The impact of investment in intellectual capital on firms' profitability

O impacto do investimento em capital intelectual na rentabilidade das empresas

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Abstract

Purpose: This study investigates the effect of investment in intellectual capital and its components on the performance of Brazilian companies listed on the Brasil, Bolsa, Balcão (B3) exchange. More specifically, we examine whether a positive relationship exists between the proxies for intellectual, structural, human, and invested capital and firms' return on assets and equity.

Originality/value: This study differs from those of Richieri (2007), Turra et al. (2015), and Brizolla and Turra (2015) by using panel data and static and dynamic econometric regression models to analyze firms' performance. It also differs from Nadeem et al. (2018) by using return on equity and return on assets to measure performance.

Design/methodology/approach: We estimated two equations employing static estimators (static OLS and fixed effect) and dynamic estimators (dynamic OLS and GMM), as proposed by Nadeem et al. (2018). We performed strict exogeneity tests to ascertain the need to use dynamic models. Thus, the first equation analyzed the effect of intellectual capital on future performance (measured by ROA and ROE). In contrast, the second equation investigated the impact of structural, invested, and human capital on these same performance indicators.

Findings: The results indicate a positive effect of investment in intellectual capital on the performance of Brazilian companies. In addition, all components of intellectual capital are significant in increasing returns on assets and equity.

Keywords: intellectual capital, human capital, structural capital, performance, VAIC

Resumo

Objetivo: O objetivo do presente estudo é investigar o efeito do investimento em capital intelectual e seus componentes na *performance* das empresas brasileiras listadas na Brasil, Bolsa, Balcão (B3). Mais especificamente, se existe uma relação positiva entre as *proxies* de capital intelectual, estrutural, humano e investido com a rentabilidade sobre o ativo e sobre o patrimônio líquido.

Originalidade/valor: Este trabalho se diferencia de Richieri (2007), Turra et al. (2015) e Brizolla e Turra (2015) por utilizar dados em painel e modelos econométricos de regressão estáticos e dinâmicos para analisar a *performance* das empresas. Também se diferencia de Nadeem et al. (2018) por utilizar a rentabilidade sobre o patrimônio, além da rentabilidade sobre o ativo para mensurar a *performance*.

Design/metodologia/abordagem: Duas equações foram propostas e estimadas por meio de estimadores estáticos (MQO e efeito fixo) e de estimadores dinâmicos (MQO dinâmicos e GMM), assim como proposto por Nadeem et al. (2018). Realizaram-se testes de exogeneidade estrita para averiguar a necessidade da utilização de modelos dinâmicos. Dessa forma, a primeira equação analisou o efeito do capital intelectual na *performance* futura (medida por ROA e ROE), enquanto a segunda equação investigou os efeitos do capital estrutural, investido e humano nesses mesmos indicadores de *performance*.

Resultados: Os resultados indicam um efeito positivo do investimento em capital intelectual na *performance* das empresas brasileiras. Além disso, todos os componentes do capital intelectual são significativos para o aumento da rentabilidade sobre o ativo e sobre o patrimônio.

Palavras-chave: capital intelectual, capital humano, capital estrutural, performance, VAIC

INTRODUCTION

Intellectual capital is highly relevant to companies, especially in the era of information and knowledge, where the results are more strongly tied to intellectual capabilities and information systems (Usoff et al., 2002). Many studies have investigated this theme and focused on understanding how intellectual capital creates value and the need to disclose that information to the market (Pulic, 2000; Petty & Guthrie, 2000; Guthrie et al., 2012). Pulic (2000) suggested a method to measure this asset, the value added intellectual coefficient (VAIC), which has become the most widely used instrument to measure intellectual capital (Kehelwalatenna, 2016).

The literature on economic development shows that society's knowledge and technological progress are critical drivers of economic growth (Hidalgo et al. 2007; Hidalgo & Hausmann, 2009; Hausmann & Hidalgo, 2011).

Findings in the international literature indicate the existence of positive relations between the performance of companies and their intellectual capital (Muhammad & Ismail, 2009; Phusavat et al., 2011; Nadeem et al., 2018; Janošević et al., 2013; Pew et al., 2007). However, other studies have not found any relationship, or even a negative relationship, between the variables of intellectual capital and performance (Firer & Williams, 2003; Hang Chan, 2009). Hence there is no consensus in the literature, leaving a gap to be filled by further investigating this relationship.

Several studies have quantitatively analyzed the relationship between intellectual capital and performance in Brazil. Turra et al. (2015) and Brizolla and Turra (2015) found a positive relationship between intellectual capital and its components with firms' performance, using data from Chilean and Brazilian companies in the first case and only Brazilian ones in the second study. Richieri (2007) indicated a positive relationship between intellectual capital and performance measures of Brazilian companies.

However, the Brazilian literature is concentrated on analyzing the perception of the importance of intellectual capital and its measurement by firms. These studies indicate that firms are becoming increasingly dependent on intellectual capital but that Brazilian companies do not measure or do not carefully manage intellectual capital, although their executives perceive this increasing dependence (Antunes, 2006; Antunes & Martins, 2007). Therefore, a significant gap in the country's literature is found in the absence of results indicating the effect of an increment in investment in intellectual capital on firms' future performance. This study investigates the impact of investment in intellectual capital and its components on the performance of Brazilian companies listed on the Brasil, Bolsa, Balcão (B3) exchange.

To address this question, we adopted part of the methodology applied by Nadeem et al. (2018), who used static (ordinary least squares – OLS – and fixed effect) and dynamic estimators (dynamic OLS and generalized method of moments – GMM) with panel data to estimate models relating the metric of the efficiency of intellectual capital proposed by Pulic (1998, 2000, 2004), called VAIC, and its components with measures of firms' profitability (return on assets – ROA – and return on equity – ROE).

The basis for this work is found in the fact that intellectual capital is particularly relevant to companies in the era of the Industrial Revolution 4.0 (Xu et al., 2018; Cabrita et al., 2018; Stachová et al., 2019), when improvement of technology and knowledge are the main strategies for differentiation in the market. Despite this relevance and the abundance of international studies, the Brazilian literature does not contain a robust corpus of empirical results, with various methods and approaches to identify manager's priorities in allocating resources to promote intellectual capital.

From an academic standpoint, this study expands the national literature while differing from the works of Turra et al. (2015) and Brizolla and Turra (2015) by using panel data and econometric regression models to analyze the annual variation of the components of interest, while those authors only performed a correlation analysis for 2013. This work also stands apart from that of Richieri (2007) by analyzing the impact of the variation of the efficiency of intellectual capital in affecting the likelihood of future growth of profitability, while that author only explored the impact of the level of the VAIC on performance variables. Finally, this study differs from that of Nadeem et al. (2018) by considering ROE as well as ROA as a performance measure. In practical terms, this work contributes to a better understanding of the impact of this type of investment on profitability. It helps to obtain responses about which component of intellectual capital has the most significant effects on performance to help managers define new market strategies.

The results indicate that the efficiency of intellectual capital has a positive effect on the performance of Brazilian companies, regardless of the metric or estimator used. We found that all the components of intellectual capital are essential to improving performance.

INTELLECTUAL CAPITAL AND PERFORMANCE OF FIRMS

Intellectual capital can be defined as an asset of firms based on knowledge (Chen et al., 2005; Demartini & Beretta, 2020). As a result of this

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definition and its uncertain nature, intellectual capital is hard to measure because the distinction between intangible assets and intellectual capital is still obscure (Petty & Guthrie, 2000).

Because of this difficulty of measurement and of implementing investments to improve intellectual capital, it is an important topic to investigate in-depth because both the economic literature (Hidalgo et al., 2007; Hidalgo & Hausmann, 2009; Hausmann & Hidalgo; 2011) and the accounting literature (Petty & Guthrie, 2000; Guthrie et al., 2012) indicate that knowledge and intellectual capital are fundamental for economic development in general. Besides this, the literature on business strategy, mainly in the Industrial Revolution 4.0, has stressed that knowledge and technology are critical factors for economic growth (Xu et al., 2018; Cabrita et al., 2018; Stachová et al., 2019).

Specifically for Brazil, Antunes (2006) and Antunes and Martins (2007) sought to verify how companies invest in and manage the elements of intellectual capital.

The metric most widely used in studies of intellectual capital is VAIC, because the data used for its calculation come from financial statements, enabling standardization of results and comparability among firms, as well as for producing reliable measures that can be applied to all firms that publish these statements (Pulic, 2000; Kehelwalatenna, 2016). The use of the value of VAIC as a proxy for intellectual capital complements existing performance measures and supplies more information on the composition of the results obtained (Appuhami, 2007).

The variables most widely used as proxies for the financial performance of firms are ROE and ROA, which demonstrate the gains achieved by effective use of the firm's resources (Ardi & Murwaningsari, 2018).

Sydler et al. (2014) analyzed the relationship between intellectual capital and returns to predict the future profitability of firms. They found that combined measures of intellectual capital and financial ratios were significantly associated with return on assets, besides the possibility of capitalizing on intangible assets by increasing intellectual capital.

Dimitropoulos and Koumanakos (2015) investigated the relationship between intellectual capital and the profitability of European football clubs between 2010 and 2015. Their results indicated that more significant investments in players and the coaching staff add value to the club and positively influence their financial performance. Asare et al. (2017) found a positive relationship between intellectual capital and profitability of 36 insurance companies in Ghana from 2007 to 2011.

In Brazil, Turra et al. (2015) analyzed the relationship between an intellectual capital metric and the financial performance of Brazilian and Chilean companies in 2013, and Brizolla and Turra (2015) conducted a study with a similar approach involving only listed Brazilian companies in 2013. Both studies used correlation analysis and found a positive influence of intellectual capital on the firms' financial performance in the period studied. Richieri (2007) investigated 237 firms between 2000 and 2005, before adopting *Internacional Financial Reporting Standards* (IFRS) by listed Brazilian companies, to analyze the relationship between firms' intellectual capital and financial performance.

Pew Tan et al. (2007) also investigated the relationship between intellectual capital and performance, focusing on the future performance of firms and the growth rate of intellectual capital. Frederickson et al. (2010) found that firms that invest in this type of capital to increase the motivation of employees and elicit greater innovation and better ideas tend to succeed in improving their performance. Based on these previous findings, we expect that firms with more significant intellectual capital will have a better capacity to generate value due to increased employee incentives. This leads to our first hypothesis:

- H1: A positive relationship exists between investment in intellectual capital and firms' performance.

For this purpose, we decompose intellectual capital into: structural capital, human capital, and invested capital. We first examine structural capital, which is linked to tools, processes, management methods, and computer programs that support the development of the firm's activities (Riahi-Belkaoui, 2003). All the firm's capacities involving infrastructure, technology, and information to help human capital carry on activities are part of the structural capital (Bontis, 1998).

Human capital consists of individuals' knowledge, skills, competencies, and ability to create and innovate (Pulic, 1998; Riahi-Belkaoui, 2003; Muhammad & Ismail, 2009). This capital results from the firm's investment in employees' training, qualification, and salaries (Sydler et al., 2014). Further, according to Nazari and Herremans (2007), employees' skills and knowledge should be maximized since these are sources of innovation and creation.

Besides finding a positive relationship with intellectual capital, Asare et al. (2017) identified that the most significant impact on the profits of insurance companies was an investment in human capital. Thus, we expect that firms with a more robust human capital index will have a greater capacity to generate value, leading to the second hypothesis:

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- H2: A positive relationship exists between investment in human capital and firms' performance.

Inkinen (2015), analyzing whether intellectual capital systematically influences the performance of firms, identified that organizational and management capabilities along with innovation are dimensions encompassed by structural capital, contributing positively to the implementation of firms by transforming knowledge into innovation, making firms more competitive and allowing them to exploit new business opportunities.

Hsu and Wang (2012) analyzed 242 firms in the high-tech sector from 2001 to 2008 via Bayesian regression. The results indicated a positive relationship between structural capital and performance, mediated by the dynamicity of the firm. Hejazi et al. (2016) examined the VAIC and its disaggregated factors and found a positive relationship between the variation of value-added structural capital and firms' performance. Likewise, we expect firms with more outstanding structural capital to generate more value, leading to our third hypothesis:

- H3: A positive relationship exists between investment in structural capital and firms' performance.

Another aspect deserving attention is the effect of invested capital, which encompasses the productive or commercial relations of the firm, such as the portfolio of customers, shareholders, banks, and suppliers (Riahi-Belkaoui, 2003; Muhammad & Ismail, 2009; Kehelwalatenna, 2016). These relations generate information that enables improving efficiency, optimizing the use of resources, and increasing innovation (Zheng, 2010). Joshi et al. (2013) investigated the relationship between intellectual capital and its components in Australian companies in the financial sector between 2006 and 2008. The aggregated results indicated a positive relationship between intellectual capital and performance. In contrast, the disaggregated results showed a more powerful influence of invested capital on performance than human and structural capital.

Phusavat et al. (2011) researched the relationship between intellectual capital and its components in large manufacturing companies in Thailand. The results found, as in Joshi et al. (2013), indicated a much more robust relationship between performance and invested capital than between performance and the other types of money, leading to the expectation that a higher level of invested capital is associated with greater capacity to generate value, hence our fourth hypothesis:

- H4: A positive relationship exists between investment in invested capital and firms' performance.

RESEARCH METHODOLOGY

The data used in this study came from the financial statements of the companies listed on the B3 exchange from 2010 to 2018, obtained from the Economatica database were processed with the Stata software. We chose 2010 as the starting year because it was the first year of complete adoption of the IFRS to prepare firms' financial statements listed on the B3. The variables were winsorized at 1% to minimize biases caused by outliers in the sample.

We excluded from the sample banks, insurance, and other financial firms, firms with negative equity in any year, and those with missing information related to the variables used in the models, resulting in 1032 observations. According to Firer and Williams (2003), the VAIC cannot measure the value added by the intellectual capital of firms suffering losses, so we excluded observations of firms with negative operating income, leaving 957 observations in the sample. We used both ROA and ROE as the performance metrics. We employed two models, the first using the VAIC and the second the decomposition of this variable as predictors of the firms' performance.

$$performance_{it+1} = \beta_0 + \beta_1 VAIC_{it} + \sum_{k=2}^{6} \beta_k control_{kit} + \varepsilon_{it} \qquad (1)$$

$$performance_{it+1} = \beta_0 + \beta_1 HC_{it} + \beta_2 IC_{it} + \beta_3 SC_{it} +_{it} \sum_{k=4}^{8} \beta_k control_{kit} + \varepsilon_{it} \qquad (2)$$

in which: $performance_{it+1}$ denotes the performance indicators of firm i on date t + 1, as measured by ROA and ROE.

The firm's statement of value added (SVA) was used to calculate the VAIC because this document contains the aggregate value of the capital and the value of human capital, variables that are included in the VAIC (Nazari & Herremans, 2007). The higher the value of the VAIC found, the greater the firm's efficiency will be in using its human capital (HC), structural capital (SC), and invested capital (IC) to generate added value (Muhammad & Ismail, 2009).

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To avoid or reduce the possible effects of biases, we used several control variables in the two models (variables that can influence firms' performance). The first is size, denoted by the logarithm of total assets (Firer & Williams, 2003; Riahi-Belkaoui, 2003; Hsu & Sabherwal, 2012) because larger companies typically have higher returns (Yazdanfar, 2013).

Our second control variable is financial leverage, widely used in the literature to influence firms' performance, as indicated by the Signaling Theory and Agency Theory (Olokoyo & Oyakhilome, 2018). However, there is no empirical or theoretical consensus regarding the sign of the effect because while the signaling theory forecasts a positive relationship in the presence of information asymmetry, agency theory posits a negative relationship due to the agency costs generated between principals (owners) and agents (creditors) (Olokoyo & Oyakhilome 2018). Here it is measured as the ratio between the total debt and equity, as done by Firer and Williams (2003).

The third control variable is shareholding composition, which is essential to consider in Brazil since the institutional environment of firms can favor some shareholders to the detriment of others, and this situation is perceived and incorporated by companies as a business strategy since it can influence their performance (Heugens et al., 2009; Wang & Shalier, 2015). This metric is calculated as the percentage of common shares detained by the majority shareholder.

Our fourth control variable is the market-to-book ratio since the vision of the market regarding a particular firm's value can affect its market strategy, as well as its return on assets (Firer & Williams, 2003; Chen et al., 2005).

The fifth control variable is age, which is vital since the older a firm is, the more information, experience, and contacts it will have, and a long track record to form its reputation. These factors help formulate the firm's strategy and thus affect its performance (Yazdanfar, 2013). We measure this variable by the logarithm of the number of years of existence.

Besides these control variables, we also consider dummies for year and sector of activity (according to the North American Industry Classification System – Naics code) since the year and sector can affect firms' profitability. Table 1 summarizes the variables of the proposed models.

When working with panel data, both with estimation by fixed effects and OLS, it is necessary to have strict exogeneity. However, according to Nadeem et al. (2018), a simultaneous relationship can exist between performance and investment in intellectual capital, mediated by time. In other words, past performance can influence investment in intellectual capital. That possibility can generate endogeneity and cause bias in the estimated coefficients.

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Table 1

List of variables of equations 1 and 2

Name	Abbreviation	Classification	Description	Sources	Expected relation
Growth of return on assets	ΔROA_{t+1}	Explained	Variation of the ratio between net income and total assets at t + 1	Janošević et al. (2013), Nadeem et al. (2018) e Cao et al. (2011)	Not applicable
Growth of return on equity	ΔROE_{t+1}	Explained	Variation of the ratio between net income and equity at t + 1	Janošević et al. (2013), Nadeem et al. (2018), and Cao et al. (2011)	Not applicable
Growth of intellectual capital	VAIC	Explanatory	Sum of HC, IC, and SC	Pulic (1998, 2000, 2004)	+
Investment in human capital	HC	Explanatory	Ratio between gross value added and spending on personnel	Pulic (1998, 2000, 2004)	+
Investment in invested capital	IC	Explanatory	Ratio between added value and equity	Pulic (1998, 2000, 2004)	+
Investment in structural capital	SC	Explanatory	Ratio between added value minus spending on personnel and added value	Pulic (1998, 2000, 2004)	+
Firm size	Size	Control	Natural logarithm of total assets	Firer e Williams (2003), Riahi-Belkaoui (2003), and Hsu e Sabherwal (2012)	+
Leverage of the firm	Leverage	Control	Ratio between debt and total assets	Firer e Williams (2003)	+/-
Shareholding concentration of the firm	Shareholding concentration	Control	Percentage of common shares detained by the majority shareholder	Heugens et al. (2009), and Wang e Shailer (2015)	-
Market-to-book value of the firm	*Market-book*	Control	Ratio between market value and book value of equity	Firer e Williams (2003)	+
Firm age	Log_Age	Control	Age of the firm	Yazdanfar (2013)	+

Source: Elaborated by the authors.

In situations of endogeneity of panel data, it is necessary to use a dynamic model. According to Gujarati (2012), a way to ascertain whether an econometric model is static or dynamic is to analyze whether the dependent variable is also a regressor. If so, the lagged dependent variable can be included as an explanatory variable. If the result is statistically significant, a dynamic model should be adopted, while otherwise, a static model should be employed.

A test of strict exogeneity was necessary. As the first test, we checked the models with and without lags of the firm performance variables (both ROA and ROE) besides whether the coefficients of these variables were statistically significant. We also applied the exogeneity test of Wooldridge (2002) to verify if past information regarding the VAIC was related to the firms' performance, permitting analysis of the simultaneity of the relationship.

After analyzing the presence of exogeneity in the model, we verified how many lags of the performance were most prudent to insert to minimize the effect of possible estimation biases. For this purpose, we applied the method used by Nadeem et al. (2018), which involves the insertion of lags in the models described by equations 1 and 2 (up to four periods) and comparing the significance of the results as more lags are inserted. The number of observations decreased since the observations up to four (initial) lags were deleted to perform these estimates.

As Nadeem et al. (2018) carried out, to afford robustness to the results, we used four estimation approaches. From the static perspective, we adopted estimation by OLS and fixed effects, with the variance of errors corrected by White's estimator. We applied dynamic OLS and the GMM from the dynamic perspective. According to Roodman (2006), we exploited the dynamic nature of a model based on instruments and generated consistent estimates. Finally, to check for possible multicollinearity problems, we used the variance inflation factor (VIF).

ANALYSIS OF THE RESULTS

Our objective was to analyze the effect of intellectual capital and its components on the profitability of listed Brazilian firms. Here we present the results of estimating the two models applied to ascertain those effects.

Table 2 reports the descriptive statistics of the variables for the characterization of the sample.

Table 2

Descriptive statistics

Variáveis	Sample	Mean	SD	Min.	1st quartile	Median	3rd quartile	Max.
%Maj. shareholding	957	0.48	0.25	0	0.26	0.47	0.63	1
ROA	957	0.0876	0.218	0.0004	0.043	0.103	0.553	0.671
ROE	957	0.182	0.887	0.0021	0.113	0.221	0.886	1.0712
Size	957	15	1.66	10.91	13.8	15.1	16.03	19.4
Leverage	957	0.3	0.18	0	0.16	0.31	0.42	0.71
Market-book	957	0.79	0.97	0.01	0.22	0.45	0.94	5.7
Age	957	42.97	27.52	2	17	43	62.5	116
VAIC	957	7.29	9.37	1.4	4.21	8.33	32.3	57.7
HC	957	6.19	5.33	1.07	2.39	5.14	29.4	54.8
IC	957	0.44	1.28	0.09	0.22	0.55	0.64	0.86
SC	957	0.64	1.12	0.21	0.44	0.72	1.28	2.03

Source: Elaborated by the authors.

Note: %Maj. shareholding represents the shareholding concentration, measured by the percentage of common shares detained by the majority shareholder; *ROA* denotes return on assets; *ROE* represents return on equity; size represents the size of the firm, measured by the natural logarithm of total assets; leverage stands for the ratio between debt and equity; market-book is the quotient between market value and book value of equity; age is the time of existence of the firms; *VAIC* is the value-added intellectual coefficient; *HC* is the ratio between gross value added and spending on personnel; *IC* is the ratio between value-added and equity; and *SC* is the ratio between added value minus expenditure on personnel and added value.

The average return on assets is 8.76%, while the mean return on equity is 18.2%. These two performance metrics are highly heterogeneous, indicating large variability of returns, even though we only considered firms with positive operating income. The ROE is also slightly more dispersed than the ROA, showing that with respect to the capability of transforming equity into profitability, the sample is still more discrepant among the firms contained in it.

An important point is how volatile the metric is that represents an investment in intellectual capital, and the components that belong to it. The standard deviations concerning the means indicate significant heterogeneity among the firms analyzed regarding investments of this nature over the years. There is a very large discrepancy between the smallest and largest growth rate of investment in intellectual capital, corroborating the idea of significant differences among the firms.

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Table 3 presents the results of the strict exogeneity tests, which help to determine the use of static or dynamic models.
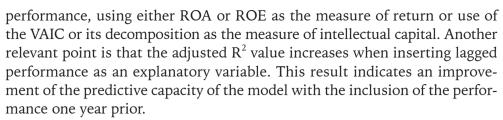
Table 3

Strict exogeneity tests

Panel A: dynamic OLS *versus* static OLS							
ROA(t)		ROE(t)		ROA(t)		ROE(t)	
Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic
VAIC 0.554**	0.321**	0.391*	0.189**				
HC				0.022**	0.029**	0.019**	0.017**
SC				0.766**	0.881*	0.749***	0.796**
IC				0.554***	0.338***	0.597***	0.397***
Perform(t-1)	0.592*		0.457**		0.332**		0.411**
Adjusted R2 0.07	0.398	0.085	0.438	0.432	0.543	0.496	0.559
Panel B: Strict exogeneity test – Wooldridge							
ROA(t)		ROA(t+1)		ROE(t)		ROE(t+1)	
VAIC 0.681***		0.221**		0.501*		0.195**	
HC		0.021		-0.087		0.018*	0.032
SC		0.776**		0.445*		0.982**	0.238**
IC		0.444***		0.123***		0.554***	0.119*

Source: Elaborated by the authors.

Note: Panel A depicts the estimates by static and dynamic ordinary least squares, both using the VAIC and its decomposition. Panel B presents the results of the strict exogeneity test of Wooldridge. *ROA* denotes return on assets; *ROE* represents return on equity; *VAIC* is the value-added intellectual coefficient, *HC* is the ratio between gross value added and spending on personnel; *IC* is the ratio between value-added and equity, and *SC* is the ratio between added value minus spending on personnel and added value. All the models are controlled by %Maj. Shareholder, which represents the shareholding concentration, measured by the percentage of common shares detained by the majority shareholder; size is measured by the natural logarithm of total assets; leverage stands for the ratio between debt and equity; market-to-book is the quotient between market value and book value of equity; age is the time of existence of the firms. Coefficients marked with one asterisk (*) are statistically significant at 1%, those marked with two asterisks (**) are statistically significant at 5%, and those marked with three asterisks (***) are statistically significant at 1%.

The results in the first panel of the table indicate the need to use a dynamic model. This result is evidenced by the fact that the lagged performance of the firms is statistically significant in explaining their current

performance, using either ROA or ROE as the measure of return or use of the VAIC or its decomposition as the measure of intellectual capital. Another relevant point is that the adjusted R^2 value increases when inserting lagged performance as an explanatory variable. This result indicates an improvement of the predictive capacity of the model with the inclusion of the performance one year prior.

Panel B also indicates a lack of strict exogeneity of the model. This result can be verified by noting that the VAIC is statistically significant in explaining the performance metrics (both ROA and ROE) in the same period when the intellectual capital is evaluated and one period ahead, providing evidence of the simultaneity of the model and thus is endogeneity. When testing the decomposition of the VAIC, the results are similar: most components can predict future performance. Only investment in human capital does not explain firms' performance (and only when using ROE as the return metric). Together, these results indicate the need for the correction of endogeneity problems.

The results of tests of the number of lags when using the dynamic panel models show one lag for ROA and two for ROE. This is confirmed because only the first lag of ROA is significant irrespective of inserting one, two, three, or four lags (results not reported). For the ROE performance yardstick, only the first two lags are statistically significant, irrespective of the number of lags used.

Table 4 presents the results of estimating the models specified by equations 1 and 2. It offers the results of the estimations with the use of the dynamic OLS and GMM. It should be stressed that when analyzing the VIF, no problems of multicollinearity were identified since its value was not greater than five in any model studied.

Table 4

Estimation of the models

Panel A: Performance measured by ROA				
	OLS	GMM	OLS	GMM
VAIC	0.321**	0.332**		
HC			0.022**	0.123***
SC			0.766*	0.886*
IC			0.554***	0.812**

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Table 4 (conclusion)

Estimation of the models

Panel A: Performance measured by ROA				
	OLS	GMM	OLS	GMM
ROA(t-1)	0.712***	0.669***	0.332**	0.621***
Adjusted R²	0.675	-	0.712	-
Controls	Yes	Yes	Yes	Yes
Control for year and sector	Yes	Yes	Yes	Yes
VIF	3.98	2.13	3.33	2.87
Panel B: Performance measured by ROE				
	OLS	GMM	OLS	GMM
VAIC	0.308**	0.329*		
HC			0.331	0.215**
SC			0.675*	1.097***
IC			0.443***	0.687*
ROE(t - 1)	0.712***	0.532***	0.765***	0.447**
ROE(t - 2)	0.234**	0.177*	0.168*	0.221*
Adjusted R²	0.583	-	0.667	-
Controls	yes	yes	yes	Yes
Control for year and sector	yes	yes	yes	Yes
VIF	4.07	2.13	4.21	2.87

Source: Elaborated by the authors.

Note: Panel A contains the estimates of the models when the performance is measured by ROA, while Panel B reports the estimates with ROE as the performance measure. The models represented by equations 1 and 2 are estimated using the dynamics OLS and GMM estimators. *ROA* denotes return on assets; *ROE* represents return on equity; *VAIC* is the value-added intellectual coefficient, *HC* is the ratio between gross value added and spending on personnel; *IC* is the ratio between value-added and equity, and *SC* is the ratio between added value minus spending on personnel and added value. All the models are controlled by %Maj. Shareholder, which represents the shareholding concentration, measured by the percentage of common shares detained by the majority shareholder; size is measured by the natural logarithm of total assets; leverage stands for the ratio between debt and equity; market-book is the quotient between market value and book value of equity; age is the time of existence of the firms. Coefficients marked with one asterisk (*) are statistically significant at 1%, those marked with two asterisks (**) are statistically significant at 5%, and those marked with three asterisks (***) are statistically significant at 1%.

The results indicate that, on average, the VAIC is statistically significant in explaining the firms' performance. This finding is independent of the metric used, i.e., the effect is the same for return on assets (panel A) and return on equity (panel B). The coefficients are positive, irrespective of the estimation method. In other words, the results show that a more significant investment in intellectual capital is associated with higher ROA and ROE of the firms, indicating that the performance improves as this type of investment increases.

The results allow validation of H1, according to which firms' performance is positively influenced by investments made in intellectual capital. These results align with those of Phusavat et al. (2011), who identified that intellectual capital contributed positively to the ROA of manufacturing firms in Thailand. The results also corroborate those of Janošević et al. (2013), Berzkalne and Zelgalve (2014), and Nadeem et al. (2018), who all found indications of better performance by companies that invest in intellectual capital.

When investment in intellectual capital is decomposed, the results about the effect of human capital on performance are not consistent. The impact of investment in human capital is statistically significant, with positive effects to explain ROA. Still, itis not significant for all the estimates when using ROE as the performance measure (significant only for the GMM analysis). These results partially validate H2 since investment in human capital is a determinant of future profitability measured by return on assets, but not according to return on equity. These results are in accordance with those presented by Youndt et al. (2004), Hsu and Wang (2012), Janošević et al. (2013), Pew Tan et al. (2007), and Phusavat et al. (2011), who all found positive effects of HC on performance.

In the case of investment in structural capital (SC), regardless of the performance metric used (ROA or ROE) and irrespective of the estimator, the effect is statistically significant and positive. In other words, firms that invest more intensively in structural capital tend to have a higher future return on equity. These results validate H3 and corroborate the findings of Janošević et al. (2013), Phusavat et al. (2011), Nadeem et al. (2018), and Muhammad and Ismail (2009). They all found positive effects of this type of investment on firms' profitability.

Finally, the variation of invested capital (IC) results also shows a statistically significant and positive effect of this type of investment on the firms' performance (measured by ROA and ROE). This result is independent of the estimation method, leading to the validation of H4. This demonstrates that greater invested capital is associated with higher future profitability of

firms, also following the observations of Janošević et al. (2013), Phusavat et al. (2011), Nadeem et al. (2018), and Muhammad and Ismail (2009).

In general, these findings indicate that a positive variation of intellectual capital tends to positively effect the future performance of listed Brazilian companies. The results also reveal that the association is not connected to an isolated component of intellectual capital but rather to all spheres, suggesting the importance of making investments of this nature and the relevance of making these investments in complementary form among the different categories of intellectual capital, not in a zero-sum manner.

FINAL CONSIDERATIONS

The objective of this study was to investigate the relationship between investment in intellectual capital and the performance of Brazilian companies, more specifically, whether a positive relationship exists between a proxy for intellectual capital (and its components) and indicators of profitability of firms listed on the B3 exchange. To reach this objective, we defined models estimated by static and dynamic approaches, following the footsteps of Nadeem et al. (2018).

The results validated our hypotheses, indicating a positive effect of intellectual capital and its components on the performance of Brazilian firms. In other words, we found that higher investments in this type of capital by the firms in our sample during the period studied were associated with higher future profitability. These results corroborate other findings in the international literature, namely by Appuhami (2007), Muhammad and Ismail (2009), Phusavat et al. (2011), Nadeem et al. (2018), Janošević et al. (2013), Youndt et al. (2004), and Hsu and Wang (2012). According to all these authors, intellectual capital is a fundamental ingredient for the profitability of firms, and investments made in any component of intellectual capital act as a relevant positive shock to performance, although with different intensity of effects, with the most substantial impact coming from invested capital.

The main contribution of this study is to clarify to managers the importance of this type of investment for the growth and maintenance of the performance of firms over time, as well as the importance of investing in all the components of intellectual capital. These investments can improve firms' profits and positively affect the national economy. Besides this, the study brings insight into the details of intellectual capital that generate better per-

formance and evidence that all these components are relevant, elucidating the need for complementary investments.

A limitation of this study is the measurement of intellectual capital by the VAIC. Although this metric is well disseminated in the literature (Janošević et al., 2013; Pew et al., 2007; Appuhami, 2007; Muhammad & Ismail, 2009; Nadeem et al., 2018; Phusavat et al., 2011), it may not faithfully represent the intellectual capital of all firms in all settings. For future studies, we recommend using samples of firms from other countries, especially Russia, India, China, and South Africa (Brics), because they are emerging countries with similar economic characteristics to Brazil. Increased sample size can permit more comprehensive findings of the importance of investments in intellectual capital, irrespective of the country analyzed, thus providing more generalized results.

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