INNOVATION AND PERFORMANCE: THE IMPACT OF RESEARCH AND DEVELOPMENT RESEARCH ON THE ECONOMIC AND STOCK MARKET PERFORMANCE OF EUROPEAN COMPANIES

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Abstract
The research paper consists in analyzing the impact of investments in research and development on the economic and stock market performance of European companies. Several studies have shown that investments in research and development have a direct and positive impact on financial performance at the level of a company, supporting the theory that investments in innovation have a long-term effect on performance.
The aim of the paper is to study the existence and intensity of the link between investment in research and development and the economic performance of European companies.
The study is developed based on the EU 2020 Industrial Research and Development Investment Scoreboard (IRI), using data from 535 companies in Europe for the period 2016-2019. The statistical research method involves regression analysis using panel data, the statistical processing being performed using the statistical program EViews, version 7.0. The research results indicate that investments in research and development have a stronger impact on performance in companies that invest more in this area than in those that invest less.

Keywords
research and development expenditure, stock market performance, economic performance, innovation and performance

JEL Classification
M41, O16

Introduction

The environment in which companies operate today is one in continuous change, characterized by the rapid advance of globalization, the emergence of new competitors and the diversification of demand. In this context, the innovative capacity of companies

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depends largely on their internal competencies, namely research and development (R&D), but also on the ability to develop strategies for managing innovation processes.
In today's economic environment, due to the existence of rich offers in all branches of activity, innovation, openness to the new, improvement can decide the success of a business, regardless of the scale at which it is organized.
Therefore, innovation, from an economic point of view, involves both the development and implementation of all ideas and technologies that lead to the optimization of goods and services. Innovation can also increase the efficiency of the production process, which is extremely important in any industry.
The aim of this research is to determine the impact of investments in research and development on the performance indicators of companies in Europe in 37 industries for the period 2016-2019, using data from a number of 536 companies.
In the study, 50% of the analyzed companies operate in five of the 37 industries, as follows: 88 companies in the pharmaceutical and biotechnology industry, 57 companies in the field of industrial engineering, 50 companies in the field of software and IT services, 44 companies in the electronic and electrical equipment industry and 26 companies in the field of hardware and equipment technology. The difference of 271 companies is scattered around 32 industries, the least representative being the food and medicine retail trade, the leisure goods industry, the tobacco industry and the life insurance industry.
The study uses as dependent variables are net sales (NS), an indicator used to assess economic performance and market capitalization (MK), an indicator used to measure stock performance.
The independent variables used in the study are R&D expenditure (RDI), used to measure companies 'investment in innovation, capital investment (CAPX), used to measure investment in companies' fixed assets and the number of employees (EMPL), indicator used to determine their influence on performance.
In the debate on the economic performance of companies as an effect of investment in innovation, the first point of interest is usually the selection of an appropriate measurement method, because investment in innovation has a wider impact on the internal and external environment of the company. Innovation itself affects not only financial results, but also the competitiveness and viability of an economic entity (Tabas and Beranová, 2014).
The article is structured on several components, starting with the introduction, followed by the theoretical framework of the study which presents representative works of several authors in the field who have conducted research on the relationship between innovation and performance. The third part of the paper includes the research methodology, being defined the source of the data necessary for the study, the research methodology by which the econometric model is defined, as well as the variables used in the model and the research hypotheses. The fourth part of the paper contains the results of the research, in which the results of the study are disseminated. The research conclusions show the connection between the research hypotheses and the results that confirm the hypotheses, as well as the general conclusion regarding the analyzed subject. The last component of the article refers to the bibliographic references where the representative works for the approached topic are specified.

1. Review of the scientific literature

Innovation, viewed from an economic point of view, involves both the development and implementation of all ideas and technologies that lead to the optimization of goods and services. Innovation can also increase the efficiency of the production process, which is extremely important in any industry.

Many authors have studied the relationship between research and development expenditures and various indicators of companies' financial performance.

Empirical research has established that corporate research and development is strongly associated with post-productivity gains, as well as gains due to rising stock prices. When companies invest in research and internal development, they engage in a process of learning and adaptation that will allow them to acquire the ability to recognize the value of new information, to assimilate it and to apply it for commercial purposes (Dindaroğlu and Takim 2013, p. 28).

Dindaroğlu and Takim (2013) analyzed the relationship between innovation indicators, measured by investments in research and development, patents and stock market performance for a group of manufacturing companies, traded on the Istanbul Stock Exchange. The results of the study showed that higher investments in research and development are associated with a higher market value.

The authors used the value of intangible assets to measure innovation, not taking into account the tangible part of innovation. They also argue that it is possible to use information on investment in research and development and patents to build a portfolio of stocks that can far exceed the index of the Istanbul stock market.

Investing in innovation can be considered an expense of new technologies and knowledge that can influence the financial and stock market performance of companies. Research and development activities, both external and internal, are widely recognized as the engine of technological progress, and the increasing level of research and development expenditures is considered to be a reliable indicator of innovative capacity (Martin and Nguyen-Thi, 2015, p. 1108).

Ludivine (2015) analyzes the role of investments in research and development and the use of information and communication technologies on the productivity of companies. The results of this study highlight the complexity of managing investments in information and communication technology and research and development to improve business innovation. The authors confirm the facilitating role of innovation in increasing performance, expressed through labor productivity.

Vithessonthi and Racela (2016) studied US listed companies for the period 1990–2013. They found that investing in research and development contributes to building new knowledge and capabilities in the long run, creating a larger knowledge base than their competitors and thus performing better. However, it has a negative impact in the short term. This suggests that the intensity of research and development is negatively correlated with the performance of the same year, but positively correlated with the future performance of the company.

In addition, investment in research and development has a negative influence on the profitability of sales of companies with high research and development intensity, but no

significant effect has been found in companies with low research and development intensity.

Grieco (2017) analyzed the relationship between the degree of innovation and the profitability of the stock market. He claims that companies that invest more in research and development have a higher degree of internal risk, in the sense that the share price may fall due to an event that affects the company, but not the market as a whole. Radical innovation reflects the stock market price both in terms of its level and volatility, empirical evidence showing that the degree of innovation of companies is positively related to the value of the company, measured by the profitability of shares. The results of the study claim that companies that invest in radical innovation achieve higher stock market performance.

Almeida (2019) studied how investments in research and development influence the performance of companies, measured by sales and operating profit. This paper aimed to verify how investments in research and development influence the performance indicators (sales and operating profit) of 548 companies investing in innovation. The results of the study showed that investments in research and development positively influence the sales and operating profit of companies. Companies that record a higher operating profit can turn investments in research and development more efficiently into profit in the following periods. Investments in research and development have a greater positive impact on profit in sectors of activity that invest more intensively in research and development.

Chen (2019) examines the impact of R&D investment behavior on corporate performance in Taiwan's semiconductor industry, facing the economic recession caused by the global financial crisis of 2008, and the study was conducted for 2005– 2016.

The conclusions show that investments in research and development at the level of companies have a positive impact on financial performance, but not in the same year in which they were made, but in the long run. The intensity of research and development this year is negatively correlated with the current performance of companies.

This can be attributed to the fact that investments in research and development are recorded as operating expenses in the financial statements, thus increasing operating expenses in a given year, leading to lower operational performance.

Saliba de Oliveira (2019) analyzed the relationship between investments in innovation and financial performance, being included in the study 5,025 companies from Brazil. The authors argue that innovation efforts do not materialize directly in financial performance. Due to the inherent uncertainty of innovative projects, such efforts must first lead to effective innovative results before they can contribute to a company's financial performance.

The results show that efforts to invest in innovation have a positive and significant influence on innovation outcomes, suggesting that companies' investments and innovation initiatives lead to effective results in terms of new products in total domestic and foreign sales.

2. Research methodology

In the process of data collection, a manual processing was required with the help of the excel program, in which the companies were sorted, starting from a number of 18,000 observations between 2011 and 2019. From these were eliminated the companies with missing years, the population being restricted to the interval 2016 - 2019.
After this processing, the companies that did not present data in at least three years from the analyzed horizon were again eliminated, thus reaching a sample of 536 companies. The data set present in the study is a balanced one, because each company is observed for the defined characteristics of Net Sales (NS), number of employees (EMPL), R&D expenditures (R&D), capital expenditures (CAPX) and market capitalization. (MK) in each year of the study.
The research paper aims to analyze the impact of research and development expenditures on the economic performance of companies in Europe, over a period of four years, respectively the period 2016-2019.
The research method used in the analysis of the impact of innovation on performance, is the use of panel data. The statistical sample surveyed includes 535 companies in Europe, resulting in 2,140 observations.
The Eviews 7.0 software package was used for data processing.
In order to analyze the impact of research and development expenditures on both economic and stock market performance, it was necessary to analyze two regression equations.
The first regression equation refers to the impact of R&D expenditures (R&D), number of employees (EMPL) and capital expenditures (CAPX) on the net sales (NS) of companies, being made according to the following model:

$$NS_{it} = c + \beta_1 * RDI_{it} + \beta_2 * EMPL_{it} + \beta_3 * CAPX_{it} + \alpha_i + \varepsilon_{it}$$

The second regression equation refers to the impact of research and development expenditures (R&D), number of employees (EMPL) and capital expenditure (CAPX) on market capitalization (MK), which is determined as follows:

$$MK_{it} = c + \beta_1 * RDI_{it} + \beta_2 * EMPL_{it} + \beta_3 * CAPX_{it} + \alpha_i + \varepsilon_{it}$$

where:

NS_{it} = the company's net sales *i* in year *t*;

MK_{it} = the market capitalization of company *i* in year *t*;

RDI_{it} = the research and development expenditures of the company *i* in year *t*;

$EMPL_{it}$ = the number of employees of company *i* in year *t*;

$CAPX_{it}$ = the company's capital investments *i* in year *t*;

c = constant;

α_i = individual effects;

ε_{it} = error.

Because, in the study, panel data were taken, which may be affected by the random error behavior, to decide which form of model estimation is optimal, with fixed effects or random effects, the Hausman test was applied.

The Hausman test compares two alternatives of some estimators, most often one obtained by a model with fixed effects, the second by variable effects to conclude which of the two is more efficient. It checks whether there are statistically significant differences between the estimates of the coefficients in the fixed effects model and the estimates of the coefficients in the random effects model.

In addition, to indicate what kind of individual effects should be considered, the application of the Hausman test is the viable solution to be able to make a decision. This allows you to decide on which model a researcher who wants to use panel data can incorporate by incorporating individual behaviors.

As a test hypothesis, this test is provided that there are no statistically significant differences between the estimates of the coefficients in the fixed effects model and the estimates of the coefficients in the random effects model, so both methods are appropriate. If the null hypothesis is rejected, it appears that only the model estimated with fixed effects is adequate.

How to interpret the Hausman Wu test:

- If **p value < 0.05**: it is preferred to use the fixed effects model;
- If **p value > 0.05**: it is preferred to use the random effects model.

The choice to estimate a model with fixed effects or a model with random effects, is conditioned by the predetermined assumptions regarding the nature of the individual effects α_i. The optimal choice of the model (with fixed effects or with random effects) will be made based on the results generated by the Hausman test.

The question from which the research starts is the following: do the research-development expenses have a positive impact on the economic performance and the stock market performance of the companies?

Numerous studies in the literature have shown that investments in research and development, both tangible and intangible, lead to increased economic and stock market performance of companies.

Economic performance can be seen as an intermediary between innovation and stock market performance, which has a strong influence on the market and stock prices.

Starting from the idea that investments in research and development positively influence the economic performance and market value of companies, we formulated the following hypotheses to be tested:

Hypothesis 1: Research and development expenditure have a positive impact on the economic performance of companies;

Hypothesis 2: Research and development expenditure have a positive impact on companies' stock market performance.

The data used for the study were collected from the EU's Industrial Research and Development Investment Scoreboard for 2016-2019. The data were selected according to the presence of the market capitalization indicator (market capitalization), and thus the database for companies in Europe was generated.

The variables used in the research are described in Table no. 1, they refer to five financial indicators selected for the study.

Table no. 1. Description of variables

Variables	Description	Symbol	Measure unit	Data source
	DEPENDENT VARIABLE			
net sales	It refers to the company's net sales less the discounts granted to customers and the value of the products returned by them. Represents the actual sales of a company during a financial year.	**NS**	mil. euros	**IRI**
market capitalization	It is calculated as the product of the number of shares issued each year and the closing price of the shares in that year.	**MK**	mil. euros	**IRI**
	INDEPENDENT VARIABLE			
investments in research and development	These are those expenses incurred by a company for the development of new products and services, in order to obtain a higher financial performance.	**R&D**	mil. euros	**IRI**
number of employees	The average number of employees of the company over a period of one year.	**EMPL**	-	**IRI**
capital expenditure	These are the capital expenditures that a company makes in order to invest in the acquisition or modernization of fixed assets, such as buildings, factories or equipment, which participate in several production cycles.	**CAPX**	mil. euros	**IRI**

Source: Authors' own calculation.

3. Results and discussion

To determine the relationship between explanatory variables and dependent variables, we used the Pearson correlation coefficient. It measures the intensity of the link between variables and allows the identification of dependent variables that best correlate with independent variables.

Table no. 2. Correlation table of the variables used in the research

	NS	*MK*	*R&D*	*CAPX*	*EMPL*
NS	1				
MK	0.602558	1			
R&D	0.605605	0.476184	1		
CAPX	0.876503	0.551982	0.44091	1	
EMPL	0.585981	0.471673	0.531137	0.456338	1

Source: Authors' own calculation.

As can be seen in Table 2, there is a level of significance of 0.60 between R&D and net sales, which shows that there is a positive link between them. The strongest and most

positive correlation is found between capital expenditures and sales, with a correlation level of 0.87.

Investments in equipment and machinery have a dictated and strong pact on sales due to the fact that they improve the production process and facilitate the way of carrying out the activity, while also ensuring a competitive advantage.

A slightly weaker, but significant correlation is found between the number of employees and sales, the level of correlation between them being 0.58. In both econometric models to be further developed, the average number of employees has a low impact on the dependent variables. In the case of market capitalization, the correlation between it and research and development expenditures was 0.47 indicating a significant and positive correlation.

Indirectly, research and development expenditures influence the market capitalization, the companies that make public these types of investments being better seen in the capital market. The level of correlation between capital expenditures and market capitalization is 0.55.

Taking into account the fact that investments in capital expenditures lead to an increase in net sales, indirectly the company will register an increase in the share price and implicitly of the market capitalization.

In the analysis of the impact of research and development expenditures, the average number of employees and capital expenditures on net sales, the Hausman test was applied using the statistical program E views.

In order to decide which form of estimation of the model is optimal, with fixed effects or with random effects, the Hausman test, present in Table no. 3, was applied.

Table no. 3. Hausman test for model 1

Correlated Random Effects - Hausman Test
Equation: Untitled
Test period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	8.306775	3	0.0401

Period random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
R_D	4.979327	5.052737	0.000726	0.0064
EMPL	0.067380	0.063833	0.000002	0.0060
CAPX	9.745376	9.774431	0.000124	0.0092

Source: Authors' own calculation.

From the application of the Hausman test, in the first regression model resulted a value p-value = 0.0401 <0.05, showing that in this case it is preferable to apply the model with fixed effects.

In order to determine the impact of investments in research and development on economic performance, the analysis of panel data was used, the method being the one with fixed effects.

Table no. 4. The results of the regression analysis, using net sales as a dependent variable

Period random effects test equation:
Dependent Variable: NS
Method: Panel Least Squares
Date: 07/19/21 Time: 12:01
Sample: 2016 2019
Periods included: 4
Cross-sections included: 536
Total panel (unbalanced) observations: 2140

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	771.4328	227.1364	3.396341	0.0007
R_D	4.979327	0.251931	19.76462	0.0000
EMPL	0.067380	0.004794	14.05570	0.0000
CAPX	9.745376	0.137045	71.11087	0.0000

Effects Specification

Period fixed (dummy variables)

R-squared	0.842593	Mean dependent var	9333.689
Adjusted R-squared	0.842150	S.D. dependent var	24272.60
S.E. of regression	9643.582	Akaike info criterion	21.18924
Sum squared resid	1.98E+11	Schwarz criterion	21.20778
Log likelihood	-22665.49	Hannan-Quinn criter.	21.19602
F-statistic	1902.975	Durbin-Watson stat	0.232651
Prob(F-statistic)	0.000000		

Source: Authors' own calculation.

$$NS_{it} = 771.432 + \beta_1 * 4.979_{it} + \beta_2 * 0.067_{it} + \beta_3 * 9.745_{it} + \alpha_i + \varepsilon_{it}$$

When the investment in research and development increases by one million euros, there is an increase of 4.97 million euros in net sales.

This demonstrates a strong and positive impact of research and development expenditures on companies' net sales. At the same time, the connection between the two is supported by the strong correlation, having a level of 0.60. As the number of

employees increases by one, there will be an increase of 0.067 million euros in the company's net sales.
The coefficient is statistically valid. But its impact is insignificant from an economic point of view, compared to the influence of the other coefficients, so that an additional commitment would lead to an increase in annual net sales by only 67,000 euros. With an increase of 1 million in capital expenditures, ie investments in the acquisition or modernization of fixed assets, such as buildings, factories or equipment, which participate in several production cycles, there is an increase of 9.7 million euros in net sales, with a significant impact on the company's economic performance. According to the data in table 4, the coefficients related to the constant and independent variables are statistically valid, because the values presented in the student test are higher than the comparison value (critical t = 2.57, for a probability of guaranteeing results of 99%) .

Table no. 5. Indicators that support the validity of the model 1

F calculat	1896.243
F critic	0.0382
R	0.918
R square	0.8425

Source: Authors' own calculation.

According to Table no. 5, it can be seen that the calculated value of F is 1896,243, and the theoretical value of F, obtained from the tables for a significance threshold of 0.01 by 3, respectively 2140 degrees of freedom, so critical F = 0, 0382. We can conclude this idea by stating that the model is statistically valid because F is calculated > F is critical.
In the first model R^2 is 0.8427, which means that the independent variables R&D, EMPL and CAPX explain 84.27% of the variation of the companies' net sales.
In the case of analyzing the impact of research and development expenditures, the average number of employees and capital expenditures on the market capitalization, the Hausman test was applied using the Eviews statistical program. In order to decide which form of estimation of the model is optimal, with fixed effects or with random effects, the Hausman test, present in Table no. 6, was applied.

Table no. 6. Hausman test for model 2

Correlated Random Effects - Hausman Test
Equation: Untitled
Test period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	1.580609	3	0.6638

Period random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
R_D	4.041361	4.091580	0.001836	0.2412
EMPL	0.069440	0.067025	0.000004	0.2397
CAPX	4.107130	4.126956	0.000315	0.2639

Source: Authors' own calculation.

From the application of the Hausman test, in the second regression model resulted a value p-value = 0.6638> 0.05, showing that in this case it is preferable to apply the model with random effects.

In order to determine the impact of investments in research and development on stock market performance, the analysis of panel data was applied, the method being the one with random effects.

Table no. 7. The results of the regression analysis, using the market capitalization as a dependent variable

Period random effects test equation:
Dependent Variable: MK
Method: Panel Least Squares
Date: 07/15/21 Time: 12:02
Sample: 2016 2019
Periods included: 4
Cross-sections included: 536
Total panel (unbalanced) observations: 2140

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4967.155	361.3549	13.74592	0.0000
R_D	4.041361	0.400801	10.08320	0.0000
EMPL	0.069440	0.007627	9.105017	0.0000
CAPX	4.107130	0.218027	18.83774	0.0000

Effects Specification			
Period fixed (dummy variables)			
R-squared	0.395993	Mean dependent var	10075.89
Adjusted R-squared	0.394294	S.D. dependent var	19713.08
S.E. of regression	15342.12	Akaike info criterion	22.11786

Sum squared resid	5.02E+11	Schwarz criterion	22.13640
Log likelihood	-23659.11	Hannan-Quinn criter.	22.12464
F-statistic	233.0692	Durbin-Watson stat	0.098389
Prob(F-statistic)	0.000000		

Source: Authors' own calculation.

$$MK_{it} = 4967.155 + \beta_1 * 4.041_{it} + \beta_2 * 0.069_{it} + \beta_3 * 4.107_{it} + \alpha_i + \varepsilon_{it}$$

With the increase of one million in investments in research and development, there is an increase of 4.04 million euros in market capitalization.

This result demonstrates a strong impact of investment in research and development on the market value of companies. In the case of the impact of the number of employees on the market capitalization, the data show that when the number of employees increases by one, there will be an increase of 0.069 million euros, market capitalization.

In this case, too, the coefficient related to the number of employees is statistically valid, but the economic value is low.

An additional commitment would lead to an increase in market capitalization by 69,000 euros. When the capital expenditures increase by one million, there is an increase of 4.1 million euros in market capitalization, having a rather large impact of capital investments on the share price on the stock exchange.

The values of the coefficients related to model 2 are statistically validated, because the tabular value related to the student test is higher than the critical value, calculated based on a probability of 99% and 2131 degrees of freedom (critical t = 2.57).

Table no. 8. Indicators that support the validity of the model 2

F calculat	232.4115
F critic	0.0382
R	0.629
R square	0.3962

Source: Authors' own calculation.

According to table 8 it can be seen that the value of critical F remained constant, because the number of independent variables was also 3, and the number of observations also remained constant. And in the case of this model it can be said that it is statistically valid, but the share of variations of the dependent variable, expressed by variations of independent variables was reduced to 0.395, the difference of about 60% being explained based on other factors that impact market capitalization. , these can be political, economic, social, environmental, cultural, etc.

The results obtained from the application of the fixed effects model showed a positive and strong effect from investments in research and development and capital expenditures and a positive one, but slightly lower from the average number of employees.

In the case of the results obtained from the application of the random effects model, a positive effect similar to the fixed effects model was obtained, with capital expenditure having a double impact in the case of the first model.
In the first regression model that aimed to verify the impact of research and development expenditures on economic performance, and in the obtained model the independent variables explain 84.27% of the variation of companies' net sales, having a correlation coefficient between research and development expenditures and net sales of 0.60, and with an increase of one million euros in investments in research and development, net sales would increase by 4.97 million euros.
Taking into account these data, hypothesis H1 is validated.
In the case of the second regression model, it aimed to verify the impact of research and development expenditures on stock market performance, and in the model obtained the independent variables explain only 39.62% of the change in stock market capitalization of companies, with a correlation coefficient between research and development expenditures and market capitalization of 0.47, and with the increase by one million euros of investments in research and development, the market capitalization would increase by 4.04 million euros.
These data show the positive impact of research and development expenditures on capitalization, consequently validating the H2 hypothesis.

Hypothesis	Result
H1 - Research and development expenditure have a positive impact on the economic performance of companies	Hypothesis accepted
H2 - Research and development expenditures have a positive impact on companies' stock market performance	Hypothesis accepted

Conclusions

Following the study on the impact of investments in research and development on the performance of companies, it was found that there is a positive link between them, investments in innovation having a significant influence on net sales and market value of companies.
We cannot admit that the influence of innovation is absolutely decisive in the evolution of companies' performance, but it has a significant influence. This conclusion is particularly important for company executives, especially in areas where innovation is the key competitive advantage.
The study was conducted based on data collected by the research team from a number of 536 companies over a period of four years, obtaining 2140 observations. In order to eliminate possible deficiencies or inconsistencies, in future research, the emphasis will be on the influence of innovation on economic performance, a result which, in turn, influences stock market performance.
Research and development expenditures have had a positive influence on both the economic performance of companies, measured by net sales, and on stock market

performance, measured by market capitalization, which validates both research hypotheses.

As perspectives of the research approach, the collection and use of both quantitative and qualitative data will be considered, in order to measure the impact of investments in innovation on performance. The econometric model will also take into account the age and size of the companies, as well as the sector to which they belong.

In our research, we analyzed the influence of investment in research and development on the economic and stock market performance of European companies, but we did not analyze the time when innovation could have an impact on performance. This needs to be studied because the process of innovation, from investment in innovation to its results, can take a longer period of time, and can have an impact on performance, both in the year in which they take place and possibly in the second, third or even fourth year after investing in innovation. This can also vary depending on the industry. In our research, we used 536 companies in Europe, but we did not take into account the specificity of the industries in which the companies operate, being limited by this aspect. In future studies, the research will be oriented towards the action of investments in research and development on performance in several industries, being specified, both the common elements of their action and the observed differences.

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