PROGRAMA DE PÓS -GRADUAÇÃO EM ORGANIZAÇÕES E MERCADOS - MESTRADO EM ECONOMIA APLICADA

PPGOM

UFPEL

WORKING PAPER

08/2016

JULHO

Intrinsic value of brazilian financial stocks and monetary policy decisions: an agent-based approach

MARCELO DE OLIVEIRA PASSOS (PPGOM-UFPel)

RAFAELA MORTOLA (IFSUL)

JEAN RODRIGUES VENENCIAN (UFPel)

MATHEUS SALIES ALQUATI (PPGOM-UFPel)

Intrinsic value of brazilian financial stocks and monetary policy decisions: an agent-based approach

Marcelo de Oliveira Passos[1]
Rafaela Mortola[2]
Jean Rodrigues Venecian[3]
Matheus Salies Alquati[4]

Abstract: The purpose of this article is to describe and analyze the results of a model of multi-agent computational finance configured to estimate monthly time series of intrinsic values and stockholder surplus (STS) of the financial stocks of theoretical portfolio of the Ibovespa value. The STS series is a new value investing tool that helps in identifying and in measuring of situations of bear market and bull market. It may be quite useful, therefore, as a risk indicator. It may be quite useful for the detection and measurement of bubbles in stock markets, as well to estimate the effects of monetary policy decisions on performance of stocks and of sectors of capital market.
Keywords: stockholder surplus (STS), monetary policy, computational finance, valuation of stock market.
JEL Classification: C63, E52, G17.

- ✓ The research which resulted in this article was financed by Capes.

[1] Adjunct professor at Department of Economics and Master`s Program in Organizations and Markets/Applied Economics in Federal University of Pelotas (Universidade Federal de Pelotas -UFPel).
E-mail: profpassos@uol.com.br.
[2] Economist at Federal Institute of State of Rio Grande do Sul (IFSUL). E-mail: rafaelamortola@gmail.com.
[3] Master in Applied Economics - Master`s Program in Organizations and Markets Applied Economics - Federal University of Pelotas (Universidade Federal de Pelotas -UFPel). E-mail: jean.venecian@gmail.com.
[4] Master student at Master`s Program in Organizations and Markets Applied Economics - Federal University of Pelotas (Universidade Federal de Pelotas -UFPel). E-mail: malquati@yahoo.com.

"Financial assets are acquired by their expected cash flows."

Aswath Damodaran

"All intelligent investment is an investment in value - get more than what you paid. You should evaluate the business to evaluate the stock."

Daniel Kahnemann

1. Introduction

This article aims to estimate: (i) a series of 84 months with the intrinsic values of the financial companies' stocks that compound the Ibovespa index; (ii) develop the monthly series of stockholder surplus (STS), which is a new value investing index that helps in identifying and in measuring of situations of bearmarket and bullmarket.It may be quite useful, therefore, as a risk indicator.

In the second section of this paper, we make a brief review of the bottom-up approach and of the modelling of market process, two topics of Agent-Based Computational Economics (ACE).

The third section describes our stochastic and multi-agent computational finance model.

In the foutrh section, the mathematical model is used as the basis for the computational model's simulations, whose graphs are analyzed with emphasis on the effects of monetary policy decisions on the STS trajectory. So, in this section we present the results of the financial macroeconomic model of computational simulations based on heterogeneus agents for the period 2008 to 2014.

In the fifth section, we make the final considerations.

2. ACE, bottom-up approach and market process modelling

According Tesfatsion (2006), Agent-Based Computational Economics (ACE) is the computational research of economic systems (understood as complex or not) that are modeled based on autonomous agents that interact and evolve. From initial conditions specified by the modeler, this system or computational economy evolves over time to the extent that its agents repeatedly interact with each other and learn from these interactions. ACE is therefore a bottom-up approach rather than top-down, like most modeling methodologies adopted in Economics. Araújo (2011) considers that:

> "The modeling of economic agents or Agent-Based Computational Economics (ACE) is the best known part of the Computational Economics. The Computational Economics is of course wider than the area of modeling economic agents. Into the first, one can include all approaches that use computing resources (technical, languages or tools) to solve problems of economic nature. Into the second, besides the intensive use of computing resources, must be present at least two characteristics: i) the development of models that reproduce the behavior of a set of elements (economic agents) and ii) the possibility of replicating this behavior whenever the model is run again. [...] Because of these characteristics, the modeling of agents is the Computational Economics component that comes closest to a laboratory approach; where each model execution simulates the behavior of a society. " (Araújo, 2011, p. 219).

The analysis of the self-organizing capacity of specific types of market processes is today one of the most active areas of research in ACE. This research has focus on the following types of markets: financial; electricity; work; retail; wholesale; entertainment and e-commerce. In his seminal article, Marks (1998) was one of the first researchers to use an ACE structure to address the issue of self-organization of the market. His research highlights for economists the potential importance of history, the interactions and learning as mechanisms capable to determining the strategic market outcomes. Marks has used an ACE model of an oligopolistic market to analyze how the sellers and fixing prices companies can compete successfully. His model used a genetic algorithm to model their companies as inductive learners with bounded rationality. Mutation and recombination operations were repeatedly applied to the set of pricing strategies used by companies as a way to allow the companies were able to try out new ideas (mutation) as well engage themselves in social mimicry (recombination), adopting the most profitable aspects of the strategies used

A result observed by Marks in his experiments was the emergence of a global optimum pricing capable to maximize joint companies without any existence of explicit collusion between the firms in this process.

At the time, this type of result of cooperation obtained through a bottom-up approach was new to many economists, since very few had read the Axelrod's (1984) seminal work on the subject.

Conventional models of financial markets based on rational choice and market efficiency assumptions are extremely rigorous and elegant in mathematical terms. Unfortunately, however, there is still no single model able to explain the basic empirical characteristics of real financial markets, including fat-tailed distributions of return on assets, higher trading volumes, the persistence and clustering in volatility return on assets, and also the cross-correlations between asset returns, trading volume and volatility.

Due largely to these well-known difficulties, financial markets have become a useful source to explain a number of observed regularities in financial data. Early studies of financial market ACE were developed by LeBaron (2000), including the influential model of the stock market developed in Santa Fe Institute by Arthur et al. (1997).

Another important study developed a dynamic theory of asset pricing based on heterogeneous traders who operated in stock market focusing on updating their price expectations individually and inductively through classifier systems (Holland, 1992).

Tay and Linn [94] hypothesized that there may be a better explanatory power in the financial models if the agents form their expectations according to how investors form their expectations in real life, ie, in a distorted way and using inductive reasoning. They argue that these features can be faithfully captured by a genetic-fuzzy classifier system, a modification of the classifier system based in Holland (1992). To test their theory, they have changed the market model of artificial stock of Santa Fe developed by Arthur, Holland, LeBaron et al. (1997), allowing traders to form their expectations inductively using a genetic-fuzzy classifier system and changing the way traders decided which prediction rules one could rely in a decision-making process. They described experimental findings showing that prices and returns on assets generated by your model, including the kurtosis measures, are very similar to real data.

Le Baron (2001) also wanted to get a better empirical fit of the model. He wanted to observe more accurately regularities in financial markets. He calibrated a computer model of the stock market based on agents and succeeded in adding macroeconomic and financial data. The vast majority of investors usually look past performance to assess the performance of its trading rules, but they also have different memories of different length. The vast majority of investors usually look past performance to assess the quality of its trading rules, but they also have memories of different length. A genetic algorithm is used to co-evolve the collection of trading rules available to the agents. The model was calibrated to incorporate growth and variability of dividend payments in the United States. LeBaron proved that the calibrated model generates returns, volume and volatility very similar to those that characterize the actual data of financial time series.

Chen and Yeh (2001) argued that social learning in the form of imitation strategies is important in the stock markets as well as individual learning. However, they also found that the pattern of the stock market models do not include the mechanisms by which such social learning actually occurs. They made an ACE framework for the analysis of artificial stock markets which includes a mechanism for additional social learning, which they called "school". Roughly speaking, this school is made up of a group of agents (eg, faculty members of business school) who are competing with each other to provide the public the best possible models for the prediction of stock returns. The success (adjustment) of the school's members is measured by the accuracy of the current forecast of its models, while the success of traders is measured in terms of their wealth. Roughly speaking, this school is made up of a group of agents (eg, faculty members of business school) who are competing with each other to provide the public the best possible models for the prediction of stock returns. The success (adjustment) of the school's members is measured by the accuracy of the current forecast of its models, while the success of traders is measured in terms of their wealth. Each trader chooses along the time between perform trade at market and take some time to attend school and test a sample of the forecast models currently proposed by school members. This test is done to try to find a model that is superior to what it is currently used. School members and traders co-evolve over time into a complex feedback loop. To test the implications of their stock market model, Chen and Yeh conducted an experiment with 14,000 periods of successive negotiations. An important finding is that the market behavior did not calm down because the forecast models that have had initial success quickly became obsolete, to the extent that they were adopted by a growing number of agents. Another important fact is that individual traders do not act as if they believe in the efficient market hypothesis, although the statistics of aggregate market suggest that the stock market is efficient.

3. Computational finance multi-agent stochastic model

3.1. Model Development

The model is deducted in four modules as described in the following subsections.

3.1.1 Module 1 - Cash flows from financial companies of Ibovespa

The model was developed using the Mathematica 9.0 software, to have greater ability to operate with symbolic mathematical calculations and Excel 2007 for its ability to solve simple models of intertemporal optimization based on one or more agents. According to Damodaran (2012), leveraged companies are best assessed on the basis of their free cash flow to the firm (FCFF)[5]. FCFF is derived from EBIT (earnings before interest and taxes). Table 1 shows how this process occurs, including their meaning and data source. The cash flows included in the model were extracted from 816 accounting statements[6] from 2008 through 2010.The cash flows

[55] Leveraged companies are those companies that use debt to finance their operations. They are not necessarily very debt-laden companies, but companies with any given burden of debt (Damodaran 2012 and Bisciari, Durré & Nyssen 2003).

[6] These data are the standardized financial statements available from the Brazilian Stock Market Regulatory Comission (Comissão de Valores Mobiliários/CVM) website.

for the two subsequent years (the 2011-2012 biennium) were estimated using the least squares method[7].

From the EBIT we have the cash flow, which will be equal to free cash flow of stockholders in the case of a non-leveraged company and will be greater than the flow of shareholders in the case of a leveraged company. The free cash flow in a non-leveraged company is the residual cash flow after the deduction of all financial needs of the company. However, the free cash flow of a leveraged firm is recorded when the company finances part of the fixed capital spending and working capital needs with debt, which reduces investment in equity.

Therefore, our model uses techniques of discounted cash flows (DCF) for leveraged companies, and its cash flows are computed from standard financial demonstrations.

Table 1 – Accounts used for cash flow calculation

Symbol	FCFF item	Meaning	Data source in period t and previous periods
(=)	NS_t	Net Sales Revenue in period t	Income Statement for period t
(-)	SC_t	Sales costs in t	Income Statement for period t
(-)	OE_t	Operating Expenses in t	Income Statement for period t
(=)	$EBIT_t$	Earning before income and taxes in period t	
(+)	Depreciation/Amortization	Depreciation/Amortization in t	Cash Flow Statement for period t
(-)	Income tax (IT) + social charges	Income Tax (IT) + Social Charges in t	Income Statement for period t
(=)	Operational cash generation	Operational Cash Generation in t	
(-)	Permanent current investiments (Working Capital)	Permanent Current Investments (Working Capital) in t	Income Statement and Balance Sheet for period t
=	$FCFF_t$	Free cash flow to the firm for period t	

Source: Adapted from Damodaran (2012), Abrams (2001) and McKinsey & Co. (2000). The methodology was adapted according to current accounting standards in Brazil.

3.1.2 Module 2 - intertemporal discount model

To project the cash flow of a company, the decision of how many periods or stages are necessary to achieve the perpetuity is a very important point. So that the volume of resulting cash inflows of new debt is calculated according to the company's position with respect to leverage. In this model, we employ only two stages. One for short and another for the long term. The model intends to estimate monthly all series of intrinsic values of financial companies that compound the Ibovespa índex and, that said, we begin with the formula of the first stage:

$$IV_A = \frac{FCFF_1}{(1+\mathrm{i}_{\mathrm{fut}}+\mathrm{rp}_1)} \quad (2)$$

[7] Excel 2007 was used to calculate the cash flows, and function PROJ.LIN was used to calculate the least squares.

Where IV_A is intrinsic value in the first stage; $FCFF_1$ 1 corresponds to free cash flow in this period; i_{fut} is the future interest rate (DI for one day and future contract maturing in T + 6) and rp_1 is the risk premium on future interest rate (i_{fut}). All variables are calculated on a quarterly basis.

In the second stage we consider that the net result of cash flows is equivalent to perpetuity. We assume that companies will have no extraordinary change in their productivity in the coming years. However, it should be remembered that the analyst should use common sense in the perpetuity, because there is no traditional parameter that fits to it as a perfect term.

The intertemporal discount formula of the second stage is:

$$IV_B = \frac{FCFF_3}{(rp_2 - g_n)/(1 + rp_1)^2} \quad (3)$$

Where: IV_B is the intrinsic value in the second stage; $FCFF_3$ corresponds to net free cash flow in the second stage, two quarters after the perpetuity period; rp_2 is the risk premium on the perpetuity; g_n is the growth rate after the end of year and perpetually. By inserting in the model the future interest rate DI (i_{fut}) we make the integration among financial data of cash flows, the expected monetary policy variable and the analyst's behavioral decision rules.

The stochastic component is embedded in the formation of expectations on g_n. Thus we have:

$$g_n = \left(\bar{b} \times i_{fut}\right) + \Upsilon \quad (4)$$

where: $\bar{b}$ is the average percentage of reinvestment (average percentage of reinvestment in capital assets as a proportion of the companies' cash flow). These percentages were calculated from their balance sheets available in the period 2005-2015 (ten-year sample) and Υ is a "shareholders' animal spirit" component, as described below.

$$b = \frac{\Delta I_{KF}}{FCFF_t} \quad (5)$$

And the variation of investment in fixed capital, in each period, is given by:

$$\Delta I_{KF} = IKF_t - IKF_{t-1}$$

Therefore, the average percentage of reinvestment for each period is:

$$\bar{b} = \sum_{t=1}^{n} \left(\frac{\Delta I_{KF}}{FCFF_t} \Big/ n \right)$$

The definition of an *animal spirit* component involves a non-stochastic part (expressed in brackets) and a stochastic another. This second part is obtained by Monte Carlo simulation, which generates pseudo-random numbers (defined by r and detailed later),

$$\Psi = \left[0,3\left(\frac{1}{\mathrm{P/E}} \right) + 0,2 \cdot WE + 0,2\left(\frac{1}{FIS/A} \right) + 0,3 \cdot ROE_{fs} \right] + \rho \quad (6)$$

where in each period, we have P/E as the price/earnings ratio of the company's share; WE as the wealth generated per employee (proxy for productivity); FIS/A as its financial intermediation income and services as a proportion of total assets (proxy for the volume of financial services); ROE_{fs} as the return on equity of the financial sector and r as the random component.

This random component is estimated by a Monte Carlo simulation that uses the following algorithm applied to *Mathematica 9.0*[8]:

$$RandomReal\ [\{ckmin, ckmax\}] \quad (7)$$

An alternative to Excel users would use the formula:

$$RAND()^* \, g_{max} - g_{min} + g_{min} \quad (7a)$$

Where: *RandomReal[ ]* is a *Mathematica 9.0* function that computes a random real number comprised in an interval; *Rand ()* is an Excel function that generates a pseudo-random number comprised in the interval [0,1]; g_{max} is the maximum growth rate of the stockholder surplus (STS); g_{min} is the minimum rate of this growth. In Table 1, on page 15, these rates are presented as the initial parameters of the model's Monte Carlo simulations.

3.1.3 Module 3 - intrinsic value and stockholder surplus of the theoretical portfolio of Ibovespa

This module considers the intrinsic value of the company and the Ibovespa theoretical portfolio, as well the value of stockholder surplus. Adding the intrinsic values of the two stages, we have the monthly intrinsic value for a company:

$$IV_A + IV_B = \sum_{t=1}^{n} \frac{FCFF_t}{(1 + i_{fut} - rp_1)} + \frac{FCFF_{n+1}}{(rp_2 - g_n)/(1 + rp_1)^2} \quad (8)$$

With the methodology described in the model, we generated a panel with 504 results from intrinsic values.

The stockholder surplus (STS), an innovative concept developed in this article, is derived from a monthly time series. This series consists in the difference between the estimated intrinsic values and the market values that make up the theoretical portfolio of the Ibovespa, as the matrix equation shows:

$$STS_{(6\times1)} = \begin{bmatrix} STS_1^1 \\ STS_1^2 \\ \vdots \\ STS_1^6 \end{bmatrix}_{(6\times1)} = \begin{bmatrix} IV_1^1 \\ IV_1^2 \\ \vdots \\ IV_1^6 \end{bmatrix}_{(6\times1)} - \begin{bmatrix} MV_1^1 \\ MV_1^2 \\ \vdots \\ MV_1^6 \end{bmatrix}_{(6\times1)} \quad (9)$$

---

[8] Some useful sources about Mathematica and its use in economics: Blachman (1992), Varian (1993), Kendrick, Mercado & Amman (2005) and Stinespring (2002).

Where: $STS_{(6x1)}$ is the stockholder surplus; $IV_{(6x1)}$ is the intrinsic value and $MV_{(6x1)}$ corresponds to the market value of six financial stocks that make up the the Ibovespa index. All of these variables are calculated for 1 month, represented by columns vectors.

As we can see in the array, the months are in rows and the monthly intrinsic values of the stocks are in columns. The stockholder surplus is the subtraction of such values of each row vector. As shown in the equation, in a aggregated perspective we have:

$$STS_{(6\times 84)} = \begin{bmatrix} STS_1^1 & STS_2^1 & \cdots & STS_{84}^1 \\ STS_1^2 & STS_2^2 & \cdots & STS_{84}^2 \\ \vdots & \vdots & \ddots & \vdots \\ STS_1^6 & STS_2^6 & \cdots & STS_{84}^6 \end{bmatrix}_{(6\times 84)} = \begin{bmatrix} IV_1^1 & IV_2^1 & \cdots & IV_{84}^1 \\ IV_1^2 & IV_2^2 & \cdots & IV_{84}^2 \\ \vdots & \vdots & \ddots & \vdots \\ IV_1^6 & IV_2^6 & \cdots & IV_{84}^6 \end{bmatrix}_{(6\times 84)} - \begin{bmatrix} MV_1^1 & MV_2^1 & \cdots & MV_{84}^1 \\ MV_1^2 & MV_2^2 & \cdots & MV_{84}^2 \\ \vdots & \vdots & \ddots & \vdots \\ MV_1^6 & MV_2^6 & \cdots & MV_{84}^6 \end{bmatrix}_{(6\times 84)}$$

Highlighting the result of stockholder surplus matrix and using an alternative notation, we have:

$$STS_{(6x84)} = IV_{(6x84)} - MV_{(6x84)} (10)$$

Where:

$$STS_{(6\times 84)} = \begin{bmatrix} IV_1^1 - MV_1^1 & IV_2^1 - MV_2^1 & \dots & IV_{84}^1 - MV_{84}^1 \\ IV_1^2 - MV_1^2 & IV_2^2 - MV_2^2 & \dots & IV_{84}^2 - MV_{84}^2 \\ \vdots & \vdots & \ddots & \vdots \\ IV_1^6 - MV_1^6 & IV_2^6 - MV_2^6 & \dots & IV_{84}^6 - MV_{84}^6 \end{bmatrix}_{(6\times 84)} \quad (11)$$

Inserting equation (8) in (11) and omitting the second column of the above equation we obtain (12).

$$STS_{(6\times 84)} = \begin{bmatrix} \sum_{t=1}^{1} \frac{FCFF_1^1}{(1+i_{fut} - rp_{1,1})} + \frac{FCFF_3^1}{(rp_{2,1} - g_{n,1,1})/(1+rp_{1,1})^2} - MV_1^1 & \dots & \dots & \sum_{t=1}^{1} \frac{FCFF_1^1}{(1+i_{fut} - rp_{1,84})} + \frac{FCFF_3^1}{(rp_{2,84} - g_{n,84,1})/(1+rp_{1,84})^2} - MV_{84}^1 \\ \sum_{t=1}^{1} \frac{FCFF_1^2}{(1+i_{fut} - rp_{1,1})} + \frac{FCFF_3^2}{(rp_{2,1} - g_{n,1,2})/(1+rp_{1,1})^2} - MV_1^2 & \dots & \dots & \sum_{t=1}^{1} \frac{FCFF_1^2}{(1+i_{fut} - rp_{1,84})} + \frac{FCFF_3^2}{(rp_{2,84} - g_{n,84,2})/(1+rp_{1,84})^2} - MV_{84}^2 \\ \vdots & \dots & \ddots & \vdots \\ \sum_{t=1}^{1} \frac{FCFF_1^6}{(1+i_{fut} - rp_{1,1})} + \frac{FCFF_3^6}{(rp_{2,1} - g_{n,1,6})/(1+rp_{1,1})^2} - MV_1^6 & \dots & \dots & \sum_{t=1}^{1} \frac{FCFF_1^6}{(1+i_{fut} - rp_{1,84})} + \frac{FCFF_3^6}{(rp_{2,84} - g_{n,84,6})/(1+rp_{1,84})^2} - MV_{84}^6 \end{bmatrix} \quad (12)$$

We partition the matrix (12) in the following row vectors:

$$STS^1_{(1\times 84)} = \left[\sum_{t=1}^{1}\frac{FCFF^1_1}{(1+i_{fut}-rp_{1,1})}+\frac{FCFF^1_3}{(rp_{2,1}-g_{n,1,1})/(1+rp_{1,1})^2}-MV^1_1 \quad \ldots \quad \sum_{t=1}^{1}\frac{FCFF^1_1}{(1+i_{fut}-rp_{1,84})}+\frac{FCFF^1_3}{(rp_{2,84}-g_{n,84,6})/(1+rp_{1,84})^2}-MV^1_{84}\right]_{(1\times 84)}$$

$$STS^1_{(1\times 84)} = \left[\sum_{t=1}^{1}\frac{FCFF^2_1}{(1+i_{fut}-rp_{1,1})}+\frac{FCFF^2_3}{(rp_{2,1}-g_{n,1,2})/(1+rp_{1,1})^2}-MV^2_1 \quad \ldots \quad \sum_{t=1}^{1}\frac{FCFF^1_1}{(1+i_{fut}-rp_{1,84})}+\frac{FCFF^1_3}{(rp_{2,84}-g_{n,84,6})/(1+rp_{1,84})^2}-MV^2_{84}\right]_{(1\times 84)} \quad (13)$$

$$STS^1_{(1\times 84)} = \left[\sum_{t=1}^{1}\frac{FCFF^6_1}{(1+i_{fut}-rp_{1,1})}+\frac{FCFF^6_3}{(rp_{2,1}-g_{n,1,6})/(1+rp_{1,1})^2}-MV^6_1 \quad \ldots \quad \sum_{t=1}^{1}\frac{FCFF^1_1}{(1+i_{fut}-rp_{1,84})}+\frac{FCFF^1_3}{(rp_{2,84}-g_{n,84,6})/(1+rp_{1,84})^2}-MV^6_{84}\right]_{(1\times 84)}$$

Adding the row vectors of the matrix system (13) - that represent the six monthly series of the stockholder surplus of all financial stocks that compound the theoretical portfolio of Ibovespa - we get the monthly series of STS. Thus,

$$\sum_{t=1}^{6} STS_{(1\times 84)} = \left[STS^1_1+\ldots+STS^6_1 \quad STS^1_2+\ldots+STS^6_2 \quad \ldots \quad STS^1_{84}+\ldots+STS^6_{84}\right]_{(1\times 84)} \quad (14)$$

This series refers to the 84 months (seven years) of 2008-2014. Returning to STS and to the row vectors system (14), we have:

$$\sum_{t=1}^{6} STS_{(1\times 84)} = \left[(IV^1_1-MV^1_1)+\ldots+(IV^6_1-MV^6_1) \quad \ldots \quad (IV^1_{84}-MV^1_{84})+\ldots+(IV^6_{84}-MV^6_{84})\right] \quad (15)$$

3.1.4 Module 4 – elasticities of STS with respect to future interest rate

We can deduce from equations (12) and using the Mathematica9.0 software, the STS of elasticities.

By differentiating (12) with respect to i_{fut} , which is the rate of future interest (DI for a day and future contract maturing in t+6), we obtain the matrix equation (13). It shows the elasticities for future interest rates of the intrinsic values of each of the financial stocks of Ibovespa theoretical portfolio

$$\frac{\partial STS_{(6\times 84)}}{\partial i_{fut}} = \begin{bmatrix} \frac{FCFF^1_1}{(1+i_{fut,1,1}+rp_{1,1,1})^2} & \cdots & \cdots & \frac{FCFF^1_1}{(1+i_{fut,84,1}+rp_{1,84,1})^2} \\ \frac{FCFF^2_1}{(1+i_{fut,1,2}+rp_{1,1,2})^2} & \cdots & \cdots & \frac{FCFF^2_1}{(1+i_{fut,84,2}+rp_{1,84,2})^2} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{FCFF^6_1}{(1+i_{fut,1,6}+rp_{1,1,6})^2} & \cdots & \cdots & \frac{FCFF^6_1}{(1+i_{fut,84,6}+rp_{1,84,6})^2} \end{bmatrix}_{(6\times 84)} \quad (16)$$

Partitioning the matrix (16), we obtain the row vectors. They represent the trajectories of the elasticities of all financial stocks of the Ibovespa related to different levels of interest rates along 84 months. So that, adding the row vectors we achieve the first objective of this article, that is, to obtain the STS elasticity series of Ibovespa's financial stocks regarding future interest rates. Therefore, with some vectorial algebra:

$$\frac{\partial STS_{(1x84)}}{\partial i_{fut}} = \left[\left(\frac{FCFF_1^1}{(1+i_{fut,1,1}+rp_{1,1,1})^2} + \ldots + \frac{FCFF_1^6}{(1+i_{fut,1,6}+rp_{1,1,6})^2} \right) \ \cdots \ \left(\frac{FCFF_1^1}{(1+i_{fut,84,1}+rp_{1,84,1})^2} + \ldots + \frac{FCFF_1^6}{(1+i_{fut,84,6}+rp_{1,84,6})^2} \right) \right] \quad (17)$$

And to achieve the second objective of this paper, we differentiate the matrix (12) in relation to rp_1:

$$\frac{\partial STS_{(6x84)}}{\partial rp_1} = \begin{bmatrix} \frac{FCFF_1^1}{(1+i_{fut,1,1}+rp_{1,1,1})} + \frac{FCFF_3^1}{(rp_{2,1,1}-g_{n,1,1}).(1+rp_{1,1,1})^2} & \cdots \cdots & \frac{FCFF_1^1}{(1+i_{fut,84,1}+rp_{1,84,1})} + \frac{FCFF_3^1}{(rp_{2,84,1}-g_{n,84,1}).(1+rp_{1,84,1})^2} \\ \frac{FCFF_1^2}{(1+i_{fut,1,2}+rp_{1,1,2})} + \frac{FCFF_3^2}{(rp_{2,1,2}-g_{n,1,2}).(1+rp_{1,1,2})^2} & \cdots \cdots & \frac{FCFF_1^2}{(1+i_{fut,84,2}+rp_{1,84,2})} + \frac{FCFF_3^2}{(rp_{2,84,2}-g_{n,84,2}).(1+rp_{1,84,2})^2} \\ \vdots & \ddots & \\ \frac{FCFF_1^6}{(1+i_{fut,1,6}+rp_{1,1,6})} + \frac{FCFF_3^6}{(rp_{2,1,6}-g_{n,1,6}).(1+rp_{1,1,6})^2} & \cdots \cdots & \frac{FCFF_1^6}{(1+i_{fut,84,6}+rp_{1,84,6})} + \frac{FCFF_3^6}{(rp_{2,84,6}-g_{n,84,6}).(1+rp_{1,84,6})^2} \end{bmatrix}_{(6\times84)} \quad (18)$$

Doing the same for rp_2, and after similar procedure, we have:

$$\frac{\partial STS_{(6x84)}}{\partial rp_2} = \begin{bmatrix} \frac{FCFF_3^1}{(rp_{2,1,1}-g_{n,1,1})^2.(1+rp_{1,1,1})^2} & \cdots \cdots & \frac{FCFF_3^1}{(rp_{2,84,1}-g_{n,84,1})^2.(1+rp_{1,84,1})^2} \\ \frac{FCFF_3^2}{(rp_{2,1,2}-g_{n,1,2})^2.(1+rp_{1,1,2})^2} & \cdots \cdots & \frac{FCFF_3^2}{(rp_{2,84,2}-g_{n,84,2})^2.(1+rp_{1,84,2})^2} \\ \vdots & \ddots & \\ \frac{FCFF_3^6}{(rp_{2,1,6}-g_{n,1,6})^2.(1+rp_{1,1,6})^2} & \cdots \cdots & \frac{FCFF_3^6}{(rp_{2,84,6}-g_{n,84,6})^2.(1+rp_{1,84,6})^2} \end{bmatrix}_{(6\times84)} \quad (19)$$

To get to the equation (20), we can partition the array (19) and replace every expression contained in these matrix cells by STS_w^s, The s index is the number of financial stock of theoretical Ibovespa portfolio. The w index designates the month in which the market value of the stock was inserted into the model and the intrinsic value of it has been estimated.

$$\begin{aligned} \frac{\partial STS_{(1x84)}}{\partial rp_{1,w}} &= \begin{bmatrix} \frac{\partial STS_1^1}{\partial rp_{1,1,1}} & \frac{\partial STS_2^1}{\partial rp_{1,2,1}} & \cdots & \frac{\partial STS_{84}^1}{\partial rp_{1,84,1}} \end{bmatrix} \\ \frac{\partial STS_{(1x84)}}{\partial rp_{1,w}} &= \begin{bmatrix} \frac{\partial STS_1^2}{\partial rp_{1,1,2}} & \frac{\partial STS_2^2}{\partial rp_{1,2,2}} & \cdots & \frac{\partial STS_{84}^2}{\partial rp_{1,84,2}} \end{bmatrix} \\ &\vdots \\ \frac{\partial STS_{(1x84)}}{\partial rp_{1,w}} &= \begin{bmatrix} \frac{\partial STS_1^6}{\partial rp_{1,1,6}} & \frac{\partial STS_2^6}{\partial rp_{1,2,6}} & \cdots & \frac{\partial STS_{84}^6}{\partial rp_{1,84,6}} \end{bmatrix} \end{aligned} \quad (20)$$

Similarly, we make the vectorial calculation for the matrix (12):

$$\frac{\partial STS_{(1x84)}}{\partial rp_{2,w}} = \begin{bmatrix} \frac{\partial STS_1^1}{\partial rp_{2,1,1}} & \frac{\partial STS_2^1}{\partial rp_{2,2,1}} & \cdots & \frac{\partial STS_{84}^1}{\partial rp_{2,84,1}} \end{bmatrix} \quad (21)$$
$$\frac{\partial STS_{(1x84)}}{\partial rp_{2,w}} = \begin{bmatrix} \frac{\partial STS_1^2}{\partial rp_{2,1,2}} & \frac{\partial STS_2^2}{\partial rp_{2,2,2}} & \cdots & \frac{\partial STS_{84}^2}{\partial rp_{2,84,2}} \end{bmatrix}$$
$$\vdots$$
$$\frac{\partial STS_{(1x84)}}{\partial rp_{2,w}} = \begin{bmatrix} \frac{\partial STS_1^6}{\partial rp_{2,1,6}} & \frac{\partial STS_2^6}{\partial rp_{2,2,6}} & \cdots & \frac{\partial STS_{84}^6}{\partial rp_{2,84,6}} \end{bmatrix}$$

From equation (21) we obtain the second purpose of this article. By adding the row vectors, we can deduce the STS elasticity series related to rp_1.

$$\frac{\partial STS_{(6x84)}}{\partial rp_{1,w}} = \left[\left(\frac{\partial STS_1^1}{\partial rp_{1,1,1}} + \frac{\partial STS_1^2}{\partial rp_{1,1,2}} + \ldots + \frac{\partial STS_1^6}{\partial rp_{1,1,6}} \right) \cdots \left(\frac{\partial STS_{84}^1}{\partial rp_{1,84,1}} + \frac{\partial STS_{84}^2}{\partial rp_{1,84,2}} + \ldots + \frac{\partial STS_{84}^6}{\partial rp_{1,84,6}} \right) \right] \quad (22)$$

Analogously, from equation (12) we add the row vectors to get the STS elasticity series related to rp_2 along the 84 months considered in the analyzed period.

$$\frac{\partial STS_{(6x84)}}{\partial rp_{2,w}} = \left[\left(\frac{\partial STS_1^1}{\partial rp_{2,1,1}} + \frac{\partial STS_1^2}{\partial rp_{2,1,2}} + \ldots + \frac{\partial STS_1^6}{\partial rp_{2,1,6}} \right) \cdots \left(\frac{\partial STS_{84}^1}{\partial rp_{2,84,1}} + \frac{\partial STS_{84}^2}{\partial rp_{2,84,2}} + \ldots + \frac{\partial STS_{84}^6}{\partial rp_{2,84,6}} \right) \right] \quad (23)$$

Where, in the case of rp_1, the cells correspond to:

$$\frac{\partial STS_{(1x84)}}{\partial rp_1} = \frac{FCFF_1^1}{(1 + i_{fut,1,1} + rp_{1,1,1})} + \frac{FCFF_3^1}{(rp_{2,1,1} - g_{n,1,1}).(1 + rp_{1,1,1})^2}$$

$$\frac{\partial STS_{(1x84)}}{\partial rp_1} = \frac{FCFF_1^2}{(1 + i_{fut,1,2} + rp_{1,1,2})} + \frac{FCFF_3^2}{(rp_{2,1,2} - g_{n,1,2}).(1 + rp_{1,1,2})^2} \quad (24)$$

and so on until:

$$\frac{\partial STS_{(6x84)}}{\partial rp_1} = \frac{FCFF_1^6}{(1 + i_{fut,84,6} + rp_{1,84,6})} + \frac{FCFF_3^6}{(rp_{2,84,6} - g_{n,84,6}).(1 + rp_{1,84,6})^2}$$

where $g_{n,w,s}$ is the expected growth rate for the month w by the stockholder of the s company ; i_{fut} is the future interest rate (DI for a day and future contract maturing in t+6) that refered to the month w and borrowed by the s company; rp_1 is the risk premium on the future interest rate (i_{fut}) and rp_2 is the risk premium on the perpetuity.

In the case of rp_2 , the cells correspond to:

$$\frac{\partial STS_{(6x84)}}{\partial rp_2} = \frac{FCFF_3^1}{(rp_{2,1,1} - g_{n,1,1})^2.(1+rp_{1,1,1})^2}$$

$$\frac{\partial STS_{(6x84)}}{\partial rp_2} = \frac{FCFF_3^2}{(rp_{2,1,2} - g_{n,1,2})^2.(1+rp_{1,1,2})^2} \quad (25)$$

and so on until:

$$\frac{\partial STS_{(6x84)}}{\partial rp_2} = \frac{FCFF_3^6}{(rp_{2,84,6} - g_{n,84,6})^2.(1+rp_{1,84,6})^2}$$

3.1.5. Module 5 - Corollaries of the model

We have 3 cases with the STS results: downside, upside and balance (IV and MV are the same). In the first case we have an upside in the Ibovespa's financial stocks. So this is a situation of bear market, ie, the financial stocks are cheap. The intrinsic value of financial companies is greater than the market value of them.

So, being Π the Ibovespa's profitability:

$STS_{(ixj)} > 0 \Leftrightarrow IV_{(ixj)} > MV_{(ixj)}$ e STS→ ∞ ⟹ Π ⟶ ∞ (26)

In the second case, there is a downside. A bull market situation. The financial stocks have a upward tendency. As result, the financial stocks' market value is greater than their intrinsic value, according to equation (24):

$STS_{(ixj)} < 0 \Leftrightarrow MV_{(ixj)} > IV_{(ixj)}$ e STS→ −∞ ⟹ Π ⟶ −∞ (27)

In the third case - rare and only theoretically interesting - there is no upside or downside, since the total market value of the financial stocks is equal to its intrinsic value:

$STS_{(ixj)} = 0 \Leftrightarrow IV_{(ixj)} = MV_{(ixj)}$ e STS→ 0 ⟹ Π ⟶ 0 (28)

The results of the STS elasticites with respect to the future interest rate correspond to four other cases:

(i) If MV > IV (dowside) and FCFF <0 (negative free cash flow), we have $\frac{\partial STS}{i_{fut}} > 0$

(ii) If MV < IV (upside) and FCFF < 0 (negative free cash flow), we have $\frac{\partial STS}{i_{fut}} < 0$

(iii) If MV > IV (downside) and FCFF > 0 (positive free cash flow), we have $\frac{\partial STS}{i_{fut}} > 0$

(iv) If MV< IV (upside) and FCFF > 0 (positive free cash flow), we have $\frac{\partial STS}{i_{fut}} > 0$

So, just in case (ii) the STS elasticity regarding the future interest rate is negative. In all the other cases it is positive. *Therefore, the STS elasticity will be negatively affected by expected interest rate only when the financial companies that compound the theoretical portfolio of Ibovespa are in upside situation and (if and only if) they present, jointly, negative net cash flow*. Otherwise, if there is a increase (reduce) in the future interest rate, the result will be a decrease (a rise) in the STS of these stocks.

4. Results

This section describes the results of the agent-based stochastic computational model simulations for the period 2008-2014. In each subsection we analyze the effects of monetary policy events (and other relevant facts associated) that occurred during this period and influenced the trajectory of the elasticities of the STS series for the future interest rate. The series are monthly and refer to these 84 months.

These monthly series correspond to the following row vectors:

- STS – stockholder surplus
- IV – vector of Ibovespa's theoretical portfolio intrinsic values.
- MV – vector of Ibovespa's theoretical portfolio market values (based on stocks closing quotes).
- i_{fut} – future interest rate (based on future contracts maturing in 6 months).
- rp_1 – risk premium on future interest tax (i_{fut}).
- rp_2 – risk premium on perpetuity.

Based on the model described in the previous section, these simulations have been prepared using the parameters defined in Table 2. These parameters correspond to the maximum and minimum growth rates for every financial stock that belongs to Ibovespa's theoretical portfolio.They also belong to the interval over which are calculated values corresponding to Monte Carlo simulation performed in Mathematica 9.0. This software generates pseudo-random numbers with quite desirable randomness. Therefore, the table 2 values are the maximum and minimum values that were entered in (12).

Table 2 - Parameters that are part of the ranges of variation of stochastic simulation model

Stock Tickers	2008 - 2010		2011 - 2012		2013 - 2014	
	g_{max}	g_{min}	g_{max}	g_{min}	g_{max}	g_{min}
BBAS3	1,64%	1,15%	1,64%	1,15%	1,64%	1,15%
BBDC3	7,28%	5,10%	7,28%	5,10%	7,28%	5,10%
BBDC4	1,27%	0,89%	1,27%	0,89%	1,27%	0,89%
BVMF3	1,79%	1,26%	1,79%	1,26%	1,79%	1,26%
ITSA4	19,28%	13,50%	19,28%	13,50%	19,28%	13,50%
ITUB4	4,45%	3,12%	4,45%	3,12%	4,45%	3,12%

Source: computations by the authors in Mathematica 9.0.

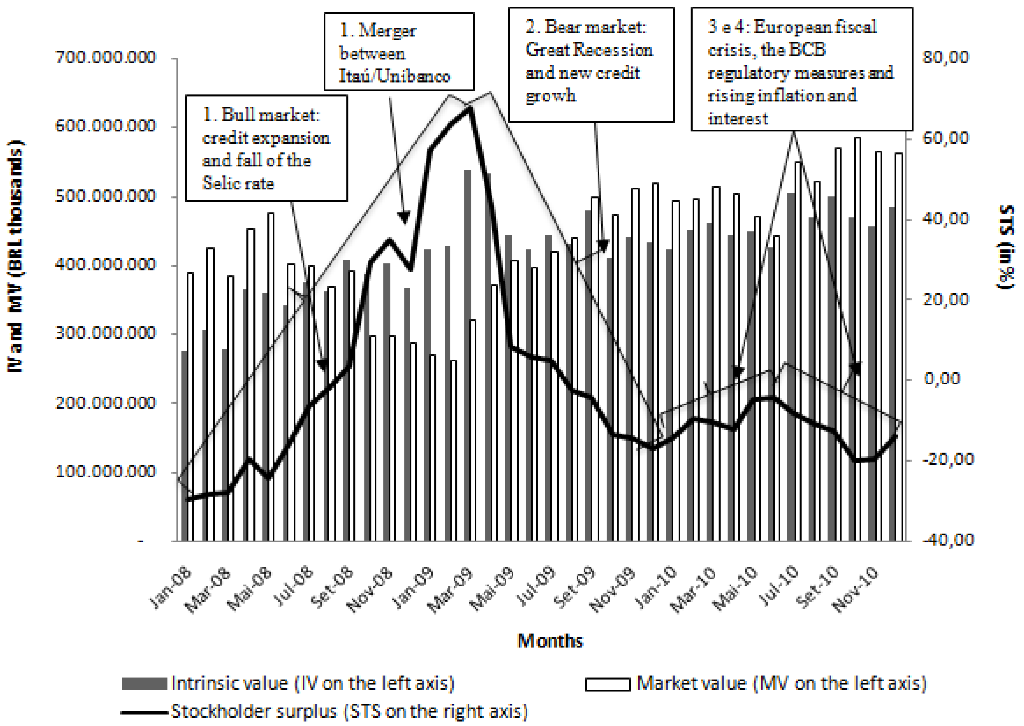
Based on these parameters, we calibrate the model according the technical recomendations of Werker and Brenner (2004) and in the following subsections we analyze the graphs of the simulations.

4.1. Effects of future interest rate on the STS of financial stocks in 2008-2010

As can be seen in Figure 1, four sub-cycles were crucial in the STS behavior in the biennium 2008-2010.

In the first sub-cycle (of bull market) there was an expansion of the Brazilian financial system credit that caused a significant increase in STS from January 2008 to March 2009. In early 2008 the financial system credit operations kept growing even with the international financial crisis which until then had not hit hard the Brazilian economic activity. Credit growth reflected the performance of free resources operations, driven by expansions in vehicle leasing for individuals and working capital to companies. An important movement within this sub-cycle was the rapid resumption of STS, after a fall in November 2008, motivated by the merger of Itaú and Unibanco. Through this merger, Itaú / Unibanco became at that time the largest private financial conglomerate in the Southern Hemisphere, the sixth largest market value of the Americas and one of the 20 largest banks in the world with a net worth estimated R$ 51.7 billion. Thus, the intrinsic value of financial companies showed a significant upward trend of 95.35%, from January 2008 to March 2009.

Figure 1 - STS (in %), IV and MV (both in BRL thousands) of financial stocks of Ibovespa theoretical portfolio: Jan / 2008 to Dec / 2010



Sources: estimates of agent-based computational stochastic model prepared by the authors; standardized financial demonstrations of the Brazilian Securities Commission (CVM), for the years 2008, 2009 and 2010, of the 6 financial stocks that compound the Ibovespa Index and BM&F Bovespa.

In the second sub-cycle (of bear market), which began in March 2009 and lasted until December of this year, there was a sharp fall in liquidity driven by the credit crunch (creditcrunch) in international banks, arising from the subprime crisis, which hit the Brazilian financial companies. During this period the intrinsic value of the brazilian financial stocks was reduced by 19.65% dropping from R$ 537.09 billion in March 2009 to R$ 431.51 billion in December of that year. We note that the overall ceiling of the sample STS (Figure 4, Annex 1) is located in this month. This represented an increase of uncertainty about the monetary policy of the FED (more specifically on the size of the necessary liquidity help operations to the recovery of the US financial sector). Not even the strongest banks in Brazil and the world would be able to face the impact of increased uncertainty without resorting to credit rationing and the increase of its liquidity. So, the credit taken by households began to cool. Furthermore, due to this scenario of greater rigidity in the credit market and increased risk aversion, the emission of stocks and debentures ceased. This contributed to inhibit financial activity and depreciate the STS of financial stocks. The Bovespa index, considering all the theoretical portfolio (Ibovespa "full" and not only financial companies) showed different trends throughout 2008. From January to May, there was a prevailing trend of remarkable gains. But in the rest of the year, his performance began to signal a worrying volatility. At the end of the year, the Bovespa index closed at 37,550 points, with an accumulated decrease of 42.1% compared to the end of 2007.

The third sub-cycle began in December 2009 and ended in May 2010. In February 2010, the loans expanded 0.8% compared to January of the same year, reaching R$ 1.44 trillion , which represented 44.9% of GDP. The intrinsic value of financial companies showed an uptrend of 3.87%, rising from R $ 431.511 billion to R $ 448.198 billion in the mentioned period. In 12 months there was a rising of 16.8%. The pace of growth in sales, which strongly dropped in 2009 and stabilized in the third quarter of this year showed that this recovery was influenced both by the expansion of sales with targeted resources and with free resources. According to the Monthly Economic Letter from IPEA (March 2010), this expansion occurred mainly on the credits with free resources (which amounted in this period, 67.1% of the total credit supply). This rebound of credit demand was driven by improvement in employment, rising wages and greater consumption. The effect of consumption on the retail, service and industrial sectors boosted the need for working capital and stimulated the investment level. There was also an incentive to demand for corporate credit. So, the IPEA Letter of Conjuncture of March 2010 pointed that:

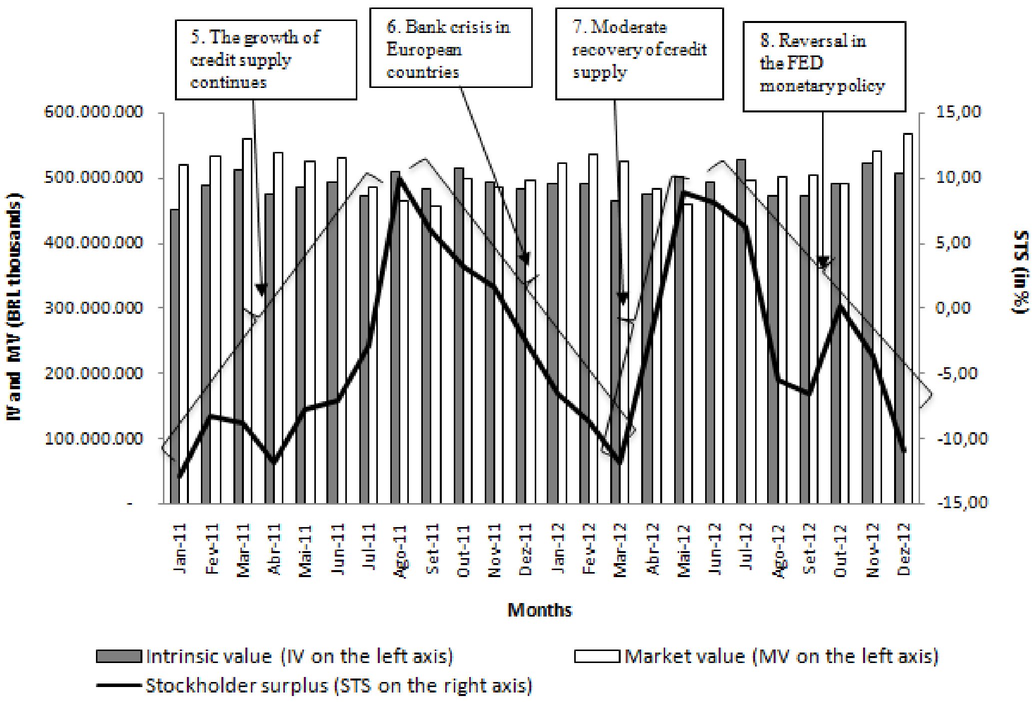
> "In particular, one can highlight: i) within individuals, the modalities of consigned-payroll loans, due to the increases in formal employment, in credit card expenses and in housing; ii) within companies, the modalities of working capital and loans made by BNDES (Social and Economic Development National Bank). One can also point out that the same reasons that allow us to estimate a higher demand for credit, allow us to relate these new operations to a better credit quality (mainly in terms of a more favorable risk profile). "(IPEA, March 2010, translated by the authors).

The fourth sub-cycle (May 2010 to November of the same year), is related to the European fiscal crisis. It resulted in the poor performance of the Stock Exchange of São Paulo (Bovespa), which had its worst quarter since the height of the financial crisis of 2008. But the effect of european crisis on the STS of financial stocks was fleeting and not too serious. Meanwhile, the "full" Bovespa Index recorded an accumulated low of 13.4% from April to June and 11.2% in the semester. The European fiscal crisis was the main determinant of market fluctuations during this semester. The news of the greek debt and its difficulty in financing its foreign debt brought negative reactions to financial markets. Countries such as Spain and Portugal were soon affected and their risk ratings were reduced. Despite indications that the Brazilian economy was recovering, the US stock market took a while to understand the European crisis. This combination of exogenous variables in our model, reduced the intrinsic value of financial stocks at 1.37% over the previous sub-cycle. Also in this sub-cycle, the BCB had to calibrate the liquidity of the financial system and put an end to some stimulus measures adopted in 2008. The rate of reserve requirements on time deposits was increased from 13.5% to 15% and payment now required only in cash. In December of the same year this rate increased from 15% to 20%. After overcoming the effects of the international crisis, financial system credit operations returned to growth in 2010. The Ibovespa rose 1% and reached 69,304 points, slightly more than the previous year.

4.2 Effects of future interest rate on the STS of financial stocks in 2011-2012

As can be seen in Figure 2, four sub-cycles help to understand the STS behavior in the biennium 2011-2012.

Figure 2 - STS (in %), IV and MV (both in BRL thousands) of financial stocks of Ibovespa theoretical portfolio: jan/2011 to dec/2012



Sources: estimates of agent-based computational stochastic model prepared by the authors; standardized financial demonstrations of the Brazilian Securities Commission (CVM), for the years 2011 and 2012, of the 6 financial stocks that compound the Ibovespa Index and BM&F Bovespa.

The fifth sub-cycle begins in December 2010 and was ended in August 2011. In December 2010, there was an increase in the reserve requirements on demand deposits and time deposits. In January 2011, the pace of loans' growth was moderate (a result of measures implemented in late 2010, which aimed to maintain the sustainable development of the credit market). However, the restrictive measures affected particularly the supply of credit for individuals. Due to the direct effect of increases in interest rates, the trend for credit supply to individuals slowed. PAREI AQUI. On the other hand, loans to companies grew in February after a decline observed in January. The total volume of loans with free and earmarked resources increased by 19% in twelve months (it rose 20.6% in the previous year). Rationing and credit restrictions were successful. They allowed a gradual slowdown of balances to appropriate levels to adjust the economy. On July 20, 2011, the Monetary Policy Committee (Copom) of the Central Bank of Brazil signaled that the monetary tightening cycle could end. At a meeting on the same date, it chose to increase for the last time the basic interest rate (Selic), which reached 12.5% per year. However, in the period July-August many European banks entered in critical condition. What saved them was the intervention of the European Central Bank (ECB). The intrinsic value of the sample's financial stocks rose by 5.56%. They exhibited a high from R $ 484.210 billion in December 2010 to R $ 511.119 billion in August 2011.

The sixth sub-cycle began in August 2011 and ended in March 2012. Between July and September 2011 the international stock markets were severely shaken again. The extent of the crisis was determined by the volume of public debt of some european states, as well by their practices of funding. So, we can point five European countries with great difficulty during this period: Portugal, Ireland, Italy, Greece and Spain. The weaknesses caused by high deficits reflected not only in the continent but in many other parts of the world.

In Brazil, the credit with free funds had not yet reacted to the monetary policy changes initiated in the second half of 2011. The balance of loans of the National Financial System (SFN) increased from 49.9% of GDP in December 2011 to 49.3% of GDP in March 2012. The Bovespa Index retreated 18.1% in 2011. In August it registered the lowest level, 48,668 points. However, it reached 56,754 points in the last day of the year.

The intrinsic value of the model's financial stocks fell by 9.09%, falling from R $ 511.119 billion in August 2011 to R $ 464.616 billion in March 2012.

The seventh sub-cycle was from March to May 2012. The evolution of monetary aggregates in 2012 reflected, in part, the impact of moderate growth in economic activity on the expansion of loans. This movement was consistent with the convergence trend in the growth rate for long-term sustainable rates. Although there are time lags between monetary policy changes and the credit market reaction, we can identify some important factors that slowed the economic recovery. They were: (i) the high degree of income committed to debt service payments; (ii) a smaller reduction than expected in the average interest rates charged by banks (that is, a rising in banks' spread) and an increase in defaults. Over the past 12 months the ratio of household debt to the SFN and the accumulated income showed an upward trend. In the first quarter of 2012, the main credit market segment responsible for the increase in defaults was the credit for the purchase of vehicles. Since early 2011, the credit default for vehicles increased steadily. As the interest charged for this loan segment were at low levels, the poor financial planning to consumers was pointed as the possible cause of the rise in default. Loans with free and specific funds increased by 16.4% in the year to R $ 2,368 billion at the end of 2012.

The intrinsic value of financial companies' stocks showed a high of 7.89%, increasing from R $ 464.616 billion to R $ 501.287 billion in the first quarter of 2012.

The eighth sub-cycle began in May 2012 and ended in March 2013. The US government began to reduce its credit supply and monetary assistence that have been granted to financial institutions (those that were helped during the crisis). The Treasury in September 2012 sold $ 149.3 million in stocks of five banks. The crisis seemed to have no end. Central banks around the world signal that there would not be another round of revisions in growth projections and the slowing global economy would deepen by the end of this year. Therefore, the Brazilian economy was affected by this scenario. Many companies reduced their investments. The government began a cycle of interventions in the economy. First reduced the taxes on car and others durable consumer goods production. This measure was accompanied by an increase in taxes on imports and foreign vehicles. Also imposed tariffs to mexican car imports and stimulated the credit through public banks, which slowed the credit supply of national private institutions. On September 14, 2012, the BCB reduced the rate of compulsory deposits and simplified its regulatory requirements. The additional rate charged on demand deposits (6%) has been reset. And the rate on time deposits was reduced from 12% to 11%. The household debt with the SFN, as well the accumulated income, have continued to grow until reach a record high of 45% in September. Operations with free resources were discharged, with the highest increase in credit to individuals. But, although the slowdown was greater in credit with free resources, this reduction also happened in the credit earmarked.

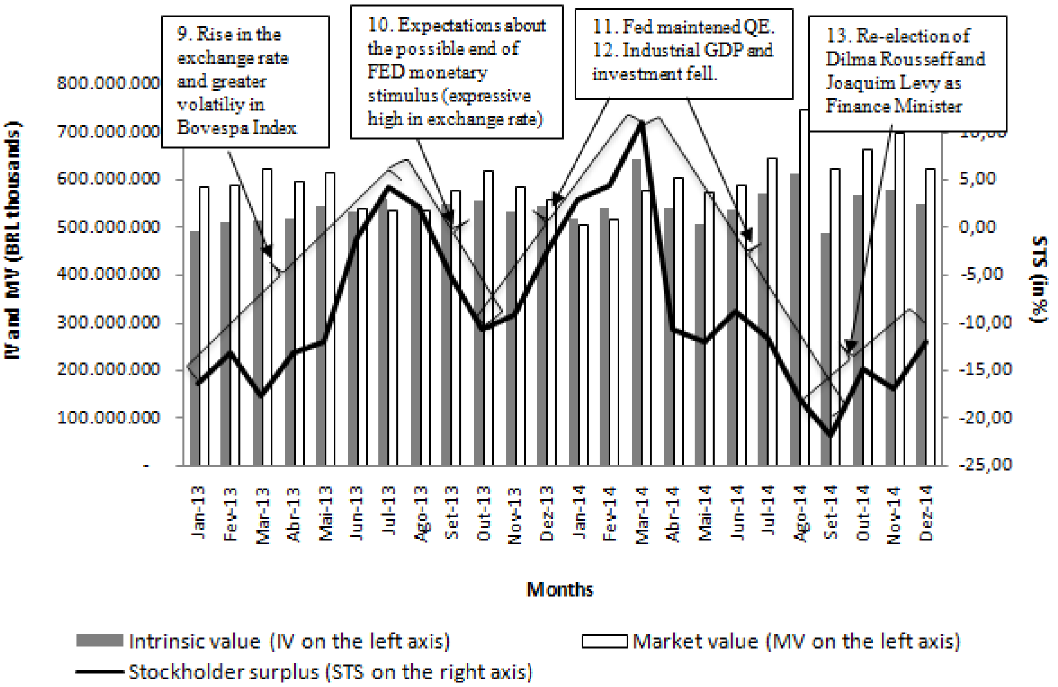
The Bovespa Index increased 7.4% in 2012, reaching 60,952 points in the last end of the year. The index registered significant volatility throughout the year, reaching maximum of 68,394 points in March and a low of 52,481 points in June.

The intrinsic value of financial companies showed a rise of 2.07% in this sub-cycle, from R$ 459.960 billion to R $ 620.957 billion.

4.3 Effects of future interest rate on STS of financial stocks in 2013-2014

As can be seen in Figure 3, four sub-cycles can describe the STS behavior in the biennium 2013-2014.

Figure 3 - STS (in %), IV and MV (both in BRL thousands) of financial stocks of Ibovespa theoretical portfolio: jan/2013 to dec/2014



Sources: estimates of agent-based computational stochastic model prepared by the authors; standardized financial demonstrations of the Brazilian Securities Commission (CVM), for the years 2013 and 2014, of the 6 financial stocks that compound the Ibovespa Index and BM&F Bovespa.

In the ninth sub-cycle, which began in March and ended in July 2013. The growth of loans of the National Financial System (SFN) has become low in 2013 over the previous year, with emphasis on the slowdown in the segment of free resources, whose has increased 7.2% on average from February to March, for a fall of 4.4% in April. The earmarked credit grew 24.6% compared to the same month of 2012. This increase was mainly driven by mortgages to individuals and, in a lesser pace, by the resources of the Social and Economic Development National Bank (BNDES) to the companies, which registered an expansion in April (accumulated values in twelve months) of 34.5% and 16 2%, respectively. In financial institutions there was a difference in the growth rate between the state-owned (29.1%) and private ones (6.4%). Inflation has affected the families budgets, that were already indebted. The BCB announced in April that the commitment of family income was rising with debts related to acquisition of property, but they were still small: about 1.5% of income. But the income commitment of households with debt service increased of 21.50% in May 2013 for 21.52% in June of that year, after three months of consecutive decline. Another relevant fact was the high dollar in May of that year. The Central Bank and the Minister of Finance adopted a more aggressive policy to contain the rise of the currency. The brazilian stock market increased its volatility and showed a downward trend throughout the year, reaching a maximum of 63,312 points in January and a low of 45,044 points in July 2013.

That said, in this subcycle the intrinsic value of financial stocks rose by 9.40%, increasing by R $ 511.671 billion to R $ 559.789 billion.

On the tenth sub-cycle, from July to October 2013. The credit supply has shown slight deceleration in July, still led by public institutions and by the directed credit. With the sharp rise of future rates, there was an increase in interest rates for loans to individuals. The default rate continued to fall during this period. According the Conjuncture Letter of IPEA of September 2013, we have:

> "The growth rate of the balance of SFN credit operations has maintained an average, since July 2012, of 16.5% per year, and recorded, in July 2013, a rate of 16.1% per year (month over same month of the previous year). This growth rate meant that the credit/GDP ratio reached 55.1% in July 2013 vis-à-vis a ratio of 51.1% in the same month of 2012 . "

The directed credit increased both in its growth rate, as in its share in the total balance of SFN credit. In July of 2013 its growth rate rose to 26.6% per year, compared to 21.7% in the same period in 2012. The share of total credit rose from 43.3% to 39.7% in the same period mentioned above. In August the dollar reached a expressive high, reaching R $ 2.45. This happened because a significant recovery of the US economy was announced. There was speculations that the Fed would reduce its monetary stimulus to the economy.

With the mentioned facts, the intrinsic value of financial companies showed, in this sub-cycle, a drop of 0.95%, dropping from R $ 559.789 billion to R $ 554.461 billion.

In the eleventh sub-cycle (from November 2013 to March 2014), the Fed met together with Federal Open Market Committee (FOMC), his committee responsible for overseeing the US open market operations. They decided to maintain the Quantitative Easing policy (QE)[9]. However, the QE monetary inflows would be gradually reduced at the end of 2013. Brazil was quoted by the Fed, in an excerpt from the Monetary Policy Report, February 2014, as the second most vulnerable emerging economy to changes in the international economic situation. The following quotation helps to understand the reversal of expectations during this period:

> "The changes in the international situation did cease the growth phase of easy export commodities from emerging economies such as Brazil. China's slowdown has cooled the boom of raw materials, and the beginning of reduction of super-expansionist stance of monetary policy in the United States raised interest rates and reduced international liquidity. The financing of current account deficits has become more difficult and more expensive. [...] Brazil was suprised by the turn of the international scenario, with an inflation of 6%, growth of around 2% and external deficit above 3.5% of GDP. The rise in domestic interest rates, combined with the current growth rate of the economy, negatively affected the evolution of public debt to GDP ratio, especially when we take into account the gross debt. In this case, there is the aggravating factor of the expensive maintenance costs of accumulated international reserves and of Treasury loans to the BNDES and other

[9] QE (Quantitative Easing) was a monetary policy strategy implemented by FED since 2009 until 2014 to overcome the Great Recession's effects. It consisted in market operations that were made through the purchase of assets backed in mortgage bonds and US Treasuries by the Fed, which injected about $ 85 billion per month in the US economy.

public banks. [...] The resumption of uncertainty about the solvency of Brazilian public accounts - in a long-term context and not alarmist, it's good caveat - worsened the perception of country risk and put pressure on assets such as foreign exchange, interest and stock market, with negative effects on investment and economic activity. The government realize this situation and took steps to recover the credibility of economic policy, opting for the traditional Orthodox menu. The basic interest rates have been increased by 3.5 percentage points, and the economic authorities committed themselves to a budget surplus of 1.9% of GDP in this year, beginning with a much lower volume of extraordinary revenues than those ones of 2013. The promise of a suplus of $44 billion, has been well received by the market. "(Conjuntura Econômica, Letter of IBRE[10], March 2014).

The Bovespa Index retreated 15.5% in 2013, closing the year at 51,501 points.

The intrinsic value of the analyzed companies increased 20.96%, from R $ 530.435 billion in November 2013 to R $ 641.618 billion in March 2014.

In the twelfth sub-cycle (from March to September 2014), the opening of new businesses in Brazil in the first half of 2014 declined 13.1% compared to the same period of previous year. According to the Focus bulletin of the Central Bank (BC), the median of forecasts for the growth of GDP went from 0.48% to 0.33%. The "new economic matrix" - the economic policy strategy adopted by the government - believed that would be possible to reduce the real interest rate with no impact on inflation. But it did not work because of highly expansionary profile of fiscal policy that pressed inflation and wages. All these measures combined with fruitless government interventions in some key-sectors of the economy inhibited private investments.

Regarding fiscal situation, we have:

"After all, the fiscal balance has worsened in recent years, and in 2014 will be significantly lower than what had been planned. An early estimate for the primary outcome (excluding non-recurring revenues) of consolidated public sector deficit in 2014, points to a level around 0.7% of GDP. As a result, the sustainability of medium and long term of the Brazilian public debt trajectory returns to the economic concerns. Consequently, the risk of lowering the rating of the brazilian sovereign risk by the major rating agencies, which could lead to loss of investment grade, is the urgent point of the fiscal policy at the beginning of the new term. " (Schymura in the Conjuntura Econômica, Letter of IBRE, November 2014)[11].

With this scenario, the intrinsic value of the analyzed financial stocks fell by 23.93% in this sub-cycle, dropping from R $ 641.618 billion to R $ 488.047 billion.

The thirteenth and final sub-cycle, which started in September 2014 and ended in the last month of the same year, was marked by: (i) the re-election of President Dilma Rousseff; (ii) the appointment of Joaquim Levy to the Ministry of Finance; and (iii) the expectations about the possible loss of investment grade.

On the appointment of Joaquim Levy, we reproduce the comment of Samuel Pessoa:

"Strongly pressed, the president gave in, making a rather radical choice as the Levy. It is not clear that she has given full autonomy to the new finance minister, but there is no doubt that Dilma took a gamble and chose a path - the fiscal adjust, so often attacked by her in the campaign, when it was associated to the victory of their opponents. Who chose Levy was not the economist Dilma Roussef, but the policy of Dilma Rousseff, who faces the

[10] Economic Conjuncture Review (Revista Conjuntura Econômica), Getúlio Vargas Foundation, March 2014.

[11] IBRE Letter of Economic Conjuncture Review (Carta do IBRE - Revista Conjuntura Econômica), Getúlio Vargas Foundation, November 2014. IBRE is the Brazilian Institute of Economics (Instituto Brasileiro de Economia).

hard learning of this craft in the highest office of the nation. In other words, fear and pragmatism won the presidential ideology. "(Pessoa, 2014, p. 11)

The appointment of Joaquim Levy has reduced temporarily the risk of loss of investment grade, that would happen only in 2015 - and therefore outside of the period analyzed in this article - with the decisions of the Standard & Poor's (S&P) and Moody's[12].

In the second half of 2014, the main impacts on GDP came from the decline in investment (5.3%) and in industrial activity (1.5%). Moreover, in September the food became more expensive and influenced the acceleration of Brazilian Consumer Price Index (IPCA-15), which ranged from 0.57%, more than doubling compared to 0.25% in August, which increased the uncertainty of economic agents.

With this increased uncertainty, all confidence indicators and expectations have deteriorated.

Finally, the intrinsic value of the financial stocks rose by 12.01% in this sub-cycle, increasing from R $ 488.05 to R $ 546.71 billion

5. Final considerations

This article developed a series of intrinsic value for six financial stocks that made part of the Ibovespa's theoretical portfolio in the period of 2008-2014. This series was the basis for the estimation of other stockholder surplus series (STS), that was computed for the same period. With this STS series, it was possible to detect and measure the periods in which these actions were expensive (bull market or downside) or cheap (or bear market upside), as well identify the impacts of monetary policy decisions on the STS trajectory.

The methodology used was the ACE (Agent-Based Computational Economics), with the use of heterogeneous agents. In the model, these agents were defined as fundamentalists stock analysts who do the valuation of them, considering that, in the process of evolution and learning, they learn, update and adapt - along the time - their valuation decisions based on the informations of quarterly balance sheets of these six financial companies.

We obtained the results for the three-year period of 2008-2010, a bull market sub-period (downside), which runs from September 2008 to June 2009, in which the STS climbed up to a maximum of 43.50% (R $ 161.376 billion) in April 2009. In this triennium, all the remaining sub-periods showed bear market situations (upsides).

Yet for the biennium 2011-2012, we had two sub-periods of bull market (downside). The first ocurred from July to November 2011. The second, from April to July 2012. In the first, there was a top of 10.03% (46,583,000) in the second, the top was 8.98% (R$ 41.327 millions). The other sub-periods of the biennium were all of bear market (upside).

Finally, in the biennium 2013-2014 there were two short periods of bull market (downside): June-August 2013 and January-March 2014 respectively, the maximum values of STS in these two periods were 4.16% (R $ 22.344 million) and 11.04% (R $ 63,807,000). In the other sub-periods of this biennium there were only cases of bear market (upside).

In addition to these results, in the fourth section we analyzed in detail the decisions of monetary policy and associated factors that affected the STS behavior in all twelve sub-cycles of the three periods mentioned.

In future research we will include other shares of the Ibovespa index in the sample. With this, one can assess whether the STS performance of financial stocks differ much from the other stocks of the productive sector.

[12] Moody's downgraded the Brazilian rating in August 2015. The S&P did the same in September 2015.

7. References

ABRAMS, J. B. *Quantitative business valuation: a mathematical approach for today`s professionals*. New York: McGraw-Hill, 2001.

ARAÚJO, T.V. *Introdução à economia computacional.* Lisboa: Almedina, 2011.

ARTHUR, W. B., HOLLAND, J., LEBARON, B., PALMER, R., and TAYLOR, P. "Asset pricing under endogenous expectations in an artificial stock market model". In ARTHUR, W. B., DURLAUF, S. N., and LANE, D. A., eds., *The economy as an evolving complex system II*(pp. 15–44), 1997.

AXELROD, R. *The Evolution of cooperation*. New York, NY: Basic Books, 1984.

AXELROD, R. The complexity of cooperation: Agent-based models of conflict and cooperation. Princeton, N.J.: The Princeton University Press, 1997.

BISCIARI, P.; DURRÉ, A.& NYSSENS, A. *Stock market valuation in the United States*. Brussels: National Bank of Belgium, 2003.

BLACHMAN, N. *Mathematica: a practical approach*. Englewood Cliffs, New Jersey: Prentice-Hall, 1992

CHEN, S. H. and YEH, C. H. Evolving traders and the business school with genetic programming: A new architecture of the agent-based artificial stock market, *Journal of Economic Dynamics and Control*, 2001.

CONJUNTURA ECONÔMICA. *Letter of IBRE (Brazilian Institute of Economics – Instituto Brasileiro de Economia)*. Rio de Janeiro: Getúlio Vargas Foundation, March, 2014.

DAMODARAN, A. *Investment Valuation: tools and techniques for determining the value of any asset.* Ney Jersey: John Wiley & Sons Ltd., 2012.

IBM. *Comentários ás respostas do Banco Central aos questionamentos do Deputado Edmar*

LEBARON, B. Agent-based computational finance: Suggested readings and early research. *Journal of Economic Dynamics and Control* ,24, 679–702, 2000.

LEBARON, B. Empirical regularities from interacting long and short horizon investorsinan agent-based stock market.*IEEE TransactionsonEvolutionaryComputation*5, 442–455, 2001.

HOLLAND, J. *Adaptation in natural and artificial systems*. Cambridge, MA: The MIT Press, 1992.

IPEA Letter of Conjuncture. *Institute of Applied Economic Research* (Instituto de Pesquisas Econômicas Aplicadas). Brasília, March, 2010. Available at: http://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=2483

IPEA Letter of Conjuncture. *Institute of Applied Economic Research* (Instituto de Pesquisas Econômicas Aplicadas). Brasília, September, 2013. Available at: http://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=19936&Itemid=3

KENDRICK, D. A.; MERCADO, P.R. & AMMAN, H. *Computational economics*.Princeton University Press, 2005.

MARKS, R. E. Evolved perception and behaviour in oligopolies.*Journal of Economic Dynamics and Control*,22, 1209–1233, 1998.

McKINSEY& COMPANY, Inc. *Valuation: measuring and managing the value of companies*. New Jersey: John Wiley & Sons, 2000.

MENNER, W. A. "Introduction to modeling and simulation". *Johns Hopkins APL Technical Digest*, v. 16, n. 1, p. 6-17, 1995.

PESSOA, S. A. in *Conjuntura Econômica Letter of IBRE (Brazilian Institute of Economics – Instituto Brasileiro de Economia)*. Rio de Janeiro: Getúlio Vargas Foundation, November, 2014.

SCHYMURA, L. G. in; *Conjuntura Econômica Letter of IBRE (Brazilian Institute of Economics – Instituto Brasileiro de Economia)*. Rio de Janeiro: Getúlio Vargas Foundation, November, 2014.

STINESPRING, J.R. *Mathematica for Microeconomics: learning by example*. Academic Press/Harcourt Inc.: San Diego, California, 2002.

TAY, N. S. P. and LINN, S. Fuzzy inductive reasoning, expectation formation, and the behavior of security prices, *Journal of Economic Dynamics and Control*, 2001.

TESTFATSION, L. "Agent-based computational economics: a constructive approach to economic theory". In: TESTFATSION, L. e JUDD, K. L. *Handbook of computational economics*.Vol. 2. Amsterdam: Elsevier, 2006.

VARIAN, H. R. *Economic and financial modelling with Mathematica*. New York: Telos, 1993.

WERKER, C. e BRENNER, T. *Empirical calibration of simulation models*. Eindhoven Institute of Technology, Netherlands, 2004. Disponívelem:https://papers.econ.mpg.de/evo/discussionpapers/2004-10.pdf