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Information Asymmetry in Stock Trading, Economic and Financial Characteristics and Corporate Governance in the Brazilian Stock Market

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ABSTRACT

This study sought to investigate the relationship between information asymmetry in the stock trading, economic and financial characteristics and corporate governance of listed companies in the Brazilian stock market in 2010 and 2011. To this end, the study relied on a theoretical framework for information asymmetry in the capital market to measure the asymmetry's magnitude based on the intraday stock-trading data of 194 companies. The primary results demonstrated that the informational asymmetry in the stock trading was positively related to the risk, return and liquidity of the shares as well as the cost of equity and the size of the companies. In addition, the asymmetry was negatively related to the abnormal return of shares. During the investigated period, the information asymmetry relationship with the liquidity and size (positive) and the abnormal return (negative) were at odds with previous research. The reasons for our results may be related to specific aspects of the Brazilian market, for example, in the case of abnormal returns, the deceleration of the Bovespa Index (IBovespa) or the reflection of the average return to negotiators without insider information during the period. In case of liquidity and size, the high index of issuance and negotiation of preferred shares may have influenced the results. Thus, this research contributes to the analysis of idiosyncratic characteristics of the capital market of a developing country, such as information asymmetry in stock trading and its association with the economic and financial characteristics and corporate governance of companies in the Brazilian stock market.

Keywords: Insider information. Insider trading. Capital market.

1 INTRODUCTION

The growth of the stock market in Brazil in recent years, particularly during the first decade of the 21st century, has attracted the attention of several companies and investors from different cultures and nationalities. Perceived as an emerging economy, Brazil has become the target of large investments, which has leveraged certain domestic companies into the international financial scene. Such developments have motivated research and discussion on insider trading in the domestic stock market, which results from information asymmetry between investors.

Information asymmetry has been previously discussed, particularly in the context of separation between the ownership and the capital control of companies, which enables conflicts of interest to emerge (Jensen & Meckling, 1976). These conflicts can cause, for example, the majority or controlling shareholder to use private information for his or her own benefit while negotiating with the company's shares. Not only the controlling shareholder but any market participant may be an insider in the trading of securities using insider information on the issuer of such securities. In this regard, insider, or private, information is that information not yet disclosed to the general public, which can provide a competitive advantage in stock trading.

Fu, Kraft and Zhang (2012) state that each financial report, in the broad sense, represents an opportunity to realize gains using private information, and the greater frequency of reports encourages the informed trader to acquire private information, thus increasing informational asymmetry. To Thevenot (2012), in the US market, the Sarbanes-Oxley Act is consistent with the concern that managers can negotiate using private information when the financial results are misrepresented. The use of this type of information in stock trading is referred to in the international literature as insider trading and qualifies as an unlawful practice in several markets (Cohen, Malloy, & Pomorski, 2012), given that one of the incentives for this practice is the opportunity to earn abnormal returns based on information on trades in the stock market that is unknown or undisclosed to the general public.

In the case of the Brazilian capital market, Vieira and Mendes (2006) emphasize that its historical evolution was based on companies with family structures and institutional investors who positioned themselves typically beyond the control of the company and that over a long period, the profile of these investors was based on short-term investments. According to Duarte and Young (2009), this situation draws attention in emerging markets, such as Brazil, particularly because of the concentration of large volumes of shares in the hands of a few investors. Combined with the low liquidity of certain papers and the deficiencies of the regulatory system, this phenomenon results in insider trading. These features tend to encourage information asymmetry and, in particular, private information in stock trading. This statement is confirmed by Carvalho (2002), who states that the basis of the Brazilian market atrophy is determined by the low level of minority shareholder protection.

Regarding information asymmetry in the capital market, Abad and Rubia (2005) report the existence of several proxies for this asymmetry, which are estimated based on covariance and transaction prices, while warning that there are doubts about their efficiency. Additionally, the same authors emphasize the probability of informed trading (PIN), or the probability of insider trading, which is estimated by the Easley, Hvidkjaer, and O'Hara (2002) model directly from the intraday trading data of shares. Therefore, Abad and Rubia (2005) emphasize that compared with the other proxies, such as the dispersion of stock returns, the issuance of American depositary receipts (ADR) and adherence to the different levels of governance, PIN has an advantage because it provides a measure of information asymmetry based on microstructure data, which is the most independent of market organization (e.g., it does not depend on the number of accounting announcements), although at the expense of an approach based on more complex techniques.

In Brazil, despite the lack of research with a relevant focus, Barbedo, Silva and Leal (2009) investigated and confirmed the presence of information asymmetry between market participants in stock trading. Moreover, Bopp (2003) and Cruces and Kawamura (2005) investigated the ADR of Brazilian companies traded on the New York Stock Exchange (NYSE) and found evidence of negotiations informed by these papers. Nevertheless, none of these studies investigated the relationship between this asymmetry, economic and financial variables and corporate governance. In most studies, the only assumption made is that information asymmetry is one cause of the variations found in variables such as capital structure (Albanez & Valle, 2009), informational efficiency (Camargos & Barbosa, 2003) and dividend payments (Iquiapaza, Lamounier, & Amaral, 2008).

In this context, Aslan, Easley, Hvidkjaer and O'Hara (2011) emphasize that business characteristics may be related to greater or lesser PIN in the market. Thus, based on the literature, several variables were identified as potentially related to PIN: risk (Easley, Kiefer, O'Hara, & Paperman, 1996), return (Easley, Hvidkjaer, & O'Hara, 2002), abnormal return (Clarke & Shastri, 2000), liquidity (Amihud & Mendelson, 1989), volatility (Halov & Heider, 2011), capital structure (Leland & Pyle, 1977), cost of capital (Easley & O'Hara, 2004), size (Aslan, Easley, Hvidkjaer, & O'Hara, 2011), market-to-book ratios (McLaughlin, Safieddine, & Vasudevan, 1998), price/earnings (Clarke & Shastri, 2000), dividend policy (Myers & Majluf, 1984), earnings management (Aboody, Hughes, & Liu, 2005) and corporate governance (Chen, Chen, & Wei, 2009).

In light of this literature, this study's research question is

as follows: What are the relationships between the probability of insider trading, the economic and financial characteristics and the corporate governance of companies in the Brazilian stock market? Thus, to fill this gap in the domestic literature, this study investigates the relationship between information asymmetry in the stock trading, economic and financial characteristics and corporate governance of listed companies in the Brazilian stock market in 2010 and 2011.

2 THEORETICAL FRAMEWORK

2.1 Information Asymmetry in the Capital Market

From the viewpoint of the efficient market hypothesis (EMH), the price of any asset in a market must fully reflect all of its relevant available information (Fama, 1970, 1991). In the capital market, relevant information is that information that may affect the future cash flow of a company or the future expectations of investors. According to Fama (1970), in an efficient market, asset prices provide adequate resource allocation signs because the information is symmetric.

The implications of information asymmetry in any market were initially analyzed by Akerlof (1970). To illustrate this phenomenon, the author used the example of the US market for used cars, in which old and defective cars are known as lemons. According to the author, in this type of market, information asymmetry is characterized by the informational level of the agents. The individual who sells a car has full knowledge of its condition, whereas the individual who purchases a car does not know such conditions. Thus, the buyer will be prepared to pay a price for the car below that which it would actually cost because the buyer does not possess all of the information necessary to verify to the car's quality, whereas those individuals who possess good cars resist selling them because they could receive a price below their vehicle's actual value.

For Leland and Pyle (1977), several markets are characterized by the difference of information available to buyers and sellers. In financial markets, information asymmetry is particularly noticeable because borrowers typically understand their guarantees, skills and moral integrity better than lenders. Therefore, borrowers have "insider" information on their own projects, for which they seek financing. Moreover, these authors believe that lenders should understand the true characteristics of the borrowers but that moral hazard, which is addressed by agency theory (Jensen & Meckling, 1976), complicates the direct transfer of information between market participants.

From the secondary market viewpoint, which is the focus of this study, the same behavior can be observed. For example, if a particular market participant possesses private information of good news (a high signal) regarding a company, before the release of this information, he or she can acquire new shares in the company by issuing a buy order and thus obtaining abnormal gains with this investment. In contrast, when a market participant has private information with a low signal, he or she initiates an order to sell the shares of the relevant company prior to the disclosure of the information and the subsequent decrease in the price of the shares.

In this context, Abad and Rubia (2005) emphasize that the financial literature recognizes two types of investor depending on the investor's level of information. On the one hand, the so-called informed agents have private information that enables them to obtain economic gains while the asset price does not reflect its fundamental value. On the other hand, the uninformed agents trade for liquidity purposes only using publicly available information and their personal convictions. In this regard, Duarte and Young (2009) observed that the effect of this asymmetry in major economies is diversifiable because of the existence of a large number of traded assets, which diminishes the advantage of informed agents over uninformed ones with respect to certain assets, given the large number of deals. However, in emerging economies, such as Brazil, where there is a large concentration of corporate capital among a few investors, there is a higher probability of abnormal gains by informed agents through obtaining private information.

2.2 Information Asymmetry Measures: The Probability of Insider Trading (PIN).

In the capital markets literature, PIN has excelled against other proxies of information asymmetry (such as volatility, abnormal profit and the number of public announcements about a company) because it is considered to be the most independent proxy of market organization because it uses the market's microstructure data and is not influenced by other, unrelated factors (Brown, Hillegeist, & Lo, 2008), for example, the largest number of advertisements during a given period, which may be a consequence of regulatory obligations. Thus, PIN is more independent because it is directly estimated from the trading data of each share through the imbalance between purchases and sales during a given period (Abad & Rubia, 2005).

PIN (Easley et al., 2002) is the result of the measurement of information asymmetry in the capital market using the sequential bargaining model of Easley, Kiefer, O'Hara and Paperman (1996), which was later refined by Easley, Hvidkjaer and O'Hara (2002) (the EHO model) and used in this study because it has been consistently validated in the international literature (Abad & Rubia, 2005; Cruces & Kawamura, 2005; Duarte & Young, 2009; Aslan et al., 2011). In Brazil, although the number of studies that use this metric are few, Barbedo et al. (2009) attest its consistency and applicability.

The EHO model is based on the imbalance between the events of buying and selling stocks at a given time. This imbalance is regarded as a sign of the existence of

informed trading, in which information events about an asset are generated independently of one another over the trading days ($t_1 \ldots n$) with probability α. Thus, a value for the asset with probability $1 - \delta$ can be created (if it means good news) or represent bad news, reducing its value, with the probability δ. In this case, "good news" indicates a high signal of the asset value, whereas "bad news" indicates a bearish signal. Therefore, the asset has an expected value, represented by variable V, whereby the occurrence of an information event (Ψ) on V may assume two values, low or high, represented by (L) and (H), with probabilities δ and $1 - \delta$, respectively.

The asset value conditioned to the low signal (L), which indicates bad news, is given by $\underline{V}$. Similarly, the asset value conditioned to the high signal (H), which indicates good news, is given by $\overline{V}$. However, information events may not occur; i.e., no new information emerges during the trading period. In this case, it is assumed that $\Psi = 0$ and that the asset value simply remains $V^*=\delta\underline{V}+(1-\delta)\ \overline{V}$, where $\underline{V}<V^*<\overline{V}$. Therefore, it is assumed that the probability that an information event has occurred is α and the probability that this event has not happened is $1 - \alpha$ (Easley, Kiefer, & O'Hara, 1997a).

Thus, the previously cited authors note that trading in the capital market is caused by informed and uninformed traders with a simple trading strategy. That is, if an informed agent observes a high signal, he or she will purchase a stock if its current price is less than $\overline{V}$. If the informed agent observes a low signal, he or she will sell if the price is above $\underline{V}$. On the other hand, it is considered to be trade balance, when at least some uninformed agents trade for non-speculative reasons, such as liquidity needs or portfolio considerations. Thus, it is assumed that if an information event occurs, the market maker expects the fraction of trades made by informed agents to be μ. Furthermore, it is assumed that the probability that uninformed agents trade while checking the asset price is $\varepsilon > 0$.

In each time t [0, T], informed agents with bad news (δ) regarding an asset sell the asset, whereas the informed agents with good news ($1 - \delta$) purchase the asset. Thus, on days with information events, orders by informed agents reach a rate μ. However, uninformed agents do not have information that guides their business dealings. Thus, orders by uninformed buyers arrive at a rate ε_b, whereas orders by uninformed sellers arrive at a rate ε_s (Easley, Hvidkjaer, & O'Hara, 2002). This trading process can be depicted in a tree diagram (Figure 1).

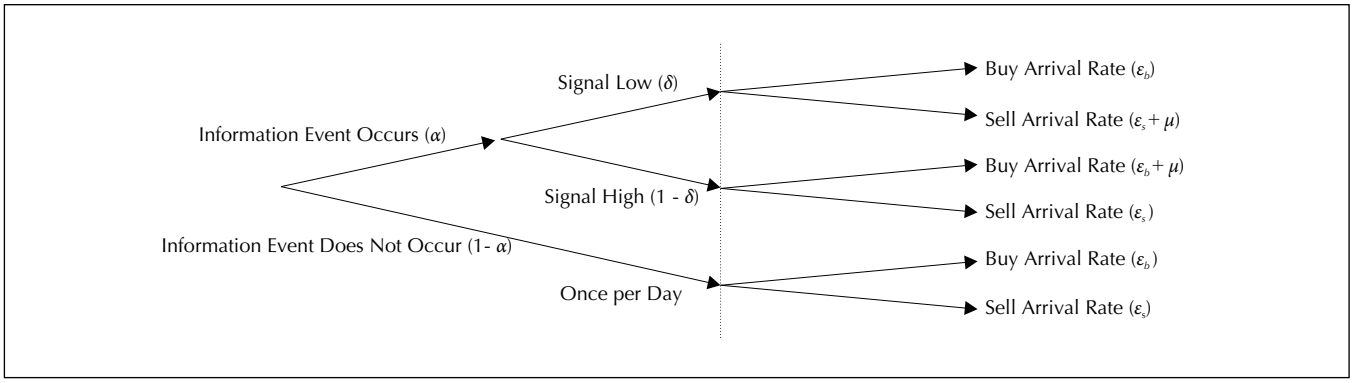

Figure 1 *Tree Diagram of the Trading Process*

Source: Adapted from Easley, Hvidkjaer, and O'Hara (2002).

The first node corresponds to the occurrence of an information event. If the event occurs (with probability α), that is, if there is private information in the market, its signal is given on the second node. There is a probability δ of the event causing a low signal and a probability $1 - \delta$ of the event causing a high signal. The third node is reached at the beginning of the trading day, whereby traders are selected at each time t to make transactions based on the previously described probabilities. If an information event occurs, it proceeds to the fourth node, where an informed agent is chosen to negotiate with probability μ. Whether an agent buys or sells depends on the signal that he or she perceives. If this information event represents a bearish signal, the arrival rate of sell orders is given by $\varepsilon_s + \mu$. If the information represents a bullish signal, the arrival rate of buy orders is given by $\varepsilon_b + \mu$. However, if no event occurs, the arrival rates of buy and sell are ε_b and ε_s, respectively, because there is no informed agent in the market ($\mu = 0$).

Thus, the model interprets the standard level of purchases and sales of a share as uninformed trading, using these data to identify ε_b and ε_s. An abnormal number of buy or sell offers is interpreted as informed trading and is used to identify μ. Additionally, the number of days on which there is an abnormal volume of purchases and sales is used to identify α and δ (Easley et al., 2002). This trading process is represented by the parameters of the EHO model (α, μ, ε_b, ε_s and δ), estimated through the maximization of a maximum likelihood function (Equation 1).

$$L(\theta|B,S) = (1-\alpha)e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} + \alpha\delta e^{-\varepsilon_b}\frac{\varepsilon_b^B}{B!}e^{-(\mu+\varepsilon_s)}\frac{(\mu+\varepsilon_s)^S}{S!} + \alpha(1-\delta)e^{-(\mu+\varepsilon_b)}\frac{(\mu+\varepsilon_b)^B}{B!}e^{-\varepsilon_s}\frac{\varepsilon_s^S}{S!} \quad (1)$$

where B and S represent buy and sell volumes of share i during the trading period t, respectively, and $\theta = (\alpha, \mu, \varepsilon_b, \varepsilon_s$ and $\delta)$ is the parameter vector. This function is a mixture of Poisson probability distributions, weighted by the probability of there being "good news" $\alpha(1 - \delta)$, bad news $(\alpha\delta)$ or no news $(1 - \alpha)$. Thus, PIN is given by Equation 2.

$$PIN = \frac{\alpha\mu}{\alpha\mu + \varepsilon_b + \varepsilon_s} \quad (2)$$

where α is the probability of an information event occurring, μ is the arrival rate of trading orders by informed agents and ε_b and ε_s are the arrival rates of buy and sell orders, respectively, from uninformed agents.

However, like any economic model, PIN has been the subject of criticism. For Aktas, Bodt, Declerck, and Oppens (2007), although PIN captures the imbalance between buy and sell orders, the metric has two imperfections: (i) it only reflects the number of orders (trades executed), although the volume of shares traded may be more relevant, and (ii) it reflects factors other than private information, such as market trends. Additionally, Easley et al. (2002) warn that it can be questioned whether PIN is not too simple to capture the imbalance in negotiations and the influence of informed trading. However, these authors note that this question was analyzed by Easley, Kiefer, and O'Hara (1997a, 1997b), who tested these possibilities by estimating two versions of the model, a restricted version (without the size of realized trades) and an unrestricted version (with the size of trades), whereby they observed that the statistics of the two models are similar. Thus, Easley et al. (2002) reject the hypothesis of assigning imbalance to random negotiations.

In the view of Hwang, Lee, Lim, and Park (2013), the great weakness of PIN as estimated by the EHO model consists of the serious rating bias of buy or sell trades. The authors emphasize that identifying the agent who triggered the negotiation (the buyer or the seller) is generally impossible using most databases available for the different markets, and inevitably, this classification has been performed using the algorithm of Lee and Ready (1991), which has flaws. Thus, the authors explain the inaccuracy in PIN pricing in different markets, considering that in the finance literature there is no consensus regarding its pricing, possibly as a result of trading misclassification. However, Lee and Radhakrishna (2000) claim that this algorithm is accurate to approximately 93.0% in the North American market. For Brazil, Silva (2009) has established an accuracy of approximately 72.0%. Thus, considering that there is no information on the triggering agent of the negotiation in the Brazilian market, the algorithm's relative accuracy and the lack of another, more precise classification method, this algorithm was chosen for this study.

Moreover, Heidle and Huang (2002) attest that the EHO model has numerous applications in the literature, which distinguishes it from other models because it enables the deduction of the probability of insider trading through parameters that are estimated from share trading data. Thus, despite its limitations, which should be considered when interpreting the results of this study, PIN was used to measure information asymmetry because it is the most independent of the market organization (Abad & Rubia, 2005) and widely used in the current research on the subject (Heidle & Huang, 2002; Cruces & Kawamura, 2005; Aktas, Bodt, Declerck, & Oppens, 2007; Brockman & Chung, 2008; Aslan et al., 2011).

2.3 Variables Related to Information Asymmetry

Based on the literature on information asymmetry in capital markets, thirteen variables were identified that may be related to the PIN estimated for Brazilian market shares (Table 1).

Table 1 *Variables Related to Information Asymmetry*

Variables	Expected Relation	Primary References
Risk	Positive	Easley et al. (1996); Abad and Rubia (2005); Aslan et al. (2011).
Return	Positive	Clarke and Shastri (2000); Easley, Hvidkjaer and O'Hara (2002, 2010); Aslan et al. (2011).
Abnormal Return	Positive	Myers and Majluf (1984); Clarke and Shastri (2000);
Liquidity	Negative	Amihud and Mendelson (1989); Abad and Rubia (2005); Agarwal and O'Hara (2007); Duarte and Young (2009).
Volatility	Positive	Clarke and Shastri (2000); Aslan et al. (2011); Halov and Heider (2011).
Capital Structure	Positive	Leland and Pyle (1977); Amihud and Mendelson (1989); Agarwal and O'Hara (2007).
Cost of Capital	Positive	Easley and O'Hara (2004); Chen, Chen and Wei (2009).
Size	Negative	Easley, Hvidkjaer and O'Hara (2002); Easley and O'Hara (2004); Agarwal and O'Hara (2007); Aslan et al. (2011).
Market-to-book	Negative	McLaughlin, Safieddine and Vasudevan (1998); Clarke and Shastri (2000); Aslan et al. (2011).
Price/Earnings	Negative	Clarke and Shastri (2000); Easley, Hvidkjaer and O'Hara (2002).
Dividend Policy	Negative	Myers and Majluf (1984); Iquiapaza, Lamounier and Amaral (2008).
Earnings Management	Positive	Aboody, Hughes, and Liu (2005); Burgstahler, Hail and Leuz (2006).
Corporate Governance	Negative	Cruces and Kawamura (2005); Vieira and Mendes (2006); Barbedo, Silva and Leal (2009).

The first variable was the stock risk, which according to Easley et al. (1996) is positively related to information asymmetry because this asymmetry creates a new type of systematic risk in the market, the risk of information, which is the existence of private information in the stock market based on negotiations. For Aslan et al. (2011), an asset with a higher volume of private information tends to be riskier, and therefore, it is natural to require a higher expected return. In this connection, Easley et al. (2002) warn that the equity return has a direct and positive relationship with information asymmetry, which suggests that the market pays a premium for such risk.

In this context, considering the premium paid by the market, Clarke and Shastri (2000) observe that the abnormal returns produced by a share are generally positively related to the existence of information asymmetry. The international literature confirms this relationship (Myers & Majluf, 1984). In this context, the presence of investors with different levels of information can be related to the lack of liquidity of assets in that market. In this regard, Amihud and Mendelson (1989) argue that the cost of adverse selection affects the liquidity of the shares in the capital market, whereby the liquidity of a security can be increased by decreasing the information asymmetry. Therefore, a negative relationship is expected. The expected relationship between information asymmetry and stock volatility is positive, given that high volatility indicates a high cost of adverse selection (Halov & Heider, 2011), which implies greater information asymmetry among investors.

The capital structure is another variable that may be positively related to information asymmetry because according to Leland and Pyle (1977), the choice of outside capital interest can signal to outside investors the occurrence of asymmetric information. Regarding the cost of equity, Easley and O'Hara (2004) argue that it is positively related to information asymmetry because investors demand a higher return for trading shares with a higher degree of private information. For Easley and O'Hara (2004), greater information asymmetry results in a premium for the highest risk and therefore the highest cost of capital. Regarding company size, Aslan et al. (2011) claim that the larger a company is, the smaller that the information asymmetry tends to be because there are more shares outstanding and more investors negotiating over the company shares. Therefore, a negative relationship is expected.

Furthermore, McLaughlin, Safieddine and Vasudevan (1998) emphasize the use of market-to-book as an information asymmetry measure. In this sense, Clarke and Shastri (2000) assert that one way to measure information asymmetry in the capital market is based on the set of growth opportunities of a company, and market-to-book and price/earnings ratios may be used as proxies for asymmetry because they can capture the future expectations of the shareholders regarding realized investments. Thus, negative relationships with asymmetry are expected.

Regarding the dividend policy, or the dividend payout, Myers and Majluf (1984) emphasize that it is negatively related to information asymmetry because it can result in underinvestment in a company, with the retention of profits (or reduction of dividends) a form of increasing the supply of resources. However, earnings management, according to Aboody, Hughes, and Liu (2005), relates positively to information asymmetry because it is viewed as a measure of information quality (Burgstahler, Hail & Leuz, 2006). Finally, the last variable potentially related to information asymmetry concerns the adoption of differentiated corporate governance practices. The adoption of such practices indicates greater protection of shareholder rights and decreased agency problems and information asymmetry, which limits the opportunities for insider trading (Chen et al., 2009).

3 METHOD

3.1 Data Sample and Collection

For this study, data on shares traded, economic-financial and governance information were collected from all of the companies listed on the Securities, Commodities and Futures Exchange (BM&FBovespa) during 2010 and 2011. The limitation of this time interval was necessary because of the high number of observations at high frequency required to estimate PIN and changes in the structure of the financial statements of these companies as a result of the full adoption of the International Financial Reporting Standards (IFRS).

To avoid selection bias, the sample was defined only after all of the data were gathered. Companies that did not have data on any of the thirteen related variables (Table 1) and shares that did not have at least one day of trading during all trading days for at least one of the quarters analyzed were excluded. Thus, the total sample included 229 shares from 194 companies over 8 quarters.

To perform the analyses, two subsamples were used. (i) One subsample was used to analyze relations between PIN and the economic, financial and governance variables, in general, when the sample consisted of 194 shares (976 quarterly observations) (one per company). This measure was taken to avoid duplication of observations of some variables for the company (such as capital structure, dividend policy, corporate governance) in the case of companies with more than one class of stock. Thus, the most traded share class of the company remained in this subsample, considering that PIN presents best estimates from stock with larger or more liquid trading volumes (Easley et al., 1996). (ii) Another subsample was used to individually analyze relationships according to each class of shares, which consisted of 143 common shares (673 quarterly observations) and 81 preferred shares (454 observations) (in this subsample, five papers were not considered because they were share "packages" that contained both

types – UNT – or share certificates for overseas trading – DR3).

The information on the economic and financial variables of the companies was collected from the Economatica® database. Information on governance and intraday stock trading data was obtained from the electronic trading platform CMA Series 4 of the CMA Group® minute by minute from January 4th, 2010 to December 29th, 2011. This database does not identify whether the intraday trading was initiated by a buying or selling agent. In market microstructure surveys, the identification of the action of these agents separately is a key issue. Silva (2009) notes that it is obvious that each transaction occurs simultaneously, a purchase and a sale, because the transaction involves a buyer and a seller. However, to apply the EHO model, it is necessary to identify whether the transaction was triggered by a buying or selling agent to be classified as a "buy" or "sell". For this purpose, we used Lee and Ready's (1991) LR Method.

In this method, the closing price of the transaction is compared with the average buy and sell price. If higher, the transaction is classified as "buy" or if lower as "sell". If the closing price equals the average price, the closing price of the current transaction is compared with the price of the previous transaction. If higher, the transaction is classified as "buy" or if lower as "sell". If equality persists, the previous transaction rating is repeated.

3.2 EHO Model: Parameter Estimate

To estimate $\theta = (\alpha, \mu, \varepsilon_b, \varepsilon_s$ and $\delta)$, which is the parameter vector of the EHO model, a maximum likelihood function was maximized conditioned to the trading history of each share (Equation 1, presented in section 2.2). However, Easley, Hvidkjaer, and O'Hara (2010) warn that maximizing this equation is a difficult task even for a computer because of the large volume of daily buy (B) and sell (S) orders of some shares, which makes the system break down because of the factorization of variables *B* and *S*, which generates infinite numbers. Thus, according to the previously noted authors, this equation should be rewritten as follows:

$$L\left((B_t,S_t)_{t=1}^{T}\right)|\theta) =$$

$$\sum_{t=1}^{T}[-\varepsilon_b - \varepsilon_s + M_t(\ln x_b + \ln x_s) + B_t\ln(\mu+\varepsilon_b) + S_t\ln(\mu+\varepsilon_s)] +$$

$$\sum_{t=1}^{T}\ln[\alpha(1-\delta)\,e^{-\mu}x_s^{S_t-M_t}x_b^{-M_t} + \alpha\delta e^{-\mu}x_b^{B_t-M_t}x_s^{-M_t} + (1-\alpha)x_s^{S_t-M_t}x_b^{B_t-M_t}] \quad (3)$$

where $M_t = min(B_t,S_t)+max(B_t,S_t)/2$, $x_s=\varepsilon_s/(\mu+\varepsilon_s)$ and $x_b=\varepsilon_b/(\mu+\varepsilon_b)$ and where the factorization of $x_b^{M_t}$ e $x_s^{M_t}$ is made to reduce the truncation error and increase the efficiency of the system. According to Easley et al. (2010), this approach is important for populations with large volumes of purchases and sales because this transformation facilitates the calculation of PIN to a greater number of trading days because it replaces the factorial of the number of buy (B!) and sell (S!) orders (without hindering the estimation process).

3.3 Regression Model: Analysis of Relations

To relate the estimated PIN to the economic and financial characteristics and corporate governance of companies, the probit regression model was used with panel data. This model was chosen because the dependent variable, which is a probability (PIN), is truncated, or censored (limited to the range [0, 1] or [0%, 100%]), and only with positive values. Moreover, the choice of panel data considered the possibility of evaluating the relationship between the dependent variable and the explanatory variables, given that this model facilitates the development of inferences regarding the possible differences between companies and, over time, the evolution of the studied variable (Fávero, 2013).

The data panel had information from 194 companies over 8 quarters. However, because of the filters used during data collection and the lack of information on several of the analyzed variables, this panel was unbalanced. Thus, to investigate the assumed research hypotheses, regressions were estimated using Equation 4.

$$PIN_{it} = \gamma_0 + \gamma_1\beta_{it} + \gamma_2 R_{it} + \gamma_3 CAR_{it} + \gamma_4 Liq_{it} + \gamma_5 Volat_{it} + \gamma_6 CT_{it} + \gamma_7 K_{eit} + \gamma_8 Tam_{it} + \gamma_9 MB_{it} + \gamma_{10} P/L_{it} + \gamma_{11} DIV_{it} + \gamma_{12} GR_{it} + \gamma_{13} GC_{it} + u_t \quad (4)$$

where PIN_{it} is the probability of insider trading, $\gamma_{1,\ldots,n}$ are the estimated parameters, β_{it} is beta, R_{it} is the return, CAR_{it} is the cumulative abnormal return, Liq_{it} is the market liquidity and $Volat_{it}$ is the volatility of share *i* in quarter *t*. CT_{it} is the proportion of debt, K_{eit} is the cost of equity estimated by the capital asset pricing model (CAPM) with the SELIC as the free risk rate, Tam_{it} is the company size represented by the logarithm of its full market value on the last business day of the quarter, MB_{it} is the market-to-book ratio, P/L_{it} is the price/earnings ratio, DIV_{it} is the dividend policy represented by the payout ratio, GR_{it} is the earnings management represented by discretionary accruals, GC_{it} is the corporate governance of company *i* in quarter *t* (taking value 1 when listed in the New Market and 0 in the others) and u_t is the error term.

Further, to consistently estimate the parameters, the regression model was analyzed with panel data that best suited the consistency and efficiency of the estimators. For this purpose, the Breusch-Pagan, Chow and Hausman tests were used.

3.4 Research Hypothesis Development

This study's central research hypothesis is based on Bopp (2003), Cruces and Kawamura (2005) and Barbedo, Silva and Leal (2009). We assume that there is evidence of the use of insider trading in the Brazilian stock market and relate this information asymmetry in stock trading to the economic and financial characteristics and corporate governance of the investigated companies (similar to Aslan et al. (2011)) using Equation 4.

H_1: The Brazilian stock market has information asymmetry in stock trading that is related to the eco-

nomic and financial characteristics and corporate governance practices of companies.

Furthermore, Carvalho (2002) notes that the Brazilian capital market is characterized by most of the companies belonging to family groups and, consequently, a high rate of issuance of preferred shares (PS) without voting rights because to financial needs must be met without losing the controlling interest by these family groups. Denardin (2007) corroborates this characteristic and emphasized that preferred stocks tend to offer less protection against the risk of information than common shares (CS). Thus, it is reasonable to expect that the information asymmetry in preferred stock trading is greater and that the relations between the economic and financial characteristics and corporate governance change from one class of share to another. Therefore, the second hypothesis of this study is conjectured, which is tested from the application of Equation 4 to each class of shares separately.

H_2: Common and preferred shares have different relations between information asymmetry in stock trading, financial and economic characteristics and the corporate governance of companies in the Brazilian stock market.

4 RESULTS

The average PIN estimated for the shares analyzed during 2010/2011 was approximately 25.0% (Table 2). This average is higher than that determined by Easley et al. (2002) for US market shares (19.1%) and close to the figure ascertained by Bopp (2003) for ADRs of Brazilian companies (23.9%) in that market for nearly a decade. It was also higher than the PIN estimated by Hwang et al. (2013) for the emerging South Korean market (20.1%) when these authors use a method similar to that used in this study.

In the Brazilian market, the most recent estimate was performed by Barbedo, Silva and Leal (2009) for 48 shares using the EHO model with a market trend adjustment: an average of 12.5%. This adjustment was not used in this study. Instead, the original EHO model was used because of its greater empirical consistency and widespread use in the international literature, which is why the PIN estimated by this study differs from that estimated by Barbedo, Silva and Leal (2009).

Regarding the PIN-related economic and financial variables in this study, it can be observed that the average beta of the stocks analyzed in this period was 0.637. The average stock return was negative (-0.7%). However, the cumulative abnormal return of these shares during 2010 and 2011 was positive (1.8%), which indicates that these shares exhibited a higher performance compared with the average IBovespa. The average liquidity of these shares was 0.521, and the average quarterly volatility was 16.270. On average, the companies analyzed had a higher proportion of debt (59.9%) and a negative cost of equity at -1.2% (Table 2).

Table 2 *PIN Descriptive Statistics and the Economic and Financial Variables (1/2010/1 – 4/2011)*

Variables	Average	Median	Minimum	Maximum	Standard Deviation
PIN	25.010	23.857	0.000	56.535	10.279
Beta	0.637	0.600	-0.272	1.914	0.376
Return	-0.662	-1.455	-94.482	316.670	21.422
Abnormal Return	1.816	1.707	-97.082	316.850	20.493
Market Liquidity	0.521	0.140	0.001	10.081	1.112
Volatility	16.270	15.326	1.352	75.518	6.242
Capital Structure	59.914	59.153	0.307	173.490	21.018
Cost of Equity	-1.247	0.385	-26.923	18.055	7.389
Size*	6.595	6.634	4.687	8.605	0.698
Market-to-book	1.022	0.641	0.041	8.572	1.192
Price/Earnings	29.354	44.642	-317.435	395.645	42.533
Dividend Policy**	0.564	0.363	-337.080	86.813	11.460
Earnings Management***	0.002	0.004	-0.558	0.718	0.076
Corporate Governance****	0.454				

Notes: * Log (market value); ** payout ratio; *** discretionary accruals; **** dummy variable taking value 1 for the New Market and 0 for other segments.

The average size of companies according to their market value was approximately US$ 22.3 billion. The relationship between the market and accounting values was approximately 1.022, and the ratio of the stock prices to

earnings per share was 29.354 times higher. The average payout ratio was 0.564, the average discretionary accrual was 0.002, and 45.4% of the analyzed shares were listed on the New Market corporate governance segment.

To investigate the association between these variables, the Spearman correlation coefficient was estimated. As shown in Table 3, PIN was positively and significantly correlated with risk (0.078), stock return (0.145), market liquidity (0.191), proportion of debt (0.078), cost of equity (0.199), and size (0.216). In contrast, PIN was negatively and significantly correlated with dividend policy (-0.075) and listing at different levels of corporate governance (-0.064). The other variables showed no significant correlation coefficient with PIN.

Table 3 *Correlation between Investigated Variables (1/2010 – 4/2011)*

	PIN	β	R	CAR	Liq	Volat	CT	K_e	Tam	MB	P/L	DIV	GR
β	0,078**												
R	0,145***	-0,227***											
CAR	-0,015	-0,137***	0,628***										
Liq	0,191***	0,470***	-0,041	-0,034									
Volat	0,061	0,412***	-0,217***	-0,079**	-0,029								
CT	0,078**	0,122***	-0,029	-0,044	0,037	0,087***							
K_e	0,199***	-0,346***	0,416***	-0,117***	-0,115***	-0,283***	0,005						
Tam	0,216***	0,286***	0,068**	0,048	0,518***	-0,234***	0,028	-0,031					
MB	-0,019	-0,150***	0,177***	0,170***	0,182***	-0,171***	-0,462***	0,032	0,224***				
P/L	0,008	-0,027	0,111***	0,092***	0,166***	-0,049	-0,173***	0,035	0,195***	0,432***			
DIV	-0,075**	-0,074**	0,010	0,086***	0,020	-0,135***	-0,088***	-0,088***	0,051	0,121***	0,396***		
GR	0,058	0,024	-0,140***	-0,042	-0,049	0,069**	-0,065**	-0,173***	-0,121***	0,025	0,028	0,139***	
GC	-0,064**	-0,058	0,027	0,059	0,081**	0,021	-0,232***	-0,042	-0,053	0,352***	0,250***	0,121***	0,111***

Notes: *PIN* is the probability of insider trading, β is the risk, *R* is the return, *CAR* is the cumulative abnormal return, *Liq* is the liquidity and *Volat* is the share volatility. *CT* is the proportion of debt, K_e is the cost of equity, *Tam* is the size, *MB* is the market-to-book ratio, *P/L* is the price/earnings ratio, *DIV* is the dividend policy, *GR* is the earnings management and *GC* is the corporate governance listing of the company. *** Significant at 1% and ** significant at 5%.

Furthermore, higher correlation coefficients can be found between the explanatory variables in Equation 4, for instance, between the return and the cumulative abnormal return (0.628), liquidity and size (0.518) and liquidity and risk (0.470). According to Brooks (2008), when the coefficient is lower than 0.8, multicollinearity does not present a problem for subsequent regression analysis. Thus, all of the variables were considered in the model.

4.1 Relations between PIN and Company Variables

To analyze the relationship between PIN, the economic and financial characteristics and the corporate governance practices of the companies, a probit regression model was estimated using panel data. Data adequacy was tested using the Lagrange multiplier (LM) from Breusch-Pagan to determine whether to estimate by pooled ordinary least squares (POLS) or random effects. The null hypothesis of adequacy of the POLS model was rejected (χ^2 = 30,226). Then, the Chow test was conducted to decide between POLS estimation or fixed effects. The null hypothesis of equality of intercepts and slope (POLS) was also rejected (F = 194.769). Finally, the Hausman test was used to decide between estimation by fixed or random effects. The null hypothesis of consistency of estimators for random effects was not rejected (χ^2 = 3.087) using generalized least squares (GLS).

Thus, given the robustness of the estimated parameters, the absence assumptions of autocorrelation, heteroscedasticity, multicollinearity and the normal distribution of residuals were evaluated. Regarding the absence of autocorrelation and heteroscedasticity, the GLS estimation assumes that the parameters are the best non-biased and therefore consistent estimators. In the case of multicollinearity, the analysis of the correlation matrix, shown in section 4 (Table 3), indicated no problems between the variables, given the magnitude of the coefficients (Brooks, 2008).

Regarding the normality of the residuals, although the Jarque-Bera normality test rejected the null hypothesis of normal distribution of residuals, this assumption was relaxed based on the central limit theorem and the law of large numbers, as suggested by Brooks (2008), in view of the large number of observations in the analyzed sample. Additionally, according to this author, in economic and financial models, cases in which extreme residuals causes the violation of such assumption are common.

The first relationship analysis considered one share per company to avoid biases caused by information duplication. Thus, Table 4 shows the statistics of the estimated model with 976 quarterly observations. The coefficient of determination (pseudo R^2) was 0.148, which indicates that 14.8% of the variations observed in PIN can be explained by the economic-financial and governance characteristics of the companies included in the model and which, according to its statistic *F* (12.891), is significant at 1%.

Table 4 *Probit Regression with Panel Data and Random Effects (1/2010 – 4/2011)*

Variables	Coefficient	Statistic *t*	Significance
Constant	5.728	1.204	0.229
Risk	2.197	1.977	0.048**
Return	0.190	3.046	0.002***
Abnormal Return	-0.172	-2.776	0.006***
Market Liquidity	0.715	1.800	0.072*
Volatility	0.058	0.928	0.354
Capital Structure	0.007	0.424	0.672
Cost of Equity	0.179	2.061	0.040**
Size	2.578	3.695	0.000***
Market-to-book	-0.035	-0.111	0.911
Price/Earnings	0.000	0.185	0.854
Dividend Policy	-0.085	-0.698	0.486
Earnings Management	0.502	0.123	0.902
Corporate Governance	-0.281	-0.408	0.684
Cross Section (companies)	194	Statistic *F*	12.891
Time Series (quarters)	8	Pseudo R^2	0.148
Observations (*n*)	976	R^2 Adjusted	0.137

Note: significance *** at 1%, ** at 5% and * at 10%.

Regarding the PIN relations identified as significant, it was possible to find that among the thirteen variables analyzed, six had statistical significance. The stock risk, represented by its beta (β), exhibited a positive (2.197) and significant coefficient at 5%, which indicates that trading with information asymmetry tended to be greater the higher the stock risk was. This result supports previous research (Easley et al., 1996; Aslan et al., 2011).

The return of stocks revealed a positive (0.190) and significant ratio at 1%, which indicates that during the investigated period, the higher the return was, the higher the trading with information asymmetry. That relationship was the expected relationship, which the current literature confirms (Easley et al, 2002;. Aslan et al, 2011) and which suggests that PIN was priced in the Brazilian stock market during the analyzed period. Moreover, the cumulative abnormal return of shares was negative (-0.172) and significant at 1%. This outcome differed from what was expected. The finance literature emphasizes the abnormal return as a proxy for information asymmetry, which suggests a positive relationship between these variables (Clarke & Shastri, 2000). In this study, this unexpected relationship may have been influenced by the performance of the Brazilian capital market according to by IBovespa, which represented the market return on the calculation of the cumulative abnormal return and which during the three investigated quarters ranged from -16.2% to 13.9%, thus possibly rendering that variable unstable.

Liquidity was another variable that presented an unexpected result. Its relation to trading with information asymmetry was significant (10%) although positive (0.715). That is, the higher the liquidity, the higher the information asymmetry was in the trading of the shares, at least during the analyzed period. This result differs from evidence from Duarte and Young (2009), who suggest a negative relationship. The result may be related to the specific characteristics of the Brazilian stock market, which has a high issuance rate of preferred shares. According to Denardin (2007), although this class of share exists in the markets of other countries, it is not as widespread as in Brazil. In this study, the five stocks with greater liquidity during the investigated period were PS (PETR4, VALE5, ITUB4, AMBV4 and BBDC4 in this order). However, when comparing the average PIN per class of shares, it was noted that PS (26.0%) had a higher average PIN than CS (24.2%), which reinforces this inference.

The cost of equity was also related to trading with information asymmetry (0.179), as in the study of Aslan et al. (2011). However, in the US market, this relationship was not statistically significant. This outcome suggests that in the investigated period, investors tended to require higher returns on invested capital when there is more evidence of insider trading.

Finally, the size of companies exhibited positive correlation (2.578) and was significant at 1%, which suggests that the greater the company size during the analyzed period was, the greater the information asymmetry in trading. This characteristic was also significant by study Aslan et al. (2011) in the US market. However, the observed relationship was negative. This relationship in Brazil may have been influenced by the high number of PS, which is uncommon in developed markets (Denardin, 2007). In theory, investors who demand PS seek higher returns, are less concerned with the management of companies and monitor the company less. In Brazil, during 2010-2011, this class

of shares exhibited the highest average PIN. Additionally, the five largest companies in this market were Petrobras, Vale, ItauUnibanco, Bradesco and Ambev, in this order. All of these companies traded CS and PS during that period, with PS representing the most liquid and riskier shares. This phenomenon may explain at least in part the positive relationship between PIN and company size.

The other variables showed no statistically significant relationship. Thus, it appears that among the six relationships identified as statistically significant in the Brazilian stock market, the results for three variables confirm the results of the international literature (risk, stock return and the cost of capital), whereas three outcomes differed (abnormal return, liquidity and size) (Table 5).

Table 5 *Summary of Expected and Observed Relationships with Information Asymmetry*

Variables	Expected Relationship	Observed Relationship
Risk	+	+
Return	+	+
Abnormal Return	+	-
Market Liquidity	-	+
Cost of Equity	+	+
Size	-	+

4.2 Relations between PIN and Company Variables According to Class of Share

Denardin (2007) notes that the Brazilian capital market is characterized by a high rate of issuance of PS, a class of shares that had a significantly different average PIN from CS. However, the author states that CS offer greater protection to their bearers. Therefore, a second analysis of the relationships was performed, which separated CS and PS into two distinct groups. Thus, a model was estimated in panel with random effects for each group, repeating the robustness tests performed in the first regression analysis.

Observing the significance of each variable in these models, up to the limit of 10%, it is noted that six variables stand out (three in each class). The variables are precisely those that were significant in the model estimated by the company (Table 4), while the others exhibited no statistically significant relationship. In the model with CS, the stock return, cumulative abnormal return and liquidity were significantly related to PIN, whereas in the model with PS, beta, cost of equity and company size were significantly related to PIN. All of these variables had the same signs as the previously observed relationships (Table 6).

Table 6 *Probit Regression with Panel Data and Random Effects According to Share Class (1/2010 – 4/2011)*

Characteristic	Common Share			Preferred Share		
	Coeffic.	Statistic t	Signif.	Coeffic.	Statistic t	Signif.
Constant	21.218	3.606	0.000***	4.291	0.728	0.467
Risk	-1.602	-1.239	0.216	2.650	1.809	0.098*
Return	0.215	2.847	0.005***	0.120	1.228	0.220
Abnormal Return	-0.184	-2.464	0.014**	-0.149	-1.566	0.118
Market Liquidity	4.576	5.592	0.000***	0.338	0.799	0.425
Volatility	0.075	1.115	0.265	0.098	1.322	0.187
Capital Structure	0.023	1.106	0.269	0.005	0.186	0.853
Cost of Equity	0.016	0.150	0.881	0.378	2.936	0.003***
Size	0.001	0.002	0.999	2.689	3.086	0.002***
Market-to-book	0.046	0.154	0.877	0.820	0.807	0.420
Price/Earnings	0.000	-0.059	0.953	0.000	-0.146	0.884
Dividend Policy	-0.060	-0.382	0.703	0.014	0.078	0.938
Earnings Management	-3.809	-0.682	0.495	-0.351	-0.062	0.951
Corporate Governance	0.439	0.451	0.652	4.291	0.728	0.467
Cross Section (shares)			143			81
Time Series (quarters)			8			8
Notes (*n*)			673			454
Statistic *F*			7.171			8.485
Pseudo R^2			0.124			0.186
R^2 Adjusted			0.107			0.165

Note: significance *** at 1%, ** at 5% and * at 10%.

We emphasize the liquidity and size variables. Among the CS, the liquidity coefficient is higher than among PS. Moreover, this relationship is significant only between CS. The relationship between these two variables is strongly influenced by the standard deviation of liquidity, which is greater among preferred shares (σ_{ON} = 0.405 and σ_{PN} = 0.797). Thus, if the liquidity level is controlled, this relationship may change.

Regarding the size, among preferred shares, the marginal coefficient was positive and higher than that of common shares. Additionally, this relationship was only significant among preferred shares. This outcome reinforces suspicions that the reversal of the expected negative relationship between PIN and company size (Aslan et al., 2011) in the Brazilian market results from the strong presence of PS, which in this market represent the most traded shares primarily of the largest companies (see section 4.1) in addition to having greater average PIN.

5 FINAL CONSIDERATIONS

This study investigated the relationship between information asymmetry in stock trading, the economic and financial characteristics and the corporate governance of listed companies in the Brazilian stock market. To this end, evidence of the use of private information was observed in stock trading in this market during the investigated period in view of the average PIN estimated at 25.0%, which indicates the chances of negotiations having been influenced by private information.

A market with high information asymmetry may have serious implications for the trading of assets particularly in emerging markets, such as the Brazilian market, because it creates an opportunity for insider trading. Thus, based on the presented results, the first hypothesis for this study, which refers to the presence of information asymmetry in stock trading related to the economic and financial characteristics and the governance of companies listed on the BM and F Bovespa, was confirmed for several investigated variables.

Regarding the relationship of insider trading by market participants to these variables, it is observed that during 2010 and 2011, it was possible to identify five variables that were positively related to information asymmetry in stock trading: risk, return, liquidity, cost of equity and company size. One variable was negatively related to the asymmetry: the cumulative abnormal return. The direct relationship between the company beta (β) and PIN may suggest that the Brazilian market agents identify higher risk in insider trading. Additionally, PIN is demonstrated to function as an alternative measure for empirical research in Brazil to assess the risk of secondary market transactions of shares.

Regarding the return and cost of equity, the evidence indicated that information asymmetry is priced in the negotiations of shares held in the Brazilian capital market, which confirms previous research in other markets, such as the US and South Korean markets. However, the abnormal return exhibited an inverse relationship with insider trading during the analyzed period. This relationship may have been influenced by the slowdown of IBovespa, particularly during 2011. An alternative explanation would be that the abnormal return could in fact be reflecting the average effect for shareholders who did not trade using insider information during the period, which causing them to achieve a return below that of informed shareholders, which is therefore consistent with the literature. Another assumption would be that in negotiations with private information, bad news is the most frequently used information. However, these assumptions should be the subject of further analysis in future research.

Liquidity and company size did not obtain the signal predicted by the current literature, which can be explained by certain unique aspects of the Brazilian environment, such as the large trading volume of PS in the secondary market. Given this scenario, the second hypothesis was postulated, which sought to examine whether the relationship between information asymmetry in stock trading, the economic and financial characteristics and the corporate governance of companies differed according to share class.

In Brazil, during the examined period, the five stocks with higher liquidity were PS and jointly accounted for 35.2% of the composition of the Brazil Index (IBrX), which comprises the 100 most liquid stocks in the market. In this connection, the characteristics of the Brazilian capital market are emphasized with a high concentration of voting shares and the dispersion of corporate capital through PS (Carvalho, 2002; Denardin, 2007) without voting rights, which have a higher PIN risk. Accordingly, when the analysis was performed according to share class, it could be observed that certain variables were significant only among CS and other shares only among PS. This results supports the study's second hypothesis: that the relationships differ between share classes.

In this aspect, PS presented risk and cost of equity as significant variables, which suggests that for this class, market participants identify the risk of insider trading and price accordingly in their buy and sell orders. In addition, the company size variable had a positive and significant relationship with PIN, which suggests the existence of a higher volume of insider trading in the operations of larger companies with PS.

In addition, the evidence for the return and abnormal return variables in the sample with CS suggests that investors strongly price the probability of insider trading for that class of share. The unexpected relationship with liquidity can be explained by other factors, such as the high concentration of control among the analyzed companies.

Other analyzed characteristics were not significant during the investigated period. These results indicate that insider trading occurs regardless whether the company is listed in the differential segment of corporate governance or that governance practices are ineffective in the negotiations that occur in the secondary market. Similarly, volatility, capital structure, market-to-book, price/earnings, dividend policy and earnings management do not display differences in trading with or without insider information. However, these assumptions should be analyzed in more depth.

Finally, it is noteworthy that studies such as this one, which examine the particularities of emerging markets, can contribute to the understanding of how the characteristics of such markets affect, for example, the operation of the capital market and information asymmetry in these markets, particularly the secondary market.

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