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DO THE EFFECTS OF INVESTMENTS ON FIRM'S PROFITABILITY PERSIST OVER TIME? Empirical Evidence from Brazil

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ABSTRACT

This paper empirically examined the relationship between past investment and firm´s profitability (measured by ROA and Tobin's q coefficient), considering five scenarios with different periods of investment over time. We employed the generalized linear mixed models (GLMM) that enabled to consider a structure of correlation for the profitability observed over time and to use a distribution of different probability for ROA and Tobin's q coefficient. A sample of 1,484 firm-year observations from Brazilian Stock Exchange was used (2001–2011). The results reveal that the effects of investments on firm's profitability didn't persist over time and highlights significant short-term relationships (contrarian effects at short horizons using ROA). Using Tobin's q, we also conducted an analysis from the perspective of the market. In this case, the past investment gives investors better expectancies over the company and positively affects short-term profitability.

Keywords: *Investment, Firm's profitability, Capital market, Longitudinal study, Generalized linear mixed models.*

1. INTRODUCTION

In a globalized world, companies are involved in a competitive market environment in which competitors act against the company, suppliers' conditions change, consumers switch their preferences, and new technologies arise. All of these factors affect competition. Thus, the results of investment can be vary from predictions, which are reflected in the economic and financial results of companies over a period of time. In this scenario and from the standpoint of the company, investment decisions are made with the aim of adding value by obtaining a profit and positive cash flows. From the perspective of shareholders, profit and positive cash flows must be reflected in stock prices (Damodaran, 2010).

Several previous studies have assessed the effects of investments from different standpoints as, including the effectiveness of investments (Biddle *et al.*, 2009), their relationship with expected stock returns (McConnell and Muscarella, 1985; Titman *et al.*, 2004; Fama and French, 2006), and their relationship with profitability or firm value (Gordon and Iyengar, 1996; Echevarria, 1997; Kim, 2001; Li, 2004; Jiang *et al.*, 2006; Hao *et al.*, 2011). The literature reveals that these studies are mostly of type cross-sectional. Furthermore, some studies were unable to demonstrate a relationship between investment and profitability (or firm value) and were therefore inconclusive (Echevarria, 1997; Kim, 2001; Jiang *et al.*, 2006) or presented conflicting evidence or mixed results (Gordon and Iyengar, 1996; Li, 2004; Hao *et al.*, 2011). A possible explanation for these difficulties is that they did not evaluate this relationship over time.

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Generally, investment decisions are made with the goal of generating positive returns and adding value to the company. Thus, the main objective of this longitudinal study was to examine the relationship between investment and firm's profitability. We stated two hypotheses to assess this relation over time: first, using ROA as an accounting indicator of performance and second, using Tobin's q coefficient as a performance indicator that reflects the expectation from the investors on the company. These hypotheses were tested using a wide class of statistical models, so-called generalized linear mixed models – GLMM (Huang and Oosterlee, 2011) assuming five scenarios designed to evaluate different periods of investment lagged in time (from 1–5 years) with regard to profitability. These models enabled analysis of profitability data in accordance with the probability distribution that was most suited to the nature of the data (Normal distribution for the ROA and Gamma distribution for Tobin's q coefficient). Moreover, allowing more suitable treatment of profitability data, greater accuracy was achieved in statistical tests carried out for the models.

Our results, which were obtained from the analysis provided by a longitudinal study considered the correlations between profitability measurements over time. Moreover, profitability variation over time was controlled by the macroeconomics variable (year's dummy) and by inherent factors to companies (past profitability, contemporary investment, company size, sector, leverage, and growth opportunities). Thus, our study highlighted significant short-term relationships (contrarian effects at short horizons when the investment was lagged up to 2 years), indicating that past investment has decreased firm's profitability (using ROA). Using Tobin's q coefficient, we also conducted an analysis from the perspective of the market. In this case, the past investment gave investors better expectancies over the company and positively affected short term profitability.

Thus, this study was conducted because of the importance of its theme and to make a contribution to the understanding of the capital market. In this context, the information regarding company investment, when associated with future profitability, is important to investors or stockbrokers when taking into account the expectations of increased future profits which are made possible by the investment, impacting future dividend and share values. According to Fortunato *et al*. (2012) such studies "*…can provide subsidies that help both the construction of scenarios for pricing and valuation of companies, as well as guidance of quality on investment decisions by its managers*".

This paper is structured as follows: review of previous studies and formulation of hypotheses (Section 2); description of methodological procedures, including variables, models, and the sample (Section 3); the main results, with corresponding statistical tests and analyses (Section 4); and conclusions (Section 5).

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

In this section, we examine the results of previous studies conducted to assess the relationship between investment and profitability. Some of these studies related investment carried out by companies to the return provided by the stock valuation in the capital markets. This type of study was first conducted in the 1980s when McConnell and Muscarella (1985) noted that there is little evidence of the effect of investment decisions on the market value of companies.

Other studies sought to relate investment carried out to profitability resulting from these assets within the company using performance assessment indicators such as ROA and Tobin's q coefficient, ROE, and ROI, among others. Gordon and Iyengar (1996) analyzed a sample of industrial companies listed in the NYSE and AMEX over the period 1989–1992 and identified a positive relationship between capital expenditures and ROI. Echevarria (1997) selected industrial firms belonging to the Fortune group in the US and listed in the Compustat for the period 1971–1990. The period 1971–1980 was used as the base period and 1981–1990 was used as the period of profitability. The author recommended that future studies should take into account the size of companies, levels of investment, sectors of economic activity, and other factors that may also be included in the assessment.

Kim (2001) conducted a study in which selected industrial companies in the United States (listed in the Compustat Annual Tapes) for the period 1976–1994. After examining the data using regression analysis, no relationship was observed between investment (current capital expenditures) and future earnings for the sample selected.

In relating investment to profitability as measured by stock returns, Li (2004) analyzed financial statement data of American companies for the period of 1962–2002 in a cross-sectional study and classified them into the portfolios of investment groups. The author identified a relationship between investment and future profitability (using stock returns and ROA), concluding that in companies with high free cash flow and low leverage, a negative relationship exists between capital investment (long-term asset accruals) and future profitability.

Titman *et al.* (2004) observed a negative relationship between capital investments and future stock returns. Fama and French (2006) showed that firms with higher book-to-market equity have higher than expected stock returns when expected profitability and investment are controlled. Moreover, given the rate of book-to-market and expected profitability, higher expected rates of investment are related to lower than expected returns. The authors stated that their results aligned with those of other studies, concluding that firms that invest larger amounts of capital show lower average returns.

In establishing a relationship between capital expenditure and profitability measured based on accounting information (ROA), Jiang *et al.* (2006) selected industrial companies listed in the Taiwan Stock Exchange for the period 1992–2002. In the study, the first five years were considered to be the period of investment and the last six years as the period of profitability. After grouping companies according to investment level, the authors concluded that investments are positively related to future profitability.

Hao *et al.* (2011) related investment growth to the value of the company, profitability (ROE), and the value of shareholder equity. The study concluded that past investment activities affect the value-accounting relationship as a result of conservative accounting practices.

Finally, Fortunato *et al*. (2012) analyzed a sample of 508 companies listed Brazilian Stock Exchange – BM&FBovespa from 1998 to 2007. The authors used a panel regression and not found relationship between investments (Capex) and operating profit – Ebit (an accounting metric). However, the results suggest a positive relationship between the investment and the market value.

According to literature analysis, the importance of the theme "past investment and firm's profitability" is apparent not only for the academic environment, but also for the capital market and to company managers. Hence, we attempted to add to the existing knowledge by exploring gaps that still exist in the literature. Based on analyses of the studies described above and, in particular, the results of Echeverria (1997), Li (2004), Titman *et al.* (2004), Jiang *et al.* (2006), Fama and French (2006) and Fortunato *et al*. (2012), the following hypotheses were proposed:

H1: there is a statistically significant relation between profitability (measured by ROA) and past investment carried out by non-financial companies.

H2: there is a statistically significant relation between profitability (measured by Tobin's q coefficient) and past investment carried out by non-financial companies.

The next section presents models, variables, data collection, and other methodological instruments that were employed to test the proposed hypotheses.

3. METHODOLOGY

In this section, we provide an operational definition of the variables, followed by a description of the statistical model used. Finally, we discuss sample selection and research design.

3.1. Operational definition of variables

We first define the following operational variables: dependent variable (profitability) and explanatory variables, including interest (investment) and a control as a means of forming our models and drawing up sample selection criteria.

3.1.1. Proxy of profitability – dependent variable

Profitability is the net profit arising from business activities and decisions; it reflects the effectiveness of operations and the effects of liquidity on asset management and liabilities in the company results and can usually be calculated based on performance measures, such as sales margins and profit margins, return on assets, and return on net worth, among others (Brigham and Houston, 2009). Indicators such as ROA, ROE, ROI, and asset turnover have been used as proxy to profitability when related to levels of corporate governance, ownership concentration, or making forecasts about future share prices, among other applications (Gordon and Iyengar, 1996; Li, 2004; Hao *et al.*, 2011). In addition to indicators for profitability calculated by accounting measures, there are indicators that use market values to measure firm's profitability. Tobin's q coefficient is recommended in the financial literature as a criterion that allows measurement of firm's performance (Wenderfelt and Montgomery, 1988; Bharadwaj *et al.*, 1999).

Two indicators were used in this study to measure the firm's profitability over time: *i*) the ROA (Weygandt *et al.*, 2009), which shows the profitability provided by the total assets of the company (calculated annually and for each company by dividing operating results by average total assets); *ii*) the Tobin's q coefficient (represented by $QTOBIN$), which shows the performance obtained by the company's shares in the stock market related to its total assets (calculated annually and for each company using as a basis the market share value on 31st December or the quotation immediately before, added to the short- and long-term liabilities divided by the total amount of fixed assets in the balance sheet of each year, in accordance with Shin and Stulz (2000)). In this case, Tobin's q coefficient indicates the future perspective of profitability by relating the values of the company's assets with the market value of its shares and liabilities.

3.1.2. Explanatory variable of interest
Investment represents the value that the company has included in its fixed assets and which it hopes to use for future benefits. In this study, investment index represents the value quoted as new long-term investments and fixed assets and deducted the fixed asset sold or written off stated in the Sources and Uses of Funds or Cash Flow statement, divided by the average total assets (according to Jiang *et al*., 2006; Kim 2001). This calculation is carried out annually for each company and can be expressed as:

$$Investment\ index = \frac{Investment}{Average\ Total\ Assets} \quad (1)$$

These values, which are considered to be investments, are the constant method of the sources of uses of funds or cash flow statements, registered as permanent investments, expected to yield returns over the long-term; thus, they are different from current assets, which refers to short-term operations. The investment index associates long-term investment with long-term profitability, which is why we only consider long-term investment and fixed assets (changes in working capital did was not considered as an investment, since these are short-term investments). Finally, we excluded companies with negative investment over the long-term. In this study, the natural logarithm of the investment index was employed and defined in (1), which was represented as the $INVEST$ variable.

3.1.3. Control explanatory variables
The control variables were used to remove the effect of determined factors, such as past profitability, investment contemporary, company size, the sector in which the company operates, leverage and growth opportunities, which can influence the relationship between investment and profitability. Previous studies used past profitability as a control variable to explain the future profitability (Li, 2004; Jiang *et al.*, 2006; Berk *et al.*, 1999). In this manner, a positive relationship between past profitability and the contemporary period can be expected since the capacity of the company to yield positive results is related to positive results in the past. Hence, in this study, past profitability was employed as a control variable. In addition, investment in the contemporary period was used as a control variable because a positive relationship was expected with contemporary profitability.

In this study, the $SIZE$ variable, measured by value of total assets, was also used as a control. Larger firms were expected to have a greater capacity to invest and obtain better financing than smaller firms; they can also exert a greater influence on markets (Ehie and Olibe, 2010).

The type of activity the company (represented by $SECTOR$ and identified by relying on constant information from the Economatica® database) is involved in determines some of the features that the firms operate with by fixing the levels of profitability, investment or capacity for innovation (Li, 2004; Han *et al.*, 2010).

We used the growth opportunity of the company as control variable (represented by $GROWTH$) that was calculated annually for each company by dividing the value of the shareholders' equity at the date of the balance sheet by the market share quotation for the same date or immediately before, a constant of the Economatica® database (Fama and French, 2006; McNichols and Stubben, 2008; Han *et al.*, 2010).

We also included the natural logarithm of leverage (represented by LEV) as a control variable (Richardson and Waegelein, 2002; Ehie and Olibe, 2010). In our study, leverage was calculated annually and for each company as the proportion between short and long-term debts divided by total liabilities of the company, representing the costly liabilities portion of the total liabilities of the company (Bodie and Merton, 1999). Leverage, when considered to be the relationship between capital itself and third-party capital reveals the involvement of third-party capital in financing assets. The decision regarding involvement of third-party capital is an integral part of financial decision-making and in Brazil, long-term resources are almost entirely offered by banks that are controlled by the State (BNDES, Caixa Econômica Federal – CAIXA, Banco do Brasil).

Finally, we include dummy variables for the year to mitigate the effects of macroeconomic factors on the behavior of ROA and $QTOBIN$, as shown in Table 1.

3.2. Model – Generalized linear mixed models
This type of study is characterized by its longitudinal nature: profitability measurements are observed or calculated for each year (semester, quarterly, or other period of time). It should be taken into account that each company has its own management practices, that the ROA or Tobin's q coefficient indicators will reflect these practices, and

that these companies are relatively independent of each other. Based on these factors, it is reasonable to expect that these indicators for a company will be correlated with each other over a period of time (or autocorrelated). For cases in which this autocorrelation is present in the data and the usual models of linear regression are being used, an important assumption regarding "independence between the observations and the residues" will not be satisfied. If the autocorrelation is strong and depends on the sign of this correlation (whether positive or negative), Type I (or Type II) errors will be inflated. These errors are used in testing hypotheses related to the selection process of the statistical models and reveal factors such as erroneously significant (or the failure to take note of important factors such as the case of the Type II error). In summary, using a model with fixed and random effects (referred to as mixed effect models) improves accuracy in the testing of hypotheses by suitably modeling correlations between longitudinal measures of the companies.

According to Fitzmaurice *et al.* (2009), this mixed model can generally be described as in the class of linear mixed models (LMM):

$$\boldsymbol{Y} = \boldsymbol{X\beta} + \boldsymbol{Zb} + \boldsymbol{\varepsilon}, \tag{2}$$

where, $\boldsymbol{Y}$ is the characteristic that is being modeled (ROA or Tobin's q coefficient), $\boldsymbol{X}$ is a matrix in which the columns contain information about exogenous variables – covariates (explanatory variables or dummy variables that represent qualitative factors), $\boldsymbol{\beta}$ is a vector parameter with a fixed but unknown value, and the $\boldsymbol{Z}$ matrix has factors related to their respective random effects contained in the $\boldsymbol{b}$ vector (a vector of random effects that aggregates all of the non-measurable or unobserved factors related to each subject, for example, the company, which respond in a different manner from one another). The random effects are assumed to be independent of the covariates of the $\boldsymbol{X}$ matrix and have a multivariate normal distribution $N(\mathbf{0}, \mathbf{D})$, with a mean vector of zeroes and a variance-covariance matrix $\mathbf{D}$. The elements of matrix $\mathbf{D}$ are mathematically related with the autocorrelation of the longitudinal measurements (McCulloch and Searle, 2001), so adjusting to the dependency structure between observations. Once the matrix $\mathbf{D}$ has been correctly estimated, standard errors of the $\boldsymbol{\beta}$ vector are properly adjusted to autocorrelation effect. The $\boldsymbol{\varepsilon}$ vector is the vector of random errors with multivariate normal distribution $N(\mathbf{0}, \boldsymbol{\Sigma})$, and $\boldsymbol{\Sigma}$ is general variance-covariance matrix. This linear model shows two random effects that together with the versatility of the normal multivariate distribution (Verbeke and Molenberghs, 2000) show great flexibility; as a result, various areas of study make use of this class of models.

In another direction, classic linear models were extended in a way that allows the response variable to have other probabilistic distributions apart from the normal distribution (e.g. binomial, Poisson, and gamma, among others). The relationship between the linear part of the model and the average of the response variable can be established through a nonlinear function called *link function* (Nelder and Wedderburn, 1972). This class is known as generalized linear models – GLM (Lee *et al.*, 2006). Several statistical models are members of this class, such as the class linear models (which adopts a normal distribution and link function identity), the logistic or probit regression model (assuming binomial distribution and link functions logit and probit, respectively), and gamma regression (assuming gamma distribution and link function log), among other models.

So, when the normal distribution is not appropriate, GLMM can be used as an alternative. In the description of this model, random effects are included in the linear predictor η_i of the GLM:

$$h^{-1}\{\mu(\boldsymbol{Y}_i)\} = h^{-1}\{E(\boldsymbol{Y}_i|\boldsymbol{b}_i, \boldsymbol{X}_i, \boldsymbol{Z}_i)\} = \boldsymbol{X}_i\boldsymbol{\beta} + \boldsymbol{Z}_i\boldsymbol{b}_i, \tag{3}$$

where $h^{-1}(\cdot)$ is a *link function* that ensures continuity and suitable linearization of fixed effects $\boldsymbol{\beta}$ and random effects $\boldsymbol{b}$. Thus, measurements showing asymmetric distribution, such as Tobin's q coefficient, can be modeled with distributions that adjust to their shape without the need of data transformations (Kitner *et al.*, 2004). This simplifies interpretation and forecasting, as well as ensures greater precision by adjusting the data on their original scale. Despite the general structure that the matrices $\mathbf{D}$ and $\boldsymbol{\Sigma}$ accommodate, only a random effect was used in this study, and when adjusted to this random effect, the errors were assumed to be conditionally independent. Thus, the vector $\boldsymbol{b}$ consists of $b_i \sim N(0, \sigma_b^2)$ and the matrix $\boldsymbol{\Sigma}$ consists of $\mathbf{I}\sigma_e^2$. Different structures for the variance-covariance matrices $\mathbf{D}$ and $\boldsymbol{\Sigma}$ were found by Verbeke and Molenberghs (2000) and SAS Institute Inc. (2011).

Regarding issues similar to those we examined in this study, the class of GLMM (Breslow and Clayton, 1993) shows great flexibility in modeling this autocorrelation, and in this way, allows prognostic factors to be detected that are related to the ROA or Tobin's q coefficient measurements. This class of models comprises other sub-classes of models such as panel data models (Wooldridge, 2010), with the added advantage of allowing data modeling with repeated measurements in time intervals that are not equidistant and even unbalanced, choosing different distributions for the response $\boldsymbol{Y}$. It is pertinent emphasize that the fixed and random effects definition in econometrics diverges from the definition found about mixed models in statistical literature. According to (Croissant and Millo, 2014) "the random effect model is instead a special case of mixed model where only the intercept is specified as a random effect, while the "random" type variable coefficients model can be seen as one that has the same regressors in the fixed and random sets".

3.3. Sample selection and research design

The research hypotheses were evaluated by investigating a sample of non-financial companies listed in the Brazilian Stock Exchange – BM&FBovespa from 2001–2011 that initially consisted of 185 companies over the study period (11 years). Data for all companies in the sample were drawn from individual and consolidated financial statements found in the Economatica® database and on the Securities and Exchange Commission of Brazil (CVM) site.

The choice of the period of analysis (2001–2011) was supported by other research studies that used two periods of study: the period of investment and the period of profitability (Kim, 2001; Li, 2004; Jiang *et al.*, 2006). According to Jiang *et al.* (2006), before a company can finalize an investment project, several years are needed to reach a conclusion and reap the benefits of the investments as well as before the projects can be abandoned. The authors also state that division into two periods – one for investment and one for profitability – may not be in accordance with the reality of each company, but this strategy makes it possible to measure the capital invested in a previous period and the profitability of a subsequent period.

The following companies were rejected from the original list: those for which it was not possible to identify investment values; those showing a failure to invest in at least 50% of the period under study; and those that showing continuous negative net worth. This led to a final sample of 137 companies that were used to construct the statistical models. To mitigate the effects of outliers in the sample, we winsorized the variables: LEV, $GROWTH$, and $INVEST$, using 0.5% and 99.5% percentiles. The final unbalanced sample consisted of 1,484 of company-year observations.

The study design adopted the following form to develop and construct the statistical models: *i*) five scenarios were initially set up with different periods of investment and profitability; *ii*) in each scenario, the relationship between contemporary profitability and past investment was analyzed, while also taking into account the control variables. Scenario 1 considers the relationship between contemporary profitability (denoted by ROA_t or $QTOBIN_t$), with investment in the immediately preceding time period ($INVEST_{t-1}$). In scenario 2, the relationship had a lagged investment of 2 time units, or rather, $t-2$ years. In the same manner, in scenarios 3, 4, and 5, there was a lagged investment in 3, 4, and 5 years; *iii*) two models for future profitability were constructed for all scenarios, one for the profitability measured by ROA_t, and the other measured by $QTOBIN_t$.

As described above, research planning enabled establishment of a relationship between contemporary profitability and past investment by varying these measures throughout the study with different time lags. For example, in scenario 1, profitability in 2011 was related to investment in 2010, and that in 2010 was related to investment in 2009, and so on, until the profitability in 2002 was related to the investment in 2001.

Operational definitions of the dependent variables and investment variable are shown in Chart 1, in the same manner as the control variables, with their respective index of time references. The expected relationships are also presented.

Chart 1: Summary table with an operational definition of the variables under study and expected relation.

Variable	Control explanatory variables	Expected relation in parentheses
$INVEST_t$	Represents the investment carried out by the company in the contemporary period t in a logarithmic scale.	(+) Jiang *et al*. (2006); Fortunato *et al*. (2012)
$YEAR_t$	Represents the dummy variables of the year in contemporary periods which will be used to control macroeconomic fluctuations over a period of time.	–
$SECTOR$	Represents the dummy variables of the sector (14 sectors: Food and drinks; Commerce; Electro electronics; Electric power and sanitation; Plastic products industry; Industrial machinery and equipment; Paper and cellulose; Oil, gas and mining; Chemicals; Steel and metal works industry; Telecommunications; Textile industry; Transport and services; Vehicles and spare parts).	(−) Li (2004); Han *et al*. (2010)

$SIZE_t$	Represents the size of the company in the contemporary period t.	(+) Ehie and Olibe (2010)
LEV_t	Represents the leverage of the company in the contemporary period t.	(−) Richardson and Waegelein (2002)
$GROWTH_t$	Represents the opportunities for the growth of the company in the contemporary period t.	(+) Fama and French (2006); Han *et al*. (2010)
ROA_{t-l}	Represents the return on assets with a time-lag of l years ($t-l$), where the l index varies from 1−5.	(+) Li (2004); Jiang *et al.* (2006)
$QTOBIN_{t-l}$	Represents Tobin´s q coefficient with a time-lag of l years ($t-l$), where the l index varies from 1−5.	(+) Li (2004); Jiang *et al.* (2006)
Variable	**Explanatory variable of interest**	
$INVEST_{t-l}$	Represents the investment carried out (in a logarithmic scale) by the company with a time-lag of l years ($t-l$), where the l index varies from 1−5.	?

Finally, a linear predictor, as described in (3), was established based on the definition of the sample and the planning of the research for contemporary profitability measured by the ROA_t:

$$\mu(ROA_t) = intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 SIZE_t + \beta_2 LEV_t + \beta_3 GROWTH_t + \beta_4 ROA_{t-l} + \beta_5 INVEST_t + \beta_6 INVEST_{t-l} + b_i, \quad (4)$$

where, $j = 1, \dots, 9$ and $k = 1, \dots, 13$, are the coefficient indexes α and γ, and represent the number of categories of the dummy variables $YEAR_t$ and $SECTOR$, which vary according to the model constructed for each scenario. The l index, which varies from 1–5, denotes the time-lag (in years) for the ROA_{t-l} and $INVEST_{t-l}$ variables, which are used in the model as past profitability and past investment, respectively. For cases in which contemporary profitability $\boldsymbol{Y_t}$ is measured by Tobin's q coefficient ($QTOBIN_t$), we use $QTOBIN_{t-l}$ as past profitability. Thus, the linear predictor was established as:

$$\mu(QTOBIN_t) = \exp(intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 SIZE_t + \beta_2 LEV_t + \beta_3 GROWTH_t + \beta_4 QTOBIN_{t-l} + \beta_5 INVEST_t + \beta_6 INVEST_{t-l} + b_i). \quad (5)$$

The index *i* indicating the variation in the company (*i*) was suppressed from expressions (4) and (5) to simplify the notation. The models described in (4) and (5) were estimated using the regression method for longitudinal data (GLMM) according to Verbeke and Molenberghs (2000), Fitzmaurice *et al.* (2009) and SAS Institute Inc. (2011).

4. RESULTS

In this section, we outline the results of the data analysis. Initially, we conducted an exploratory analysis to show the behaviour of the variables used in the models. Next, the results of the longitudinal regression models (unbalanced data) were used to evaluate the hypotheses of the study (**H1** and **H2**).

4.1. Exploratory analysis

Table 1 provides a descriptive statistical account of the investments and firm's profitability in the sample over a period of time (2001–2011). The evolution of investments carried out by the 1,484 of company-year observations in the sample is shown. Although the data are shown as historical values, the first observation that can be made is that there is a decrease in investment for the period 2002–2003 (the initial period of the 1st Lula's mandate) with regard to 2001. This same decrease is also shown in the investment indexes after the year 2008 (as a result of the world economic crisis). In regards to the profitability indicators (ROA and $QTOBIN$), more rapid changes were observed in the values of Tobin's q coefficient over a period of time. This suggests that an indicator that takes account the market value of companies can more rapidly reveal how firm's profitability evolves rather than being an indicator of profitability accounting.

Table 1: Investment and profitability of the sample companies

Period (Years)	Average Total Asset (in R$ billions)	Investment Index (average)	ROA (average)	$QTOBIN$ (average)
2001	60.4832	0.0853	0.0962	0.6138
2002	71.6889	0.0656	0.0981	0.6142
2003	78.8657	0.0658	0.1094	0.7372

2004	85.9208	0.0699	0.1349	0.9984
2005	94.4575	0.0791	0.1101	1.0037
2006	110.9516	0.0878	0.0965	1.1996
2007	121.8915	0.0885	0.1032	1.4077
2008	149.4785	0.1022	0.1187	0.9203
2009	158.8679	0.0686	0.0915	1.1766
2010	197.0447	0.0685	0.0971	1.1318
2011	219.0301	0.0674	0.0868	1.0585

Evidence is required to support the conclusion that if the data analysis is conducted based on indicator average for the period of investment and profitability (as carried out by Kim, 2001; Jiang *et al.*, 2006; Hao *et al.*, 2011), a linear regression model cannot incorporate variations in the profitability indicators over a period of time, as shown in Table 1.

Profitability indicator behaviors in the contemporary period of the study (ROA_t and $QTOBIN_t$) are shown in Figure 1. The return on assets distribution (ROA_t) showed a symmetrical distribution around an average of 0.1040 and standard deviation of 0.0913. Tobin's q coefficient ($QTOBIN_t$) showed strong asymmetry distribution of 0.9909 and standard deviation of 0.8516.

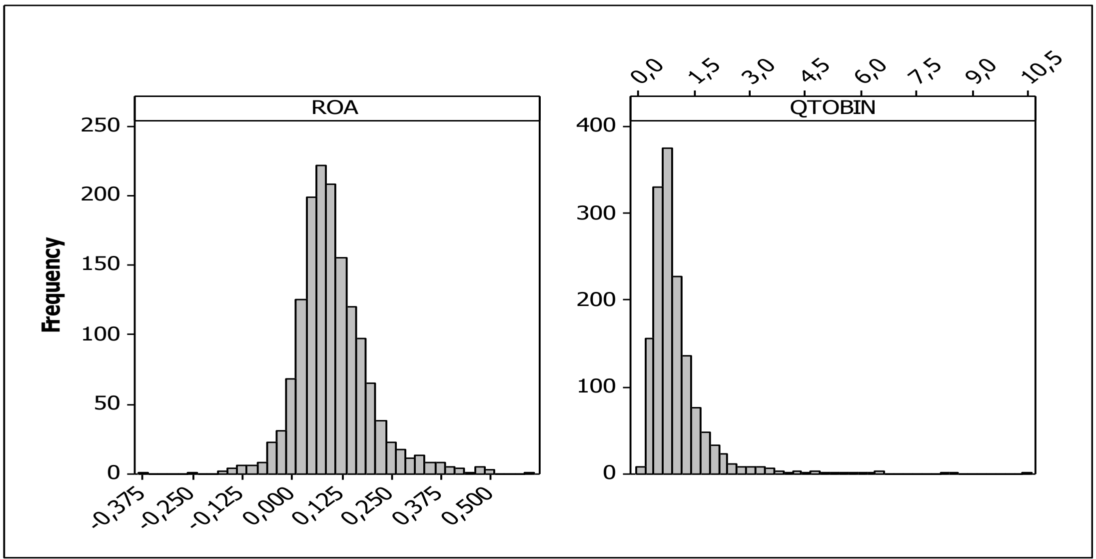

Figure 1: Histogram showing indicators of profitability (ROA and Tobin´s q coefficient).

Finally, Table 2 shows a correlation matrix for the variables used in the models that are based on the Spearman correlation. The correlations indicated that the returns on assets in the contemporary period (ROA_t) were positively correlated with $INVEST_t$, $SIZE_t$ and $GROWTH_t$, while Tobin´s q coefficient ($QTOBIN_t$) was positively correlated with $INVEST_t$, $SIZE_t$, LEV_t and $GROWTH_t$.

Table 2: Spearman´s correlation matrices between the variables in the models

Variables	ROA_t	$QTOBIN_t$	$INVEST_t$	$SIZE_t$	LEV_t
$QTOBIN_t$	0.392 †0.000	-			
$INVEST_t$	0.170 †0.000	0.203 †0.000	-		
$SIZE_t$	0.065 *0.013	0.226 †0,000	0.166 †0.000	-	
LEV_t	-0.005 0.839	0.270 †0.000	0.164 †0.002	0.281 †0.000	-
$GROWTH_t$	0.350 †0.000	0.876 †0.000	0.168 †0.000	0.210 †0.005	0.200 †0.000

Levels of significance: ' * ' 5% ' † ' 1%.

4.2. Results of regression

Various GLMM models were evaluated to examine the existence of a relationship between contemporary profitability (measured by the ROA_t and $QTOBIN_t$ indicators) and past investment, in accordance with the five scenarios described in the *Sample selection and research design* section and the linear predictors provided in (4) and (5). Adjustment of the models was carried out by SAS® 9.3 Statistical Software using the maximum likelihood method based on adaptive quadrature. The GLIMMIX procedure (SAS Institute Inc., 2011, Chapter 3) enabled adjustment of the GLMM to be carried out with a wide range of discrete and continuous statistical distributions (binomial, Poisson, normal, gamma, beta among others). Finally, in addition to specifying the suitable distribution probability for the nature of the data, it was possible to select a link function related the mean value of the dependent variable (profitability) to the linear predictor (covariates or explanatory variables).

The Normal (Gaussian) distribution with an identity link function was used for the construction of regression models for profitability measured by the ROA_t. The choice of this distribution was determined by the analysis in Figure 1 where the return on assets (ROA_t) shows a symmetrical behavior around the mean. The models developed for the five scenarios set out in the *Sample selection and research design* section are reported in Table 3 together with the adjusted measurements of the models (AIC and BIC information criteria) and the variance estimations: residual (σ_e^2) and the random effect due to the companies (σ_b^2).

We start the interpretation of the results of Table 3 with "Model Fit Statistics". In each of the five scenarios, information is shown regarding sample size and AIC and BIC information criteria. The size of the sample declined over time from Scenario 1 to Scenario 5. Regarding AIC (Akaike's information criteria) and BIC (Schwarz' Bayesian criterion) information criteria (Litell *et al.*, 2006; SAS Institute Inc., 2011), these are measurements used to estimate adjustment of the regression models, calculated by a likelihood function. The lower the criteria value, the better is the adjustment of the model selected. Hence, within each scenario, it is presented the model with the best adjusted based on the set of explanatory variables proposed in the linear predictor described in (4).

We analyzed the information in the "Covariance Parameter Estimates" to assess whether the generalized linear mixed model (with random effects) is more appropriate for data adjustment. This data shows the residual variance estimates (σ_e^2) and the random effect (σ_b^2). Linked to each variance estimate, the standard error (s.e.) is shown, allowing determination of confidence intervals. When the variance measurement linked to the companies (σ_b^2) and used for the Scenario 1 model and its standard error were examined, variance was relatively small. This suggests that for this scenario, intra-class correlation (between the measures of profitability within the companies over a period of time) is negligible and thus a classic linear model can be used that treats each repeated measure of profitability independently. However, this was not verified for the other scenarios and the variances due to company effects indicate that there is correlation between the repeated measures that affect the accuracy of the estimates and testing of the hypotheses. This result highlights the importance of using the GLMM class of models to analyze these data.

The Gamma distribution with a logarithmic link function was used to construct regression models used for profitability measured by Tobin's q coefficient ($QTOBIN_t$). The choice of this distribution was made based on the analysis in Figure 1 where the distribution of profitability ($QTOBIN_t$) showed right asymmetry behavior. In this case, the logarithmic link function enabled profitability $QTOBIN_t$ to be related to the linear predictors using the expression $\boldsymbol{\mu}(QTOBIN_t) = \exp(\boldsymbol{X}_i\boldsymbol{\beta} + \boldsymbol{Z}_i\boldsymbol{b}_i)$. This relationship has the advantage of assuring the positive nature of the profitability measurements calculated using Tobin's q coefficient.

The models developed for the five scenarios outlined in *Sample selection and research design* section are shown in Table 4. The same interpretation given to the results in Table 3 for the importance of using the GLMM class of models for data analysis of profitability can be extended to the results shown in Table 4 (the class of model enabled use of a probability distribution that is more appropriate to the nature of the $QTOBIN_t$ data, in this case, a Gamma distribution).

Finally, we interpreted the relationship between the explanatory variables and firm's profitability by examining the coefficients and the p-value of the fixed effects models carried out in five scenarios, as shown in Tables 3 and 4. The $SIZE_t$ variable did not show statistical significance and was thus excluded from all of the models evaluated from Tables 3 and 4.

The models of profitability measured by ROA_t were composed of the following variables: $YEAR_t$, $SECTOR$, LEV_t, $GROWTH_t$, ROA_{t-l}, $INVEST_t$ and $INVEST_{t-l}$. The $YEAR_t$ variable was used to control the macroeconomic effects in the profitability data (ROA_t and $QTOBIN_t$). The $SECTOR$ variable was significant in scenarios 2–5, whereas the only case when the past profitability ROA_{t-l}, did not show significance was in the scenario when *l* = 5.

Table 3: Generalized linear mixed models for ROA_t using a Gaussian distribution and identity link function.

Fixed Effects	Scenario 1 (l = 1) Coefficient	p-value	Scenario 2 (l = 2) Coefficient	p-value	Scenario 3 (l = 3) Coefficient	p-value	Scenario 4 (l = 4) Coefficient	p-value	Scenario 5 (l = 5) Coefficient	p-value
$Intercept$	0.0804	<0.0001†	0.1134	<0.0001†	0.1816	<0.0001†	0.1642	<0.0001†	0.1553	<0.0001†
$YEAR_t$	-	<0.0001†	-	<0.0001†	-	<0.0001†	-	0.0002†	-	<0.0001†
$SECTOR$	-	0.2304	-	0.0873+	-	0.0964+	-	0.0887+	-	0.0788+
LEV_t	-0.0616	<0.0001†	-0.1121	<0.0001†	-0.1355	<0.0001†	-0.1360	<0.0001†	-0.1483	<0.0001†
$GROWTH_t$	0.0189	<0.0001†	0.0289	<0.0001†	0.0323	<0.0001†	0.0296	<0.0001†	0.0334	<0.0001†
ROA_{t-l}	0.5828	<0.0001†	0.2970	<0.0001†	0.1245	0.0004†	0.0944	0.0129+	0.0342	0.4119
$INVEST_t$	0.0082	0.0027†	0.0095	0.0004†	0.0101	0.0005†	0.0096	0.0019†	0.0091	0.0067†
$INVEST_{t-l}$	-0.0078	0.0044†	-0.0095	0.0007†	-0.0039	0.2024	0.0000	0.9968	-0.0016	0.6775
Model Fit Statistics										
	N =	1,217	N =	1,094	N =	966	N =	839	N =	714
	AIC =	-3,255.29	AIC =	-2,830.52	AIC =	-2,465.64	AIC =	-2,096.69	AIC =	-1,758.44
	BIC =	-3,167.69	BIC =	-2,745.84	BIC =	-2,383.88	BIC =	-2,017.85	BIC =	-1,682.52
Covariance Parameter Estimates										
$Cov\ Parm$	**Estimate**	**s. e.**	**Estimate**	**s. e.**	**Estimate**	**s. e.**	**Estimate**	**s. e.**	**Estimate**	**s. e.**
$Companies\ (\sigma_b^2)$	0.000132	0.000123	0.001218	0.000253	0.002229	0.000384	0.002568	0.000439	0.002884	0.000481
$Residual\ (\sigma_e^2)$	0.003724	0.000179	0.003543	0.000168	0.003373	0.000170	0.003413	0.000188	0.003358	0.000203

Levels of significance: ' + ' 10% ' * ' 5% ' † ' 1%.

Generalized linear mixed models to:

Scenario 1: $\mu(ROA_t) = intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 GROWTH_t + \beta_3 ROA_{t-1} + \beta_4 INVEST_t + \beta_5 INVEST_{t-1} + b_i$.

Scenario 2: $\mu(ROA_t) = intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 GROWTH_t + \beta_3 ROA_{t-2} + \beta_4 INVEST_t + \beta_5 INVEST_{t-2} + b_i$.

Scenario 3: $\mu(ROA_t) = intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 GROWTH_t + \beta_3 ROA_{t-3} + \beta_4 INVEST_t + \beta_5 INVEST_{t-3} + b_i$.

Scenario 4: $\mu(ROA_t) = intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 GROWTH_t + \beta_3 ROA_{t-4} + \beta_4 INVEST_t + \beta_5 INVEST_{t-4} + b_i$.

Scenario 5: $\mu(ROA_t) = intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 GROWTH_t + \beta_3 ROA_{t-5} + \beta_4 INVEST_t + \beta_5 INVEST_{t-5} + b_i$.

The assumptions of normality and homoscedasticity about residuals were satisfied (according diagnostics in SAS Institute Inc., 2011, p. 347-352).

Table 4: Generalized linear mixed models for Tobin´s q coefficient ($QTOBIN_t$) using a Gamma distribution and logarithmic link function.

	Scenario 1 (*l* = 1)		Scenario 2 (*l* = 2)		Scenario 3 (*l* = 3)		Scenario 4 (*l* = 4)		Scenario 5 (*l* = 5)	
Fixed Effects	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
$Intercept$	-0.5079	<0.0001†	-0.4337	<0.0001†	-0.3742	0.0003†	-0.3960	0.0002†	-0.2753	0.0058†
$YEAR_t$	-	<0.0001†	-	<0.0001†	-	<0.0001†	-	<0.0001†	-	<0.0001†
$SECTOR$	-	0.9480	-	0.8824	-	0.8853	-	0.9187	-	0.8548
LEV_t	0.7600	<0.0001†	0.8466	<0.0001†	0.5496	0.0062†	0.4473	0.0269*	0.1882	0.3779
LEV_t^2	-0.8566	0.0025†	-1.2764	<0.0001†	-0.8045	0.0075†	-0.5235	0.0807+	-0.5133	0.1014
$GROWTH_t$	0.4971	<0.0001†	0.5207	<0.0001†	0.5308	<0.0001†	0.5271	<0.0001†	0.5423	<0.0001†
$GROWTH_t^2$	0.0153	0.0096†	0.0222	0.0011†	0.0351	<0.0001†	0.0284	<0.0001†	0.0276	0.0014†
$QTOBIN_{t-l}$	0.1041	<0.0001†	0.0334	0.0045†	-0.0142	0.1900	-0.0136	0.2040	-0.0025	0.8227
$INVEST_t$	0.0099	0.3109	0.0289	0.0022†	0.0247	0.0065†	0.0154	0.0763+	0.0182	0.0409*
$INVEST_{t-l}$	0.0258	0.0084†	0.0192	0.0479*	0.0089	0.3619	-0.0021	0.8162	-0.0023	0.8253
Model Fit Statistics										
	$N =$	1,217	$N =$	1,094	$N =$	966	$N =$	839	$N =$	714
	$AIC =$	-476.09	$AIC =$	-340.32	$AIC =$	-379.32	$AIC =$	-456.95	$AIC =$	-402.11
	$BIC =$	-382.65	$BIC =$	-249.80	$BIC =$	-291.72	$BIC =$	-372.27	$BIC =$	-320.35
Covariance Parameter Estimates										
$Cov\ Parm$	**Estimate**	**s. e.**	**Estimate**	**s. e.**	**Estimate**	**s. e.**	**Estimate**	**s. e.**	**Estimate**	**s. e.**
$Companies\ (\sigma_b^2)$	0.05226	0.007200	0.05883	0.008075	0.06834	0.009171	0.07392	0.009819	0.06289	0.008461
$Residual\ (\sigma_e^2)$	0.03961	0.001702	0.03819	0.001745	0.03076	0.001512	0.02356	0.001262	0.02069	0.001226

Levels of significance: '+' 10% '*' 5% '†' 1%.

Generalized linear mixed models to:

Scenario 1: $\mu(QTOBIN_t) = \exp(intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 LEV_t^2 + \beta_3 GROWTH_t + \beta_4 GROWTH_t^2 + \beta_5 ROA_{t-1} + \beta_6 INVEST_t + \beta_7 INVEST_{t-1} + b_i)$.

Scenario 2: $\mu(QTOBIN_t) = \exp(intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 LEV_t^2 + \beta_3 GROWTH_t + \beta_4 GROWTH_t^2 + \beta_5 ROA_{t-2} + \beta_6 INVEST_t + \beta_7 INVEST_{t-2} + b_i)$.

Scenario 3: $\mu(QTOBIN_t) = \exp(intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 LEV_t^2 + \beta_3 GROWTH_t + \beta_4 GROWTH_t^2 + \beta_5 ROA_{t-3} + \beta_6 INVEST_t + \beta_7 INVEST_{t-3} + b_i)$.

Scenario 4: $\mu(QTOBIN_t) = \exp(intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 LEV_t^2 + \beta_3 GROWTH_t + \beta_4 GROWTH_t^2 + \beta_5 ROA_{t-4} + \beta_6 INVEST_t + \beta_7 INVEST_{t-4} + b_i)$.

Scenario 5: $\mu(QTOBIN_t) = \exp(intercept + \alpha_j YEAR_t + \gamma_k SECTOR + \beta_1 LEV_t + \beta_2 LEV_t^2 + \beta_3 GROWTH_t + \beta_4 GROWTH_t^2 + \beta_5 ROA_{t-5} + \beta_6 INVEST_t + \beta_7 INVEST_{t-5} + b_i)$.

The assumptions of normality and homoscedasticity about residuals were satisfied (according diagnostics in SAS Institute Inc., 2011, p. 347-352).

In the models using $QTOBIN_t$ such as profitability, a quadratic relationship was identified with the LEV_t and $GROWTH_t$ variables (when carrying out exploratory data analysis). Next, the models of profitability were composed of the following variables: $YEAR_t$, $SECTOR$, LEV_t, LEV_t^2, $GROWTH_t$, $GROWTH_t^2$ $QTOBIN_{t-l}$, $INVEST_t$ and $INVEST_{t-l}$. The $SECTOR$ variable was not significant in the 5 scenarios employed, whereas LEV_t and LEV_t^2 only showed statistical significance in the scenario when l = 5. Past profitability measured by $QTOBIN_{t-l}$ showed no significance in the scenario when *l* = 3–5.

As expected based on previous studies (Li, 2004; Jiang *et al.*, 2006), past profitability measured by ROA_{t-l} showed a positive relationship with ROA_t. However, when the past profitability was measured by $QTOBIN_{t-l}$, this positive relationship was observed until the *l* = 2 time-lag and became insignificant from the period of the *l* = 3 time-lag. This suggests that profitability in the distant past loses significance when measured using a market indicator. The contemporary investment $INVEST_t$, which was also used as a control variable, showed a significant positive relationship with contemporary profitability in all scenarios examined (*l* = 1–5).

Regarding past investment $INVEST_{t-l}$, controlled by $YEAR_t$, $SECTOR$, LEV_t, $GROWTH_t$, ROA_{t-l}, and $INVEST_t$, the results showed a significant negative relationship with ROA_t until the time-lag l = 2 years, becoming insignificant from the period of the time-lag *l* = 3. The same occurred for $QTOBIN_t$, although a significant positive relationship was observed until the time-lag *l* = 2 years.

5. CONCLUSIONS

Because of the importance of investment carried out by companies for economic development and the capacity of investment to bring about wealth for the company and shareholders by creating new jobs, increasing the volume of consumption, and creating new investment opportunities, the purpose of this study was to examine the relationship between the investment carried out and the firm's profitability.

In interpreting the results of this study, the model based on ROA empirically demonstrated that different sectors have different requirements for investment and profitability. For the model based on Tobin's q coefficient, the sector did not exert an influence in the explanation of the firm's profitability. We observed a negative association between leverage and ROA, as well as the same relationship between leverage and Tobin's q coefficient. These findings reveal a typical situation of Brazilian companies, in which firms have a higher dependence on bank capital. Consequently, this type of resource creates financial expenses, leading to decreased profits. However, regarding control variables, it could be shown that both contemporary investment and past profitability are important factors in determining the contemporary profitability of a company, suggesting that current investment and corporate earnings reflect competitive advantages for companies.

The results indicate that hypotheses **H1** and **H2** were validated. It is important to note the negative relationship between past investment and profitability identified in the model, in which was measured by ROA. The results are in accordance with Jiang *et al.* (2006) and are different of the study conducted by Fortunato *et al*. (2012) in the Brazilian market, that not observed relationship between past investment and profitability (measured by operating profit Ebit). Additionally, our results revealed that this relationship was weakening (coefficient and significance) over time. Our understanding is that in short term (time-lag from 1 and 2 years) past investment reduces the firm's profitability, but in the long-term, past investment is not important for explaining contemporary profitability. It suggests that the dampening effect from investment on future profitability becomes less severe or vanishes in years in the distant past. Thus, this is an indication that the company must make new investments to maintain its rate of profitability.

The results for Tobin's q coefficient were very similar to those obtained by ROA as an indicator of profitability. However, in this case, we observed a positive relationship between profitability and investment (contemporary and in the first two time-lags of the year), indicating that investors have better expectancies over the company, bringing about a positive effect on profitability in the short term. These results are contrast to those obtained by Titman *et al.* (2004), Li (2004) and Fama and French (2006), but are in accordance with the results obtained by Fortunato *et al*. (2012).

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