

Economic and Financial Performance of the Brazilian Pulp and Paper Industry.

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Abstract—The evaluation of economic, property and financial aspects of the economy can be made through analysis of the Financial-Economic indicators that, when properly forecasted, can bring great benefits to the company and its shareholders. Over the last few years, several authors have studied the relationship between these indicators and macroeconomic variables. The objective of this paper is to determine the influence of GDP (Gross Domestic Product), Exchange Rate, SELIC Rate (Brazil's interest base rate) and inflation rate on the performance of four publicly held company of Brazilian pulp and paper sector: Fibria, Suzano Papel e Celulose, Celulose Irani and Klabin. For this analysis, two models were applied to the database, one using only the past data of the indicators themselves and another using past both data and macroeconomic variables. According to the evaluation criteria used, for the studied period, the performance of the macroeconomic variables was significant to predict the changes in the economic-financial indexes.

Keywords—Macroeconomic Variables, Neural Network, Paper and pulp Sector, Performance Indicator.

I. INTRODUCTION

The pulp and paper sector in Brazil has considerably increased its share on worldwide traded volume. The performance it is explained by Hora and Melo [18], and shows that high productivity of forestry activity – resulting from extensive investments in research and development – associated with proper climatic conditions brings a competitive differential to the Brazilian pulp and paper industry. Production capacity is also at focus, and the main companies in the sector make important investments, in order to keep the supply of wood in expansion. According to Biasus *et al.*[5], a new pulp mill has a capacity of up to 1.5 million tons / year, with investments of up to R\$ 4 billion. In 2015, the Pulp and Paper sector accounted for 6% of the Brazilian Industrial GDP.

In this article, we analyze the results of some of the main market players such as Suzano, Fibria, Klabin and Celulose Irani, which accounts for more than 85% of the industry market share, and how they boosted the industry with their projects between 2000 and 2010 (Vidal and Hora, [37]). Now, the sector is expected to face some major changes resulting from the merger of Suzano and Fibria, as it was recently announced in the main Brazilian

national media¹, forming together the largest market pulp company in the world, with a 70% of national market share. Within this context, the industry in the country, between the years of 1970 and 2013 had annual growth rates for pulp and paper, respectively, of 7.1% and 5.4%, placing Brazil in a leading position worldwide.

Recent studies have found evidence of the relationship between macroeconomic variables and economic and financial indicators of different sectors and companies. Costa *et al.*[8] used financial statements of 82 companies and three macroeconomic variables (GDP, SELIC and IPCA - Extended Consumer Price Index) to analyze that relation. Guidini *et al.*[16], analyzed 111 companies from the main sectors of the Brazilian economy, and their financial indicator's behavior to the exchange rate, interest rate, inflation, exports and imports, as well as external growth. Those studies, as well as others exposed in this paper confirm the aforementioned relationship.

The objective of this article is to analyze the influence of macroeconomic variables on the economic and financial performance of the Brazilian pulp and paper sector from 2002 to 2017. In an initial stage, we used the methodology of Toda and Yamamoto[36] to investigate

¹See Veja [9] magazine.

whether there is a dependence between the variables. In the second stage, the relationship between the variables is tested using Artificial Neural Networks (ANN) to model the indicators of the Brazilian Pulp and paper sector, considering some macroeconomic variables as explanatory variables.

The article is structured in five parts, in addition to the introduction. Section 2 presents the Pulp and Paper sector, its dynamics and importance to Brazil and world economy. Financial indicators are presented in section 2.2, classified into four groups: Liquidity, debt and structure, activity, performance and profitability. Macroeconomic variables are then presented in the following, and the way they are able to influence the economic-financial indicators of companies. Section 3 presents the Toda-Yamamoto test and section 4 presents the Neural Networks and the architecture adopted in this article, with the discussion of the metrics used to compare the results. In section 5, we present the descriptive statistics of the variables used and the analysis of the results obtained. Finally, in section 6, we present some conclusions.

II. LITERATURE REVIEW

2.1 Pulp and paper industry

The pulp and paper industry is composed of two large industrial segments that, although making part of the same industry, are distinct from each other, each one with its own production process. The first one is the pulp, which produces different types of cellulose and pastes. The second industrial segment in this sector is paper production, responsible for the production of several related products.

Cellulose is the main raw material for paper production, but not every industry works with both processes. Santos [34] explains that pulp and paper production presents a production chain with technically independent steps. This implies that not every paper mill produces or needs to produce pulp, and not every pulp mill produces paper.

According to Indústria Brasileira de Árvores (Brazilian Tree Industry) (2015), there are two types of pulp: short fiber, which is mainly derived from eucalyptus, ideal for the production of paper for printing, writing and sanitary purposes (toilet paper, paper towels, napkins). The other type is long fiber, which derived from coniferous species such as pine, used in the production of more resistance types of papers, such as those designated for packaging and for the use as inner layers of

paperboard. Beyond packaging, newsprint is also one of the uses for long fiber pulp.

Hora and Melo [18] explain that the Brazilian pulp and paper industry is very competitive, associating that prominent position to the high productivity of forestry activity, derived from decades of intensive investments in research and development, as well as Brazil's soil and climatic conditions.

According to Vidal and Hora [37], Brazil is in a prominent position in world pulp production, especially considering the production of short-fiber market pulp, with a 38% share in 2010 in the world market.

In this scenario, Hora and Melo [18] report that between 1970-2013, Brazilian pulp production grew at an average rate of 7.1% per year, and paper production accompanied this movement at a rate of 5.4% per year, placing Brazil among the world's largest pulp and paper producers. Recent data from the Indústria Brasileira de Árvores (IBÁ, 2017) indicates that from January to October 2017, pulp exports grew at 2.9% growth rate, in comparison with the previous year, reaching 16 million tons traded, reaffirming the importance of this sector for the Brazilian economy.

2.2 Economic and financial indicators

According to Adamowicz *et al.* [1] in the business world, the terms "economic" and "financial" are daily employed. Thus, the authors explain that Economic Analysis is the study of equity, its capacity of generating profit or loss, and the payment capacity of the company.

To evaluate the economic and financial performance of the Brazilian pulp and paper industry, sixteen indicators were selected and classified into four groups: Liquidity, debt and structure, market/risk analysis and performance and profitability. The liquidity indicators used in this research are: Overall Liquidity, Current Ratio and Quick Liquidity. The indicators of debt and structure selected for this article were: Fixed Assets to Equity Ratio, Total Liabilities divided by Total Assets, Debt/Equity Ratio, Interest Rate Coverage Ratio and Cash and Cash Equivalents to Equity Ratio. The activity indicators (market / risk analysis) used in this research are: Days of Payables Outstanding, Days of Inventory Outstanding, Days of Sales Outstanding, Operating Cycle and Financial Cycle. The indicators of performance and profitability are: Asset Turnover, Return on Assets and Net Margin.

The Overall Liquidity Ratio shows the company's payment ability (in the long term), relating (in the short and long term) everything that has already been assumed as debt with everything that might be converted into cash. The Current Ratio shows whether the company will be able to pay its (short-term) commitments. The Quick Liquidity Ratio, on the other hand, calculates the corporate payment capacity, disregarding its inventories. One of the possibilities is that it might be understood as an early indicator on the probability of a company to fulfill or not with its (short-term) obligations.

The debt and structure ratios calculate the company's financial situation, considering the average profile of other companies operating in the same segment. According to Marion [22], debt ratios shows the level of indebtedness of a company and the composition of his debt. On the other hand, Fixed Asset to Equity Ratio shows how much of the Equity is applied into Permanent Assets, which might result on weaker or stronger dependence on third party resources for the maintenance of the company.

"Growing investments on Fixed Assets refers to the percentage that noncurrent assets, with exception of long term assets, represents when divided by the Equity and has the objective of showing if company's resources are mainly allocated into fixed assets, investments or intangible assets (which is the same of the difference between Non-current assets and Long-Term assets) or if there is a surplus of own funds to finance working capital." (Saporito, [35], p.162, translation by authors)

According to Berto [4], the Total Liabilities Index on debt-to-equity ratio, shows the total levels of third-party capital use, composed of short-term (Current Liabilities) and long-term (Long Term Liabilities) sources, in relation to shareholders equity (Shareholders' Equity). The Interest Rate Coverage Ratio and Cash and Cash Equivalent Ratio measures the company's ability / capacity to make the expected interest payments on outstanding contracts. According to Athar [2], this index can also measure the number of times the company's profit can decrease without affecting the remuneration due to third party resources.

Activity indicators represent the assessment of the uncertainties inherent in the company's operations and how they affect its financial operations, from cash flow management to investment resource allocation. Its main objective is to help decision making by the company

manager, whose decisions are always related to risk avoidance or minimization.

According to Marques *et al.* [23], Days of Payables Outstanding covers the period between the purchase and payment of goods (or raw materials). According to Gitman [15] (p. 54), Days of Payables Outstanding accounts for "average payment period of debts to company's suppliers". This index indicates the number of days that the company takes to pay its suppliers.

Days of Inventory Outstanding has the objective of calculating the average period that products stays in the stock during the year, from the entry of the raw material (purchase) to the output as finished products (sale). "This index shows the average number of days a unit is in stock." (Blatt, [6]). Through Days of Inventory Outstanding ratio, the company can determine if the average receivable period is aligned with the desired prospects, regarding the current cash flow path to the planned cash flow.

According to Ross *et al.* [31] the Operational Cycle is the necessary time to acquire the stock, process and sale, receiving the payment of this Sale. According to Gitman [14](p.509), "... the period between the beginning of the production process and the payment of sales of the finished product to the customer." In turn, in the Financial Cycle everything will depend on the bargaining power a company has with suppliers. According to Marques *et al.* [23], the Financial Cycle is the time between payment to suppliers and receipt of sales. The greater the negotiating power of the company with suppliers, the lower the Financial Cycle.

The performance and profitability indicator measure the performance the company achieved in that period. "A possible conceptualization of performance within organizations is the ability of the company to achieve its strategic objectives through the implementation of strategies within its planning process" (Fischmann and Zilber, [12], translated by authors).

The Return on Asset, also known as ROA, shows the company's performance and its calculation aims to estimate the total profit of the company, identifying the proportion of net profit in relation to Total Assets of company. According to Junior and Begalli [21], this indicator shows the return on Total Assets without looking at the source, either from owners, company's operations or third parties. For these authors, the bigger the indicator, the better it will be for the company. The Turnover reveals how much the company has sold to each

currency unit invested in its Total Asset, and in the same way as ROA, big values reveals a positive situation for the company.

The Net Margin shows us whether the company is obtaining net profit: it informs the value of the net profit for each unit of sale or the net profit by period. According to Junior and Begalli [21], this indicator demonstrates the company's ability to generate profit compared to net sales revenue.

2.3 Economic-financial indicators and macroeconomic variables

The relationship between national/foreign economic cycles and business activity has always been at focus both by academic and corporate research, looking for ways of connecting and forecasting the interactions between them. In this sense, there is a constant attempt to capture those interactions through the use macroeconomic variable and financial/economic indicators, combined and studied with the assistance of the available statistical tests. Santos *et al.* [33] analyzed the relationship between economic cycles in Brazil and the economic-financial performance of publicly traded companies using real GDP per capita as economic performance indicator through the cross-correlation test. To measure the economic and financial performance of the companies, the authors selected nine indicators classified into four groups: profitability; liquidity, debt and structure, market/risk analysis. According to the authors, the results suggest that, for some sectors, the evidence for economic and financial indicators is robust for the economic cycle from 1995 to 2005.

According to McGahan and Porter [24], there are four factors that can influence companies' performance: (i) macroeconomic factors - common to all companies; (ii) sectoral factors - that influence companies of the same sector, such as rivalry among companies, consumer preference, taxation; (iii) conglomerate factor - as corporate culture; and (iv) company-specific factors such as products and processes, human capital and competitive advantage. Oxelheim [28] suggested that shareholders need to be informed about the effects of macroeconomic variables on earnings as a measure of the macroeconomic risk in the business. On the other hand, companies need to be aware of the behavior of some macroeconomic variables such as: interest rate, exchange rate, inflation, unemployment, exports, imports, political instability.

The macroeconomic variable GDP can be used to evaluate, for example, how economic-financial indicators behave through economic cycles, especially in Pulp and

Paper sector, which presents a strong connection to growth cycles through overall industry needs. The tree industrial sector in Brazil, according to Carvalhaes [7], is responsible for 6.2% of the Industrial Gross Domestic Product (GDP), with gross revenue of R\$71.1 billion in 2017, and US\$ 8.9 billion on exportation, occupying 0.9% of the national territory. These data ratify the importance of the sector in the national economy.

The exchange rate is another macroeconomic variable which can be connected to business activity and from which researches can find valid information with forecasting potential about business. Regarding the Pulp and Paper, which produces and trade commodities priced in international markets, this relation is of major importance. In case of this sector in Brazil, the exchange rate can be used to evaluate how economic and financial business indicators react to the appreciation or devaluation of the Real against the US Dollar.

Base interest rate is also one macroeconomic variable, which traditionally appears in economic analysis, being connected to the pace of investments. In the case of Brazil, the base interest rate is the SELIC rate². As the base rate defined by monetary authorities, it serves as the basis for all other market rates or investments decision and can be used to assess how economic and financial indicators behave through changes in rates on loans, financing and forward sales/receipts. Medeiros *et al.* [25] analyzed the financial statements of Petrobras, using variables such as Brazilian GDP, domestic and foreign interest rates, international oil prices, exchange rates and country risk. In making this econometric model, the author states that despite the chosen company for the study, the model could be generalized to analyze the financial statements of any company. As a result, Medeiros *et al.* [25] concluded that the domestic interest rate has a direct impact on the company's financial assets and liabilities, as well as on financial income and expenses, referring respectively to receivables and payables and to loans and financing in the currency of the country. Furthermore, Medeiros *et al.* [25] also point out GDP in the article as the main economic activity indicator of a country, with direct impact on a company's Net Revenue, expressing the value of the country's production

²SELIC comes from the initials of Special Settlement and Custody System, electronic platform of Brazil's Central Bank for managing government bonds. See: <http://www.bcb.gov.br/htms/selic/selicintro.asp?idpai=SELIC> for further details.

during a determining period and being independent of the nationality of the production facilities.

Lastly, the variable that measures inflation – IPCA – can be used to evaluate how the economic-financial indicators react to the increase (fall) of prices in the economy. Paredes and Oliveira [29] presents an investigation on the impact of macroeconomic and risk factors on the measurement of company's corporate value. Using data from Bovespa enlisted companies between 1995 to 2013 and applying Ohlson Model (MO) with a set of macroeconomic variables³, Paredes and Oliveira [29] verified that the Consumer Price Index (IPCA) was statistically significant for the calculation of the behavior of the market value of companies from certain sectors.

2.4 Data Collection and Processing

The data used in this article is divided into two groups: economic-financial indicators and macroeconomic variables. The economic-financial indicators were calculated based on the financial statements provided by the companies of the sector and available at the companies internet websites. The time series of macroeconomic variables exchange rate and SELIC interest rate were collected on the website of Brazil's Central Bank (BACEN) and GDP/ IPCA time series data were collected on the website of the Applied Economic Research Institute (IPEA). All data used on the research is on quarterly basis and the analysis covers the first quarter of 2002 and the third quarter of 2017, on a total of 48 quarters or 192 months.

The software used for the application of Artificial Neural Networks was the R-Project. The “neuralnet” package provided a great tool for application of the proposed model in this article because it allowed flexible configurations, through customized choice of error and activation function.

III. THE TODA-YAMAMOTO TEST

In order to investigate whether is there any dependence between macroeconomic variables and the economic and financial performance of the Brazilian pulp and paper industry from 2002 to 2017, it was used the causality test following the methodology of Toda and Yamamoto [36]. According to Fochezatto *et al* [13], the

test can be applied to a co-integrated systems without the need for unit root pre-tests, also allowing variables to have different integration orders.

According to Morrone [26], the Toda-Yamamoto test contemplates four steps. First, it is necessary to define the number of lags (h) according to the maximum order of integration of the VAR model (Auto-Regressive vectors) to be applied; the. The next step consists in the direct estimation of a VAR for the analyzed variables at level; and finally, the last step involves performing the Wald constraint test on the first (k) parameters, in order to examine Granger's non-causality hypothesis.

On the other hand, the application of the Toda-Yamamoto procedure involves three steps according to Fochezatto *et al.* [13]. The first is the definition of the optimal number of lags (z) and the maximum order of system integration (e). The second is the estimation of a VAR with variables at level with a total of (z + e) lags, as follows:

$$y_t = \mu + \sum_{i=1}^{p+m} \alpha_i y_{t-i} + \sum_{i=1}^{p+m} \beta_i x_{t-i} + u_{1t} \quad (1)$$

$$x_t = \mu + \sum_{i=1}^{p+m} \gamma_i x_{t-i} + \sum_{i=1}^{p+m} \delta_i y_{t-i} + u_{2t} \quad (2)$$

Where y_t represents the economic-financial performance index; x_t the macroeconomic variables; μ is a constant; u is a white noise error term assumed as $\sim (0, \sigma^2)$ and without autocorrelation; the subscript t refers to the time period and i denotes the lag ($i = 1, \dots, k$). The subscript m is the maximum order of integration of the variable in the system and p is the optimal lag length of y_t and x_t

The maximum order of integration m in the VAR system was defined through the “var.select” function available in the “vars” package from the R-Project software. The function gives the information criteria and final prediction error for the sequential increase of the order of delay until a VAR (p) process, based on the same sample size. We then used the Akaike, Schwartz and Hannan-Quinn information criteria for the decision of the maximum lag applied to the VARs models.

The third step consists in the application of the Wald constraint test in the first p coefficients to test the non-causality hypothesis. In this sense, there will be causality from x to y if the hypothesis $H_0: \beta_i = 0$ is rejected and the hypothesis $H_0: \delta_i = 0$ is not rejected⁴.

³GDP per capita, SELIC rate, Consumer Price Index (IPCA), Exchange Rate and Risk as variables. See Paredes [29] for further details of the model.

⁴For further details, see Fochezatto *et al.* [13].

IV. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANN) models constitute a method of solving computational problems by constructing a system that simulates the human brain operation and thus reproduces its characteristics, such as learning, association and generalization. According to Ferneda[11], Neural Networks constitute a field of computer science linked to artificial intelligence, seeking to implement mathematical models that resemble biological neural structures.

According to Fayal [10], the ANN models constitute an important nonlinear statistical technique capable of solving a great range of highly complex problems. Therefore, they are useful models in situations where it is not possible to explicitly define a list of rules.

There are already several studies on the use of computational intelligence on time series forecasting. Bebarta *et al.* [3] presents a model of recurrent neural networks using technical indicators to predict future prices in the Indian stock market. Pommerenzenbaum [30] through Artificial Neural Networks proposes a prediction model of the price series of the Ibovespa index. Jaybhay *et al.*[20] proposes a model to predict the daily closing price of the Bombay Stock Exchange Index (BSE) by combining price and news data into a feed-forward neural network, obtaining results with high accuracy.

The basic unit of a neural network is the artificial neuron, which processes its inputs through a weighted sum considering pre-selected weights or parameters of the network, and an activation function. Gurney [17] and Ortega [27] presents a detailed discussion on the information processing by ANN. By combining several neurons, an artificial neural network is formed. Each of these neural networks differentiated themselves through their architecture and the way that the weights and connections are associated and adjusted during the learning process. This architecture depends on the type of problem in which the network can be used. (Ferneda, [11]).

Data modeling through neural network goes by the following process. Initially, the network is presented with a data set. This phase is called training and, at this moment, the learning process takes place through a continuous adjustment of the synaptic weights. Subsequently, this network must be tested by presenting patterns never seen by it, and its performance is evaluated.

4.1. The Adopted Architecture

In this paper, the Multi-Layer Perceptron (MLP) network architecture was used. An MLP typically consists of an input layer, with one or more hidden layers and an output layer. It has a feedforward architecture type, which is characterized by the direction of data propagation and the interconnection structure. In this network, data is propagated from input to output and there are no connections between neurons of the same layer or of previous layers (Pasquoto, 2010).

Neural network learning process occurs in two phases (Rumelhart *et al.*, [32]). In the first phase, an input pattern is presented to the neurons and its effect propagates through the network, layer by layer, producing a network output. The network output is subtracted from a desired output producing the error. Then, this error is retro propagated backwards, which causes adjustments in the synaptic weights.

In this article, we tried to estimate the performance of the economic-financial indicators through two models, one using only the past data of the indicators themselves and another using past data and macroeconomic variables. As can be seen:

$$Ind_t = f(Ind_{t-1})(3)$$

$$Ind_t = f(Ind_{t-1}, GDP_t, Interest\ rate_t, Exchange\ Rate_t, Inflation_t)(4)$$

In model (3) the economic-financial indicator depends only on its past data. In the model (4), besides depending on its past data, it depends on four contemporary macroeconomic variables, they are: The Gross Domestic Product (GDP or PIB), the interest rate represented by the SELIC rate, the exchange rate ("Câmbio") and the inflation represented by the IPCA.

The parameters involved in defining an MLP network range from the number of intermediate layers, the number of neurons in these layers, the definition of activation functions up to the training algorithm. In this case, we use only one hidden layer and we vary from 1 to 7 the number of neurons in that layer. For the activation functions, it was used the tansig (Hyperbolic tangent sigmoid) and logsig (Logarithmic sigmoid) functions. For the training algorithm, it was used the traingdx (Gradient descent backpropagation with momentum and adaptive rate).

The definitive configurations of each network were based on the Mean Absolute Deviation (MAD), on the Mean Absolute Percentage Error (MAPE) and on the

Root Mean Square Error (RMSE) metrics, and the selection criteria for the networks was lowest values for each of the selected metrics. The time equals 3,000 and the training error is close to 2%.

4.2. Model Comparison Metrics adopted

When projecting the historical values, it is possible to compare the actual values with the estimated values. This comparison provides the error level of the forecast generated by the model when making projections over the historical data. From this error, you can calculate metrics to measure the model performance and is possible to compare results from different methods.

There are several metrics used, in this case we use MAD, MAPE and RMSE. The MAD represents the standard deviation of the fitted value against the mean in the same data units.

$$MAD = \frac{\sum_{k=1}^N |a_k - y_k|}{n} \quad (5)$$

Where n being the number of forecasted values, a_k is the desired output for the prediction index k , and y_k is the forecasted output for the index k . MAPE is a measure of precision, expressed as a percentage through the following formula:

$$MAPE = \frac{\sum_{k=1}^N |a_k - y_k|}{N} \times 100\% \quad (6)$$

Where N is the number of forecasted values, a_k is the desired output for the prediction index k and y_k is the forecasted output for the index k . The RMSE does a similar calculation to the MAPE for the quadratic error as can be seen below:

$$RMSE = \sqrt{\frac{\sum_{k=1}^N |a_k - y_k|^2}{N}} \quad (7)$$

Larger errors are penalized in this metric. In this way, a technique that presents optimal results in most forecasted values, but has high errors in a specific forecast, will presents a high RMSE.

V. ESTIMATION RESULTS

Table 1, 2, 3, 4 and 5 presents the descriptive statistics on the analyzed variables in the article. For each series containing the variations of the indicators of the pulp and paper sector we present the maximum and minimum variation of the indicator for the period (July 2002 to

November 2017), the mean, standard deviation and variation coefficient.

Table 1 - Debt Descriptive statistics of variables and indicators.

Indicator	Maximum	Minimum	Mean	Standard-deviation	Variation Coefficient
Interest Rate Coverage Ratio	458%	-593%	-16%	143%	-920%
Total Liabilities divided by Total Assets	10%	-21%	0%	5%	1799%
Debt/Equity Ratio	63%	-53%	2%	18%	898%
Fixed Assets to Equity Ratio	47%	-34%	1%	12%	1678%
Cash and Cash Equivalent to Equity Ratio	240%	-87%	1%	51%	8397%

Source: Elaborated by authors based on data provided by companies' websites, BACEN and IPEA.

Table 2 - Liquidity Descriptive statistics of variables and indicators.

Indicator	Maximum	Minimum	Mean	Standard-deviation	Variation Coefficient
Overall Liquidity	60%	-16%	1%	10%	1155%
Current Ratio	47%	-26%	2%	13%	619%
Quick Liquidity	47%	-34%	2%	14%	602%

Source: Elaborated by authors based on data provided by companies' websites, BACEN and IPEA.

Table 3 - Activity Descriptive statistics of variables and indicators.

Indicator	Maximum	Minimum	Mean	Standard-deviation	Variation Coefficient
Days of Inventory Outstanding	25%	-20%	0%	8%	1798%
Days of Payables Outstanding	65%	-39%	2%	17%	903%
Days of Sales Outstanding	361%	-30%	7%	47%	682%
Financial Cycle	79%	-35%	3%	19%	631%
Operating Cycle	49%	-20%	1%	10%	703%

Source: Elaborated by authors based on data provided by companies' websites, BACEN and IPEA.

Table 4 - Performance and Profitability Descriptive statistics of variables and indicators.

Indicator	Maximum	Minimum	Mean	Standard-deviation	Variation Coefficient
Asset Turnover	426%	-34%	8%	58%	696%
Net Margin	270%	-395%	-4%	106%	-2669%
Return on Asset	799%	-273%	23%	173%	761%

Source: Elaborated by authors based on data provided by companies' websites, BACEN and IPEA.

Table 5 - Macroeconomic Variables Descriptive statistics of variables and indicators.

Indicator	Maximum	Minimum	Mean	Standard-deviation	Variation Coefficient
Exchange rate	30%	-12%	1%	8%	1203%
GPD (PIB)	8%	-7%	3%	4%	149%
Interest rate (SELIC)	39%	-23%	-1%	1%	-130%
Inflation rate (IPCA)	7%	0%	2%	1%	65%

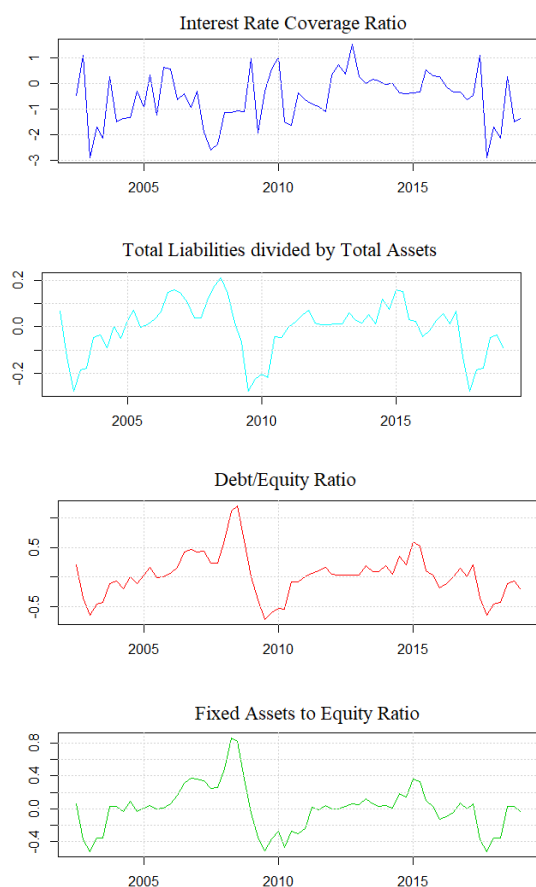
Source: Elaborated by authors based on data provided by companies' websites, BACEN and IPEA.

According to Table 1, 2, 3, 4 and 5, the sector presented variation of -4% for the mean Net Margin,

which indicates that the sector presented stable average performance in the analyzed period. The sector presented a variation of the average Financial Cycle in the period of 3% and a standard deviation of 19%, revealing some stability in the bargaining power of the companies that make up the sector with its suppliers. The Return on Asset Index showed a maximum growth of 799% and a minimum of 273% in the analyzed period, which reveals some variability in the efficiency of the asset application. Regarding the behavior of the macroeconomic variables, as can be seen in Table 1, 2, 3, 4 and 5, the Interest Rate presented in average a fall of 1% with a standard deviation of 1%. The exchange rate, the GDP and the Inflation rate presented average growth in the analyzed period of 1%, 3% and 2%, respectively.

Fig. 1, 2, 3 and 4 show the quarterly variation of the indicators over the analyzed period.

Fig. 1 – Debt Group

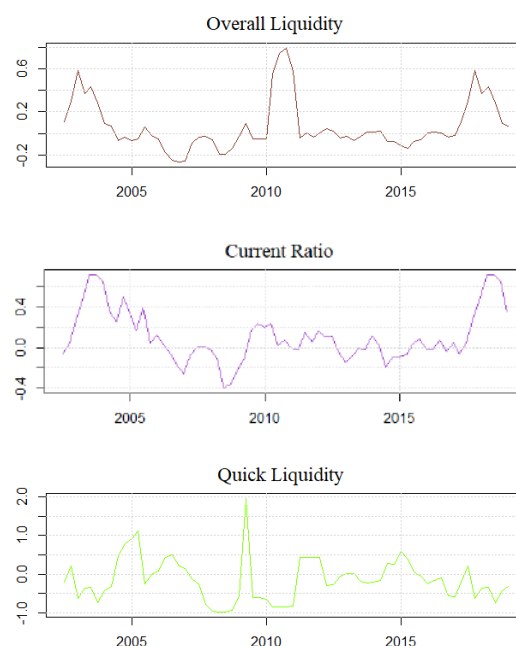


Source: Authors based on the data provided in the Balance Sheets of companies in the paper and pulp sector.

As can be seen in Fig. 1, the indicators show variability in the analyzed period. The Interest Coverage

Index Ratio shows variability around (-1%) over the period, while the Total Liabilities divided by Total Assets, Total Liabilities over Equity (Debt / Equity Ratio) and Fixed Assets to Equity Ratio showed a growth trend at the beginning of the series and stability at the end of the period. The level of cash and cash equivalents varied around (0.0%) with a peak in 2009.

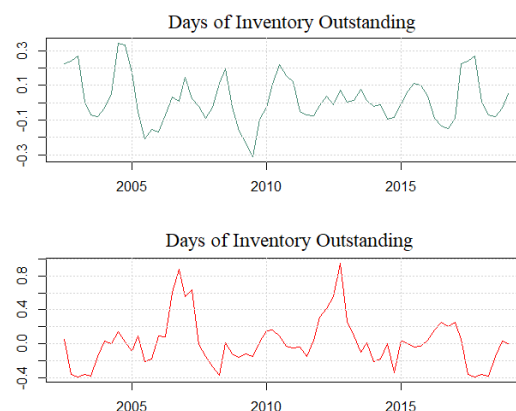
Fig. – Liquidity Group

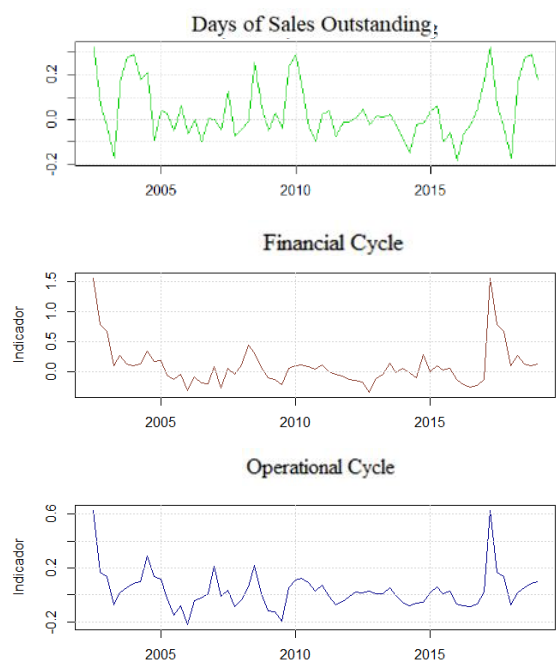


Source: Authors based on the data provided in the Balance Sheets of companies in the paper and pulp sector.

As can be seen in Fig. 2, Overall Liquidity peaked in 2011 and at the end of the analyzed period (2017), while the Current Ratio showed a downward trend and subsequent stability until the end of 2015. Quick Liquidity presented moderate variability and a peak in 2019.

Fig. 3 – Activity Group

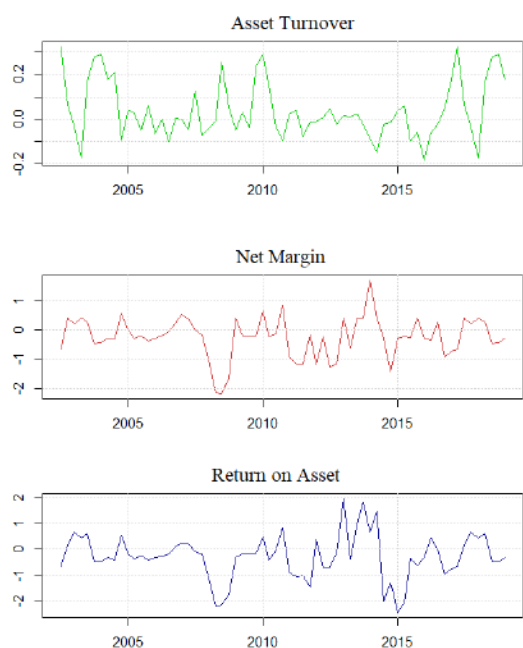




Source: Authors based on the data provided in the Balance Sheets of companies in the paper and pulp sector.

The indexes that compose the Activity Group do not present similar movements. Financial Cycle (days) is the most stable and Days of Sales Outstanding (days) is the most unstable index.

Fig. 4 – Performance and Profitability Group



Source: Authors based on the data provided in the Balance Sheets of companies in the paper and pulp sector.

The Asset Turnover showed the lowest variability in the period, while the Net Margin and Return on Asset presented similar movements. As can be seen, all the indicators presented some stability in the last quarters of the sample.

Table 6 - P-values from Toda-Yamamoto test [36]

Economic-financial indicators		Macroeconomic Variables			
		Exchange Rate	GDP	Interest rate (SELIC)	Inflation rate (IPCA)
Debt	Interest Rate Coverage Ratio	0,220	0,600	0,000	0,002
	Total Liabilities divided by Total Assets	0,000	0,045	0,000	0,006
	Debt/Equity Ratio	0,043	0,000	0,040	0,013
	Fixed Assets to Equity Ratio	0,001	0,000	0,000	0,000
	Cash and Cash Equivalent to Equity Ratio	0,038	0,000	0,000	0,000
Liquidity	Overall Liquidity	0,000	0,510	0,000	0,000
	Current Ratio	0,730	0,014	0,001	0,000
	Quick Liquidity	0,000	0,000	0,000	0,001
Activity	Days of Inventory Outstanding (days)	0,001	0,400	0,000	0,000
	Days of Payables Outstanding (days)	0,052	0,002	0,016	0,000
	Days of Sales Outstanding (days)	0,001	0,001	0,000	0,001
	Financial Cycle (days)	0,380	0,000	0,001	0,000
	Operating Cycle (days)	0,019	0,700	0,130	0,000
Performance and Profitability	Asset Turnover	0,000	0,002	0,000	0,048
	Net Margin	0,048	0,000	0,000	0,000
	Return on Asset	0,050	0,000	0,009	0,001

Source: Elaborated by authors based on data provided by companies websites, BACEN and IPEA.

Table 6 presents the p-values of the Toda-Yamamoto test applied to determine the dependence between macroeconomic variables and the economic and financial performance of the Brazilian pulp and paper sector from 2002 to 2017. Note that the tests and the modeling were applied to the quarterly variations of the series (Figs, 1, 2 and 3).

As can be seen in Table 6, the macroeconomic variables that were related to the Interest Rate Coverage Ratio were only the Interest Rate (SELIC) and the inflation rate (IPCA). It should be noted that: (i) the SELIC Rate is the base interest rate of the economy, so all other rates are related to it in some way and (ii) the SELIC Rate is a monetary policy instrument used by the government to curb inflation. Therefore, the test result corroborates our expectations that these two variables were related to the Interest Rate Coverage Ratio.

According to the p-value found, for all the others indicators in the “Debt” group, the macroeconomic variables tested (Exchange rate, GDP, Interest rate and Inflation rate) presented p-values lower than 0.05. Therefore, for the estimation and forecasting of debt indexes we can use the four macroeconomic variables mentioned above.

The application of the Toda-Yamamoto test [36] on the diagnose about the existence of any relationship between the Overall Liquidity Index and the

macroeconomic variables allowed us to find that the variables Exchange Rate, Interest Rate and Inflation Rate presented p-values close to zero, which indicates the possible dependence of the liquidity index to these variables. The test result corroborated our expectations, as the index measures how much liquid resources the company has to cover each monetary unit of (short and long term) contracted debts. As mentioned above, the debts are related to interest and, depending on the company, may be tied to the exchange rates.

The test also revealed that the variables GDP, Inflation and Interest Rate are relevant for the estimation and forecast of the Current Ratio. It is known that Inflation rate, recession or economic expansion and the base interest rate can influence the demand and supply of goods produced by a company. Since the Current Ratio includes information on these variables, we can confirm the result of the test.

In relation to the Days of Inventory Outstanding, it was verified the dependence on the following variables: Exchange Rate, Inflation and Interest Rate. Since the Days of Inventory Outstanding calculates the average term that the products stay in stock throughout the year, it is assumed, at first, that the Exchange Rate, Inflation and Interest Rate can influence the sales flow of the company and consecutively the inventory of the same. Therefore, the test result seems consistent.

The test results for the Financial Cycle and the macroeconomic variables revealed that the variables GDP, Interest and Inflation rates presented p-values equal to or close to zero. It should be noted that the financial cycle is the time between the payment made to suppliers and sales receipt. In the process of buying raw material, producing, selling and receiving the value from its customers the company can be influenced by the interest rate, for example, and this may be important for the buyer's decision to buy something (in) cash or to finance their purchases. GDP and Inflation can influence the postponement of the final consumer purchase, increasing the sale time of the product and consecutively the receipt. Therefore, the test result corroborates our expectations.

According to the performed simulations, the variables Exchange Rate and Inflation Rate are relevant for the estimation and forecasting of the Operating Cycle. The fact that companies in the pulp and paper sector export their production justifies such dependence on the Exchange Rate. As previously mentioned, inflation rate is a key variable for the decision of the demanders of goods and services in general.

As can be seen in Table 6, all macroeconomic variables used in the analysis were relevant for forecasting and estimating the Performance and Profitability Indexes. It is worth mentioning that these indicators measure the profitability and performance that a company can present for a given period. We consider, according to all the above assumptions, that for these indicators of profitability and performance the Exchange Rate, GDP, Interest Rates and Inflation rate were relevant, since the Performance and Profitability Indexes are final indicators of the manufacturing, storage, sales and receipts process.

After performing the tests previously mentioned by the authors, we used the Neural Networks to model the economic-financial indexes together with the selected macroeconomic variables. For the Neural Network training, we used the first 30 observations from each time series. Later, in order to evaluate the performance of the Neural Networks we used the rest of the series formed by the variations of the performance-financial indexes and the macroeconomic variables. Table 6 shows the error measures for the two models applied, the first model using only the past data of the indicators themselves (Equation 1) and another (Equation 2) using the macroeconomic variables.

According to Table 7, 8, 9 and 10, for the great majority of the variations of the economic-financial performance indexes the macroeconomic variables brought improvements in the neural networks performance, reducing the forecast errors. In these examples, the three error measures (MAD, RMSE and MAE) presented some decrease, in comparison with the measures calculated using the errors coming from the network with only one entry (the time series itself, with one period lag). For all variations of the economic-financial performance indexes, at least two of the three adherence measures presented improvements for the network that used macroeconomic variables among their inputs.

Table 7 – Debt - Error measures calculated from the forecasted errors obtained by the Neural Networks

Indicator	Error measures					
	MAD	RMSE	MAE	MAD	RMSE	MAE
	without macroeconomic variables			with macroeconomic variables		
Interest Rate Coverage Ratio	47,7%	23,6%	74,0%	24,1%	21,7%	67,9%
Total Liabilities / Total Assets	2,9%	1,3%	4,5%	2,1%	1,2%	3,4%
Debt/Equity Ratio	10,1%	3,2%	11,2%	5,3%	3,3%	9,8%
Fixed Assets to Equity Ratio	9,4%	11,8%	26,6%	7,9%	10,8%	23,0%
Cash and Cash Equivalent to Equity Ratio	110,9%	11,3%	25,8%	8,0%	11,2%	23,3%

Source: elaborated by authors based on data provided by companies websites, BACEN and IPEA.

Table 8 – Liquidity - Error measures calculated from the forecasted errors obtained by the Neural Networks

Indicator	Error measures					
	MAD	RMSE	MAE	MAD	RMSE	MAE
	without macroeconomic variables			with macroeconomic variables		
Overall Liquidity	3,0%	2,6%	7,5%	4,3%	2,4%	6,3%
Current Liquidity	9,4%	2,4%	9,0%	6,8%	2,2%	8,3%
Quick Liquidity	8,7%	2,6%	9,6%	8,3%	2,3%	8,6%

Source: elaborated by authors based on data provided by companies websites, BACEN and IPEA.

Table 9 – Activity - Error measures calculated from the forecasted errors obtained by the Neural Networks

Indicator	Error measures					
	MAD	RMSE	MAE	MAD	RMSE	MAE
	without macroeconomic variables			with macroeconomic variables		
Days of Inventory Outstanding	6,6%	2,5%	9,2%	1,1%	0,5%	2,0%
Days of Payables Outstanding	8,8%	5,2%	15,7%	7,3%	4,1%	12,2%
Days of Sales Outstanding	6,7%	2,2%	8,0%	6,1%	1,8%	7,0%
Financial Cycle	10,5%	3,4%	14,7%	10,4%	4,6%	12,2%
Operating Cycle	5,2%	2,1%	7,6%	3,9%	1,1%	4,4%

Source: elaborated by authors based on data provided by companies websites, BACEN and IPEA.

Table 10 – Performance and Profitability - Error measures calculated from the forecasted errors obtained by the Neural Networks

Indicator	Error measures					
	MAD	RMSE	MAE	MAD	RMSE	MAE
	without macroeconomic variables			with macroeconomic variables		
Asset Turnover	21,2%	8,5%	30,6%	2,8%	4,8%	17,7%
Net Margin	53,7%	27,8%	87,9%	45,6%	27,5%	84,5%
Return on Asset	114,8%	62,4%	198,3%	63,4%	60,6%	172,3%

Source: elaborated by authors based on data provided by companies websites, BACEN and IPEA.

It should be noted that for the evolution of the Interest Rate Coverage Ratio, Net Margin and Return on Asset, the applied neural networks presented high error measures, thus requiring a little more attention in the analysis.

Thus, for the Brazilian pulp and paper sector, during the studied period, it was verified that the performance of the macroeconomic variables was significant to forecast the changes in the economic-financial indexes. The obtained results in our tests are consistent with those presented in the articles by Guidini *et al.*[16], Santos *et al.*[33], Costa *et al.*[8] and Medeiros *et al.*[25].

VI CONCLUSION

The Pulp and Paper sector plays a fundamental role in the Brazilian economy. The differentials and advantages Brazil have on rotation cycle time and productivity makes Brazil one of the main territories for the development of this industry, essential in the contemporary world.

The economic-financial indicators place us in relation to a company situation. When such information is

organized as a time series data set, it reveals the evolution of a corporation over time, providing data for analysis to be measurable.

The causality test following the approach defined by Toda and Yamamoto [36] to investigate the existence of dependence relation between macroeconomic variables and the economic and financial performance indicators of the Brazilian pulp and paper sector was extremely relevant. When considering only the macroeconomic variables indicated by the test as inputs to the Artificial Neural Networks (ANNs), the error measures presented a decrease, compared to the measurements when we used all the macroeconomic variables, thus proving the importance of the dependency relationship test approach proposed by Toda and Yamamoto[36].

Neural Networks used as a forecasting tool has shown again its promising ability, since only few errors presented in this study exceeded the ratio of 10%. That is, when comparing the actual indexes with those predicted by the neural network, the difference was small in most comparisons, confirming the effectiveness of the ANNs for the anticipation of scenarios. The exceptions were the Return on Asset, Interest Coverage Ratio and Net Margin, which will require a more detailed analysis in future works.

As for the main objective of this article, it was verified that the 16 indexes of economic-financial performance analyzed by the neural networks performed better when it was also used GDP, SELIC Rate, IPCA Rate and Exchange Rate as information inputs to the analysis. The results obtained corroborate with those presented by Guidini *et al* [16], Santos *et al*[33], Costa *et al*[8] and Medeiros *et al.* [25].

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