A Behavioral and Rational Investor Modeling to Explain Subprime Crisis: Multi Agent Systems Simulation in Artificial Financial Markets

Chapter · October 2018

DOI: 10.1007/978-3-319-68876-3_6

3 authors, including:

Yosra Ridha Ben Said
University of Sfax
15 PUBLICATIONS **19** CITATIONS

SEE PROFILE

Dalel Kanzari
higher Institute of applied sciences and Technology of Sousse
32 PUBLICATIONS **42** CITATIONS

SEE PROFILE

A behavioral and rational investor modeling to explain subprime crisis: Multi Agent Systems simulation in Artificial Financial Markets

Yosra Ben Said
Doctor in Finance.
Financial and Accounting Methods Department, FSEG Mahdia.
Monastir University, Tunisia.
E.A.S research unit, Mahdia.
yosra.bensaid@yahoo.f
+21696986966

Dalel Kanzari
Doctor in Computer Science.
Computer Science Department, ISSATSo
Sousse-university, Tunisia.
COSMOS-ENSI laboratory, Tunis.
kndalel@yahoo.fr
+21697618137

Marwa Bezzine
Student in computer science.
ISG-Sousse. Tunisia.
marwabezzinecherif@gmai.com

Abstract

The aim of this paper is to explain the financial crisis via the investors' psychological behavior and rational reasoning. We specifically focus on three main biases: overconfidence, loss aversion and mimetic behavior.

We propose a new conceptual model of financial decision-making representing the stock market dynamics during the crisis period. We construct an artificial financial market that has two types of investors: institutional and individual. The latter are classified into two groups: the noise traders and the mimetic investors.

A simple experimentation of our model is elaborated to simulate the behavior of the investors during the different phases of a crisis: the formation and the break-up of the speculative bubble. We conclude that the interaction between rational and irrational behavior and the investor's psychology must be considered in the explanation of financial crises, overconfidence and loss aversion are two behavioral biases very relevant to explain the formation and bursting of bubbles. Finally, mimetic behavior amplifies disturbances in the financial market and limits arbitrage.

KEYWORDS: Financial crisis; Behavioral finance; Rational behavior; Investor's psychology; Overconfidence; Loss aversion; Mimetic behavior; Multi-agents simulation.

1. Introduction

Finance has evolved a lot since the market efficiency theory of Fama French (1970). The field of behavioral finance (DeBondt and Thaler 1985; Shleifer and Summer 1990; Shleifer and Vishny 1997), inspired by sociological and psychological sciences, is considered nowadays as the most attractive research area that aims to explain the investor behavior during the financial crisis period and its impact on the others' behaviors.

Financial crises are characterized by a cyclical downturn in the financial system: after a phase of euphoria and increased asset prices, the values collapse. This type of reversal can be observed in the securities markets (market crash), in the banking system (bank failures), on the debt securities market (the state solvency crisis), or in the foreign exchange market (collapse in the currency value). These crises often appear in combination.

On goods and services markets, rising prices usually leads to a decline in demand allowing an equilibrium return. However, in the financial markets, the demand increases with prices and nobody knows the "right" future level of the stock price or the exchange rate. The agents define their own strategies face to the uncertain future. They have at least two methods: they can conduct their own analysis based on assets' fundamental value or observe the other market participants decisions to derive their own behavior. It is the mimetic behavior where the agent imitates the buying or selling behavior of other agents.

This mimetic behavior can be the source of speculative bubbles in which the price of a financial asset deviates from its fundamental value. Although some agents will be aware of the overvaluation of the financial asset, they will continue to buy it because they assume the price will continue to rise. This irrational behavior leads to the formation of speculative bubbles. At some point, agents begin to anticipate a fall in prices; they will then sell their assets and will be followed by other agents. Stock prices collapse and the bubble bursts. The crises of the financial market are mainly related to the bursting of these bubbles.

These irrational bubbles can also be explained by the irrational behavior of certain investors: the noise traders (Shleifer and Vishny 1997). This type of investor presents several predictive biases: they form their predictions with excessive confidence, they generally do not use all the information they hold, they tend to revise their forecasts too slowly, and they seem to ignore the elementary probability calculation.

Unlike traditional finance, behavioral finance allows an irrational assessment by investors. It considers that the arbitrage of rational investors is not able to return prices to its fundamental

value. The psychological effect has always been of great importance in financial crises. Several research papers (Statman 2011; Shefrin and Statman 2011; Abbes 2012) explain the subprime crisis through investor psychology and answer two main questions: How do bubbles form? And how did the stock market collapse? Many behavioral biases are adopted such as excessive optimism, extrapolation bias, the theory of overconfidence, the loss aversion, and so on. Nevertheless, this work remains theoretical and not experimented.

In our work, we use models of multi-agent systems in an artificial financial market to reflect the complexity of the financial market system (Hoffmann et al. 2007; Kouwenberg and Zwinkels 2015; Rekik et al. 2014), the interactions between agents themselves and between agents and their environment. We show that the heterogeneity of investors, the interactions between rational behavior and irrational behavior on the one hand, and agents' interactions with the external environment on the other hand, explain the formation and break-up of speculative bubbles and thus the financial crisis.
We construct an artificial financial market composed of two types of investors: institutional investors (rational) and individual investors (irrational). As an experimental example, we choose the most recent and important financial crisis: The subprime crisis where a housing bubble was at the origin of this financial crisis (Levitin and Wachter 2012). In 2006, following irrational reasoning, real estate prices were pushed to very high levels and formed the subprime bubble. The later didn't take long to burst and collapse the financial market.

The first section presents the empirical literature on behavioral finance and their potential to explain financial crises. Section two introduces the relevance of multi-agent simulation in explaining the functioning of financial markets. In section three, we propose a behavioral approach to explain the formation and break-up of speculative bubbles. In section 4 we elaborate an SMA model that can take into account the investors' psychological characteristics, the interactions between investors themselves and their environment. Finally, in section 5, we simulate the financial decision aid model that confirms our hypotheses. We conclude that the investors' behavioral biases and the mimetic behavior on the market strongly contribute to explain the subprime crisis.

2. Behavioral Finance and financial crisis

The behavioral finance researchers focus on how bubbles form and how they break down. In other words, why an asset might become overvalued? There are many theories that deal with

the formation and the burst of subprime bubble. The objective is then to test and refine the theories of asset market overvaluation and undervaluation that already exist in the behavioral finance literature. Some works are interested in investor's beliefs, some others focus on investor's preferences whereas other works adopt the herding behavior.

2.1. Investor's beliefs

Several behavioral finance works are based in the investors' beliefs to explain the assets mis-evaluation in the stock market. The most important are:

Excessive optimism: a bubble forms when some investors show beautiful opinion far from the reality, their skills and asset's prospects (Easterwood and *Nutt* 1999). These optimistic investors under react to negative information and over react to positive information. They interpret in an optimistic way the new information. As a consequence, the assets will be overvalued.

Representativeness heuristic/extrapolation bias: The investors underestimate the long-term averages and they give more weight to the most recent experiences (Barberis et al. 2001; Shefrin 2000; Barberis et al. 1998). Such investors become excessively pessimistic for the former loser assets and excessively optimistic for the former winner assets. The first ones will be then underestimated, the second overestimated (Barberis et al. 1998; Manzan and Westerhoff 2005) .

*Overconfidence theory***:** the overconfident individuals overestimate their information (Illusion of knowledge) and their capacities. Each one believes he can beat the market (Odean and Gervais 2001; Daniel et al. 1998). The overconfident investors overreact to the private information and under react to the public information. After successive earnings on the market, they become more aggressive in their transactions the next period. They also underestimate the risk and opt for the risky assets (Chuang and Lee 2006).

Reference point: By forming their estimations, the investors begin with an initial arbitrary value, a reference point and they fit shyly to the new information as suggested by Kahnemann and Tversky (1979). This reference point can be the asset price or the past assets prices trend. These investors become more tolerant of risk.

*Confirmation bias***:** it is the investors' tendency to overweight information that confirm their prior beliefs and to underweight information that disconfirm those beliefs.

2.2. Investor's preferences

The preferences based theories highlight the impact of the investors' choices on their decision making process, the most relevant are:

The prospect theory/Loss aversion: People tend to feel the loss more than the earnings for the same scale. They are so desperate that they are going to take big risks to avoid any other loss in the future (Barberis et al. 2001; Kahnemann and Tversky 1979). This feeling of punishment urges the investors to avoid selling the losing assets. They prefer to sell others better yields' assets. (Odean 1998)

Ambiguity Aversion: Presented by Tversky and Kahnemann (1991) as the fact that the people are averse to situations where they do not feel able to assign probabilities to future outcomes.

Narrow framing: Often people make the separation between decisions which must be combined and they ignore the interactions between them.

Opaque framing: Most of people are sensitive to the way a subject is presented. For example, something offered for three dollars a day can seem cheaper than in 1095 dollars a year.

The house money effect: Having experienced gains, some investors are less concerned about future losses and become less risk averse because of a "house money" effect (Barberis et al. 2001).

2.3. Mimetic behavior

Mimetic or herd behavior become increasingly linked to financial crisis. It can be defined as a set of individual behavior presenting correlations (Graham 1999). However, numerous investors can be brought to buy the same assets because they received correlated information. Consequently, the notion of imitation assumes that a group of investors make the wrong decision at the same time. We can explain in several ways why the investors are influenced by the decisions of their peers. Firstly, the latter may hold private information about the return on the investment and their decisions reveal this information (Hirshleifer et al. 1994). Secondly, money managers can imitate others when the incentives are based on yield reference (Scharfstein and Stein 1990). Lastly, the investors can have an intrinsic preference for conformity (Zwiebel 1995).

Numerous behavioral biases: extrapolation bias, reference point, narrow framing and conservatism can be considered as the origin of the real estate bubble formation and the overvaluation of the subprime credits. The overconfidence and loss aversion are two relevant behavioral biases but not seriously adopted. Those two biases have been proposed to explain various anomalous finding in security market (Chuang and Lee 2006). Several empirical papers have investigated their presence and impact in the stock market (Odean 1998; Broihanne et al. 2014). The financial crisis can be better understood by using the overconfidence, loss aversion biases with mimetic behavior. The mimetic behavior can be

also a key element in the explanation of the behavior of the individual investors who in difficult situation choose to follow the professional ones.

3. The financial markets and the SMA Approach

Since the early twentieth century, fundamental and empirical researches on the functioning of financial markets have increased. These researches are often interdisciplinary. Indeed, financial markets have several aspects: financial (the study of economic issues), mathematics (study of price series properties) and human (study of the psychology of economic actors). Yet none of these disciplines today happens to offer a complete theory able to overcome the complexity of the markets. Computational finance, a crossroads of several research fields (computer science, game theory and finance), emerged to overcome the limitations of previous work. This new discipline reproduces the market functioning in artificial worlds, perfectly controlled. These worlds are reproduced through parallel executive computer systems; called Multi-Agent Systems (SMA). Freed of constraints that make these experiences physically impossible in reality, these later are essentially used to imitate the markets functioning and the investors' behaviors and to test predefined hypotheses and theories. Hoffmann et al (2007); Kouwenberg and Zwinkels (2015); Rekik et al (2014); Levitin and Wachter (2012) and Alfarano et al (2010) adopted the SMA models in an artificial market to explain the functioning of financial markets and anomalies in these markets. Hoffmann et al (2007) study the use of social simulation in linking micro level investor behavior and macro level stock market dynamics. For developing the SMA model, they introduced the bounded rational concept, the prospect theory of Kahneman and Tversky (1979), the conformity behavior concept and theories on different social network.

To explain the excess volatility in the stock market, Kouwenberg and Zwinkels (2015) introduced a multi-agent model of an artificial market, based on mimetic behavior among two types of traders: fundamentalists and noise traders. To explore the market dynamics from a behavioral perspective, Rekik et al (2014) built a multi agent model in an artificial stock market composed of fundamentalists, non fundamentalists and loss aversion investors. The results show that heterogeneous agents with behavioral biases help to explain the dynamics of prices in the Stock Financial Market. Levitin and Wachter (2012) showed that a multi agents model with chartists and fundamentalists endogenously produces boom and burst cycles. Their result shows that interaction between agents can explain the bubbles in the absence of underlying fundamental news.

4. A behavioral explanation approach to the financial crisis

The subprime crisis is a financial crisis occurred in 2007 in the US housing market. Subprime are home loans at variable rates used in the United States. They were considered risky but profitable as long as the real home price was increasing fast (Demyanyk and Hemert 2011). American households were seduced by these long-term credits which allowed them to reach housing rather easily.

Consequently, rating agencies assigned the best grade "*AAA*" on these credits, the thing that which incited several banks and investors to sell these home loans into secondary market of mortgage backed bonds. Nevertheless, when the households were not able to service the variable interest rates, they were not able to pay off their credits. Housing prices as well as the mortgage backed value began to decline, which results in a lack of confidence in the housing market in the end of 2007.

Indeed, the most important cause of this crisis results from the extraordinary variability of the American monetary policy during the recent years. Yet, latter is naturally decided by public authorities and not determined by the market. Fed passed from a 6, 5 % interest rate in 2000 to a 1, 75 % rate in 2001 and 1 % in 2003. There was then a slow rise from 2004 until it reached 4, 5 % in 2006.

During low interest rate and easy credit period, the world was submerged by liquid assets (Mah-Hui 2008). To take advantage of this opportunity of easy profits, financial institutions over loaned to less and less reliable borrowers. When returned to more normal interest rates, the excesses of the past appeared in broad daylight: it was the explosion of the "financial bubble".

Although these macroeconomic explanations are defended by many studies (Demyanyk and Hemert 2011; Levitin and Wachter 2012), they are still insufficient to describe the market functioning in crisis. Homogeneity of investors, their interaction and their psychology are of great importance in the explanation of financial crises.

This paper attempts to explore the financial crisis through the psychology of the individual investors, and the interaction between the individual and the institutional investors. The individual investors constitute an important group in the stock market and their decision-making behaviors have an influence on the fluctuations of assets' prices (Haufmann et al. 2007). The institutional investors are the main determinants of price dynamics, their stock price expectations are frequently correct.

In our model, institutional investors are rational whereas individual investors are noise traders, not fully rational; the arbitrage is risky and limited. Individual investor can be overconfident, loss adverse or mimetic. We test two hypotheses:

– Hypothesis 1(H1): The overconfidence and mimetic behavior of individual investors are the main origin of the bubble formation. The upward trend in subprime assets is a result of the massive purchases of securities by the institutional which consequently led to important earnings on the market. Consequently, the noise traders have overvalued their capacities and the earning opportunities on the market. Their overconfidence and their optimism increase. Supported by the mimetic behavior of some individuals, everyone wants to buy the subprime assets and realize more profits. As a result of this purchase pressure, the subprime assets become overvalued and the subprime bubble is formed.

– Hypothesis 2 (H2): The loss aversion and mimetic behavior of individual investors are the main origin of the bubble burst and the financial crisis. At first, the subprime assets' values flopped and then the institutional investors sell their subprime assets. The majority of investors suffered important losses. Consequently, the noise traders become loss adverse and pessimists. They sell their subprime assets and are followed by mimetic investors. Finally, the subprime assets are strongly undervalued and the bubble breaks down.

To rebalance their portfolios and pay off their losses, the institutional investors sell some of their risky asset holdings: Having heavily suffered losses, the investors become excessively pessimistic and loss adverse. The majority of individual investors influenced by the institutional ones sell their better yield assets to avoid more losses in the future. Finally, most assets on the market are strongly undervalued which results in the financial crisis.

5. The proposed investors' agent-based models

To take into account the impact of the behavioral aspect on the investors' decision making process and test our hypotheses H1 and H2, we propose a multi agent system where we model the investors' behaviors and the interactions during the financial crisis.

In our approach, the investor is presented by an autonomous intelligent agent that is able to make decision based on information, it perceives (qualitative and quantitative stimuli), its perceptual process (which guarantees the information mining and filtration) and its decision making process.

5.1. The investors' models

The market in our model is populated by three types of agents: institutional investors, noise traders and mimetic traders. All investors are only interested in short time capital earnings and

not motivated by long term rent income (Kouwenberg and Zwinkels 2015). Institutional investors are fundamentalists. Individuals (noise traders and mimetic traders) are irrationals, they switch between overconfident and loss adverse behaviors and some of them can adopt simply a mimetic behavior. For determining the expect return $E_t\ (R_{t+1})$, each type of investors has its own rule.

The fundamentalist rule, showed in equation (1) is based on the expectation of the mean reversion of the market price towards the long term fundamental value.

$$E_t\ (R_{t+1}) = \alpha(P_t - F_t) \quad (1)$$

F_t is the log real fundamental price; $\boldsymbol{\alpha} < 0$ is the speed of mean reversion expected by institutional investors.

The noise trader investors suppose a positive autocorrelation in housing returns. Their rule is described by the equation (2):

$$E_t(R_{t+1}) = \beta(\sum_I^L R_{t-I+1}) \ (2)$$

β (>0) is the extrapolation parameter, L(>0) is a positive integer that indicates the number of lags.

The behavioral attitude of each noise trader influences the decision of buying or selling, their rule is the equation (3):

$$E_t(R_{t+1}) = \beta(\sum_I^L R_{t-I+1}) * B_j \ \ (3)$$

B_j: is the bias of each investor j. If $0 < B_j < 1$, then investor j is loss adverse else if $B_j > 1$, then investor j is overconfident.

All investors (Institutional and individual) take a decision of buying and selling according to the sign of the expected return. So if $E_t(R_{t+1}) > 0$ then investors buy the asset, else the investors sell the asset.

The individual investor with mimetic behavior observes the investment behavior of the others investors and evaluates whether there are more selling or more buying agents and then imitates the dominant behavior. The Mimetic rule depend on the ratio of the equation (4)

$$ratio = \frac{selling\ advice}{buying\ advice} \ (4)$$

If $ratio > 1$, then the mimetic investors sell the asset else the mimetic investors buy the asset.

5.2. The perceptual process

The perceptual process represents the first stage in the decision making proceeding which guarantees the information mining and filtration. Thus the investor agent receives various kinds of qualitative and quantitative stimuli. The stimuli affect the investor decision of the buying or selling assets.

- *Qualitative stimuli*: we propose three kinds of qualitative stimuli that can affect the investor behavioral attitude :
  - The expert's advice: it can be the advice of buying or selling an asset or just doing nothing.
  - The stock trend estimates: there is the forecast trend for an asset. It can be an upward, bearish or stable trend.
  - The market trend: it can be an upward, bearish or stable trend.
- *Quantitative stimuli*: to determine the expected returns, investors need the fundamental value and past prices of assets.
- *Market assets*: we classify the financial markets securities in two types of assets: assets A and assets B. The assets A correspond to the subprime assets which marked the beginning of the crisis. The assets B are the other financial market securities which were severely touched by the crisis.
- *Data filtering*: the stock trend estimates belong to an interval (0, 1); if the forecast trend is close to 0, there is a drop in assets prices but if it is close to 1, there is an increase in assets prices. Also, the market trend belong to an interval (0.1); if the market trend is close to 0, it is a bearish trend but if it is close to 1, it is an upward market trend.
- *Trusted filter*: The expert's advice also belongs to the interval (0, 1); the values close to 0 correspond to buying advice while the values close to 1 indicate selling advice.

5.3. The Decision making process

The decision making process treats qualitative and quantitative stimuli filtered by the perceptual process. An investor can have a behavioral attitude and makes his analysis to take a decision of buying or selling an asset.

We suppose that the investor can buy any asset at any time and it can sell any asset at any time. Then, the portfolio characteristics do not affect the investor's decision. But, on the other hand, the investor decision changes the portfolio's composition and values.

We propose three classes of investors: the rational investor, the behavior investor and the mimetic investor.

5.3.1. The rational investor's model:

As shown in the Fig. 1, the rational investor's decision RD is generated from the rational analysis. The latter is based on the equation (1). The rational investor broadcasts selling or buying advice to the other agents.

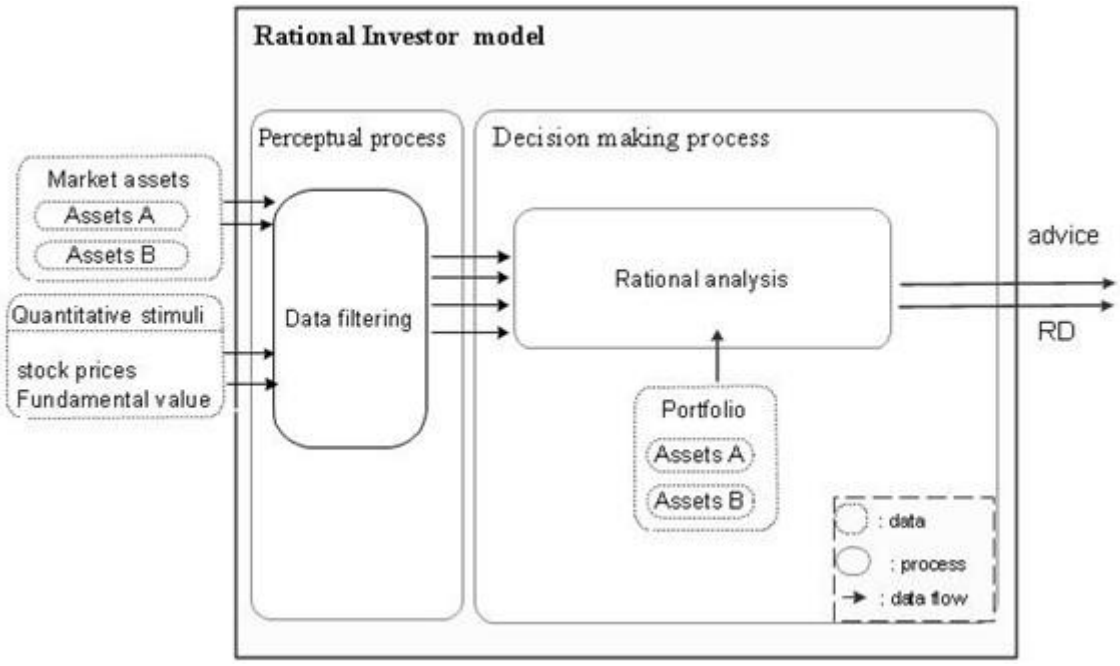

Fig. 1: The rational investor's model

5.3.2. The behavioral investor's model:

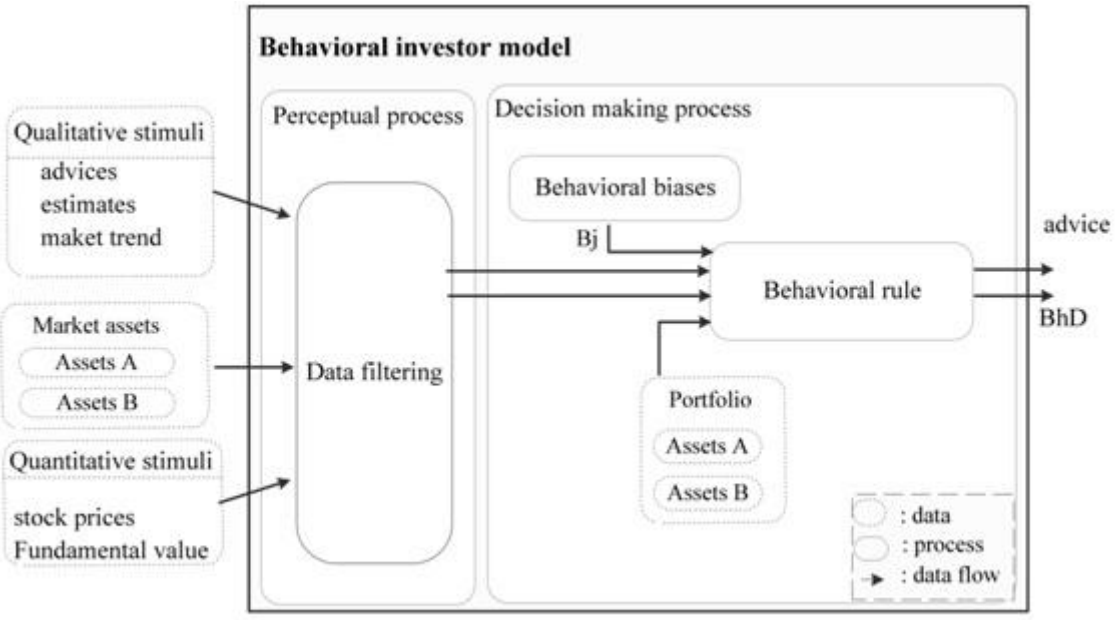

Fig. 2: The behavioral investor's model

The Fig. 2 shows the behavioral investor's Decision BhD that is based on the behavioral biases and rules. The latter is based on the equation (3). The behavioral investor broadcasts selling or buying advice to the other agents.

5.3.3. The mimetic investor's model:

The Fig. 3 shows the mimetic investor's Decision MD that is based on the mimetic biases and rule. The latter is based on the equation (4). The mimetic investor broadcasts selling or buying advice to the other agents.

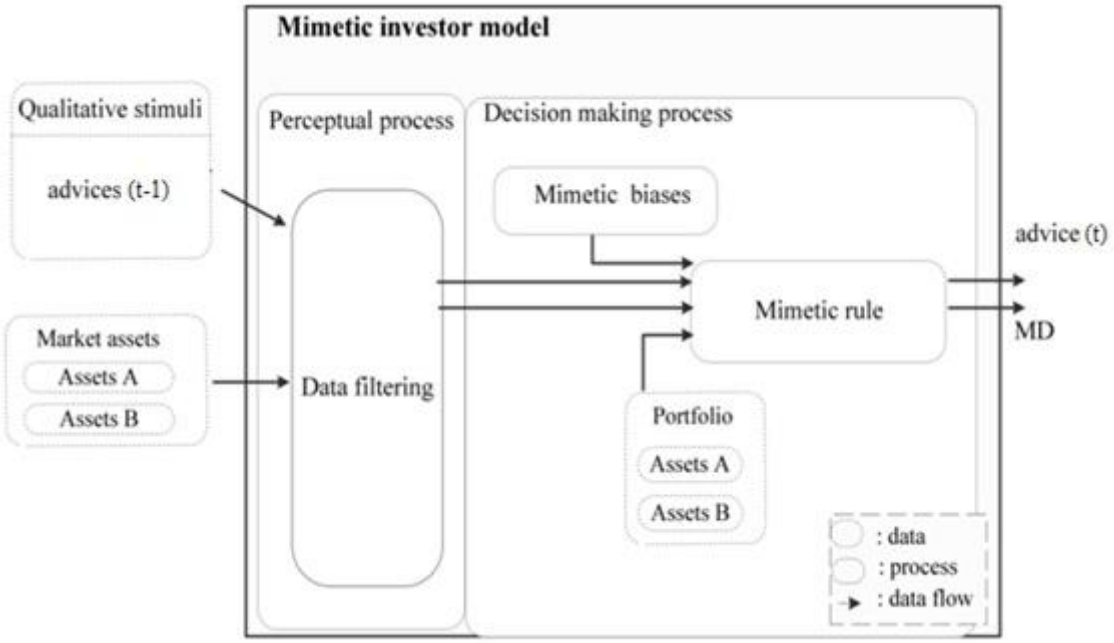

Fig. 3: The mimetic investor's model

6. Simulation and results

6.1. Simulation

The aim of experimentations is to evaluate and to simulate the investors' behavior during crisis as well as the spread effect on the others behaviors. The investors' behaviors are simulated by multi-intelligent agents systems by means of the open-source software program, NetLogo version 5.0.5 (Tisue and Wilensky 2004)

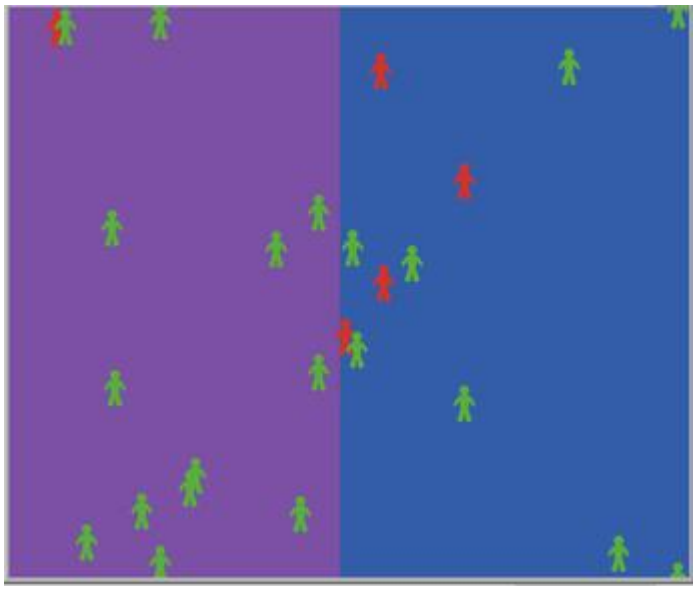

Fig. 4: Artificial stock market simulator

As shown in Fig. 4, the agents in red represent the institutional investors and those in green represent the individual investors. The purple area is the purchase area and the blue is the sales area.

The experimentations focus on the dynamic interaction between institutional and the individuals; those later take advice of selling or buying from the institutional and tend to imitate their behavior.

The progress of the exchanges keeps the following protocol:

1. The incoming of different new stimuli, which are the advice, estimates, market trend, fundamental values and past stock prices, to the artificial market for one type of assets (assets A or assets B).
2. Some of individuals have a mimetic behavior.
3. Qualitative stimuli affect the behavioral attitude and then the noise traders' decision.
4. Quantitative stimuli affect the agent's analysis and then the decision of buying or selling.
5. The final decision can be only a buy or a sell one of one type of assets (A or B). The noise traders adopt the behavioral decision, the institutional investors take the rational decision and the mimetic agents take the predominant decision.
6. Investors simultaneously submit their sell or buy orders. Each investor's portfolio will be rebalanced.
7. After each experiment, we have a general advice that will be used as a qualitative stimulus in the next experimentation; so if we have more buying (selling) orders, we have then buy (sell) advice.

6.2. Results and interpretations

6.2.1. The subprime bubble Identification

Before the subprime crisis release, the prevailing character at the investor's is overconfidence with optimism (H1)

In a first stage of the real estate bubble formation, there are massive subprime securities purchases by the expert investors and also some of the noise traders. Demand of subprime assets exceeds their supply; the assets prices didn’t stop increasing. The subprime trend is then bullish (see Fig. 5).

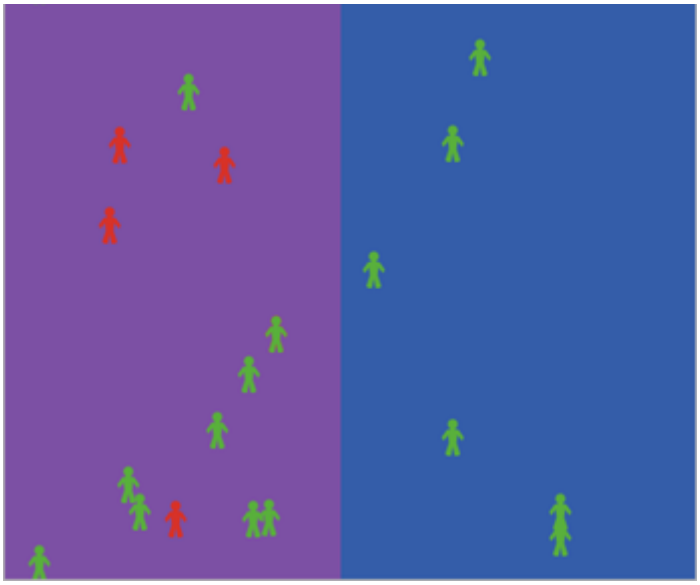

Fig. 5: The simulation of the subprime bubble formation

In the second stage, the individual investors also continue to buy the subprime assets further to their mimetic behavior (see Fig. 6). This latter engenders the overvaluation of the subprime assets and the subprime bubble formation.

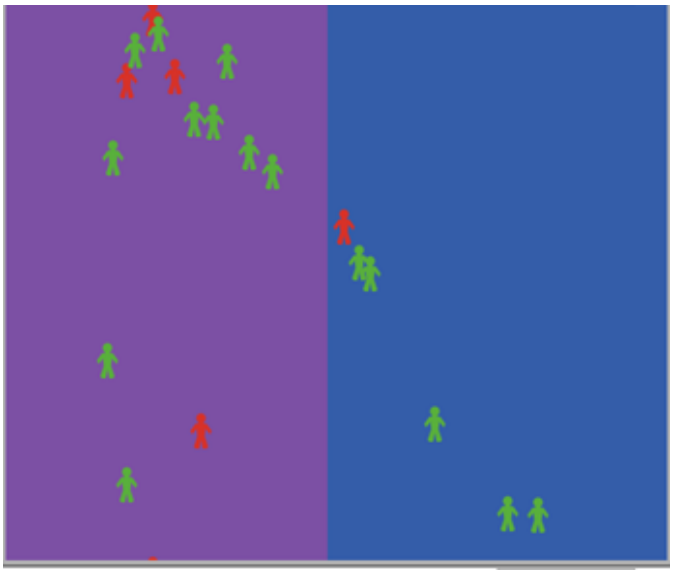

Fig. 6: The simulation of the investors' mimetic behaviors

6.2.2. The subprime crisis identification

The dominant characters at the investors are the loss aversion with the pessimism (H 2).

The subprime crisis is marked by two main stages: the bubble burst and the dramatic decline in risky asset classes' values.

When the subprime prices drop, there are massive sales of these securities by the expert investors and also some of the noise traders (Fig. 7). The mimetic investors follow the predominant decision and also sell their subprime assets. Consequently, the subprime prices strongly fall and the subprime bubble has burst.

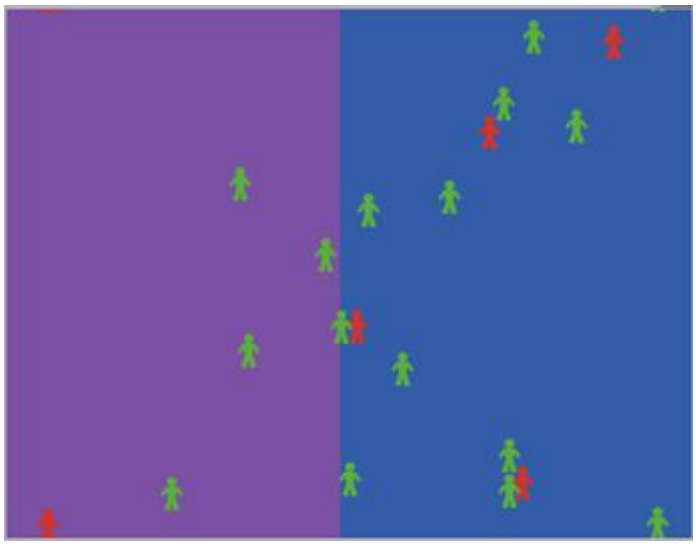

Fig. 7: the simulation of the investor's behaviors during the bubble burst

The risky assets prices (asset B) keep the same trend and they are not affected by the bubble burst. Then and in order to balance their portfolios, the expert investors decide to sell their risky assets (see fig. 8).

Consequently, this massive sale of the risky securities by the experts is followed by another one of the individual investors because of their loss aversion and their mimetic behaviors. The sale pressure of the risky assets contributes to the asset prices fall and the total stock market collapse (see fig. 8).

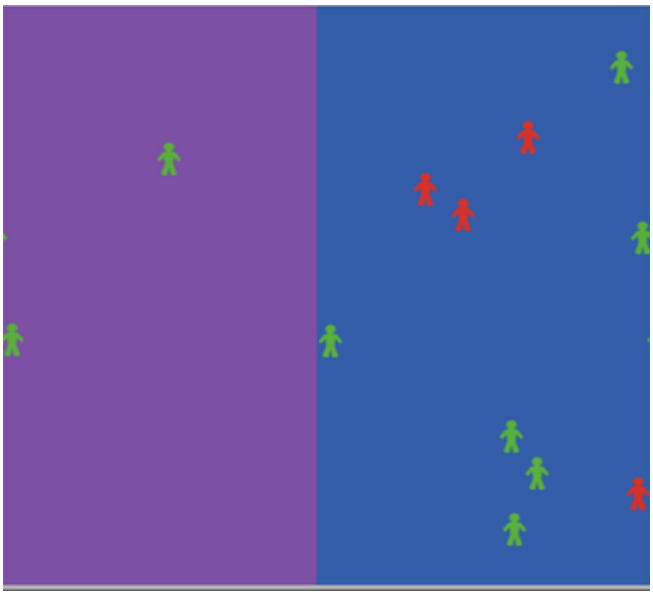

Fig. 8: the simulation of the stock market collapse

Our simulations models for artificial stock market confirm our hypothesis H1 and H2. We demonstrate that both overconfidence and optimism biases are at the origin of the overvaluation of the subprime assets and the subprime bubble formation. On the other hand, loss aversion and pessimism can be considered as an eminent factor of the subprime bubble burst and the subprime crisis of 2008. Especially, the mimetic behavior at the individuals is viewed as an important factor that amplifies the phenomenon.

7. Conclusion

Our study provides an interesting introduction to behavioral bias and its effects on economic phenomena such as financial crises. We focus on three main biases: overconfidence, loss aversion and mimetic behavior.

We propose a new conceptual model of financial decision-making representing the stock market dynamics during the crisis period. We build an artificial financial market that has two types of investors: rational (institutional) and irrational (individual). The latter are classified

into two groups: the noise traders and the mimetic investors. Our model examines the interaction between rational and irrational behavior and its importance in explaining the financial crisis.

A simple experimentation of our model is elaborated to simulate the behavior of the investors during the different phases of a crisis: the formation and the break-up of the speculative bubble. We conclude that the investor's psychology must be considered in the explanation of financial crises, that overconfidence and loss aversion are two behavioral biases very relevant to explain the formation and bursting of bubbles. Finally, mimetic behavior amplifies disturbances in the financial market and limits arbitrage.

Future research could improve the proposed financial decision aid model, introduce other behavioral biases (over-extrapolation of past price changes, belief manipulation, ambiguity adverse...) and replicate this research using Netlogo.

References

Abbes, M.B. (2012). Does overconfidence bias explain volatility during the global financial crisis? *Transition Studies Review* 19(3), 291- 312.

Alfarano, S. Lux, T. & Wagner, F. (2010). Excess Volatility and Herding in an Artificial Financial Market: Analytical Approach and Estimation. *MPRA_paper_*24719.pdf

Barberis, N. Huang, M. & Santos, T. (2001). Prospect Theory And Asset Prices. *Quarterly Journal of Economics*, 116, 1-53

Barberis, N. Shleifer, A, & Vishny, R. (1998). A Model of Investor Sentiment. *Journal of Financial Economics*, 49 (3): 307-343.

Broihanne, M.H. Merli, M. & Roger, P. (2014). Overconfidence, risk perception and the risk-taking behavior of finance professionals. *Finance Research Letters*, 11(2), 64-73.

Chuang, W. & Lee, B. (2006). An Empirical Evaluation of then Overconfidence Hypothesis. *Journal of Banking and Finance*, 30, 2489-2515.

Daniel, K. Hirshleifer, D. & Subrahmanyam, A. (1998). Investor Psychology and Security Market Under- and Overreactions. *Journal of Finance*, 53(6), 1839-1885.

De Bondt , W. & Thaler, R. (1985). Does the Stock Market Overreact. *Journal of Finance*, 40 (3), 793-805.

Demyanyk , Y & Hemert, O.V. (2011). Understanding the Subprime Mortgage Crisis. Review of Financial Studies, 24(6), 1848-1880.

Easterwood , J.C, Stacey R. & Nutt, S.R. (1999). Inefficiency in Analysts' Earnings Forecasts: Systematic Misreaction or Systematic Optimism? *Journal of Finance*, 54(5), 1777-1797.

Graham, J.R. (1999) .Herding among Investment Newsletters: Theory and Evidence. *Journal of Finance*, 54(1), 237-268.

Hirshleifer, D. Subrahmanyam, A & Titman, S. (1994). Security Analysis and Trading Patterns When Some Investors Receive Information before Others. *Journal of Finance*, 49(5), 1665-1698.

Hoffmann, A. O. I, WJager, W. & von Eije, J.H. (2007). Social Simulation of Stock Markets: Taking it to the Next Level. *Journal of Artificial Societies and Social Simulation*, 10(2), 7.

Hoffmann, A, Post, T. & Pennings, J. (2013). Individual investor perceptions and behavior during the financial crisis. *Journal of Banking & Finance*, 37 (1), 60-74

Kouwenberg R. & Zwinkels RCJ. (2015). Endogenous Price Bubbles in a Multi-Agent System of the Housing Market. *PLoS ONE 10(6): e0129070.*

Kahneman, D. & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk by. *Econometrica*, 47(2), 263-291.

Levitin, A & Wachter, S. (2012). Explaining the housing bubble. *Georgetown Law Journal*, 100, 1177-1258.

Manzan, S & Westerhoff, F. (2005). Representativeness of news and exchange rate dynamics. *Journal of Economic Dynamics and Control*, 29 (4), 677-689.

Michael Lim Mah-Hui (2008)." Old Wine in New Bottles: Subprime Mortgage Crisis - Causes and Consequences" Journal of Applied Research in Accounting and Finance (JARAF), Vol. 3, No. 1, pp. 3-13

Odean, T (1998). Are Investors Reluctant to Realize Their Losses ? *Journal of Finance*, 53(5), 1775–1798.

Odean, T & Gervais, S. (2001). Learning to Be Overconfident. *Review of Financial Studies*, 30, 1–27.

Rekik, Y , Hachicha. W. & Boujelbene, Y. (2014). Agent-based Modeling and Investors' Behavior Explanation of Asset. *Procedia Economics and Finance*, 13, 30 – 46.

Shleifer, A. Summer, L. & Waldmann, R. (1990A). Noise trader risk in financial markets. *Journal of Political Economics*, 98,703–738.

Shleifer, A & Vishny, R. W. (1997). The Limits of Arbitrage. *Journal Of Finance*, 52 (1).

Shleifer, A. & Vishny, R. W. (1997). The Limits of Arbitrage. *Journal of Finance*, 52 (1): 35-55.
Shleifer, A. & Vishny, R. W. (1997). The Limits of Arbitrage. *Journal of Finance*, 52 (1): 35-55.
Shefrin, A. & Statman, M. (2011). Behavioral finance in the financial crisis: market efficiency, Minsky and Keynes. *Working paper, Santa Clara University*.

Shefrin, H. (2002). Beyond Greed and Fear: Understanding Behavioral Finance and the Psychology of Investing. *New York: Oxford University Press*.

Statman, M. (2011). Efficient Markets in Crisis. *Journal of Investment Management*, 9(2).

Scharfstein, D. & Stein, J. (1990). Herd Behavior and Investment. *American Economic Review*, 80(3), 465-479.

Tisue, S. & Wilensky,U. (2004). NetLogo: A Simple Environment for Modeling Complexity. *The International Conference on Complex System*s, Boston, May 16–21.

Tversky, A. & Kahneman, D. (1991). Loss Aversion in Riskless Choice: A Reference-Dependent Model. *The Quarterly Journal of Economics*, 106(4), 1039-1061

Zwiebel, J. (1995). Corporate Conservatism and Relative Compensation. *Journal of Political Economy*, 103(1), 1-25.