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Article

Market Value and R&D: an analysis of companies listed on B3

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Abstract

The relationship between the companies' market value and research and development (R&D) investment is not fully comprehended. Thus, this study investigates whether greater investments in R&D increase the companies' market value by analyzing 61 companies listed on the Brazilian Stock Exchange (B3) between 2010 and 2018. Financial data were collected through the Economatica® platform, and data on R&D investment were gathered from the companies' reports to the country's securities and exchange commission (CVM). The research adopted Pearson's correlation and multiple linear regression with fixed effects and robust errors for data analysis, which were arranged in a panel. The correlation analysis indicated a positive relationship – although weak – between market value and R&D, which means that, when analyzed linearly and in isolation, the greater the investment in R&D, the greater the valuation of shares in the capital market. On the other hand, the analysis of the variables together using the regression method showed that the explanatory variable R&D has a negative impact of R$0.016 on the market value of the companies analyzed for each R$1.00 spent on R&D. In sum, the positive relationship between the companies' market value and investment in R&D has not been validated. However, the studies suggest that R&D investments contribute to the maximization of organizational performance. Future studies should explore this relationship considering the influence of the COVID-19 pandemic and should also analyze specific market segments and longer periods.

Keywords: Market value. R&D. Regression. Organizational performance. B3.

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Valor de mercado e P&D: uma análise de empresas listadas na B3

Resumo

A relação entre o valor de mercado das empresas e o investimento em pesquisa e desenvolvimento (P&D) ainda não é completamente compreendida. Nesse sentido, o objetivo deste trabalho é investigar se mais investimentos em P&D se traduziriam na valorização de mercado das empresas. Para isso, foram analisadas 61 empresas listadas na B3 entre 2010 e 2018. Foram coletados dados financeiros na plataforma Economatica® e dados relacionados com o investimento em P&D nos relatórios das empresas no site da Comissão de Valores Imobiliários. Para a análise dos dados, utilizaram-se a correlação de Pearson e a regressão linear múltipla com efeitos fixos e erros robustos dispostos em painel. A análise de correlação indicou uma relação fraca positiva entre a variável Valor de Mercado e a variável P&D. Isto é, analisados de forma isolada, os resultados indicam que, linearmente, quanto mais investimento em P&D, maior a valorização das ações no mercado de capitais. Em contrapartida, ao utilizar o método de regressão para analisar conjuntamente as variáveis, verificou-se que a variável explicativa P&D apresenta um impacto negativo de R$ 0,016 no valor de mercado das empresas analisadas para cada R$ 1,00 despendido em P&D. Conclui-se que, embora a relação positiva entre o valor de mercado das empresas e o investimento em P&D não tenha sido validada, há indicativos de que esse investimento pode contribuir para a maximização da performance organizacional. Para estudos futuros, indica-se a realização de trabalhos que levem em consideração o cenário pandêmico, assim como a análise de segmentos de mercado específicos e um período de análise maior.

Palavras-chave: Valor de mercado. P&D. Regressão. Performance organizacional. B3.

Valor de mercado e I+D: un análisis de las empresas que cotizan en B3

Resumen

La relación entre el valor de mercado de las empresas y la inversión en investigación y desarrollo (I+D) aún no se comprende completamente. En este sentido, el objetivo de este trabajo es investigar si mayores inversiones en I+D se traducirían en la valoración de mercado de las empresas. Para ello, se analizaron 61 empresas que cotizan en la bolsa de valores B3 S.A. entre 2010 y 2018. Los datos financieros se recopilaron a través de la plataforma Economatica® y los datos de inversión en I+D, de los informes de las empresas en el sitio web de la Comisión de Valores Inmobiliarios. Para el análisis de los datos se utilizó la correlación de Pearson y la regresión lineal múltiple con efectos fijos y errores robustos, que se organizaron en un panel. El análisis de correlación indicó una débil relación positiva entre las variables Valor de mercado e I+D, el resultado indica que, a mayor inversión en I+D, mayor valoración de las acciones en el mercado de capitales. Al utilizar el método de regresión para analizar conjuntamente las variables, se encontró que la variable I+D tiene un impacto negativo de R$0,016, por cada R$1,00 invertido en I+D, sobre el valor de mercado de las empresas analizadas. Aunque no se ha validado la relación positiva entre el valor de mercado y la inversión en I+D, existen indicios de que dicha inversión puede contribuir a la maximización del desempeño organizacional. Como estudios futuros, se recomienda realizar trabajos que tengan en cuenta el escenario pandémico, así como el análisis de segmentos de mercado específicos y un mayor período de análisis.

Palabras clave: Valor de mercado. I+D. Regresión. Desempeño organizacional. B3.

INTRODUCTION

According to data from B3 S.A. – Brasil, Bolsa, Balcão (B3), the Brazilian stock exchange, the stock market grew sharply in the first decades of the 21st century, with significant gains by investors who, motivated by a number of factors, began to look more closely at variable income investments. In March 2020, there were more than 1.7 million individuals with some position in stocks and, of this total, around 50% had five or more assets in their portfolios.

In 2021, the number of investors jumped to 3.8 million individuals – a 224% increase (B3, 2021a). Hence, the growing number of investors fosters research and analysis on which indicators cause stock prices to swing, thus providing an opportunity for more assertive decision-making.

Studies show that companies that invest more in research and development (R&D) achieve a higher return on equity in the United States, China, and other markets. This supports the idea that more resources invested in R&D can predict a better financial performance of investors and organizations (LU, 2020). According to Fama and French (2007), the most widely used capital asset pricing model was proposed by William Sharpe and John Lintner, known as CAPM. Through this model, it is possible to make forecasts for helping investors; however, it has limitations, and alternative ways should be considered to assess fluctuations and predict stock values.

Organizations seek to create strategies for their survival and growth (YU et al., 2018). Among these organizations, there are publicly traded companies listed on stock exchanges, which are also concerned with the return to shareholders, and one of the most adopted strategies is investing in R&D. Andreassi and Sbragia (2002), by analyzing the relationship between R&D investments and business results, showed that the capital used in R&D, for improving existing products or creating new ones, was responsible for a 37% increase in revenue in the addressed companies.

Xiang et al. (2020) assessed R&D spending data of 5,178 U.S. firms between 1980 and 2018. They analyzed the volatility between firms' financial investment in R&D and market response, and identified a strong positive answer to stock valuation. Sofronas, Archontakis and Smart (2019), by analyzing 133 European firms over 11 years, totaling 1,463 observations, also confirmed the relationship between firms' market appreciation and R&D investments. However, occasional events, like global crises, can weaken this relationship.

Corporate governance practices, such as transparency in disclosing investment data, can support the appreciation of publicly traded companies. Hence, companies that value greater data transparency tend to achieve higher returns on shares (CAIXE and KRAUTER, 2014).

In this regard, this article checked the existence of a significant relationship between R&D investment and the valuation of companies listed on B3. We sought to assess if firms that spend more in R&D tend to achieve higher market value. Therefore, the research problem led to the following question: "Do companies listed on B3 that invest in R&D and disclose their investments tend to have a higher market value?".

This paper brings contributions that can help both companies and investors. Firms can use the results to make decisions related to the allocation of resources for R&D and boost their source

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of fundraising, by attracting investors from the stock market. For investors, the paper can assist in investment decisions, as results can indicate the appreciation of their shares or the return through dividends.

The sections of the paper include a theoretical framework, which presents a discussion on the relevant topics for the research; methodological procedures, which describe the statistical and econometric tools used; the result analysis, which elucidates the calculations for the correlation and regression analyses; and final remarks, which summarize the results attained and highlight the contributions to the topic addressed, research limitations, and suggestions for future studies.

THEORETICAL BACKGROUND

Investment in research and development (R&D)

In a scenario of constant changes in global markets, especially those triggered by technological development, R&D investment is essential for the sustainability of organizations – public, private, or third sector – and nations. With the escalation of the competitive environment, the need for reinvention, in order to preserve space or ensure the survival of companies, is *sine qua non*. To this end, there are specific areas within companies that are responsible for developing ideas for new products or improving existing products (WANG and ZHANG, 2020).

Schumpeter (1942) argued that the higher organizations' investment in R&D, the higher their return. Taking it into consideration, companies that allocate greater financial and human resources to work on new ideas will have a greater return on these investments. When it comes to resources for R&D, there is a trade-off to consider: companies carry out other activities that also need resources, such as production and the expansion of the physical structure, among others.

In a study of R&D funding in small and large companies, Hall (2002) concluded that small companies have high capital costs that are minimally controlled by venture capital. In large companies, on the other hand, this relationship between capital cost and risk is mixed and, for the most part, there is a preference for financing these R&D activities with own resources. The author also observes that, in countries with a poorly developed capital market, there are limits for venture capital as a solution to the funding gap in companies' R&D actions.

According to Rocha et al. (2016), who associated statistical performance variables with companies' increased sales, there was a positive relationship between R&D investment and their financial results. For every 1% more invested in R&D, there was an increase of 0.20% to 0.25% in sales. In technology intensive firms, this increase in sales can reach 0.40%. Hence, there is a potential positive impact when relating R&D investment with positive results in sales and financial indicators.

In a study that related the disclosure of Brazilian companies' R&D expenditures with shares listed on B3, Adriano et al. (2020) observed that the mere release of R&D data did not imply appreciation in the value of companies' shares, confirming Hungarato and Lopes (2008). They also noted that companies with high technological intensity describe, in their accounting reports,

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resources allocated to R&D as investments, while firms with low technological intensity treat these resources as expenses.

The results of Adriano et al. (2020) and Hungarato and Lopes (2008) are relevant for our paper, because their hypothesis is opposite to ours; we argue that more investments in R&D stimulate companies' valuation. In addition, on the disclosure of R&D expenditures, Silva and Reis (2012) mention limitations in the analysis of companies, precisely because of the low disclosure of information on these investments. Therefore, there may be companies listed on B3 that invest in R&D, but do not release these data or do it partially. Those that reveal their investments, both in R&D and in other sectors, may contribute to investors' decision-making and bring greater transparency.

To understand the scenario of constant changes in the market, this study was based on updated data on the relationship between R&D investment, stock valuation, and the consequent appreciation of the organization.

The survival of organizations and their financial sustainability depend more and more on innovative processes, since they operate in an increasingly competitive environment, where the decision to allocate or not resources in R&D can be decisive for their financial results in the market, positive or negative (DAMANPOUR, 1991).

Impact of R&D investment on market value

According to Ballester, Garcia-Ayuso and Livnat (2003) and Crisóstomo and González (2006), investors consider companies' capital invested in R&D as an asset before the market, since these investments can lead to growth and more return on traded shares. Accordingly, Chan, Martin and Kensinger (1990) showed a positive impact of 1.32% on the share value of high technology companies, relating them to the announcement of an increase in R&D investment. This scenario was kept even with profit decrease of the analyzed organizations, as opposed to the results of Adriano et al. (2020) and Hungarato and Lopes (2008). These findings indicate that investors evaluate companies' strategic applications, not only the short-term gains, at the time of investment decision.

Izidoro et al. (2020), when examining the relationship between R&D investment and stock returns, in a sample of 23 publicly traded companies of the electric power segment, listed on B3 between 2011 and 2018, concluded that the capital used in R&D favored the appreciation of their shares. The study also showed that the positive impact on firms' shares took, at least, three years to materialize, suggesting that the return on R&D investments – in particular, in share valuation – was long-term; that is, it did not show immediate effects – in the short or medium term – on the valuation of companies' shares.

Gupta, Banerjee and Onur (2017) mention that, in developing countries, R&D investments result in a positive impact on stock valuation, especially in industries with a lower degree of competitiveness. In developed countries, the positive impact could be observed at all competitive levels. Gharbi, Sahut and Teulon (2014), in an empirical study, showed a strong positive relationship between capital allocation in R&D and the appreciation of shares of technology-intensive companies.

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Similarly, Marçal and Flach (2020), when analyzing R&D investments made by five information technology (IT) companies listed on B3, between 2010 and 2018, found a positive relationship between this type of investment and companies' market value. However, they highlight that large amounts of capital invested in R&D do not necessarily result in the valuation of companies' shares, when compared to their direct competitors; also, less investment in R&D does not inevitably lead to lower market value of companies' shares.

For Adriano et al. (2020), there is no consensus in the literature concerning the positive and sustainable impact of R&D investment on companies' market value. This understanding is supported by Chan, Martin and Kensinger (1990), who concluded that non-technology-intensive firms showed a negative relationship between R&D investment and share value, contradicting the results of studies that addressed similar analyses. Chan, Lakonishok and Sougiannis (2001) also found no evidence suggesting that R&D investment generated future returns in the shares of the companies they studied. In addition, Espíndola, Santos and Vasconcelos (2018) analyzed the amount invested in R&D and the market value of 440 publicly traded companies listed on B3, between 2011 and 2015, and found no increase in their market value resulting from those investments.

Nunes, Serrasqueiro and Leitão (2012) argue that capital invested in R&D results in the optimization of organizational performance, since companies become more capable of innovating and launching products and services in the consumer market (JIN et al., 2022), potentially achieving valuation of their shares. However, as Kim et al. (2021) mention, R&D investment is usually associated with higher levels of uncertainty, which may influence the decisions of capital market investors. In addition, R&D intensive firms tend to represent a higher risk for the decision maker that looks for higher returns, when compared to firms that are not R&D intensive (ABDOH and LIU, 2021).

Given the relationship between R&D investment and its potential impact on firms' market value; considering that R&D investments intend to enhance firms' innovation capacity (TUNG and BINH, 2022); that this capacity is a vector of economic growth for organizations (SCHUMPETER, 1934; KOGAN et al., 2017); and that R&D investment is an effective variable for explaining stock returns (KIM and PARK, 2020), we developed the following research hypothesis:

H_0: The more a company invests in R&D, the higher its market value tends to be.

METHODOLOGICAL PROCEDURES

Data for this study were collected from publicly traded companies listed on B3, through the Economatica® platform. Reports of R&D investments were received from the Brazilian Securities and Exchange Commission (CVM). There were 61 companies that fit the analysis criteria. For data assessment, we used software Stata®, version 14.1.

We defined the period of companies' data analysis (from 2010 to 2018) according to the changes in the accounting statement structure of the Balance Sheet and the Income Statement, in line with the International Financing Reporting Standards (which replaced the International Accounting

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Standards in 2001), thus ensuring the harmonization of reports and information, and the reliability of interpretations and decision-making (RAMOS et al., 2015).

In addition to information on R&D investments, we analyzed the financial indicators periodically published for investors, in order to understand the market value of these companies and relate it with the variables examined. As dependent variable of this study, we defined the market value of companies, based on the definition by Brealey et al. (2002), which considers the price of each share multiplied by the number of shares in the market. We also added other companies' assets that can affect their size, such as short and medium-term debentures, funding, advance on exchange contracts, and short-term investments.

The definition of independent variables was based on other studies that considered the companies' market value, R&D investments, and specific variables, according to the proposal of each study. We adopted the variables chosen by Lu (2020), Xiang et al. (2020), and Yu et al. (2020), who used the market value and the investments in R&D of the companies they analyzed. We took as assumption the paper by Caixe and Krauter (2014), relating data transparency practices, through corporate governance policies, with companies' market value. We assumed a positive relationship between them, and considered reasonable the hypothesis that companies that disclose their R&D data can achieve a higher market appreciation.

In addition to Caixe and Krauter (2014), other studies have also explored and confirmed the relationship between corporate governance practices and the disclosure of data on R&D investments (BLACK, JANG and KIM, 2006; SILVEIRA, BARROS and FAMÁ, 2006; AMMANN, OESCH and SCHMID, 2011). These papers were also used to define the variables and hypotheses of Caixe and Krauter (2014). Therefore, companies that disclose their data on R&D investments may achieve more appreciation of their market value, that is, better market response to these practices (HUANG et al., 2022).

We used the following regression equation:

$$VM = \beta 0 + \beta 1.\text{PED} + \beta 2.\text{TAM} + \beta 3.\text{ROE} + \beta 4.\text{LIQ} + \beta 5.\text{ENDIV} + \text{E}$$

Where:

a) VM = Market Value / Total Asset. Market value is represented by: Quotation × Total Shares + Short-term (CP) and Long-term (LP) Debentures + CP and LP Financing + Advances on Exchange Contracts – Cash and Short-term Investments. Dependent variable.
b) PED = R&D Investments / Total Asset. Variable of interest.
c) TAM = Log of Total Asset. Control variable.
d) ROE = 100 ∗ p/P ∗ √ (n/N * v/V). p = number of days with at least one trade of the share in the analyzed period; P = total number of days in the analyzed period; n = number of trades with the share in the analyzed period; N = number of trades with all shares in the analyzed period; v = cash volume traded with the share in the analyzed period; V = cash volume traded with all shares in the analyzed period. Control variable.
e) LIQ = Net Profit / Average Net Equity. Control variable.
f) ENDIV = (Long-term liabilities / Total Liabilities)*100. Control variable.

g) E represents error.
h) $\beta 0$ represents the intercept.
i) $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$ e $\beta 5$ represent the angular coefficients.

As statistical basis, we used Gujarati and Porter's (2011) study, which better analyzes and measures the effects of variables that, in some cases, cannot be observed in a cross-section or in time series. For the analyses, we used multiple linear regression, relating a dependent variable with exploratory variables; in this model, we estimate the value of the dependent variable under the effects of exploratory variables, through a deviation to a mean value.

To define the best model, we carried out Breusch-Pagan tests, a random model analysis, and a Hausman test, which helped choosing between fixed and random effects and used robust errors to handle heteroscedasticity and autocorrelation problems (GUJARATI and PORTER, 2011). In addition to these authors, we also used Wooldridge (2006) as a reference for the tests.

To mitigate the influence of discrepant values in the sample, we used the Winsorize method, which allows replacing the extreme values of a set by the percentage value of each extremity – in this paper, we used the 5% level. Before doing the robust tests, we made some preliminary assessments, such as the variance inflation factor (VIF), to test for multicollinearity between the variables, the Wooldridge test, to examine autocorrelation, and the Wald test, to check for the presence of heteroscedasticity.

RESULTS AND ANALYSES

The 61 companies analyzed belong to different market segments (Figure 1 and Annex 1), highlighting those of electric power (29.51%), oil exploration, refining, and distribution (6.56%), steel industry (6.56%), and textiles, clothing, and footwear (6.56%). To define each company's market segment, we used the Sector Classification of Companies Listed on B3, prepared and provided by B3 (2021b). To determine that classification, B3 (2021c) considered the contribution of their products or services for their revenues.

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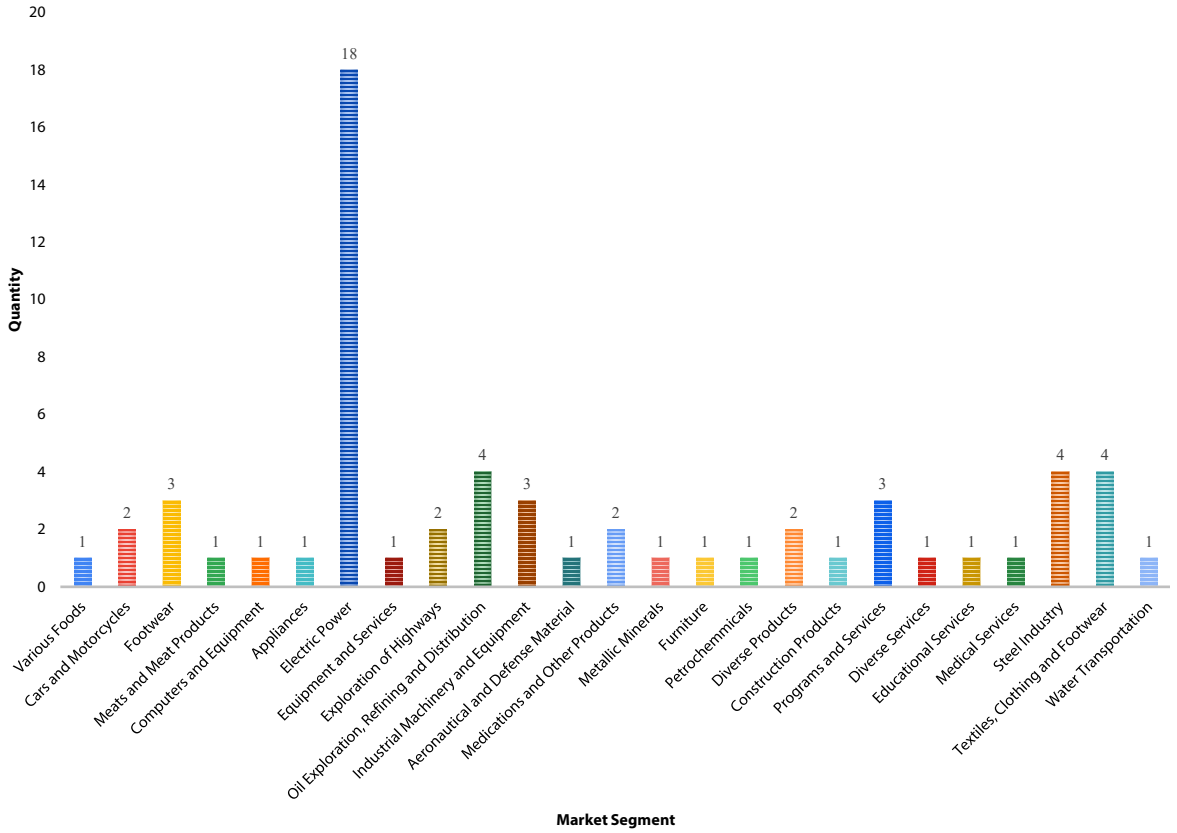
FIGURE 1

Distribution of the analyzed companies by market segment



Source: Elaborated by the authors based on the Sectorial Classification of Companies traded on B3 (2021b).

Table 1 shows that the dependent variable (VM) has 528 observations. The mean value of the shares is R$ 0.87, with a standard deviation of R$ 0.75 in the share values; the lowest value share corresponds to R$ 0.10, and the highest to R$ 2.87. As for the explanatory variable (PED), there are 387 observations and an average invested value of R$ 6.24 million.

TABLE 1

Descriptive statistics of the sample and variables used

Variable	Observation	Mean	Std. deviation	Minimum	Maximum
VM	528	0.8745197	0.7536332	0.1036427	2.870736
PED	387	6.241711	7.755476	0.4833971	31.12574
TAM	544	8.88468	1.573877	5.628531	11.30811
ROE	483	0.0906242	0.1589051	-0.2618725	0.4132596
LIQ	549	0.3816104	0.4953861	3.14e-06	1.709981
ENDIV	544	58.01773	19.19143	22.41187	90.01377

Source: Elaborated by the authors.

Through the correlation analysis between the variables (Table 2), we found a weak positive relationship, 0.33 (SANTOS, 2018), between VM and PED variables. This result indicates that as the amount invested in R&D increases, the market value of firms also increases. Initially, this value confirms the validation of our hypothesis.

The correlation between VM and TAM variables, in turn, shows a weak negative relationship, of 0.39, which indicates that, linearly, the size of the organization negatively affects its market value. The correlation between variables VM and ROE shows a weak positive relationship, of 0.40, suggesting that the higher the indicator investment over equity, the higher the market value of the organizations studied. The correlation between VM and LIQ variables shows a negative relationship, of 0.10, that is, the liquidity of the organizations decreases their market value. Finally, the correlation between variables VM and ENDIV points to a weak negative relationship, of 0.43, suggesting that the indebtedness of companies affected negatively their market values (SANTOS, 2018).

TABLE 2

Correlation matrix

	VM	PED	TAM	ROE	LIQ	ENDIV
VM	1.0000					
PED	0.3336*	1.0000				
TAM	-0.3940*	-0.4734*	1.0000			
ROE	0.4036*	-0.0211	-0.0128	1.0000		
LIQ	-0.1083*	-0.2537*	0.7092*	0.0111	1.0000	
ENDIV	-0.4370*	0.0405	0.1651*	-0.1376*	0.0465	1.0000

*Statistically significant values at 5%.
Source: Elaborated by the authors.

Based on the regression model (Table 3), the explanatory variable PED, significant at 5%, has a negative influence of R$ 0.016 in the market value of the companies analyzed (VM, dependent variable), for each R$ 1.00 spent on R&D. This indicates that, when a company increases R&D investment, its market value tends to decrease. This result suggests that the companies analyzed: a) failed to position themselves consistently before investors, since the amounts spent on R&D did not result in the effective exploration of the potential markets for which the products or services were developed (SUNG, PARK and YOO, 2019); b) investors may have perceived the risk inherent to R&D activities as high (KIM et al., 2021), which unbalances the cost-benefit ratio negatively; or c) investors did not achieve the expected gain in the years considered by the study, or in previous years (ABDOH and LIU, 2021).

TABLE 3

Regression model

VM	Coefficient	Std. Deviation	t	P > t	[95% Confidence Interval]	
PED	-0.0165777	0.0071939	-2.30	0.025	-0.0309676	-0.0021878
TAM	-0.3481472	0.1449598	-2.40	0.019	-0.63811	-0.0581845
ROE	0.3762	0.0684558	5.50	0.000	0.2392679	0.5131321
LIQ	1.626999	0.5889505	2.76	0.008	0.4489222	2.805075
ENDIV	-0.012475	0.0029677	-4.20	0.000	-0.0184114	-0.0065387
_CONS	4.257837	1.232856	3.45	0.001	1.791758	6.723917

Source: Elaborated by the authors.

In addition, this result may stem from the fact that innovations resulting from R&D investments, in general, require a long time to effectively consolidate in the market (SUNG, PARK and YOO, 2019). Therefore, the positive impact on share valuation and positive cash generation occurs in the long term (LI, LYTVYNENKO and PHILIPPOFF, 2021; IZIDORO et al., 2020).

Likewise, based on the proposed model, the size of the company (TAM) affects negatively the amount invested in R&D (PED), significant at 5%, in the value of 0.3481. One of the possible causes of this result is that disbursement for R&D-related projects involves human resource costs, such as hiring, training, and retention, as well as costs with supplies and infrastructure, which facilitate the R&D process (CHO and LEE, 2020).

Regarding the ROE variable, there is a positive influence on the company's value, significant at 1%, in the value of 0.37. This result is consistent with Petcharabul and Romprasert (2014), who found a positive and significant relationship between stock appreciation and ROE. This result indicates that ROE is important for investors' decision making (OMRAN and RAGAB, 2004), since it can predict the future return of traded stocks (ELLEUCH, 2009).

As for liquidity (LIQ), the indicator influences positively the market value of the company, significant at 5%, at 1.62, which can be justified by its relevance for the investor; through the analysis of liquidity, it is possible to anticipate which stocks should have more return (CHOI and SIAS, 2012).

Through the ρ (rho) test (Table 4), we found that the set of independent variables enable explaining around 80% of the variability of the response variable, indicating that the model has an adequate fit (GENEST, NEŠLEHOVÁ and RÉMILLARD, 2013).

TABLE 4

P test (rho)

SIGMA_U	0.56682649	Within limits	0.3000
SIGMA_E	0.28624626	Between the limits	0.3414
RHO	0.79679814	General	0.3319

Source: Elaborated by the authors.

The VIF test (Table 5) shows no multicollinearity between the variables of the proposed model, since its value was less than 5, suggesting that the estimates of the regression parameters (Table 3) are not questionable (LIN, FOSTER and UNGAR, 2011).

TABLE 5

VIF, Wooldridge, and Wald tests

F	0.0000
AVERAGE VIF	1.75
WOOLDRIDGE	0.0000
WALD	0.0000

Source: Elaborated by the authors.

The Wooldridge test (Table 5), used to measure the autocorrelation between variables, showed a positive result, as the value found for the test was statistically significant at 1%, confirming the null hypothesis (WOOLDRIDGE, 1991). As for the Wald test (Table 5), which checks the presence of heteroscedasticity, it concluded that data are heteroscedastic (significant at 1%), confirming the null hypothesis (CARNEIRO, 2012). Hence, for the treatment and correction of autocorrelation and heteroscedasticity, the robust errors were used (GUJARATI and PORTER, 2011; GUIRADO, 2019).

In brief, through the correlation analysis between the proposed variables, there is a positive relationship between the market value of the companies analyzed and the amount invested in R&D. That is, R&D investments generate positive gains for companies' valuation. However, when the variables are analyzed together, through regression, we found an inverse relationship. This means that, when a company increases R&D investments, its market value tends to decrease.

Therefore, the hypothesis raised – the more a given company invests in R&D, the higher its market value tends to be – was not confirmed. The results of the regression model adopted, which analyzed together the variables indicated in this paper, showed a negative impact of R$ 0.016 on the market price of the companies, for each R$ 1.00 spent on R&D.

FINAL REMARKS

This paper investigated the relationship between the market value of companies and their investment in R&D. We analyzed 61 companies listed on B3, between 2010 and 2018. After studying companies' financial data, available on the Economatica® platform, and the information on R&D investments, available on the CVM website, and using descriptive statistics, correlation analysis and regression with panel data, we could not confirm the research hypothesis.

Through correlation analysis, we found a weak positive relationship (SANTOS, 2018) between VM and PED variables. Analyzed separately, the result indicates that the more investments in R&D, the higher the valuation of shares in the capital market. The same relationship was found for the ROE variable. By contrast, variables TAM, LIQ, and ENDIV showed a negative relationship when assessed separately with the VM variable. As they decrease, VM increases. Therefore, corroborating Chan, Martin and Kensinger (1990), Izidoro et al. (2020), Gupta, Banerjee and Onur (2017), and Marçal and Flach (2020), we found a positive relationship between the market value of the analyzed companies and their R&D investment.

Although the result of the correlation shows a positive association between market value and R&D investment, when using the regression method to analyze the variables proposed by the model together, we found that the explanatory variable PED has a negative impact of R$ 0.016 for each R$ 1.00 spent in R&D, on the market value of the companies (VM). This result indicates that, when a firm increases the amount invested in R&D, its market value tends to decrease. This suggests that the results from R&D investments, in general, require a long time to effectively consolidate in the market (SUNG, PARK and YOO, 2019).

The conclusions on the regression model are supported by Chan, Lakonishok and Sougiannis (2001) and Espíndola, Santos and Vasconcelos (2018): there is no evidence of future returns for companies' shares resulting from R&D investment. Furthermore, variables TAM and ENDIV affect negatively firms' market value. By contrast, variables ROE and LIQ affect their value positively.

In addition, this paper contributes to understanding the relationship between companies' market value and R&D investment, by using five variables inherent to organizations that trade their shares in the capital market.

As limitations of the research, we highlight the sample size (61), the lack of information on R&D investment by some companies, and the disproportional number of companies in the electric power segment, which is compelled, by specific state regulation, to invest in R&D (ESPÍNDOLA, SANTOS and VASCONCELOS, 2018).

We suggest future research that takes into consideration the pandemic scenario triggered by COVID-19. We also suggest applying the proposed model to specific market segments, for a longer period of analysis, and other financial, macroeconomic, and socioeconomic variables and indicators.

Finally, although the hypothesis raised in this paper was not validated, it is healthy to consider that R&D investment can lead companies to innovate (JIN et al., 2022), thus generating potential gains in organizational performance (NUNES, SERRASQUEIRO and LEITÃO, 2012), sustained growth, and reducing unwanted impacts of crises and recessions, making them more competitive (STEFANI et al., 2020; TUNG and BINH, 2022). In addition, as mentioned by Kim et al. (2021),

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R&D investments can influence investors' decision, given their high degree of uncertainty on future earnings. However, the return of R&D investment on stock appreciation is long-term. Therefore, it is not reasonable to expect immediate or guaranteed results in advance (YU et al., 2020; IZIDORO et al., 2020; CHAN, LAKONISHOK and SOUGIANNIS, 2001; LI, LYTVYNENKO and PHILIPPOFF, 2021).

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ANNEX 1

BOX 1

Companies analyzed and their market segments

Company	Segment	Company	Segment	Company	Segment	Company	Segment
Alpargatas	Footwear	Copel	Electric Power	Gerdau Met	Steel industry	Metal Leve	Cars and Motorcycles
Ampla Energia	Electric Power	Cosan	Oil Exploration, Refining and Distribution	Grendene	Footwear	Metalfrio	Industrial Machinery and Equipment
Anima	Educational Services	Cosern	Electric Power	Guararapes	Textiles, Clothing and Footwear	Petrobras	Oil Exploration, Refining and Distribution
Arezzo Co.	Textiles, Clothing and Footwear	CPFL Energia	Electric Power	Hypera	Medications and Other Products	Portobello	Construction Products
B2W Digital	Diverse Products	Dtcom Direct	Diverse Services	Inds. Romi	Industrial Machinery and Equipment	Positivo Tec	Computers and Equipment
Biomm	Pharmaceuticals and Other Products	Eletrobras	Electric Power	Iochpe-Maxion	Cars and Motorcycles	Rede Energia	Electric Power
Braskem	Petrochemicals	Embraer	Aeronautical and Defense Material	Kepler Weber	Industrial Machinery and Equipment	Sid. Nacional	Steel Industry
BRF S.A.	Meats and Meat Products	Enauta Part	Oil Exploration, Refining and Distribution	Le Lis Blanc	Textiles, Clothing and Footwear	Sinqia	Programs and Services
CCR S.A.	Exploration of Highways	Energias BR	Electric Power	Light S/A	Electric Power	Totvs	Programs and Services
CEEE-GT	Electric Power	Energisa	Electric Power	Linx	Programs and Services	Tran Paulista	Electric Power
Cemig	Electric Power	Eneva	Electric Power	Log-In	Water Transportation	Triunfo Part	Exploration of Highways s
Cesp	Electric Power	Engie Brasil	Electric Power	Lojas Americanas	Diverse Products	Ultrapar	Oil Exploration, Refining and Distribution
Cia. Hering	Textiles, Clothing and Footwear	Equatorial	Electric Power	Lupatech	Equipment and Services	Unicasa	Furniture
Coelba	Electric Power	Fleury	Medical Services	M.DiasBranco	Various Foods	Usiminas	Steel Industry
Coelce	Electric Power	Gerdau	Steel industry	Magaz. Luiza	Appliances	Vale	Metallic Minerals
						Vulcabras	Footwear

Source: Elaborated by the authors based on the Sectorial Classification of Companies traded on B3 (2021b).

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