Impact of Investments in R&D in Business results: A laboratory study with Business Games

Track: Management Education and Teaching Cases

Abstract

We evaluated the impact of investments in R&D in business results in a competitive Business Game. The research, set in a competitive oligopolistic industry, backed up on a Literature Review of: Innovation, R&D, and Corporate Performance. Correlations were calculated between the Company Investments in relation to the industry average for: investments in R&D, potential market, sales volume, gross revenue, net income, market share and internal rate of return (IRR). The results have not indicated any correlation and corroborate the studied literature content. The Business Game revealed extreme versatility for driving this nature of research.

Keywords: R&D investments; Business results; Business Games.

1. Introduction

Stiff competition among organizations is demanding more and more investments in Innovation and Technology in order to generate competitive advantage. This phenomenon affects businesses in general, considering the broad nature of transformations and a need for rapid spread of innovation.

In developed countries, the investment in Business Innovation Policies is in evidence for many years, while in developing countries, an example of Brazil, such dynamics is still incipient. Knowledge Management and Research & Development are themes still ignored by some companies and practiced with restrictions by many others. Jensen et al (2004:664) confirm that "there are many papers who studied the spending on research and development (R&D) in developed countries, but despite the issue being extremely important, there is little replication to Brazil". In addition, most Research & Development activities are concentrated in the Academic environment or Government Institutions (CRUZ, 2004:198).

R&D activities should align the organization's strategic thinking, building competitive advantage. According to Bremser and Barsky (2004:229), for some companies R&D programs are critical to achieve and sustain a certain level of competitiveness. In this sense, it is believed that the study of the relevance of this activity in organizations is set up as an important item within the strategic thinking. Especially in technological services companies or products manufacturers, where the success is associate to their ability to innovate, Jensen et al (2004:662) argue that "one of the main factors actively influencing the innovation process is the spending on R&D". It is therefore to research group conduct theoretical and empirical investigation in order to know the existing cause-effect relations between investments in R&D (Independent Variable) and the results obtained by companies (Dependent Variables).

In this study the results of the companies observed in the business game are supposed to follow similar patterns to the market as the business gaming seek to portray, in a simplified manner, the complex reality of the companies through the delimitation of some variables and restricting the impact of other variables in the model (ROSAS & SAUAIA, 2006:3). The choice of business gaming environment for this research provides some advantages for data collection, the observation of managerial behavior and conditioning variables, within a perspective of control and examination of its effects, among them investments in R&D and the results on the business indicators.

This study is divided into three sections: 1) Literature Review (Innovation, R&D, Corporate Performance, Business Games); 2) Research Development Methodology (Research Problem, Research Methods, Description of Experiment and Data Collection Procedures); Results (Descriptive Analysis of Results and Discussion); 3) Final Considerations (Conclusions, Contributions and Limitations, Proposals for New Studies and References).

2 Literature Review

2.1. Innovation and Research & Development (R&D)

In the current market scenario, innovation is one of the policies used by companies to remain competitive. Neely *et al.* (1998:8) state that innovation involves the exploitation of an idea. They claim that invention may become an innovation if it takes place within the economic context of a commercial transaction of a product, a process or a service.

In this sense, Andreassi and Sbragia (2001:72) state that the "Research & Development" is the most classic of innovative activities and has been gaining momentum "influencing the process of technological innovation of enterprises and dominating the state of the art new technologies".

Popadiuk and Santos (2006:2) define innovation as "the adoption of a device, purchased or produced in-house, of a system, a program, a process, a product or a service that is new to the adopter company."

It's worth noting that a company invests in R&D not only aimed at innovations that cause disruption in what already existed. The innovation can be incremental or rupture. According to Neely et al. (1998, p.8-9), innovation can be directed to three dimensions: product innovation, process innovation and innovation in the organization. In all cases, investments are needed for the companies that can generate something new and to ensure the competitiveness of the product on the market.

Andreassi and Sbragia (2001, p.1) define R&D as "creative work developed on a systematic basis to increase the stock of knowledge." According to Jensen *et al* (2004, p 663), the R&D concept is based on three grounds:

- Basic research - theoretical or empirical work that seeks to understand phenomena and observable facts, without stopping to a particular explanation;
- Applied research - research conducted when you want to explain a given phenomenon with a practical purpose, and

- Experimental development - application of knowledge acquired in the development of new techniques, processes, or products, among others.

Given the concept of R&D and the areas where it can be applied, Brown and Swenson (1988) suggest a model to represent the R&D activity within the organization, including its inputs, processing and possible outputs (Figure 1).

1. Inputs	2. Processing	3. Outputs	4. Transferring	5. Outcomes
	R&D Lab Activities			
Equipment				
People	Project Development	Patents	Manufacture	Sales increase
Facilities	Research	New products	Marketing	Cost reduction
Ideas	Tests	New processes	Engineer	Products improvement
Information	Results	Facts/Knowledge	Operation	Capital value

Figure 1. The R&D function seen as a system. Source: Brown and Svenson (1988).

The R&D function (Figure 1) receives various types of inputs, including equipment, people, facilities, ideas, and information that are considered by the model's authors as the most relevant to the processes. Within the R&D lab, projects, surveys, and tests are developed to obtain results. Such procedures directly generate outputs of R&D, namely: patents, new products, new processes, new facts and knowledge. These outputs are received by the functional areas of the company to the process and generate the final results, here called outcomes.

Taking the example of Figure 1 and the R&D definitions, it is worth mentioning that the process of research and development in an organization can become quite complex, given the size of the company how the inputs will be managed.

2.2. R&D and Business Performance

In this section of the article will be presented some concepts of business performance measurement, as well as an overview of the main findings of previous research on the results obtained by companies with their investments in R&D. Neely *et al* (1998:29) question the existence of a real link between innovation and company performance. According to Geroski (1994:130), this question can be answered from two points of view. First, investing in new products and processes leads the company to a differentiated competitive position. Secondly, the process of innovation transforms a company as its internal processes improve and makes it more flexible and adaptable to market changes. Regardless of the type of investment made, managers expect the companies could produce with superior performance.

Martins (1999, p.74) points out some published studies with criticism of traditional performance measurement systems - based only on productivity and financial results - which brought to the literature a number of new measurement models propositions of performance: Smart-Performance Pyramid; performance measurement system for time-based competition; Balanced scorecard; Measuring models for added value; Structures of management indicators; Quantum Performance;

performance model for world-class manufacturing; Seven performance criteria; System for measuring the integrated and dynamic performance. The most widely used in business today seems to be the Balanced Scorecard. According to Kaplan and Norton (1993:134) the Balanced Scorecard provides a "comprehensive framework that reflects the company's strategic objectives in a coherent set of performance measures."

There are several ways to establish performance measures in the balanced scorecard or any other measurement system according to criteria that are linked to the profile of each organization. Leinonen (2001) *apud* Mettänen (2005:181), proposes the 'seven steps model' for determining the performance measures: 1) clarification of vision and strategy; 2) process description; 3) recognition of the success factors; 4) definition of the measures; 5) top down approach of dissemination of the measures; 6) definition of key reports; 7) determining how to collect the data and how to report results.

In this regard, Donnelly (2000) *apud* Bremser and Barsky (2004:233) highlights some metrics commonly used to assess spending on Research and Development by organizations: a) spending on R&D as a percentage of sales, b) new products approved, c) number of development projects approved, d) total supported active projects, e) total patents, f) percentage of current sales of new products, g) percentage of the budget resources allocated to investments in R&D, h) changes in the effectiveness of R&D, i) percentage of resources dedicated to support new product, and j) development of average cost per product. Once stablished the performance measures of R&D and the point where the measurement of this performance will be anchored, we evaluate the existing impact between dependent and independent variables of the process. Therefore, we seek to relations between what is being invested and what results these investments produce in relation to expected performance. Andreassi (2000:66) created a summary (Table 1) of the main authors and approaches in the literature on the relationship between R&D and business results.

Table 01 - Relationship between Investment in R&D and Business Results

Relationship	Results Found
Spending on R&D and profitability	Controversial relationship. High correlation when considered absolute values (Parassuraman and Zeren, 1983). Considering figures, the correlation depends on the sector analyzed (Morbey, 1989)
Spending on R&D and sales	Odagiri (1983) found stronger correlation between spending on R&D and growth in sales in subsequent periods, than between growth in revenues and expenditures in R&D in subsequent periods. Morbey and Reither (1990) and Brener and Rushton (1989) found a positive and significant correlation between spending on R&D and sales growth in subsequent periods. Brener and Rushton (1989) found no correlation between revenue growth and spending on R&D in subsequent periods.
Spending on R&D and market share	In Schumpeterian theory oligopolistic structures facilitate innovation. While Matesco (1993) states that such a relationship is very influenced by the degree of industry rivalry, for Chandler in the technologically advanced industries, products and processes are improved to maintain and expand its market.
Spending on R&D and new products	Wolf (1995) found a strong positive correlation between the variables.
Patents and market share	Scherer (1965) found no significant correlation.
Patents and profitability	Scherer (1965) found no significant correlation.
Patents and sales	Odagiri (1983) cites the works of Scherer and Branch, which found a positive and significant correlation between patents and evolution in sales.

Source: Adapted from Andreassi (2000:66).

In most cases (Table 1) were no significant correlations in the literature, however, there are signs of positive and significant relationship between spending on R&D and net income (for absolute values, according to Parasuraman and Zeren, 1983), spending on R&D and sales (Odagiri, 1983), spending on R&D and market share, and between patents and evolution of sales (Odagiri, 1983).

In his study Andreassi (2000:172) stated that only the variables "number of doctors, teachers and graduates allocated to R&D by number of employees" and "percentage of concluded innovation projects", as proposed in the conceptual model, differentiate the most innovative companies of the least innovative. The author also points out the difficult to measure the variable "percentage of concluded innovation projects" and suggests to be considered the number of employees allocated to R&D as the great advantage of the most innovative companies, compared to other companies.

3. Methodology of Research Development

3.1. The Business Games

To capture the essence of research with players working in companies based in a competitive laboratory environment it was created here a brief history of the business games, and described some of the key concepts on the subject.

Keys and Wolfe (1990:309) mention the emergence of the use of games with educational function about 3000 years A.C. Such games were for the war simulations, in order to train soldiers. One of the most famous at that time was the Indian game Chaturanga, which resembled chess of today. However, one of the best designed games ever appeared in the eighteenth century and was known as New Kriegspiel of George Venturini authorship. With the emergence of new versions, the war games have evolved into strategy games, which have become popular as business games. According Keys and Wolfe (1990:309), the first known version of Business Game was named Top Management Decision Simulation, developed for the American Management Association (AMA). The first game aimed at students has been applied for the first time in 1957 at the University of Washington, at the hands of Schreiber. During the 1950’s business games were spread out in the North America. Jackson (1959) mentioned Monopologs as a business simulator for material supply practice used by the American Army (Rosas, 2006:30). In Brazil, the business game arrived in the mid-70s through the universities. One of the first essays addressing the theme was conceived in the master's FEA / USP by Tanabe (1973). Sauaia (1995:9) mentioned that business games can simulate managerial situations for small, mid and big size companies, in a local or international perspective. In this environment decision makers may be successful or make mistakes in a risk free setting without being fired by investors, in order to practice knowledge and skills in this experiential learning environment.

Rosas (2006:41) mentioned that in the 70s, could be found research in business games area at the Polytechnic School of USP, the Getúlio Vargas Foundation in São Paulo and later in the mid 80, at the Federal University Santa Catarina. In his

dissertation, a pioneer in Brazil, Tanabe (1973:24) defines business game as an exercise where decisions are made, structured on a model that simulates a business situation, where participants have the task to manage the simulated companies. Sauaia (1995:8) extends this definition in the first thesis on the subject, stating that business gaming is "a method of 'experiential learning'.

Tanabe (1973:24) made a distinction between the objectives of simulation and business games. The simulation, according to the author, aims to "get specific solutions for each problem, in particular," as the game aims to train participants through teaching techniques and scenarios to observe their behavior. For Brazilian authors as Tanabe (1973), Sauaia (1995; 2007) and Roses (2006), business games to have two main functions: 1) Education: train and develop executives and business experts, and be applied in higher education and graduate courses; 2) Research: laboratory used to test hypotheses and theories field of knowledge in Administration and related studies. The decision-making process in business games allows participants to act in several management roles, defining strategic and functional goals, implementing decisions and controlling the results (SAUAIA, 1995:42). The main advantage of business games is that the processes move forward without losing real money and generate experiential learning very similar to real experiences. Since 2002 the Simulab research group works in the FEA/USP/SP studying, applying, and designing business simulations (SAUAIA, 2007).

3.2. Research method

This study of exploratory nature was based on the quantitative analysis of data from nine competing companies, managed in the laboratory context, bringing together the history of investment and business results in a period of four quarterly rounds of the game, that is one year of operation. The quality of primary data is high, since in this *stricto sensu* course graduate students had 50% of the grade out of the performance in the business game, ensuring the responsible involvement of all decision makers. The environment consisted of a Management Laboratory, conceptually characterized by Sauaia (2008) as the combination of three conceptual pillars: 1. The organizational simulation – an artifact described by a set of economic rules in the simulation manual; 2. The business game - experiences of the players in which decisions are made under uncertainty; 3. Applied research - critical analysis written individually by participants to report their deep reflections testing hypotheses or measuring the effectiveness of their management policies in the business game.

There was collected secondary data from literature and primary data of the decisions taken by the participants in the game, the decision reports generated by the system and all results. For data analysis, descriptive statistics (line graphs) were produced, and also bivariate correlations, using the Spearman index for nonparametric data statistics (SIEGEL, 1981). The Brown and Svenson (1988) model was adapted as the basis for the construction of the research problem and study guidelines to the purposes of this research. According to the theoretical model, the resources invested in R&D (financial and human) are treated as inputs (Inputs), while the output (sales, revenues generated by new products, market share, cost

reduction through process improvements, and profit), the results (outputs) of the enterprise are presented. Among inputs and outputs there are R&D activities, which generate the effects of R&D and these, in turn, lead to business results. Influencing this system there are: the business industry in which companies operate (electronics); the size of the companies (average) and the origin of their capital (100% of shareholders' equity in the business game).

In the definition of Schiffman & Kanuk (2000:465) a model is "a representation of reality designed to show relationships between various elements of a system or process under investigation." Given the simplification of relationships studied in the economic model of organizational simulator, we have adapted (Figure 2) the variables of the conceptual model of Brown and Svenson (1988) and Andreassi (2000:75).

R&D Investments		**Processing System**		**Company Results**
Inputs				Outcomes
Financial resources		R&D Activities		Net profit
Applied to R&D				Gross revenue
50% for products				Sales volume
50% for processes				Market share
				IRR

Industry Characteristics

Figure 2. Conceptual model adapted to the research variables: relationship between R&D and results in the business game.

Source: Adapted from Brown and Svenson (1988); Andreassi (2000:75).

3.3. Description of the Laboratory Environment and Data Collection

a. The Research Environment

This research presents an analysis developed with companies participating in a management game and data collected in a quarterly basis. This is a relevant factor to be highlighted, since the studies found in the literature are based on data collected annually. With the use of laboratory design, the results could be collected every quarter, in which there have been four rounds of play, corresponding to one year of operations. This procedure signals an advantage of the Applied Social Sciences laboratory and certainly would be much more difficult if collected from real companies.

For this study, we used the industrial business simulation SimuLab (SAUAIA, 2008). During the game participants worked in companies structured in six functional areas of Planning, Marketing, Production, Human Resources, Finance and President (CEO). The game allowed the players to see results immediately after each round, processed by the facilitator. In the business simulation manual there are described the economic rules, objectives and an overview of the economic environment, so that players can design, develop and implement their competitive strategies. According to Sauaia (2008), companies start their activities under the same conditions with the same type of product - a small electronics, multitasking

appliance. This product will be differentiated over time as a result of management actions on the marketing mix (tangible and intangible attributes) and on the other functional variables of the company, with the course of the game.

In this sense, the type of strategy and policies to be taken in a game varies according to the specific market they want to reach and the public for which they are destined the company's shares. For purposes of this study it was only listed the decisions relating to the game that will be used as a basis for inferences about the conceptual model adopted.

b. Collection and Processing of Data

A the beginning of the business game was held a trial round for a better understanding of the economic rules and then there were four official rounds of decision making, with the effective participation of nine competing companies that formed the basis for the collection of experimental data. Each round was for a set of decisions involving various functional areas of the organization. Among those decisions was the investment in R&D, treated as an independent variable in this study.

In the business game decision makers made private decisions under uncertainty and information asymmetry. They were inserted individually in the simulator (software) in search for superior performance in a competitive environment. After processing the input data, the facilitator generated reports for each company, indicating its performance in that particular round and sharing publicly some relevant information on the market and competitors. The research of each player, therefore, was performed by access to complete reports provided by the game administrator, which contained the internal data of investments and the results of the nine competitors.

The array of primary data can be found in Appendix I at the end of the article. The data analysis here presented consists of two steps: 1) Construction of graphs with percentage data investments and results of the companies; 2) correlation analysis between the dependent variables and the independent of the model. The variables are arranged and were treated as follows (% quarterly and annually):

- Independent Variable: Investments in R&D - were collected the amounts invested in R&D in each period of the game.
- Dependent Variables: Gross Revenue, Net Income, Potential Market (demand), Market Share (%), Sales Volume, and Internal Rate of Return (IRR).

The figures were collected in nominal value, however, to obtain more uniform graphic profile and comparing investments in R&D to the internal rate of return and market share, both are presented in percentage format, adopted the value concerning investments in R&D, as well as other nominal variables (potential market, sales volume, revenue, and net income). The figures were calculated according to the following equation:

$$Variable_{Relative} = \frac{V_{X,pn}}{\sum Vpn}$$, were,

Vx, tx = variable x in a period n

ΣVpn = The sum of all variables of a period.

According to this formula, it was calculated the correlations and constructed the graphs, considering the value of the weighted contribution of each company in relation to the total period for the variable studied.

After collected the data, it was built a matrix for tabulation in SPSS statistical software, with the help of Microsoft Excel, for some necessary additions. For processing the correlation, it was considered the first period Investment in R&D. The objective was therefore to assess the investment made in the first period than the other. According to Sauaia (2007:25), investment in R&D impact on the results of the game as follows: 20% in the short term (the quarter itself), 30% in the medium term (the second quarter) and 50% in the long term (the third quarter). Similarly, for graphics analysis, we considered the evolution of the results from the initial investment in R&D.

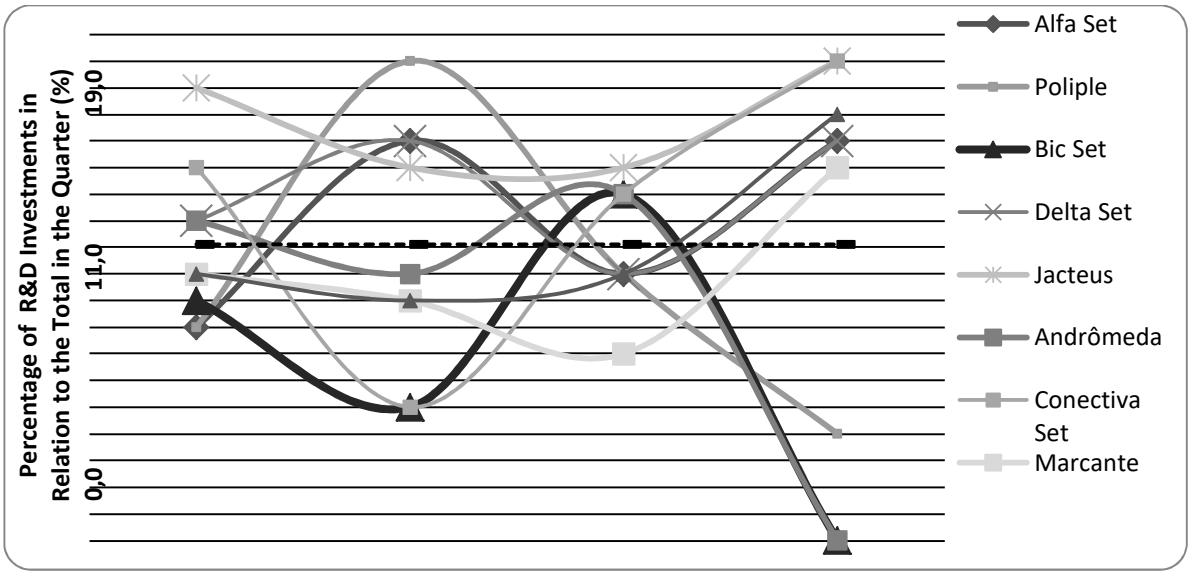

Figure 3: R&D Investment: Comparison between the competitors. Source: Data of this research

4. Data Analysis and Discussion of Results

4.1. Descriptive Analysis Data

In this section, the main results of the research will be presented, describing the contents and found the correlation coefficient calculated for the studied variables and the presentation of the most relevant graphics to direct the study's findings. The graphs of all nine competitors were not included, given the similar results. Thus, the extreme cases were examined, as the weighted values invested in R&D by the companies were compared to the average (Figure 03).

Note in Figure 3 - the mean value of investments in the sector in each quarter was about 11% - the companies that stand out in relation to the percentage of sector's R&D investments in the first quarter were:

Poliple investment was about 8%, the lower in relation to total

Jacteus invested the largest amount, about 17% on the whole.

These are companies whose graphs are analyzed. Figure 04 presents data and results of the Company Poliple. It is observed that in the first quarter, the company made a low investment in R&D (Figure 03) and, in fact, obtained a decrease in most indicators in the subsequent period. However, in the second quarter, the company made the second largest investment in R&D sector (Figure 03), and even then, the results of the next period, which should have a 20% impact continued to fall. In the fourth quarter sees an increase in the company's indicators, which can be attributed to the cumulative effect of earlier investments in R&D. investing much more than Poliple in R&D, Jacteus company obtained (Figure 05) in the second quarter, a slight increase in their indicators, with particular emphasis on net income, with a considerable increase (35%).

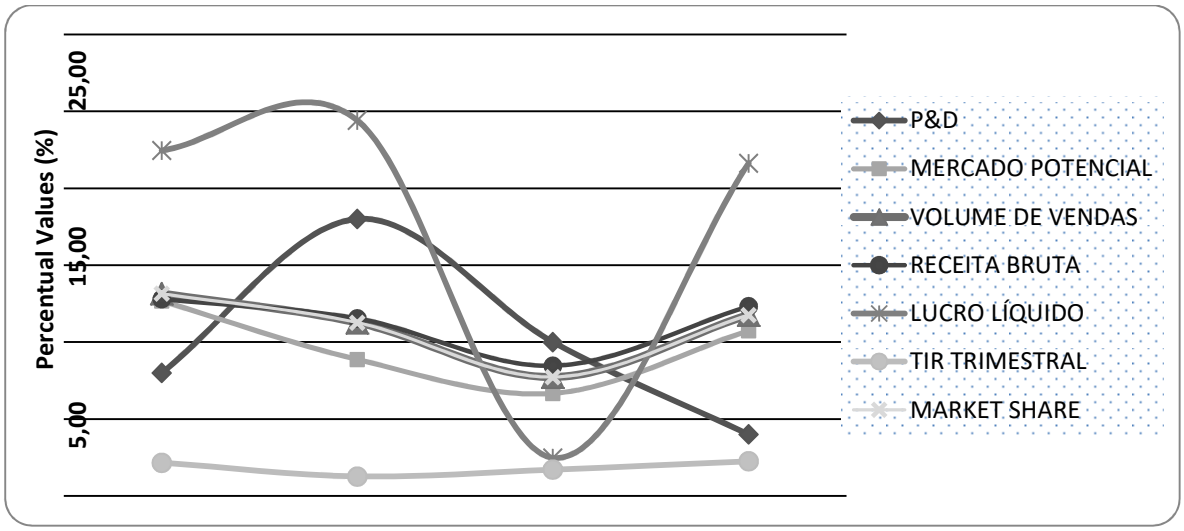

Figure 04: Company Poliple. Source: Research Data
Legend: R&D = R&D; Mercado Potencial= Potential Market; Volume de vendas= Sales volume; Receita bruta= Gross revenue; Lucro líquido = Net profit; TIR trimestral = Quarterly IRR.

Figure 4 presents data and results of Poliple company. In quarter 1 Poliple made a small investment in R&D (Figure 3) that caused a reduction in most of performance indicators in quarter 2. In quarter 2 this company made the second higher investment in R&D in the industry (Figure 3), and the results in quarter 3 remain falling even though there was expected that they should rise 20%, as indicated by the economic rules. Only in quarter 4 there is a raise of Poliple's indicators, due to the accumulation effect of the previous investments in R&D.

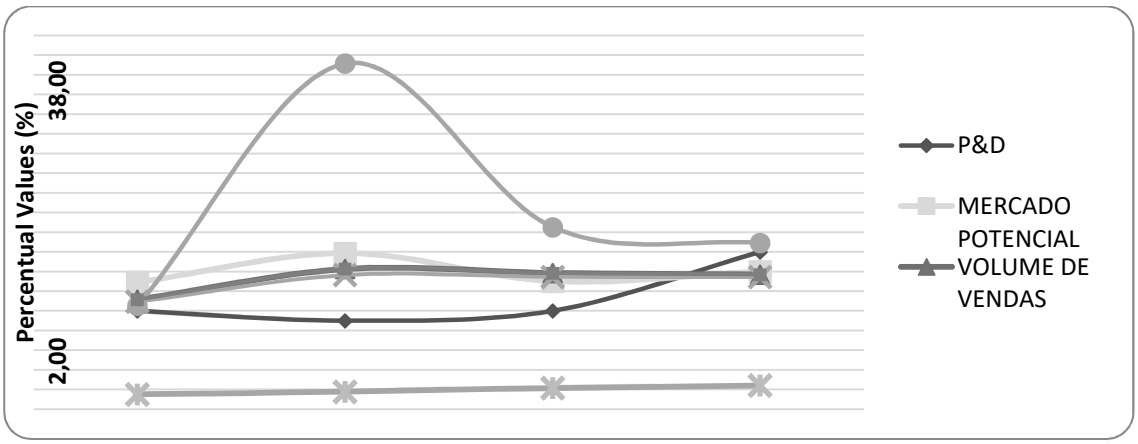

Figure 05: Company Jacteus. Source: Research Data

Legend: R&D = R&D; Mercado Potencial= Potential Market; Volume de vendas= Sales volume

Investing much more than Poliple, Jacteus company (Figure 5) get increased the net profit indicator in 35%, in quarter 2., Jacteus also increased the potential market in quarter 2, in comparison to Poliple, which least invested in the first period. The company Jacteus generated only in the second period a potential market 3.5% higher than its competitor (Poliple), which, for the fragmented industry with nine competitors, is of considerable value that represents about 30% of initial market share of each company.

It is observed in Table 1 that there was no significant correlation between the variables. It should be remarked a small correlation (0,354) of high significance (5%) between R&D investments in the quarter 01 and the Potential Market in the Quarter 03, indicating there was a superior demand and, as a consequence, an opportunity to the hole industry to increase sales in that quarter 3. If companies were able to produce and supply their demand these sales could turn into revenues and profit, creating economic value for the industry. This is a possible indication that in the long run, investing in R&D is an important factor in increasing the potential market for all companies operating in the industry in high-tech markets.

Table 1 – Correlations among Variables – (Quarterly Values; Significance)

	Quarter 1	**Quarter 2**	**Quarter 3**	**Quarter 4**
	Potential market			
Investment R&D_Q1	-0,304; 0,427	0,650; 0,349	**0,354; 0,058**	0,295; 0,440
	Sales volume			
Investment R&D_Q1	-0,430; 0,248	0,439; 0,237	-0,008; 0,983	0,203; 0,601
	Gross revenue			
Investment R&D_Q1	0,439; 0,237	0, 439; 0,237	-0,034; 0,931	0,152; 0,696
	Net profit			
Investment R&D_Q1	-0,565; 0,113	0,396; 0,291	-0,295; 0,440	-0,329; 0,387
	Market Share			
Investment R&D_Q1	-0,464; 0,208	0,473; 0,199	-0,008; 0,982	0,202; 0,601
	Internal Rate of Return			
Investment R&D_Q1	-0,413; 0,268	0,194; 0,616	0,109; 0,778	0,219; 0,570

Source: Research data.

4.2. Discussion based on the theoretical framework

Taking into account the results presented in this study, some considerations should be registered for a better understanding of the data and results, in relation to the theory, since these variables have already been studied in similar studies (Andreassi, 2000). Thus, the weak correlations between variables addressed in this research corroborate the results obtained in the theory, which also found no significant correlations between investment in R&D and the organization's results. In fact, about the impact of R&D on gross revenue, the theory considers two key factors: revenues and subsequent spending on R&D expenditures and R&D investments that led to subsequent revenues.

For this research, the second situation was considered (R&D investments that led to subsequent revenues), given that, in the game, the investment in R&D in period 1 generates results for subsequent quarters. Thus, in Table 1 we see the results of a survey conducted by Odagiri (1983), where investments in R&D are strongly related to subsequent companies' revenue. In the cases observed in this study, the calculated correlation was not significant for the industry. However, in the graphic analysis we note that one of the companies analyzed grew its gross revenue after more significant investments in R&D.

We also analyzed in this article the relation between Investments in R&D and Sales Volume. In the studied literature we didn't found references to this relationship, but this analysis was included in this research, adopting as a premise the idea that investments in R&D differentiate the product and, because of that, could generate a higher sales volume for the company. Finally, there is the importance of R&D to generate potential market. However, it is known that, according to the simulation model (Sauaia, 2007), R&D investments exert major impact on the generation of potential market. In practice, the correlation between these variables was weak (0,354) and isolated, but significant (5%), suggesting that the competing companies aware of this situation could have taken advantage of the opportunity to reach higher sales and better results from R&D investments.

The relationship between investments in R&D and Market Share (Market Share) has been studied. Theoretical studies (see Table 01) showed that, particularly in oligopolistic markets, products demand innovation and invest in R&D is one of the important policies to achieve and maintain market share. In this sense, there was no significant correlation between R&D variables and Market Share (Table 1). Another index for which no results were found in the theory on the impact of investments in R&D was the internal rate of return. This rate represents quite broadly the results for the investments made in the company, was used in this work to set a view of the influence of R&D on the overall results of each company studied. As in other cases already presented, there were no significant correlations between these two variables. It is worth highlighting some interesting facts regarding the companies studied. The fourth quarter accounted for almost all businesses, a large growth in results, and, in most cases, the fourth quarter was the least received investments in R&D, which may

suggest a reflection because in the fourth quarter, investment in R&D accumulated all the previous three quarters. This statement is based on the simulation model, where investments in R&D affect the results of companies, most significantly in the medium and long term.

5. Conclusions and Final Thoughts

5.1. Conclusions

This study aimed to evaluate the impact of investments in R&D in companies' results using a set of companies in the management laboratory (Sauaia, 2008), a learning and researching controlled environment in which many investigations have been produced since 1986 in various functional areas as Strategic management, Marketing, Production, Human Resources, Finance and Leadership, among others.

Due to the simplified structure of the laboratory setting many controlled analysis were carried out with the observation of a lower amount of variables and an increased frequency of collection. In this sense, the idea of the study was to seek correlations between investment in R&D and organizational performance indicators of nine companies operating in the business gaming environment.

In the laboratory setting, only one variable indicated the existence of correlation between R&D investments and evolution of the demand after three quarters, which indicates that the impact of other variables pertaining to the model, as well as R&D, can be considered relevant and soften the effect of investments in R&D in the results obtained by the organization. In particular, the other marketing mix variables considered in the game as (a) prices and pricing policies; (b) communication, promotion and distribution also impacted the results of the correlation calculation. Another point that should be considered in the context of the game is how the combination of investments, considering R&D, machinery and equipment maintenance among others, may have favored or not the final results for each company. Consideration of these issues assumes that the consumer behavior in the game setting is rational (Sauaia, 2008), objectively comparing the conditions that are offered by each company in the market. In the game there is not the idea of emotional consumer. The motivation to purchase product is performed by the best combination of conditions of sale and attributes (market mix) that each particular company offers. Thus, the higher the investments in research and development by the companies, the bigger could have been the demand for products, even if the companies have not obtained favorable economic results due to managerial inefficiency of no product offering, and weak management of other service factors of consumption, perceived by the modelled consumer.

Bringing the conclusions of this study to the organizational environment, it highlights the importance of continuously investigating the activity of R&D in the organization, since the fact that there is no regular and direct relationship between

R&D and the results obtained by the companies does not mean that this activity is less important or can be eliminated. Instead, the permanent study of this function in search of new technologies (improvements in products, in processes and in organizations) and the continuous development of products and services that create or satisfy desires of consumers could be associated with the business profile of each company. Organizations working with innovations strongly based on technology, for example, could develop more effective R&D policies since the market signals are interpreted (inputs) and transformed into outputs that meet and stimulate the growth of demand. Thus, depending on the market where the company operates and how competitors are developing their strategies, investments in R&D may be more or less relevant. In fact, in high-tech companies whose products and services have life cycles becoming shorter, it is essential to have a well-structured R&D, getting consistent investments to the sector in which the company operates. A company having a product that demands low degree of innovation, could have their final results less affected by not having invested so much in R&D, compared to another company of the software industry, for example. This study did not focus on this type of analysis, since the scenario was based on an oligopoly that has evolved into a monopolistic competition. Similar companies at the beginning of the game and producing the same product became differentiated after four quarters in an oligopolistic competition industry.

Finally it is concluded that investing in research and development does not guarantee, directly, positive results for organizations. However, the need to create and maintain a vector oriented to R&D for innovations in organizations, whatever the business is, may be a key to success. In this sense, depending on the level of innovation required by the industry, the higher should be the level of investment in R&D to create and sustain innovations.

5.2. Contributions Limitations and Propositions

Even in a simulation scenario that used mathematical and computational resources, business games were able to reproduce much of the actions and reactions observed in companies engaged in a particular type of market. a decision making environment was established to observe the relevant variable impacts. Although our results cannot be generalized, given the size and non-probabilistic sample, it brings significant contribution to studies in academia and application in organizations from the perspective of the theoretical framework and the description of the research design in a laboratory context.

Most studies found in the literature take into account the sales results and discount the importance of measuring the potential market generated in part by investments in R&D. This is one of the relevant study contributions, which signal alerts to those companies observing only the sales indicators, gross revenue, net profit and market share, for example, not taking into account the generated potential market not supplied. The reasons why this occurred could only be observed due

to management failures in the laboratory. In this sense, companies are able to explore practice the potential market analysis techniques, turning only for the internal results, which could be regularly calculated by organizations.

The development of this laboratory study allows the isolation of some variables, the parameterization of the economic context and tracking results in a quarterly basis, but did not examine the manifestations of emotional imprint in the game, commonly found in a business environment, a topic that may be subject to future studies.

In relation to new studies, we consider two possible scenarios for the development of research on the topic in and out of business games. Within the business gaming environment, we suggest the development of regression analysis, containing a greater number of variables in the model, so that it can set the degree of influence of each variable in business results. We also suggest the collection of data from a larger number of companies. As this study was developed with a smaLl group of graduate *strico sensu* students we had few individuals available for sampling. An alternative would be to replicate this study with undergraduate students, where classes are more populated. Within the business market, another idea would be to apply a few rounds of the game with micro and smaLl entrepreneurs, incubated or directly operating in the market, including new variables that are not addressed in this study. There is also the possibility of analyzing the variables from the perspective of other techniques such as structural equation.

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7. Apendix 1

Matrix of Data

Companies	R&D_01	%	R&D_02	%	R&D_03	%	R&D_04	%	R&D_Sum	%∑	R&D_Ave
ALFA SET	140000	8	300000	15	145000	10	160000	15	745000	12	106433
POLIPLE S/A	140000	8	350000	18	150000	10	50000	4	690000	11	98577
BIC SET	150000	9	100000	5	200000	13	0	0	450000	7	64290
DELTA SET	200000	12	300000	15	145000	10	160000	15	805000	14	115005
JACTEUS	300000	17	260000	14	220000	14	200000	18	980000	15	140006
ANDRÔMEDA	200000	12	200000	10	200000	13	0	0	600000	9	85719
CONECTIVA SET	250000	14	100000	5	200000	13	200000	18	750000	12	107147
MARCANTE	170000	10	173000	9	107000	7	150000	14	600000	9	85718
KEEP WALKING	180000	10	180000	9	160000	10	170000	16	690000	11	98576
Total	1730000	100	1963000	100	1527000	100	1090000	100	6310000	100	
Companies	NET P.01	%	NET P.02	%	NET P.03	%	NET P.04	%	NET P. Sum	%_∑	NET P. Ave
ALFA SET	183228	32	-373755	-68	269445	27	274644	20	353562	10	50507
POLIPLE S/A	130397	22	134682	24	25026	2	303186	22	593291	17	84763
BIC SET	142023	24	15025	3	322020	32	-506598	-36	-27530	-1	-3924
DELTA SET	172084	30	167641	30	143729	14	99777	7	583231	16	83329
JACTEUS	40816	7	178761	32	156102	15	271165	19	646844	18	92414
ANDRÔMEDA	-264920	-46	313945	57	254862	25	204007	15	507894	14	72562
CONECTIVA SET	67864	12	-134661	-24	-19925	-2	139746	10	53024	1	7573
MARCANTE	48338	8	56355	10	-327770	-32	379118	27	156041	4	22290
KEEP WALKING	61041	11	193875	35	186973	19	236785	17	678674	19	96963
Total	580871	100	551868	100	1010462	100	1401830	100	3545031	100	

Companies	GR01	%	GR02	%	GR03	%	GR04	%	GR. Sum	%_∑	GR. Ave
ALFA SET	3196723	12	2023564	7	3554849	12	3977922	13	12753058	11	3188265
POLIPLE S/A	3446453	13	3226004	12	2450028	8	3703616	12	12826101	11	3206525
BIC SET	3245160	12	2352307	8	4017289	14	215549	1	9830305	9	2457576
DELTA SET	3539583	13	3849479	14	3549513	12	3459048	12	14397623	13	3599406
JACTEUS	2901069	11	3441331	12	3397300	12	4083131	14	13822831	12	3455708
ANDRÔMEDA	2442037	9	3781903	14	4090500	14	3649325	12	13963765	12	3490941
CONECTIVA SET	2889200	11	2549187	9	2545756	9	3692891	12	11677034	10	2919259
MARCANTE	2328426	9	2927212	10	1454209	5	3221734	11	9931581	9	2482895
KEEP WALKING	2946000	11	3811108	14	3894067	13	4040186	13	14691361	13	3672840
Total	26934651	100	27962095	100	28953511	100	30043402	100	113893659	100	
Companies	SVOL01	%	SVOL02	%	SVOL03	%	SVOL04	%	SVOL. Sum	%_∑	SVOL. Ave
ALFA SET	532787	12	281051	6	573363	12	652118	13	2039319	11	509830
POLIPLE S/A	579236	13	504063	11	365676	8	578690	12	2027665	11	506916
BIC SET	536390	12	388811	9	698659	15	36846	1	1660706	9	415177
DELTA SET	599929	14	652454	15	596557	13	606851	12	2455791	13	613948
JACTEUS	453292	10	537708	12	530000	11	628174	13	2149174	12	537294
ANDRÔMEDA	375698	9	600302	13	681750	14	598250	12	2256000	12	564000
CONECTIVA SET	466000	11	414502	9	413944	9	605392	12	1899838	10	474960
MARCANTE	369591	8	455952	10	213854	5	536956	11	1576353	9	225197
KEEP WALKING	491000	11	637309	14	654465	14	672244	14	2455018	13	350722
Total	4403923	100	4472152	100	4728268	100	4915521	100	18519864	100	
Companies	PM01	%	PM02	%	PM03	%	PM04	%	PM. Sum	%_∑	PM. Ave
ALFA SET	532787	12	281051	5	666065	12	772719	12	2252622	10	563156
POLIPLE S/A	579236	13	504063	9	365676	7	685665	11	2134640	10	533660
BIC SET	536390	12	388811	7	698659	13	369861	6	1993721	9	498430
DELTA SET	599929	13	874337	15	596557	11	606851	10	2677674	12	669419
JACTEUS	453292	10	694585	12	669344	12	726822	11	2544043	12	636011
ANDRÔMEDA	375698	8	687359	12	681750	12	708417	11	2453224	11	613306
CONECTIVA SET	532161	12	894059	16	877435	16	1077944	17	3381599	15	845400
MARCANTE	369591	8	455952	8	213854	4	536956	8	1576353	7	394088
KEEP WALKING	589965	13	900932	16	713506	13	892350	14	3096753	14	774188
Total	4569049	100	5681149	100	5482846	100	6377585	100	22110629	100	5527657
Companies	MS01	MS02	MS03	MS04	MS_Ave	MS_Sum	IRR01	IRR02	IRR03	IRR04	IRR_ANNUAL
ALFA SET	12	6	12	13	11	44	3	0	1	2	7

POLIPLE S/A	13	11	8	12	11	44	2	1	2	2	9
BIC SET	12	9	15	1	9	36	2	1	2	1	3
DELTA SET	14	15	13	12	13	53	3	2	2	2	9
JACTEUS	10	12	11	13	12	46	2	2	2	2	10
ANDRÔMEDA	9	13	14	12	12	49	-2	1	2	2	9
CONECTIVA SET	11	9	9	12	10	41	2	0	1	1	4
MARCANTE	10	8	5	11	9	34	1	1	0	1	5
KEEP WALKING	11	14	14	14	13	53	2	2	2	2	10

Legend: MS = market share; IRR= Internal rate of return; PM= potential market; SV= sales volume; NP= net profit; GM= gross margin; R&D= research and development.