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Do Investments in Innovation and Quality Management Systems Ensure Superior Financial Performance? A Quantitative Study of Brazilian Publicly Traded Companies

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ABSTRACT

Investments in innovation and quality management systems have long been presented as tools that can boost organizational performance. In Brazil, empirical, systematic, and rigorous research on such relations on such relations is still scarce. Given this context, this study sought to verify, using multiple linear regressions, how investments in innovation, and adoption of the six sigma methodology and ISO 9001 certification, impacted the financial performance, in terms of profitability, of the 101 Brazilian publicly traded companies comprising the study sample in fiscal year 2019. Regression results shows evidence that Brazilian publicly traded companies are having little success in regards to financial results by their six sigma efforts, and that R&D efforts and ISO 9001 certification exert positive and significant impact on profitability, via the ROA index. The interaction between ISO 9001 and R&D came close to significance, indicating a possible synergistic effect to be tested in future studies. Besides contributions to the entrepreneurial field, aiding companies to direct their efforts toward initiatives capable of positively impacting profitability, such findings also help advance academic knowledge.

KEYWORDS

Innovation, Quality Management Systems, Performance

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1. INTRODUCTION

Investments in innovation and quality management systems have long been presented as tools to boost organizational performance around the world. Innovations in general are those which help create and disseminate new knowledge, allowing for economic expansion and development of new products and production methods.

Despite recent publications worldwide that pointed to positive (Alkunsol et al., 2019; Latan et al., 2020; Lamine & Kaouthar, 2018; Uluskan et al., 2017), non-significant (Oprime et al., 2019; Dos Santos et al., 2016; Galetto et al., 2017), and negative (Dall'Agnol, 2020; Yoo et al., 2019; Xu et al., 2019) impacts on organizational performance associated with the joint or independent adoption of quality management systems and investments in research and development, we see very little empirical, systematic, and rigorous research investigating these relations. Besides, most of the recent quantitative articles published on the topic were based on respondents' opinions, without analyzing financial and/or accounting data.

In Brazil, studies on the relationship between investments in innovation and the adoption of quality management systems, focusing on six sigma and ISO 9001 standards, are even scarcer and more methodologically fragile, than those in the Europe and the United States. One such example is the work published by Dall'Agnol (2020), who used an unusual proxy – "average age of fixed and intangible assets" –, disregarding R&D expenses, to measure innovation effort; and Oliveira et al. (2019), who assigned zero values to R&D investments, when these were not published in explanatory notes, and without directly consulting the companies.

Given this scenario, this paper seeks to verify how investments in innovation and adoption of the six sigma methodology and ISO 9001 certification impact the financial performance, in terms of profitability, of Brazilian publicly traded companies.

Due to the nature of our research question and the gap identified by a literature review, we defined and tested five hypotheses using multiple linear regressions. Results show evidence that the Brazilian publicly traded companies studied are having little success in regards to financial results with their six sigma efforts, and that R&D investments combined with ISO 9001 exerted a synergistic, positive interaction effect on the Net Margin variable, and that R&D investments associated with six sigma had a synergistic, or negative interaction effect.

Besides contributing to the business field, helping companies direct their efforts towards initiatives capable of positively impacting profitability, such findings have also contributed to advancing Brazilian academic knowledge, since the literature search undertaken found no academic articles whose samples comprised organizations headquartered in Brazil, and that jointly investigated the relations between the three constructs analyzed here, much less using a quantitative approach based on financial and accounting data, that is, not based on respondents' opinion.

2. THEORETICAL FRAMEWORK

This chapter presents the three core and guiding constructs of this research: quality management systems, innovation, and performance.

2.1. QUALITY MANAGEMENT SYSTEMS

Considering the scope of this study, the next sections briefly address the six sigma and ISO 9001 quality management systems.

2.1.1. Six Sigma and ISO 9001

Brazil took over ten years to first implement the six sigma methodology, which emerged at Motorola in 1987 (Werkema, 2012) and aims to reduce variation in production by eliminating defects to a very low level, using various quality tools for its disciplined and highly quantitative implementation. Each phase of the DMAIC (Define, Measure, Analyze, Implement, and Control) cycle employs specific statistical tools that are chosen based on the needs of each project. Several organizations that claim to use the six sigma methodology actually use primarily non-complex tools to develop their projects, especially those located in Brazil, for lack of familiarity and technical knowledge on the use of tools classified as complex (Werkema, 2012; Antony & Desai, 2009; ASQ, 2021; Pulakman & Vogues, 2010).

While several studies have reported huge financial savings from adopting the methodology, others suggest that its benefits do not outweigh the costs and efforts required for its proper implementation (Antony et al., 2019; Jesus et al., 2016).

Establishing criteria for a quality management system to ensure conformity of products and services and facilitate transactions in international trade, ISO 9001 seeks: prevention of non-conformities, continuous improvement, and focus on customer satisfaction (ISO, 2021).

Since its first edition in 1987, the ISO 9001 Standard has been revised five times, incorporating elements of process management and continuous improvement, with the last update occurring in 2015 (ISO, 2021). Importantly, obtaining the ISO 9001 certification does not necessarily guarantee the quality of the final product or production process, but rather standardization, as wrell as facilitating and meeting export and import criteria between companies from different countries (Castello et al., 2019). Besides, the quality system requirements developed by ISO do not dictate how they should be met in any particular organization, seeking to make its implementation flexible and respect the cultural and business specificities of each organization (Ingason, 2015)

The next section will address the second guiding construct of this research, "innovation."

2.2. INNOVATION

According to the Oslo Manual (2018), innovations assume adoption or development of new or significantly improved products, goods, services, processes, marketing methods, or business practices to improve organizational performance and increase productivity (Damanpour, 2014).

Considering that organizations can choose to develop their own innovations (alone or in cooperation with other organizations) or acquire innovations from third parties, the Oslo Manual defines some innovative activities, such as R&D (OECD, 2021). According to the manual, R&D activities include the following properties: basic or applied research to acquire new knowledge or modify existing techniques, development of new concepts for products, processes or methods seeking to estimate whether they are feasible, and may include development, testing, and additional research to modify designs and/or technical functions (OECD, 2021).

The next section very briefly addresses the third guiding construct of this research: "performance."

2.3. ORGANIZATIONAL PERFORMANCE

Organizational performance can be analyzed using several approaches (Kaplan & Norton, 1992), such as by measuring profitability, costs, growth, and efficiency (Foster, 2007). Ross et al. (2015), on the other hand, argue that the ROA, ROE, and Net Margin (NM) indexes are the most well-known, and used for measuring profitability, and are intended to measure the efficiency with which companies use their assets and manage their operations, that is, their financial performance.

The Net Margin index is calculated by the ratio between net income and sales revenue, representing how much percentage net income is generated for each monetary unit of sales. The ROA (Return on Assets) index is calculated by the ratio between net income and total assets of the company, measuring net income per monetary unit of assets. The ROE (Return on Equity), index, in turn, is calculated by the ratio between net income and the company's total equity. It measures how shareholders have fared during the year, and "is the true measure of net income performance" (Ross et al., 2015).

2.4. PUBLICATIONS RELEVANT TO THE CONCEPTUAL MODEL

This section discusses and presents academic papers retrieved from the Web of Science, Scopus, and Emerald databases, containing the following expressions in their tiles: "innovation and performance," "six sigma and performance," "six sigma and innovation," "ISO 9001 and performance" and "ISO 9001 and innovation." We prioritized articles published in the last 5 years (2016 - 2020) and with a Qualis CAPES B2 or higher, considering the assessment area "public and business administration, accounting sciences and tourism," quadrennium 2013-2016.

2.4.1. Publications on innovation and performance

Wang (2019) found a positive association between radical innovation and performance in small and medium-sized companies. Tung and Binh (2021) revealed that investments in R&D positively impact revenues, profits, return on assets (ROA), and return on equity (ROE). Dall'Agnol et al. (2020) showed that companies with higher profitability invest less in innovation, a result that deviates from common sense, therefore highlighted by this literature review. Caldas et al. (2019), in turn, by using linear regressions in a sample of 890 Italian industries, showed that spending on intrasectoral innovation and collaboration positively affects organizational performance.

Almeida et al. (2019) investigated how R&D investments influence the performance measures of "sales" and "operating profit" and stated that R&D investments positively influence sales and operating profit of firms as a whole. Yoo et al. (2019), on the other hand, found that R&D investments differentially affect future performance (measured using ROA proxy) and sustainable growth according to the life cycle of firms. Dai et al. (2019) showed that firms oriented towards development activities benefit from increased profitability, and that those oriented towards research activities show higher productivity gains. Xu et al. (2019) revealed that R&D investments showed no significant relationship for large firms, and negatively impacted the financial performance of small companies.

Ostadhashemi and Fadaei Nejad (2019) investigated the moderating role of R&D spending structure on accounting performance and market value of firms, using multivariate regression model and panel data analysis. Results indicated a significant positive relationship between R&D investments and its moderating effect on performance increase. Conversely, Hungarato and Teixeira (2012) found no statistically significant relationship between the two.

Luo et al. (2018) specifically researched medical biotechnology industries located in Shanghai, with the results showing significantly positive correlations between R&D spending and patent rights with financial performance and growth. The quantitative study by Lome et al. (2016), in turn, concluded that firms which devoted considerable resources to R&D activities performed significantly better during the 2009 financial crisis than those that did not.

Saunila et al. (2014) confirmed evidence of significant relationship between innovation capability and company performance in the presence of performance measurement. Camisón and Villar-López (2014) showed that organizational innovation capability favors the development of technological innovation capability, and that both lead to superior organizational performance.

Walker et al. (2015) integrated the empirical findings of 52 independent samples drawn from 44 academic papers by means of support score and meta-analysis – for complementarity and reliability. The results of both procedures showed that managerial innovations positively impact organizational performance.

Rocha et al. (2018) analyzed the contribution of R&D investments to sales growth for 2,000 firms, suggesting that R&D investments support higher sales growth, especially for the best-performing firms, or those located at the upper end of sales distributions. Iandolo and Ferragina (2019), in turn, collected evidence that firms with "persistent efforts" at innovation and exporting generate better productivity outcomes than those classified as having "non-persistent efforts".

Finally, using correlation analysis, Morbey and Reithner (1990) investigated the relationship between R&D investments intensity and the increase in sales, productivity, and profitability in a sample of 727 companies. Results revealed a direct relationship between R&D intensity and subsequent sales growth, but no direct relationship between R&D investments intensity and growth in profit margin (profitability).

2.4.2. Publications on quality and performance management systems

Alkunsol et al. (2019) investigated the effects of lean six sigma project implementation on the performance of Jordanian pharmaceutical manufacturing organizations, finding thatdata collected from managers and subjected to correlation and multiple regression analyses for hypothesis testing revealed strong correlation between lean six sigma project implementation and business performance. Oprime et al. (2019) investigated, by means of statistical analyses, specific characteristics of six sigma projects as fostering innovations (incremental and radical) and financial performance in projects. Results showed no statistical evidence that innovations affect the financial performance of projects, but the adoption of six sigma showed a positive relationship with project performance.

In a broader perspective on QMS, Lamine and Lakhal (2018) found a positive impact of TQM and Six Sigma adoption on organizational performance. Latan et al. (2020), by means of structural equation modeling, revealed a positive relationship between "continuous innovations" arising from QMS and performance. Importantly, the results obtained by Lamine and Lakhal (2018), Latan et al. (2020) and Alkunsol et al. (2019) were based on respondents' perceptions about organizational performance and not on financial and/or accounting data.

Uluskan et al.'s (2017) quantitative analysis suggested that performance seems to be favorable and directly influenced by the success of implementing six sigma. Pavol (2016), in turn, by means of correlation analysis, found an insignificant effect between ISO 9001 standards adoption, improvement in business results, and cost reduction. Whereas the quantitative study by Galetto et al. (2017) failed to confirm a significant positive relationship between ISO 9001 certification and corporate performance.

In a longitudinal study, Foster (2007) revealed a statistically significant relationship between six sigma adoption and free cash flow per share, EBITDA, and asset turnover. However, no statistically significant relationships were found between six sigma adoption and the variables ofsales revenue, ROA index, ROI index, and total assets. Ertürk et al. (2016), in turn, analyzed, through interviews, the effects of six sigma adoption by companies producing white goods in Turkey on performance indicators, and pointed to a significant improvement in the companies' performance indicators in several items.

Aba et al. (2015) investigated the impact of ISO 9001 certification on the performance of ISO 9001 certified US firms, including one year prior to certification, the year of certification, and the three fiscal years after certification. Statistical analyses showed a significantly better performance compared to the year before certification and also that certified firms performed better than non-certified firms. Based on a Likert scale questionnaire, Ilkay and Aslan (2012) compared the performance of ISO 9001 certified and non-certified small and medium-sized enterprises in Turkey, and found no statistically significant differences between the certified and non-certified companies in terms of performance.

Shafer and Moeller (2012) investigated the impact of six sigma adoption on corporate performance and found evidence that, overall, adopting the process positively impacts organizational performance. Lastly, Swink and Jacobs (2012) evaluated the operational impacts of six sigma adoption by means of an event study, which revealed positive impacts between six sigma adoption and the ROA index (a proxy used to measure profitability), and small improvements in sales revenues.

2.4.3. The Brazilian context

The literature search performed found no academic articles that sought to jointly analyze the relationships between the three constructs: innovation, quality management systems, and financial performance using a sample of Brazilian organizations. The simple fact that only five articles developed by Brazilian authors (Dall'Agnol, 2020; Oliveira et al., 2019; Dos Santos et al., 2016; Queiroz, 2010; Andreassi & Sbragia, 2002) were referenced in this research supports this argument.

Queiroz (2010) found no evidence of a positive and statistically significant relationship between R&D spending and short-term profit growth in Brazilian companies. Dos Santos et al. (2016), in turn, revealed evidence that variables associated with investments in innovation do not significantly explain performance.

Andreassi and Sbragia (2002) showed evidence that investments in R&D are highly correlated with the future share of new products in total corporate revenue and that, unlike what occurs in other countries, it is sales results that seem to condition future R&D investments and not the other way around. Oliveira et al. (2019), in turn, analyzed the relationship between abnormal returns and the R&D expenditures of publicly traded Brazilian companies by means of regression analysis with panel data. Results showed a negative and statistically significant relationship between innovation and abnormal return.

2.4.4. Compilation of publications and research hypotheses

The sections above presented theoretical arguments and conclusions from studies that had similar goals or parts, containing analyses similar to this research. Importantly, this literature review, and the conclusions arising from the analyzed studies, showed some inconsistency in the results, confirming the lack of consensus about the interrelationships between quality management systems, innovation and performance. Sometimes positive, sometimes insignificant, sometimes negative relations were found (Figure 1).

Relationship between constructs	Authors	Results
Innovation and Performance	Tung et al. (2021); Yoo et al. (2019); Dai et al. (2019); Ostadhashemi and Fadaei Nejad (2019); Wang (2019); Caldas et al. (2019), Almeida et al. (2019); Iandolo e Ferragina (2019); Luo et al. (2018); Rocha et al. (2018); Lome et al. (2016); Karabulut (2015); Walker (2015); Saunila et al. (2014); Camisón and Villar-López (2014); Andreassi and Sbragia (2002); Morbey and Reithner (1990)	Positive relationship
	Yoo et al. (2019); Xu et al. (2019); Oprime et al. (2019); Dos Santos et al. (2016); Hungarato and Teixeira (2012); Queiroz (2010); Morbey and Reithner (1990)	Non-significant relationship
	Dall'Agnol (2020); Yoo et al. (2019); Xu et al. (2019)	Negative relationship
Quality management systems and performance	Alkunsol et al. (2019); Oprime et al. (2019); Latan et al. (2020); Lamine and Kaouthar (2018); Uluskan et al. (2017); Ertürk et al. (2016); Aba et al. (2015); Shafer and Moeller (2012); Swink and Jacobs (2012); Foster (2007)	Positive relationship
	Galetto et al. (2017); Pavol (2016); Ilkay and Aslan (2012); Foster (2007)	Non-significant relationship

Figure 1. Compilation of academic publications
Source: Authors of this study

Importantly, the works mentioned used completely different approaches, theoretical models, methodologies and variables from each other, demonstrating the non-uniformity of the metrics choices used to measure innovation, performance and quality management systems.

The hypotheses resulting from the literature review, and the theoretical argumentation are listed below according to their adherence to the specific objectives explained in the introduction of this paper and will be tested by multiple regression analysis.

- **h1:** Adoption of the six sigma methodology positively impacts the financial performance of Brazilian publicly traded companies.
- **h2:** Adoption of ISO 9001 certification positively impacts the financial performance of Brazilian publicly traded companies.
- **h3:** Higher investments in innovation positively impact the financial performance of Brazilian publicly traded companies.
- **h4:** There is a significant and positive interaction between the joint occurrence of obtaining ISO 9001 certification and higher investments in innovation in the impact on the financial performance of Brazilian publicly traded companies.
- **h5:** The joint occurrence of six sigma adoption and higher investments in innovation show significant and positive interaction in the impact on the financial performance of Brazilian publicly traded companies.

Financial performance will be measured by three proxies, namely return on assets (ROA), return on equity (ROE) and net margin. Figure 2 shows the conceptual model underlying the choice of variables and formulation of the research hypotheses.

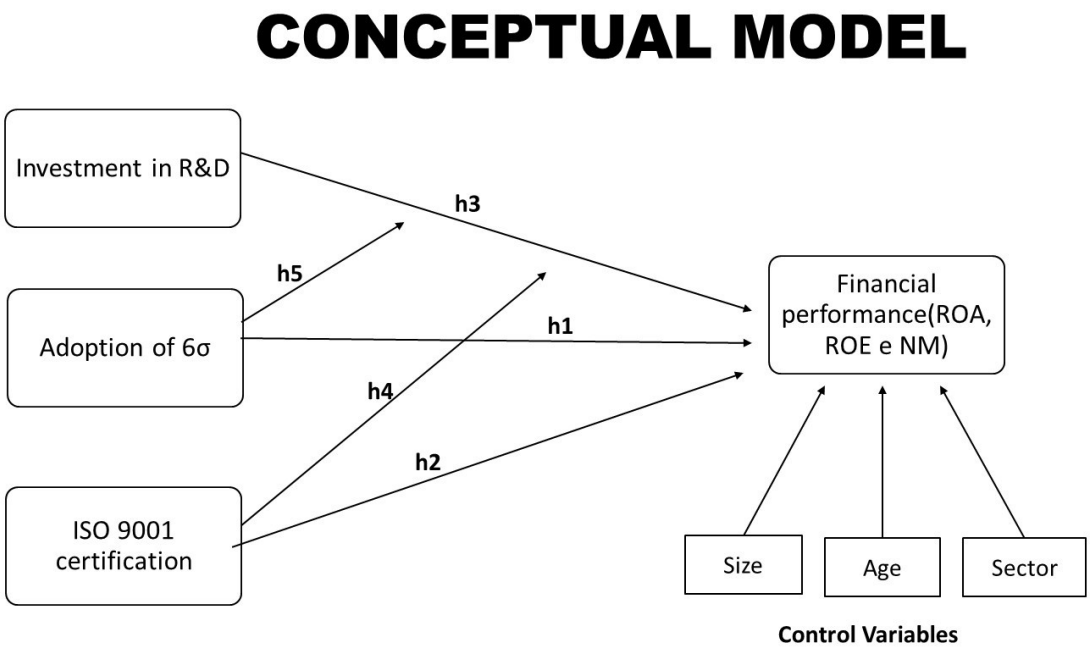

Figure 2. Conceptual Model
Source: Authors of this study

3. METHODOLOGICAL PROCEDURES

This empirical-positivist research used a quantitative strategy for data analysis and treatment. Using a non-probabilistic sampling method, based on a naturally restricted universe of companies listed on B3 from previously selected sectors, we reached a total original sample of 101 companies. Accounting data were extracted from the Economática database. The publicly traded companies analyzed belong to the "industrial goods," "oil, gas and biofuels," "basic materials" and "non-cyclical consumption" sectors.

Analyses used linear regression models with cross-section data, and thus did not consider an order of observations over time. Such simplification was motivated by the great difficulty in obtaining consistent longitudinal data on R&D expenditures beyond the 2019 fiscal year in Brazilian publicly traded companies that comprised the sample, constituting an important limitation of this study. Studies such as Caldas et al. (2019), Yoo et al. (2019), Dai et al. (2019), Alkunsol et al. (2019), among others also used cross-section linear regression models.

Our choice of sectors – "industrial goods," "oil, gas and biofuels," "basic materials" and "non-cyclical consumption" – aimed to select a sample composed mostly of large companies, as they represent the focus of six sigma adoption and ISO 9001 certification, as found by several studies (Swink & Jacobs, 2012).

"Trimmed data at 5%" was applied to exclude companies whose data significantly distorted the sample; thus, companies that ranked in the top and bottom 5% of the sample (for the dependent variable) were excluded as outliers. Consequently, the regressions for ROA, ROE and NM, which will be presented in the Results section, have samples of 90, 91 and 90 companies, respectively.

"Quality management systems" was measured by the following variables: adoption of six sigma program and/or ISO 9001 certification in at least one production process, started at least four years ago (Ozkan et al., 2017; Antony et al., 2016; Aba et al., 2015; Swink & Jacobs, 2012; Shafer & Moeller, 2012; Foster, 2007; Ozan, 1992). To identify companies certified ISO 9001 and/or adopting the six sigma methodology, we followed the procedure proposed by Swink and Jacobs (2012) by consulting multiple data sources (research websites, books, professional and academic journals, newspapers and business magazines articles, direct queries via e-mail, telephone, and investor relations channel).

Damanpour (2014) highlights several difficulties in measuring a dynamic and subjective process such as innovation. To circumvent them, we chose to investigate the construct "innovation" through the proxy of R&D expenditures published in the explanatory notes, and also via direct consultation with the companies in the sample. This proxy will be operationalized as the value of R&D investments divided by net operating revenue, both for the year 2019, in line with other works (Caldas et al., 2019; Ostadhashemi & Fadaei Nejad, 2019; Swink & Jacobs 2012; Andreassi & Sbragia, 2002).

Considering our research question and objectives, and the arguments and analysis presented, we chose to analyze performance based on the profitability sphere of organizations. As such, we decided to use the ROA, ROE and Net Margin metrics as proxies for measuring the construct "performance" (Ross et al., 2015). The resulting hypotheses were tested by means of multiple regression analysis carried out using SPSS software (Statistical Package for the Social Sciences), having as control variables: the logarithm of last year's sales revenue (representing the company size), company age (since immature companies may present less competitive advantage) and sector (the four previously mentioned that will be tested via dummies variables). Missing data were replaced by the variable average, following Tsikriktsis' (2005) recommendation. Equation 1 shows the regression used.

$$\text{Performance (Y)} = a1*(\text{ISO}) + a2*(\text{SS}) + a3*(\text{R\&D}) + a4*(\text{ISO})*(\text{R\&D}) + a5(\text{SS})*(\text{R\&D}) + a6*(\text{size}) + a7*(\text{age}) + a8*(\text{sector 1}) + a9*(\text{sector 2}) + a10*(\text{sector 3}) + \varepsilon.$$

Equation 1. Equation
Source: Authors of this study

4. RESULTS AND DISCUSSION

Results and their discussion and analysis are presented below.

4.1. REGRESSION OF ROA AS DEPENDENT VARIABLE

Table 1 presents the means and standard deviations of the characteristics present in the sample composed of 90 companies, after exclusion of outliers.

Table 1
Descriptive statistics: ROA

	Mean	SD
ROA	1.3307	7.9404
LN_Sales	14.3373	2.33953
ISO	0.7889	0.41038
SIX_SIGMA	0.4222	0.49668
R&D	0.0213	0.07494
Age	38.6333	17.24213
Industrial	0.4889	0.50268
Petrochemical	0.1000	0.30168
BasicMaterials	0.1667	0.37477
ISOxR&D	0.0128	0.04436
SIX_SIGMAxR&D	0.0046	0.01255

Source: Authors of this study

Table 2 shows that the regression models with ROA as dependent variable were significant, with P-values of less than 0.05, considering the regressions without and with interactions between variables.

Table 2
ANOVA: regression model significance: ROA without outliers

Model	F		P-value	
Regression	Without Interactions	With Interactions	Without Interactions	With Interactions
	2.385	2.209	0.023	0.025

Source: Authors of this study

According to Table 3, the adjusted R^2 showed values of 0.111 and 0.12, the Durbin-Watson test presented values of 2.497 and 2.582 – the second being slightly above the ideal range (between 1.5 and 2.5) –, and the Breusch-Pagan test showed satisfactory values of 0.567 and 0.715, both greater than 0.05, considering the regressions without and with interactions between variables.

Table 3
Coefficient of determination and Durbin-Watson test: ROA

Adjusted R^2		Durbin-Watson		Breusch-Pagan	
Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions
0.111	0.12	2.497	2.582	0.567	0.715

Source: Authors of this study

Table 4 shows that the coefficients were significant and positive for the independent variables ISO 9001 and R&D, considering significance levels of 0.05 and 0.1 respectively.

In the regression with interactions, "ISOxPeD" was positive and almost significant (p-value = 0.105), for a 0.1 significance level. This potential positive synergistic effect between ISO and R&D should be further investigated. The tests for multicollinearity (VIF) were satisfactory (with values less than 10). Considering P-values below 0.1, the interactions were not considered significant.

Table 4
Regression coefficients: ROA

Model	Standardized Coefficients Beta		t		P-value		VIF	
	Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions
(Constant)			−2.273	−1.979	0.026	0.051		
LN_Sales	0.183	0.164	1.588	1.403	0.116	0.165	1.328	1.379
ISO	0.277	0.229	2.36	1.89	0.021	0.062	1.376	1.485
SIX_SIGMA	−0.136	−0.071	−1.157	−0.53	0.251	0.598	1.377	1.837
R&D	0.196	0.083	1.864	0.659	0.066	0.512	1.107	1.625
Age	0.226	0.236	2.098	2.202	0.039	0.031	1.159	1.164
Industrial	−0.023	−0.065	−0.171	−0.472	0.865	0.638	1.758	1.915
Petrochemical	−0.219	−0.273	−1.901	−2.294	0.061	0.024	1.33	1.436
BasicMaterials	−0.072	−0.098	−0.565	−0.739	0.574	0.462	1.645	1.786
ISOxR&D		0.218		1.638		0.105		1.799
SIX_SIGMAXR&D		−0.087		−0.719		0.474		1.489

Source: Authors of this study

4.2. REGRESSION OF ROE AS DEPENDENT VARIABLE

Table 5 presents the means and standard deviations of the characteristics present in the sample composed of 91 companies, after exclusion of outliers.

Table 5
Descriptive Statistics: ROE

	Mean	SD
ROA	7.6955	13.10268
LN_Sales	13.9857	2.5916
ISO	0.7582	0.43052
SIX_SIGMA	0.3846	0.4892
R&D	0.0207	0.07461
Age	39.4286	17.06728
Industrial	0.5055	0.50274
Petrochemical	0.0989	0.30018
BasicMaterials	0.1758	0.38278
ISOxR&D	0.0123	0.04416
SIX_SIGMAxR&D	0.0042	0.01234

Source: Authors of this study

As the regression models with ROE as dependent variable was not significant (Table 6), with P-values greater than 0.1, considering the regressions without and with interactions between variables, the hypotheses could not be confirmed.

Table 6
ANOVA: regression model significance: ROE

Model	F		P-value	
Regression	Without Interactions	With Interactions	Without Interactions	With Interactions
	1.258	1.377	0.277	0.206

Source: Authors of this study

Although not significant, the regressions had satisfactory values in the multicollinearity and heteroscedasticity tests (Table 7).

Table 7
Coefficient of determination and Durbin-Watson test: ROE

Adjusted R^2		Durbin-Watson		Breusch-Pagan	
Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions
0.022	0.04	1.865	1.936	0.153	0.379

Source: Authors of this study

Table 8 shows that none of the coefficients was significant, as all P-values were above 0.1, excepting the variable Six Sigma and the interaction SEIS_SIGMA x R&D. As already mentioned, the regression model test was not significant.

Table 8
Regression coefficients: ROE

Model	Standardized Coefficients Beta		t		P-value		VIF	
	Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions
(Constant)			−0.356	−0.068	0.723	0.946		
LN_Sales	0.099	0.074	0.823	0.612	0.413	0.543	1.33	1.389
ISO	0.085	0.036	0.676	0.277	0.501	0.783	1.447	1.552
SIX_SIGMA	−0.294	−0.215	−2.394	−1.55	0.019	0.125	1.383	1.808
R&D	0.095	−0.03	0.868	−0.227	0.388	0.821	1.106	1.605
Age	0.195	0.206	1.737	1.848	0.086	0.068	1.162	1.169
Industrial	−0.025	−0.073	−0.172	−0.493	0.864	0.623	1.9	2.046
Petrochemical	0.003	−0.058	0.027	−0.459	0.979	0.648	1.39	1.49
BasicMaterials	−0.104	−0.136	−0.761	−0.975	0.449	0.333	1.706	1.839
ISOxR&D		0.248		1.797		0.076		1.786
SIX_SIGMAXR&D		−0.113		−0.908		0.367		1.464

Source: Authors of this study

4.2.1. Regression of NM as dependent variable

Table 9 presents the means and standard deviations of the characteristics present in the sample composed of 90 companies, after exclusion of outliers.

Table 9
Descriptive Statistics: NM

	Mean	SD
NET_MARGIN	0.5069	15.31558
LN_Sales	14.3166	2.26362
ISO	0.7778	0.41807
SIX_SIGMA	0.4111	0.49479
R&D	0.0105	0.02073
Age	39.6	16.62123
Industrial	0.5111	0.50268
Petrochemical	0.0778	0.26932
BasicMaterials	0.1778	0.38447
ISOxR&D	0.0085	0.01852
SIX_SIGMAxR&D	0.0046	0.01256

Source: Authors of this study

Although Table 10 shows P-values lower than 0.05, considering the regressions without and with interactions between variables, the regression models with NM as dependent variable were discarded for failing the heteroscedasticity test, thus the hypotheses could not be confirmed (Table 11).

Table 10
ANOVA: regression model significance: NM

Model	F		P-value	
Regression	Without Interactions	With Interactions	Without Interactions	With Interactions
	2.859	2.946	0.007	0.003

Source: Authors of this study

Table 11
Coefficient of determination and Durbin-Watson test: NM

Adjusted R^2		Durbin-Watson		Breusch-Pagan	
Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions
0.143	0.179	2.152	2.076	0.000	0.000

Source: Authors of this study

Table 11 shows that regressions with Net Margin had to be discarded for they failed the heteroscedasticity test (Breusch-Pagan). We tried to remedy the problem using weighted regressions as suggested by Lyon and Tsai (1996), but none of the independent variables was significant in this new model. The results of these additional regressions were not included for reasons of brevity.

Table 12 shows some significant variables, but heteroscedasticity was present anyway, thus the hypotheses could not be confirmed.

The multiple linear regressions and the other tests performed sought to investigate whether investments in R&D, ISO 9001 and Six Sigma positively impact the profitability of Brazilian publicly traded companies.

As for the low determination coefficients (adjusted R^2), this finding does not necessarily represent a limitation (Chalmer, 1986). The present research sought not to predict financial performance, but rather to explain and relate predictors, and to verify which selected variables impact positively or negatively the analyzed dimensions.

Considering the sample of Brazilian publicly traded companies that comprised this study, after exclusion of the outliers, the data presented show statistically significant relationships between R&D and ISO 9001 and the ROA index. The interaction "ISO x R&D" was positive and almost significant (p-value = 0.105), for a significance level of 0.1, in its effect on the ROA variable.

4.3. DISCUSSION

Although our results show no evidence of statistically significant relations between all three constructs analyzed, they still configure important findings for indicating that Brazilian publicly traded companies are obtaining little success in terms of financial results through their efforts in six sigma. They also show that efforts in R&D and ISO 9001 certification have a positive and significant impact on profitability, by means of the ROA index. These results partially confirm hypotheses H2 and H3. As for hypothesis H4, the interaction "ISO9001 x R&D" was positive and almost significant in its effect on ROA. In the light of the literature review done on the topic, our results regarding the relationships between the constructs "innovation" and "performance" corroborated those found by Tung et al. (2021); Yoo et al. (2019); Dai et al (2019); Lome et al. (2016); Ostadhashemi and Fadaei Nejad (2019); Wang (2019); Caldas et al. (2019), Almeida et al. (2019); Luo et al. (2018); Rocha et al. (2018); Saunila et al. (2014); Camisón and Villar-López (2014). As for the relationships between the constructs "QMS" and "performance," we found congruent results with the studies by Oprime et al. (2019); Latan et al. (2020) and Aba et al. (2015).

Analyzing separately the relationship between the constructs "QMS" and "performance," the results obtained lead to the belief that merely adopting the six sigma 9001 methodology is not necessarily associated with higher profits. Even in the case of the impacts of ISO 9000 certification, the results only partially confirmed the hypotheses. According to Piazza and Abrahamson (2020), management methodologies such as QCCs (quality control circles), TQM, six sigma, process reengineering, as well as more recent practices such as agile management process are notorious for raising and falling in popularity, often unpredictably they can fall into disuse or be reborn in new guises that may last for decades, emerging, disappearing and often overlapping under the influence of different gurus, like wave sequences. The study of this phenomenon gave rise to the literature on managerial fads in management.

As highlighted by De Mello Cordeiro (2004), mimetic behaviors led many Brazilian organizations in the past to adopt quality management systems without the proper incorporation of the new management tools and philosophies necessary for their success. Analyzing the arguments raised

Table 12
Regression coefficients: NM

Model	Standardized Coefficients Beta		t		P-value		VIF	
	Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions	Without Interactions	With Interactions
(Constant)			–2.144	–1.692	0.035	0.095		
LN_Sales	0.224	0.196	1.954	1.721	0.054	0.089	1.36	1.41
ISO	0.185	0.106	1.588	0.855	0.116	0.395	1.411	1.671
SIX_SIGMA	–0.15	–0.021	–1.307	–0.155	0.195	0.877	1.369	1.915
R&D	–0.185	–0.392	–1.828	–1.985	0.071	0.051	1.063	4.226
Age	0.186	0.156	1.777	1.511	0.079	0.135	1.132	1.15
Industrial	–0.022	–0.073	–0.169	–0.53	0.866	0.598	1.756	2.05
Petrochemical	–0.331	–0.326	–2.981	–2.986	0.004	0.004	1.284	1.29
BasicMaterials	–0.189	–0.207	–1.479	–1.586	0.143	0.117	1.694	1.857
ISOxR&D		0.413		1.91		0.06		5.064
SIX_SIGMAXR&D		–0.286		–1.935		0.057		2.366

Source: Authors of this study

by the author, in light of the results found, we can assume that part of the organizations in our sample have implemented Six Sigma and ISO 9001 quality management systems as a "fad," without being duly integrated into a strategy for improving financial results.

Regarding specifically ISO 9001 certification, which impacted performance as measured by ROA, several authors cite benefits from its implementation. Del Castillo-Peces et al. (2018), and Susnienė and Sargūnas (2018), for example, cite improvements in of market share, brand equity gain, improvement in operational efficiency, and coordination with suppliers. Fonseca et al. (2019), in turn, highlight adoption of risk-based thinking, improved alignment with other QMSs, increased commitment from senior management, and improved knowledge management as benefits from adopting the standard.

Susnienė and Sargūnas (2018) and Rodriguez-Arnaldo and Martinez-Lorente (2020) discuss indirect benefits of ISO 9001 certification for performance, as a strategic marketing tool, facilitating exports and the maintenance of current contracts, and even being required by financial institutions for granting certain credit lines.

Regarding six sigma methodology, the only independent variable that presented no statistical significance in relation to the three profitability variables (ROA, ROE, and NM), this study highlights the research by Antony (2007) who, in a panel, discusses with experts in six sigma (academics and professionals in the field in over five countries) to what extent six sigma would become yet another managerial fad or if, in fact, it would be perpetuated in companies. In summary, the experts argued that when the steps described in the methodology were followed, and the six sigma management philosophy was duly incorporated, according to their experiences, companies obtained better financial performance and a reduction in corporate inefficiencies than those obtained by other approaches. But in companies where the leadership treated six sigma as a passing fad, that is that they did not face with due commitment the achievement of the proposed objectives or in organizations where it was unduly inserted by the "consulting industry," there were no results and, possibly, in these cases the methodology will fall into disuse.

As for the constructs "innovation" and "performance," the statistical significance found in relation to ROA suggests that even relatively small and sometimes not effective investments can impact financial results. On this topic, Rivero (2017) argues that Brazil, in line with other Latin American countries, still invests little in R&D.

De Negri et al. (2018) point out that, despite government efforts to implement relatively broad innovation policies, the results have been negligible in Brazilian. A possible explanation for this ineffectiveness of Brazilian investments in innovation lies in the lack of corporate strategic direction of these expenditures. Considering this hypothesis, Brazilian companies and the government would be "missing the mark," that is, investing in strategies that are not reflected in consistent competitive advantages. Moreover, Rivero (2017) argues that, due to more attractive government incentives, many companies choose to allocate resources for innovation to purchase of capital goods and not to R&D.

Rivero (2017) also points out that in many advanced capitalist and Asian countries, professionals with master's degrees and PhD are concentrated in private companies, working in engineering, technological sciences, biological sciences, and agriculture. In Brazil, however, these professionals are concentrated in the public sector and academia, while private companies "clamor for qualified labor," but end up hiring cheaper professionals. To us, such a scenario can enlarge the distance between knowledge, innovation and development, if productive links between the productive and academic sectors are not established.

5. CONCLUSIONS

This study sought to verify how investments in innovation and adoption of quality management systems impact the financial performance of Brazilian publicly traded companies. Although the literature include publications that point to positive and negative impacts on organizational performance associated with the adoption, jointly or independently, of these three constructs, very little empirical, systematic and rigorous research on these relationships exists. Besides, most quantitative articles published on the topic are based on respondents' opinion, without considering financial and/or accounting data by means of rigorous quantitative analysis. Such studies are even scarcer in Brazil, especially when compared to Europe and the United States.

The regression results show that R&D efforts and ISO 9001 certification have a positive and significant impact on profitability, via the ROA index. These results partially confirm hypotheses H2 and H3. As for hypothesis H4, the interaction "ISO9001 x R&D" was positive and almost significant. This potential synergistic effect between ISO 9001 and R&D should be better investigated in future studies.

Importantly, although our results show no evidence of statistically significant relations between all three constructs analyzed, they still configure important findings for indicating that Brazilian publicly traded companies are obtaining little success in terms of financial results through their Six Sigma efforts.

The study adopted a non-probabilistic sampling method, considering the naturally restricted universe of companies listed on B3 for the "industrial goods," "oil, gas and biofuels," "basic materials" and "non-cyclical consumption" sectors. Accounting data were extracted from the Economática database, derived from the financial statements and explanatory notes of the publicly traded companies in the sample. Moreover, we should note that numerous variables, besides investments in innovation and adoption of ISO 9001 and Six Sigma quality management systems, can impact the profitability of publicly traded companies.

Another important limitation of this study, perhaps the most important, lies in the simplifying assumption that R&D investments would have a rapid impact on organizational performance. Alternatively, one could argue that our premise was that the investments made in 2019 are typical or representative of each company's annual investments in the recent past. We had great difficulty in obtaining longitudinal data on R&D expenditures from the Brazilian publicly traded companies in the sample, and this motivated such simplification. A recommendation for future research is to consider, in the regressions, a delay between R&D investment variable and the dependent variables (the performance proxies). This methodological approach could help validate, more convincingly, the results and evidence collected and presented herein.

Another recommendation for future studies, if it becomes possible to have more robust and broader access to consistent data on R&D investments over the years, is to use the alternative approach of multivariate panel data regressions, which could potentially bring new insights – as in this alternative approach, the dependence on the time factor would be modeled.

Finally, this study has fulfilled its main goal by providing findings that contribute to bringing closer together and strengthening the dialogue between academia and the business environment. Besides its theoretical contribution to the field, this paper aims to contribute to improving the performance and competitiveness of Brazilian publicly traded companies, encouraging more conscious and diligent investments in innovation and quality.

REFERENCES

Aba, E. K., Badar, M. A., & Hayden, M. A. (2015). Impact of ISO 9001 certification on firms financial operating performance. *International Journal of Quality & Reliability Management*, *33*(1), 78-89. https://doi.org/10.1108/IJQRM-02-2014-0021

Alkunsol, W. H., Sharabati, A. A. A., AlSalhi, N. A., & El-Tamimi, H. S. (2019). Lean Six Sigma effect on Jordanian pharmaceutical industry's performance. *International Journal of Lean Six Sigma*, *10*(1), 23-43. https://doi.org/10.1108/IJLSS-01-2017-0003

Almeida, C. A., Del Corso, J. M., Rocha, L. A., da Silva, W. V., & da Veiga, C. P. (2019). Innovation and performance: the impact of investments in R&D according to the different levels of productivity of firms. *International Journal of Innovation and Technology Management*, *16*(05), 1-21. https://doi.org/10.1142/S0219877019500366

Andreassi, T., & Sbragia, R. (2002). Relações entre indicadores de P&D e de resultado empresarial. *Revista de Administração da Universidade de São Paulo*, *37*(1), 72-84.

Antony, J. (2007). Is Six Sigma a management fad or fact?. *Assembly Automation*, *27*(1), 17-19. https://doi.org/10.1108/01445150710724658

Antony, J., & Desai, D. A. (2009). Assessing the status of Six Sigma implementation in the Indian industry: results from an exploratory empirical study. *Management Research News*, *32*(5), 413-423. https://doi.org/10.1108/01409170910952921

Antony, J., Setijono, D., & Dahlgaard, J. J. (2016). Lean Six Sigma and Innovation–an exploratory study among UK organisations. *Total Quality Management & Business Excellence*, *27*(1-2), 124-140. https://doi.org/10.1080/14783363.2014.959255

Antony, J., Sony, M., Dempsey, M., Brennan, A., Farrington, T., & Cudney, E. A. (2019). An evaluation into the limitations and emerging trends of Six Sigma: an empirical study. *The TQM Journal*, *31*(2), 205-221. https://doi.org/10.1108/TQM-12-2018-0191

American Society for Quality (ASQ). (2022) Learn About Quality. Milwaukee, ASQ. https://asq.org/quality-resources/six-sigma/belts-executives-champions

Caldas, L. F., de Oliveira Paula, F., & Macedo-Soares, T. D. L. van A. (2019). Industry innovation spending and openness to collaboration as levers for firm performance. *European Journal of Innovation Management*. *22*(4), 617-638. https://doi.org/10.1108/EJIM-04-2018-0075

Camisón, C., & Villar-López, A. (2014). Organizational innovation as an enabler of technological innovation capabilities and firm performance. *Journal of business research*, *67*(1), 2891-2902. https://doi.org/10.1016/j.jbusres.2012.06.004

Castello, J., De Castro, R., & Marimon, F. (2019). Use of quality tools and techniques and their integration into ISO 9001: a wind power supply chain case. *International Journal of Quality & Reliability Management*, 9(5), 1090-1106. https://doi.org/10.1108/IJQRM-07-2018-0171

Chalmer, B.J. (1986). *Understanding Statistics.* CRC Press.

Dai, X., Guo, Y., & Wang, L. (2019). Composition of R&D expenditures and firm performance. *Technology analysis & strategic management*, *32*(6), 739-752. https://doi.org/10.1080/09537325.2019.1705967

Dall'Agnol, M. (2020). *O esforço em inovação e sua associação com o ambiente competitivo: um estudo das empresas listadas na B3.* Anais do Congresso Brasileiro de Custos-ABC. https://anaiscbc.emnuvens.com.br/anais/article/view/4786

Damanpour, F. (2014). Footnotes to research on management innovation. *Organization Studies*, *35*(9), 1265-1285. https://doi.org/10.1177%2F0170840614539312

De Mello Cordeiro, J. V. B. (2004). Reflexões sobre a Gestão da Qualidade Total: fim de mais um modismo ou incorporação do conceito por meio de novas ferramentas de gestão?. *Revista da FAE*, *7*(1), 19-33.

De Negri, F., Rauen, A. T., & Squeff, F. D. H. S. (2018). Ciência, inovação e produtividade: por uma nova geração de políticas públicas. *Desafios da nação*, *1*, 533-560.

Del Castillo-Peces, C., Mercado-Idoeta, C., Prado-Roman, M., & del Castillo-Feito, C. (2018). The influence of motivations and other factors on the results of implementing ISO 9001 standards. *European Research on Management and Business Economics*, *24*(1), 33-41. https://doi.org/10.1016/j.iedeen.2017.02.002

Dos Santos, J. G. C., Góis, A. D., Rebouças, S. M. D. P., & da Silva, J. C. L., Filho. (2016). Efeitos da inovação no desempenho de firmas brasileiras: Rentabilidade, lucro, geração de valor ou percepção do Mercado. *Revista de Administração Unimep*, *14*(3), 155-183. https://doi.org/10.15600/1679-5350/rau.v14n3p155-183

Ertürk, M., Tuerdi, M., & Wujiabudula, A. (2016). The effects of six sigma approach on business performance: A study of white goods (home appliances) sector in Turkey. *Procedia-Social and Behavioral Sciences*, *229*, 444-452. https://doi.org/10.1016/j.sbspro.2016.07.154

Fonseca, L., Domingues, J. P., Baylina, P., & Harder, D. (2019). ISO 9001: 2015 adoption: A multi-country empirical research. *Journal of Industrial Engineering and Management*, *12*(1), 27-50. http://doi.org/10.3926/jiem.2745

Foster, S. T., Jr. (2007). Does six sigma improve performance?. *Quality Management Journal*, *14*(4), 7-20.

Galetto, M., Franceschini, F., & Mastrogiacomo, L. (2017). ISO 9001 certification and corporate performance of Italian companies. *International Journal of Quality & Reliability Management*. *34*(2), 231-250. https://doi.org/10.1108/IJQRM-04-2015-0064

Hungarato, A., & Teixeira, A. J. C. (2012). A Pesquisa e Desenvolvimento e os preços das ações das empresas brasileiras: um estudo empírico na Bovespa. *Revista de Educação e Pesquisa em Contabilidade (REPeC)*, *6*(3), 282-298. https://doi.org/10.17524/repec.v6i3.283

Iandolo, S., & Ferragina, A. M. (2019). Does persistence in internationalization and innovation influence firms' performance?. *Journal of Economic Studies*, *46*(7), 1345-1364. https://doi.org/10.1108/JES-04-2019-0152

İlkay, M. S., Aslan, E. (2012). The effect of the ISO 9001 quality management system on the performance of SMEs. International Journal of Quality & Reliability Management 29 (7), pp. 753-778.

Ingason, H. T. (2015). Best project management practices in the implementation of an ISO 9001 quality management system. *Procedia-Social and Behavioral Sciences*. *194*(3), 192-200. https://doi.org/10.1016/j.sbspro.2015.06.133

ISO. (2021). *ISO 9000 quality management*. http://www.iso.org/iso/home/standards/management-standards/iso_9000.htm.

Jesus, A. R., Antony, J., Lepikson, H. A., & Peixoto, A. L. (2016). Six Sigma critical success factors in Brazilian industry. *International Journal of Quality & Reliability Management*. *33*(6), 702-723. https://doi.org/10.1108/IJQRM-08-2014-0120

Karabulut, A. T. (2015). Effects of innovation types on performance of manufacturing firms in Turkey. Procedia-Social and Behavioral Sciences, 195, 1355-1364.

Kaplan, R. S., & Norton, D. V. (1992). The balanced scorecard: measures that drive performance. *Harvard Business Review*, *70*(1), 71-79.

Lamine, K., & Lakhal, L. (2018). Impact of TQM/Six Sigma practices on company's performance: tunisian context. *International Journal of Quality & Reliability Management*, *35*(9),1881-1906. https://doi.org/10.1108/IJQRM-05-2017-0097

Latan, H., Jabbour, C. J. C., de Sousa Jabbour, A. B. L., de Camargo Fiorini, P., & Foropon, C. (2020). Innovative efforts of ISO 9001-certified manufacturing firms: Evidence of links between determinants of innovation, continuous innovation and firm performance. *International Journal of Production Economics*, *223*(c), 107-526. https://doi.org/10.1016/j.ijpe.2019.107526

Lome, O., Heggeseth, A. G., & Moen, Ø. (2016). The effect of R&D on performance: do R&D-intensive firms handle a financial crisis better?. *The Journal of High Technology Management Research*, *27*(1), 65-77. https://doi.org/10.1016/j.hitech.2016.04.006

Luo, Y., Hu, Z., & Yu, K. (2018). The impact of the R&D expenditure and patent rights towards operating Performance in medical device Industry–An empirical study. *Revista de Cercetare si Interventie Sociala*, *61*, 187-197.

Lyon, J. D., & Tsai, C. L. (1996). A comparison of tests for heteroscedasticity. *Journal of the Royal Statistical Society: Series D (The Statistician), 45*(3), 337-349. https://doi.org/10.2307/2988471

Morbey, G. K., & Reithner, R. M. (1990). How R&D affects sales growth, productivity and profitability. *Research-Technology Management*, *33*(3), 11-14. https://doi.org/10.1080/08956308.1990.11670656

OECD. (2021). *Main science and technology indicators*. https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

Oliveira, A. M., Magnani, V. M., Tortoli, J. P., Figari, A. K. P., & Ambrozini, M. A. (2019). A relação entre as despesas com P&D e o retorno anormal das empresas brasileiras. *RAM. Revista de Administração Mackenzie*, *20*(5), eRAMF190106. https://doi.org/10.1590/1678-6971/eramf190106

Oprime, P. C., Pimenta, M. L., Jugend, D., & Andersson, R. (2019). Financial impacts of innovation in Six Sigma projects. *Total Quality Management & Business Excellence*, *32*(7-8), 829-851. https://doi.org/10.1080/14783363.2019.1641076

Ostadhashemi, A., & Fadaei Nejad, M. E. (2019). To study moderating role of ownership structure on R&D expenditure policies on accounting performance and market value. *International Journal of Financial Engineering*, *6*(01), 1950003. https://doi.org/10.1142/S2424786319500038

Ozan, T. (1992). International quality study: Best practices report. New York: Ernst and Young.

Ozkan, B., Rubio, J. F., Hassan, M. K., & Davis, J. R. (2017). Six Sigma, stock returns and operating performance. *Management Research Review*, *40*(3), 331-351. https://doi.org/10.1108/MRR-12-2015-0291

Pavol, G. (2016). Analysis of performance improvement of wood processing companies in Slovakia and the Czech Republic through the implementation of quality management systems. *Acta Facultatis Xylologiae Zvolen*, *58*(1), 113-124. https://doi.org/10.17423/afx.2016.58.1.13

Piazza, A., & Abrahamson, E. (2020). Fads and fashions in management practices: taking stock and looking forward. *International Journal of Management Reviews*, *22*(3), 264-286. https://doi.org/10.1111/ijmr.12225

Pulakanam, V., Voges, K. E. (2010): Adoption of Six Sigma: Review of Empirical Research. International Review of Business Research Papers, v. 6, n. 5, p. 149-163.

Queiroz, O. R. D. (2010). *Impacto do crescimento dos gastos em P&D na taxa de crescimento dos lucros das empresas de acordo com o modelo OJ: um estudo no mercado de capitais brasileiro*. Anais do Congresso Anpcont, Natal.

Rivero, P. S. (2017). Desenvolvimento e inovação no Brasil. *Revista Latitude*, *12*(2), 461-507.

Rocha, L. A., Khan, A. S., Lima, P. V. P. S., Poz, M. E. S. D., & Almeida, C. A. S. D. (2018). O impacto dos investimentos em P&D no desempenho das empresas: aplicações no uso de regressão quantílica com variáveis instrumentais. *Revista de Economia Contemporânea*, *22*(3), e182235. https://doi.org/10.1590/198055272235

Rodriguez-Arnaldo, O., & Martínez-Lorente, A. R. (2020). What determinants influence the diffusion of ISO 9001 by countries?. *The TQM Journal*, *33*(1), 223-246. https://doi.org/10.1108/TQM-03-2020-0055

Ross, S. A., Westerfield, R. W., Jaffe, J., & Lamb, R. (2015). *Administração financeira*. AMGH Editora.

Saunila, M., Pekkola, S., & Ukko, J. (2014). The relationship between innovation capability and performance: the moderating effect of measurement. *International Journal of Productivity and Performance Management*, *63*(2), 234-249. https://doi.org/10.1108/IJPPM-04-2013-0065

Shafer, S. M., & Moeller, S. B. (2012). The effects of Six Sigma on corporate performance: an empirical investigation. *Journal of Operations Management*, *30*(7-8), 521-532. https://doi.org/10.1016/j.jom.2012.10.002

Susnienė, D., & Sargūnas, G. (2018). ISO 9001 IN ORGANIZATIONS: INFLUENCING FACTORS AND BENEFITS. *Taikomieji tyrimai studijose ir praktikoje-Applied research in studies and practice*, *14*(1), 5-12.

Swink, M., & Jacobs, B. W. (2012). Six Sigma adoption: operating performance impacts and contextual drivers of success. *Journal of Operations Management*, *30*(6), 437-453. https://doi.org/10.1016/j.jom.2012.05.001

Tsikriktsis, N. (2005). A review of techniques for treating missing data in OM survey research. *Journal of Operations Management*, *24*(1), 53-62. https://doi.org/10.1016/j.jom.2005.03.001

Tung, L. T., & Binh, Q. M. Q. (2021). The impact of R&D expenditure on firm performance in emerging markets: evidence from the Vietnamese listed companies. *Asian Journal of Technology Innovation*, *2021*(1), 1-19. https://doi.org/10.1080/19761597.2021.1897470

Uluskan, M., Godfrey, A. B., & Joines, J. A. (2017). Integration of Six Sigma to traditional quality management theory: an empirical study on organisational performance. *Total Quality Management & Business Excellence*, *28*(13-14), 1526-1543. https://doi.org/10.1080/14783363.2016.1150173

Walker, R. M., Chen, J., & Aravind, D. (2015). Management innovation and firm performance: an integration of research findings. *European Management Journal*, *33*(5), 407-422. https://doi.org/10.1016/j.emj.2015.07.001

Wang, D. S. (2019). Association between technological innovation and firm performance in small and medium-sized enterprises: the moderating effect of environmental factors. *International Journal of Innovation Science*, *11*(2), 227-240. https://doi.org/10.1108/IJIS-04-2018-0049

Werkema, C. (2012). *Criando a Cultura Seis Sigma.* Elsevier Brasil.

Xu, J., Liu, F., & Chen, Y. H. (2019). R&D, advertising and firms' financial performance in South Korea: does firm size matter?. *Sustainability*, *11*(14), 3764. https://doi.org/10.3390/su11143764

Yoo, J., Lee, S., & Park, S. (2019). The effect of firm life cycle on the relationship between R&D expenditures and future performance, earnings uncertainty, and sustainable growth. *Sustainability*, *11*(8), 2371. https://doi.org/10.3390/su11082371

AUTHOR'S CONTRIBUTION

LLB – formal analysis; writing, proofreading, and editing.
PSF – formal analysis; writing, reviewing and editing.
ARJ – formal analysis; writing, reviewing and editing.
FSF – formal analysis; writing, reviewing, and editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.