Title: A Critical Review of " The R&D Cycle: The influence of product and process R&D on Short-Term ROI"-2

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Abstract: A paper titled "The R&D Cycle: The influence of product and process R&D on Short-Term ROI" is critically reviewed in this individual report.

A Critical Review of " the R&D Cycle: The Influence of Product and Process R&D on Short-Term ROI"-2

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Research Paper Evaluation
of
The R&D Cycle: The Influence of Product and Process R&D on Short -Term ROI

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By
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Table of Contents

Research Paper on Prof. Jehiel Zif and Daniel J. McCarthy " The R&D Cycle: The Influence of Product and Process R&D on Short -Term ROI"

Introduction

The decision to invest in R&D is one of the most complicated issue in order to produce high profitability. Prof. J. Zif and D. J. McCarthy explored the relationship between the total R&D budget and two major components, product and process R&D, and examined the relationship between these two types of R&D and the return on investment (ROI) of the business by applying the cyclical pattern. Abernathy [1] insisted that the different conditions are required for product and process innovation and there is a real danger that if both types of innovative capability are sought in one productive unit, effectiveness will not be realized. Also, from the study of Abernathy and Utterback [1] together, they found that in the mass production stage, the total R&D funding should be reduced to decrease uncertainties and more of that amount should go to process R&D. Moreover, they also found that the effect of process innovation on market performance depends upon the level of product innovation. (the contribution model of R&D to ROI is shown in exhibit A)

Concepts

Prof. J. Zif and D. J. McCarthy observed the proportion of product and process R&D on the total R&D budget in each stage of R&D intensity, categorized into three stages, Efficiency Focus, Innovation Focus, and Extensive R&D and their contribution on

the short-term ROI.

Prof. J. Zif and D. J. McCarthy applied two inferences, S-curve response function and the limited compatibility of product and process R&D, to help in building a model of the profit implications of R&D intensity. The first inference indicates that the relationship between input and output of R&D follows an S-curve. They also implicitly assumed that there are two years lag between the R&D input and output. The second inference is the notion that process R&D is mostly incompatible with product R&D.

Finally, Prof. J. Zif and D. J. McCarthy demonstrated a clear relationship between product and process R&D and short-term ROI (with a two-years lag), even though this relationship is not very strong. They found that process R&D is most valuable at low levels and at high levels of R&D, where product R&D is less effective.

Methodology

Prof. J. Zif and D. J. McCarthy used reliable data to make assumptions. Two hypotheses were set up. The first was that "the total R&D investment increases, the proportion of process R&D out of the total R&D is declining and the proportion of product R&D is increasing." The second was that "the impact of lagged product and process R&D on the short-term ROI of a firm varies with the total level of R&D spending." Two forms of analysis, a correlation analysis of the hypothesized relationship and the nonparametric tests (chi-square) in order to test the stability of the finding, were applied.

Prof. J. Zif and D. J. McCarthy collected data from the 1989 PIMS database of the

Strategic Planning Institute, the largest on-going study of individual business units. The data were selected from 2018 industrial business units that spent money on R&D during 1971 to 1988, and the majority of data is from the 1980's. All selected industrial businesses included firms that produce capital goods, raw materials, components, supplies, and semifinished assemblies.

Prof. J. Zif and D. J. McCarthy analyzed the level of R&D intensity of selected business units by dividing them into ten groups of approximately equal size with increasing levels of total R&D/Rev.

Contributions to Research Literature

Prof. J. Zif and D. J. McCarthy came up with two results. The first demonstrated that the increase in the total R&D/Rev, product R&D/Rev is increasing faster than process R&D/Rev (see Fig.1 in exhibit B). The second presented the pattern of correlations for two years lagged product and process R&D with ROI for all industrial businesses, by the level of total R&D/Rev (see Fig.2 in exhibit B). At early stage of total R&D/Rev (up to about 1%) the correlation of product R&D/Rev with ROI is negative, while the correlation of process R&D/Rev is positive. This situation is gradually reversed as total R&D/Rev increases beyond 1%. However, with the further increase in total R&D/Rev beyond 3%, another gradually turns around in the correlations. At high levels of total R&D/Rev, product R&D/Rev is negatively correlated with ROI while process R&D/Rev is positively correlated. For both types, there are diminishing returns in short-term ROI with the increase in the level of total R&D/Rev.

Prof. J. Zif and D. J. McCarthy's outcome can help all top-level managers to illustrate a clear overview of the influence of R&D and resource allocation between product and process R&D on the corporate profitability.

Moreover, the level of R&D spending can apply to the corporate strategy. At the low level of R&D spending, called Efficiency Focus Stage, it incorporates with the *imitation strategy.* At the medium level of R&D spending, called Innovation Focus Stage, it incorporates with the *innovation strategy.* At the high level of R&D spending, called Extensive R&D Stage, it incorporates with the *technology leadership or differentiation strategy.* In top-down planning process, the company will set their corporate strategy at the top management level before operation strategy for each department. Therefore, The clear illustration of the relationship between corporate strategy and R&D spending is very useful. After top managers know what their corporate strategy is, they can determine how much they have to put in R&D expenditure. Furthermore, they can suitably allocate their R&D resources between product and process R&D.

Strengths

Prof. J. Zif and D. J. McCarthy used a reliable database, PIMS (see detail in exhibit C), and more than 2,000 business units from almost all industrial businesses as sample group. Prof. J. Zif and D. J. McCarthy explicitly defined all operational variables –product R&D, process R&D, total R&D, lagged R&D, and ROI– because some variables, especially ROI, can be defined in many different ways [3] (see detail in exhibit D).

Prof. J. Zif and D. J. McCarthy 's statistical methodology was quite simple. They used the correlation and chi-square analysis, so as not to complicate for any interested people who do not have deep background knowledge in statistic to understand. Moreover, Prof. J. Zif and D. J. McCarthy used two well known inferences, the S-curve respond function and the limited compatibility of process and product R&D, to explain the cyclical implications of R&D intensity. Finally, Prof. J. Zif and D. J. McCarthy clearly demonstrated their outcome by using visual illustrations, graphs.

Weaknesses

Prof. J. Zif and D. J. McCarthy did not clarify and support their assumption of a two-years lag between the R&D investment and the expected ROI. In my opinion, the length of time lag could vary according to type of industrial business, variety of corporate strategy, and the duration of product life cycle that Assistant Prof. Abbie Griffin mentioned in his research. [4]

As Prof. J. Zif and D. J. McCarthy mentioned that there were no statistical data that can directly show the relationship between R&D expenditure and the firm's ROI.

A limitation I see in their methodology is the division of the 2018 industrial SBUs into ten groups of approximately equal size with increasing levels of R&D/Rev. This method caused their outcome so general that it could not directly apply to any specific business area or size of firms. From the research of Wesley M. Cohen and Steven Klepper [5], they concluded that in the larger firms, the return on R&D investment tends to be higher than smaller firms due to the greater production. Thus, I would like to see that in

future research all data will be divided by the size of firms and the types of business area as well, because I expect its outcome should to be more specific.

As Prof. J. Zif and D. J. McCarthy investigated that the relationship between R&D spending and ROI is not very strong. Therefore, they should compare the degree of this relation with the relation from other factors that also affect the corporate ROI.

Conclusions

Prof. J. Zif and D. J. McCarthy's research paper was well-stated and explicitly approached. Prof. J. Zif and D. J. McCarthy referred to many research papers to make their paper stronger. Their outcomes were very useful for everyone who works or is interested in R&D budget management to realize and illustrate the significance of R&D to their corporate profitability. Prof. J. Zif and D. J. McCarthy clearly gave an overview of the relationship between product and process R&D and short-term ROI within two-years lag, even though it is not too strong.

Future Work

In my opinion, there are four future works that should be prospected. The first should be done by applying to the same concept and methodology, but the different data analysis to identify the relationship between R&D spending and corporate profitability, besides dividing data into ten groups of equal size. The four new data analysis will be applied according to four different criteria –size of firms, type of business area, variety of corporate strategy, and duration of product life cycle. Another new data analysis will be

done by arranging data according to chronological order and then deeply focus during the year 1980 to 1985, the period of economic recession. [6] (see details in exhibit E) Thus, we will see how much of the R&D budget should be spent to effectively shield a company from economic crisis and whether product or process R&D was more influent.

The second should be focused on the influence of product and process R&D spending on the other variables besides ROI, especially on the unmeasurable variables such as customer's satisfaction. As Paul A. Schumann Jr., Derek L. Ransley and Donna C.L. Prestwood [7] mentioned "R&D is too complex a subject for a few measurements to determine its performance."

The third study should change the criteria from R&D spending to the R&D project life cycle and then investigate its effect on ROI. According to Robert E. Burkart [8] mentioned that "the uncertainty of R&D can be reduced by producing the short R&D project cycle times."

The last research I propose should compare the degree of the relationship between R&D spending and ROI with that of the relationship between other factors that affect ROI.

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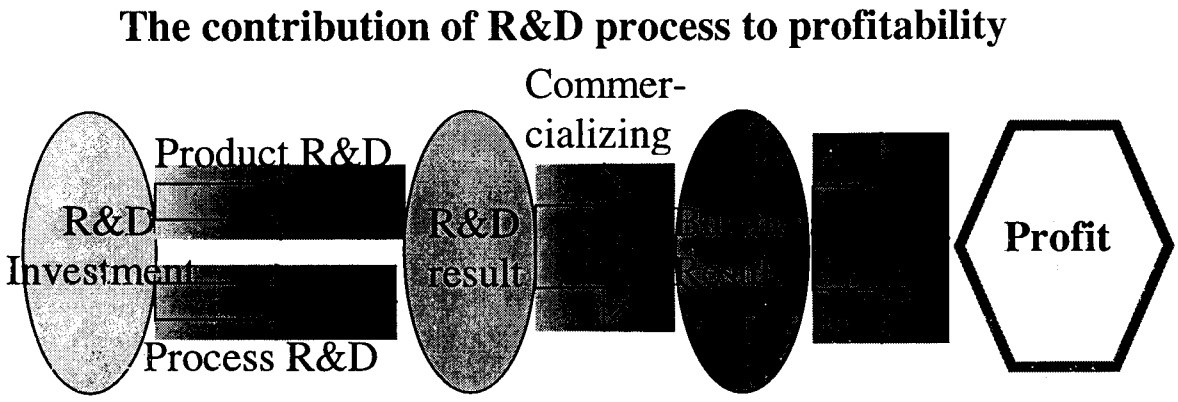
Exhibit A: The contribution model of R&D and ROI



Source: Adapted from Takuro Munezawa, R&d Management Methodology for better performance, Innovation in Technology Management: The key to Global Leadership, PICMET'97, July 27-31, p. 515-519

Exhibit B: Result of Prof. J. Zif and D. J. McCarthy's reseach

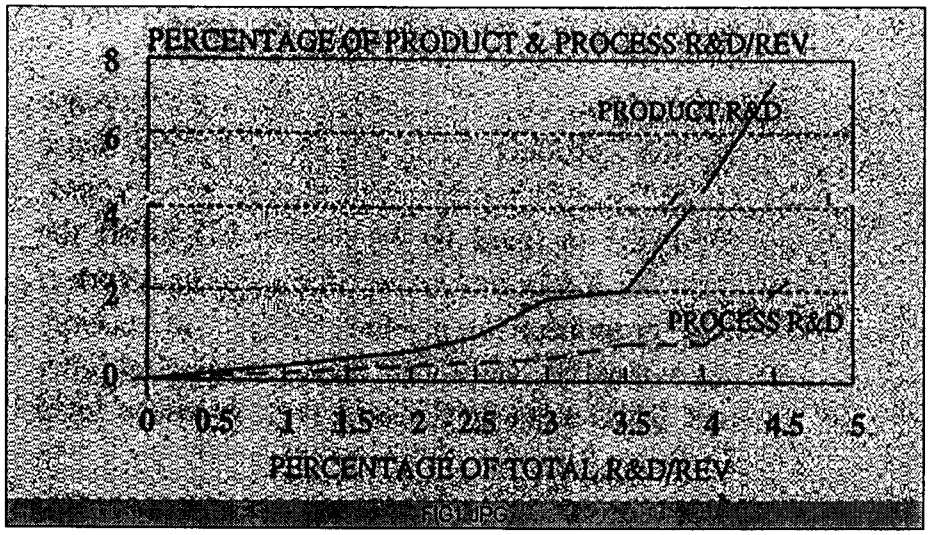


Fig.1. Process and Product R&D/Rev as afunction of total R&D/Rev.

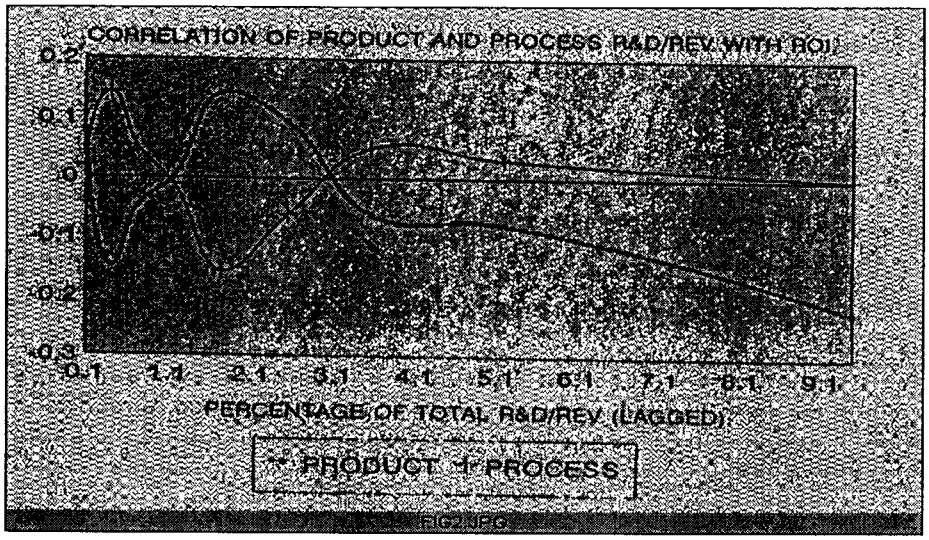


Fig. 2. Correlation of Product and Process R&D/Rev with ROI

Exhibit C: The PIMS Program

The PIMS Program[3]

In the early 1960s, General Electric embarked on an internal project to attempt to explain the differences in profitability among its various SBUs. This project was later expanded through a nonprofit research group to include SBUs from many diverse companies. The PIMS database now contains data from over 3000 SBUs representing more than 450 firms. Some of these SBUs have been in the database since 1970. Each SBU supplies to the PIMS database detailed information such as:

- ROI (return on investment)
- Market share
- Investment intensity—the ratio of investment to sales
- R&D expenditures
- Marketing expenditures
- Perceived product quality—the percent of offerings that were superior to those of competitors, and the percent perceived by the SBU managers as inferior

Analysis of these data has revealed that highly capital-intensive businesses tend not to have high ROI because of the high investment and because capital-intensive industries tend to be characterized by vigorous price competition. Another finding, discussed in Chapter 10, is that high-quality products can be more profitable than low-quality products, regardless of whether or not a low or high price is charged.

In addition to general findings and observations, the PIMS project provides member firms with reports that indicate what ROI an average SBU "should" be expected to make, given its characteristics in terms of the PIMS variables. These reports can be used to evaluate SBU performance.

Also available is a PIMS-based prediction of how the SBU's ROI would change if a policy change were made, such as increasing expenditures on R&D. Although such predictions are suggestive and provide an inexpensive way to explore policy changes, taking them too seriously is foolish. They are based largely on relationships between SBUs. The problem is that firms that spend more on R&D are different in many ways from firms that spend little on R&D—in particular, each has an R&D organization and a philosophy that is unique. It is unrealistic to think that if a firm increases its R&D expenditures, it will suddenly be similar to the firm with the large R&D expenditures and actually perform as well.

The PIMS data and analysis are not without problems. The key market-share variable is sensitive to the product-market definition used by the SBU manager. Other variables such as perceived product quality depend on subjective judgments. In cross-section analysis, differences in ROI that appear to be caused by market share or other variables could actually be caused by differences among industries or among strategic groupings of firms. Also, the sample of firms in the PIMS database is likely to be biased toward larger firms that are industry leaders.

Source: David A. Aaker, Strategic Market Management, Wiley, 1995, p.160

Exhibit D: Variety of ROI definitions and applications

1. Average annual profit ÷ average value of assets employed.
2. Average annual cash flow ÷ average value of assets employed.
3. Current-year profit ÷ gross assets.
4. Current-year profit ÷ net assets.
5. Current-year cash flow ÷ gross assets.
6. Current-year cash flow ÷ net assets.
7. Same as 3-6 above but exclude the effect of inter on long-term debt (method of financing)
8. Same as 3-6 above but substract current liabilities from assets.

Exhibit E: How recessions happened during the two periods of early 1980.

Jan. 1980-July 1980: Turmoil in Iran causes oil prices to soar again, sending the inflation rate into double digits. Carter imposes credit controls, which cause consumer spending to contract.

July 1981-Nov. 1982: As in the early 1980 recession, the Fed's Paul Volker is determined to strangle inflation, which has hit stunning levels, by tightening up on the money supply. He keeps money tight well into the downturn, which is long and severe.