

**TESTING THE HYPOTHESIS OF MARKET EFFICIENCY THROUGH
ARTIFICIAL NEURAL NETWORKS: A CASE STUDY WITH THE TEN MAJOR
IBOVESPA SHARES IN THE FIRST QUARTER OF 2011**

Luiz Henrique Debei Herling

Universidade Federal de Santa Catarina
lhherling@gmail.com

Marcus Vinicius Andrade de Lima

Universidade Federal de Santa Catarina
marcus.lima@cse.ufsc.br

Gilberto de Oliveira Moritz

Universidade Federal de Santa Catarina
gomoritz@cse.ufsc.br

Pedro Henrique Marangoni

Universidade Federal de Santa Catarina
pedromarangoni@hotmail.com

ABSTRACT

Fuel market is facing political, economic, social and environmental problems that are fuzzing the future of fossil energy sources and in face of these facts, countries are looking for hybrid and electric vehicles as part of solution in transportation sector due to the fact of electric vehicles use few or no fossil fuel. The objective in this article was to identify options until 2020 to introduce electric vehicle in the urban traffic of São Paulo city and to develop this study the method of literature review in secondary sources was used to present electric vehicle technologies and to identify parameters that were assessed through morphological analysis technique. In morphological analysis, sets of values were defined by the author for these parameters, possible combinations were structured, clearly impractical deployment options before 2020 were discarded and some viable solutions were analyzed in details. These analyses concluded that there are viable options for actual days in São Paulo city, but important requirements regarding technology, politic, market, infrastructure and innovation in products and services still need to be

addressed and it is the main reason of electric vehicle remain unnoticed by consumers as an viable option. The challenges are great and the actors who are willing to solve them will find a promising market to explore.

Key-words: Electric vehicles. Morphological analysis. Urban traffic.

RESUMO

As instabilidades político-econômicas e as pressões socioambientais que afetam o mercado de combustíveis têm tornado nebuloso o futuro de médio e de longo prazo das fontes fósseis de energia e, diante dessas incertezas, muitas nações estão buscando soluções como os veículos elétricos ou híbridos para a questão do transporte, pelo fato de demandarem pouco ou nenhum combustível fóssil. Neste trabalho objetivou-se identificar possibilidades válidas e aplicáveis até 2020 para a introdução de veículos elétricos no tráfego urbano da cidade de São Paulo. No desenvolvimento do estudo foi usado o método de pesquisa bibliográfica em fontes secundárias para a apresentação das tecnologias e a identificação das variáveis que, posteriormente, foram avaliadas pelo método de análise morfológica para a estruturação das opções identificadas. Na análise morfológica, o autor selecionou as variáveis para análise e definiu conjuntos de valores para elas. As combinações de tais conjuntos de valores foram estruturadas, opções claramente impossíveis ou pouco viáveis até 2020 foram descartadas e as possibilidades desejáveis ou viáveis foram analisadas de forma mais detalhada. Dessas análises, concluiu-se que existem opções viáveis para a atual realidade da cidade de São Paulo, mas importantes requisitos tecnológicos, políticos, de mercado, de infraestrutura e de inovação em produtos e serviços ainda não foram atendidos e, por isso, os veículos elétricos continuam não sendo percebidos pelos consumidores como uma opção viável aos veículos com motor de combustão interna. Os desafios ainda são grandes e os atores que se dispuserem a resolvê-los encontrarão um mercado promissor para explorar.

Palavras-chave: Veículos elétricos. Análise morfológica. Tráfego urbano.

1 INTRODUCTION

In the current economic context, there are numerous investment opportunities available in the market. Surplus agents, which, according to Keynes (1983), are those who have incomes higher than consumption and always look for investing their savings in order to maximize their capital, end up by financing the deficit agents, who need to raise funds to finance themselves.

The contemporary world evolution is incorporated in the corporate financial issues scope. When it comes to finances, since 1929 with the Great Depression until the 1940st the studies were focused primarily in the liquidity and fund raising. Thereafter, it has begun the concern about investment analysis and then it has come up theories involving the current capital market, as the portfolios theory, of Markowitz.

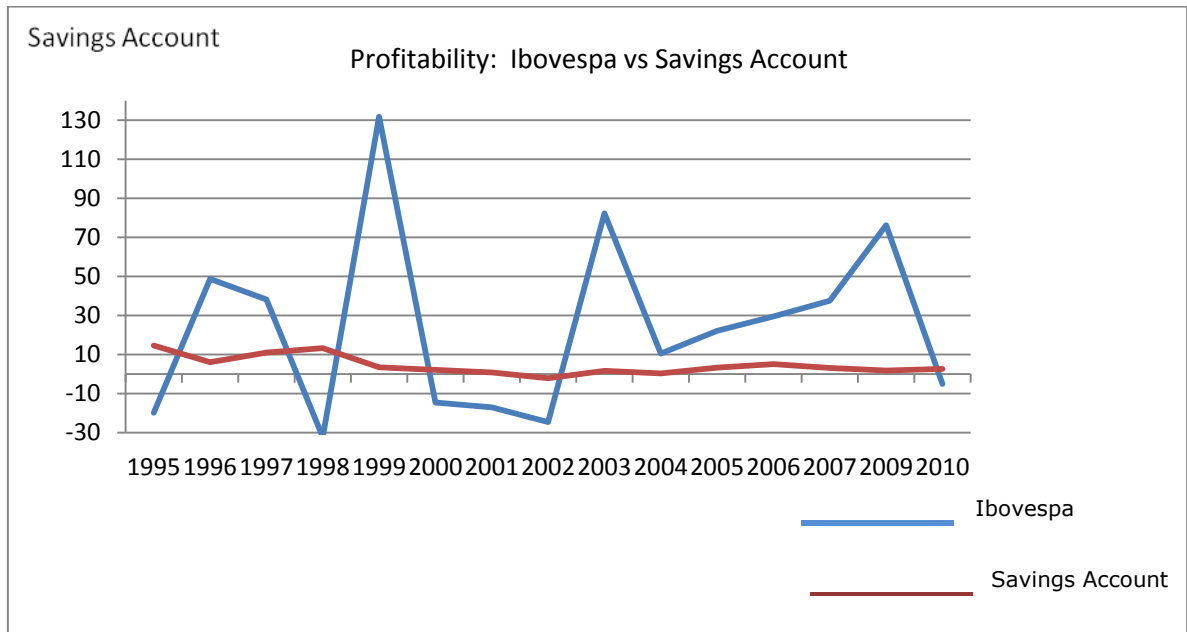
In the current financial administration, there are several methods for investments evaluation. Gitman (2010) presents the main methods of investment analysis such as the *Payback* method, the Net Present Value (NPV) and the Internal Rate of Return (IRR) used by the companies. It is possible to see that, throughout time, companies are increasingly concerned about evaluating their investments in order to check whether they are attractive or not.

Basically, so that a project is approved, this project returns must, in real terms, be higher than the cost of capital, and this cost, according to Ross, Westerfield and Jaffe (2007), will be evaluated according to the source, which can be an own source or an external source. Gitman (2010) also points out that one of the major objectives of the financial manager is to seek investments that maximize the return on the capital, generating ever greater wealth for the investor. Based on these arguments, it is clear that investors will always seek to invest their funds in assets that will provide them the highest return.

Throughout the years, the stock market has been attracting more and more investors due to the fact that it provides very attractive profitability compared to other investment options such as savings accounts and fixed income bonds.

We cannot disregard the inherent risk measurement in each operation. Take as an example the decision to invest in two assets that offer different returns. One of them is the investment in savings accounts and the other the investment in the capital market, more specifically in the stock market.

For comparison purposes between the two most common types of investments in the Brazilian portfolio, it is presented in Figure 1, a profitability comparison between an investment in the São Paulo Stock Exchange (Ibovespa) and an investment in the saving accounts.



Graph 1: Profitability: Ibovespa versus savings account

Source: Authors' calculations.

It can clearly be seen that the Stock Exchange of São Paulo (Ibovespa) Index, although providing higher profitability in some moments when compared to the returning rates of the savings accounts, had, throughout the study period of its profitability, an oscillation in its returning rate much higher than the savings accounts profitability oscillation, leading to the conclusion that stock investments are subject to a higher degree of risk than investments in savings accounts considering the oscillation of its return. When calculating the standard deviation of each investment, it is found that the investment in the stock exchange oscillation is much higher than of the savings accounts - 46.62 against 4.83 - showing a deviation 9.6 times higher and highlighting the discrepancy regarding the risk.

As the studies in finance advanced, Markowitz (1952) started using fundamentalist criteria for decision making and assets valuation. His best known

work is the portfolios theory. His studies in fundamentalist analysis have been evolving, along with his pupil, William F. Sharpe, known for creating the CAPM - capital asset pricing model, which consists of a model to assess the capital cost under risk conditions, taking into account the *beta* (systematic risk) and the investment award and also reflecting the profitability plus the risk in favor of the investor.

Prior to these studies, more precisely 50 years before Markowitz studies, Charles Dow in 1894, presented theories that were aimed at the identification of market trends lines. His theory, the Dow Theory, is considered the oldest of the theoretical explanations for the existence of broad trends in the capital markets, leading then to technical analysis.

The theory holds that the traded shares will always follow a raising and falling trend at any time. Therefore, it is up to the investors to use techniques to identify the moments of buying and selling, and consequently increase their profitability by carrying out the operations in the best possible times. It is evident that such identifications are complex and measure several variables.

Within the technical analysis, other studies have currently been using artificial neural networks. We can highlight the work of Cartacho (2001) and Freitas (2001) as good examples regarding the use of artificial neural networks for predicting future values of financial assets (stocks, indexes, options, etc.).. These good results have stimulated further studies which use artificial neural networks, as is the case of this article.

This computational method for data prediction is a subset of the Artificial Intelligence and has been used only in the university environment, in research companies and in large investment firms. This article aims to show that the individual investor can also use this resource, as well as to test its functioning in the face of the market efficiency theory related to liquidity.

The neural network presented by Marangoni (2010), which will be used in this study, uses data such as stock price, its liquidity ratio, moving averages and other trend indicators indexes, which will be detailed in the theoretical foundation of this article. These data are used as inputs to the neural network, and as from the running of the program, predictions will be made concerning the future behavior of the daily closing price for the stock in question - it will be analyzed the Ibovespa 10 stocks with the highest weight in the first four months of 2011.

According to the Stock Exchange, Commodities and Futures Exchange (BM & FBovespa) website, the Bovespa index, or IBOV, is the most important indicator of the prices average performance of Brazilian stock market. Its relevance derives from the fact that Ibovespa depicts the behavior of the most traded stocks on the BM & FBovespa. The website also highlights its tradition since it maintained the integrity of its historical series without any methodological change since its inception in 1968.

The index reflects not only stock prices variation, but also the impact of the benefit distribution, and is considered an indicator that measures the total return of its component stocks.

Also according to the BM&FBovespa website information, "the basic purpose of Ibovespa is to serve as an average indicator of the market behavior. To this end, its composition seeks to get as close as possible to the actual configuration of the negotiations on the cash market (round lot) on the BM & FBovespa."

The shares in the theoretical portfolio of Bovespa Index account for over 80% of the number of transactions and of the financial volume observed on the cash market, leading to the conclusion that they are the highest in liquidity when it comes to purchasing and selling.

The ANN model (Artificial Neural Networks) will be applied to evaluate which action that makes up the index offers a better return rate, being the criteria used to evaluate in which stock investors shall invest, according to the predictions offered by the network. In addition, stocks will be analyzed based on their liquidity and purchasing decisions will be taken based on them. The purpose of this study is to answer whether the tool developed by Marangoni (2010) identifies the better profitability stocks according to stocks identified through the liquidity analysis.

2 INVESTING IN STOCK EXCHANGE

The financial manager stands between the company's activity and the financial markets, his role is to decide the basic issues regarding to which investments to make and how to finance (Brealey, Myers & Allen, 1998).

Following this thought, Ross (2007) points out that the role of the financial manager is to take decisions that increase the value of the company, being aware of where they are stepping in, with a market vision, taking advantage of the opportunities given and always aiming at higher flights.

Not only entrepreneurs but also investors in general have been seeking for better investment opportunities, and the stock market has proven to be throughout time an important channel to reach these goals.

2.1 SPOT MARKET OF SHARES

All the companies need to raise funds in different moments of its existence. It is known that this capital can be own or third party (Gitman, 2010).

When issuing shares, the company is admitting new partners, which classifies the investors as holders of fractions of the company. Thus, this capital is classified as equity and is remunerated based on the profits that the company has managed to get during the financial year.

The shares in turn, according to Assaf Neto (1999), are securities or shares representing a smaller fraction of the capital stock of a company. Thus, the shareholder is not a creditor of the company, but a co-owner.

This stock market works through a stock exchange. The stock exchanges, according to Pinheiro (2009), are economic institutions that have as their main objective the public trading commercial for bonds and securities, which leads to the conclusion that it is the place where you purchase and sell stocks.

Individuals and legal entities will participate in the Stock Exchange, the former, in search of investment alternatives, the latter, in search of fundraising and, in other cases, looking for alternative investments for their capital. Agents operating in this market can be classified, according to Pinheiro (2009), in three types of attitude:

- speculators: agents who use the market for short-term profits without worrying about the shares they are buying. They seek opportunities for purchasing and selling stocks;

- investors: they use the market to obtain long-term yields;
- financial managers: they need the market to raise funds at low cost and invest funds with no risks, with suitable deadlines.

2.2 EFFICIENT MARKET HYPOTHESIS

The Stock Exchange is a highly disciplined, regulated and supervised body. Based on these characteristics addressed by Pinheiro (2009), and together with the other features displayed by Assaf Neto (1999), such as the mandatory publishing of accounting results in the public media, it is evident that investors possess a lot of information on the company's economic situation. On the other hand the media, which are intended to "sell information," do publish a lot of information on companies operating in the Stock Market. However it is important to emphasize that the available information are not essential for the decision-making due to the fact that such information reflect past events or past decisions and to access part of them in a global way does not generate "advantage" for the making decision moment, considering these are information to which everyone has access, a common knowledge information.

Eventually, investors end up absorbing such information, which influence their behavior regarding their attitudes of purchasing and selling. With this influenced attitudes the shares' supply and demand are altered, changing consequently their price in a particular time.

Brealey, Myers and Allen (2008) state that the market is efficient when the information available reflect in its quotation: "In competitive markets, the current stock price reflects the information of the prices track record."

Brealey, Myers and Allen (2008, cited in Kendall, 1953) suggest that stocks follow a random walk, i.e., that the price changes are independent of each other. To illustrate it, imagine that a stock is traded today at \$30 and the market expectation is that it will reach \$120. Soon after realizing this potential gain, investors start purchasing these stocks even at higher prices, e.g. \$80, then destroying the cycle, because they will only stop buying when the abnormal profitability is reached. The trend is that the market always adjusts to new information (Gitman, 2010).

According to such information, investors should not waste time searching for moments of raising and/or falling share prices aiming at high profitability in the stock market, because the market itself would be in charge of it. It is admitted, in the efficient market hypothesis that the shares with higher liquidity, i.e., the most heavily negotiated are the ones that will have lower profitability in certain portfolios. If an investor uses these concepts to buy shares, he/she will surely invest their capital in the share which presents the best liquidity, taking on higher risk and therefore expecting a better profitability.

However, according to what is highlighted by Pinheiro (2009), the basic hypothesis of fundamentalist analysis is that the capital market is efficient in the long term, abnormalities may occur in the short term and that these abnormalities will be corrected in the future, and so that they exist, it is necessary to meet some points such as:

- 1) competitiveness: must be free;
- 2) transparency;
- 3) liquidity: good functioning of the secondary market;
- 4) size: that enables lower transaction.

However, this ideal market does not exist (Pinheiro, 2009). The efficiency degree can be defined making the relationship between information and price and characterizing it in:

- 1) weak: reflects the historical data;
- 2) medium or semi-strong: it also reflects the public available information;
- 3) strong: all the information, including those private ones, are reflected in the quotation.

2.3 ANALYSIS OF STOCKS

Nowadays the stocks analysis can be done using two main forms: fundamentalist analysis and technical analysis.

Fundamental analysis - which emerged strongly in the 1950s, based on the works of Markowitz (1952) and the further works developed by Sharpe (1964) - takes into account the company's fundamentals, such as information

about its profits, dividends, market share, liquidity, level of indebtedness, among others.

According to the history depicted in the work of Pinheiro (2009), the technical analysis started with the Japanese in the 1700s, when they began to formulate the "future price of rice" by tracking historical prices, giving rise to the graphics known today as *candlesticks*.

Technical analysis is in fact, according to Pinheiro (2009), "the study of past movements in prices and trading volumes of financial assets, in order to make predictions about the prices future behavior".

This analysis is one of the major tools used by investors and has been developing pretty much every year. With advancements in the information technology, it is inevitable to use computational tools for these models development which facilitates in many ways its application and its understanding among investors.

The technical analysis will differentiate itself from the fundamentalist analysis, especially because the technical analysis takes into account only the supply and demand factors of the domestic market. It's actually a study on the prices behavior aiming at identifying moments of purchasing and selling.

Such analyzes are carried out through Charts that can be of Line, Volume, Bars, Point and Figure, and last, the *candlesticks* Charts. Technical indicators are also used.

One of the fastest growing sections in the studies of technical analysis is the use of Artificial Neural Networks (ANN) for time series predictions and therefore, the achievement of greater success to identify the optimum time for purchasing and selling stocks, as well as to earn better profitability in the marketplace.

2.3.1 Artificial Neural Network

Haykin (1999) states that the neural network is "a processor distributed in a massive and parallel way, consisting of simple processing units that have a natural tendency for storing experimental knowledge and making it available for use." Also according to the author, it resembles the human brain in two respects:

- 1) knowledge is acquired by the network as from its environment through a learning process;
- 2) strength of connections between neurons (the synaptic weights) is used to store the acquired knowledge.

The artificial neurons that "copy" the biological neurons way of operation in the human brain are the base of a neural network. The entries (inputs) to the neurons come through the dendrites. These, in turn, can also act as exits (outputs) interconnecting the neurons. Mathematically, the dendrites would be the total sum. The axons on the other hand, only found in the output cells, have a synaptic function - when active, they transmit an electrical signal - and are also responsible for connecting the other neurons through their dendrites.

The ANNs are best understood when these three concepts are well known:

- 1) algorithm: characterized as a routine for a computational process, it consists of a series of primitive operations, properly interconnected, on a set of objects;
- 2) *perceptron*: network with neurons disposed in layers. The neurons learn to respond "1" when it is true and "0" when it is false, according to the inputs;
- 3) *feedforward* networks: Consist of perceptrons with several layers, where the knots are directly connected to the inputs and outputs, generating the feedback.

2.3.2 Marangoni's ANN

This article will use the tool developed by Marangoni (2010), after obtaining some data needed for its implementation, the *inputs*.

- For didactic purposes, the stocks analyzed will be with referenced in this section as *share*:
 - a) daily closing price of the share, related to one hundred days prior to the date zero;
 - b) business amount of the share, referring to one hundred days prior to the date zero;

- c) trading volume of the share, referring to one hundred days prior to the date zero;
- d) total number of Ibovespa trades, referring to one hundred days prior to the date zero;
- e) business volume in Ibovespa, referring to one hundred days prior to the date zero;
- f) IBOV, referring to one hundred days prior to the date zero;
- g) negotiability index;
- h) Roc3;
- i) Roc10;
- j) Rsi14;
- k) %r (14).

After obtaining these data, these values are normalized to the range between -1 and 1 for understanding the network. Moreover, it is used the simple moving averages in some predictions as proposed by Murphy (1999), to identify points of input and output through the crossings of these averages. The next step is the application of an ANN *multilayer perceptron* with a two layers type *backpropagation*.

This ANN uses the following parameters:

- 1) Day of forecast: 20;
- 2) days for training and validation: 100;
- 3) neurons: 30;
- 4) Layers 2 (one hidden);
- 5) term of *momentum*: 0.6;
- 6) training seasons (iterations): 10,000;
- 7) MSE: 10^{-10} ;
- 8) Estimated R^2 : 1.

Marangoni's tool has the ability to predict 20 future quotations of daily closing price.

3 METHODOLOGY

As for the approach of the problem, it was used the quantitative research because such research uses the procedures for collecting information and also for their treatments. Richardson (1999, p. cited for 70 Beuren, 2006, p. 92) emphasizes that the quantitative approach is characterized by the use of quantification both in terms of gathering information, and in terms of their treatment through statistical techniques, as from the most simple as percentage, mean, standard deviation, to the most complex, such as correlation coefficient, regression analysis, etc..

The quantitative research typically shows itself as suitable when there is the possibility of quantifiable measure of variables and inferences as from a population sample, using specific instruments. This type of research uses numerical measurements to test scientific data and hypotheses, or to seek numerical patterns related to everyday concepts (Gil, 1999).

The data will be analyzed quantitatively. According to Chizzotti (2000), the quantitative analysis provides the measurement of predetermined variables, trying to verify and explain their influence on other variables, by analyzing the frequency of incidences and statistical correlations. The researcher describes, explains and predicts.

The data for the program operation will be obtained through research in database of Economática ®. After gathering the data, mentioned here in the theoretical foundations, they are standardized, tabulated and classified. From then on, it is made the relation and assembly of inputs required for running the network developed by Marangoni (2010), reproduced in computational software called MATLAB, R2010a model.

After execution quotations were found for 20 days, which characterizes short-term investments. These predictions will be conflicted with the real market behavior having as zero date the 1st of January, 2011.

The tool was applied in the 10 most important Ibovespa shares of the first four months of 2011. At the time of the survey, the TOP 10 of Ibovespa were the following: PETR4, OGXP3, VALE5, ITUB4, BVMF3, GGBR4, PETR3, BBDC4, USIM5 and BBAS3.

The expected and the actual profitability will then be calculated with the aid of appropriate formulas of Finance Mathematics and the HP12C calculator.

The theory of investment analysis suggests that investors deposit their funds measuring the relationship between risk and return.

Thus, they will invest in a stock that will provide the best return, being this consistent with the degree of risk they want to assume. From the perspective of ANN use, the investors' decision will be the stock that offers the highest profitability.

On the other hand, based on the market efficiency hypothesis, it is expected that the most profitable stocks are those having a low liquidity.

Nevertheless, this study seeks to establish the relationship between the tool developed by Marangoni and the market efficiency hypothesis.

4 RESULTS ACHIEVED

Table 1: Results PETR4

PETR4		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 27,00	R\$ 27,29
04/01/2011	R\$ 26,90	R\$ 27,17
05/01/2011	R\$ 27,22	R\$ 26,92
06/01/2011	R\$ 27,11	R\$ 26,79
07/01/2011	R\$ 26,73	R\$ 26,73
10/01/2011	R\$ 26,98	R\$ 26,97
11/01/2011	R\$ 27,15	R\$ 27,35
12/01/2011	R\$ 27,90	R\$ 27,24
13/01/2011	R\$ 27,31	R\$ 26,96
14/01/2011	R\$ 27,55	R\$ 26,99
17/01/2011	R\$ 27,45	R\$ 27,25
18/01/2011	R\$ 27,72	R\$ 27,41
19/01/2011	R\$ 27,30	R\$ 27,44
20/01/2011	R\$ 27,27	R\$ 27,42
21/01/2011	R\$ 27,05	R\$ 27,56
24/01/2011	R\$ 27,00	R\$ 27,36
26/01/2011	R\$ 26,83	R\$ 27,13
27/01/2011	R\$ 26,87	R\$ 27,35
28/01/2011	R\$ 26,67	R\$ 27,36
31/01/2011	R\$ 27,09	R\$ 27,43
01/02/2011	R\$ 27,64	R\$ 27,22
Rentabilidade	1,28%	-0,24%

Source: Authors' calculations

Table 2: Results VALE5

VALE5		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 48,20	R\$ 48,20
04/01/2011	R\$ 49,60	R\$ 50,81
05/01/2011	R\$ 50,52	R\$ 52,11
06/01/2011	R\$ 51,25	R\$ 52,76
07/01/2011	R\$ 51,01	R\$ 52,99
10/01/2011	R\$ 50,59	R\$ 51,85
11/01/2011	R\$ 50,74	R\$ 50,72
12/01/2011	R\$ 51,15	R\$ 51,14
13/01/2011	R\$ 52,10	R\$ 52,28
14/01/2011	R\$ 51,93	R\$ 52,84
17/01/2011	R\$ 52,23	R\$ 51,77
18/01/2011	R\$ 52,86	R\$ 50,68
19/01/2011	R\$ 53,41	R\$ 50,14
20/01/2011	R\$ 52,68	R\$ 49,87
21/01/2011	R\$ 52,12	R\$ 49,73
24/01/2011	R\$ 52,51	R\$ 50,87
26/01/2011	R\$ 52,74	R\$ 51,76
27/01/2011	R\$ 52,46	R\$ 50,70
28/01/2011	R\$ 52,10	R\$ 51,29
31/01/2011	R\$ 51,05	R\$ 51,11
01/02/2011	R\$ 50,99	R\$ 52,26
Profitability	5,78%	8,41%

Source: Authors' calculations

Table 3: Results OGXP3

OGXP3		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 20,00	R\$ 20,00
04/01/2011	R\$ 20,03	R\$ 20,38
05/01/2011	R\$ 20,15	R\$ 19,22
06/01/2011	R\$ 20,60	R\$ 18,29
07/01/2011	R\$ 20,67	R\$ 17,89
10/01/2011	R\$ 20,75	R\$ 18,71
11/01/2011	R\$ 20,75	R\$ 18,73
12/01/2011	R\$ 20,33	R\$ 18,87
13/01/2011	R\$ 20,31	R\$ 18,49
14/01/2011	R\$ 20,00	R\$ 18,63
17/01/2011	R\$ 20,00	R\$ 18,97
18/01/2011	R\$ 19,78	R\$ 19,86
19/01/2011	R\$ 19,87	R\$ 19,79
20/01/2011	R\$ 20,11	R\$ 19,47
21/01/2011	R\$ 19,65	R\$ 19,70
24/01/2011	R\$ 18,77	R\$ 19,39
26/01/2011	R\$ 18,15	R\$ 19,58
27/01/2011	R\$ 18,93	R\$ 19,41
28/01/2011	R\$ 18,19	R\$ 19,94
31/01/2011	R\$ 17,96	R\$ 20,34
01/02/2011	R\$ 17,21	R\$ 20,25
Profitability	-13,95%	1,25%

Source: Authors' calculations

Table 4: Results ITUB4

ITUB4		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 39,13	R\$ 35,20
04/01/2011	R\$ 39,25	R\$ 36,50
05/01/2011	R\$ 39,56	R\$ 37,16
06/01/2011	R\$ 40,16	R\$ 37,27
07/01/2011	R\$ 39,21	R\$ 37,54
10/01/2011	R\$ 38,25	R\$ 37,67
11/01/2011	R\$ 38,56	R\$ 37,35
12/01/2011	R\$ 38,79	R\$ 35,92
13/01/2011	R\$ 39,81	R\$ 36,10
14/01/2011	R\$ 38,94	R\$ 36,21
17/01/2011	R\$ 39,18	R\$ 37,01
18/01/2011	R\$ 38,63	R\$ 36,57
19/01/2011	R\$ 38,13	R\$ 36,58
20/01/2011	R\$ 37,72	R\$ 36,11
21/01/2011	R\$ 36,80	R\$ 36,33
24/01/2011	R\$ 36,81	R\$ 36,06
26/01/2011	R\$ 37,07	R\$ 36,05
27/01/2011	R\$ 36,55	R\$ 36,59
28/01/2011	R\$ 36,70	R\$ 36,24
31/01/2011	R\$ 35,90	R\$ 35,70
01/02/2011	R\$ 35,20	R\$ 36,75
Profitability	-10,04%	-6,09%

Source: Authors' calculations

Table 5: Results BVMF3

BVMF3		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 13,37	R\$ 11,62
04/01/2011	R\$ 13,40	R\$ 11,81
05/01/2011	R\$ 13,09	R\$ 11,90
06/01/2011	R\$ 13,29	R\$ 11,68
07/01/2011	R\$ 12,96	R\$ 11,84
10/01/2011	R\$ 13,02	R\$ 11,51
11/01/2011	R\$ 12,57	R\$ 11,59
12/01/2011	R\$ 12,61	R\$ 11,56
13/01/2011	R\$ 12,22	R\$ 11,61
14/01/2011	R\$ 12,37	R\$ 11,61
17/01/2011	R\$ 12,42	R\$ 11,76
18/01/2011	R\$ 12,19	R\$ 11,54
19/01/2011	R\$ 12,01	R\$ 11,53
20/01/2011	R\$ 11,92	R\$ 11,33
21/01/2011	R\$ 11,95	R\$ 11,15
24/01/2011	R\$ 12,19	R\$ 11,06
26/01/2011	R\$ 12,13	R\$ 11,42
27/01/2011	R\$ 12,01	R\$ 11,31
28/01/2011	R\$ 11,85	R\$ 11,37
31/01/2011	R\$ 11,62	R\$ 11,49
01/02/2011	R\$ 11,86	R\$ 11,63
Profitability	-9,44%	-11,22%

Source: Authors' calculations

Table 6: Results GGBR4

GGBR4		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 22,67	R\$ 21,35
04/01/2011	R\$ 23,13	R\$ 21,60
05/01/2011	R\$ 23,81	R\$ 21,72
06/01/2011	R\$ 23,95	R\$ 21,89
07/01/2011	R\$ 24,04	R\$ 22,62
10/01/2011	R\$ 24,08	R\$ 22,64
11/01/2011	R\$ 23,75	R\$ 22,71
12/01/2011	R\$ 23,94	R\$ 22,49
13/01/2011	R\$ 24,73	R\$ 22,24
14/01/2011	R\$ 24,32	R\$ 22,11
17/01/2011	R\$ 24,20	R\$ 22,24
18/01/2011	R\$ 23,91	R\$ 22,22
19/01/2011	R\$ 23,94	R\$ 22,36
20/01/2011	R\$ 23,22	R\$ 23,14
21/01/2011	R\$ 22,75	R\$ 22,50
24/01/2011	R\$ 22,58	R\$ 22,87
26/01/2011	R\$ 22,50	R\$ 22,90
27/01/2011	R\$ 22,08	R\$ 22,89
28/01/2011	R\$ 21,70	R\$ 22,38
31/01/2011	R\$ 21,00	R\$ 23,05
01/02/2011	R\$ 21,35	R\$ 23,54
Profitability	-5,82%	3,84%

Source: Authors' calculations

Table 7: ResultsPETR3

PETR3		
Date Data	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 30,30	R\$ 30,55
04/01/2011	R\$ 30,06	R\$ 30,10
05/01/2011	R\$ 30,63	R\$ 30,05
06/01/2011	R\$ 30,45	R\$ 30,11
07/01/2011	R\$ 30,00	R\$ 29,94
10/01/2011	R\$ 30,21	R\$ 29,96
11/01/2011	R\$ 30,50	R\$ 30,20
12/01/2011	R\$ 31,47	R\$ 30,10
13/01/2011	R\$ 30,50	R\$ 29,72
14/01/2011	R\$ 30,77	R\$ 29,79
17/01/2011	R\$ 30,47	R\$ 30,04
18/01/2011	R\$ 30,95	R\$ 30,19
19/01/2011	R\$ 30,14	R\$ 30,49
20/01/2011	R\$ 30,10	R\$ 30,86
21/01/2011	R\$ 29,87	R\$ 30,57
24/01/2011	R\$ 30,01	R\$ 30,41
26/01/2011	R\$ 29,50	R\$ 30,46
27/01/2011	R\$ 29,61	R\$ 30,64
28/01/2011	R\$ 29,35	R\$ 30,50
31/01/2011	R\$ 30,05	R\$ 30,14
01/02/2011	R\$ 30,69	R\$ 29,94
Profitability	0,46%	-2,00%

Source: Authors' calculations

Table 8: Results BBDC4

BBDC4		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 32,90	R\$ 32,51
04/01/2011	R\$ 33,20	R\$ 32,02
05/01/2011	R\$ 33,82	R\$ 32,07
06/01/2011	R\$ 32,93	R\$ 31,99
07/01/2011	R\$ 32,37	R\$ 32,85
10/01/2011	R\$ 32,43	R\$ 32,12
11/01/2011	R\$ 32,60	R\$ 32,46
12/01/2011	R\$ 33,23	R\$ 31,90
13/01/2011	R\$ 32,83	R\$ 31,64
14/01/2011	R\$ 33,13	R\$ 32,12
17/01/2011	R\$ 32,68	R\$ 31,91
18/01/2011	R\$ 32,71	R\$ 31,66
19/01/2011	R\$ 32,32	R\$ 31,68
20/01/2011	R\$ 31,74	R\$ 31,18
21/01/2011	R\$ 31,48	R\$ 31,59
24/01/2011	R\$ 31,97	R\$ 32,71
26/01/2011	R\$ 31,78	R\$ 33,26
27/01/2011	R\$ 31,91	R\$ 33,20
28/01/2011	R\$ 31,15	R\$ 32,57
31/01/2011	R\$ 30,68	R\$ 32,78
01/02/2011	R\$ 30,72	R\$ 31,87
Profitability	-5,50%	-1,99%

Source: Authors' calculations

Table 9: Results USIM5

USIM5		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 39,13	R\$ 39,13
04/01/2011	R\$ 39,25	R\$ 37,41
05/01/2011	R\$ 39,56	R\$ 38,78
06/01/2011	R\$ 40,16	R\$ 39,44
07/01/2011	R\$ 39,21	R\$ 39,45
10/01/2011	R\$ 38,25	R\$ 38,41
11/01/2011	R\$ 38,56	R\$ 38,42
12/01/2011	R\$ 38,79	R\$ 38,86
13/01/2011	R\$ 39,81	R\$ 39,51
14/01/2011	R\$ 38,94	R\$ 39,04
17/01/2011	R\$ 39,18	R\$ 37,12
18/01/2011	R\$ 38,63	R\$ 36,16
19/01/2011	R\$ 38,13	R\$ 35,73
20/01/2011	R\$ 37,72	R\$ 35,93
21/01/2011	R\$ 36,80	R\$ 36,67
24/01/2011	R\$ 36,81	R\$ 38,03
26/01/2011	R\$ 37,07	R\$ 38,48
27/01/2011	R\$ 36,55	R\$ 38,50
28/01/2011	R\$ 36,70	R\$ 39,33
31/01/2011	R\$ 35,90	R\$ 39,47
01/02/2011	R\$ 35,20	R\$ 39,43
Profitability	-10,04%	0,77%

Source: Authors' calculations

Tabela 10: Resultados BBAS3

BBAS3		
Date	Closing Value (Actual)	Closing Value (Network Prediction)
03/01/2011	R\$ 27,29	R\$ 27,29
04/01/2011	R\$ 27,00	R\$ 27,04
05/01/2011	R\$ 26,90	R\$ 26,85
06/01/2011	R\$ 27,22	R\$ 26,84
07/01/2011	R\$ 27,11	R\$ 27,01
10/01/2011	R\$ 26,73	R\$ 26,95
11/01/2011	R\$ 26,98	R\$ 26,90
12/01/2011	R\$ 27,15	R\$ 26,79
13/01/2011	R\$ 27,90	R\$ 27,00
14/01/2011	R\$ 27,31	R\$ 27,12
17/01/2011	R\$ 27,55	R\$ 27,02
18/01/2011	R\$ 27,45	R\$ 26,84
19/01/2011	R\$ 27,72	R\$ 27,02
20/01/2011	R\$ 27,30	R\$ 26,84
21/01/2011	R\$ 27,27	R\$ 27,15
24/01/2011	R\$ 27,05	R\$ 27,31
26/01/2011	R\$ 27,00	R\$ 27,60
27/01/2011	R\$ 26,83	R\$ 27,14
28/01/2011	R\$ 26,87	R\$ 26,99
31/01/2011	R\$ 26,67	R\$ 26,92
01/02/2011	R\$ 27,09	R\$ 26,93
Profitability	-0,73%	-1,32%

Source: Authors' calculations

The Tables 1-10 show that the values found by the network and the actual closing price elapsed according to the corresponding date. It appears that the model in fact is more useful to predict times of raising and falling (entrance and exit from the market) i.e., the model is more useful for predicting time of purchasing and sale than to measure the expected return of a given assets portfolio in its *target* time.

When the efficient market hypothesis is assumed, where investors have access to information and such information are reflected in the prices, the model finds upward trend lines (UTL) and downward trend lines (DTL).

Chart 2 compares the actual and the predicted by the model for better visualization. In this case, the shares VALE5 were picked up for having the best profitability of the portfolio studied.

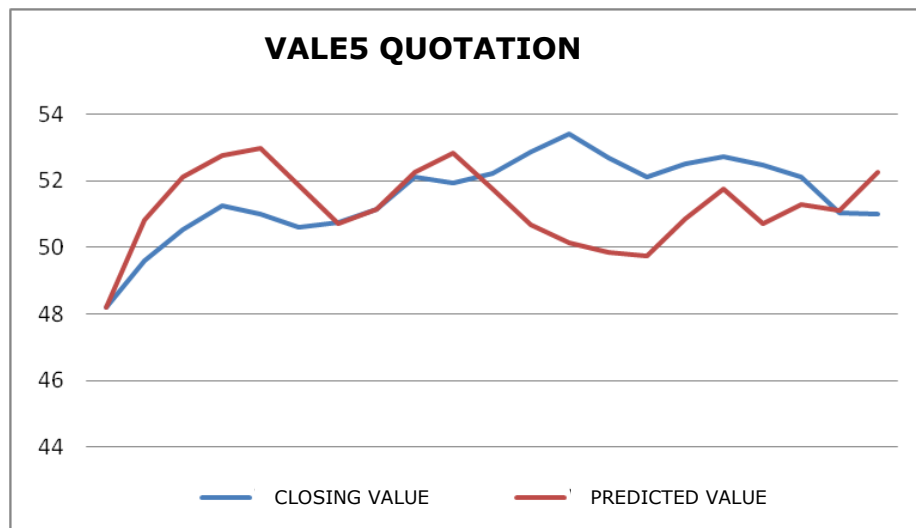


Table 2: Quotations VALE5

Source: Authors' calculations

Notice that the model is able to identify the trends that actually occurred in the market. In short-term operations, in the case of VALE5, the model was able to visualize a profitability, for the period of 30 consecutive days, very close to what actually happened, which in this case would serve as an important tool for the investors, generating a good chance to succeed in their applications.

After the analysis, the prediction that came closest was the BVMF3 share. According to the data from all the tables shown above, it is possible to calculate

the deviations between the predicted and the actual of each share, in percentage terms, by presenting them.

Actual Profitability vs Predicted Profitability			
Share	Actual Profitability	Predicted Profitability	Variation Actual vs Predicted
BBAS2	-0,73%	-1,32%	80,49%
VALE5	5,78%	8,41%	45,62%
BVMF3	-9,44%	-11,22%	18,80%
ITUB4	-10,04%	-6,09%	-39,40%
BBDC4	-5,50%	-1,99%	-63,89%
USIM5	-10,04%	0,77%	-107,63%
OGXP3	-13,95%	1,25%	-108,97%
PETR4	1,28%	-0,24%	-118,93%
GGBR4	-5,82%	3,84%	-165,88%
PETR3	0,46%	-2,00%	-536,17%

Table 11: Deviation of profitability calculations

Source: Authors' calculations.

Table 11 reveals that the model applicability has better results if used to know the trend lines and not the profitability. It is believed that in accordance with the market efficiency hypothesis in the long term such abnormalities are corrected. It is suggested that, for greater reliability, the tool is enhanced to predict larger series within a short term, reducing such deviations and thereby enhancing up and becoming more effective.

When analyzing the portfolio profitability it is expected a return higher than the other investments such as savings accounts, since the risk for this option over the other is greater. When the results come together, it was built up the suggested model table and what actually occurred.

Ideal Purchasing Sequence	
Purchasing Sequence using Net	Ideal Purchasing Sequence (Occurrence)
VALE5	VALE5
GGBR4	PETR4
OGXP3	PETR3
USIM5	BBAS3
PETR4	BBDC4
BBAS3	GGBR4
BBDC4	BVMF3
PETR3	USIM5
ITUB4	ITUB4
BVMF3	OGXP3

Table 12: Ideal Purchasing Sequence

Source: Authors' calculations.

According to the model, the share that should be chosen for investment in terms of profitability is VALE5, which predicts a return of 8.41% for the studied period. According to the information about what happened in the market, the profitability achieved was 5.78% in the period. Despite the high deviation between what happened and what model had predicted, taking into account the events and the other shares behavior, the model was right on the decision to invest. Table 12 shows the ideal and the predicted purchasing order. Notice that the model hits precisely the order of return of two shares (VALE5 and ITUB4).

According to the market efficiency hypothesis displayed on the theoretical reference of this article, the investor could also make investment decisions based on the liquidity of the shares that is composing the analyzed portfolio. To this end, Table 13 shows the liquidity in the 0 date.

IN – Studied Portfolio	
Share	IN
VALE5	0,833441344
PETR3	1,016396666
ITUB4	1,029927224
USIM5	1,029927224
BBAS3	1,041888278
PETR4	1,041888278
OGXP3	1,058231238
BBDC4	1,082664518
GGBR4	1,454883835
BVMF3	1,567452228

Table 13: IN of the portfolio studied

Source: Authors' calculations.

The market efficiency hypothesis assumes that the shares with the least liquidity will be the most profitable ones; therefore Table 13 classifies the purchase order in accordance with this hypothesis.

Table 14 presents the comparison between the ANN purchasing recommendations and the efficient market hypothesis tools.

Ideal Purchasing Sequence		
Purchasing Sequence using Net	Ideal Purchasing Sequence (Occurrence)	Purchasing Sequence (Efficient market hypothesis)
VALE5	VALE5	VALE5
GGBR4	PETR4	PETR3
OGXP3	PETR3	ITUB4
USIM5	BBAS3	USIM5
PETR4	BBDC4	BBAS3
BBAS3	GGBR4	PETR4
BBDC4	BVMF3	OGXP3
PETR3	USIM5	BBDC4
ITUB4	ITUB4	GGBR4
BVMF3	OGXP3	BVMF3

Table 14: Sequence of ideal purchasing 2 models *versus* occurred

Source: Authors' calculations.

Notice that both the ANN tool and the tool based on the market efficiency hypothesis were right when in their prediction they identified VALE5 as the most profitable share.

FINAL REMARKS

It is important to notice that, in two other shares, the models showed exactly the same prediction (USIM5 and BVMF3) and that in two others, only the positions were reversed (PETR4 and BBAS3). This enables to conclude a ratio of 50% of accuracy between the ANN and the market efficiency hypothesis.

The purpose of the study was to evidence that the use of artificial neural networks for the stock market presents itself as an additional tool among many other that already exist for such analyzes.

However, as mentioned, the investor will always make a relation between the risks and the returns of the shares he will invest in. The model is limited to consider only quantitative variables, disregarding the investor's substantive thought and action. To this end, the perspective is that, in the future, if the tool

is consolidated, we can mix the use of ANN's with studies in behavioral finance to verify the investor's acceptability in the face of this methodology.

REFERÊNCIAS

- Assaf Neto, A. (1999). *Mercado financeiro* (2a ed.). São Paulo: Atlas.
- Beuren, Ilse Maria. Colauto, Romualdo Douglas; Coleta, análise e interpretação dos dados. In. Beuren, Ilse Maria. (Org). *Como elaborar trabalhos monográficos em contabilidade*. 3.ed. São Paulo: Atlas, 2006.
- Brealey, R. A., Myers, S. C. & Allen, F. (2008). *Principles of corporate finance* (8th ed.), 304. New York: McGraw-Hill.
- Cartacho, M. S. (2001). *A utilização de um modelo híbrido algoritmo genético/redes neurais no processo de seleção de carteiras*. Dissertação de Mestrado, Faculdade de Ciências Econômicas da Universidade Federal de Minas Gerais, Belo Horizonte: MG.
- Chizzotti, Antônio. *Pesquisa em ciências humanas e sociais*. São Paulo: Cortez, 2000.
- Fama, E. F. (1970, May). Efficient capital markets: a review of theory and empirical work. *Journal of Finance*, 25(2), 383-417.
- Freitas, S. O. *Utilização de um modelo baseado em redes neurais para a precificação de opções*. (2001). Dissertação de Mestrado, Faculdade de Ciências Econômicas da Universidade Federal de Minas Gerais, Belo Horizonte: MG.
- Gil, A.C. *Métodos e técnicas de pesquisa social*. 5. ed. São Paulo: Atlas, 1999.
- Gitman, L. J. (2010). *Princípios de administração financeira* (12a ed.). São Paulo: Pearson.
- HAYKIN, Simon. *Redes Neurais – Princípios e Práticas*. 2ed, 59. São Paulo: Pearson,1999.
- Leal, R. P. C., Oliveira, J. & Soluri, A. F. (2003, janeiro/março). Perfil da pesquisa em finanças no Brasil. *Revista de Administração de Empresas*, 43(1), 91-104.
- Kendall, M. G. Hill, A. B. The Analysis of Economic Time-Series-Part I: Prices. *Journal of the Royal Statistical Society. Series A (General)*, Volume 116, Issue I (1953), 11-34.

Keynes, J. M. (1983). *A teoria geral do emprego do juro e da moeda*. São Paulo: Abril Cultural.

Marangoni, P. H. (2010). *Redes neurais artificiais para previsão de séries temporais no Mercado acionário*. Monografia de conclusão de curso, Universidade Federal de Santa Catarina, Florianópolis: SC.

Markowitz, H. Portfolio Selection.. *The Journal of Finance*, Vol. 7, No. 1. (Mar., 1952), pp. 77-91. Murphy, J. J. (1999). *Technical analysis of the financial market*. New York: New York Institute of Finance.

Pinheiro, J. L. (2009). *Mercado de capitais: fundamentos e técnicas* (5a ed.), 456. São Paulo: Atlas.

Ross, S. A.; Westerfield, R. W. & Jaffe, J. F. (2007). *Administração financeira*. São Paulo: Atlas.

Sharpe, William F. 1964. "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk." *Journal of Finance*. 19:3, pp. 425-442