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Polynomial Regression Analysis of Interaction between Resources and its Impact on Firm Profitability: Insights from the Indian IT Industry

Sneha Singh [1] and Sanjeev Kumar Sharma [2]

[1] University Business School, Panjab University, Chandigarh, India

[2] University Institutes of Applied Management Sciences, Panjab University, Chandigarh, India

snehasinghkalra@gmail.com; sksharma@pu.ac.in

Abstract. The intangible resources: research and development (R&D) intensity, marketing intensity, and cost-efficiency-enabling resources, although empowering the three core functionalities of any firm, are rarely studied together. This paper aims to investigate how these different resources interact with each other to impact a firm's profitability in a highly dynamic industry, here, the Indian IT industry. As the individual impact of these resources on firm profitability can be linear or non-linear, this study attempts to delineate the resulting complex interaction of the resources and its effect on profitability. Profit Margin and Return-on-Sales (ROS) are the chosen indicators of firms' profitability as they are independent of the types of financing leveraged in any firm and provide a level-playing field to firms of varying sizes. For calculating the values of the various indicators of resources and profitability, this research relies on the secondary data of the top 18 companies functioning in the Indian Information Technology (IT) industry. The secondary data of these firms are included in the study for five years (FY 2016 - FY 2020) to overcome seasonal variances if any. The individual impacts of the three resources on profitability are gauged with the help of scatterplots and their subsequent curve-fitting. Polynomial regression is employed to capture the interaction of the resources' linear and non-linear effects on profitability. The four-dimensional (4D) visualizations of the results from the polynomial regression equations assist in interpreting these interactions of the resources. A modified form of the response surface analysis, this visualization accommodates three predictor variables in the same visualization and demonstrates the levels of various resources at profitability extrema (maxima/minima). The results indicate that the resources like R&D and marketing intensities have a quadratic effect on profitability, exhibiting a U-shaped curve. However, the cost-efficiency-enabling resources demonstrate a linear impact on the firm profitability. The results also indicate that, at nearly all levels of R&D and marketing intensities that exceed their minimum threshold levels, the prevalence of more cost-efficiency-enabling resources leads to higher profitability. An important implication of this research is the optimal utilization of intangible resources in a firm for higher profitability.

Keywords: cost-efficiency, information technology, marketing intensity, r&d intensity, regression analysis

1. Introduction

The Indian Information Technology (IT) industry, a substantial contributor to India's GDP, accounted for nearly 52% of the total services exports from the nation in FY 2020 (IT & BPM Industry in India, n.d.). However, firms in the IT industry experience very short product life cycles because of the prevalence of high rates of technological obsolescence (Jain et al., 2019). Moreover, the industry's client base is primarily overseas, and the resources proliferate the geographical boundaries (Upadhya, 2004; Zaheer et al., 2009). Consequently, the firms are under constant pressure to be profitable owing to the levels of competition in the Indian IT industry, both at domestic and global levels (Jain et al., 2019). Effective resource allocation and management, thus, becomes inevitable for them. According to the Resource-Based View (RBV), the resources possessed by a firm also determine its competitive standing in the market (Barney, 2001). The three resources critical to any IT firm correspond to the three core functionalities of competitive strategy development and implementation, leading to a sustained competitive advantage. These core functionalities are innovation, marketing, and operational efficiency (Krasnikov & Jayachandran, 2008). Each of these functionalities serves a different purpose and requires contrasting resources. The result is a daily trade-off in resource allocation faced by the managers of IT firms (Garcia et al., 2003). Innovation, especially in high-tech industries, has research and development (R&D) as its focal element (Bican & Brem, 2020). R&D intensity is the resource that helps in creating entry barriers for the competitors by gaining a first-mover advantage (Scherer, 2015). On the other hand, marketing intensity is a beneficial resource for selling products/services, especially when they are of high-tech nature (Kim & Lee, 2011). It helps increase the barriers to imitation for defending its market position (Mizik & Jacobson, 2003). R&D and marketing intensities are the resources that help in differentiating a firm from its competitors, while operational efficiency or cost-efficiency-enabling resources favors cost-leadership (Pattnaik & Elango, 2009). Cost-efficiency attainment requires streamlining or benchmarking the processes and investing in areas such as bulk production or economies of scale (Allen & Helms, 2006; Krasnikov & Jayachandran, 2008).

Despite the significant implications of these resources, namely, the R&D intensity, marketing intensity, and cost-enabling resources on firm prospects, only a few studies have focused on exploring the interaction of the three. In the past, studies have mainly focused on two resources, especially R&D and marketing intensities (Olson et al., 2001). The primary aim of these studies has been to assess the relative impact of resources on firm performance (Krasnikov & Jayachandran, 2008). Research on analyzing the interaction of all three resources and their influence on profitability is rare. Moreover, there is a disagreement in the literature on the type of relationship these resources have with profitability. A few papers suggest that the relationship is linear, while others demonstrate a non-linear relationship (Artz et al., 2010; Chen & Hsu, 2010; King & Slotegraaf, 2011; Markovitch et al., 2020; Vithessonthi & Racela, 2015; Yeh et al., 2010). This paper attempts to address these gaps in the existing literature and analyze the impact of the complex interaction of the three resources on firm profitability, especially in a highly dynamic industry like the Indian IT industry.

The contributions of this study, therefore, are threefold. Firstly, this research attempts to empirically examine the impact of resources on the profitability of Indian IT firms. The individual influence of resources, as well as their interactions, is investigated. Secondly, this study demonstrates delineating the complex interaction of the resources and their effect on the firm profitability. With the help of Polynomial Regression Analysis and four-dimensional (4D) visualizations, gauging the levels of various resources at profitability extrema (maxima/minima) is simplified. A modified form of the response surface analysis, these visualizations accommodate the three resources in the same view. Finally, this study attempts to aid the managers of the Indian IT industry firms in the optimal utilization of resources that serve different purposes.

2. Review of Literature

Nearly 4.5 million people are part of the workforce in the Indian IT industry (IT & BPM Industry in India, n.d.). The industry is also a vital source of FDI inflows in India, and its contribution to India's GDP can be expected to reach close to 10% by 2025 (IT & BPM Industry in India, n.d.). Being such a vital driver of the Indian economy, maintaining the soundness of the firms operating in the industry becomes crucial. Profitability is one such measure for appraising the health of the firms (Albertazzi & Gambacorta, 2009; Lipunga, 2014). Profitability can be estimated with the help of indicators like (i) Return on Assets, (ii) Return on Equity, (iii) Return on Investment, and (iv) Net Profit Margin (or Profit Margin) (Stratopoulos & Dehning, 2000). However, the measurement of Profit Margin and Return-on-Sales (ROS) do not rely on the types of financing leveraged in a firm (i.e., debt or equity) compared to the other profitability indicators. As a result, these indicators are better suited for analysis when firms of varying sizes are part of the sample (Hazarika, 2021). These indicators provide a level-playing field for all firms, big and small, and are, therefore, included in this study as measures of firm profitability.

The RBV theory posits that the heterogeneity of resources is the source of variability in the performance of the firms within the same industry (Barney, 2001; Peteraf & Barney, 2003; Zott, 2003). As this research is conducted in the purview of the Indian IT industry, the factors like environmental conditions and government regulations equally impact all the firms operating in the same industry. What varies intra-industry is the resource constituency of these firms. One of the prime components of RBV is its supposition that the valuable resources bring a competitive advantage to the firm and are rare and hard to replicate (Lockett & Thompson, 2001). The competitive advantage is sustainable if such resources are difficult to imitate (Wade & Hulland, 2004). This view advocates that the factors internal to a firm accompany competitive advantage that further drives profitability (Spanos et al., 2004). These factors (or resources) could be tangible, like human resources or financial capital (Kamasak, 2017). They can also be intangible, like innovation, research, marketing, or efficiency-enabling resources (Fernández et al., 2000; Kamasak, 2017; Knott, 2009; Kristandl & Bontis, 2007; Pak et al., 2015). The intangible resources, being more tacit, are more difficult to imitate and, thus, more favorable for attaining competitive advantage (Gómez & Vargas, 2012). The three intangible resources, namely, R&D intensity, Marketing intensity, and Cost-efficiency-enabling resources, are, therefore, deemed the quintessential resources for the scope of this research.

R&D intensity refers to the extent to which a firm lays strategic emphasis on innovation (Lin et al., 2006). The R&D intensity of a firm in a financial year can be derived by calculating the ratio of R&D expenditures to its annual sales (Tyagi & Mahajan, 2022; Wang, 2011). Higher R&D intensity signals the degree of importance placed on innovation and R&D-related activities while designing the firm's strategy (Heyden et al., 2017). Recent studies indicate that R&D Intensity tends to have a non-linear relationship with firm profitability (Artz et al., 2010). It can be argued that the benefits accrued with the R&D intensity eventually outweigh the associated costs, thus, exhibiting a U-shaped relationship with profitability. As the level of R&D intensity exceeds a threshold value, it reaches a position where it can leverage the economies of scale and spread the costs of the R&D to be profitable (Artz et al., 2010; Lee & Rugman, 2012). Therefore, although profitability decreases with an initial increase in R&D intensity, it can later be expected to increase with a further increase in R&D intensity beyond a certain threshold or benchmark.

Marketing intensity refers to the emphasis placed by a firm on its marketing-related activities and allocating resources for the same (Bae et al., 2017). These activities include advertising, brand management, and customer engagement (Bae et al., 2017; Chaudhuri et al., 2020). The marketing intensity of a firm can be measured as the ratio of Selling, General, and Administrative expenses (SG&A) to the net sets of the firm (Pattnaik & Elango, 2009; Peng & Beamish, 2014). A higher value of marketing intensity for a firm signifies that it places significant weight on disbursing resources for marketing activities, indicating its financial health (Bae et al., 2017). One can expect marketing intensity to exhibit a non-linear relationship with profitability (Chen & Hsu, 2010). At lower levels of marketing intensity, the firms may not be able to overcome the competitive rivalry arising from counterproductive reactions of the players in the market (King & Slotegraaf, 2011). As a result, it can be argued that a minimum level of investment in marketing-related activities is required to derive profitability from the marketing intensity (Chiao et al., 2006). Investments greater than the threshold value lead to higher profitability.

Cost-efficiency-enabling resources refer to the ones that help the owner firm attain cost-minimization with economies of scale and value chain optimization (Pattnaik & Elango, 2009). Operational efficiency, calculated as the total sales per unit cost of sales, can be used as a proxy for measuring the cost-efficiency-enabling resources of the firm (Elango & Pattnaik, 2007). Cost efficiency, considered a significant driver of profitability by the existing literature, helps minimize the wastage of resources and enhance earnings and cash flows (Greene & Segal, 2004; Tan & Floros, 2012). These resources, therefore, can be expected to have a linear effect on profitability (Baik et al., 2013).

As the individual impacts of the three intangible resources (R&D intensity, marketing intensity, and cost-efficiency-enabling resources) on the firm profitability tend to be different from one another, it becomes imperative to assess how these resources interact and impact the profitability of any firm. With an intention to discover the optimum level of investments in each of these resources for attaining the desired firm profitability, this study addresses three important research questions: (i) What levels of these resources can maximize the firms' profitability? (ii) What levels of these resources lead to low profitability levels? (ii) What works best for profitability: degree of agreement or variance in the levels of the different resources?

3. Research Methodology

3.1. Sampling and Data Collection

According to NASSCOM, the top 11 firms in the Indian IT industry account for nearly 40% of the industry's market share (Analysis of the IT-BPM Industry, n.d.). The top 20 firms claim 60% of the market share (Bhattacharjee & Chakrabarti, 2015). The top 20 firms, therefore, were initially targeted for the study to account for a sizeable market share in the sample. These firms are selected based on their market capitalization, and their data is collected for a period of five years (FY 2016 - FY 2020) to overcome seasonal variations, if any. Out of these 20, two firms could not be considered for the analysis, with one merging with another during FY 2016 till FY 2020 and another incorporating in FY 2017, resulting in data not being available for the entire five-year period (FY 2016 - FY 2020). The analysis, therefore, is conducted utilizing the data of the remaining 18 firms. The required data is collected from the annual reports of these firms.

3.2. Data Pre-processing

As the first step of data pre-processing, the data of the firm resources (R&D intensity, marketing intensity, and cost-efficiency-enabling resources) and profitability (profit margin and ROS) are standardized with the help of a two-step transformation (Templeton, 2011). The values of these standardized variables range between -3 and +3. The second and third steps in the data pre-processing pertain to the predictor variables of the polynomial regression analysis for capturing the non-linear and interaction effects. The second step is calculating the squared values of the transformed variables for the three resources for capturing the non-linearity. The third step is the creation of new variables to capture the interaction among these resources. The interaction variables are calculated by multiplying the transformed values of the resources. For example, the interaction between R&D intensity and marketing intensity is calculated as R&D Intensity*Marketing Intensity. With these, the independent variables in the polynomial regression analysis include the following: (1) R&D Intensity, (2) Marketing Intensity, (3) Cost-efficiency-enabling resources, (4) R&D Intensity (squared), (5) Marketing Intensity (squared), (6) Cost-efficiency-enabling resources (squared), (7) Interaction of R&D Intensity with Marketing Intensity, (8) Interaction of R&D Intensity with Cost-efficiency-enabling resources and (9) Interaction of Marketing Intensity with Cost-efficiency-enabling resources.

3.3. Visualization for the Individual Effects

Prior to the polynomial regression analysis, scatterplots of the two-step standardized measures of resources against the similarly transformed profitability measures are created to assess the impact of individual resources on firm profitability. Such plots aid the interpretation of the individual relationships of resources with profitability. Alongside the scatterplots, the lines/curves of fit (linear or non-linear, as applicable) are also included for aided interpretation.

3.4. Polynomial Regression Analysis

Polynomial regression helps capture the non-linear effect and analyze the impact of nuanced interaction among the three resources, namely, R&D Intensity, Marketing Intensity, and Cost-Efficiency-enabling resources, on the firm profitability. Two polynomial regression analyses are performed, one for each of the profitability measures as dependent variables (or outcome variables), i.e., Profit Margin and ROS. The SPSS (v21) is the software used for polynomial regression analyses, and two regression equations, thereby, are generated.

3.5. Visualization for the Interaction Effects

Polynomial regression equations with three predictor variables (X, Y, and Z) and an outcome variable (P) take the following form (see (1)) (Shanock et al., 2010):

$$P = b_o + b_1X + b_2Y + b_3Z + b_4X^2 + b_5Y^2 + b_6Z^2 + b_7XY + b_8XZ + b_9YZ + e \quad (1)$$

Relying solely on the polynomial regression equation to provide a holistic picture of the nuanced interactions among the predictor variables is challenging (Qiu et al., 2020). Visualizations like response surface analysis, thus, bring perspective to the comprehensive view of the relationships under study (Qiu et al., 2020). The coefficients of the two regression equations are used to calculate the predicted values of the profitability (profit margin and ROS) by varying the combination of the resources' values to range between -3 and +3 (values of the two-step standardized variables vary between -3 and +3). When the polynomial regression analysis involves one outcome variable with two predictor variables, a three-dimensional (3D) plot of the results from the regression equation helps visualize the outcomes (Shanock et al., 2010). In such a case, the X-axis and Y-axis represent the two predictor variables, and the Z-axis represents the outcome variable. This study involves an outcome variable along with three predictor variables. Consequently, the regression results are plotted in a 4D view. This 4D view is an extension of the 3D plot with color as the fourth dimension, for example, in Bovolo & Bruzzone (2013). The predicted values of profitability are plotted against those of the three resources in the 4D view. The three resources (values: -3 to +3) represent the three axes (X, Y, and Z), while the predicted values of profitability are depicted with colors. The Python codes for preparing these visualizations are provided in the Appendix.

4. Results and Discussion

The following sections provide details about the individual effects of the resources on firm profitability, followed by the effect of their interactions on profitability. And finally, the implications of this study are discussed.

4.1. Individual Effects

The (individual) effects of the resources on firm profitability are assessed with the help of scatterplots presented in figures 1-6. The horizontal axis represents the resources (standardized), and the vertical axis represents profitability (standardized). The dotted curves in scatterplots from Fig. 1-6 represent the best fit curves. For R&D and marketing intensities, these are quadratic curves showcasing non-linear relationships. And, for cost-efficiency-enabling resources, the curves are actually the best fit lines showcasing linear relationships.

Fig. 1 and 2 are the scatterplots illustrating the relationship between R&D intensity and profitability (Profit Margin and ROS, respectively). These figures demonstrate that R&D intensity's impact on profitability measures (Profit Margin and ROS) is curvilinear or U-shaped, and such an effect can also be termed the quadratic effect. The minima of the curve of fitted values, represented as dotted lines, indicate the presence of threshold values beyond which R&D intensity leads to higher profitability. Until the investments in R&D intensity meets the threshold level, increasing investments in R&D intensity results in negative returns. In other words, when the value of R&D intensity is lower than this threshold, the profitability benefits accrued from the R&D intensity are lesser than the costs of investment in the R&D.

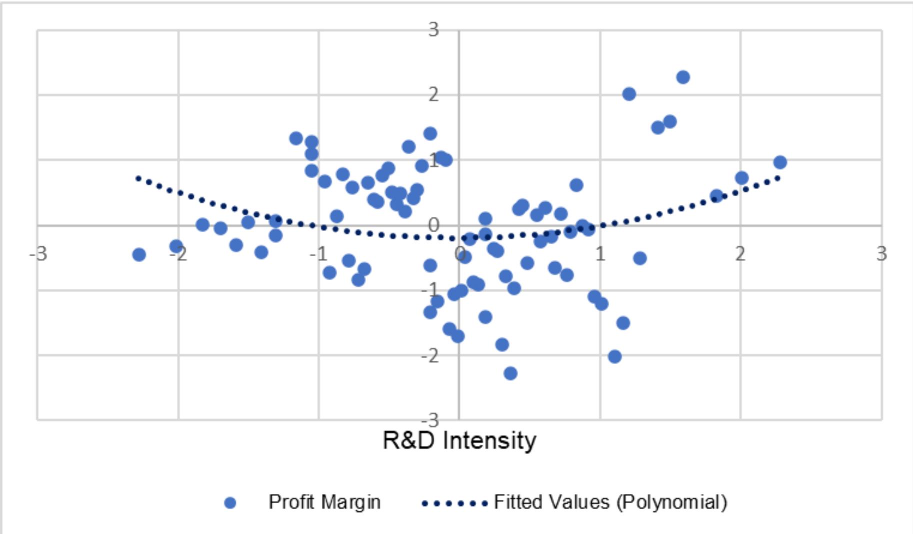


Fig. 1: The individual effect of R&D intensity on profit margin

Beyond the threshold level, the higher the investment in the R&D intensity, the better the profitability. Therefore, the optimum levels of investment in the R&D intensity are the ones that lean towards the higher end in the industry-wide investment spectrum and exceed the threshold.

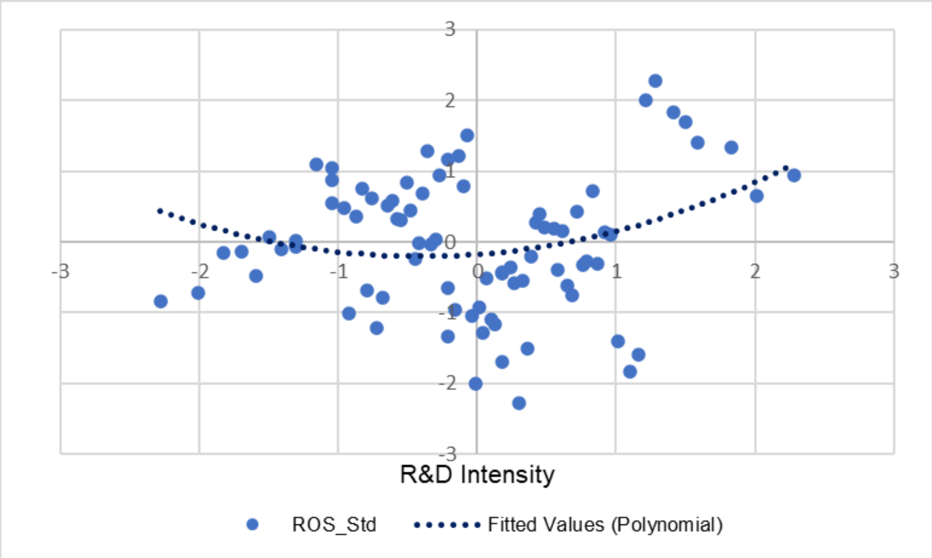


Fig. 2: The individual effect of R&D Intensity on ROS

The scatterplots in Fig. 3 and 4 demonstrate the relationship between marketing intensity and firm profitability (Profit Margin and ROS, respectively). These figures highlight that the individual effect of marketing intensity on Profit Margin and ROS is similar to their relationship with R&D intensity.

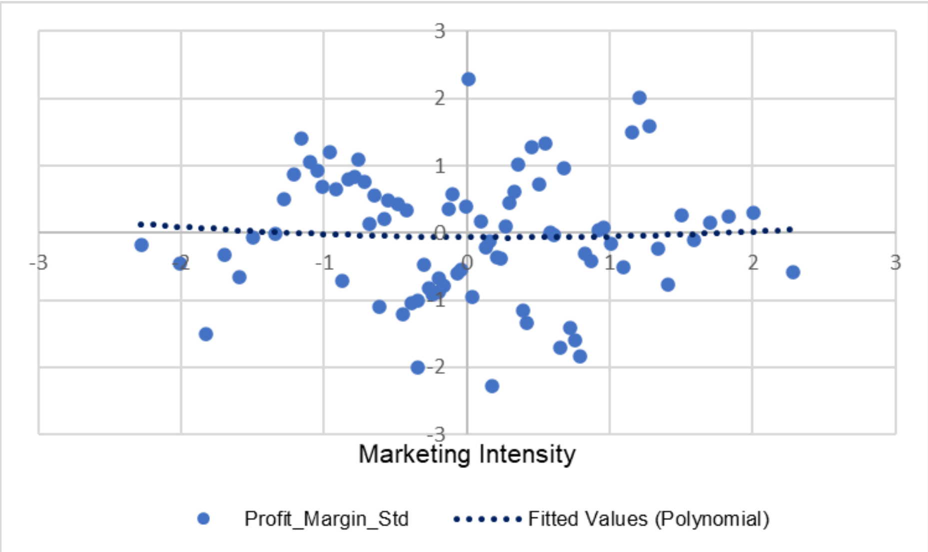


Fig. 3: The individual effect of marketing intensity on profit margin

The U-shaped or curvilinear shape of fitted values highlights the existence of the point of minima, which can also be called the threshold value. While investments in marketing intensity beyond this threshold reap superior benefits, investments below the threshold value lead to a decline in profitability. The range of optimum investment in the marketing intensity, thus, lies beyond the threshold value, where an increase in marketing intensity results in a steady rise in profitability.

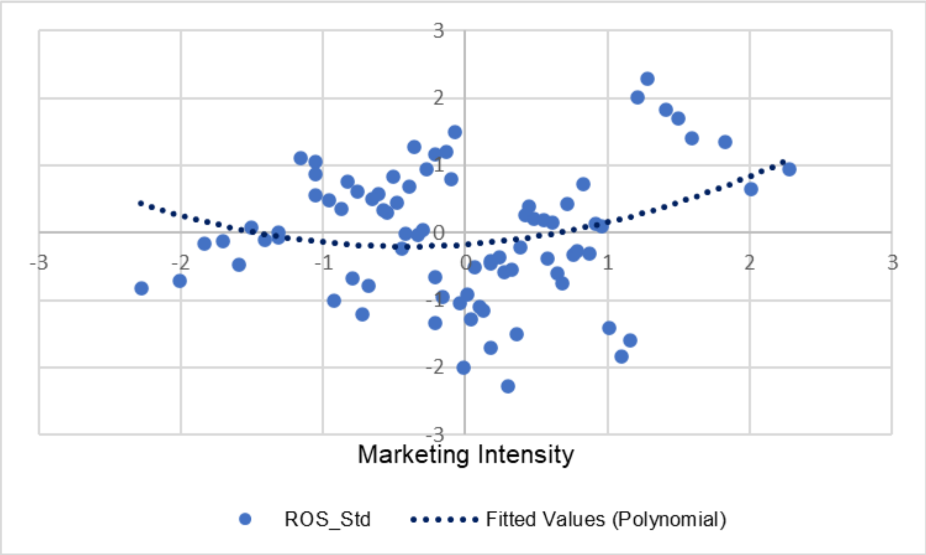


Fig. 4: The individual effect of marketing intensity on ROS

The scatterplots of firm profitability against the cost-efficiency-enabling resources, Fig. 5 and 6, underline the linear (individual) impact of the cost-efficiency-enabling resources on both Profit Margin and ROS. Therefore, higher investments in cost-efficiency-enabling resources result in better profitability. Optimum levels of cost-efficiency-enabling resources, thus, sway towards the higher end of the industry spectrum.

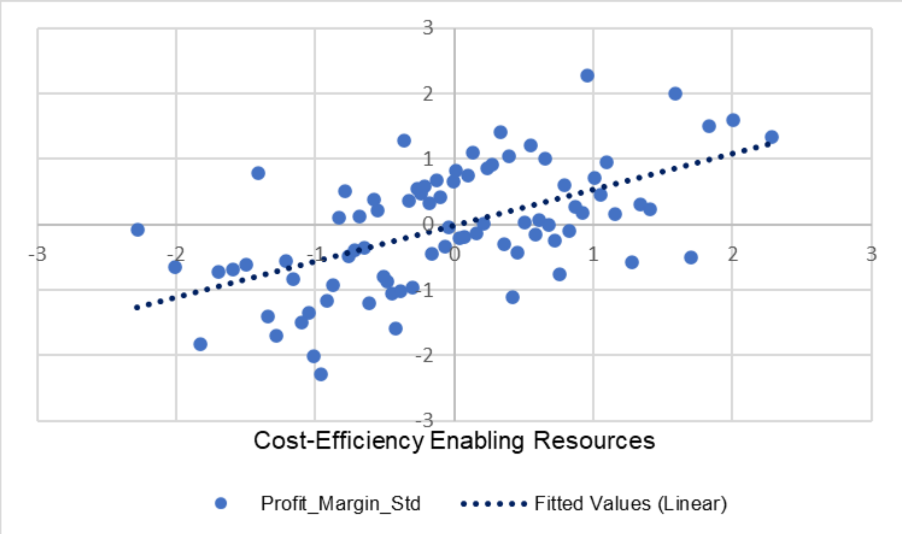


Fig. 5: The individual effect of cost-efficiency-enabling resources on profit margin

These plots confirm that not all resources linearly impact profitability. While the relationship of firm profitability with R&D and marketing intensities is non-linear and quadratic, cost-efficiency-enabling resources' impact on profitability is linear. The question that arises here is: What is the combined effect of these resources on firm profitability? Analyzing how these resources interact with each other and impact profitability becomes the indispensable next step. The following subsection discusses the application of the Polynomial regression analysis and 4D visualizations in delineating the complex interaction of the resources and its impact on profitability.

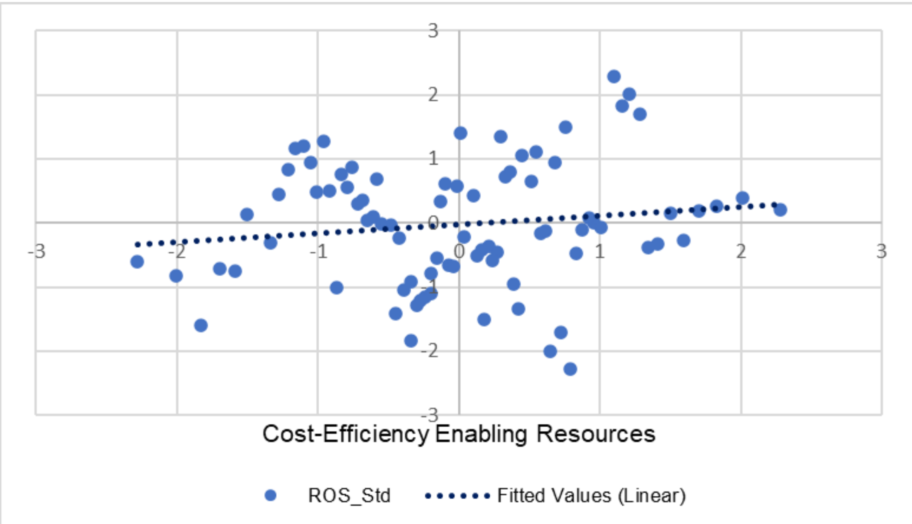


Fig. 6: The individual effect of cost-efficiency-enabling resources on ROS

4.2. Interaction Effects

The first step in gauging the influence of the interaction of resources on firm profitability is conducting the Polynomial regression analysis, followed by the 4D visualizations. The outcome variables in the polynomial regression analyses are the two measures of profitability. To assess the linear (X, Y, Z), non-linear (X^2, Y^2, Z^2), and interaction effects (XY, XZ, YZ) of the resources, the predictor variables included in the polynomial regression analysis are the linear terms, the squared terms, and the interaction variables of the resources, as also discussed in section 3.2.

Table 1 enlists the results of the polynomial regression analyses. The values of Beta are the standardized regression coefficients representing the strength of the relationship between the predictor and outcome variables. The statistically significant predictor variables with p-values less than 0.05 have been highlighted with **. As observed from the highlighted values of Beta in Table 1, both linear and squared terms of R&D and marketing intensities significantly impact Profit Margin and ROS. It implies that both R&D and marketing intensities have a non-linear (quadratic) effect on profitability. While the cost-efficiency-enabling resources exhibit a significant and positive relationship with Profit Margin and ROS, their squared values do not have any statistically significant relationship with any of these measures of profitability. This observation establishes that the relationship between cost-efficiency-enabling resources and profitability is linear. Furthermore, the impact of the interaction of R&D and marketing intensities on firm profitability is not statistically significant. However, the interactions of cost-efficiency-enabling resources with both R&D and marketing intensities have a statistically significant effect on profitability.

Table 1: Results of the polynomial regression analysis

Predictor Variables	Outcome Variable: Profit Margin			Outcome Variable: ROS		
	Beta	t	S.E.	Beta	t	S.E.
R&D Intensity (X)	-.31**	-3.25	-.30	-.22**	-2.49	.03
Marketing Intensity (Y)	-.53**	-5.65	-.51	-.42**	-4.77	.00
Cost-efficiency-enabling resources (Z)	.86**	8.31	.83	.86**	8.97	.00
R&D Intensity (squared)	-.14**	-1.65	-.11	-.16**	-2.02	.05
Marketing Intensity (squared)	-.29**	-2.83	-.23	-.31**	-3.23	.00
Cost-efficiency-enabling resources (squared)	.12	1.11	.09	.09	.92	.36
R&D Intensity * Marketing Intensity	-.05	-.54	-.05	-.07	-.74	.46

Predictor Variables	Outcome Variable: Profit Margin			Outcome Variable: ROS		
	Beta	t	S.E.	Beta	t	S.E.
R&D Intensity * Cost-efficiency-enabling resources	.31**	2.75	.33	.34**	3.27	.00
Marketing Intensity * Cost-efficiency-enabling resources	.24**	1.98	.24	.30**	2.66	.01

*** p<0.05; Beta: Standardized Regression Coefficients; S.E.: Standard Error; t: t-statistic.*

The two polynomial regression analyses equations, as obtained from the unstandardized regression coefficients, are (see (2) and (3)):

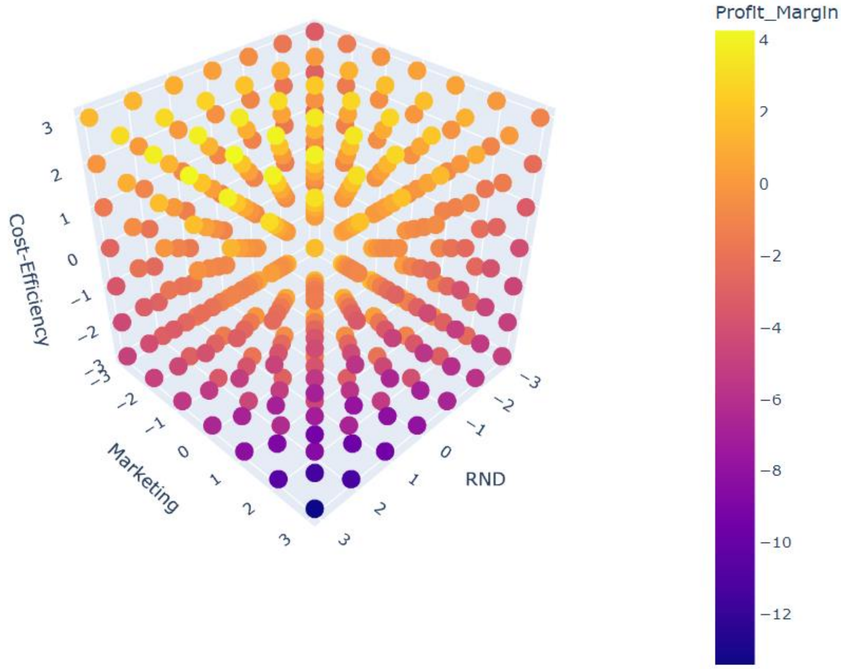
$$Profit\ Margin = .047 - .303X - .513Y + .830Z - .113X^2 - .226Y^2 + .091Z^2 - .051XY + .318XZ + .238YZ \quad (2)$$

$$ROS = .085 - .224X - .415Y + .860Z - .133X^2 - .248Y^2 + .073Z^2 - .068XY + .363XZ + .306YZ \quad (3)$$

where, X=R&D Intensity, Y=Marketing Intensity, and Z=Cost-efficiency-enabling resources.

These regression equations provide a mathematical view of the relationship between the resources, their interactions, and firm profitability. However, these do not give a clear picture of the combination of various levels of resources for attaining maximum or minimum profitability. It also does not provide a clear picture of whether different combinations of resources can lead to the same level of profitability. The next step, therefore, is the creation of 4D visualizations using the polynomial regression equations to aid the interpretation. Based on the two regression equations (see (2) and (3)), different predicted values of profitability (Profit Margin and ROS) are calculated by varying each predictor variable to bear the values ranging between -3 and +3. The value of -3 for R&D intensity, for example, represents the lowest R&D intensity (standardized) among the top 18 firms during FY 2018 - FY 2020, while +3 represents the highest. A value of 0 indicates the industry average. These values are then plotted in a four-dimensional form, as shown in Fig. 7-10. In these figures, the X-axis represents the R&D intensity, Y-axis the marketing intensity, and the Z-axis represents the level of cost-efficiency-enabling resources. Colour is added as the fourth dimension in these visualizations representing the different values of profitability obtained by varying the values of resources.

Figures 7 and 8 demonstrate the interaction of resources to impact Profit Margin. These figures provide visual insights on the Profit Margin extrema suggesting the presence of a range of the extrema instead of a single point of maximum or minimum. As observed from Fig. 7., the minima for Profit Margin lie near the bottom-most corner of the frontal end of the cube, where the R&D and marketing intensities have the highest values (+3), and the cost-efficiency-enabling resources have the lowest value (-3). The Profit Margin maxima exist near the cube's ceiling in Fig. 7, where both R&D and marketing intensities range between medium to high, and the cost-efficiency-enabling resources reach their highest. Fig. 8 indicates the top view of the visualization of the resources' interactions and their impact on the firm profitability shown in Fig. 7. Fig. 8 highlights that if the values of the cost-efficiency-enabling resources increase at nearly all combinations of R&D and marketing intensities, the Profit Margin increases. The only exception is the point where R&D and marketing intensities are very low (below the threshold values). At this point, an increase in cost-efficiency-enabling resources observes a declining Profit Margin. Similar are the results for ROS (see Fig. 9 and 10).



Fog. 7: Front View of the resources’ interaction effect on profit margin

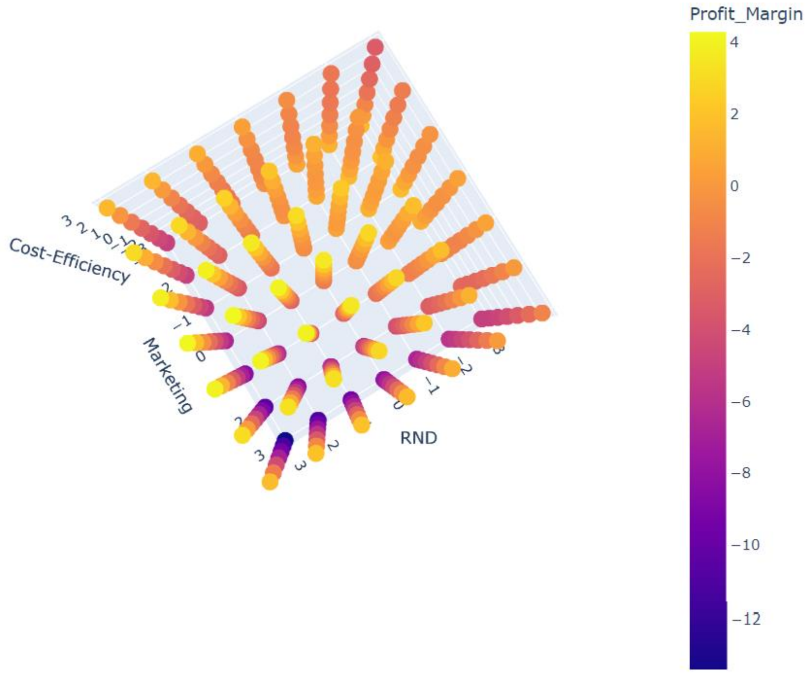


Figure 8: Top view of the resources' interaction effect on profit margin

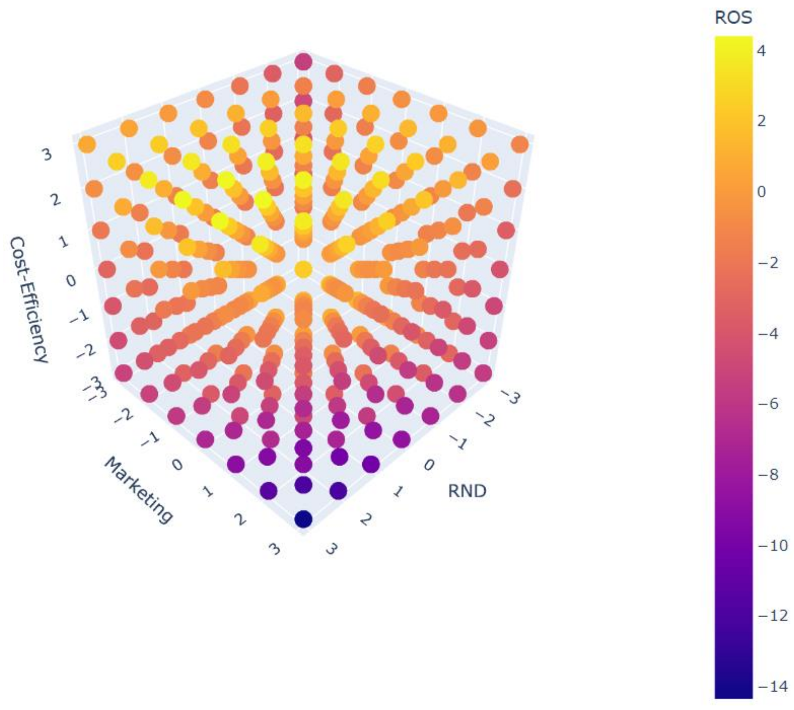


Fig. 9: Front view of the resources' interaction effect on ROS

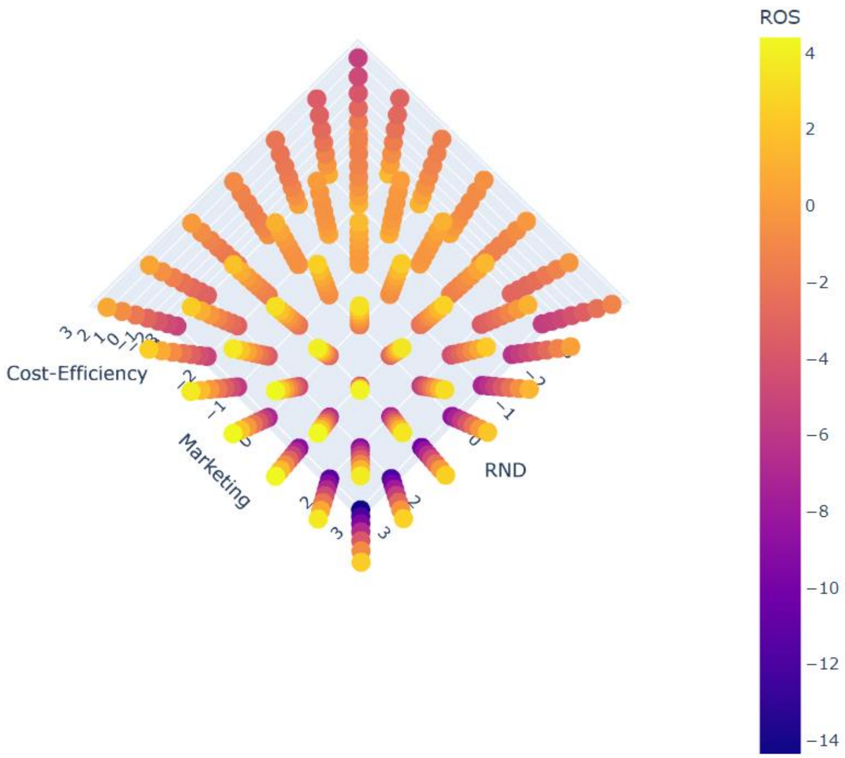


Fig. 10: Top view of the resources' interaction effect on ROS

These findings assert that increasing cost-efficiency-enabling resources will increase profitability only when the R&D and marketing intensities exceed their minimum threshold/benchmark values. In other words, it is critical for the R&D and marketing intensities to exceed their minimum threshold values for cost-efficiency-enabling resources to reap the desired benefits. If the R&D and marketing intensities are lower than their thresholds, increasing cost-efficiency-enabling resources will only prove detrimental to the firm profitability. Therefore, the optimal combination of these resources for maximum profitability is R&D intensity between 1 and 3 (medium to high-end of industry spectrum), marketing intensity between -1 and 1 (industry average), and cost-efficiency-enabling resources = 3 (high-end of industry spectrum).

By supporting calculative investments in intangible organizational resources (R&D intensity, marketing intensity, and cost-efficiency-enabling resources) for the desired profitability, this research has important implications for both the researchers and managers/decision-makers of the Indian IT industry. Firstly, this research provides a mechanism for managers in the Indian IT industry in informed decision-making and optimal utilization of resources to maximize the firm's profitability. Secondly, extending the response surface analysis and including the three predictor variables under the same view, this study demonstrates the utilization of 4D visualizations for enhanced interpretation of the polynomial regression analysis by researchers. Thirdly, although IT is a high-tech industry, this research highlights the significance of investments in other intangible resources like marketing and operational efficiency and not only limiting the investments to R&D and innovation. Fourthly, the study also extends its support to marketers and researchers in addressing the criticisms that discredit the role of marketing-related activities in high-tech industries. Finally, this research emphasizes that there is no single formula for high firm profitability. Acknowledging the minimum threshold levels, increasing investments in cost-efficiency helps improve profitability at all combinations of R&D and marketing intensities.

5. Conclusion

By providing empirical evidence of the individual and interaction effects of the resources on firm profitability, this study stresses the importance of investing in intangible organizational resources in the Indian IT industry. The findings of this research substantiate that the resources: R&D intensity, Marketing intensity, and Cost-efficiency-enabling resources do interact with each other to influence the firm profitability. Although the individual effects of R&D and marketing intensities on profitability are non-linear, the impact of cost-efficiency-enabling resources is linear. When both the R&D and marketing intensities are in agreement, i.e., they exceed their minimum threshold levels, increasing cost-efficiency results in increased profitability for any firm. Very high levels of profitability prevail where all the resources are at elevated levels, with a remarkably high level of cost-efficiency-enabling resources. The region of lowest profitability is characterized by high R&D and marketing intensities, followed by a low value of the cost-efficiency-enabling resources.

This research, like any other study, also has its limitations. These limitations also pave the way for future research in the respective areas. Firstly, this research bases its investigation on the purview of the Indian IT industry. Including other high-tech industries in the sample in future research can help generalize the findings of this study. Furthermore, the analysis encompasses only the measures of profitability not impacted by the financial leverage employed by the firms. Including other profitability measures (for example, ROE, ROA, and ROI) in future studies will be beneficial in substantiating this research. Thirdly, this research focuses on a five-year duration (FY 2016 to FY 2020). Future works in the area can include ten years or more to compare the relationship of the resources with profitability in the short-term versus long-term. Last yet not least, the duration of the data collected spans the pre-Covid-19 era. It will be interesting to study the consequences of Covid-19 on the resources and their interaction and impact on the firm profitability.

Appendix

The code and the input CSV (Comma-Separated Values) file are hosted on the GitHub server and can be accessed with the below URL.

URL: https://github.com/snehasinghkalra/4D_Plot.git

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