Inefficiency in Hedge Strategies at São Paulo Stock Exchange: A Random Coefficients Modeling Approach

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Abstract

Literature has not reached a consensus on how the firm and industry effects influence the stock price performance of publicly-traded companies over time. Based on the premise of significant changes in the stock price performance of companies listed on São Paulo Stock Exchange (Bovespa) in recent years, and the occurrence of these variations in function of the characteristics of each firm and activity industry, this study uses hierarchical modeling with repeated measures to propose an approach that permits analyzing random effects as an alternative for profitability evolution analysis. Through a sample of 45 companies working in ten industries during an eight-year period (2001-2008), totaling 317 observations, low representativeness of the activity industry is verified to distinguish the mean annual profitability and the growth rates of stock prices among companies listed on Bovespa in recent years.

Key words: hedge strategy; hierarchical linear modeling; firm effect; industry effect; São Paulo Stock Exchange.

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Introduction

Many relevant studies in Brazilian and international positive accounting research address aspects of how a given group of variables influence a specific behavior that provides information for decision makers. And multivariate quantitative data tools have proliferated in important accounting studies that aim to create models to explain reality and empirically verify observed phenomena.

According to Iudícibus and Lopes (2004), the positive focus in accounting aims to describe how accounting is developed in the real world and predict what will occur. Thus, its goal is to examine why organizations take certain decisions to the detriment of others in a market and economic context.

Hence, as stated by Watts and Zimmerman (1986) and Iudícibus and Lopes (2004), accounting theory aims to explain and foresee accounting practice, without a strict need to address future phenomena only. In many cases, it specifically looks at already existing but not yet observed behaviors.

In this approach, many studies use quantitative data analysis techniques to solve problems and elaborate models that explain and forecast reality, mentioned by Holthausen and Watts (2001). According to Barth, Beaver and Landsman (2001), many relevant studies use econometric techniques and without them, could present inferences of limited validity. However, it is fundamental that the appropriate choice of each technique be based on an underlying theory and in accordance with the research goal.

In this sense, this research adopts the multilevel approach, exploring the effects of the activity industry and firm characteristics on the performance of companies listed on São Paulo Stock Exchange (Bovespa), between 2001 and 2008. According to Goldszmidt, Brito and Vasconcelos (2007), the search for the origins of some companies' performance is a central theme in strategic research, and a research line on performance variance components has offered important empirical support in this search.

According to the same authors Goldszmidt, Brito and Vasconcelos (2007), this research lines goes back to the work by Schmalensee (1985) and Rumelt (1991), followed by a series of other studies that analyzed the firm, corporation, industry and year effects, such as Roquebert, Phillips and Westfall (1996), McGahan and Porter

(1997), Brush and Bromiley (1997), Brush, Bromiley and Hendrickx (1999) and Bowman and Helfat (2000).

This article contributes to the study of sources of heterogeneity in the stock price evolution of companies listed on Bovespa, using multilevel techniques. First, stock profitability variations over time are assessed in firms from the same industry and different industries. Then, stock profitability variations over time are assessed in firms from the same industry and different industries and, next, variables related to companies and industries which may explain stock price variations between companies over time. Hence, a three-level approach will be used. The first level is related to the variation over time (repeated measure), the second to the firm characteristics and the third to industry variables.

Through the hierarchical modeling approach with repeated measures, the firm and industry effects are explored, using a sample of 45 firms in 10 industries, over an eight-year period (2001-2008).

The next two sections present a literature review on hierarchical modeling and discuss the main concepts related to the application of this technique with three levels and repeated measures, particularly in studies using the firm effects on performance. Section 3 presents the method and the model proposed in this research. Section 4 presents the results and respective discussions. The main conclusions are discussed in the last section.

1. Multilevel Models and the Firm and Industry Effects on Profitability[1]

Most data studied in social sciences derive from phenomena in which the subjects naturally appear hierarchically (Soto and Morera, 2005). According to Raudenbush et al. (2004), data that are behavioral, social or related to performance variables commonly present nested structures and each sub-model represents the structural relations and residual variability occurring at that level.

Many situations display a hierarchical structure, such as students belonging to schools that belong to secretaries of education, patients at clinics, voters in election zones, homes in cities and cities in states, individuals in economic industries and

[1] The terms *time effect*, *firm effect* and *industry effect* refer, respectively, to the effects of the time evolution, organizational attributes and activity industry characteristics on a given performance variable (in this case, the stock profitability of companies listed on Bovespa).

companies in industries or countries of origin. Hierarchies correspond to the idea that subjects belonging to the same group share a set of stimuli that favors homogeneity.

According to Gelman (2006), multilevel models are a generalization of regression methods and, hence, can be used for a range of goals, including prediction, data reduction and causal inference based on experiments and observational studies. Hofmann (1997), Kreft and Leeuw (1998), Snijders and Bosker (1999), Raudenbush and Bryk (2002), Hox (2002) and Goldstein (2003) present recent and significant contributions on the subject.

In comparison with classical linear regression or analysis and covariance models, the advantage of multilevel models is that they consider the analysis of hierarchically structured data. These models propose an analytic structure in which the distinct levels at which data articulate can be recognized, and in which each sub-level is represented by its own model (Draper, 1995). Each of these sub-models, according to Soto and Morera (2005), expresses the relation between the variables at a given level and specifies how the variables at this level influence the relations established at other levels.

A classical regression model applied, for example, to a context of company performance analysis in a given industry, can be:

$$y_i = \beta_0 + \beta_1 . X_{1i} + r_i \qquad (1)$$

Equation (1) represents the relation between the performance variable (firm profitability for example) and the predictive variable (if its capital is strictly national or multinational for example). The constant β_0 represents the mean profitability of companies in this industry working with national capital. β_1 is the slope of the regression line and represents the profitability increase for firms working with multinational capital. Term r_i refers to the distance of company i's profitability from the expected profitability of companies with the same characteristic (national or multinational capital). On the other hand, if the analysis is elaborated for firms from two different industries, two distinct equations need to be defined:

$$y_{i1} = \beta_{01} + \beta_{11} . X_{11i} + r_{i1} \qquad (2)$$

$$y_{i2} = \beta_{02} + \beta_{12}.X_{12i} + r_{i2} \quad (3)$$

The coefficients β_{01} and β_{02} represent the mean expected profitability for companies in each of the industries. β_{11} and β_{12} are the slopes and similarly represent the increases in mean profitability when the origin of the firms' capital changes.

In fact, many activity industries can present mutual variations, in cut-off points as well as slopes. Hence, it is hardly practical to estimate a regression equation for each of them.

In other words, estimating the firm and industry effects demands a two-level model, including j industry at level 2 and i firms at level 1. Formally, there are i = 1, ..., n_j units at level 1 (in this case firms), which are nested with each j = 1, ..., J units at level 2 (in this case, industries). Hence, the level-1 model can be written as:

$$y_{ij} = \beta_{0j} + \beta_{1j}.X_{1ij} + \beta_{2j}.X_{2ij} + ... + \beta_{Qj}.X_{Qij} + r_{ij}$$

$$y_{ij} = \beta_{0j} + \sum_{q=1}^{Q} \beta_{qj}.X_{qij} + r_{ij} \quad (4)$$

Where:

- β_{qj} (q = 0, 1, ..., Q) are the level-1 coefficients;
- X_{qij} is the vector of q predictive level-1 variables (firm variables) for case i (firm) in unit j (industry);
- r_{ij} is the random effect of level 1; and
- σ^2 is the variance of r_{ij} (level1 variance). It is assumed that the random term $r_{ij} \sim N(0, \sigma^2)$.

Likewise, the level-2 model can be written as follows:

$$\beta_{qj} = \gamma_{q0} + \gamma_{q1}.W_{1j} + \gamma_{q2}.W_{2j} + ... + \gamma_{qS_q}.W_{S_q j} + u_{qj} \quad (5)$$

$$\beta_{qj} = \gamma_{q0} + \sum_{s=1}^{S_q} \gamma_{qs} . W_{sj} + u_{qj}$$

Where:

- γ_{qs} (q = 0, 1, ..., S_q) are the level-2 coefficients;

- W_{sj} is the vector of predictive level-2 variables (industry variables); and

- u_{qj} is the random effect of level 2. It is assumed that, for each unit j, the vector (u_{0j}, u_{1j}, ..., u_{Qj})´ presents a normal multivariate distribution, which each u_{qj} element having a zero mean and variance of Var(u_{qj}) = τ_{qq}.

For each pair of random effects q and q´, it is given that:

$$\mathrm{Cov}(u_{qj}, u_{q'j}) = \tau_{qq'} \quad (6)$$

Similar models have been widely used in literature about the strategy to compare variances in variables at firm and industry level in the composition of company performance. In this sense, researches by Mauri and Michaels (1998), Chang and Singh (2000), Ruefli and Wiggins (2003) and Short et al. (2007) stand out.

Other authors have analyzed the effect of country of origin on company performance, particularly Collins (1990), Christmann, Day and Yip (1999), Brito and Vasconcelos (2003), Hawawini, Subramanian and Verdin (2004), Makino, Isobe and Chan (2004), Makino, Beamish and Zhao (2004) and Goldszmidt, Brito and Vasconcelos (2007). Yet others have studied the city or micro-location effect to assess certain phenomena in people, companies or real estate, such as Price, Nero and Gelman (1996), Gelman (2006) and Fávero and Belfiore (2008).

This research intends to study the industry effect on stock profitability in a time perspective, i.e. using hierarchical models with repeated measures.

2. Three-level Hierarchical Models with Repeated Measures

Models that consider variation over time in performance assessment have been increasingly used, representing new challenges to elaborate research projects and create unbiased indicators (Raudenbush and Bryk, 2002). Bliese and Ployhart (2002) present how the modeling of random coefficients can be used to develop and test growth models in longitudinal data analysis. According to Short et al. (2006), the hierarchical models with repeated measures offer additional advantages because they allow researchers to model specific predictive variables at each analysis level, offering answers on the exact influence of the firm, industry or location levels over time.

The three-level models consist of three sub-models, in which there are t = 1, ..., T_{ij} years at level 1, which are nested in each i = 1, ..., n_j firms that, in turn, are nested in j = 1, ..., J industries. Hence, it is given for level 1 that:

$$y_{tij} = \pi_{0ij} + \pi_{1ij}.YEAR_{tij} + e_{tij} \quad (7)$$

Where:

- t = 1,2, ...,T_{ij} (years), j=1,2 ..., J (industries) and i=1,2, ..., n_j (firms);
- π_{0ij}: expected valued of performance variable (mean) of company ij in year 1;
- π_{1ij} is the growth rate of the performance variable of company ij; and
- σ^2 is the variance of ε_{ij} (variance of a given firm over time). It is assumed that the random term $e_{tij} \sim N(0, \sigma^2)$.

Each level-1 coefficient becomes a dependent variable in the level-2 model. Hence, the latter can be written as:

$$\pi_{pij} = \beta_{p0j} + \beta_{p1j}.X_{1ij} + \beta_{p2j}.X_{2ij} + ... + \beta_{pQ_pj}.X_{Q_pij} + r_{pij}$$

(8)

$$\pi_{pij} = \beta_{p0j} + \sum_{q=1}^{Q_p} \beta_{pqj}.X_{qij} + r_{pij}$$

Where:

- β_{pqj} (q = 0, 1, ..., Q_p) are the level-2 coefficients;

- X_{qij} is the vector of predictive level-2 variables; and

- r_{pij} is the random effect of level 2. It is assumed that, for each unit i, the $(r_{0ij}, r_{1ij}, ..., r_{pij})'$ vector presents a normal multivariate distribution, in which each element r_{pij} has a zero mean and variance equaling $Var(r_{pij}) = \tau_{\pi pp}$.

For each pair of random effects p and p´, it is given that:

$$Cov(r_{pij}, r_{p'ij}) = \tau_{\pi pp'} \quad (9)$$

In the same sense, the level-3 model can be written as:

$$\beta_{pqj} = \gamma_{pq0} + \gamma_{pq1}.W_{1j} + \gamma_{pq2}.W_{2j} + ... + \gamma_{pqS_{pq}}.W_{S_{pq}j} + u_{pqj}$$

(10)

$$\beta_{pqj} = \gamma_{pq0} + \sum_{s=1}^{S_{pq}} \gamma_{pqs}.W_{sj} + u_{pqj}$$

Where:

- γ_{pqs} (s = 0, 1, ..., S_{pq}) are the level-3 coefficients;

- W_{sj} is the vector of predictive level-3 variables; and

- u_{pqj} is the random effect of level 3. It is assumed that, for each level-3 unit, the random effects vector (u_{pqj}) presents a normal multivariate distribution, with a zero mean and covariance matrix T_β, whose maximum dimension depends on the number of specified coefficients when random effects are present and is:

$$\sum_{p=0}^{p}(Q_p + 1) x \sum_{p=0}^{p}(Q_p + 1) \quad (11)$$

Even twenty years after the pioneering work by Schmalensee, the theme still attracts interest. Many recent studies have applied hierarchical models with repeated measures for company performance assessment, particularly Bergh (1993), Bergh (1995), Deadrick, Bennett and Russell (1997), Adner and Helfat (2003), Hough (2006), Misangyi et al. (2006), Short et al. (2006) and Goldszmidt, Brito and Vasconcelos (2007).

3. Definition of Variables, Hypotheses and Method

Models that consider time variation in performance assessment have been increasingly used, representing new challenges to formulate performance measurement problems (Raudenbush and Bryk, 2002). And, according to Short et al. (2006), the application of hierarchical models permits testing the relation between performance and different environmental variables simultaneously. Hence, it is believed that using this type of modeling allows for new scientific research aimed at determining the influence of time, organizational and even regional aspects on company performance, favoring the formulation of new strategies. Next, the sample, variable selection, hypotheses for testing and the method itself are presented.

3.1. Sampling and Variable Selection

The stock profitability database of companies listed on Bovespa was the source for this research. Initially, data were extracted from all company groups available in the database for the period from 2001 to 2008. The original base comprised almost 60 companies from 14 industries over an eight-year period, totaling 435 observations.

Following the same logic proposed by Goldszmidt, Brito and Vasconcelos (2007) for observation exclusion criteria, companies with missing data for the explanatory variables or performance variable (annual stock price profitability) were eliminated. Moreover, the criteria attempted to avoid indetermination in the allocation of different effects through the presence of at least two cases in each factor. Hence, companies were only maintained if they presented two or more periods of the dependent variable reported in the base, as well as two or more firms active in a given industry or year.

Finally, 317 observations composed the final sample, with 45 companies from 10 industries. This treatment offers an advantage in the use of multilevel models, as these permit verifying which firm or industry effects offer a better explanation for performance variation over time.

The performance variable adopted for analysis corresponds to the annual profitability of the company's stock price and, in case more than one class of stocks exists, the profitability of the most traded stock during the period is used. Level-2 and level-3 variables were also obtained through this same database and are shown in chart 1.

Chart 1: Definition of level-two and level-three variables

Level-two Variables (Firm)	
ROA	Mean return on assets
ROE	Mean return on equity
GR	Mean working capital
ML	Mean net margin
VL	Mean market value
PL	Mean price/profit ratio
LA	Mean earnings per share
Level-three Variables (Industry)	
PPIB	Mean participation (%) in Brazilian GDP
PE	Mean participation (%) in Brazilian exportations

According to chart 1, company (level 2) and industry-related variables (level 3) refer, respectively, to each company's mean accounting ratios across the period under analysis and to each industry's mean participation (in percentage) in Brazilian GDP and exportations.

These variables will be used to sustain, or not, the research hypotheses, formulated next.

3.2. Hypotheses for Testing

This research looks for significant differences, over time, in the stock profitability of companies listed on Bovespa, and analyzes if these differences are due to existing variations among firms and among activity industries and, if yes, why these differences occur.

The hypotheses for testing are in line with the logic proposed by Short et al. (2006) and can be formulated as follows:

Hypothesis 1: The annual profitability of companies listed on Bovespa varies significantly over time (from 2001 to 2008).

Hypothesis 2: The annual profitability of stocks varies significantly over time among companies in the same industry.

Hypothesis 3: The annual profitability of stocks varies significantly over time among companies in different industries.

Hypothesis 4: The annual profitability of companies listed on Bovespa followed a linear trend during the period between the 2001 and 2008 financial market crises and difference exists among the firms.

Hypothesis 5: Some firm characteristics, such as ROA, ROE, among others, explain the variation in stock profitability over time.

Hypothesis 6: The industries' characteristics, such as participation in GDP and exportations, explain the profitability differences between stocks over time among companies listed on Bovespa.

To verify each of these hypotheses, both the method and the proposed models need to be presented.

3.3. Method

The method for hierarchical models with repeated measures involves a series of nested regressions that are interactively defined through maximum likelihood estimation in the full concept (Raudenbush and Bryk, 2002). According to Hofmann, Jacobs and Baratta (1993) and Short et al. (2006), hierarchical models are more adequate than any other technique to analyze repeated measures, as they are capable of investigating and identifying, individually and over time, systematic change patterns in the performance variable among the observations under study. Hence, this analysis method considers once single performance trajectory for each firm, considering the presence of random effects among observations to explain the evolution of these respective performances over time.

The models use 3 analysis levels representing, respectively, individual changes in firm performance over time (level 1), stock profitability variation among firms in the same industry (level 2) and variation among industries (level 3).

To verify the first three hypotheses, a model is proposed without predictive variables (null model), which estimates the variance components in each firm (over time), among firms and among industries. The modeling uses χ^2 tests for components among firms and among industries (Raudenbush et al., 2004). Hence, the null model can be written as:

Null Model

Level 1 (Repeated Measure):

$PROF_{tij} = \pi_{0ij} + e_{tij}$, $e_{tij} \sim NID(0, \sigma^2)$ (12)

PROF: performance variable represented by annual stock profitability;

$t=1,2, \ldots, T_{ij}$ (years), $j=1,2 \ldots, J$ (industries) and $i=1,2, \ldots, n_j$ (firms);

π_{0ij}: expected (mean) PROF of company ij's stocks in year 1 (2001); and

σ^2: variance "inside" the firm.

Level 2 (Firm):

$\pi_{0ij} = \beta_{00j} + r_{0ij}$, $r_{0ij} \sim NID(0, \tau_{\pi\_0})$ (13)

β_{00j}: mean of expected PROF's in 2001 for industry j; and

τ_{π_0}: variance of expected PROF's in 2001 for industry j.

Level 3 (Industry):

$\beta_{00j} = \gamma_{000} + u_{00j}$, $u_{00j} \sim NID(0, \tau_{\beta\_0})$ (14)

γ_{000}: general mean of expected PROF's in 2001; and

τ_{β_0}: variance between expected PROF's in 2001.

To check the fourth hypothesis, two models are proposed which include a trend (variation over time) component in level 1. The first model does not include random effects and only tests if the firms' performance follows a linear trend over time. The second model includes random effects and tests for significant variation between firms over time in terms of performance trend.

Linear Trend Model without Random Effects

Level 1 (Repeated Measure):

$PROF_{tij} = \pi_{0ij} + \pi_{1ij}.YEAR_{tij} + e_{tij}, \quad e_{tij} \sim NID(0, \sigma^2)$ (15)

PROF: performance variable represented by annual stock profitability;

$t=1,2, \ldots, T_{ij}$ (years), $j=1,2 \ldots, J$ (industries) and $i=1,2, \ldots, n_j$ (firms);

π_{0ij}: expected (mean) PROF of company ij in year 1 (2001);

π_{1ij}: growth rate of company ij's PROF; and

σ^2: variance "inside" the firm.

Level 2 (Firm):

$\pi_{0ij} = \beta_{00j} + r_{0ij}, \quad r_{0ij} \sim NID(0, \tau_{\pi\_0})$ (16)

$\pi_{1ij} = \beta_{10j}$

β_{00j}: mean of expected PROF's in 2001 for industry j;

β_{10j}: mean of expected growth rates in industry j; and

τ_{π_0}: variance of expected PROF's in 2001 for industry j.

Level 3 (Industry):

$\beta_{00j} = \gamma_{000} + u_{00j}, \quad u_{00j} \sim NID(0, \tau_{\beta\_0})$ (17)

$\beta_{10j} = \gamma_{100}$

γ_{000}: general mean of expected PROF's in 2001;

γ_{100}: mean expected growth rate of PROF's; and

τ_{β_0}: variance between expected PROF's in 2001.

Linear Trend Model with Random Effects

Level 1 (Repeated Measure):

$PROF_{tij} = \pi_{0ij} + \pi_{1ij}.YEAR_{tij} + e_{tij}, \; e_{tij} \sim NID(0, \sigma^2)$ (18)

PROF: performance variable represented by annual stock profitability;

$t=1,2, \ldots, T_{ij}$ (years), $j=1,2 \ldots, J$ (industries) and $i=1,2, \ldots, n_j$ (firms);

π_{0ij}: expected (mean) PROF of company ij in year 1 (2001);

π_{1ij}: growth rate of company ij's PROF; and

σ^2: variance "inside" the firm.

Level 2 (Firm):

$\pi_{0ij} = \beta_{00j} + r_{0ij}$, $\quad r_{0ij} \sim NID(0, \tau_{\pi\_0})$ (19)

$\pi_{1ij} = \beta_{10j} + r_{1ij}$, $\quad r_{1ij} \sim NID(0, \tau_{\pi\_1})$

β_{00j}: mean of expected PROF's in 2001 for industry j;

β_{10j}: mean of expected growth rates in industry j;

τ_{π_0}: variance of expected PROF's in 2001 for industry j; and

τ_{π_1}: variance of expected growth rates in industry j.

Level 3 (Industry):

$\beta_{00j} = \gamma_{000} + u_{00j}$, $\quad u_{00j} \sim NID(0, \tau_{\beta\_0})$ (20)

$\beta_{10j} = \gamma_{100} + u_{10j}$, $\quad u_{10j} \sim NID(0, \tau_{\beta\_1})$

γ_{000}: general mean of expected PROF's in 2001;

γ_{100}: mean expected growth rate of PROF's;

τ_{β_0}: variance between expected PROF's in 2001; and

τ_{β_1}: variance between expected growth rates.

According to Short et al. (2006), the significance of individual performance changes is tested in two ways. The first is a χ^2 test that compares deviation statistics for the model that includes the year effect (linear trend model) and the null model. The second offers a t-test for the fixed effects and χ^2 for variance components. The significance of the fixed effect for the periods suggests that the time effect is constant for all firms. However, the inclusion of random effects helps to verify the existence of significant performance variability, over time, between firms in the same industry (level 2) and in different industries (level 3).

If the previous hypotheses are verified, predictive variables can be included in level 2 and 3 to verify hypotheses 5 and 6, and the model becomes:

Full Model

Level 1:

$$PROF_{tij} = \pi_{0ij} + \pi_{1ij}.YEAR_{tij} + e_{tij} \quad (21)$$

Level 2:

$$\pi_{0ij} = \beta_{00j} + \beta_{01j}.(ROA) + \beta_{02j}.(ROE) + \beta_{03j}.(GR) + \beta_{04j}.(ML) + \beta_{05j}.(VL) + \beta_{06j}.(PL) + \beta_{07j}.(LA) + r_{0ij} \quad (22)$$

$$\pi_{1ij} = \beta_{10j} + \beta_{11j}.(ROA) + \beta_{12j}.(ROE) + \beta_{13j}.(GR) + \beta_{14j}.(ML) + \beta_{15j}.(VL) + \beta_{16j}.(PL) + \beta_{17j}.(LA) + r_{1ij}$$

Level 3:

$$\beta_{00j} = \gamma_{000} + \gamma_{001}.(PPIB) + \gamma_{002}.(PE) + u_{00j}$$
$$\beta_{01j} = \gamma_{010} + \gamma_{011}.(PPIB) + \gamma_{012}.(PE)$$
$$\beta_{02j} = \gamma_{020} + \gamma_{021}.(PPIB) + \gamma_{022}.(PE)$$
$$\beta_{03j} = \gamma_{030} + \gamma_{031}.(PPIB) + \gamma_{032}.(PE)$$
$$\beta_{04j} = \gamma_{040} + \gamma_{041}.(PPIB) + \gamma_{042}.(PE)$$
$$\beta_{05j} = \gamma_{050} + \gamma_{051}.(PPIB) + \gamma_{052}.(PE)$$
$$\beta_{06j} = \gamma_{060} + \gamma_{061}.(PPIB) + \gamma_{062}.(PE)$$
$$\beta_{07j} = \gamma_{070} + \gamma_{071}.(PPIB) + \gamma_{072}.(PE) \quad (23)$$
$$\beta_{10j} = \gamma_{100} + \gamma_{101}.(PPIB) + \gamma_{102}.(PE) + u_{10j}$$
$$\beta_{11j} = \gamma_{110} + \gamma_{111}.(PPIB) + \gamma_{112}.(PE)$$
$$\beta_{12j} = \gamma_{120} + \gamma_{121}.(PPIB) + \gamma_{122}.(PE)$$
$$\beta_{13j} = \gamma_{130} + \gamma_{131}.(PPIB) + \gamma_{132}.(PE)$$
$$\beta_{14j} = \gamma_{140} + \gamma_{141}.(PPIB) + \gamma_{142}.(PE)$$
$$\beta_{15j} = \gamma_{150} + \gamma_{151}.(PPIB) + \gamma_{152}.(PE)$$
$$\beta_{16j} = \gamma_{160} + \gamma_{161}.(PPIB) + \gamma_{162}.(PE)$$
$$\beta_{17j} = \gamma_{170} + \gamma_{171}.(PPIB) + \gamma_{172}.(PE)$$

The interpretation of the coefficients is as above.

4. Results

Using HLM 6.04 software, first, the null model was applied, according to Snijders and Bosker (1999), Raudenbush and Bryk (2002) and Short et al. (2006).

Table 1 presents the variance decomposition among the levels. Only 0.08% of performance variability occurred among firms (χ^2 = 29.85, p>0.50), while a relevant percentage of performance variance (99.15%) was due to the time evolution in each firm. On the other hand, 0.77% of the variance is due to differences among industries (χ^2 = 12.58, p<0.20).

Table 1: Variance Decomposition: Null Model

Fixed Effect	Coefficient	Standard error	t
General mean PROF (γ_{000})	19.33**	2.61	7.42
Random Effect	**Variance Component**	**df**	χ^2
Time Variation (e_{tij})	1678.69		
Variation among Firms (r_{0ij})	1.33	35	29.85
Variation among Industries (u_{00j})	13.07*	9	12.58
Variance Decomposition	**% per Level**		
Level 1 (time)	99.15		
Level 2 (firm)	0.08		
Level 3 (industry)	0.77		

** p<0.10.

* p<0.20.

As expected, variance among firms from different industries is greater than among firms from the same industry. Nevertheless, differences in annual stock profitability among companies working in different industries are not significant at 10% (only at 20%), which demonstrates that hedging investments in companies from different industries did not necessarily minimize risks or favored greater returns for investors in the period between 2001 and 2008.

Tables 2 and 3 offer the results of the models, including the level-1 trend, without and with the random effects, respectively. The model without random effects (table 2) shows that the variable corresponding to the year (linear trend) with a fixed effect is significant ($t = -2.15$, $p<0.10$). The analysis of table 3, which presents the results of the linear trend model with random effects, shows that the variance component for the linear trend is not significant ($\chi^2 = 21.36$, $p>0.50$).

Table 2: Variance Decomposition: Linear Trend Model without Random Effects

Fixed Effect	Coefficient	Standard error	t
General mean PROF (γ_{000})	30,61**	6.17	4.96
General mean of PROF (γ_{100}) growth rates	-2,34**	1,08	-2.15
Random Effect	**Variance Component**	**df**	χ^2
Level 1			
Time Variation (e_{tij})	1654.49		
Level 2			
Initial PROF of Firms (r_{0ij})	1.26	35	28.17
Level 3			
Mean PROF of Industries (u_{00j})	9.73*	9	12.27

** p<0.10.

* p<0.20.

Graph 1 specifies the negative sign of the γ_{100} coefficient for the period.

Graph 1: Linear Trend Model without Random Effects

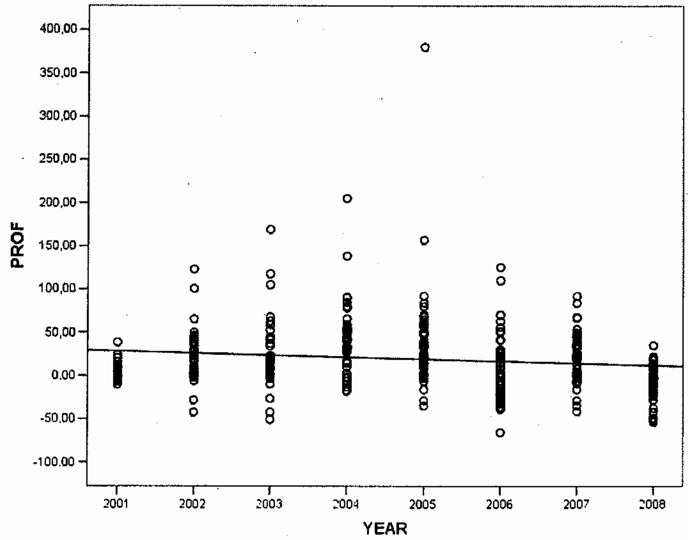

Table 3: Variance Decomposition: Linear Trend Model with Random Effects

Fixed Effect	**Coefficient**	**Standard error**	**t**
General mean PROF (γ_{000})	30.76**	6.15	5.00
General mean of PROF (γ_{100}) growth rates	-2.37**	1.09	-2.17
Random Effect	**Variance Component**	**df**	χ^2
Level 1			
Time Variation (e_{tij})	1648.19		
Level 2			
Initial PROF of Firms (r_{0ij})	1.65	35	20.57
Trend Change Rate of Firms (r_{1ij})	0.06	35	21.36
Level 3			
Mean PROF of Industries (u_{00j})	71.19	9	11.12
Trend Change Rate of Industries (u_{10j})	1.29	9	8.73

** p<0.10.

The analysis of tables 1, 2 and 3 shows that only hypothesis 1 and part of hypothesis 4 are supported. Hypotheses 2 and 3 are not supported at a significance level <0.10, as there is no significant variability in the stock profitability of companies working in the same industry, nor among companies from different industries during the study period.

Thus, hypothesis 5 is automatically discarded. As hypothesis 3 can be supported at a significance level <0.20, hypothesis 6 will now be evaluated. Therefore, the full model will be tested, however, without any level-2 predictive variable and without considering random effects at this same level. Hence, the final model tested becomes:

Level 1:

$PROF_{tij} = \pi_{0ij} + \pi_{1ij}.YEAR_{tij} + e_{tij}$

Level 2:

$\pi_{0ij} = \beta_{00j} + r_{0ij}$

$\pi_{1ij} = \beta_{10j}$

Level 3:

$\beta_{00j} = \gamma_{000} + \gamma_{001}.(PPIB) + \gamma_{002}.(PE) + u_{00j}$

$\beta_{10j} = \gamma_{100} + \gamma_{101}.(PPIB) + \gamma_{102}.(PE) + u_{10j}$

Table 4: Variance Decomposition: Full Model with Two Levels

Fixed Effect	Coefficient	Standard error	t
General mean PROF (γ_{000})	34.88**	13.51	2.58
PPIB (γ_{001})	-26.51	71.46	-0.37
PE (γ_{002})	-13.52	30.96	-0.44
General mean of PROF (γ_{100}) growth rates	-3.43*	2.28	-1.50
PPIB (γ_{101})	7.71	10.52	0.73
PE (γ_{102})	2.91	4.76	0.61
Random Effect	**Variance Component**	**df**	**χ^2**
Level 1			
Time Variation (e_{ti})	1646.72		
Level 2			
Initial PROF of Firms (r_{0ij})	0.21	35	26.57
Level 3			
Mean PROF of Industries (u_{00j})	64.66*	7	11.02
Trend Change Rate of Industries (u_{10j})	1.08	7	8.59

** p<0.10.

* p<0.20.

Table 4 presents the results of this model. The analysis of this table shows that the variables related to the industry's participation in GDP and Brazilian exportations are not representative to distinguish annual mean profitability of stocks and their growth rates among industries across the study period. Hence, other industry variables may be exerting reasonable influence (sig.<0.20) on the differences in mean annual profitability between companies from different industries. However, it is highlighted that there are no significant differences in the growth rates of stock profitability between companies in different industries.

In general, only two of the six hypotheses initially presented were supported by the results of the hierarchical models. The results obtained through these variance component analysis models are not restricted, as presented, to the specification of the variance composition of annual stock profitability, but favor the analysis of how certain firm or industry characteristics influence this performance across the study period.

5. Conclusions

Many studies adopting three-level hierarchical modeling with repeated measures, in which the third level represents the effect of the activity industry, find significant variability among companies from different industries. In this research, on the other hand, the lack of significant variability (with sig.<0.10) at the third level can derive from the fact that all industries presented a similar performance after the 2001 financial market crisis, with the consequent growth of annual stock profitability for most companies until 2004 and a severe fall in 2008, deriving from the high-risk mortgage crisis on the American real-estate market. It is possible that this phenomenon homogeneously affected the companies' stock profitability during the inter-crises period, in function of the characteristics present in Brazil, such as tax burden, interest rate, credit acquisition mechanisms or considerable dependence on commodity trades, which evidences the lack of a differentiated approach to stimulate the stock profitability of companies working in different industries, and also explains that hedge strategies do not always provide investors with a coherent form of diversification.

The contribution to the hierarchical modeling study allows the researcher to assess important nuances in longitudinal databases. However, the limitations of this technique refer to the determination of the research question, which should be defined according to the natural hierarchical structure of the data and the logic the software works with. If, on the one hand, the data structure needs to be nested in hierarchical levels, on the other, it permits missing or censured data, without the need for data balancing, like in other techniques, such as structural equations (Short et al., 2006).

Another contribution refers to estimating the impact of the time variation on stock profitability, as well as among companies and industries. Many authors have structured studies in this sense, providing researchers a possibility to prioritize aspects that deserve greater attention. If the industry effect is stronger, a closer look should be taken at the impacts related to the differences among industries to compose diversified portfolios. If, on the other hand, the differences among companies explained the largest part of the variance, which is not the case in this study, a focus on strategic management and on differences among organizations would be stimulated.

The third contribution of this study is the attempt to add predictive variables at firm and industry level. Many studies look at the variance decomposition, however, without evaluating the impacts deriving from the presence of certain variables, mainly aiming to determine where the main part of the variability occurs (Rumelt, 1991). Applications with linear hierarchical models offer researchers new possibilities of testing more complicated hypotheses, without the risk of violating the premises inherent in other techniques, such as regression by the ordinary least squares method.

Alternative approaches deserve further study in companies whose stocks are traded on Bovespa. Other predictive variables at industry level can be applied to determine new strategies and create different models. Changing the analysis period, expanding the interval to earlier years, reducing it to shorter periods or even excluding the atypical year 2008, can favor a deeper understanding of the mechanisms ruling stock profitability performance factors of companies listed on Bovespa.

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