DOES THE LEVEL OF CORPORATE GOVERNANCE PREDICTS THE FINANCIAL PERFORMANCE OF THE COMPANY? EVIDENCE FROM THE BRAZILIAN MARKET THROUGH ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

This study aimed to develop models of artificial neural networks to predict the financial performance of companies in and outside the governance levels of the B3 (before, BM&FBovespa). The models were developed using data from companies in the Brazilian stock market from 2005 to 2017. For these models, it was stipulated as a hypothesis that the models, which corresponded to the companies in the governance segments, would be most successful in predicting the performance of companies than those, which represent the ones that were not in the levels of governance. The results confirmed the hypothesis. In addition, they indicated that the performance of not belonging to corporate governance levels companies is more sensitive to oscillations in the external environment, making it difficult to forecast this indicator. This work

Cláudia Olímpia Neves Mamede Maestri, Vitor Borges Tavares, Antônio Sérgio Torres Penedo,
Vinícius Silva Pereira, Rooney Ribeiro Albuquerque Coelho

was the first in Brazil to construct models through techniques of artificial intelligence – more specifically neural backpropagation network – to predict the performance of the company by relating it to aspects of corporate governance.

Keywords: Financial Performance. Corporate Governance. Artificial Neural Networks.

1 INTRODUCTION

In a scenario of corporate fraud such as that experienced by the United States with Enron, Global Crossing and Bernard L. Madoff, by Brazil with Banco Santos, Boi Gordo, Daslu (Costa & Wood Jr, 2012) and, more recently, the OGX (Valor Econômico, 2015), Petrobras, Construtora Odebrecht (Estadão, 2015), among others, the study of corporate governance practices becomes even more relevant in the middle of the second decade of the 21st century.

Corporate governance practices were implemented in Brazil in December 2000, with the insertion of corporate governance segments and requirements that go beyond the companies' obligations under the Brazilian Corporate Law (Law 11388/07). The purpose of this creation was to improve the evaluation of companies that voluntarily decide to join one of the segments and to provide a trading environment that stimulates the interest of investors and the valuation of companies (BM & FBovespa, 2019).

In this context, Silveira, Leal, Carvalhal-da-Silva, and Barros (2010) studied the general corporate governance scores from 1998 to 2004 evaluating the determinants and evolution of voluntarily adhering to the levels of corporate governance practices in Brazil. The authors visualized that the level of corporate governance practices of the company is constantly improving, but there is still a lot of room for advancement, that voluntarily adhering to new, more stringent listing requirements is positively associated with improvements in the level of corporate governance practices of the company and that reducing or not using non-voting shares improves corporate governance practices.

Several studies have also emerged on the relationship between the adoption of governance practices and the financial performance of companies. Among them are: Srour (2005), Okimura, Silveira and Rocha (2007), Macedo and Corrar (2012), Ferreira, Santos, Lopes, Fonseca and Nazareth (2013) and Catapan and Colauto (2014). As support for the use of statistical techniques, such as logistic regression, Monte Carlo, multivariate analysis and the use of mathematical programming techniques, such as data envelopment analysis (DEA).

In addition to these studies, we highlight the work of Chi (2009) with the development of a neural network to analyze corporate governance indices in Taiwan. Artificial neural networks (ANNs), according to Zahedi and Rounaghi (2015), are computational models, inspired by the central nervous system, used to estimate or approximate functions that may depend on a large number of inputs, usually unknown, and are commonly presented such as interconnected neuron systems, which can calculate input values in a way that input neurons feed values to each of the neurons in the hidden layer, and the hidden layer supplies them to the output layer.

The financial performance of companies and some of the variables that have an impact on them are subject to oscillations due to the entropy of the systems. In these cases, according to Burrell and Folarin (1997), traditional statistical techniques may not be effective in predicting the behavior of economic and financial indicators.

Forecasting is a crucial factor in companies' decision-making processes. It allows estimating uncontrollable results and competes for the best choice among the possible alternatives. Due to their importance, financial and economic forecasts attract the interest of researchers. During the last decades, several approaches have emerged that differ from prediction goals, nature of the information used, and mathematical apparatus (Bodyanskiy & Popov, 2006).

3 of 14

Does the level of Corporate Governance predicts the financial performance of the company?
Evidence from the Brazilian market through artificial neural networks

Regarding prediction techniques, artificial neural network models have superior performance compared to other techniques (Oliveira, Nobre & Zárate, 2013). According to Chen, Huang and Kuo (2009), this method uses past experience to learn about the problem and uses fuzzy logic to describe it in a way similar to the human brain, and to deal with the imprecision and uncertainty associated with the data.

In recent years, artificial neural networks have developed successful research models to predict, detect, and summarize the structure of financial market variables without relying too much on specific assumptions and error distributions (Duan & Stanley, 2011).

Thus, the present study aimed to develop models of artificial neural networks to predict the financial performance of companies belonging to and not belonging to the levels of governance of B3 (formerly BM & FBovespa), this work being the first in Brazil to construct models by means of artificial intelligence techniques - more specifically neural backpropagation - to predict the financial performance of the company in terms of aspects of corporate governance and company-specific characteristics.

The backpropagation neural network approach is particularly useful in studies of this type, providing an independent review with approval of the prediction model and being able to increase the scope, reliability and predictability of the model, in addition to facilitating the quantification, comparison of the influence and contribution of field data in the modeling process, which helps to predict the financial performance of the market-based company (Chi, 2009).

In addition to this introduction, the second section presents the theoretical foundation that allowed the literary understanding on Corporate Governance and its relation with the financial performance of companies. In the third, the methods of the research are evidenced and, in the fourth, the results are discussed. Finally, the final considerations of the research are carried out in the fifth section.

2 THEORETICAL FOUNDATION

Corporate governance is a set of mechanisms by which capital providers guarantee themselves the return on their investment, and external investors protect themselves against expropriation by insiders (Shleifer & Vishny, 1997; La Porta, Lopez-de-Silanes, Shleifer & Vishny, 2002). According to the Brazilian Institute of Corporate Governance (IBGC, 2015), it is a system by which organizations are directed, monitored and encouraged, involving practices and relationships between owners, board of directors, board of executive officers and control bodies.

In Brazil, according to IBGC (2015), good corporate governance practices allow the alignment of interests, preservation, and optimization of the company's value, which facilitates its access to capital, thus contributing to its longevity.

Studies on corporate governance practices related to variables such as stock return volatility, firm market value, cost of capital, financial performance and efficiency have contributed to clarification as to whether adherence to the corporate governance listing segments provides more benefits than costs to businesses.

Malacrida and Yamamoto (2006) analyzed whether the level of disclosure of accounting information presented by the Ibovespa companies influences the volatility of the return of their shares when traded on the São Paulo Stock Exchange, since it is expected that companies with a higher level of lower volatility of the returns of their shares. We collected information published by 42 companies belonging to Ibovespa, by means of the annual reports in the period from January 2, 2002 to April 30, 2003. After segregating these companies into three distinct groups, according to their specific levels of disclosure (higher, medium and lower), statistical tests were applied in order to verify the existence of significant differences between the level of disclosure of companies and volatility of the return of their shares. It was verified that higher average level of disclosure results in lower average volatility of stock returns.

Cláudia Olímpia Neves Mamede Maestri, Vitor Borges Tavares, Antônio Sérgio Torres Penedo,
Vinícius Silva Pereira, Rooney Ribeiro Albuquerque Coelho

Black, Carvalho, and Sampaio (2014) reported the governance practices of Brazilian companies in 2004, 2006 and 2009 to build a broad corporate governance index and analyze the evolution of corporate governance in Brazil and the association between governance and company value. They found that corporate governance practices improved significantly over this period. This evolution is due to two main factors: 1) growth in the New Market and Level II (NM and L2) listings, mainly through IPOs of new companies, and 2) best practices in non-NM and L2 companies, mainly by means of the adoption of governance elements necessary for listing NM and L2. Governance practices for companies already listed in NM and L2 were stable. The adoption of elements of the governance index, developed by the authors, is necessary for the listing NM and L2 and predicts greater value of the company. In contrast, the adoption of the remaining elements of the index does not predict the value of the company. Thus, changes in governance seem to respond to investors' preferences.

In this context, Tavares and Penedo (2018) verified that the practice of corporate governance is directly proportional to the interest in making adherence to B3's corporate governance segments. That is, companies that adopt more demanding governance mechanisms adhere more proportionally to the levels of corporate governance of the Brazilian stock market compared to those that practice less governance.

Catapan and Colauto (2014) aimed to examine whether there is a relationship between corporate governance and economic and financial performance in Brazilian companies listed on BM & FBOVESPA (current B3), considering the years 2010-2012. For this purpose, data were collected from DIVEXT - CVM's information disclosure system and Empresas Net software - also from the CVM, with regression application with data in panels to analyze the relationships. The result showed a direct relationship between the companies' market value and level of disclosure, showing that the greater the disclosure of information, the greater the market value of the companies. It was also observed a relationship between the Corporate Governance Index and two variables: Tobin's q and Return On Assets-ROA.

Almeida and Dalmácio (2015) investigated how competition in the product market and the level of corporate governance affect the accuracy of analysts' forecasts. Using a sample of Brazilian stock-market firms covered by analysts, they found that competition in product markets provides incentives to increase the flow of information, but not necessarily to improve its quality. However, strong corporate governance improves the financial reporting process and, consequently, the quality of analysts' forecasts. The main evidence from the study shows that analysts who accompany companies in highly competitive and strong corporate governance sectors are the most accurate. Another evidence from the study is that corporate governance alone contributes to improving analysts' accuracy and reducing forecast drift, reinforcing the idea that it plays a relevant role in weak institutional environments such as the Brazilian context. Thus, the quality of the informational environment is reinforced when companies implement corporate governance mechanisms aimed at improving the quality of the financial information process.

Badele and Fundeanu (2014) studied Romania, a market in which governance began in conceptual terms and regulations in the early 2000s, because political, legal, economic, and social aspects were developed slowly and with difficulty. The authors argue that good corporate governance adds value and helps reduce the cost of capital. In addition, they consider governance practices to be important factors in attracting investment and increasing financial performance and long-term competitiveness.

Huang, Cheng and Tseng's (2014) study aimed to explore the effect of governance mechanisms (including formal and social controls) on cooperative buyer-supplier performance in supply chains. Empirical evidence from a survey of 106 companies participating in the Taiwanese "Satellite Production System Center" indicates that: (1) there is an inverted U-relationship between formal control and performance cooperative; (2) social control has a positive effect on consistent cooperative performance; and (3) the joint use of formal control and

5 of 14

Does the level of Corporate Governance predicts the financial performance of the company?
Evidence from the Brazilian market through artificial neural networks

social control could improve cooperative performance in supply chains, but only in cases with moderate use of formal control. Otherwise, social control becomes a support factor that repairs the damage of the cooperative performance of formal control.

Nguyen, Locke, and Reddy (2015) investigated the relationship between the concentration of ownership and the financial performance of firms in Singapore and Vietnam. They observed how the relationship is moderated by the quality of national governance by considering two different types of national governance systems (well developed versus the underdeveloped). The effect of concentration of ownership on financial performance in these markets persists even after considering the dynamic nature of the relationship. The finding supports the prediction of agency theory about the effect of effective control of large shareholders in highly concentrated markets. In addition, they found that the quality of national governance does not matter when explained by the relationship of concentration of ownership in financial performance. The positive effect of the concentration of ownership on the financial performance of firms operating under the underdeveloped national governance system (Vietnam) tends to be stronger than in the well-established system (Singapore). This result is consistent with the argument that ownership concentration is an efficient corporate governance mechanism that can replace the poor quality of national governance.

In this way, considering that aspects of corporate governance provide less volatility in the return of shares (Malacrida & Yamamoto, 2006), higher quality of forecasts by analysts (Almeida & Dalmácio, 2015) and better preservation and optimization of company value (IBGC, 2015), we have the hypothesis of this work:

H1: the models with corporate governance have more stable financial performance, presenting less error in the model of neural networks.

3 METHOD AND DATA

The present study had Brazilian companies with shares listed in B3 from 2005 to 2017, with the exception of financial institutions, because they have different accounting and financial structures, such as high indebtedness, low fixed assets, and high working capital, among others.

The starting point of this study was the work of Chi (2009), whose objective was to construct a conceptual artificial neural network model to explain the transversal variation in the financial performance of companies with Corporate Governance in Taiwan. From this, the present study aimed to develop an artificial neural network model to predict the financial performance of the participating and nonparticipating companies of the corporate governance listing segments in Brazil, whose variables are shown in figure 1:
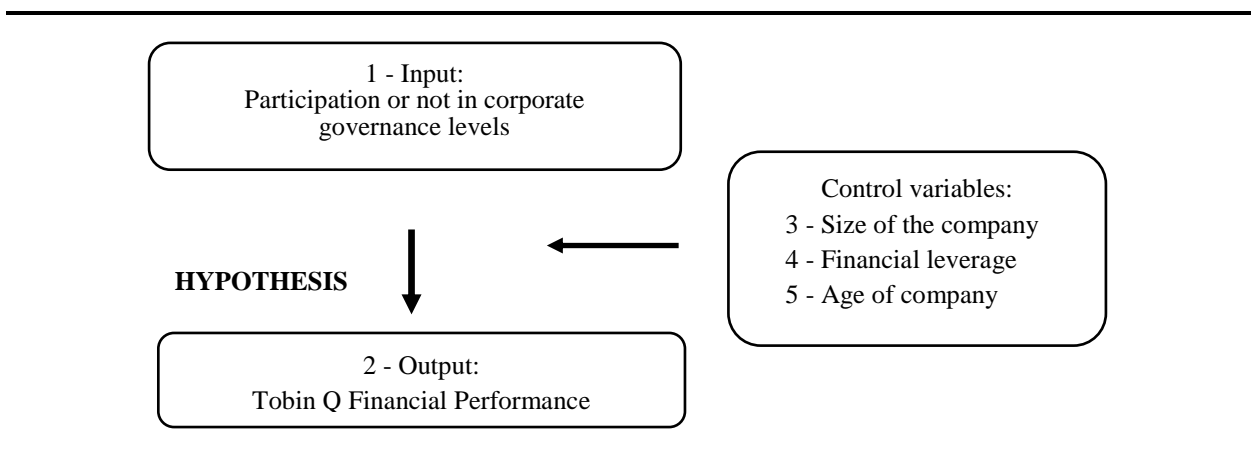

Figure 1. Theoretical-Hypothetical Model
Source: Prepared by the authors (2018)

Cláudia Olímpia Neves Mamede Maestri, Vitor Borges Tavares, Antônio Sérgio Torres Penedo,
Vinícius Silva Pereira, Rooney Ribeiro Albuquerque Coelho

In relation to the variables participating in the model, the independent variable was segregated between companies participating in the governance listing segments with the attribution of value one and non-participating companies of those segments with zero value attribution, both of which were collected from B3, according to Maestri's study , Teruel and Ribeiro (2017) and Rodrigues and Ambrozini (2015).

The dependent variable formed by the financial performance was measured by the Q method of Tobin, according to studies by Silva (2004), Leal (2004) and Catapan and Colauto (2014). Its calculation was based on the simplified formula developed by Chung and Pruitt (1994) in which the company's financial performance is measured by the relation between the market value of the company and the replacement value of its assets, whose data were collected directly from the Economatica base, according to a study by Ferreira et al. (2013).

Control variables were firm size, financial advantage, and company age. The size of the firm can measure potential advantages of scale, scope and market power (Chi, 2009) and, according to studies by Silva (2004), Alencar (2007) and Chi (2009), was calculated by the logarithm of total assets. In addition, Watts & Zimmerman (1990) and Tang (2010) consider that a highly leveraged company is associated with a higher risk and, therefore, its performance is weakened. The data corresponding to these two variables were collected directly in the Economatica database. The financial advantage is calculated according to Equation 1 or, if the indicator of the financial result is null, according to Equation 2:

$$AF = (LL + PAM) \times AT/(PL + PAM) / (LL + PAM - RF) \qquad \text{Equation (1)}$$

If RF is null, then:

$$AF = (LL + PAM) \times AT/(PL + PAM) / (LL + PAM - RFA - JPL) \qquad \text{Equation (2)}$$

Wherein:

AF = Financial Leverage;
LL = Net Profit;
PAM = Minority Shareholder Participation;
AT = Total Assets;
PL = Stockholders' Equity;
RF = Financial Result;
FRA = Financial Result of the Previous Period; and
JPL = Interest on Shareholders' Equity.

The age of the company, which is positively related to good governance practices (Ariff, Ibrahim & Othman, 2007; Almeida & Santos, 2008), was obtained by means of individual consultation on the website of the National Corporate Taxpayer Registry (CNPJ) , being measured, according to Chi's study (2009), as the logarithm of the number of years since its creation.

The method for the analysis of this research, like that of Chi (2009), was the development of an artificial neural network. This method simulates how the human brain performs tasks, through electronic components and computer programming. Like the brain, an artificial neural network is efficient in storing empirical knowledge and has great adaptive capacity (Haykin, 2001).

Neural networks have the ability to, from learning, generalize the information learned (Laboissiere, Fernandes & Lage, 2015). Thus, by providing an optimal generalization of output, ANNs minimize subjectivity in the decision-making process (Bodyanskiy & Popov, 2006).

In a study that examined the effectiveness of stock price prediction models in Istanbul using different techniques, Egeli, Ozturan and Badur (2003) found that RNA models outperform

7 of 14

Does the level of Corporate Governance predicts the financial performance of the company?
Evidence from the Brazilian market through artificial neural networks

classical price forecasting methods. In agreement with this result, Olson and Mossman (2003) obtained better precision when they used artificial neural networks to predict the return of Canadian actions compared to other techniques.

Leshno and Spector (1996) compared the predictive capacity of the neural network with linear discriminant analysis and quadratic discriminant analysis, and their results indicate that the predictive capacity of the neural network model is clearly more accurate than the discriminant analysis models classics.

Also paralleling techniques, Oliveira, Nobre and Zárate (2013) argue that, compared to conventional techniques, ANNs have been more efficient in predicting behavior and trends. Thus, neural networks are effective techniques for non-linear and non-parametric constructions, and have overcome linear approaches, econometric models and other conventional methods in a large number of financial problems (Burrell & Folarin, 1997).

In the context of learning a neural network, there are several algorithms for this purpose, having as their difference the way they modify the synaptic weights of a neuron. In relation to the algorithms, the most used in the scientific work has been the backpropagation, as in the works of Kolarik and Rudorfer (1994), Torres Jr, Machado e Souza (2005), Pao (2008), Chi (2009) , Song, Liu and Chen (2012) and Tavares and Penedo (2018).

According to Haykin (2001), the backpropagation algorithm has the function of adjusting the free parameters of the neural network in order to reduce the error of the model output. This algorithm includes an input layer, one or more hidden layer (s), and an output layer, representing a type of supervised learning, with error correction learning that calculates an output layer error and propagates the error to determine how individual substantial factors contribute to the exit error (Haydar, Agdelen & Özbeseker, 2006).

As for the structure of the neural network model of the present work, it was defined according to Hecht-Nielsen (1990), which states that with only one hidden layer it is already possible to calculate any function from the supplied data. The hidden layer performs the intervention between the input layer and the output layer in a useful way, providing high-order statistical extractions with a global perspective, resulting from the addition of synaptic connections and neural interactions (Haykin, 2001). In the model proposed by Hecht-Nielsen (1990), the hidden layer must have approximately $2i + 1$ neurons, where i is the number of input variables. Thus, the model developed in the present study comprised three input variables (size, advantage and age), a hidden layer composed of 7 $[(2 * 3) + 1]$ neurons and an output layer (Tobin Q financial performance) with a neuron, according to Figure 2.
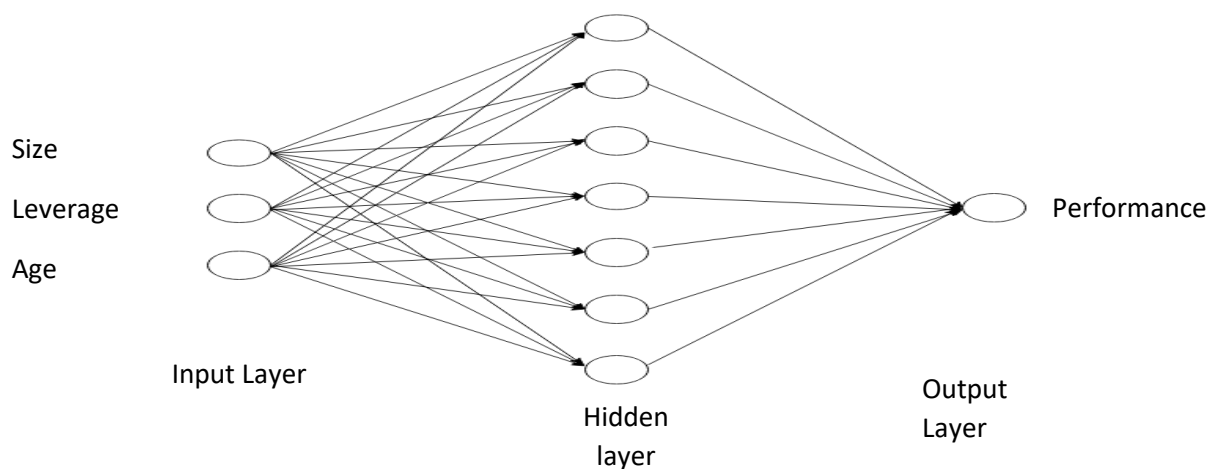

Figure 2. Neural Network Model
Source: Prepared by the authors (2018)

Cláudia Olímpia Neves Mamede Maestri, Vitor Borges Tavares, Antônio Sérgio Torres Penedo,
Vinícius Silva Pereira, Rooney Ribeiro Albuquerque Coelho

In order to run the model, the sample was split between companies that had participation in corporate governance levels and those that did not.

4 RESULTS

Tables 1 and 2 present the descriptive statistics of the present study. Table 1 shows the input and output variables of the backpropagation model of the neural network, with the summary of the observations, average, median, standard deviation, minimum and maximum. It should be noted that the neural network has the capacity to adapt to the data and therefore there was no need to treat outliers, for example.

Table 1
Descriptive statistics of the study variables (period: 2005 to 2017)

Variables	Obs	Average	Median	Standard Deviation	Minimum	Maximum
Governance	2.865	0,4356	0,0000	0,4959	0,0000	1,0000
Performance	2.865	11,8387	0,5755	554,1977	0,0069	29.653,3100
Size	2.865	9,3813	9,3480	1,2037	3,2968	17,9144
Leverage	2.865	1,3599	1,5600	223,1222	- 10.011,4100	5.704,0200
Age	2.865	1,5050	1,6465	0,2880	0,5599	2,1004

This table provides the model participants with the summary of the observations, average, standard deviation, minimum and maximum, where **Governance** was defined as 1 for participating companies and 0 for non-participants of the Corporate Governance listing segments; **Performance** measured by Tobin's Q by the ratio between the market value of the company and the replacement value of its assets; **Size** is measured by the logarithm of the total assets of the company; **Financial Leverage** is defined by Equation 1 or Equation 2; **Age** is measured by the logarithm of the number of years since the establishment of the company.

Source: Research data (2018).

For the sample studied, Table 2 shows the total of 2,865 observations, in which approximately 44% of the companies in the sample participate in some segment (or level) of B3's corporate governance. The average for the financial performance of companies - measured by the Q of Tobin - is 11.8387 with a median of 0.5755, which suggests that for most companies in the sample, the market may be devaluing the company, since its value market is lower than its asset value. The average size of companies, measured in logarithm, is 9.3813 with median 9.3480, signaling asset values of R $ 2,406,460,301.00 and R $ 2,228,445,045.00, respectively. The average financial advantage is 1.3599 with a median of 1.5600, which shows that most companies have a financial advantage ratio greater than 1, meaning that most are indebted to leverage their business. The mean age of companies, measured in logarithm, is 1.5050 with a median of 1.6465, which shows that, between a minimum of 0.5599 (3 years) and a maximum of 2,1004 (123 years), the age of most companies is greater than 44 years.

Table 2 includes a matrix of classification of variables, allowing the visualization of a positive view among people and levels of corporate and financial governance, between size and age and size and financial performance. Variable advantage correlates negatively with age. Age is a negative relationship with participation in corporate governance. In short, all variables with low correlations between them indicate low endogeneity and low autocorrelation.

Table 2
Matrix of correlation of variables

Variables	Governance	Size	Leverage	Age	Performance
Governance	1,0000				
Size	0,2487*	1,0000			
Leverage	-0,0341	-0,0080	1,0000		
Age	-0,0225*	-0,0302*	-0,0034*	1,0000	
Performance	-0,0171	-0,0785*	-0,0002	-0,0318	1,0000

This table provides the correlation matrix of variables, where **Governance** was defined as 1 for participating companies and 0 for non-participants of the Corporate Governance listing segments; **Performance** measured by Tobin's Q by the ratio between the market value of the company and the replacement value of its assets; **Size** is measured by the logarithm of the total assets of the company; **Financial Leverage** is defined by Equation 1 or Equation 2; **Age** is measured by the logarithm of the number of years since the establishment of the company.
(*) Significance of 0,05.
Source: Research data (2018).

These variables participated in the backpropagation neural network with 70% of the sample for training, 15% for validation and the remaining 15% for testing. According to Song, Liu and Chen (2012), the training sample directly involves the formation of the network that continues to make the adoption and adaptation according to the error of this sample. The validation sample serves to test the network's versatility and stop training when network versatility is no longer optimized. The test sample tests the predictive effect of the network after its formation. The total predictive sample of the backpropagation neural network of this study was 2,865 data, of which 2,005 were for training, 430 for verification and 430 for testing.

As a result, the models developed to predict the financial performance of companies belonging to and not belonging to the levels of governance of B3 between 2005 and 2017 presented, on average, a Mean Square Error (MSE) of 1.26 and 2.99, respectively. The best annual forecasting model for companies in the governance segments resulted in an MSE of 0.24, and the worst model, 2.97; and for companies not participating in the governance segments the best MSE was 0.32 and the worst 8.72. Figure 3 presents the comparison of the prediction error of the corresponding models to the participating companies and non-participants of the segments of corporate governance.
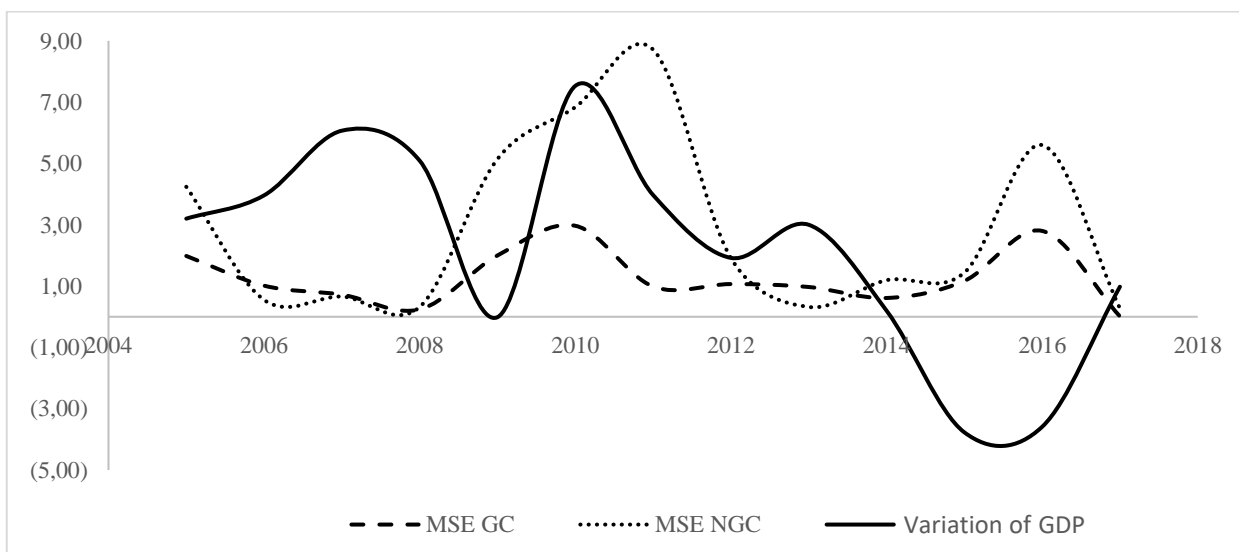

Figure 3. Results of the forecast models, and comparison with the variation of GDP
Source: Research data (2018).).

In order to portray periods of economic stability and instability, the comparison between the results between the models and the GDP oscillation during the study period was inserted. In

Cláudia Olímpia Neves Mamede Maestri, Vitor Borges Tavares, Antônio Sérgio Torres Penedo,
Vinícius Silva Pereira, Rooney Ribeiro Albuquerque Coelho

this way, it is possible to analyze how the forecast of the profitability of the shares occurs in different macroeconomic scenarios.

Without a period of economic comparison (2005 to 2008 and 2011 to 2014), a review of the financial attendance of companies in corporate governance cranes was similar, with regard to the measurement of the mean-square error, to the non-listing, presented separately compared to non-corporate governance models. However, in the period of greater GDP oscillation, the prediction of the financial performance of companies not participating in the levels of accounting governance presents more unstable results in relation to the models of participating companies.

This result indicates that companies belonging to the levels of corporate governance are more able to face periods of instability and maintain financial performance close to the standard. Differently from these, non-governance companies are more sensitive to scenarios with greater changes in the external environment, which makes their financial performance fluctuate more in such circumstances, making it difficult to predict financial performance.

Thus, the results portray the inference made above that the prediction of the financial performance of companies not listed in the corporate governance segments is significantly worse than the companies listed in these segments at times of great fluctuations in the macroenvironment.

In addition, a similarity is seen between the success of the prediction that refers to the tendency of increase or fall of the error of the models. The difference is in the degree to which the error occurs, significantly higher in unstable periods for companies not participating in levels of governance.

In addition, the results suggest that the time of perception of (relative) stability in the macroenvironment is perceived by the companies belonging to the levels of faster governance. Companies that are not in these segments have a delay to understand the external scenario and to approximate the financial performance of the pattern.

In other words, the factors that make prediction difficult cause impacts in both models (the correlation between model error is high, 0.63, but the models corresponding to companies not belonging to the corporate governance segments have greater oscillation over time) . Therefore, the financial performance of companies belonging to governance levels is being more stable over time.

5 FINAL CONSIDERATIONS

This work developed models of neural networks to predict the financial performance of companies belonging to and not belonging to the levels of corporate governance. To do this, a robust and proven method of forecast studies was used. It is known that this was the first in Brazil that used neural networks to predict the financial performance of companies in the context of corporate governance.

The developed models obtained good results in predicting the financial performance of the companies, as measured by the Q of Tobin, with a mean square error of 1.27, on average, for companies at levels of governance, and 2.86 for unlisted companies in the corporate governance segments.

It has been common to carry out research that analyzes how corporate governance changes the variation of financial performance, that is, whether it provides better financial performance to companies or if they have inferior results. However, this study examined how corporate governance affects the stability of firms' financial performance.

In this analysis, it was verified that the predictive models of financial performance of the companies listed in the corporate governance segments obtained, on average, better performance than the models corresponding to the prediction of the financial performance of companies not listed in the governance segments. In addition, it was verified that in times of crisis, the success in predicting the financial performance of companies not listed in the governance segments

11 of 14

Does the level of Corporate Governance predicts the financial performance of the company?
Evidence from the Brazilian market through artificial neural networks

decreases significantly compared to the models that contemplate the companies listed in the corporate governance segments.

These results suggest that corporate governance contributes to the stability of firms' financial performance and to organizational resilience in high entropy-intensive scenarios. That is, in unstable macroeconomic scenarios, good corporate governance allows the company to be better structured and maintain its financial performance more stable.

In future research it is suggested to analyze how the variation in financial performance of forecasting models in the different levels of corporate governance of B3 (formerly BM & FBovespa) occurs because it is believed that New Market companies have a greater capacity to maintain their performance over the years, suffering less pressure from the external environment.

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