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**THE IMPACT OF R&D ON FIRM INNOVATIVE  
PERFORMANCE**

***ROBERTO SBRAGIA***  
FEA-USP

***ISAK KRUGLIANSKAS***  
FEA-USP

***ALDEN S. BEAN***  
CIMS- Center for Innovation Management Studies

***M. JEAN RUSSO***  
CIMS- Center for Innovation Management Studies

***ROGER L. WHITELEY***  
CIMS- Center for Innovation Management Studies

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[rsbragia@usp.br](mailto:rsbragia@usp.br) ou [ikruglia@usp.br](mailto:ikruglia@usp.br)

# THE IMPACT OF R&D ON FIRM INNOVATIVE PERFORMANCE

## First Author

Roberto Sbragia  
PGT- Center for Policy and Management of Technology  
University of São Paulo  
Brazil  
Phone: 55.11.210-4640  
Fax: 55.11.816-8044  
E-mail: rsbragia@usp.br

## Co-Authors

Isak Kruglianskas  
Faculty of Economics, Business Administration and Accountancy  
Business Administration Department  
PACTo - Program of Management on Science and Technology of the Institute  
of Administration Foundation  
University of São Paulo  
Phone: 55.11.210-4640  
Fax: 55.11.816-8044  
E-mail: ikruglia@usp.br

Alden S. Bean, M.Jean Russo and Roger L. Whiteley  
CIMS- Center for Innovation Management Studies  
Lehigh University  
United States  
Phone: 1.610.758-3427  
Fax: 1.610.758-3655  
E-mail: asb2@lehigh.edu

# THE IMPACT OF R&D ON FIRM INNOVATIVE PERFORMANCE: A COMPARATIVE ANALYSIS BETWEEN BRAZIL AND THE UNITED STATES

*Roberto Sbragia*  
*PGT- Center for Policy and Management of Technology*  
*University of São Paulo, Brazil*

*Isak Kruglianskas*  
*Faculty of Economics, Business Administration and Accountancy*  
*University of São Paulo, Brazil*

*Alden S. Bean, M. Jean Russo and Roger L. Whiteley*  
*CIMS - Center for Innovation Management Studies*  
*Lehigh University, United States*

**Abstract:** Databases regarding Industrial R&D Indicators are being implemented since 1992 in Brazil, by ANPEI - National Association for R&D of the Industrial companies, and United States, by IRI - Industrial Research Institute, following similar methodologies designed by professors from PGT/USP and CIMS/LU. This paper is intended to present a comparative analysis using data of both cases focusing on the impact of the R&D intensity on the innovative performance of the firms. Common indicators and correlation analysis will be used exploring data from fiscal years 95, 94 and 93, from both countries, in order to describe the results, identify differences and similarities, and interpret and generalize the findings.

**Keywords:** Industrial Firms; Innovation Indicators; Research & Development Management; Science & Technology Policy.

## Introduction

The relationship between investment in R&D and company performance has been a subject of great interest both in the specialized press and the academic world. In specialized magazines the most visible results have been published by *Business Week* on its R&D scoreboard, and in the academic world the results have been published in various specialized journals. In both types of publication the analyses made throughout the years have shown a consistent positive association, which has been measured through correlation indexes, between the amount of R&D, measured in expenditure relative to sales revenues, and the subsequent growth of the company, measured primarily in terms of productivity and increase in sales, and, secondly, in the profit and the growth of the share prices (Morbey & Reithner, 1990; Morbey, 1989; Franko, 1989; Morbey, 1988).

In spite of this, no definitive relationship between the variables has yet been established, mostly due to the fact that, firstly, the correlation indexes are made up of measurements which are notoriously bad at showing the relationship between cause and effect, and, secondly, that R&D investment cannot be seen as a “direct” factor which contributes to performance, but rather as one which works through a number of connecting links. In fact, it has been widely recognized that R&D investment brings the increase in knowledge, technical skills, and innovation, which potentially result in the competitive advantages which largely determine the success of a business. However, this does not necessarily imply, due to the presence of innumerable external and internal factors, that business performance will increase in terms of volume of sales, market share, profit, attractiveness for investment. How then can the role of R&D in the success of a business be shown in a more realistic way, one which is less subject to negative interpretations?

This paper uses information available on the following databases: “R&D Industrial Indicators” of the IRI- Industrial Research Institute, USA, and ANPEI- National Association for R&D of Industrial Firms , Brazil. Its aim is to present and discuss the existence of possible associations between the amount and profile of R&D resources and the company’s innovative performance, mainly understood in terms of the revenue generated by new or modified commercialized products and savings resulting from improvements in the productive process.

Certain methodological elements which support the present study are now described. Then the collected data are presented and discussed. Finally, a number of conclusions are established in order to orient future studies and business decisions.

## **Methodological Issues**

### ***1. Database Histories and Stages of Development***

The IRI database, called the **Industrial Research Institute’s R&D Database**, was set up in 1992, based on an internal effort to provide data to associated companies in order to make benchmarking feasible. Only companies associated with the IRI, totalling approximately 300 large firms and responsible for about 80% of the American expenditure on R&D, participated in this survey. The historical series has data on the fiscal years of 1992, 1993, 1994 and 1995, for companies as a whole and specific industries (Whiteley, Bean and Russo, 1997). It is operated by Lehigh University/CIMS- Center for Innovation Management Studies, an entity which is accredited by IRI, and which, in 1995, began to receive official government support through the NSF- National Science Foundation, because of its interest in business statistics.

The Brazilian database, called the **ANPEI’s Technological Innovation Industrial Firm Indicators Database**, was also set up in 1992, from a government initiative of the MCT- the Ministry of Science and Technology, which,

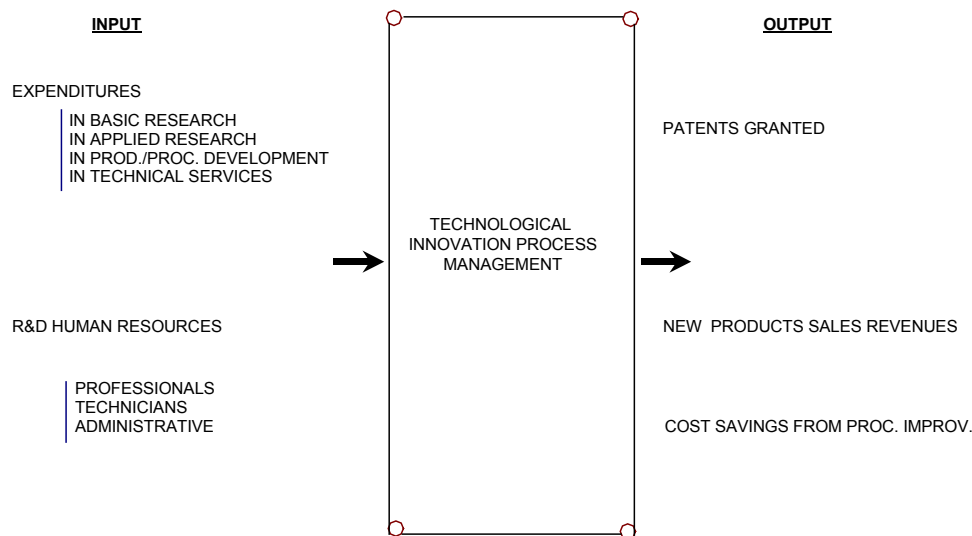
stimulated by the need for an improved knowledge of companies' expenditure on R&D, gave ANPEI, with the financial help of FINEP, SEBRAE and 40 other entities, the task of implementing and operating the database. It had the technical support of the University of São Paulo, through PACTo- the Program on Management of Science and Technology. In contrast to the IRI database, the Brazilian database is located at ANPEI and contains data of the fiscal years of 1993, 1994 and 1995, just on the company as a whole (Sbragia and Kruglianskas, 1977). In addition, once again differently to IRI, of a total of 1,100 companies it includes a large number which are not affiliated with ANPEI. Of all the companies, only 140 gave information for each of the three years. In 1995, the 650 companies that provided information were responsible for about 50% of the Brazilian Industrial GDP - Gross Domestic Product approximately 70% of total company spending on R&D.

## ***2. A Database Conceptual Model and Main Common Operational Procedures***

The simplified conceptual model of both the databases is shown in Figure 1, containing a number of input indicators, called **R&D Intensity**, and a number of output indicators called **R&D Results**.

Both databases were conceived and operate according to the following theoretical and operational procedures:

- They encompass the theoretical inputs involved in quantification problems of Science and Technology expenditures that have their conceptual basis in the Frascati Handbook (OCDE, 1975). In this sense, both Databases use the enlarged R&D concept, adding some of the so-called correlated technical-scientific activities, as for instance, the Technical Services.
- They emphasize the usefulness of information generated for the companies, as a way to create the adequate receptivity for the system, for government, and other organizations.
- They search for an adequate balance between the coverage and depth of information demanded from the participating companies, trying not to overburden the answering party as well as having too superficial information
- At the current stage they stress much more the construction of a core of basic data than the precision and completeness of the business information obtained through the data-collection tools, assuming that these enhancements will be added at a latter stage, with the progressive evolution of the participants.
- They classified companies according to their numerical ratings of the SIC - Standard Industrial Classification (up to 4 digits). However, they do not make available data on industrial segments not having more than 5 companies as part of the Database.



**Figure 1: Database Conceptual Model**

- They operate through annual data collection tools (Annual R&D Survey), distributed to the companies from April/May each year. Such tools contain instructions in filling out the survey, although, mainly in the Brazilian case, they are accompanied by an orientation and follow-up work, as well as by an involvement strategy of professional associations representing different industrial sectors, aimed at making it easier to identify and involve possible new participants for the Database.
- They annually disseminate information (Annual R&D Survey Results) to the participating companies, in a restricted and confidential way, and to the community at large, by way of academic publications.

### **3. Variable Definitions**

Two input and four output variables were defined for this study (Tipping, Zeffren & Fوسفeld, 1995):

#### *Input Variables:*

- R&D Intensity: the R&D Expenditures as % of Sales Revenues;
- R&D Profile: the Basic Research, Applied Research, Product+Process Development, Technical Services Expenditures as % of R&D Expenditures

#### *Output variables:*

- New Sales Ratio (NSR): the ratio of Sales Revenues in the year from product development commercialized in the last 5 years to the Total Sales Revenues in the year;

- Cost Saving Ratio (CSR): the ratio of savings in the cost of goods in the year from process development or product changes adopted in the last 5 years to the Gross Profit in the year;
- R&D Yield: the contribution to Gross Profit in the year from the sale of new and improved products and from the lower cost of goods from new and improved processes or new formulations [R&D Yield = Gross Profit (NSR + CSR)];
- R&D Return: the ratio of R&D benefits in the year to R&D expenditures in the year (R&D Return = R&D Yield/R&D Expenditures).

#### **4. Sample**

In the American case, all the companies which reported their data as a company to the IRI in the fiscal years 1993, 1994 and 1995 were selected. The yearly totals varied from 63 to 88. In order to make the the Brazilian comparison more valid, only large and mega companies (500 or more employees), who reported their data to ANPEI during the same period, were selected. The yearly totals were 71 or 72, depending on the year. The main characteristics of the two samples can be compared in Table 1.

### **Results**

It can be seen in Table 1 that the average size of the companies in the American sample was very much larger than that of the Brazilian companies, 6.5 times in terms of the number of employees and 13 times in terms of sales revenues, which suggests the staff productivity (sales revenue/employee) was almost twice as high for the American companies, and gross profit was almost 18 times as high.

On average, the amount of R&D invested by American companies is 43 times greater, in absolute terms, than that of Brazilian companies. When the amount invested in R&D per sales revenues unit is considered in relative terms, the American companies invested 4 times more. The analysis of how these resources are invested in terms of the various categories of R&D expenditure (basic research, applied research, product/process development and technical services) is inconclusive due to differences in the ways the companies from the two countries classify their expenditures.

The data in Table 1 also show that the way of allocating human resources to R&D is different. The fact that the American companies allocate almost 27 times as many employees to R&D reinforces the fact that they value it more. The American companies also give greater qualitative value to R&D as there are six times as many Ph. Ds working in the American technical teams. They also spend about 46% more per employee.

**Table 1: Profile of the Analyzed Firms (average values per firm)**

SELECTED INDICATORS	UNIT OF MEAS.	U.S.A			BRAZIL			USA/ BRAZIL*
		FY1993 (N=63)	FY1994 (n=87)	FY1995 (n=88)	FY1993 (n=71)	FY1994 (n=72)	FY1995 (n=72)	
<b>ECONOMIC/FINANCIAL</b>								
Number of Employees	Number	39,896	33,927	28,019	5,160	6,201	4,094	6.58
Sales Revenues	US\$MM	10,789	9,947	8,320	683	784	782	12.91
Gross Profit	US\$MM	2,825	3,324	2,900	170	206	123	18.13
<b>R&amp;D INTENSITY</b>								
R&D Expenditures	US\$1,000	338,400	317,100	234,100	6,193	6,669	7,530	43.6
R&D Expenditures/Sales Revenues	%	3.4	3.2	3.1	.7	.8	.9	4.0
Basic Research Expenditures/R&D Expenditures	%	3.1	1.7	3.0	2.3	5.6	6.8	.5
Applied Research Expenditures/R&D Expenditures	%	14.6	15.4	18.3	23.4	25.5	28.2	.6
Product and Process Development Expenditures/R&D Expenditures	%	64.8	64.3	61.5	44.5	39.2	41.9	1.5
Technical Services Expenditures/R&D Expenditures	%	19.4	18.5	17.3	28.8	26.2	22.1	.7
R&D Personnel (Full Time Employees)	Number	2,728	2,571	1,272	73	84	87	26.9
Technical Personnel/R&D Personnel	%	81.3	83.6	82.8	82.7	74.4	78.4	1.0
Ph.D./R&D Technical Personnel	%	19.6	19.2	21.0	2.4	2.8	5.4	5.6
R&D Expenditures/R&D Personnel	US\$1,000	123.2	130.2	136.1	78.8	87.7	100.2	1.4
<b>R&amp;D RESULTS</b>								
Patents in the Country	Number	120.50	109.7	80.8	2.48	17.1	21.0	49.4
New Products Sales Revenues/ Total Sales Revenues (NSR)	%	23.2	19.3	21.3	33.2	34.1	34.8	.6
Cost Savings from Process Improvement/Gross Profit (CSR)	%	5.6	6.4	6.7	5.2	4.0	4.2	1.4
R&D Yield = [Gross Profit (NSR+CSR)]	US\$1,000	419	318	542	25	47	29	12.6
R&D Contribution = (R&D Yield/Gross Profit)	%	27.9	21.7	24.0	30.7	32.9	36.2	.7
R&D Return = (R&D Yield/R&D Expenditures)	Number	4.5	2.9	4.3	2.6	4.6	2.7	1.2

\* Ratio of 93-95 average values

In terms of the presumed results of R&D, Table 1 suggests that the American companies take out, on average, almost five times as many patents. However, in the last five years, the American companies have managed to launch only 62% of the number of new products of the Brazilian companies. In terms of savings achieved through R&D, the gross profit of the American companies averaged just over 6% while the profit of the Brazilian companies was less than 4.5%, an advantage of 39% for the American companies.

On further analysis, it can be seen that the value of the Gross Profit that is presumably derived from R&D investment, given by the "R&D Yield", is 12 times greater for the American companies, explained by the higher volume of sales and profits. However, when the relative contribution of R&D for the gross profit, given by the "R&D Contribution", is calculated, the American performance is only 73% of that of the Brazilian companies. This figure can be explained by the greater number of new products launched by the Brazilian companies in their total sales revenues. But when the "R&D Return" is analyzed, the American companies have an advantage of 18% due to the greater volume of sales revenue.

The correlation chart in Table 2 was designed in order to analyze possible associations between R&D investment and the innovation performance of the companies employing the variables selected for this study, using Spearman's non-parametric index (Siegel, 1975). This table shows a number of significant correlations ( $p \leq 0.05$ ) between the input variables which refer to the fiscal years of 1993, 1994 and 1995, and the output variables for 1995, both for the Brazilian and the American companies. It can therefore be stated that the number of significant correlations for the American companies is higher than for the Brazilian companies although some of these correlations are apparently more difficult to analyze from the viewpoint of the underlying logic.

It is also interesting to note that in both cases there is a significant positive correlation of the "Research Intensity" in 1993, 1994 and 1995 with the 1995 "New Sales Ratio", which strengthens the hypothesis that there is a strong association between total expenditure on R&D and product innovation. In the American companies, there were also significant positive correlations between the investment in "Product/Process Development" in 1994 and 1995 and the "New Sales Ratio" in 1995, which, agreeing with the data from Table 1, clearly shows that today investment in R&D is largely responsible for product development.

It can also be seen in Table 2 that there were positive correlations for the American Companies between the "Research Intensities" in 1993, 1994 and 1995 and the 1995 "R&D Yield". The same reasoning applies here as one of the largest parts of the "R&D Yield" is obtained through the multiplication of the gross profit by the "New Sales Ratio". One of the possible explanations of the non-occurrence of these same correlations in the Brazilian sample may be linked to the fact that the profit of the Brazilian companies varies from year to year, from sector to sector,

and from company to company as a result of the transition period the Brazilian economy is passing through.

**Table 2: Spearman Correlation Coefficients ( $p \leq 0.05$ ) for all Industries**

Output Variables		USA (FY1995)				BRAZIL (FY1995)			
		New Sales Ratio	Cost Saving Ratio	R&D Yield	R&D Return	New Sales Ratio	Cost Saving Ratio	R&D Yield	R&D Return
Input Variables									
FY 1993	Research Intensity	0.4431 (n=35)		0.7636 (n=21)		0.5694 (n=32)			
	Basic Research								
	Applied Research								
	Process/Product Development		0.6205 (n=14)						
	Technical Service								
FY 1994	Research Intensity	0.4599 (n=35)		0.7584 (n=21)		0.4629 (n=31)			
	Basic Research								
	Applied Research								
	Process/Product Development	0.4940 (n=33)	0.5237 (n=19)		0.7500 (n=16)				
	Technical Service								
FY 1995	Research Intensity	0.4980 (n=33)		0.7039 (n=21)		0.5011 (n=32)			
	Basic Research		0.4466 (n=25)						
	Applied Research				-0.436 (n=22)				
	Process/Product Development	0.4741 (n=46)							
	Technical Service						0.3292 (n=44)		

There are also significant correlations between the investment in “Process/Product Development” in 1993 and 1994 and “Cost Saving Ratio” in 1995, which makes sense, as part of this expenditure is directed to process improvements. In fact, according to the methodology used by the IRI database since its implementation, these process savings are linked to investments made in the last five years. In the case of the Brazilian companies, these correlations cannot be made, perhaps because of the way data were collected before the fiscal

year of 1994, when they referred to savings resulting just from R&D investments made in the previous year. On the other hand, it can be seen that there is a positive correlation between the expenditure on “Technical Service” in 1995 with the “Cost Saving Ratio” in 1995 in the Brazilian companies, which is partially explained by the emphasis given by the Brazilian companies to short-term investment in order to reduce operational costs.

In the American case there is a positive correlation between the 1995 “R&D Return” and the emphasis given by the companies to “Product/Process Development” in 1994, as well as the negative association between this variable and the investment in “Applied Research”. These two correlations taken together tentatively suggest that the recovery of the investments in R&D can be most directly associated with development projects.

## **Conclusions And Final Considerations**

The aim of this study, using a sample of companies from the United States and Brazil, was to present and discuss possible associations between R&D investment and firm innovative performance. The basic premise is that the value of R&D investment first becomes apparent when innovations that sustain or improve the business position of the company are seen to be working. However, it should be made clear that the aim of this paper, like many other studies in the area, is not to predict a definitive solution to the problem, but rather to make a contribution toward increasing knowledge and, in practical terms, to look for the best parameters to guide decision-making.

Taking into account the various limitations of this study, which largely derive from the selection process and questions regarding representativeness of the samples under consideration, we can make the following conclusions, which will act as theoretical and practical ideas for future discussion.

- both in the Brazilian and American samples, there is a consistent positive association between the amount of R&D investment in 1993-95, seen in the R&D Expenditures/Sales Revenues index, and the rate of product innovation in 1995, seen by the share in the total revenue of that year of products launched in the last five years. This suggests that in both countries, but more specifically in Brazil, there is a considerable scope for new and improved products, particularly in the present climate of economic globalization and the search for new market niches, which will therefore stimulate greater investment in R&D;
- in the American sample, there were consecutive positive associations between “R&D Intensity” in 1993, 1994 and 1995 and the “R&D Yield” in 1995, suggesting that a large amount of the gross profit of these companies, discounting other variables, is associated with recent investment in R&D;
- in the United States the savings in costs, resulting from process improvements, shown by the “Cost Saving Ratio” in 1995, are positively associated with the part of the R&D resources invested in “Product/Process Development”,

particularly in 1993 and 1994, which suggests that the use of technology in the US by the companies in the sample is directed more to increasing innovations than toward the exploration of new frontiers of knowledge. Although this was not clearly shown by the indexes, with perhaps the exception of the positive correlation in 1995 between the investment in “Technical Services” and the “Cost Saving Ratio”, it can be said that this reasoning is also valid for the Brazilian sample, especially in the search for greater improvements in efficiency;

- finally, following the previous conclusions and the theoretical and underlying logic, the general idea is strengthened that R&D investment directed toward “Product/Process Development” nowadays has a better chance of return in relation to expenditure.

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