Agent-based model and valuation: a new approach for analyzing monetary policy's transmission mechanism effects.

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Área 6: Macroeconomia.

Resumo: Desenvolvemos um modelo de finanças computacionais baseado em quatro agentes heterogêneos. Cada um deles estima, utilizando quatro técnicas diferentes, os valores intrínsecos das três principais instituições financeiras do setor bancário brasileiro: Itaú / Unibanco, Banco do Brasil e Bradesco. Após somar esses valores, calculamos as elasticidades do valor intrínseco do setor bancário, como um todo, em relação às variações da taxa básica de juros do Brasil (taxa Selic definida pelo Copom). Finalmente, fizemos algumas simulações usando essa nova abordagem de análise do mecanismo de transmissão. Os resultados mostram que o impacto dessas mudanças no setor bancário não afeta negativamente seus valores intrínsecos. De fato, na maioria das situações, os bancos aumentam seu valor intrínseco com taxas de juros básicas mais baixas. Eles também perdem muito pouco valor intrínseco quando as taxas de juros sobem. Isso explica por que os investidores brasileiros geralmente compram ações de bancos como forma de se proteger contra o aumento das taxas de juros, além de ajudar a entender a alta resiliência e solidez desses três bancos, conhecidos como grandes financiadores da dívida do governo federal.

Palavras-chave: mecanismo de transmissão da política monetária, finanças computacionais baseada em agentes, valuation de ativos, setor bancário.
JEL: E52, G12, C63.

Abstract: We have developed a computational financial model based on four heterogeneous agents. Each one of them estimate, using four different techniques, the intrinsic values of the three main financial institutions of Brazilian bank sector: Itaú / Unibanco, Banco do Brasil and Bradesco. After to sum this values, we compute the elasticities of the bank sector's intrinsic value, as a whole, in relation to the changes of basic interest rate of Brazil (Selic rate as defined by Monetary Policy Committee of Central Bank of Brazil). Finally, we made some simulations using this new approach of transmission mechanism analysis. The results show that the impact of these changes on bank sector's tend not to negatively affect its intrinsic values. In fact, in the majority of situations, the banks increase their intrinsic value with lower basic interest rates. They also lose very little intrinsic

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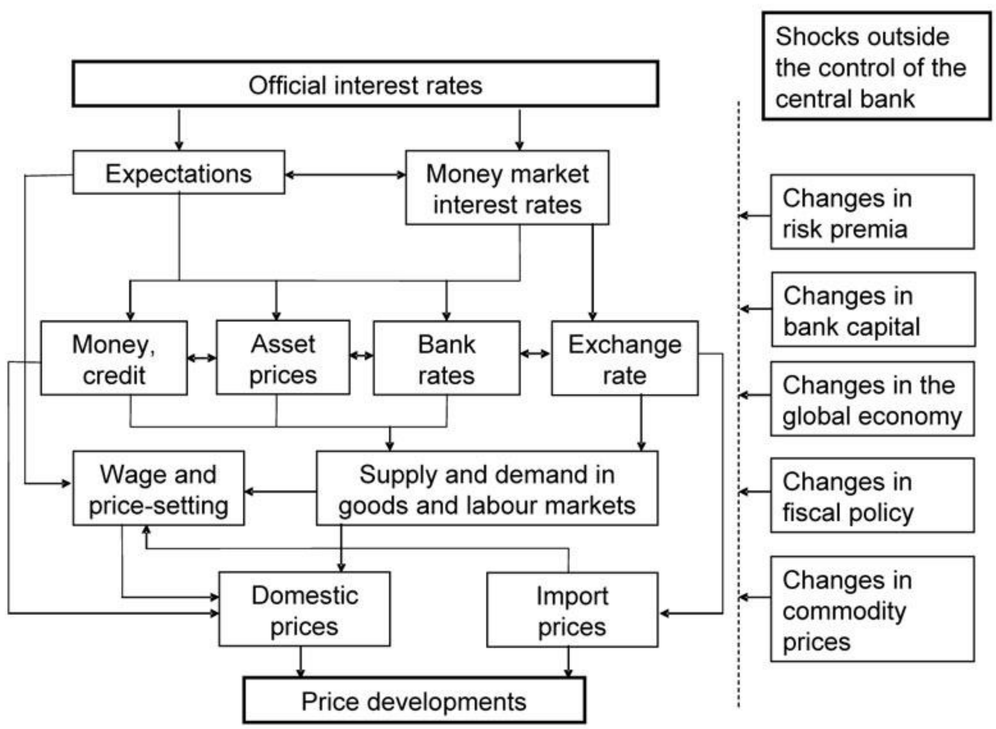
value when interest rates go up. This explains why Brazilian investors usually buy banks stocks as a way to protect themselves against rising interest rates, as well it helps to understand the high resilience and solidity of these three banks, which are known as major financiers of the federal government's debt.
Keywords: mechanism transmission of monetary policy, agent-based computational finance, asset valuation, bank sector.
JEL: E52, G12, C63.

1. Introduction

According European Central Bank, the transmission mechanism of monetary policy is “the process through which monetary policy decisions affect the economy in general and the price level in particular.”

Figure1 illustrates the different transmission channels of monetary policy decisions (ECB).

Figure 1 – The channels of transmission mechanism



Source: European Central Bank (2017)
(https://www.ecb.europa.eu/mopo/intro/transmission/html/index.en.html)

The purpose of this article is to investigate the effect of Central Bank of Brazil's policy decisions of change the basic interest rate on the intrinsic values of the main banks that compose the Brazilian banking sector. We use a new methodology, based on a model with four heterogeneous agents that make fundamentalist valuations of these three main banks of Brazil banks, according to the four most used valuation models.

In this sense, the proposed simulation agent-based model offers answers on how much the increases or reductions in the Selic rate by the Monetary Policy Committee of the Central Bank can increase or decrease the intrinsic value (or "fair value") of Brazilian banks.

According to Loayza and Schmidt-Hebbel (2002, p. 3) there are five transmission channels of monetary policy[5]. The first and most traditional of them is the interest rate channel. In the view of these authors, it is commonly considered as the most important channel and depends on other connections that have been analyzed in the macroeconomic literature. They also claim that, at the outset, there is no reason to focus on only one asset price, the interest rate, as the single transmission channel of monetary policy. The cited authors consider that decisions of the monetary authority can lead to important effects on stock prices, bonds, real estate and exchange rates. Therefore, we consider that is important not only to verify the effects of monetary policy on asset prices, but also on their intrinsic values, which are defined by valuation techniques widely used by fundamentalist analysts in various financial markets around the world.

2. Valuation models and agent-based computational finance modelling

The first subsection reviews the valuation literature and the second, the agent-based computational finance modelling literature.

The second subsection comments the key articles on bottom-up approach and agent-based models in Finance.

2.1. Valuation models

The focus of this review is on the literature on discounted cash flow valuation models.

Bodie, Kane and Marcus (2009, 589) consider that the intrinsic value of a stock (the ultimate object of valuation techniques) corresponds to the present value of the cash payments to its buyer, which includes dividends and amounts arising from the final sale of the shares, discounted at an appropriate risk-adjusted interest rate.

With a similar but broader view, Damodaran (2006, p. 3) considers asset valuation to be at the heart of many analytical activities that are done in finance. It is useful both in the study of market efficiency and in the analysis of corporate governance issues or in the comparison of different investment decision rules for the capital budget.

Analysts usually use a diverse set of valuation models. There are those that are simple and there are others well refined. Some examples: i) discounted cash flow model - the focus of this article - that relates the value of an asset to the present value of expected future cash flows in that asset; ii) settlement and accounting evaluation model, which aims to evaluate the existing assets of a company, using accounting estimates of value or the own book value as the beginning of the process; (iii) a model that estimates the value of an asset taking into account the pricing of other "comparable" assets in relation to a common variable (such as profits, cash flows, book value or

[5] The five channels: (i) interest rate; (ii) exchange rate; (iii) monetary and credit aggregates; (iv) asset prices; and (v) expectations. We simply try to substitute the “asset prices” channel for an “intrinsic value" channel.

sales); iv) a contingent valuation model that uses pricing options to measure the value of the assets that resemble to, in general or in part, the options (this class of models fits the theory of real options).

According to Parker (1968), the pioneering interest rate tables date back to 1340. And it is the same Parker who attributes to the first publication on the subject, the "*Pratica della Mercatura*" of 1766, to Francesco Pegolotti, a Florentine businessman and politician.

However, the truly seminal contributions to discounted cash flow valuation techniques were established by Alfred Marshall (1907) and Bohm-Bawerk (1903). Both explored the notion of present value in their works in the early twentieth century, influencing Irving Fisher, who developed and sophisticated it in *The Rate of Interest* of 1907 and *The Theory of Interest* of 1930. In both works, Fisher Proposed four alternative approaches to analyzing investments. According to him, they would generate the same results.

He argued that when faced with various investment alternatives, one should choose the investment: (i) which has the highest present value at the market interest rate; ii) whose present value of the benefits exceeds the present value of the costs; (iii) whose "rate of return on sacrifice" exceeds the market interest rate; or (iv) that compared to the next most expensive investment, generate a rate of return on the cost higher than the market interest rate. It should be noted that the first two approaches represent the net present value rule. The third is a variant of the internal rate of return (IRR) approach. The latter corresponds to the marginal rate of return approach.

As Fisher did not go deeply into the notion of the rate of return, other economists came to explore the idea better. Starting from the analysis of a single investment, Boulding (1935) deduced the internal rate of return of an investment from its expected cash flows and from an initial investment.

Keynes (1936) argued that the "marginal efficiency of capital" could be calculated as the discount rate that makes the present value of an asset's returns equal to its current price and that is equivalent to the rate of return (the same of Fisher) of an investment.

Samuelson (1937) explored the differences between the internal rate of return and net present value approaches. He also argued that rational investors should maximize the net present value, not the IRR.

In the past 50 years, discounted cash flow models have spread and expanded their scope for insurance and business valuation. There is no doubt, according to Damodaran (2006), that this impulse was aided and stimulated by the developments of portfolio theory, on the one hand.

For fundamentalists (and unlike chartist) the value of a stock is different from the price of it, and investors seek to know how the value oscillations occur and try to anticipate possible price swings.

The classic form for this type of approach is the dividend discount model, which is the basis of corporate finance theory. The value of a company is the sum of all expected dividend payments, discounting their present net value.

However, these components are marked by uncertainty.

2.2. Bottom-up approach and agent-based models

This subsection reviews the literature on the use of agent models and self-organizing capabilities for specific types of negotiations and market processes.

These areas of research are today some of the most active in ACE (Agent-Based Computational Economics).

In his seminal paper, Marks (1998) was one of the first researchers to use an ACE framework to address the issue of market self-organization. His research highlights to the economists the potential importance of history, interactions and learning for determining strategic market outcomes. Marks used an ACE model of an oligopolistic market to analyze how selling and price-fixing firms can compete successfully. His model used a genetic algorithm to model its companies as inductive learners with limited rationality.

One result observed by Marks in his experiments was the emergence of an optimum global price formation of joint maximization among firms, without any explicit collusion between firms in that process. At the time, this type of evolution-cooperation outcome that emerged through a bottom-up approach was new to many economists, since very few had read Axelrod's seminal work on this subject.

The first ACE financial market studies were developed by LeBaron (2000a and 2000b), including the influential stock market model developed at the Santa Fe Institute by Arthur, Holland et al. (1997).

Holland (1992) has developed a dynamic theory of asset pricing based on heterogeneous stock market traders that update their price expectations individually and inductively through classificatory systems.

LeBaron (2001) was also interested in obtaining a better empirical adjustment of the model to observe regularities in the financial markets. Calibrating a computer model of agent-based stock markets, it succeeded in aggregating macroeconomic and financial data. All investors use past performance to evaluate the effectiveness of their trading rules. But they have different length memories. Thus, a genetic algorithm was used to jointly evolve the trading rules available to agents. The model was also calibrated to incorporate the growth and variability of dividend payments in the United States.

LeBaron showed that the calibrated model generated return, volume and volatility very similar to those that characterize the real data of the financial time series.

3. Valuation model from heterogeneous agents

In the first subsection, we comment on how the design of the heterogeneous agents of the model was done. The model is then presented in four modules.

3.1. The agent’s design

The model has four heterogeneous agents. They are “valuators-agents” or fundamentalist analysts who make the valuation of Itaú/Unibanco, Banco do Brasil and Bradesco. These are the largest banks that are part of the theoretical portfolio of the Bovespa Index. Together, they add 46,4% to the total assets, 46,8% of net worth, 60,9% of the number of agencies and 49,3% of deposits in Brazilian banking sector.

Table 1 – The size of Itaú/Unibanco, Banco do Brasil and Bradesco

Units	Agencies	Net worth	Assets	Deposits	Net profits
Number/US$	14.289	254.860.687	2.855.297.093	743.042.088	17.597.553
% of Brazilian bank Sector	60,9%	46,8%	46,4%	49,3%	44,4%

Source: Statistics of Central Bank of Brazil (BCB)[6].

Each of the four "valuators agent" uses a different model of discounted cash flow. These four models are the most important and researched in the valuation literature. According to Fernández (2008), the models of discounted cash flows that are currently receiving the most attention from financial researchers, fundamental analysts and valuation experts are (except the third) the ones we will use in our model of agents: Myers (1974), Miles and Ezzell (1980), HPR (Harris and Pringle, 1985, and Ruback, 1995)[7], Damodaran (1994) and Fernández himself (2004 and 2008).

These four heterogeneous agents do not exchange information with each other. They only do the valuation of the mentioned banks. Each of them are specialized in one valuation model only.

Besides this, we must add some aspects to better detail how the design of this agent-based model was done.

For Lebaron (2006), when constructing an agent-based financial market model, the modeler faces a number of basic questions that must be answered regarding design. The author states that probably the most relevant of the issues is the design of the economic environment itself. For LeBaron (2006), the design of financial models based on the agent should be based on the definition of the following characteristics:

- Preferences – Questions about preference types are critical. Should they be simple preferences of the mean / variance type, or should they be in the form of constant and standard relative risk aversion? Also, another important point is whether the preferences are of the myopic type or are they intertemporal? Intertemporal preferences are the object of this work model because discounted cash flow models are, by nature, intertemporal and use discount rates between different periods of time. LeBaron (2006) states that they bring more realism to the cost of greater complexity in the learning process.
- Price determination – many models focus on the fundamental problem of price formation and the method for pricing is critical. In this model the focus is on the formation of intrinsic values (which are also informally called "fair prices" by fundamentalist analysts).
- Evolution and learning - for simplicity, it is assumed here that agents evolve and learn by obtaining information in the balance sheets of each quarter in the sample.

6 http://www.bcb.gov.br/pt-br/#!/n/INFOANAECOFINAN

7 This model are not appropriated for valuing banks, and it is becoming least used for non-financial firms.

- Information's representation – an important question on how to describe how information is presented to agents and how they process it. Theoretically, this is the difficult task of converting large amounts of time series of information into a concise plan to be presented to the agent and to facilitate its interpretation. In this model, the four agents seek their information in series of cash flows elaborated from banks' quarterly balance sheets. Once they have a history of these flows, they design these balance sheets and finally discount them using interest rates and other parameters that differ between the four models, as we will see in the next section. However, there is no type of learning obtained through interaction between them. Thus, each agent is specialized in one single valuation model and and ignores the behavior or the models used by the others.
- Social learning – For simplicity, we assume that in the model there is no type of learning obtained through the interaction between agents. Thus, each agent is specialized only in one valuation technique and ignores what others do.
- Benchmarks – The last important design issue is the creation of useful comparisons of benchmarks. It is very important to have a set of parameters for which market dynamics are well understood. The agent-based model proposes a comparison between four different results obtained by the heterogeneous agents. In this comparison, it is possible to perceive more similar patterns than relevant differences among them, as we will see in section 4.

3.2. Data sources, forecasts and cash flow

The model was developed using Gretl (forecasting cash flow using SARIMA method)[8], Mathematica 9.0 (for the deduction of elasticities and modelling the heterogeneous agents and their different models), and Excel 2010 (for plotting and storing the final results and balance sheet data). Our "valuators agents" model uses discounted cash flow techniques for three obviously leveraged companies, and their cash flows were made using the standardized financial statements in accordance with CVM rules.

The following tables follow a methodology adapted to Brazilian accounting standards and based on the definitions of Fernández (2008), Damodaran (2012) and Copeland, Koller and Murrin (2001).

The table 2 shows the consolidated cash flow model[9] used for bank sector.

Table 3 describes the sources of the model parameters.

[8] To make the text more concise and clear, we have left the estimates of the Sarima model available at http://marcelopa.dominiotemporario.com/Pesquisa.php

[9] This cash flow is the result of the sum of the cash flows of the three banks mentioned.

Table 2 -Forecast of balance sheets (balances) and company results accounts

Financial income
(+) Revenue from services rendered
(-) Expenses on financial intermediation
(=) Gross profit from financial intermediation
(-) Provision for loan losses
(+) Non-financial revenue (includes foreign exchange income)
(-) Non-financial expense
(-) Taxes
(=) Net revenue
(+) Non-operational items
(+) Depreciation
(=) Operational cash flow
(+) Balance (sources)
Loans due (gross)
(-) Provisions and unrealized revenue
(=) Borrowings paid (net)
(+) Elevation of deposits
(+) Increase in external indebtedness
(+) Increase in other forms of liabilities
(+) Elevação de contas a pagar
(-) Balance (uses)
New loans granted
(+) Increase in held securities
(+) Increase in receivable accounts
(+) Increase in net tangible assets
(+) Increase of other assets
(-) Decrease in deposits
(-) Decrease in external debt
(=) Free cash flow to the share capital

Sources: Balance sheet, income statements of Itaú/Unibanco, Banco do Brasil and Bradesco. Elaboration of authors based on Fernández (2008), Damodaran (2012) and Copeland, Koller and Murrin (2001).

Table 3 – Sources of parameters used in the model

Parameters	*Meaning and data used*	*Sources*
R_F	R_F = 12-month LTN return - Average IPCA expectations for the next 12 months. LTN is a national treasury bond.	Central Bank of Brazil (Banco Central do Brasil - BCB).
Kd	Required return on company debt.	Authors’ calculations.
K_M	K_M = equity risk premium = R_F + P_M.	BM&F/Bovespa and BCB
βi	βi = quarterly beta of PETR3.	Authors' calculations based on BM&F/Bovespa data
βd	Beta of the company’s debt, given by $Kd = R_F + \beta d . P_M$.	Authors' calculations based on BM&F/Bovespa data
βu	Beta of unlevered company’s stocks, given by $Ku = R_F + \beta u . P_M$.	Authors' calculations based on BM&F/Bovespa data
β_L	Beta of levered company’s stocks, given by $Ke = R_F + \beta_L . P_M$.	Authors' calculations based on BM&F/Bovespa data
P_M	P_M = Brazilian prime rate (TPB or “taxa preferencial brasileira”)	Central Bank of Brazil (Banco Central do Brasil - BCB).
T	Tax burden = total taxes paid / net sales revenue	Bank’s income statements and Exame Magazine’s “Best and Bigger Yearbook” (“Melhores e Maiores” da Revista Exame). The tax burden data were obtained from the yearbook and converted into reais at the commercial exchange rate R $ 3,25 / 1 US$ (whose source is Focus Report of BCB).

Source: Elaboration of authors based on Fernández (2008), Damodaran (2012) and Copeland, Koller and Murrin (2001).

3.3. Four models, four agents, four valuators.

We now describe the four models that serve as valuation methods for each of the four agents.

Table 4 -Equations used in all the four valuation models

Equations
$Ke = R_F + \beta d \cdot P_M$
1) $VAC_0 = \sum_{t=1}^{\infty} \frac{CFac_t}{(1+Ke_1)...(1+Ke_t)}$
2) $D_0 = \sum_{t=1}^{\infty} \frac{CFd_t}{(1+Kd_1)...(1+Kd_t)}$
3) $VAC_0 + D_0 = \sum_{t=1}^{\infty} \frac{CF_t}{(1+WACC_1)...(1+WACC_t)}$
4) $WACC_t = \frac{VAC_{t-1} \cdot Ke_t + D_{t-1} \cdot Kd_t \cdot (1+T_t)}{VAC_{t-1} + D_{t-1}}$
5) (3) – D_0 = VAC_0
6) $VTS = \frac{[(D_{t-1} = VA_{t-1}) \cdot Ku \cdot T]}{1+Ku}$
7) $Vu_0 = \sum_{t=1}^{\infty} \frac{CF_t}{(1+Ku_1)...(1+Ku_t)}$
8) VTS + Vu_0
9) (8) - D_0 = VAC_0

In the tables of the four agents and their respective models, we have the following nomenclature of the variables: the VTS is the *value of tax shields*, which is the value of the reduction of the taxable income of an individual or legal entity. This reduction is obtained through legal deductions arising from interest payments, medical expenses, philanthropic donations, depreciation and amortization, etc. Such deductions affect part of the taxpayer's taxable income in a given year or differ in future years due payments (Fernández, 2004 and 2006). With this, the tax benefit reduces the total amount of taxes payable by a company or taxpayer; D_0 is the value of the debt in the current period, which in this model is equal to VA_0, the current value of the expected flows for the shares; Kd is the the required return of the company's debt; T is the tax rate on the company; Ke is the required profitability of the company's shares (or the cost of own resources); Ku is the required profitability of the shares of the company not leveraged (with D = 0); Vu is the value of the shares of the company not leveraged (with Div = 0) and VAC_0 is the value of the shares in the present (in t = 0); WACC is the weighted average cost of capital; βcdv is the beta for a leveraged (with debt) company, βu being that of a unlevered company (without debt); The R_F is the risk-free rate; the P_M is the prime market risk rate.

Table 5 - Myers (1974) - first agent

Equations
$VTS = \frac{[(Div_0 = VA_0) \cdot Rdve \cdot Ti]}{1 + Rdve}$
$Rcdv = Rsdv + \frac{[(Vsdv_0 = VA_0) - (VAC_0 = VA_0)]}{(VAC_0 = VA_0)} \cdot (Rsdv - Rdve)$
$VAC = (Vsdv_0 = VA_0) + VTS - (Div_0 = VA_0)$
$WACC = Rsdv - \frac{[(VTS \cdot (Rsdv - Rcdv) + (Div_0 = VA_0) \cdot Rcdv \cdot Ti]}{VAC}$

Table 6 - Miles and Ezzel (1980) - second agent

Equations
$VTS = \frac{[(D_{t-1} = VA_{t-1}) \cdot Kd \cdot T \cdot (1 + Ku)] / (1 + Kd)}{Ku}$
$Ke = Ku + \frac{(VAC_0 = VA_0)}{VAC_0 + D_0} \cdot (Ku - Kd) \cdot \left[1 - \left(\frac{T \cdot KdRdve}{1 + Kd}\right)\right]$
$VAC = (Vu_0 = VA_0) + VTS - (D_0 = VA_0)$
$WACC = Ku - \frac{[(D_0 = VA_0) \cdot Kd \cdot T]}{VAC_0 + D_0} \cdot \frac{1 + Ku}{1 + Kd}$

Where: D-1 is the debt in the previous period that is equal to Vt-1, the value of the share income flow also in the previous period (In the same way as Fernández (2004 and 2008) and in opposition to the models of Myers (1974), HPR (1985 and 1995) and Damodaran (1994), where this identity is defined for both variables at t = 0 and not at t-1).

In the model of Miles and Ezzell (1980), we also have the following identities:

$$\beta_L = \beta_u + \frac{(D_0 = VA_0)}{(VAC_0 = VA_0)} \cdot (\beta_u - \beta_d) \cdot \left\{1 - \left[\frac{T \cdot Kd}{1 + Kd}\right]\right\} \quad (3.11)$$

$$Kd = R_F + \beta_L \cdot P_M \quad (3.12)$$

Where it is possible to observe that the definition of the Kd is (apparently) the same in the four models. But in fact, the calculation of β_L is modified from model to model, which causes the results to differ, even though R_F and P_M are the same for all models.

Table 7 - Damodaran (1994) – third agent

Equations
$VTS = [(D_0 = VA_0) \cdot Ku \cdot T] - [(D_0 = VA_0) \cdot (Kd - P_M) \cdot (1-T) / Ku]$
$Ke = Ku + \left[(D_0 = VA_0) \cdot (1+T) / (VAC_0 = VA_0)\right] \cdot (Ku - P_M)$
$VAC = (Vu_0 = VA_0) + VTS - (D_0 = VA_0)$
$WACC = Ku \cdot \left[1 - \frac{(D_0 = VA_0) \cdot T}{VAC_0 + D_0 = VA_0}\right]$
$\beta_L = \beta_u + \frac{(D_0 = VA_0) \cdot T}{VAC_0 + D_0} \cdot (\beta_u - \beta_d)$

Table 8 - Fernández (2004 and 2008) - fourth agent

Equations
$VTS = \frac{[(D_{t-1} = VA_{t-1}) \cdot Ku \cdot T]}{1 + Ku}$
$Ke = Ku + \left[(D_0 = VA_0) \cdot (1-T) / (VAC_0 = VA_0)\right] \cdot (Ku - Kd)$
$VAC = (Vu_0 = VA_0) + VTS - (D_0 = VA_0)$
$WACC = Ku \cdot \left[1 - \frac{(D_0 = VA_0) \cdot T}{VAC_0 + D_0 = VA_0}\right]$
$\beta_L = \beta_u + \frac{(D_0 = VA_0) \cdot T}{VAC_0 + D_0} \cdot (\beta_u - \beta_d)$

4. Results

This section is divided into two subsections. The first one analyzes the estimates of the four agents of the computational model. The second shows the formulas of the elasticities that each agent uses and that were computed in Wolfram Mathematica 10.0. In this subsection, we also explore the results of these simulations. That is, we investigate the responses of intrinsic values of the banking sector to the variations in the basic Selic interest rate defined by the Copom.

All results of the following tables have been converted to US dollars using a exchange rate of BRL 3.25 = 1 US$. This is the exchange rate predicted for the end of 2017, by Focus Report[10].

4.1. Intrinsic value estimates of Brazilian bank sector

Assuming the interest rate of 12.25%, prevailing in May 2017, the four valuators agents obtained the results of table 9.

Table 9 – Main valuations' results obtained by the four agents (in US$ thousands)

Valuations' Results	Agent 1 – Myers (1974)	Agent 2 – Miles & Ezzell (1980)	Agent 3 – Damodaran (1994)	Agent 4 – Fernández (2004 and 2008)
VAC	973.290.002	976.734.323	699.265.762	973.307.010
WACC	0,29340	0,28154	0,56893	0,28497
β_L	0,02714	-0,02128	-0,071925587	-0,071925587

Source: Authors' estimates based on bank's quarterly balance sheets, according table 4.

We note that the VAC results of agents 1, 2 and 4 are very close. The result of agent 3, however, is quite different. In fact, some assumptions of Damodaran's model, especially the formula he uses for calculating his VTS, explain the difference in results. Therefore, we will do our analysis considering the results of agents 1, 2 and 4. That is, we will analyze the estimates of the models of Myers (1994), Miles & Ezzell (1980) and Fernández (2004 and 2008), who showed greater adherence to financial information of the three banks' consolidated balance sheets.

4.2. Results of agents' simulations considering different basic interest rate's scenarios.

As expected, the elasticities of the intrinsic values of the financial sector in relation to the variations in the basic Selic rate were similar in the calculations of agents 1, 2 and 4.

The interesting thing is to realize that the intrinsic values of the banking sector tend to fall with the increase of the basic rate of interest (Selic rate). This runs counter to a common view in

[10]Edition of May 26, 2017. This is a weekly publication of Central Bank of Brazil, available at: http://www.bcb.gov.br/pec/GCI/PORT/readout/readout.asp .

Brazil that banks become more profitable with the Selic rate increase. Although their intrinsic values do not fall too much at higher interest rates, it is clear that when the Selic rate falls below 10% the elasticities show a considerable increase in their intrinsic values. In future articles, we will investigate whether such a conclusion is due to the expansion of its credit volume and, above all, what type of credit provided is more profitable for the banks (table 10)[11].

Table 10 – Elasticities of the intrinsic values of Brazilian bank sector in relation to the variations in the basic Selic rate (US$ thousands)

Basic Selic Interest Rate	Agent 1 Myers (1974)	Δ%	Agent 2 Miles & Ezzell (1980)	Δ%	Agent 4 Fernández (2004 and 2008)	Δ%
7%	995.044.544	2,2352%	998.439.025	2,2222%	995.054.174	2,2344%
8%	990.959.916	1,8155%	995.286.844	1,8994%	991.321.863	1,8509%
9%	990.738.390	1,7927%	994.456.077	1,8144%	990.693.402	1,7863%
10%	982.707.822	0,9676%	986.130.586	0,9620%	982.721.651	0,9673%
11%	981.972.142	0,8920%	981.972.142	0,5363%	978.555.073	0,5392%
12%	974.343.533	0,1082%	977.785.444	0,1076%	974.360.186	0,1082%
12,25%	973.290.002	-	976.734.323	-	973.307.010	-
12,50%	972.234.681	-0,1084%	975.681.416	-0,1078%	972.252.043	-0,1084%
13%	970.118.650	-0,3258%	973.570.223	-0,3239%	970.136.722	-0,3257%
14%	965.864.911	-0,7629%	969.326.209	-0,7585%	965.884.408	-0,7626%
15%	961.582.043	-1,2029%	965.053.126	-1,1959%	961.602.969	-1,2025%

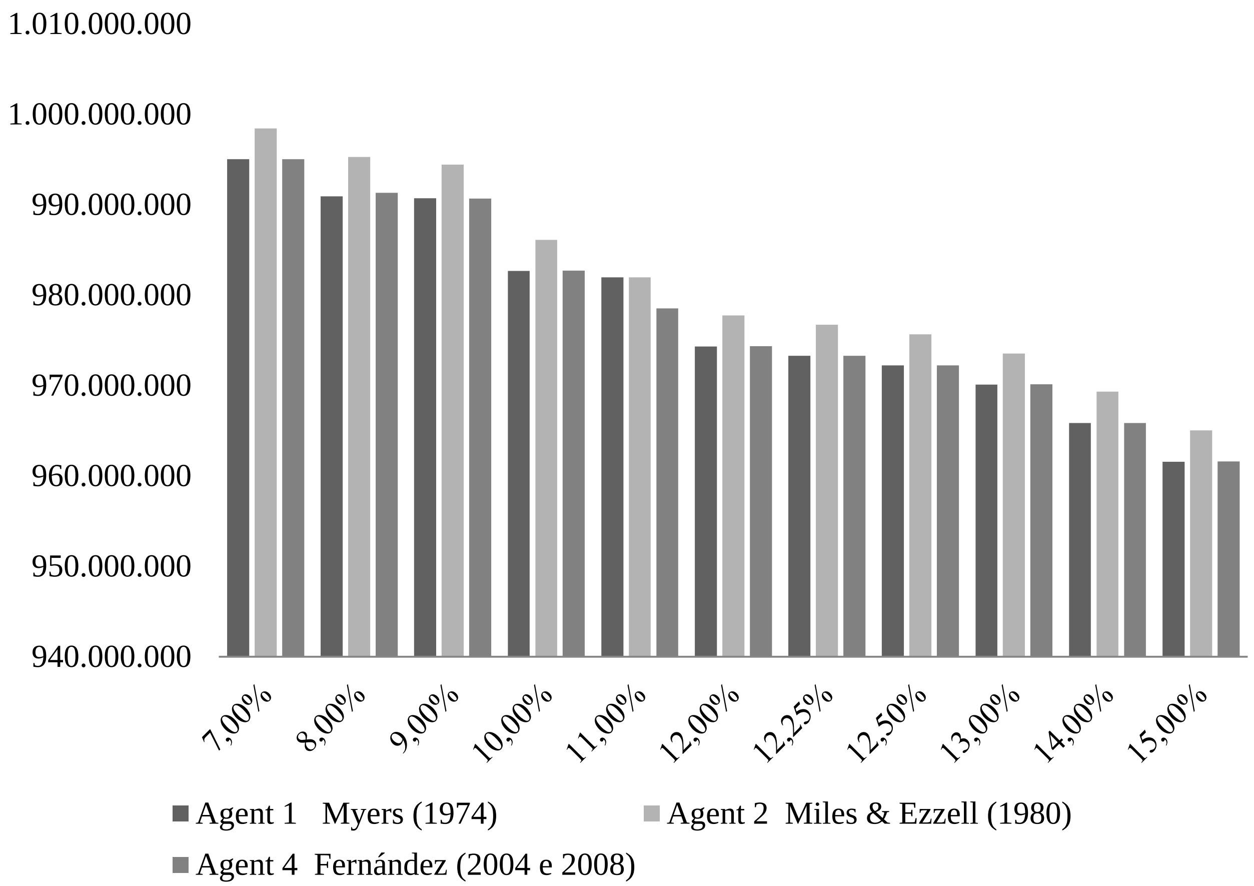
Source: Authors' simulations based on bank's quarterly balance sheets, according table 4.

Within the range of 10% to 15% of the Selic rate, the elasticities, in modulus, are very close, according to the calculations of agents 1, 2 and 4.

This corroborates a very common practice of stock market investors in Brazil: when there is a recession or when interest rates rise, they usually protect their assets by buying stocks from banks. This pattern is observable in figure 2.

[11] We omitted the results of Agent 3, which uses the Damodaran model (1994). It offers completely opposite results to the other three. We believe that this is due to the peculiarities of this model that is most widely used for non-financial companies, due to the calculation of VTS, as mentioned before.

Figure 2- Intrinsic values of Brazilian Bank Sector versus changes in basic interest rate (US$ thousands)



Source: Authors' simulations .

4. Conclusions

We have developed a agent-based computational finance model with the objective of estimating the impact of changes in the basic interest rate on the intrinsic value of the Brazilian banking sector.

Each of the four heterogeneous agents of the model estimated four different intrinsic values of the three main financial institutions of the Brazilian banking sector: Itaú / Unibanco, Banco do Brasil and Bradesco.

With this new approach of analysis of the mechanism of transmission by the interest channel, we obtained results that showed that the Brazilian banks increase their intrinsic value when the basic rate of interest falls. But they also lose very little value when this rate rises (which is very common in monetary policy practiced in Brazil).

This explains why Brazilian investors often buy shares of banks as a way to protect themselves against rising interest rates. The results also help understand the high resilience and solidity of these three banks, known as major federal government debt lenders.

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