observed relationships. Ultimately, this analysis reinforces the essential role of strategic R&D investments in corporate profitability and provides a foundation for future research and financial strategy development in innovation-intensive industries.

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