ISCTE Business School
Instituto Universitário de Lisboa

The Investor Behavior on Extreme Situations of Speculation and Crash: A Game Theory Approach based on the Iterated Prisoner's Dilemma

Rui Miguel Constantino da Silva

Dissertation submitted as partial requirement for the conferral of

Master in Finance

Supervisor:

Prof. Doutor José António Filipe, Auxiliary Prof.
ISCTE-IUL – Department of Quantitative Methods

Co-supervisor:

Prof. Doutora Ana Cristina Costa, Auxiliary Prof.
ISCTE-IUL – Department of Political Economics

December 2011

Resumo

A presente dissertação visa proceder a um estudo do comportamento do investidor em situações de especulação e *crash* nos mercados bolsistas. É efectuada uma abordagem às características comportamentais do investidor, sobretudo as que se relacionam com questões do foro cognitivo e de escolha, de modo a obter um perfil tanto individual como agregado do comportamento do investidor em eventos extremos.

Deste modo o presente trabalho encontra-se estruturado em duas partes. A primeira relaciona-se com uma abordagem à literatura existente relativamente à definição do investidor, particularmente nas questões vocacionadas com a racionalidade, processamento de informação, motivações e necessidades e propriedades que influenciam a tomada de escolha, com uma definição do problema subjacente ao presente estudo, seleccionando para tal os eventos que implicaram os *crashes* bolsistas de 1929 e 2000.

Numa segunda parte (a partir do Capitulo 4) é efectuada uma análise concreta ao comportamento do investidor nesses mesmos eventos via modelação pela teoria dos jogos, em particular, através da aplicação do Dilema do Prisioneiro Iterativo a um sub-jogo que possui como problema-base a existência entre jogadores de atitudes de cooperação, para manutenção das posições ou mesmo investimento em activos sobreavaliados e que são o foco da bolha especulativa, e não cooperação, que implica a atitude contrária.

Acabou por ser inferida a possibilidade de existência de cooperação entre os agentes por um curto espaço de tempo, tendo os equilíbrios obtidos demonstrado instabilidade.

Palavras-chave: Crises Financeiras, Bolhas Especulativas, Comportamento do Investidor; Dilema do Prisioneiro Iterativo

JEL Classification System: C73; G01

Abstract

The present dissertation aims to develop an analysis to the investor behavior on situations of speculation and crash on stock markets. An approach to the main investor behavioral features is made, mainly the ones related with cognitive and decision-making questions in order to obtain an individual and the aggregate behavioral profile of the investor on situations of extreme events.

Thus, the present work is structured on two main parts. The first one is related to the literature review about the definition of the investor, mainly considering questions linked to rationality, information processing, motivations and needs and properties which define the decision making process; contextualized the main problem of the study. In this part the events that leaded to the stock crashes of 1929 and 2000 were selected.

On the second part (from Chapter 4) a concrete analysis to the behavior of the investor is made for these events through game theory, particularly, making use of the Iterated Prisoner's Dilemma model to a sub-game that possesses as the main problem the existence, between players, of cooperation attitudes, aiming the maintenance of their positions or even their investments on overvalued assets, which are the main cause of the speculative bubble, and defection, which implies the opposite posture.

The possibility of cooperation among the agents is inferred for a brief period of time, being demonstrated also that the *equilibria* were unstable for these situations.

Keywords: Financial Crisis, Speculative Bubbles, Investor Behavior; Iterated Prisoner's Dilemma

JEL Classification System: C73; G01

Acknowledgements

After the long adventure that this work has represented, it is appropriated to give some acknowledgements to several people who have contributed to this project, on the most diverse ways.

First I would like to express my gratitude to my supervisors, Professor Ana Costa who believed on my idea and capabilities and dismissed to me several very productive meetings that I will miss, but that at the same time never stop questioning my work and advances; and to Professor José Filipe, who cared about this dissertation from day one, being present in all key moments, which however didn't invalidate his tight opinions and suggestions.

To my dear friends Cristiano Oliveira and Miguel Ganito, I give the most sincere acknowledgements for being patient and for their friendship on every thought hour, supporting me like no others were capable.

To my mother I would like to say that I love her and I recognize her efforts to bring me to this position from the day that I entered on the academic world.

To Tatiana Gomes I would like to give a word of gratitude for her efforts dispended on my side in thought hours and for her understanding of my problems and challenges.

I still like to give my acknowledgments to Professor Doctor João Lobo Antunes and Dr. Fátima Gomes for their support on the thematic related with Neurosciences.

Table of Contents

Index of Figures

List of Abbreviations

APT: Arbitrage Pricing Theory

ARA: Absolute Risk Aversion

CAPM: Capital Asset Pricing Model

CCAPM: Consumption Capital Asset Pricing Model

EMH: Efficient Market Hypothesis

FED: Federal Reserve System

GM: General Motors Company

I&D: Investigation and Development

IPD: Iterated Prisoner's Dilemma

IPO: Initial Public Offering

NIPD: N players Iterated Prisoner's Dilemma

P/E: Price over Earnings

RCA: Radio Corporation of America

RF: Risk Free

RRA: Relative Risk Aversion

VMPC: Ventromedial Prefrontal Cortex

Sumário Executivo

A presente dissertação visa proceder a um estudo do comportamento do investidor em situações de especulação e *crash* nos mercados bolsistas, configurando uma análise das características comportamentais constantes do comportamento do investidor, sobretudo as relacionadas com questões do foro cognitivo e de escolha de modo a tentar obter um perfil tanto individual como agregado comportamental em eventos extremos.

Deste modo é efectuada uma revisão e análise crítica sobre a visão da teoria financeira e outras abordagens, provenientes da economia e finança comportamental, evolucionismo e neurociência, sobre as vertentes relacionadas com a racionalidade e processamento de informação, motivações e necessidades implícitas no processo de tomada de decisão e as características associadas ao momento de escolha em si, destacando-se as abordagens provenientes da *Hyperbolic Discounting*, *Prospect Theory* e *Mental Accounting*. Este bloco de informação acaba por possibilitar e sustentar a introdução de novas premissas na construção de modelos que possuam o indivíduo como um dos principais intervenientes.

A esta revisão associa-se ainda uma definição do problema base do presente estudo, os eventos extremos nos mercados bolsistas, sendo efectuada uma breve revisão sobre os eventos históricos que propiciaram as crises financeiras de 1929 e 2000, com realce para os momentos identificados com a bolha especulativa e *crash* subjacente.

Por último é efectuada uma análise ao comportamento do investidor tomando por base o problema já descrito e as abordagens alternativas debatidas inicialmente. Deste modo foi configurada a aplicação de uma variação do modelo enunciado enquanto Dilema do Prisioneiro Iterativo a um sub-jogo com N jogadores e um horizonte temporal infinito, incidindo este sob as situações extremas de mercado. O problema subjacente então ao modelo definido contempla, por um lado a possibilidade de num determinado momento de tempo existirem entre os jogadores participantes atitudes de cooperação com vista à manutenção de uma situação de bolha especulativa através do desenvolvimento de acções que visam a conservação ou mesmo investimento em activos que se encontram sobreavaliados, e por outro lado a ascensão e mesmo a dominância de atitudes de não cooperação tanto nos momentos identificados com a existência de uma bolha especulativa como com o *crash* bolsista.

Acabou por ser inferida a possibilidade de existir cooperação entre os investidores no mercado em momentos de especulação, no entanto subjugada por atitudes de não cooperação, o que origina a existência de dois equilíbrios mínimos de cooperação e não cooperação que se afiguram instáveis em virtude das características base definidas para o investidor.

Chapter 1 - Introduction

The financial markets are very complex and are always changing, being a field so dynamic that can be hard, but simultaneously very passionate, to analyze it. Particularly, on the last few years, the shift pace and the expansion of globalization made this thematic much more complex than what it was many years ago. An increasing flow of studies and analysis was a natural consequence, which caused innumerous postulates to become less acceptable, principally because their application to the problems of today were not so efficient like were to the problems of the past.

Nevertheless, the real focus is principally related with the fact that the markets got more unstable, showing on the last years more extreme events than ever, with periods of strong speculation and crashes which have an impact so strong that become almost inseparable of other contexts, like macroeconomic or monetary.

Maybe because of this circumstance, different approaches had been launched on the most recent years, trying to provide alternatives and new views over the dynamic of the market, what may have been one of the reasons behind the choice for the theme analyzed on this work.

Thus, the main hypothesis to be tested on the present dissertation is related to the fact that investors on extreme situations of speculation and crash on stock markets develop attitudes of: a) cooperation on a speculative time period in way to ensure the maintenance of a situation or the guaranteeing of positions that imply benefits over what is normally expected; b) non cooperation on prior and even exact moments of crash, when the stock market becomes more unstable.

To test this hypothesis it is used first a methodological approach based on considerations about the behavior of the investors, recognizing his cognitive and intellectual limitations and the prevalence of different and heterogeneous motivations and needs. This methodological approach aims then to delimit some characteristics of his choice and behavior under situations of uncertainty. Next some extreme real events are presented in which some characteristics of the investor could be typified, being chosen the stock market crashes of 1929 and 2000 (focuses on Dow Jones Industrial Average and Nasdaq Composite, respectively). An important premise settled was that the investor's decisions are restricted to stocks (and bonds only in order to minimize the risk) being assumed that investment on other instruments (like derivatives) is linked to stocks. Finally the settled hypothesis was tested making use of a model related to the game theory. The choice for this kind of approach is related with the

focus made by this area on the behavior and decisions of players on an individually and if it is wanted, aggregated way, showing the impact of the dynamics and actions made by players. And because it is not an objective of the present work to realize quantitative results or predications, the game theory approach seemed to be a feasible instrument to be used.

Thus, the work is structured on the following way. After this introduction, on Chapter 2 is made a review over the assumptions of the investor's behavior, more concretely rationality, information processing, motivations and decision-making, presenting the view of the financial theory, especially asset pricing and portfolio theory, and alternative theories related to behavioral economics and finance, evolutionism, neurosciences and psychology.

On Chapter 3 the problem is identified, providing a brief review over the crashes of 1929 and 2000, principally in what concerns to the prior moments to the speculation, the bubble itself and the following crash, highlighting both the investor and the market behavior.

On Chapter 4 is tested the hypothesis launched, with resource to game theory, applying the problem to a sub-game with T periods of time and N players through the Iterated Prisoner's Dilemma, analyzing then specially the strategies used by the players (investors) and the equilibriums obtained on the periods related to the speculative bubble and the crash.

Finally is made a brief discussion over the obtained results and are launched further research possibilities that have arisen.

Chapter 2 - Theory about several features of investor behavior

Since the beginning that the human being has been on a direct or indirect way the focuses of the theories developed by the financial and social sciences in general, and the comprehension of his behavior and the following translation of that features on models had represented one of the central points of success of these models, on a micro or macro point of view.

Especially on the financial markets area of research, this thematic has played a role of major importance. Like can be saw on the first important approaches to the portfolio theory made initially by Markowitz (1952) and later by Sharpe (1962) or Ross (1976), the definition of the behavior of the investor is an important factor to the explanatory capability of these kind of models.

However, the lack of accuracy on the explanation of several situations had launch from many years from this part new approaches, principally to the definition of the features that characterize the investors and their decisions, which has open new possibilities to understand some events and situations.

1. The rationality postulate and the deficiencies on the information processing

The rationality and consequently the processing and use of information on the process of decision-making have been two thematic that always intrigued the economic and financial authors across many years. The association to the economic man of the proposition of rationality, made by several theorists, has been used across the years as a powerful assumption for several models in order to accomplish the best possible results using the most simplified assumptions. With the use of this assumption, it is assumed that the agent has the knowledge to make the best decisions possible given the existing environment and limitations, with the support of a well-organized and stable system of preferences, subjected to perfect information in a possible uncertain context, which leads him to the best possible action (Simon, 1955).

Given this, it is consequently assumed that in a perfect information context the agent can process correctly the information and make the right decisions, and only in cases of asymmetry of information the agent can perform possibly imperfect decisions.

However, despite the acclamation of the postulate of rationality as a vital assumption for several models, the Keynesian theory, for example, has showed that it is possible to construct good predictive models not surrounding the postulate of rationality (Blaug, 1992). Like Arrow

(1987: 70) refers: "*I don't know any serious derivation about the currency demand based on rational optimization*".

By this way, on the following pages it will be provided a deepest analysis over these issues, starting with a brief review over the view of the orthodox financial theory and then the vision of the behaviorists, evolutionists and neuroeconomics theorists. The main objective of this sub-chapter is to provide an alternative theoretical background that can support the fact of not applying the utilitarian orthodox of perfect rationality on the model that will be derived on Chapter 4.

1.1.The financial theory vision of rationality

Markowitz (1952) brought for the first time in the history of financial theory a well design approach about the selection of assets and the construction of a portfolio. In his attempt to explain the allocation and selection of securities in a portfolio, he made a set of assumptions among which stood out the proposition of rationality. Particularly, it is assumed that the investor maximizes (or should) the discounted expected returns, he diversifies (or should) his funds among all the securities which lead to the maximum expected return and hold the mean-variance portfolio, all this in a perfect information context (Markowitz, 1952).

Some years later, in the articles of William Sharpe (1964), John Lintner (1965) and Jan Mossin (1966), the Capital Asset Pricing Model, known as CAPM, was developed. This model focuses on the relationship between the risk and expected return of an asset and the following and subsequent equilibrium. The set of assumptions used is very similar to the ones made by Markowitz. All the investors are rational mean-variance optimizers and, by deduction, if all the investors are rational, then they all analyze securities in the same way and share the same beliefs, being the expectations homogeneous (Bodie *et al*, 2009).

Another important asset pricing model is the Arbitrage Pricing Theory (APT) of Stephen Ross (1976). It is similar to the previous one but it is a more general model than the CAPM because the security returns are described through a factor or a set of factors that can be macroeconomic, financial or sector explanation variables. The principal assumption that matters for this chapter is the one referring to the fact that a well-functioning security market do not allow for the persistence of arbitrage opportunities because there are not mispriced securities for a long period of time (Bodie *et al*, 2009; Ross, 1976).

Thus, despite not being reported some other important models, we reach a final point of our brief review over the rationality postulate on the financial theory, the Efficient Market

Hypothesis (EMH). The link between the assumptions referred above and the EMH is essentially based on the fact that the market is efficient and the individuals are rational. Basically, a market is efficient if the assets that are traded reflect all the available information in a given time, and if the price of the asset adjusts quickly as possible to the new information, we can observe a random walk since the prices change on an unpredictable and random way (Bodie *et al*, 2009).

1.2. The behaviorists critique and alternative

Despite the huge advances that the theories priory presented brought to the evolution of the financial and economic theory, such approaches tend to fail in certain situations because they are usually based on a normative analysis, which is concerned with the rational solution for the decision-making problem. Such solution is based on a definition of the ideal decisions to approximate, instead of a descriptive analysis that is more concerned with the manner in which real people actually make decisions. (Kahneman and Riepe, 1998)

The critique made, among others, by the behavioral finance is that almost all investors suffer from biases of judgment and decision-making, sometimes called cognitive illusions. Or this reason, now and then, the investor do not process the information correctly and tend to assume risks that does not acknowledge and anticipate, leading to incorrect probability distributions and inconsistent and systematically suboptimal decisions (Bodie *et al*, 2009; Kahneman and Riepe, 1998).

One of the most known biases is the overconfidence. When the investor makes his own prediction often he sets the confidence interval too tight, thinking in certain quantities and anchoring in his own prediction. Whereas, unfortunately, few people can calibrate well their predictions, it is natural to see judgment errors based on wrong personal predictions. Also, this phenomenon is expected in changing environments where the agent faces different problems every day and cannot learn with past examples as quickly like other agents on more stable environments (De Bondt, 1998; Kahneman and Riepe, 1998). If the investor was rational, the environment would be indifferent to his decision and his decision would be well calibrated, making very often the right predictions with a behavior equal or similar to the described on financial models.

Another very important bias that supports the behavior finance critique to the postulate of rationality is optimism. The agent tends to rely too much on his own beliefs and talents, exaggerating on the future outcome. If we mix optimism with the overconfidence, we will get

an overestimation of the knowledge possess by the investor and an underestimation of the risks, what gives an illusion of control on the majority of the events (Kahneman and Riepe, 1998; Shiller, 2000).

While the two referred biases are a great constrain to the investor decision-making process, the hindsight bias can also play an important role because encourages the agent to view the future more predictable than it really is, and this will lead to a promotion of overconfidence. If the event had been predicted, many of the bad situations would have been avoided because almost every person would have modified what they were doing (Shiller, 2000).

Another bias that is strictly related to the overconfidence phenomena is the over-reaction to change events. By nature, the investor belief that random moves are more likely to occur than systematic ones and this leads him to perceive patterns where they do not exist, indicating too much confidence in his judgments on uncertain events (Kahneman and Riepe, 1998).

All of these four judgment biases are generated and amplified by some types of anchors. In general, people tend to anchor too much because, at moments of ambiguous and complex decisions, their decisions are influenced by the most available anchor. The overconfidence and optimism biases may appear in situations where the investor makes use of quantitative anchors, like the most recently remembered price and nearest milestone to a major index. These anchors can lead to judgment errors, giving in some situations a better prediction than what could be seen. On the other hand, moral anchors can be responsible by the hindsight bias, because when the market is in a bad shape, people tend to hold on to stories and intuitive reasons to embrace their investments and to see the world more predictable than it really is. The fragility of these anchors, besides the amplification of the judgment biases, lies on the difficulty of the agent to use them to think ahead to contingent future decisions (De Bondt, 1998; Shiller, 2000).

Another limitation to the rational decision process relies on the heuristics used by the investor. The definition of heuristic has changed across the years. In the original Greek definition, preserved by Duncker (1945), heuristic "serves to find out or discover" and is used to describe strategies such as "looking around" and "inspecting the problem". Few years later, for Simon (1955), heuristics are strategies that facilitate decisions. In last years, the term has evolved, especially in the decision-making area, to denote strategies that help finding and discovering correct answers to problems in the probabilistic area of decision (Goldstein and Gigerenzer, 2002).

However, the use of heuristics in solving problems, if we are dealing with an optimizer behavior, sometimes judgment errors and inefficient final outcomes can be generated. One of

these heuristics is the representativeness heuristic. In uncertain situations, a judgment is made by looking to familiar patterns and making an assumption that the future will resemble on past patterns. In these cases, even without a sufficient consideration about these patterns, the probabilities can be forgotten and the emergence of overconfidence is seen. Individuals dealing with uncertain environments like financial markets can make use of this short-cut and fall on decision mistakes (Shiller, 2000; Tversky and Kahneman, 1974). Besides, a heuristic that reflects a lack of information processing on the agent is the recognition heuristic. It is used in cases in which the agent is facing a choice between two or more objects. In these cases, the known object has a higher value on the individual decision criterion. This heuristic relies on low cognitive ability and is often systematic. The problem focuses on the fact that the individual chooses the recognized object because he has more information about it and the act against the recognized object requires more cognitive effort (Pachur and Hertwig, 2006; Volz *et al*, 2006). Along with the two heuristics seen before, another that influences the decision-making process is known as the adjustment and anchoring heuristic. The anchoring process was treated early, but in this case it is associated to the mental short cut of the adjustment. In some uncertain situations, the agent makes estimations for the final outcome starting on a given initial value that is adjusted among the time to yield the final result. Obviously, different initial or starting points yield different estimations that are biased toward the initial values, a phenomena caused by the anchoring. This problem is caused essentially by insufficient adjustment and biases in the evaluation of events that are known as conjunctive, events that must occur in conjugation with anothers, like a multiple step plan; and disjunctive, events that are successful if at least on event is favorable (Tversky and Kahneman, 1974).

1.3. Evolutionism approach

Other approach that might represent a different way of seeing the rationality postulate is the one related to the evolutionism. As it is known, the application of the Darwinist theory of evolutionism to the economic and social sciences has been a controversial thematic across recent years, principally because some authors consider the basis of the theory too mechanic and biological to be applied to sciences' dynamics as the ones that are dealing with social and economic problems (Aldrich *et al*, 2007).

Despite these critiques, the Evolutionism is today an important theory that can give a valid alternative to the rationality postulate.

The critique to the rationality postulate, implied on the financial and economic theory is sustained, in the most general and simplified way, by the theory of Mayr (1988) known as paradigm of program-based behavior.

The essential point of Mayr's theory is based on the fact that the behavior and action of an agent can be seen and guided by programs encoded to face certain types of situations. These programs allow the agent to anticipate and face the consequences of potential choices made by him in uncertain environments. These programs are constructed and mutated by a process of learning and evolution through which they become more adapted to relevant characteristics of given problems and environments. This process tends to eliminate and replace programs that are not adequate for new programs with new characteristics and knowledge's, all with the objective of making the decision-making more accurate. Thus, programs tend to be more adapted to the different problems, being a product of the agents' evolution and learning (Mayr, 1988; Vanberg, 2004).

The implication that really matters for this discussion relies on the possibility for specific actions to be not rational (on an optimizer way of thinking), even with programs well adapted to the particular problem and environment. This theory allows the possibility of existence of a systematic account for observed behaviors that can be considered as irrationals and that are classified as anomalies (Vanberg, 2004).

1.4. The role of emotions and the neuroeconomics analysis

The role of emotions in the decision-making process and in questions related to the analysis of utilitarian rationality has gain on the last years a growing number of followers. Beside, one field that had dedicated efforts in this study is the neuroeconomics. One of the main points of research in neuroeconomics is the relation between the brain activity and the process of choice and decision-making under uncertain conditions. The neural reactions to some situations of choice can conduct to a better understanding of how some decisions and actions are made.

There are two examples given by Damásio (1994) that illustrate this problem. The first one is the Phineas Gage example. Phineas lived in the middle of the 19th century in New England. He was Foreman, working on the construction of a railroad. In a given day, when he was trying to detonate a pile of rocks, an iron bar was projected to his face, entering in the left side of his face and getting out by the top of the head. Phineas was not dead and went to the hospital in a very conscientious mood. With the knowledge of today, it was diagnose a lesion

in the Ventromedial Prefrontal Cortex, with the rest of the important Brain Lobes fully intact. In two months time, he resumed the normal life but was never more the same. The equilibrium between the intellectual and instinctive sides was destroyed. He passed to be capricious and vacillating, displaying a lack of emotive actions, making innumerous plans for the future which were easily abandoned. Not being able to work as Foreman, he went to other jobs but with the same result. His faculty to make decisions coherent with his knowledge was impossible. He died years later from a pathology known as *status epilecpticus.*

The other example is from an individual named by Damásio as Elliot. Elliot had a brain tumor known as Meningioma, surgically treated but with the removal of frontal lobe tissue and with damage in the Ventromedial Prefrontal Cortex (the temporal, occipital and pariental regions were intact, the same as the basal ganglions and thalamus) made by a lesion in the cortical region. Despite this, he has recovered well but, like Phineas, was never more the same. Rare were the situations in which he was angry, not displaying an expression of internal emotional resonance. This is explained by a deficient access to the social knowledge, essential to the more advanced stages of reasoning. In some tests made to him, it was revealed an inability to make an efficient decision and in some times could not get to do one (Procrastination).

In these both cases and in others, patients with lesions in the Ventromedial Prefrontal Cortex showed diminished emotional responsively and reduced social emotions, closely associated to moral values. They can also sometimes exhibit tolerance to anger and frustration above normal, which can lead in most of the cases to bad or inefficient decisions. Despite those defects, the capacities for general intelligence, logic reasoning and knowledge are preserved (Koenigs *et al*, 2007).

This profile of a VMPC (Ventromedial Prefrontal Cortex) patient can be explained by the Somatic Marker of Damásio (1994). In cases of decision-making in which it is necessary to evaluate the future consequences, the somatic marker classifies the future action as good or bad. The somatic state makes the decisions more quickly and effective. With lesions on the Ventromedial Prefrontal Cortex, fails on the somatic signals that guide the action are generated. By this way, the patients show indifference to the possible future consequences from their actions, only looking to the present perspectives. (Butman and Allegri, 2001; Damásio, 1994)

The main conclusion, according to some empirical studies of Bechara *et al* (1994, 1996 and 1997), and Koenigs *et al* (2007), VMPC patients have more utilitarian judgments and act more according to the economic and financial doctrine of rationality, which can be not the best strategy (because this behavior does not take into account the importance of emotions on

the decision-making process). In the studies considering card games, VMPC patients prefer risky plays and dangerous bets, not considering the future outcomes of their actions. In the study of Koenigs *et al* (2007), VMPC patients do not see difficulty on decisions in more emotional and stressful situations, what leads to more inefficient decisions/outcomes in a utilitarian way.

What can be deducted is that the emotional side plays an important role in the decision-making process, leading to more efficient choices. It is known that non controlled emotions can lead to irrational behavior. But the reduction of emotions can lead to an equal irrational behavior (Damásio, 1994).

If emotions are responsible for irrational and rational decisions, the individual is not fully rational. But without emotions and with an increase in the utilitarian judgment, his decisions can be equally irrational and so, the postulate of rationality implied in most of the models cannot be right.

2. The motivation and the needs paradox

The acts and behaviors of an individual observed day by day are derived usually from a set of needs that in turn imply several motivations. These motivations are so inherent to the human being that their existence eventually became absorbed by the innumerous and demanding acts made across life. However, if these motivations and their origin (it is meant needs) did not exist, the life of the individual would be so monotonous and devoid of meaning that would not have existed any important marcs on the human history. The analysis of these motivations can also represent a powerful instrument to understand the origin of actions and attitudes made by individuals on their life and even the maintenance of standard choices or mutation of preferences. Also, it was this that leaded the first serious and concrete approaches to this thematic.

The first approaches made and well recognized were the ones from Sigmund Freud and essentially from William McDougall. It was the last one who presented, for the first time, on 1909 in his book "*Introduction to Social Psychology*", the first serious and concrete approach to this theme through his theory of instinct. In this study, McDougall defends that a motivation is not more than a visible response of the human instinct. The motivations are triggered by human instincts which, often, are impossible to contain in silence. However, serious critics did not take long to come over this rigid theory because, unlike an instinct, that by nature assumes a strand almost impossible to control, a motivation can be derived from a complex process of reasoning and response to needs that the individual should analyze and

consider. In addition, a motivation can be refined according to the past examples and experience of the individual (Hull, 1952).

Giving this scenario, what is in concrete a motivation? According to Davidoff (1976), a motivation stems from an "internal state that results from a need and that activates a behavior usually driven to accomplish the activating need". By this way, as can be seen on the *Homeostatic Model of Motivation of Davidoff* (Figure 1), a motivation starts from a need which is assessed intellectually and cognitively by the human being, which then evaluates the requirement for the existence of a motivation. After this evaluation, a behavior is verified (or not) and then the restoration of the equilibrium inside the individual.

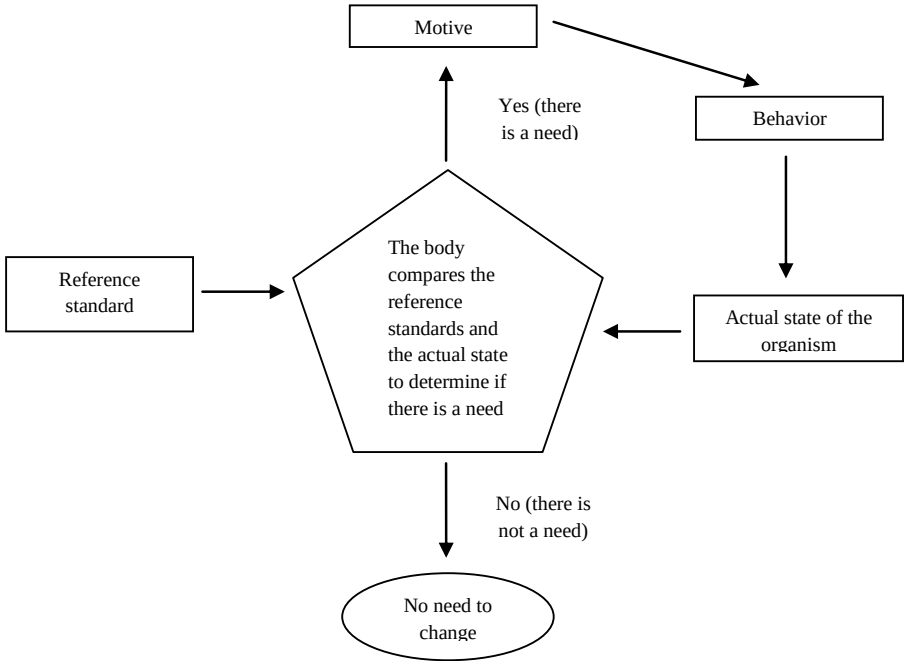


Figure 1: Homeostatic Model of Motivation (Davidoff, 1976)

However, the process of formation of a motivation cannot ignore the importance of the instinct, like the model of Davidoff necessarily does. Thus, a model has been proposed that contemplates catalysts such as the intuition and reasoning factors. This model, denominated of dual system process, sets two systems that influences' the formation of a motivation and the subsequent action. As can be seen in the Figure 2, there is a System 1 related with intuition, which provides operations that usually are fast, automatic and effortless, with a high influence of emotional components, which are difficult to control. And there is also a System 2 that configures the reasoning, which imply actions and operations that are generated on a slowly process and are more consciously monitored, implicating a higher degree of control by

the agent. However, on this second system, as a consequence of the limited mental processing, it is possible to see conflicts and disruptions among needs (Kahneman, 2003).

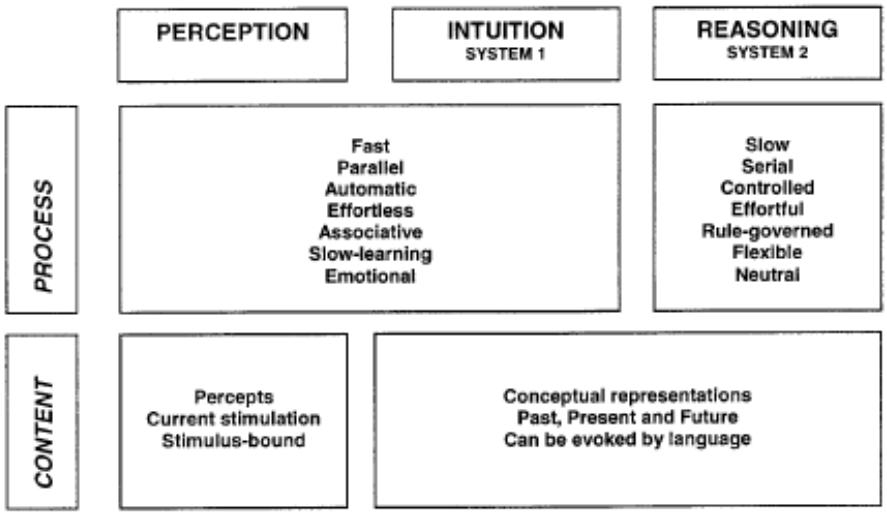


Figure 2: Dual System Process (Kahneman, 2003)

However, the System 1 is not rigid to the response to instinctive reactions and can be influenced by some sort of stimulations. Nevertheless impressions to objects and perceptions will be generated, which are not voluntary. On the other hand, System 2 involves judgments and analysis, being them what stimulates the reasoning. It also provides monitoring to the results from itself and the ones from System 1 (Gilbert, 2002; Kahneman, 2003).

This idea of monitoring is expressed essentially during the presence of simultaneous needs (another lack of Davidoff model), unless the individual has a rigid priority chain (which is not the cause on the majority of times). Before the Dual System model, this problem was already analyzed by Kurt Goldstein "*Organism theory of personality*" (1939), in which is proposed that, dealing with several simultaneous needs, as it is the case in the most of the times, it is not possible for an individual to satisfy all of the needs at the same time, so the importance of some inside the individual overlap others, principally for its urgency for the organic equilibrium. This statement diminishes the mental processing and monitoring exhaustion and elaborates an action process more dynamic by the individual.

So it was concluded that can exist several layers of needs that together originate a hierarchy. Thus, only when a most urgently need is satisfied, the individual can be concentrated on satisfying another one, otherwise, an internal imbalance takes place and the agent will not be able to accomplish the satisfaction of another need without the most basic quenched.

2.1. What impels the investor on financial markets?

The theories and models inherent to the assets selection and to the building of portfolios ended up to never exploit too much this thematic, even because, according to these theories, the objective of the investor always holds with the improvement of the actual state. However, the doubts arise as to the fate that the investor wants to give to the funds that will acquire on the market, and principally, to which needs and motivations will these funds be directed. This is a persistent question because some needs and motivations in most of the times dictate the risk that the investor is willing to suffer.

For Markowitz (1952), in his *mean-variance theory*, the agents should discount their expected returns (derived from investments) and then proceed to a diversification of the asset portfolio in order to minimize a portion of the risk and sometimes adjust that same risk to the preferences of the investor. However, the premise implied for this kind of action was based on the fact that the investor only wants to invest in order to improve his actual financial condition, from the present to the future. Nevertheless it wasn't argued what could have caused different preferences for levels of risk that can be assumed. Later, on the Consumption Capital Asset Pricing Model (CCAPM) theory of Rubinstein (1976), Lucas (1978) and Breeden (1979) this issue was explored on a more detailed way, mainly due to the consideration of a beta associated to the risk premium, which was replaced in order to consider a trade-off between the amount of capital that the investor wishes to obtain to invest in goods and services and the return associated with the market index. From this model it can be considered that an investor who gives higher priority to the investment in consumption is someone who holds the most urgent needs to be met and want to get a faster return on their investment, which ultimately can be also linked to a more adverse market scenario. However, despite these developments regarding the study and application of psychological and motivational considerations to the investor, remained to not be explored in more detailed way which specific needs absorb the capital obtained on the market.

Thus, a more concrete specification of the requirements that investors may feel motivated to meet can be obtained by an application of the *Maslow's Motivation Theory*. This theory propounded by Abraham Maslow (1943) in the scientific article "*The theory of human motivations*" appears based on the ideas of Kurt Goldstein (1939) that first addressed the possibility of an individual who possesses and is guided by a defined hierarchy of needs, which in turn imply motivations that drove the agent to trigger a behavior. These needs arise

ultimately defined and organized according to their importance for the balance of the human being.

Therefore, as Goldstein proclaimed, despite the existence of numerous simultaneous requirements, the individual turns out to assign a particular priority to each one of them, establishing a series of layers of a pyramid of needs. Thus, if the most basic need is not met, the individual cannot direct his attention for the next needs layer, and at the earliest time possible, he will focus all its attention on first meeting the more basic need. However, the demonstrated satisfaction will come mostly from the last need satisfied. Thus, in concrete terms, Maslow recognizes five levels of needs, as presented in the figure below.

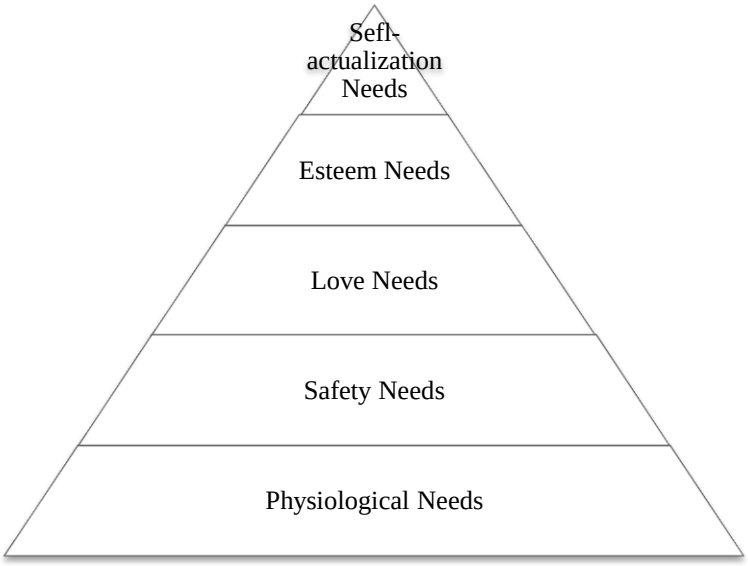


Figure 3: The pyramid of needs of Maslow (Maslow, 1943)

The first four levels are associated essentially with physiological needs, while the latter belongs to the psychological level (Maslow, 1943).

Thus, taking into account the approach made by Maslow, it is possible to establish a connection between this theory and the investor behavior in financial markets. This because, if the first priority of the investor is not losing money, as it is averse to loss, then this motivation arises from the explicit requirements told on the first level of Maslow, like the more complex desires are based on meeting more complex needs that belong to higher levels of the pyramid. Thus, taking into account the work of Brouwer (2008), the needs expressed by Maslow to the investor can be adapted on following way:

1) Physiological needs: These are needs related to the balance of the body such as eating, drinking, sleeping, breathing, etc... In the case of an investor this need fits because he should have, at different times of the investment maturity, enough cash to buy goods and services that enable it to meet basic needs inherent for his survival. However, in periods of excess of cash, it can be direct it to the satisfaction of other levels of needs.

2) Safety needs: They are the needs to shield the possibility of the agent running out minimum conditions of survival. Thus, in the presence of this requirement it is necessary for the investor to hold a portfolio constructed in a way that only allows the existence of a minimal risk of failing to achieve basic needs both in the present and in the future.

3) Love Needs: Needs related to the possession of conditions to take care of family and loved ones in general, which degenerates in savings constituted for the academic life of children or for marriage. So it can be translated into investments that will help to achieve an easier and more successful life. In such cases the investor must direct capital to investment funds as a way of allowing regular savings.

4) Esteem Needs: Needs targeted for the satisfaction of the wish of fulfillment, confidence, independence, and a high degree of prestige, reputation and recognition. In such cases the investor's objective is to obtain high returns on his investments in order to provide the means to create plans for an early retirement, for a dream travel or to purchase luxury goods. In this case some risks become acceptable but the maximum risk that the investor is willing to accept depends on his psychological determinants and the concrete objectives that he wants to achieve. In these situations there is space for subcategories, according to the different objectives of the investor.

5) Self-Actualization Needs: In this level are inserted needs such as the search for answers and the realization of several personal interests, which of course, varies from person to person. This level becomes so extended that can comprehend sometimes the desire of the investor on understating the dynamics of the market and the challenge of beating it. In this case the investments are highly risky.

However this hierarchy of needs is not completely rigid because ultimately is influenced by the level of aspiration of the investor, who makes the hierarchy not so inflexible. Thus the investor starts his journey in the market building on a given reference point (usually the *status quo*), that mutates along the evolution of the agent. Thus, in periods of expansion and higher returns, the level of aspiration may mutate and cause a positive desire for the satisfaction of needs that are at a higher level that was determinate to achieve at that moment. For this reason it can be considered that in extreme times, such as those seen in the scenarios of speculation and crash, the defined hierarchy of needs cannot be considered immutable (Levy, 1992, Shefrin and Statman, 2000).

3. The dynamics of the investor behavior

Arriving to this point on our study it seems appropriate to analyze the particularities of the investor on a dynamic environment, promoting and detailing the factors that determine his behavior on the market.

On the dynamic of investment, many decisions are made and this process of decision-making can be seen as highly intensive and exigent, and a definition of the features that determine that process is seen as an important factor for the definition of a profile of the investor. Thus, on this chapter a review of the preferences of the investor, the way he makes a choice and the determinants that affect the process of decision-making are made.

3.1. The vision of the orthodox financial theory

Mainly on the financial theory the investor features make part of aggregate models that try to explain on a macro way the behavior of the market, which implies that the set of assumptions made for the investor will be more general and not so precise.

Dealing with this context, the first assumption to be set is referred to the preference of the investor to smooth his consumption, because of: (1) Time Consumption and the (2) Risk Dimension. The (1) is based on the fact that consumption is higher than the income on the early years of active life, because of situations like the ones referring to the purchase of a house or a car. However, during those times savings are constituted, which will be spent after retirement when the income is zero, being the consumption positive. The (2) is related to the risk dimension factor, based on the fact that the future is uncertain and that many states of nature can occur, what in turn makes necessary a smoothing of consumption to avoid an

excessive concentration of consumption on a period that may be unfavorable (Danthine and Donaldson, 2005).

Based on this, the process of decision-making can be divided in situations of certainty and uncertainty. If on certainty the assumption of rationality can be accepted (with the appropriate reserves because the choice has a dependency from the framing of the problem) with every investor having a complete preference relation and the property of transitivity in a continuous relation, the theories about the choice under uncertainty are not so easy to be totally accepted. In these situations (like a lottery), it is assumed that the preference relation is complete, transitive and continuous, with an independence of irrelevant alternatives. This last assumption is not common ground because it depends for example on the manner which the problem is placed (framing), what will be analyzed in more detail later on in this sub-chapter (Danthine and Donaldson, 2005; Huang and Litzenberger, 1988).

Another assumption that is made is related to the fact that the investor is risk-averse because on the majority of times he wishes to avoid a fair gamble (when in an uncertainty environment), so his utility function is concave because as the wealth increases, the utility from the additional consumption decreases (known also as decreasing marginal utility). However, despite not being assumed directly on the portfolio theory, this degree of risk-aversion can be measured on two ways: a) in terms of absolute risk aversion (ARA) that is the sensitivity to the amount and; b) relative risk-aversion (RRA) that is the sensitivity to the proportion of wealth in stake. By this way it is assumed that an investor will only play a fair game if there is a certainty equivalent, that is, if there is an amount of money that is certain equivalent to the investment that he could make (Holt and Laury, 2002).

Assuming the propositions told, the problem for the investor is to maximize the expected utility of his wealth allocated on the possible investments. To do that he has mean-variance preferences, so when facing investments with same mean, he will choose the one with smaller variance, and when facing investments with same variance, he will choose the one with the larger mean (Markowitz, 1952).

Every investor will generally possess the market portfolio and will invest on a risk-free asset (to respect the two fund separation), so the wealth will be allocated between the rf (risk free asset) and the tangency portfolio. But because the investor is risk-averse he will only invest on the risky asset if his expected return is higher than the rf (McDonald and Siegel, 1986).

Then it will be respect mean-variance dominance:

$$\text{Asset a dominates asset b if } \begin{cases} \mu_a \geq \mu_b \text{ and } \vartheta_a < \vartheta_b \\ \text{or} \\ \mu_a > \mu_b \text{ and } \vartheta_a \leq \vartheta_b \end{cases} \quad (1)$$

Also he will look for changes on the composition of the portfolio in what respects to the correlation, which implies that the construction of the portfolio will take in consideration mainly securities that have a correlation between]-1;1[(Bodie *et al*, 2009; Markowitz, 1952).
Also, it is assumed that an investor with a higher level of risk-aversion will allocate less wealth on the stock market, which however can sometimes depend on the intrinsic utility function of the investor.
Also according to the CAPM all investors possess the market portfolio and because of that they will be pleased when the market goes up and sorrowful when goes down, which implies, because they respect the law of decreasing marginal utility, that what really matters for the investor is to get additional good payoffs on bad times (of low market returns), which in turn implies the investor to be less enthusiastic with additional ones on good times. What can be concluded from this sentence is that the investors like assets with low covariance with the market (Bodie *et al*, 2009).

3.2. An alternative based on behavioral economics and finance

3.2.1. Hyperbolic discounting

Most of the decisions made by an investor involve a trade-off between outcomes/choices that will have their effects on different periods, which on the real markets imply that the investor have to decide between investment options that can be more valuable on a future horizon than in the present. This relation is captured, on a conventional analysis, by a discount function. With the help of this instrument it is possible to measure the utility obtained from a series of future consumption situations, occurring at regular intervals, which leads to the calculation of a Discounted Utility Function.

$$U' = \sum_{d=0}^{n} F(d)\, u\big(c(t+d)\big) \quad (2)$$

where *F(d)* is the discount function, *t* the time of evaluation and *c(t+d)* the resources consumed at time *t+d*.

Thus the discount function is a declining function of delay and often given by a discount rate *r*, which is the proportional change in the value of *F(d)* over a standard time period. Also it is important to notice that the decision maker is impatient and the rate of change of *F(d)* is the pure rate of time preference. In addition, the rate in which money should be discounted, for rational decision makers, must equal their marginal rate of substitution between the present and the future to the market interest rate.

Hereupon, for example, if we actually prefer 5€ in 3 months to 4€ in 2 months, then in 2 months time we will prefer the 5€ on 1 month than 4€ immediately, if there are no sudden need for cash. However, this may not occur with certainty and can imply inconsistency of time preference. Taking the examples given by Ainslie (1975), Ainslie (1991) and Read (2003), if we have a choice between two alternatives: a smaller-sooner (X) and a larger-later (Y), while the larger-later alternative is preferred when both are substantially delayed, when smaller-sooner alternative becomes imminent it undergoes a rapid increase in value and is briefly preferred. For example, the smaller-sooner reward can be the pleasure from a cigarette and the larger-later reward might be good health. On one week in advance, it is preferred the prospect of good health, but as time passes the desire for the cigarette grows faster than the desire for good health, until, for what may be a very brief period, the cigarette is preferred.

Because of this kind of situations it is not easy to the agent to make plans for the future and stick to them, which degenerates on procrastination. Also, as we can see on this example, the discount rate does not change always proportionally to the value of *F(d)* over a standard time period like the one referred. Because of this time inconsistencies an hyperbolic discount function can be the best way to illustrate this type of behaviour, instead of exponential discount functions like the ones assumed when the decision maker is a rational agent, because it consider that a briefly change on the preferences across a time period can exist, which is a temporary reversal of preferences (Read, 2003). By this way it can be said that individuals do not always smooth their consumption because, at one point of time, it is possible to the agent to reverse his preferences (Steel and König, 2006).

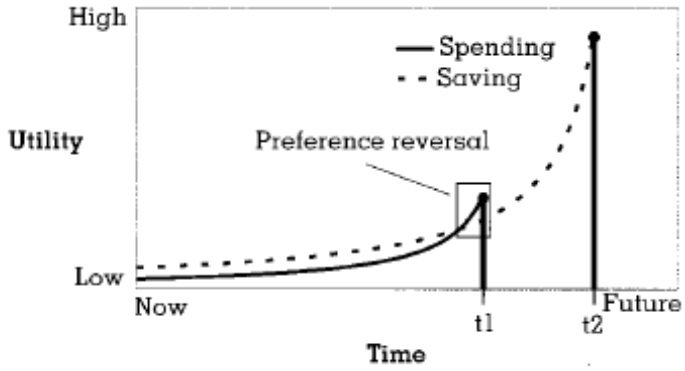


Figure 4: Possibility of reversal of preferences (Steel and König, 2006)

Another point that is not consensual is the consideration that money should be discounted at the prevailing market rate (Thaler, 1981). The fact is that people do not apply to all decisions the same rate, being instead this rate highly domain dependent and even in the domain context dependent from the choice context (Chapman and Elstein, 1995). By this way, several anomalies can be summarized, besides the time inconsistency, linked to the constant discount theory:

(1) Delay effect: if we elicit the present-value of a delayed outcome or the future value of an immediate outcome, then the obtained value of the discounting factor will be larger as longer the delay (Read, 2003).

(2) Interval effect: The difference between the delays of two outcomes is the interval between them. So discounting depends strongly on the length of this interval, in what longer intervals lead to smaller discount rates or larger discount functions (Read, 2001).

(3) Magnitude effect: This means that the discount rate is higher for smaller amounts (Green *et al*, 1997; Read, 2003; Shelley, 1993)

(4) Direction effect: the discount rate obtained by increasing the delay to an outcome is greater than that from reducing that same delay (Loewenstein, 1988; Read 2003).

(5) Sign effect: The discount rate is lower for losses than for gains (Antonides and Wunderink, 2001; Thaler, 1981).

(6) Sequence effects: A sequence is a set of dated outcomes all of which are expected to occur, such as one's salary or mortgage payments. People usually prefer constant or increasing sequences to decreasing ones, even when the total amount in the sequence is held constant (Chapman, 1996).

3.2.2. Prospect theory

For the orthodox financial theory, the evaluation of outcomes and the process of decision-making can be analyzed taking in consideration the expected utility theory. In this theory is assumed that the investors attempt to maximize the expected utility in their choices between risky options, giving weight to each outcome according with their probability and being chosen the one with the highest weighted sum (Luce and Raiffa, 1952). It is also assumed that the psychological value of money or goods follow the rule of diminishing marginal utility, which is represented by a concave utility function[1], implying the presence of risk aversion (Levy, 1992).

The Prospect Theory however posits a different way of analyzing this problem. It is assumed that the agents evaluate outcomes based on the deviations from a given reference point instead of net assets level or value. The real deal however is the identification of this reference point. On a moment zero is usually assumed to be the status quo, but can be on some cases the aspiration level or another point. Allying to this, the agent is not always risk-averse, varying this level of risk according with the fact if we are dealing with gains or losses (Kahneman and Tversky, 1979).

For example, on an experiment made by Kahneman and Tversky (1979) it was placed a problem dealing with a certain outcome of $ 3000 vs. 80% chance of winning $ 4000 and 20% chance of winning nothing. 80% of the respondents choose the certain outcome. However, when dealing with the same problem but on a negative frame, 92% chosen to gamble an 80% chance of losing $ 4000 and 20% of losing nothing to a certain loss of $ 3000. In both cases was chosen the option with lower expected value, which is incoherent with the expected utility theory and highlights the profiles of risk. What is suggested is that individual utility functions are concave for the domain of gains and convex on the domain of losses, which is a pattern known as the reflection effect to the reference point, which implies that the sensitivity to changes in assets decreases as one move further from the reference point in both directions (Kahneman and Tversky, 1979; Laury and Holt, 2000).

[1] Individuals can have sometimes increasing or constant marginal utility for a particular good.

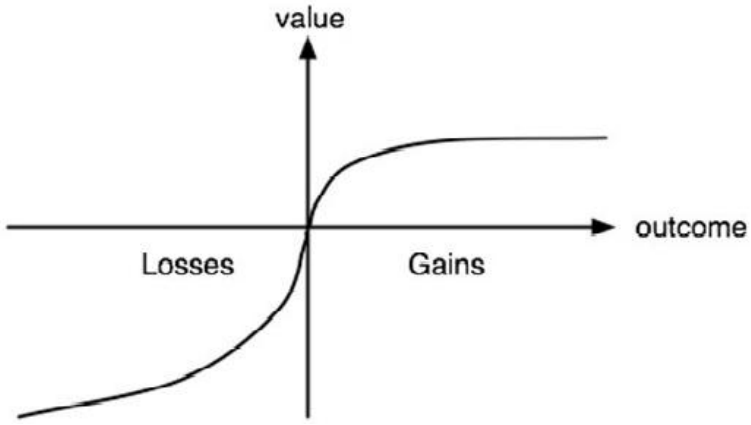


Figure 5: Prospect Theory utility function (Kahneman and Tversky, 1979)

However, as it was seen on the previous example, the propensity for risk depends on the manner that the problem is situated, that is, the way it is framed. For example, on Kahneman (2002), it was given to subjects the hypothetical choice between programs to outbreak a disease which is expected to kill 600 people. On the first attempt: program A was correspondent to 200 people saved and in the program B there was a 1/3 chance that 600 people would be saved (no one die) and 2/3 that no people will be saved. On a second attempt: program A was related to a death of 400 people and program B correspondent to 1/3 of people not dying and 2/3 people dying. The results shown that on the first attempt the majority of the respondents had chosen the program A, which indicates risk aversion. However, on the second attempt it was mostly chosen program B, which is a behavior related to risk-seeking. What can be concluded is that on the first attempt the possibility of certainty on saving people was more attractively than a probability, while accepting the certain death of people is more aversive impelling the agent to seek more risky alternatives (Kahneman, 2002).

Allied to this context there are two types of effects that influences the process of decision-making of the individual. First the certainty effect, which impels the individuals to overweight outcomes which are certain relative to outcomes which are merely probable. Also, they overweight small probabilities and underweight moderate or high probabilities, being the latter effect more pronounced. So extremely likely but uncertain outcomes are often treated as if they were certain, a situation known as the pseudocertainty effect (Levy, 1992). Also changes on probabilities near to 0 or 1 have a greater impact on preferences than comparable changes in middle probabilities range, leading to behaviors of subproportionality (Tversky and Kahneman, 1986).

3.2.3. Mental accounting

The mental accounting theory has proven to be a partial effective and efficient approach, along with the prospect theory, to understand the behaviour of the agents and particularly the investors. For Kahneman and Tversky (1984), mental accounting is an outcome frame which specifies a set of elementary outcomes that are evaluated jointly and the manner in which they are combined, being a reference outcome that is considered neutral or normal. It by nature supports three important features: it is used the prospect theory value function over gains and losses relatively to some reference point; both gain and loss functions display diminishing sensitivity; on the initial reference point (*status quo*) the agent is risk averse (Thaler, 1999).

One of the main propositions of this theory is related with the fact that people behave according with the hedonic framing proposition, which means that they segregate gains and integrate losses (because the respective functions are concave and convex) and more specifically, integrate smaller losses with larger gains and segregate small gains from larger losses (Thaler, 1985; Thaler, 1999). However, this proposition can sometimes fail, principally in what matters to the integration of losses, as Thaler and Johnson (1990) shown on their investigation. Sometimes people think that is a good to integrate losses, which intuitively implies that it should diminish the marginal impact and suggest that a prior loss make them more sensitive toward subsequent losses (Thaler, 1999).

So what mental accounting predicts is that, if we buy, for example, *s* stocks at *p* price, the investment will worth initially *[s * p]* and will fluctuate according with the evolution of stocks on the market. The fact is that even with changes over the time, which implies theoretical gains or losses, only when this position is sold it becomes a realized gain or loss. So it will be open an account with *[s * p]* and will be close with the realized result, which can compensate or not the initial investment. But because closing an account at a loss is painful for the investor, the prediction of mental accounting is that the investors will be reluctant to sell securities that have declined in value. If on a given moment the investor has a need for cash, he will look for his asset portfolio (which contains for example *n* securities) and will sell the ones that increased their value face the moment they were purchased. This hypothesis however contradicts a rational analysis that postulates that the investor should sell the securities that had decreased their value face to the initial value. However, the assumption made by the mental account theory can be supported on the example of Odean (1998) that, using data from trades made by a big brokerage firm, had shown that investors were more willing to sell one of their stocks that had increased in value than one that had decreased.

Another particularity analyzed by mental accounting is related to the fact that sometimes the investor suffers from a behaviour denominated of myopic loss aversion. This behaviour analyzed in detail on the Equity Premium Puzzle of Benartzi and Thaler (1995) focuses on the difference in the rate of return of equities and a safe investment such as treasury bills, which historically has been very large (6% on the USA on the past 70 years) and that resulted on a appreciation of 1 dollar invested in equities that represents almost 120 times the return from the dollar invested on treasury bills. However the primary destiny of investment on these years was T-Bills. This puzzle was explained building on the fact that the loss aversion of the investor is strictly dependent of the frequency with which he reset his reference point (or how often he counts his money). The result was that people are indifferent between stocks and T-Bills if they only evaluate changes on their portfolio with an interval of 13 months, so the investor can suffer from myopic loss aversion because this myopic behaviour prevents him from using the best strategy on a long horizon and impels him to think principally about the present, which leads him to evaluate very often the composition of the portfolio. However, when the period of evaluation is larger, the attractiveness of stocks increases (Thaler *et al*, 1997; Thaler, 1999).

Chapter 3 - On the main world financial crisis: The anatomy and history of bubbles and crashes

Bubbles and Crashes are unique situations which have been studied across the years. The interest among the economic and financial theorists for this theme may reside on the fact that almost all propositions about the rationality of the investor and then the rationality of the market can be violated. Thus, in what concerns to this study, the construction of a more realistic and improved profile of investor can be build on this kind of situations because the efficient market hypothesis can have no descriptive validity.

Hereupon, what is a crash? What can explain its occurrence? What can be the underlying causes?

According to the efficient market hypothesis, a crash occurs when a dramatic piece of information is revealed. However, this approach can be considered reductive once it cannot be known what piece of information has caused the problem, and if can be known, for an impact of this dimension, a preceding period must have existed creating the conditions for the impact. In contrast with the market efficient hypothesis it can be said that in these situations the market has entered in an unstable phase and consequently it is enough sometimes a small disturbance, which is endogenous, to trigger a shock (Sornette, 2003). This unstable phase can be described, looking to the 1929 and 2000 crashes, as the moments in which the stock prices no more followed the previews growth trend and instead of that, it revealed an unstable and undetermined fluctuation, with special emphasis on losses.

The fact is that this situation is preceded by a previous acceleration ascent on the market prices, known as bubble, created by an increasing interaction and coordination between the investors, which can last for months or years. The relations of coordination developed are unaware and provided by the general belief of a new state of things, primarily triggered by the ascension of a given sector or industry. The generated expectations and beliefs tend to be accepted by the group of investors and this is the help that prices need to ascend in some days on a vertical way (Galbraith, 1954; Kindleberger *et al*, 2005; Sornette, 2003).

What can be concluded is that the market unstable position will collapse and the piece of information that has trigged the reaction can be considered secondary (Sornette, 2003).

Hereupon, in the next pages of this chapter a brief review of some historical stock market crashes will be provided in order to prepare and introduce the problem for the application of

the game theory model. However, these historical events were selected based on some restrictions.

- First, these events would have happened in the United States of America. Despite the globalization on the financial markets, there are cultural, social and other kind of differences between the investors of different countries that can lead to diverse behaviors and practices that can skew the analysis.

- Second, these extreme events must have happened primarily on the stock market. It was excluded events with origin on other security markets and that have contaminated the stock market, leading him to a crash or to an unstable position.

- Third, it was chosen events with long periods of speculation and formation of bubble and with a high degree damage crash. Because of this last rule, the Black Monday of 1987 is not in the list. The crash was strong but the recuperation was also very quick, improving the difficult to draw an investor profile.

With these restrictions was chosen two stock market crashes: The Great Crash of 1929 and the Dot-Com Crash of 2000. Both represent an optimal context of Bubble and Crash, meeting the restrictions imposed above. Both have long periods of speculation and strong crashes. The expectations and the behavior of the investor were similar, despite the industry or the sector that had leaded the beliefs.

It is important to refer that the financial crisis of 2008 was not chosen because it can be assumed that her origin was not principally based on speculative moments created by the investors, but principally by Institutions like banks and other financial companies. Also, the focus of this event is not the stock market but the real estate market, which in turn had contaminated the first. And finally because the effects of the crisis are still in progress and the subsequent effects are difficult to dissociate from others, like the recessive macroeconomic landscape.

1. The Great Crash of 1929

The decade of 1920 was the golden and dark age for some individuals. With the finish of World War I, the expectations and beliefs on a prosperous decade where enormous. The economic growth and development were increasing; the consumption was growing at a fast pace; the same for the industry sector; and the level of prices was stable (See Annex 1).

It was time of American dream, a dream in which life should be better, richer and fuller for every person. It was a vision of social order, with the ability for every person to attain the fullest stature of their innately capability. It was the time to break the barriers of the old social hierarchy (Adams, 1931).

In the late 1910s, the rich were becoming richer in a faster pace that the poor were becoming less poor. Because of this, the financial and real estate markets arose as opportunities to fulfill the American dream, to get richer with the minimum effort and to invert the tendency verified in the last years (Galbraith, 1954). And was this desire that leaded the bases for the first premonition of what would happen in 1929 and that had origin the search for the real estate market across the USA, with special focus in the Florida real estate market, and that has burst on 1926.

The problem to accomplish this desire was that individuals believed that they were meant to be richer, despite their intellectuality limitations, that is, cognitive limitations based on a limited rationality and in the use of heuristics that degenerate on decision biases. The risky attitudes were more current and the irrational element more present. An entire industry was born to accomplish and to provide services to investors on the stock market, since houses of brokers, investment banks and investment trusts. A creation of a bubble was inevitable, the same for the following crash (White, 1990).

The next pages will provide a review of some key elements that are a powerful tool for the explanation of the proliferation of the bubble, finishing with a detailed analysis of the prior months to the crash and the moment of the collapse.

1.1. The premonition – The growth the American real estate market and the Florida land boom

On the beginning of the 1920s, the first manifestation of speculative behavior and irrational illusion came from the real estate market. The boom originated was focused specially on the residential housing (White, 1990). As shown in Annex 2, can be observed from 1921 to 1925

a growth at a fast pace of the number of housing starts and the home price and building costs index were following this same tendency. This boom was fueled by good macroeconomic conditions, referred above, and by a desire for the realization of the American dream, in particular the one concerned to the fact that every individual should possesses his own house. The conditions were appealing and the profile of the investor was being mutated to a search of investment opportunities, with short term profitability, over the constitution of savings.

The most clarified example of this boom in the real estate market was seen in Florida. This American state had suffered a great development on the level of life and in transports, and given its climate it was a perfect location for a speculative wave on real estate. In this time the investors were easily influenced and they want simply an excuse to believe in something. And that excuse and belief come from the expectation that Florida would become a dream place, full of opportunities and rich people enjoying the local conditions. Thus has begun to circulate a belief that everything with time would become high valuable. Adding to the formation of positive expectations, a real estate market began to grow making the expectations of the investor more real. With time the land was becoming more valuable and possession of lands brought opportunities for good profits. The reasons for the investment on these lands after some time began to disappear, exceeded by the possibility of easy profits and the prices kept high because the number of investors was growing each day. The problem arose on the beginning of 1926, when the number of new investors and houses began to decrease. Consequently the prices also began to decline and started to be felt a slow crash, with the Great Crash of 1929 cutting off all perspectives of recuperation (Gailbraith, 1953; White, 2009).

What has happened in Florida represents a particular case of the fall on the real estate market across USA. The lessons learned indicate that the American individuals confirmed on the beginning of the 1920 decade a strong desire for enriching and so they searched for opportunities to accomplish that desire in an easy way and requiring minimum effort. One solution was the land in Florida. Of course, as the crash was slow, the investors did not realize the dangers of careless investments and the euphoria would continue on the stock market, mainly on stocks of the emergent sector of the 1920 decade, the utility sector. Again, the investors would need only an excuse to belief that they were meant to be richer and that was a way of getting rich very quickly and easily. In what concerns to the real estate market of Florida, the recuperation only happened after World War II.

1.2. From the prior years to the Great Crash – Euphoria and mania

On the beginning of the 1920 decade the conditions for an expansion of the stock market were created. Despite the good macroeconomic conditions, the stock prices were low and the dividend reasonable. The majority of the companies were getting high profits and the tendency seemed to continue. Some of these companies were newly emergent large-scale commercial and industrial enterprises that took advantage of new processes and technologies. These enterprises were capturing economies of scale and scope and seemed to be very efficient in their production processes. Whereas the utility sector was passing a great transformation, especially due to the type of enterprises, the rapid growth of the modern industrial enterprises was evident. The real problem, just observable on the post-crash times, was that at that time the potentially high returns were involved in great uncertainty because the markets were poorly developed and the companies held unbalance structures (Chandler, 1977; White, 1990).

The great increase on the volume and prices of the stock market, particularly in the Dow Jones Industrial Average had begun on 1927. The previous years were lined by a growth on the interest of the investors for the stock market, but prices were more volatile and the volume was small. The shy growth until 1925 was followed a period of strong volatility on 1926, associated with expectations of an unstable macroeconomic scenario, being the growing trend recaptured on 1927 (see Figure 6).

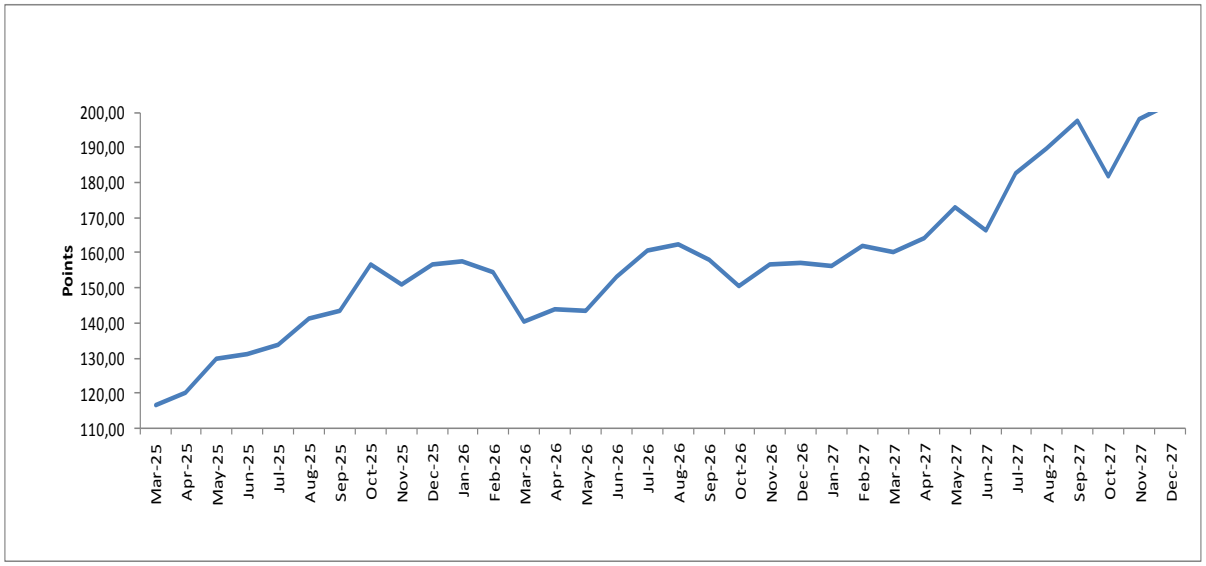


Figure 6: The monthly evolution of the DJIA between 1925 and 1927 (EconStats: http://www.econstats.com)

This following recovery was a product of a reversion in what concerns to the macroeconomic expectations and busted by a series of circumstances, which stood out the decrease in half percent made by the Federal Reserve in the discount rate, which increased the demand for Government Bonds. However, this proved to be a good opportunity for commercial banks and some investors, who held those bonds to sell them and to forward those subsequent funds to the stock market (Gailbraith, 1954).

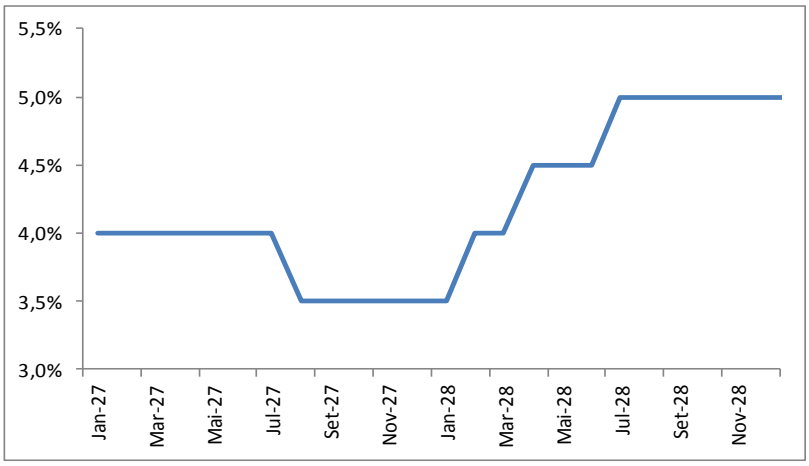


Figure 7: The evolution of the Federal Reserve Discount Rate between 1927 and 1928 (Federal Reserve Economic Data: http://research.stlouisfed.org)

In the beginning of 1928 stock prices start to grow at a faster pace (see Figure 8). Like in the real estate market boom in the early 20s, investors only wanted an excuse to believe in something, and at that time, the belief that the stock market would make the investors richer easily started a new "gold rush". Stocks started to grow 10 or 20 basis points by day and the utility and the stocks of new technologies' companies led the gains (Gailbraith, 1954). Among these companies were included: GM, RCA, American Tel and Tel, US Steel, Westinghouse, Du Ponts, General Electric, Wright Aeronautic. In particular, the GM was even more attractive after the temporary production shut down of Ford, which had allowed the increase of GM sales. The GM behavior was also characterized by speculative announcements; in particular the one made on 1928, saying that GM stock price should reach a value 12 times higher than the a price at the moment and promise a return to the stockholders of 60% of earnings. The positive feedback in the stock price and the volume increase on the stock market were a natural reaction from the investors to this "easy profits". The other companies stocks referred above were also growing at a fast pace, not by the influence of announcements like the one made by GM, but because they seemed quite attractive and the fast growing did anticipate high dividends in the future (Allen, 1931; Gailbraith, 1954; White, 1990).

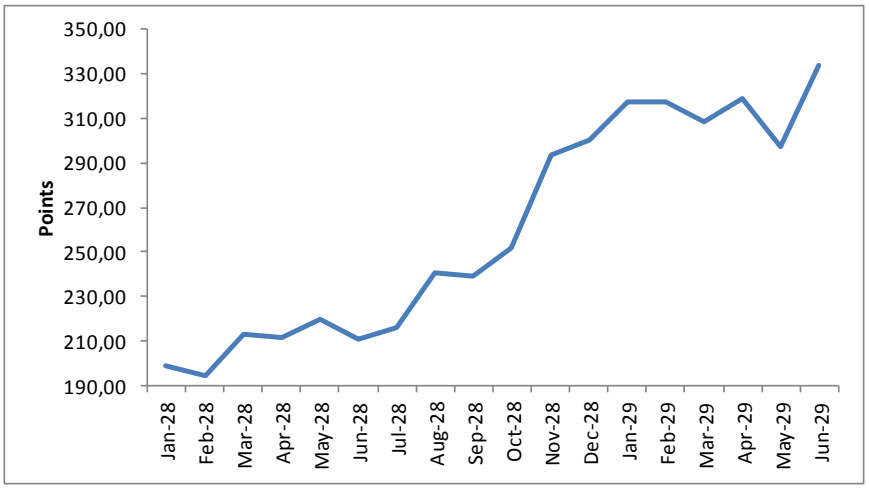


Figure 8: Dow Jones Industrial Average between January 1928 and June 1929, monthly data (EconStats: http://www.econstats.com)

The volume in the market started to increase on a frenetic way. On June of 1928 the volume surpassed the utopian mark of 5.000.000 stocks and in November reached more than 6.000.000 stocks (Gailbraith, 1954). Also, according to Gailbraith (1954) and Allen (1931), that year sealed the beginning of the speculative bubble, more specifically on March, because stocks increased between March and April, in average 15%.

Given the context of the 1920s and especially after 1927, it got evident that those investors would need support and that originated a new market to explore. In what concerns to the commercial banks, the regulation of the 19th century that limited the ability to provide long-term loans was exceeded by setting up wholly-owned securities affiliates, which were allowed to enter in all aspects of the investment banking and brokerage business. On the other hand, the investors lacking of capital to purchase a diversified portfolio of stocks saw a new industry of services develop on the figure of investment trusts. They served a function similar to the mutual funds of today and at that time helped to eliminate this problem for the investor. The trusts were an investment corporation that aimed to purchase and sell assets on public, being the results invested priory on they want. Beside this new industry of services, new ways of investing on the stock market appeared. One of them was the margin deposits and negotiation. The buyer, with margin, contract a loan to buy a given number of stocks and these stocks will be on the possession of the broker as a guaranty of the loan. The buyer will benefit from any value increase and with the same and fixed loan value. Whereas the investor was anxious to invest and to benefit with the constant increases on the market, this kind of service sent to the market supplementary funds (Gailbraith, 1954; Sornette, 2003; White, 1990).

1.3. The year of 1929 and the Great Crash

The year of 1929 began a lull of the market. Despite the fact that in January the volume exceeded, according with Gailbraith (1954), in five days the 5.000.000 of stocks traded, February brought a decrease in the UK reference rate and a slowdown in the volume of the market. In March was observed for the first time on this year what will come in October. In March, 25 the market registered falls on stock prices and with an increase on the rate of broker loans to 14%, in March, 26 a wave of fear came to the market and the volume reached the impressive value of more than 8.000.000 stocks traded. The prices started to fall vertically. The panic started not only among the investors, but also on the brokers. The interest rate on the brokers' loans reached 20% and telegrams began to fall asking for the delivery of the guaranty deposits. This panic among almost all actors on the market was stopped only by the announcement of Charles Mitchell, saying that the Federal Reserve would be always on the obligation of stopping any possible crisis (Gailbraith, 1954). It was the power of information doing its work. Also, 1929 would be marked by the extreme flux of information from the most diverse sources trying to bring calm and confidence to the markets.
By this time the volume of brokers' loans, an indicator representing very well the degree of speculation on the market[2], was reaching high levels. But on the other hand the interest rate indexed to these loans was more volatile than in other times. We can see on this dichotomy a conflict of expectations. On one side, the investors believed that the market would continue to rise. By the other hand, brokers were more uncertain (White, 1990).
Until August the market had a normal behavior, with trading days seen as the last of the great 1920s. But despite this behavior, some macroeconomic indicators were telling a little different story. On July the industrial production index reached the maximum value and started to drop on the following months (see Annex 1.2). The problem was based on the fact that the stock market only reflects this context with some delay, and only when the investors and all the market becomes aware of what is happening at a more macroeconomic level. But, by this time, the confidence of the investors was still high (Gailbraith, 1954).
On September and October the market started to slowdown, and for Gailbraith (1954) and Allen (1931), September represents the end of the golden days. Despite this, on the beginning of October the expectations about the future were optimistic.

[2] It can be considered that greater the amount of loans higher the negotiation on margin. High levels of loans indicate that the investor was having good expectations about the evolution of the market

If on October, 15 the expectations were good, on October, 19 they were starting to reverse. News were flowing that the stock prices were drooping and the guarantee margins were raising, what means that the prices were reaching a value so low that no longer were representing the guarantee needed to the loans maid. On October, 21 the market was unstable but on the end of the day, the losses were covered. A normal idea started to flow: sell the stocks and buy gold. On October, 23, despite the announcement made by the bankers that the market was fine, the losses continue to be seen and this context made way to the pre-crash on October, 24 (Gailbraith, 1954; Sornette, 2003).

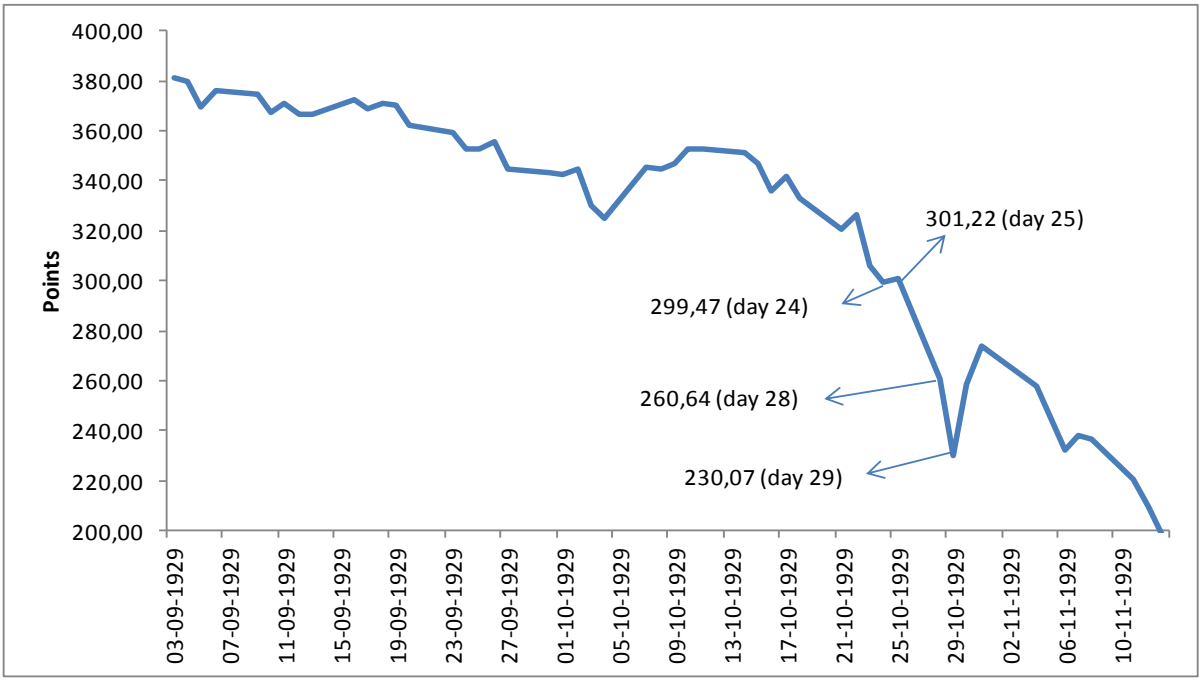


Figure 9: Dow Jones Industrial Average daily data on October 1929 (EconStats: http://www.econstats.com)

On that day the volume reached 12.900.000 stocks traded and the panic started to be seen (Figure 9). The prices started to fall and most of transactions were with the purpose of selling stocks. The uncertainty was fueling the panic. This was only controlled at mid day when a group of bankers met to discuss what to do and how to save the stock market. They decided to gather resources to help the stock market. But, weren't the resources that stabilized the market; instead were the words from the bankers that restored the confidence among the investors. With this relief, investors started to trade again in order to make part of the new wave of increases on prices. At the end of the day the majority of losses were compensated. The wave of confidence on bankers restored the calm and it was said that everything would

go back to normal. What was important now was let not run way the opportunity to buy stocks that were cheaper (Gailbraith, 1954; Sornette, 2003).

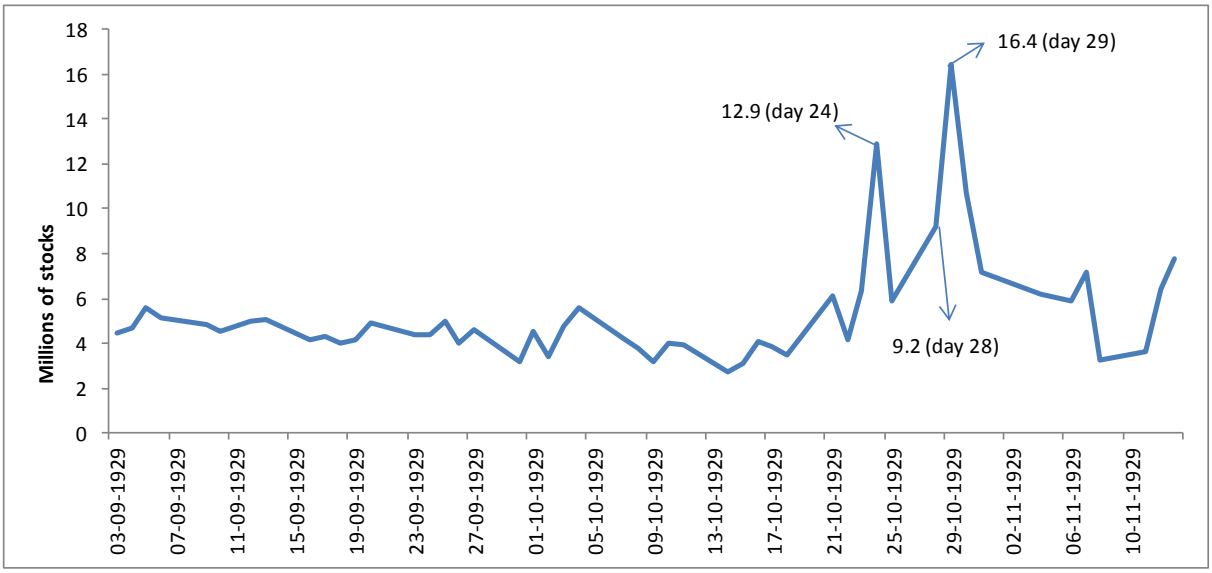


Figure 10: Dow Jones Industrial Average daily volume on October 1929 (EconStats: http://www.econstats.com)

Despite the restored levels of confidence, October, 28 started with losses and was a very difficult day to the stock market. The volume was high and the majority of the stocks were drooping. The Dow Jones Industrial Average dropped almost 40 points and in the end of the day the volume was very high. Also, at the end of the day, bankers meted again and unlike the previous meeting, now the concern was how to not help the market without increasing the wave of panic. And, how could be seen in the next day, October, 29, this idea did not result. The day, known as the Black Tuesday, had recorded a final loss a little small that the previous day but all the bad characteristics of the previous days were conjugated. The volume hit a historic maximum of 16.410.000 stocks and the Dow Jones Industrial Average dropped almost 30 points. The major company stocks continued to fall and stocks of trust funds were going to zero value as far as the volume of brokers' loans was decreasing. The bankers were seen as an important cause of the situation and the help they promised before never happen in that day. The panic and the fear were installed (Gailbraith, 1954; White, 1990 and 2004). In the next days' some recuperations came and the real goal was to restore the confidence among the major actors in the market. Unfortunately that didn't happen in the following months, despite the brief recuperation in December. The margin calls decreased on 25% and the volume of brokers' loans decreased as well. This scenario provoked bankruptcy in some companies and the trusts funds were seen as a negative factor to the recuperation because their

stocks worth every day less and less and in November were unsalable (Allen, 1931; Gailbraith, 1954; White, 1990).

2. The Nasdaq Crash of 2000

The 1990s marked one of the most prosperous times on the USA economic and financial history. The good macroeconomic indicators, the bullish market, the launch of Internet and the advances on the technological and biotechnological sectors brought to the American individuals the hope for long and prosperous times.

Like on the 1920s, these global conditions - economy, market and the emergence and development of a new sector - were appealing to the generation of expectations and beliefs surrounding a New Economy. However, unlike the 1920s, when the majority of the investors were discovering the possibilities of the financial markets, especially the stock market, on the 1990s a big part of the population was no longer considering the market as an unknown thing, but as something that was inherent to the function of the economy. In particular, the investor group was not so restricted like on other times, and the knowledge was wider to different classes. Having an asset portfolio or investing on the stock' market was normal, so normal like going to the supermarket or paying bills. And being so rooted this sentiment and culture on the population wasn't surprising to see the majority of the investors at this time looking off for new and potential good investments.

Thus, this can be the baseline scenario to the analysis of this financial event. At this time, the desire of the investor was precisely satisfied with the appearance and emergence of brand new sectors: internet and technological industries. These sectors brought to the market a whole kind of new possibilities and most important of all, new stocks. In a matter of time, the hope for a New Economy was built around these companies and the major channel of investment was fuelled by it, like was seen on the 1920s with the utility sector. A period of enthusiasm was seen and the creation of a speculative bubble cannot be seen as a surprise. Unfortunately, despite some differences in some events, the end of this period was less dramatic but similar, in what concerns to impact and magnitude, to the Great Crash.

Hereupon, on the following pages it will be provided an analysis to the proliferation and development of the web and tech companies, the role of the investor and then the emergence and the evolution of the speculative bubble, finishing with a view on the crash of March/April, 2000.

2.1. The first years of the 1990s: The arising of web companies and the investor profile

On the beginning of the 1990s, the US macroeconomic environment was unstable. According to the FED (Federal Reserve), the US economy was in recession and the inflation and unemployment rates were increasing. As a consequence, the real *per capita* consumption reached on 1991 the lower value on that decade (see Annex 3).

The recovery began on 1992, coinciding with the IPO (Initial Public Offer) of the American Online, the first big internet company. This act (meant IPO) began, however, to be usual in this sector on the following years, taking place on well-known companies like Yahoo, Amazon or E-Bay (Liu and Song, 2001).

But, despite the IPO of American Online, the internet only appeared on news again in 1993, specifically on November. But, by that time, very few people were aware of this new industry and even fewer had access to it. However, with time, the computer and the possibility to access the internet grabbed an importance similar to the television, mostly because of the sense of mastery of the world and the possibility of accomplishing tasks that were impossible on the past. Also, the possibility of making part of the US economic growth when a web site or other application is created increased the attractiveness of the Web (Shiller, 2000).

Hereupon, it was not a surprise seeing an exponential growth on IPO of web companies, mainly because they were moved by the interest of the investors on the potential and opportunities of the web, which over time caused enormous P/E (price over earnings) values and stock returns. The fact is that the subsequent bubble generated by the expansion of dot-com companies and later tech and bio-tech companies was essentially a consequence of a new and different mentality in the investors and the population in general in relation to what was seen on previous decades, seeing, like on the 1920s, in these sectors an opportunity to get rich with the minimum effort (Shiller, 2000).

Also, this desire for investment and richness was expanded to a cultural basis. A successful business person became to be much more revere than a brilliant scientist or artist. The examples of success on the financial markets allied to the bullish trend were giving the idea increasingly certain that the investment on stocks was a quick vehicle for getting rich, with no effort. But were not only the individual investors that were pushing the market, the growth of pension plans and mutual funds were rising the demand for stocks, particularly on tech and dot-com stocks, that were growing at a furious pace (Shiller, 2000).

Like on the 1920 decade, the stock market appeared as a world of opportunities to the general investor, who became excessively optimist about the future and with time started to neglect

the risks and to see the market more predicted than it really was. What can be awkward is that has passed, by this time, 60 years from the biggest crash on the American financial history, and the individuals and investors probably were more aware about the market and his behavior. But, despite of this, some attitudes and behaviors started to arouse again, and, as it will be seen, the end was similar to the one saw on the 1929 (Liu and Song, 2001; Shiller, 2000; White, 2004).

2.2. The speculative wave: Evolution of Nasdaq, web and tech companies and the investor behavior

To understand the creation and development of the Nasdaq speculative bubble it is important to see and to analyze the motives that triggered the situation. It is clear that the behavior of the web companies cannot explain alone the speculative wave. Like on the 1920s, an analysis of the companies and investors' behaviors turn to be the most efficient approach to be made.

The speculative wave that was seen on the Nasdaq Composite Index on the late 1990s is mostly of the times associated with the explosive number of IPO's, the dramatic rise on the web companies' stock prices and also with the interest and expectations of the investors on this sector. Let's see an example of this. The Nasdaq Composite Index passed from 755 points on the beginning of 1995 to 5.000 points on March 2000, which represents a valorization of 522%. Also the speculative bubble can be isolated and seen on the end of 1998 and beginning of 1999, when the return rates of the Nasdaq assumed values frequently above 10% (Liu and Song, 2001; Sornette, 2003).

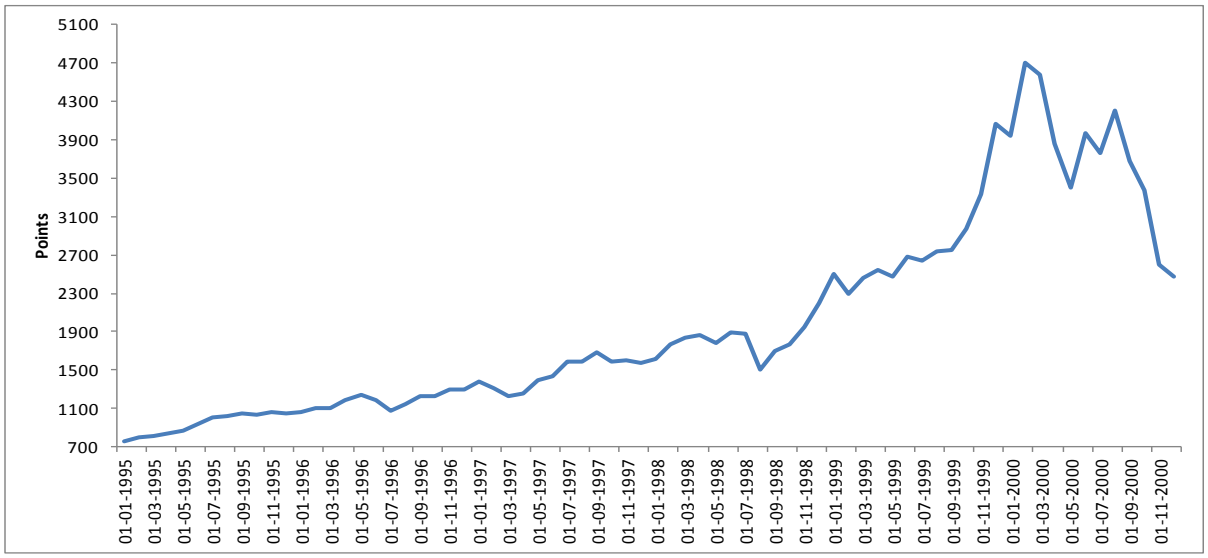


Figure 11: Nasdaq Composite between 1995 and 2000, monthly data (Yahoo Finance: http://finance.yahoo.com/)

This evolution can be analyzed on two parts. The first one, until 1997, was almost explained uniquely by the raise of the sector and the expectations and beliefs generated among the investors that eventually created the thought that this was the sector of the future. This expectations changed the natural course of the market, proliferating an abnormal demand on web stocks, which increased their prices on a drastically way. And with this picture arises the second part of the explanation for the raise on Nasdaq, specially after 1998, that is the reaction and response of the market and companies (Shiller, 2000).

The companies that were a part of the index by this time and that entered on the market sooner, like Yahoo and e-Bay, were having success and improving their results, prices and market share and were giving the right and expected signs to the investors. This was the most excellent environment for more companies to join the market, even if it was too soon, like it was the case on many situations.

And that was really the case, a rush to the market by web and tech companies, many of them only with few years or months of existence, making the offer bigger and giving the sign to the investor that the market was developing at a fast pace, driving them to buy more and more stocks, even speculating in some, leading a wave of money to the market. The problem was that many of these new companies that entered on the process of IPO were not as strong as the stock price reflected but, their price was rising every day. In conclusion, they were creating an illusion of a sector and a market that in reality was not true. Thus, the main question was: why did these companies start a process of IPO and why did they enter on the market so soon.

Two explanations for this can be given, both with the same base denominator, the investor. The first one is related to the possibility of the internet and tech stocks being irrationally overpriced. The recent past perform of these companies on the market and the future prospects of growing, allied with the beliefs of investors, made some of the young companies entered on the market sooner in order to take advantage of the irrational high prices. The problem was that, because these companies were too young and their financial structure was unbalanced, the price of their stocks was not the reflection of their real performance, only the result of the investor beliefs and expectations on the sector, and mostly of the times not in the company. This evidence with time overvalued the stocks of the entire sector and index (Liu and Song, 2001; Schultz and Zaman, 2000).

A second explanation was the rush to grab market share. On an industry with an enormous potential, an IPO provides the capital to allow the company to lose money on several quarters while it is investing on marketing and I&D and creates the possibility to acquire other companies and improve the market share. By consequence, the increase on the market share

brings economies of scale, implying lower costs and more efficient development, what in a medium horizon will improve the results of the company and his stock price (Liu and Song, 2001; Schultz and Zaman, 2000).

What can be concluded is that the market changed mostly because of the expectations of the investors, that posted positive signs to the internet and tech companies that tried to made a gain with this, going to market and throwing to the investor signs of expansion on the sector. With time, the stocks' prices were not based on fundamentals, but principally on the beliefs of both kind of actors on the market, that were cooperating and improving the stock prices, what was beneficiating the purposes of both.

The problem was that, as the Nasdaq was improving, also was the overpricing and speculation, as can be seen by the volume of short selling made. For example, a median web firm on 2000 was having almost 6 times as much of its public float shorted (Hand, 2000).

As will be seen, this was a situation predicted to collapse.

2.3. The year of 2000 and the Crash[3]

The most surprisingly thing about this financial event is the similarities with the Great Crash, and even on the months after the crash, the resemblances are curious. The 2000 year on Nasdaq began, despite contradictory expectations on some analysts, at the same pace of 1999, with tech and dot-com stocks increasing despite the perspectives of raise on the interest rates. On January, 4, with all other indices decreasing, the Nasdaq reached a record, railing to more than 4.000 points, living in a self world where the investors were believing each day on a secular trend.

But the volatility and the fragility of Nasdaq started to be seen on January, 7 when Lucent Technologies, a maker of telephone equipment, warned about profits and sales in values below its predictions. After this announcement, investors started the typical strategy at this time, the rotation of the portfolio between new and old economy stocks. This rotation until April was each day more frenetic and was straightly connected with increasing levels of myopic risk aversion. But despite this, it was seen a canalization of almost all available money (such as dividend and tax gains) to dot-com and tech stocks, as the drops on the market were being seen as normal corrections.

[3] This point 2.3 was made essentially using news from the New York Times and New York Daily News, section of economy and markets, from January to April

The problem at this time was that some analysts were subestimating the strength and the power of investors actions, staying sided to fundamentals, believing that they were strongest than psychological moods. Despite that, the majority of the financial analysts were avoiding dot-com stocks.

Also, by this time, the volume of short selling continue to be pretty high, with an average of 2.4 billion shares shorted, indicating a strong bearish sentiment across the aggressive group of investors, despite the growing of 2 or even 3 digits on the Nasdaq stocks.

Another curious circumstance was related with the fact that, despite the rise in treasury bonds yields (who passed from 4,8% in 1998 to 6,3% in 2000), the return rates of Nasdaq stocks did not decline. Taking into account the academic economic rules, when the yields rise, they can hurt stocks by 3 ways (Campbell and Ammer, 1993; Fleming *et al*, 1998; Li, 2002; Shiller, 1982; Shiller and Beltratti, 1992):

- Slowing the economy by forcing consumers to spend less on goods and services and more on debt payments, which decreases the corporate profits;

- It increases debt costs for businesses;

- It diminishes future profits because they pass to be discount at a higher rate.

At this time there was no effect on the stock returns, what can be seen as a clear indicator of a speculative bubble on Nasdaq. A possible explanation can be related with the investors' expectations on those stocks, essentially based on their good past performance and in the expected high consumption on the sectors to which they give support, which were skewing their predictions.

The investment fever continued in February, as demonstrated by the fact that in this month the record of credit held by investors on margin debt trade on the last 25 years was reached. The interesting fact is that the last time that there had been such high volume of credit on the hands of investors was precisely on September 1987, the previous month to the Black Monday of 1987.

On March, on the last days before the fall, Nasdaq reached the milestone record of 5.000 points, when just four months before was at 3.000 points. The problem associated with this

was that the greater returns brought a serious increase on volatility which ultimately increased the risk and consequently the costs of margin debt.

However, these dreamful days stooped on March, 10, when the Nasdaq reached for the last time the barrier of 5.000 points. After that, on the next 3 days the Nasdaq recorded the same number of point drops, what set the index at 4.500 points, on the so-called "correction days".

Allied to these situations, the FED began to show concern about the overspeculation on the market, indicating the risk to the economy, mostly because this new economy companies were too dependent from the old economy.

The anxiety and uncertainty started to proliferate significantly when on March, 20 the Nasdaq recorded his biggest historical percentage loss, which was later exceeded negatively on March, 30. The question that began to soar, even in the most optimistic investor, was: such a large number of corrections in such short period of time were normal?

The month of April ended up bringing the confirmation of what was really happening. It was not a period of correction or adjustment but the burst of a bubble. After all, the traditional laws of economy were applicable to the Nasdaq. If on March, 10 the Nasdaq was finding himself above in 24% to the January register, on April the gain was only at 12%. Almost immediately the rates of the margin debt started to increase, even more than in March, and the lenders of credit were being more suspicious about the behavior and the future of the Nasdaq. On the other hand, it were more common the mutation and the roll-over on the composition of an individual portfolio, principally in naïf investors, who bought tech and dot-com stocks just because they were growing.

The April, 4 was the day that confirmed, even to the more skeptical investor, the worst. The market opened on that day with innumerous sell orders, what in a short period of time launched the Nasdaq to a fall of almost 14% and the volume for historical records, all of this in a day without any significant bad news. The market only recovered when began to circulate the rumor that hedge funds were buying stocks and bringing liquidity to the market, all of this when the panic was already installed. The day ended up only with a decrease of 2%, but the fear was settled.

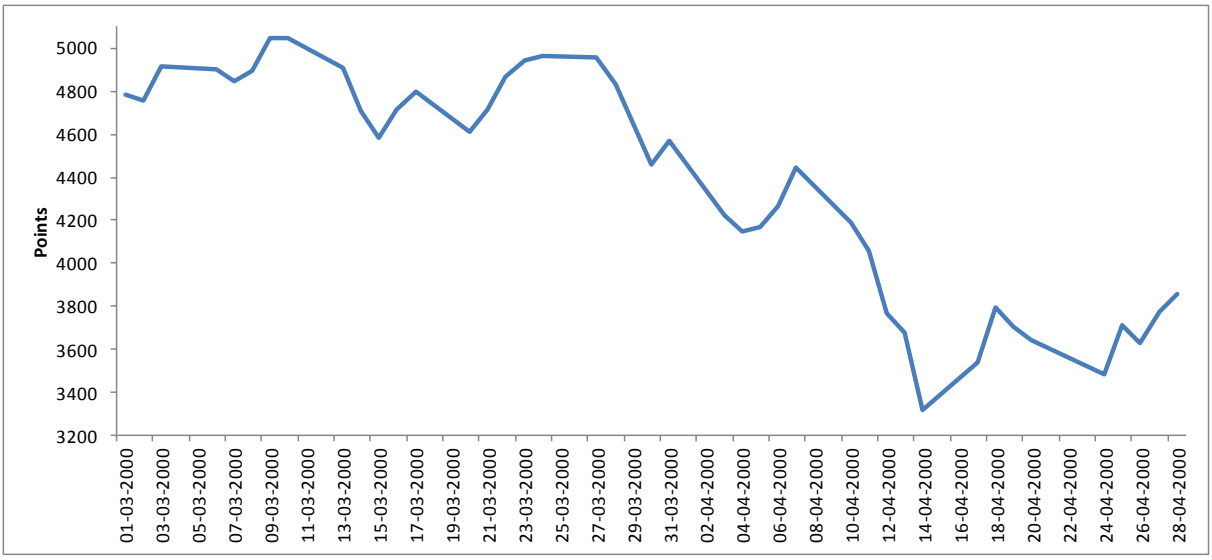


Figure 12: Nasdaq Composite between January and April 2000, daily data (Yahoo Finance: http://finance.yahoo.com/)

The volatility of the market was beginning to cause damages to the majority of the investors that were losing capital and running out of cash to cover their losses. On the other hand some aggressive investors were seeing in this situation a special occasion to buy stocks and to gain with recuperation to the prior levels of February. However, even the biggest tech and dot-com companies were announcing losses and the commercial banks began to refuse to grant money to invest on dot-com stocks, starting a run to convertible bonds.

The decline however continued, and at April, 12 the Nasdaq had already lost more than 25% since its pinnacle, closing the session of that day losing more than 7% to 3.769 points, which represented the lowest close value since January. On April, 14 the market was already fully aware of what was happening and that day was the biggest 1 day point loss of Nasdaq in historical terms, decreasing more than 10% to 3.321 points. That week closed with a 7 day fall of 25%, the worst week of the index history.

Nasdaq never more reached the levels seen on this period. The mythical barrier of 5.000 points was never more hit and drops widened for a few more months. In addition, the USA went to macroeconomic recession on the following periods and innumerous tech and dot-com companies went bankrupt.

Chapter 4 - A Game Theory Approach

1. An introduction to game theory

The Game Theory field of research, despite the deep interconnection with the economic scientific area, is long analyzed on the most diverse research areas. The basic premise of this theory lies on the analysis of a conflict problem between two or more individuals that act on one or more periods of time in order to take benefit from a given situation, which can imply a loss or even a profit to the adversaries, depending on the strategy used. In formal terms, the first concrete and recognized approach to this theory was made by John Von Neumann and Oskar Morgenstern (1944) on the book "*Theory of Games and Economic Behavior*". However, before was made an initial approach, also by Von Neumann, on his study published on 1928 denominated "*Zur Theorie der Gesellschaftsspiele"*.

Nevertheless, the big impulse to this area was seen on the 1950s, mainly by the papers of John Nash, who with his definition and idea of equilibrium (Nash, 1950a; Nash, 1951) jointly with the Prisoner's dilemma of Tucker (not published) helped to establish the idea of non cooperative games; and with the bargaining analysis (Nash, 1950b; Nash, 1953), together with the nucleus concept (Gillies, 1953) formed the basis of cooperative games.

On the following years many evolutions were made, with emphasis on the works related to the perfect equilibrium on sub-games of Selten (1965; 1975) and Harsanyi (1967); conflict and cooperation by Schelling (1956; 1960); development of Supergames by Aumann (1959); and also applications on other areas of research by Shapley and Shubik (1954) on political science or Braithwaite (1955) in philosophy.

In basic terms, the game theory, like was referred above, illustrates a problem that contains more than 1 agent, dealing with a situation of conflict against each other or versus the nature (specific case). The main objective is related to the achievement of the desires and motivations of the players, that are accomplished through the use of strategies, what can involve in the majority of times the maximization of the utility of a partial or final result, dealing at the same time with exogenous factors like information, and based on a context of perfect or limited rationality.

2. The classification and formalization of games

When dealing with game theory there are set of specificities that broaden the range of options and expands the possibilities in what concerns to the creation of games and models. Because of this is provided a brief classification of intrinsic factors and characteristics to games.

i) Cooperation and Non Cooperation games

In the most basic evaluation, games can be divided in two formal types: games of cooperation and non cooperation. Basically, games of cooperation are essentially based on self-interest, which can be bypassed with the existence of incentives to cooperation, which can be achieved through negotiation. This was addressed by Nash (1950b) on the bargaining theory, allowing for the possibility of building alliances in order to maximize the result of one or more groups. In these cases the utility can be transferred between players, which can encourage the achieving of a Pareto environment. These kind of games make use of several propositions, being the more important ones related to the superadditivity (the value of the union of coalitions isn't lower than the sum of the values of each coalition individually seen), monotonicity (a stable set of preferences) and the possibility of existence of a veto player (that, in a simplified way, means a player that makes part of all wining coalitions, implying that a coalition without this player is a losing one) (Kalai and Samet, 1985).

Non cooperative games are related mainly to the desire by the intervenient players to achieve personal goals and, despite the interaction between them, there are no possibility of coalitions, even with the possibility of communication between them. Thus, this type of game appeals to the optimization of the final result, being central the strategies used by each player. Then the objective of the game is to find an internal stable equilibrium in which no player has an incentive for deviation from the strategy chosen, being this known also as Nash Equilibrium.

However, an important feature to realize is that, despite the evident differences between this two types of games, they can evolve and mutate, being possible to see a transition between cooperative and non cooperative games.

ii) Perfect and imperfect information

When a game has perfect information, all the players have access to the same information and if they are rational then they will make similar or identical choices. However, in games with imperfect information, not all the players have the same information at the same time, which can bring advantage to a given player or group.

iii) Simultaneous and non simultaneous or sequential games

On simultaneous games all the players made their decisions at the same time and they ignore the moves made by other players. On sequential games, however, the players are aware of the actions made by others, which can mutate with time the strategy adopted.

iv) Constant and variable sum games

Constant sum games imply that the total of payoffs obtained by the players are always equal or constant, which means that if one player improve his result, then other player will be worse (example: chess).
Variable sum games imply that the total of the payoffs are not always equal, which can be consubstantiate in games of positive and negative sum.

Adding to the particularities identified, it is important to refer that a game can be constituted by 2 or more players that play against each other or the nature (which is a non player because has only random actions and moves), making plays or actions in one or more periods of time and in the case of more than 1 period, on discrete or continuous time. The strategies used can be pure (like cooperate or defect) or mixed, which implies the allocation of probabilities to each possible action. The result obtained by each player on every round is captured by a payoff function that translate the utility resulted from the round or the incentive to make a given move. Finally, the combination of strategies, which are the set of strategies constituted by the best individual strategy for each player, can culminate on equilibrium, that can be pure, like the Pareto or Nash equilibrium (implying that all players follow the same strategy), or minimal, when only the majority of the players are sharing the same strategy, like can be seen on commons tragedy.

3. The definition of the game and the Iterated Prisoner's Dilemma

The present work deals with a thematic related with the behavior of the investor on stock market on extreme situations, that is, in situations of speculation and crash. Taking this context, the game to be chosen, in order to obtain a significant explanatory efficiency, must contain more than two individuals and, in this case, a finite but indeterminate number of investors. Despite the possibility of doing a model with the players acting individually or as different groups, it was chosen the first alternative (N players acting individually) because the junction of individuals in groups can represent a complex matter, given the need to have access to an enormous amount of information in order to realize groups with a higher percentage of similarities.

Also it was discarded a one period static model because it reveals a significant lack of efficiency on situations in which the behaviors and actions tend to evolve with time and in response to the actions of adversaries. By this way it was selected to modulate a game with T infinite periods of time. However the temporal horizon of the present game will be comprehended between $[0+d;T-d]$, $d\neq0$, implying the analysis of a sub-game. It was selected this procedure because the objective is to focuses on the speculation and crash periods, which are only a fraction of the time T. Then, there are d periods of time before the speculation period and d periods after the crash, which implies that the game has not a final result but a partial result, because the game itself will evolve continuously to other states after the end of the sub-game analyzed.

Is an objective also to analyze the appearance of both cooperative and non cooperative behaviors across the maturity of the game, what excludes games that do not take in consideration the possibly of evolution of aggregate behaviors and subsequent equilibriums. The context of information is asymmetric and imperfect, and is perceived and used gradually by the players, which not implies *à priori* that they have advantage over the others. Thus, allied to this, the game is sequential, because the investors do not take actions at the same exactly period of time, opening possibilities to the application of strategies that mutate in response to other players actions.

Finally, it is assumed that the investor is not fully rational, which implies that despite the prior objective of optimizing his result, his actions can lead him to inefficient outcomes. Thus, considering this proposition, the following game will not be based on a payoff function that translates the result of the game for the player, but on a function that will explain the incentive to cooperation and defection.

Also, the investor preferences are not stable and rigid, which implies that actions can be quite different in different time periods, making preferences more close to a hyperbolic function, that considers the possibility of preference reversal.

Considering the propositions enounced, it was selected to apply an Iterated Prisoner's Dilemma game (IPD), for N players and for the temporal horizon mentioned, with non zero sum result, which indicates that the benefits and incentives to cooperate are not necessarily the same for defecting.

In the basic form (for 2 players), the IPD assumes that each player has the choice to cooperate or defect, being repeated or iterated the game several times (many as wanted) in a sequential way, implying that the strategies used can mutate according with each player previous action. It is important to refer that the players do not know the length of the game, which invalidates an end behavior effect that may arise on supergames with finite time periods (Selten and Stoecker, 1986).

Thus, the game can be presented on the following matrix form.

	Cooperate	**Defect**
Cooperate	R R	T S
Defect	S T	P P

Figure 13: Standard Payoff Matrix (canonical form) of the IPD for 2 players

Also, the game will only be an IPD if the following propositions are respected:

a) $T > R > P > S$;

b) $R > \frac{S+T}{2}$

In the bases of the game it is assumed the possibility of arising of circumstantial cooperative equilibriums that will not be dominant and stable (Aumann, 1959). As the number of iterations rise it is possible to reach a Nash Equilibrium, but only if the players have monotonic preferences, which with 2 players can be more easily achieved.

However the 2 player form of the game is considered to be reductive because when we are dealing with real-life situations, an N player game can achieve results more close to what is seen in reality (Davis *et al*, 1976).
By this way, it is used more often (like will be the case on the present study) an N player IPD, which implies 3 things:

- Each player faces two choices, between cooperation and defection;
- The defection (D) is a dominant pure strategy for each player and he will be better if always choose that option;
- The equilibriums achieved are not stable in some cases, principally in cases of cooperation (C).

Thus, the game can be presented in the following way.

Number of Cooperators	0	1	…	X	…	N-1
Cooperate	C_0	C_1	…	C_x	…	C_{N-1}
Defect	D_0	D_1	…	D_x	…	D_{N-1}

Figure 14: Matrix presentation of the IPD for N players

Like on the 2 players form, with N players the game will be only an IPD if the following conditions are achieved:

a) $D_x > C_x$ for $0 \leq x \leq N-1$

b) $D_{x+1} > D_x$ and $C_{x+1} > C_x$ for $0 \leq x < N-1$

c) $C_x > \frac{(D_x+C_{x-1})}{2}$ for $0 < x < N-1$

On a concrete model the C_{N-1} and D_{N-1} will be payoff functions that translate the incentive to actions of cooperation and/or defection.
One of the important features of this model is the possibility of mutation on the behavior and actions made across the game (dealing only with pure alternatives) and this can be translated with resource to the strategies used. The more important ones are:

- Always Cooperate or Defect: They are the more simple strategies, implying that the game will be at the same stable point at all shoots (the several repetitions of the game);

- Random (mixed strategy): The player gives a 50% probability to cooperate or defect in each round. However this strategy implies an excessive rigidness to the behavior of each player;

- Tit-for-Tat: In this type of strategy the player on the first move chooses defect and then it plays or replicate the action made by the adversary;

- Pavlov: The same as the Tit-for-Tat, however on the first move it is chosen to cooperate. In this strategy it can be said that the cooperation may arise more easily because on the first round the players demonstrate that they are opening to cooperate instead of defecting and win more;

- Spite: The player cooperates always until the adversary defects, then he defects in all subsequent moves;

- Soft majo: In this case the player plays the opponent's most used move and cooperates in case of equality (on the first move he cooperates because is also considered to be a equality).

Nevertheless, on the real world the players do not know the actions made by others on real time, being present a delay that can arise from innumerous factors. Because of that, the investor only knows the adversary moves with a l period delay, improving his knowledge of the game with time (memory), that is, he will learn with the evolution of the game. This learning ability is a very important factor in order to avoid the possibility of superrational

players, and also, even with the learning and delay premises, he can made some mistakes, because he can't process all the available information, implying the selection of pieces of information with the use of anchors and heuristics, which can lead to the possible judgment errors.

4. The application of the Iterated Prisoner's Dilemma to the investor behavior on extreme situations problem

After the contextualization on the model to be applied (IPD), its application to the thematic and to the hypothesis of the present work is made. Thus, the presentation of this application is structured as followed: first the definition of the problem and the parameters of the model is made and then the obtained results are analyzed.

4.1. The definition of the problem

Looking to the problem expressed on Chapter 3 (financial crashes of 1929 and 2000) it can be seen that the investor faces two distinct situations. The first is related to the context of speculative bubble whereupon the investor was increasing or maintaining his positions on overvalued stocks, especially from companies belonging to the new sector of the time (utility in the 1920s and dot-com and new technologies in the late 1990s). At that time he was being driven on one hand, by the desire of maximizing his profits and, on the other hand, by emotional considerations like euphoria and mania. Also, despite the short duration of the speculative bubble that were generated, the returns and the volatility implied on the stocks can be seen as a thing more related to the increasing demand by investors for them than to other factors, what brings the idea of a more deterministic trend on those periods than on other times, in which the random walk is more prevailing.

The second situation is related to situations of crash, which has a different profile. Unlike the bubble context, the investor tries to avoid at all cost losses. However, this outlook does not appear unexpectedly, which imply that the transition made between the period of speculation and crash is not sudden. On the prior months before the crash, both in 1929 and 2000, a market scenario compound with more volatility and with rising trend on prices more unstable was observed. It can be also assumed that, by this time, some investors were starting to launch doubts about the real value of the stocks that they had on their portfolios. However, initially the defection from these positions was made by a minority and was on the moment of crash

that the big parcel of investors started to sell their positions, which has the effect of decreasing the liquidity and increasing the volatility on the market.

Taking into consideration these two contexts, we can present the problem to be applied to the IPD on the following way: the investor has two choices, either on speculation and crash. Or he cooperates with the rest of the investors in order to maintain the speculative bubble and the rising trend, or he defects, and invests on other kind of assets, what means that he is not interested on maintaining the situation of speculation. Thus, the players on the game have the following possible actions:

- **Cooperation (C)**: can be seen as a coordination between investors in order to maintain (even if unconsciously) the speculative bubble by investing or sustaining positions on stocks that are overvaluated;

- **Defection (D)**: logically is the opposite situation, that is, the investor is not interested on maintaining the bubble and that can involve two possible actions: or the investor do not want to invest on this kind of stocks or he has these stocks and does not want to maintain his position, which impels him to sell them, not supporting the trend.

The defection can also result on the possibility of exiting the game or maintaining in the same, however with positions on other assets.

Therefore, the objective of the game is to verify what kind of behaviors are generated on both situations and the existence of possible equilibriums, that may be not stable but provide an explanation to the individual behavior of the investor and over the aggregate group of investors.

4.2. The formalization of the game

4.2.1. Players

The number of player in the game is indeterminate but is a finite set of dimension N. Also for each player $i \in N$ is a nonempty set A_i of actions available that are pure: cooperation or defection. The players are also characterized by the following propositions:

- They are not fully rational, acting more according with the postulate of limited rationality of Simon (1955), which implies that they can, in some periods of the game, not optimizing their actions, what may allow the existence or maintenance of cooperative long periods;

- They do not have monotonic preferences or a stable set of preferences, which means that there isn't a relation $\succsim_i$ on A. Instead they can possibly have hyperbolic preferences, what allows the possibility of mutation on the preference set and reversion of a preference A over preference B in a given time period T_i;

- The risk profile of the players/investors respects the Prospect Theory utility function, what means that they are not always risk averse. That degree will depend on and vary according with if they are dealing with gains or losses. Also, their behaviors towards risk should depend on their motivations, being assumed that on speculation they are pointing to the realization of higher needs on the Maslow modified scale, and in crash for the satisfaction of more basic needs.

- It is possible to a player to exit the game when he defects, however that type of attitude is not dominant across all the elements of the group of players, meaning that when they defect, it is yet possible to make part of the game, but with investments on other assets or even observing to enter again on a later period of time.

4.2.2. Time

This game considers an infinite time period T. However, the game begins a few periods before the beginning of the bubble and when this analysis ends, the game continues, evolving in more *d* time periods. This implies also that the model occurs in a sub-game, that does not not represent a problem because, like as it is argued by Friedman (1991), a game that begins on a given time period that is not coincident with the time period T_0 may have all the same characteristics of a game and realize the same *equilibria*.

4.2.3. Payoff or incentive function

The payoff function on the IPD works as a mathematical translation of the incentive to cooperation. Thus, there are two payoff functions, one for cooperation and another to defection. However, each one of them is not static and stable, varying with the number of cooperators, which also varies according with the strategies used by each player.

The payoff functions are denominated by C_x and D_x and belong to a space set N of the number of cooperators between $\{0, 1, 2, \ldots, N\text{-}1\}$.

4.2.4. Information and strategies

The following game will be played on an imperfect information context, being assumed that the players on several moments have to make decisions without knowing all game history and the adversaries' choices (Fiani, 2004). However, being the investor not fully rational, it is implied that, even on a perfect information context, the decisions made would not be supported on all the information known because of their cognitive limitations.
Also, the players' actions are supported on the use of the Tit-for-Tat strategy. However because the game begins on $0+d$ time periods, we do not know when the first move of defection really happened. Nevertheless, it is important to say that players take into consideration the choices made by adversaries, however with a l lag period, which is not standard for all players. This has to be assumed because, without lagging, the game was on a short period stabilized on a Nash Equilibrium of defection (being then the preferences monotonic). Also, they will not remember all the previous moves from the lag period, because there is a lot of information, being assumed instead that only a few moves prior to the lag period it will be remembered.

4.3. The model and the results analysis

The problem for the investors is to preserve initially the speculative bubble, maintaining their positions or investing on assets that are overvaluated, which implies cooperation on the actions made. However, with the evolution of time, more investors will share similar investment decisions, what implies an incentive to cooperate higher than to defect. But, with

the maturity of the bubble, some investors realize that the situation can be unstable and they see on defection a more appealing incentive.

Being this the problem, the following payoff functions can be applied, proposed by Seo, Cho and Yao (2000).

$$C_x = \frac{1}{2}x^2 - k \; for \; 0 \leq x \leq N \tag{3}$$

$$D_x = \sqrt{2x} \;\; for \; 0 \leq x \leq N \tag{4}$$

Denote that x translates the number of cooperators on the game in each time period T_i and k is an unknown variable that indicates the exogenous incentive to defection, which can include any type of information (even a crucial piece that can trigger the crash), being seized only by some players. However they will start to defect when this parameter k becomes too big, making the incentive to cooperation smaller than the respective one to defect.

Also, as referred, the players make use of a Tit-for-Tat strategy, what implies that the decisions made will take into consideration the actions taken by other players, but only considering a small number of moves and with temporal lag.

$$l = \; y, for \; all \; T_i \tag{5}$$

$$m = (\omega * T) - l, for \; all \; T_i \tag{6}$$

Therefore, based on the idea of Axelrod (1987), the equation (5) indicates the number of lag periods on all the time T_i period, and equation (6) provides a quantification of how much periods of information can a player remember prior to the lag, where ω is a number of periods prior to the lag (being this a constant).

However, the players will remember only the moves made by some adversaries, mostly because it is a context of incomplete information and because the investor cannot assimilate a very high amount of information.

Thus, as shown in Figure 15, with a small k, despite the natural dominance of defection, as the number of cooperators grows, the incentive to the cooperation will increase more quickly than the one respected to defection, what will implicate an intersection between both

incentives on a given point in time, becoming the cooperation more appealing on further moments.

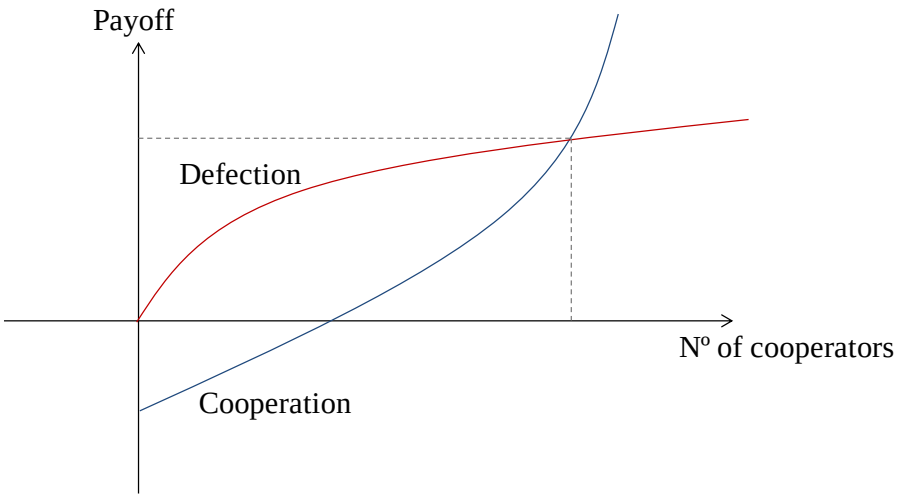


Figure 15: The evolution of the payoff result to Cooperation and Defection across a growing number of cooperators

Therefore, the game can be analyzed on two distinct parts.

The first one begins on the first intersect point, described on Figure 16 as point (1). The k value by this time is small and the investors are making use of a Tit-for-Tat strategy. As was mentioned, the moment of the beginning of the game is not relevant for the present study. By this way, this period started in point (1) is linked to sentiments of euphoria and mania, like was seen on the 1929 and 2000 bubbles, when more and more investors were investing on positions that were overvalued.

The number of cooperators becomes to rise at a fast pace and the origin of this movement can be related with the desire to make gains with the stocks that belong mostly to the sectors of the new economy, as it was seen with utility sector on 1929 and dot-com and technologies on 2000. Thus, as the existing cooperators are maintaining their positions, what is partially related to the strategy being used, new players are becoming to cooperate in order to make part of the evident returns. By this way, with a rising trend of cooperating players, the speculative bubble grows and the same happens for the incentive that sustain it.

This scenario can be characterized as a minimal equilibrium of cooperation, because the number of cooperators is bigger than the number of defectors, and the growth of the incentive to cooperate is more accentuated that the one linked to defection. Then, with the maintenance of a low k, the number of cooperators continues to rise to a point in which the equilibrium reaches his strongest position (point (2) on Figure 16). Thus, the peak of the speculative

bubble (or minimal equilibrium of cooperation) on the point (2) is coincident with moments saw on the two events previously analyzed. On the Great Crash of 1929 it is related essentially to the end of the year of 1928, when the volume of stocks traded passed utopian marks, for that time, of 5 and 6 millions stocks. On the crash of 2000, this moment is coincident with the reach by the Nasdaq of 5.000 points.

After this point, the equilibrium becomes more unstable. On the events described, after the peak, the markets begun to be more unstable and more volatile, and the investors, banks and states to be more anxious and nervous. The irregularity of the market can be seen as a result of a rising number of investors starting to defect. The explanation for this defection may reside on the value of the parameter k. This parameter contains pieces of information that indicates that the bubble is not stable and that is better to begin to leave the positions held on overvalued assets before a stressful drop on the market. However, these informations are only captured by some investors. Thus, some of them begun to non cooperate and the equilibrium becomes more volatile.

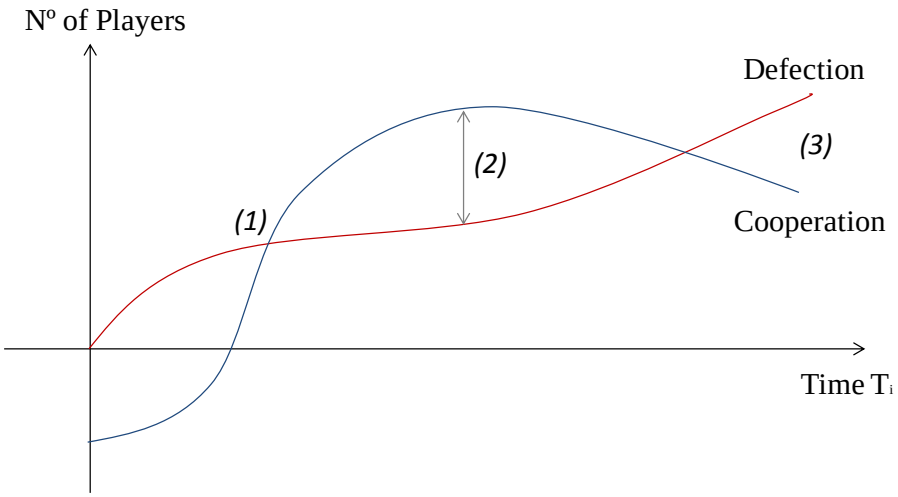


Figure 16: The evolution of the number of players cooperating or defecting across time: (1) indicates the beginning of the minimal equilibrium of cooperation; (2) Point in time in which the minimal equilibrium of cooperation is more strong; (3) Beginning of the minimal equilibrium of defection which will become more strong but not stable as a solution of the game

This moment marks the beginning of the end of that period. As more players become aware of the key pieces of information, they start to see the cooperative payoff diminishing in a faster pace than the one related to defection, residing the explanation for that event on the value of k, that is cutting the incentive. Then is a causality relation in which, more k implicates less cooperation and then a decreasing trend on the cooperative incentive.

As the players are making use of a Tit-For-Tat strategy, they start to realize some defective actions on some other players and then they also start also to replicate their actions and choosing to defect, which implicates a reversal of preferences, which were relatively stable in a long period of time (period coincident with the speculation). This will imply another intersection between the number of players cooperating and defecting. This intersection will provide the moment (3) and can be associated to the beginning of the crash.

As referred, the moment after the peak of the bubble is related to an environment of increasing volatility and anxiety from the agents on the market. The more unstable variations of the market can be interpreted as more defective actions made by players. Then, when more players are defecting than cooperating, the game reaches a new equilibrium, a minimal defection equilibrium, which is coincident with the moments related with the crash on the market. As more players defect, less are the incentives, however, the incentive to cooperate becomes smaller in a faster pace than the one related to defection. Thus, the gain of stability on the equilibrium is coincident with the drop of the market, implying also domination over the previous one.

Nevertheless, this equilibrium will not be stable for a long period of time because the set of preferences of the investors is not rigid, implying the inexistence of a Nash point of equilibrium. However, in future time periods the dominating equilibrium will evolve to other types of states.

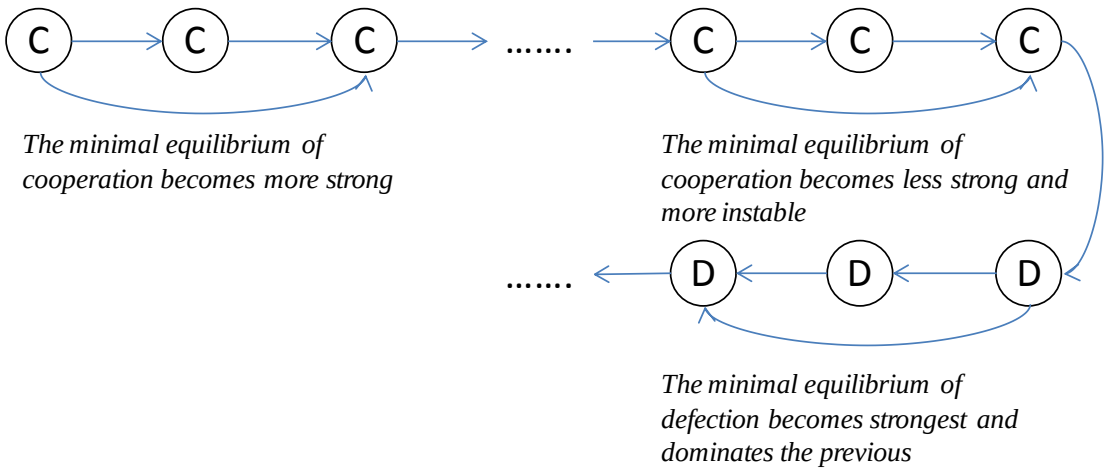


Figure 17: An illustrative scheme of transition between the equilibriums of the game

As is established on Figure 17, the problem includes three phases. The first one is related to the growth of the minimal equilibrium of cooperation, coincident to the expansion of the speculation period. A second period is characterized by an increasing instability on the

markets, associated to more defective actions made by the investors, which volatilizes the equilibrium. Finally the last period, marking the transition between equilibriums, which is coincident with the crash on the markets and imply the domination of the defective choice for the majority of the players.

Chapter 5 - Conclusion notes

The present work was defined essentially as an approach to the behavior of the investor on extreme situations on the stock market. The main motivation was to light some features about the investor profile in order to understand the actions made by him individually and on an aggregate way during events that are unusual on the stock market. And being those events more common on the present days, it makes sense to try to bring some new approaches on the particularities that make up the financial markets.

Thus, in order to obtain a realistic investor profile on those situations, it was launched different alternatives and approaches about the main features of the investor. It was analyzed first the postulate of rationality, confronting the existed literature from asset pricing and portfolio theory with the ideas of the behaviorists and neuroscientists, substantiating that, first, the economic agent is not rational, being maybe more close to the notion of limited rationality of Simon (1955) and second, that is possible to construct feasible models and theories which do not take as central premise the pure rationality. From the behavioral economics and finance, to the evolutionism approach and neuroeconomics, all seem to agree that the utilitarian agent is not the most efficient way to approach some problems and they also launch alternatives that corroborate this point of view.

Another major important feature is related to the role of motivations and needs on the behavior of the agent, which brings the possibility that the decisions and choices made by an economic agent have behind a complex and dynamic system of motivations and needs that have systematical mutations. So the understand of what impels the individual to make given choices may reside on what needs and motivations he want to accomplish. Also, the process of decision-making itself can be even more complex if we take in attention the considerations related with the set of preferences. If in the real world the offer options are systematically changing and if the individual itself has a dynamic and mutated set of preferences, which can be biased by the influence of limited rationality and information processing, then the process of decision making has to be more complex than is shown and derived by some theories. Considerations about the utility function and the set of preferences, the degree of risk aversion or the process of accounting gains and losses by the economic agent become so complex that it could be difficult to resume all in simple axioms. However, it is shown that the complexity of the profile of the agent imply that new models and the one analyzed in this study have to take into account this kind of considerations.

Taking into account these alternative statements, the model generated through the Iterated Prisoner's Dilemma had launched the hypothesis of the existence of minimal equilibriums of cooperation (on the speculative bubble event) and defection (on the prior moments and across the crash period), which however are not stable because of the perceptions of key informations by players and their impact on the set of preferences. However, what was seen is that there is a successive role of equilibriums if we want to see the game as a whole and not as a sub-game. Another important fact is that the individuals acting as a group do not secure the cooperation and the self-interest is a factor of major importance on the decisions made. Nevertheless, the motivations possess by the investor in the speculative bubble event can degenerate on attitudes of coordination, what is seen in the majority of times on commons tragedies on natural resources. In conclusion, it was seen that the hypothesis launched can be corroborated by the model used. However, the results can vary in line with the type of event that is analyzed.

In future it can be analyzed with more detail the importance of information on the strategies used by the players on the game and the possibilities of expansion of the methods used in games that incorporate current normal situations on the stock market. It can be also tried an adaptation of the possibilities that arise from this model to asset pricing models and also developed forecasting systems of disequilibriums and structure breaks on the financial markets, taking into account principally the profile of investor.

References

Adams, J. T. (1931), *Epic of America*, Little, Brown, and Company, Boston

Ainslee, G. (1975), Specious Reward: A behavioral theory of impulsiveness and impulse control, *Psychological Bull 82*, 463-496

Ainslee, G. (1991), Derivation of "Rational" economic behavior from Hyperbolic Discount Curves, *American Economic Review 81*, 334-340

Aldrich, H.E., G.M. Hogdson, D.L. Hull, T. Knudsen, J. Mokyr and V.J. Vanberg (2008), In Defense of Generalized Darwinism, *Journal of Evolutionary Economics 18(5)*, 577-596

Allen, F. L. (1931), *Only yesterday, an Informal History of the Nineteen-Twenties*, Harper and Row, New York

Antonides, G. and S. R. Wunderink (2001), Subjective time preference and willingness to pay for an energy-saving durable good, *Zeitschrift Fur Sozialpsychologie 32 (3)*, 133-141

Arrow, K.J. (1987), Economic theory and the hypothesis of rationality, in Eatwell, J.M., M. Milgate and P. Newman (Eds.), *The New Palgrave: a dictionary of Economics*, London: Macmillian, 69-74

Aumann, R. J. (1959), Acceptable points in general cooperative n-person games, in R. D. Luce and A. W. Tucker, (Eds.), *Contributions to the Theory of Games IV - Annals of Mathematics Study*, 40, Princeton University Press, Princeton New Jersey, 287-324

Axelrod, R. (1987), The evolution of strategies in the Iterated Prisoner's Dilemma, in L. Davis (Ed.), *Genetic Algorithms and Simulated Annealing*, Morgan Kaufmann, San Mateo, 32-41

Bechara, A., A. Damásio, H. Damásio and S.W. Anderson (1994), Insensitivity to future consequences following damage to human prefrontal cortex, *Cognition 50*, 7-12

Bechara, A., H. Damásio, D. Tranel and A. Damásio, (1996), Failure to respond autonomically to anticipate the future outcomes following damage to prefrontal cortex, *Cognition 6*, 215-225

Bechara, A., H. Damásio, D. Tranel and A. Damásio, (1997), Deciding advantageously before knowing the advantageous strategy, *Science 275*, 1293-1295

Benartzi, S., and R. Thaler (1995), Myopic Loss aversion and the equity premium puzzle, *The Quarterly Journal of Economics 110 (1)*, 73-92

Berenson, A. (2000), Investing – Technology defies another dictum, *New York Times*, February 6

Berenson, A. (2000), A record volume as stocks surge on the big board, *New York Times*, March 17

Berenson, A. (2000), As some look for more fireworks, the Dow takes a dip, *New York Times,* March 18

Berenson, A. (2000), So much for the theory that old-economy stocks are finally regaining their place in the sun, *New York Times,* March 23

Blaug, M. (1992), *The Methodology of Economics, or How economists explain,* Cambridge University Press

Bodie, Z., A. Kane and A.J. Marcus (2009), *Investments,* McGraw – Hill (8th edition)

Braithwaite, R. B. (1955), *Theory of games as a tool for the moral philosopher,* Cambridge University Press, Cambridge.

Breeden, D. (1979), An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities, *Journal of Financial Economics 7,* 265-296

Brouwer, P. J. S. (2009), Maslowian Portfolio Theory: An alternative formulation of the Behavioral Portfolio Theory, *Journal of Asset Management 9,* 359-365

Buttman, J. and R.F. Allegri (2001), A Cognição Social e o Córtex Cerebral, *Psicologia: Reflexão e Crítica 14(2),* 275-279

Camerer, C. F, G. Loewenstein and M. Rabin (2004), *Advances in Behavioral Economics,* Princeton University Press, New Jersey

Campbell, J. Y. and J. Ammer (1993), What moves the stock and bond markets? A variance decomposition for long-term asset returns. *Journal of Finance* (48), 3-37

Carlson, M. (2006), A Brief History of the 1987 Stock Market Crash with a Discussion of the Federal Reserve Response, *Finance and Economic Discussion Series, Division of Research & Statistics and Monetary Affairs Federal Reserve Board*, 2-24

Chandler, A. D. Jr. (1977), *The Visible Hand: The Managerial Resolution in American Business,* Harvard University Press

Chapman, G. B., and S. A. Elstein (1995), Valuing the future – Temporal Discounting of Health and Money, *Medical Decision Making 15 (4),* 373-386

Chapman, G. B. (1996), Temporal discounting and utility for health and money, *Journal of Experimental Psychology Learning Memory and Cognition 22 (3),* 771-791

Damásio, A. (1994), *O Erro de Descartes – Emoção, Razão e Cérebro Humano,* Publicações Europa-América, Mem Martins

Danthine, J. P. and J. B. Donaldson (2005), *Intermediate Financial Theory*. Elsevier Academic Press, (2nd Edition)

Davidoff, L. (1976), *Introduction to Psychology,* McGraw-Hill

Davis, J. H., P. R. Laughlin and S. S. Komorita (1976), The social psychology of small groups, *Annual Review of Psychology 27*, 501-542

De Bondt, W.F.M. (1998), A portrait of the individual investor, *European Economic Review 42*, 831-844

Donovan, A. (2000), The neediest cases: A wider reach for Wall-Street's Boom, *New York Times*, January 26

Duncker, K. (1945), On problem solving, *Psychological Monographs 58(5)*

El-Faizy, M. (2000), Shares to be doled out privately, but sale to public still year away, *New York Daily News*, January 3

El-Faizy, M. (2000), Techs keep Nasdaq rolling and renewed rate fears ruin Dow's new year, *New York Daily News*, January 4

El-Faizy, M. (2000), New dose of interest-rate fears fuels markets' flop, *New York Daily News*, January 25

El-Faizy, M. (2000), Nasdaq down, Dow up with focus on the FED, *New York Daily News*, March 21

El-Faizy, M. (2000), FED hike can't halt stocks, Dow, Nasdaq soar despite quarter-point rise in short-term rates, *New York Daily News*, March 22

El-Faizy, M. (2000), Dow, Nasdaq hurdle downhill, suffer biggest 1-day point loss, *New York Daily News*, April 15

Fiani, R. (2004), *Teoria dos Jogos para cursos de administração e economia*, Elsevier, Rio de Janeiro

Fleming, J., C. Kirby and B. Ostdiek (1998) Information and volatility linkages in the stock, bond, and money markets. *Journal of Financial Economics* (49), 111-137

Friedman, J. W. (1991), *Game theory with applications to economics*, Oxford University Press, London (2nd Edition)

Gilbert, D. T. (2002), Inferential Correction, in T. Gilovich, D. Griffin and D. Kahneman (Eds.), *Heuristic and Biases*, Cambridge University Press, New York, 167-184

Galbraith, J. K. (1954), *The Great Crash 1929*, Houghton, Mifflin Company, Boston

Gillies, D. B. (1953), *Some theorems on n-person games*, PhD Project, Department of Mathematics, Princeton University Press, New Jersey

Gilpin, K. N. (2000), Demand for Technology shares drives Nasdaq to record, *New York Times*, February 8

Gilpin, K. N. (2000), Shares close lower on declines by Microsoft and Banks, *New York Times,* March 28

Gilpin, K. N. (2000), Shares prices fall as analyst reallocates model portfolio, *New York Times,* March 29

Gilpin, K. N. (2000), Nasdaq posts its first gain of the week, *New York Times,* April 1

Gilpin, K. N. and M. Richtel (2000), Nasdaq goes into free fall before making a recovery, *New York Times,* April 5

Gilpin, K. N. (2000), April 23-29: Ritalin for Nasdaq?, *New York Times,* April 30

Goldstein, D.G. and G. Gigerenzer (2002), Models of Ecological Rationality: The Recognition Heuristic, *Psychological Review 109(1),* 75-90

Goldstein, K. (1939), *The organism: A Holistic Approach to Biology,* The American Book Co, New York

Green, L., J. Myerson and E. McFadden (1997), Rate of temporal discounting decreases with amount of reward, *Memory and Cognition 25*(5), 715-723

Gross, D. (2000), Desperation of the Dot-coms, *New York Times,* April 7

Hand, J. R. M. (2000), The role of book income, web traffic, and supply and demand in the pricing of U.S. Internet Stocks, *European Financial Review 5(3), 295-317*

Harsanyi, J. C. (1967), Games with incomplete information played by 'bayesian' players, parts i, ii and iii, *Management Science 14 (3),* 159-182

Hershey Jr., R. D. (2000), The Markets: Investors Flee Technology; Dow rises and Nasdaq falls, *New York Times,* January 7

Hershey Jr., R. D. (2000), Nasdaq surges as Dow drops after Greenspan comments, *New York Times,* February 18

Hershey Jr., R. D. (2000), A Nasdaq correction, now back to business, *New York Times,* March 19

Hershey Jr., R. D. (2000), Flight from technology bolsters pillars of old economy, *New York Times,* March 30

Holt, C. A., and S. K. Laury (2002), Risk Aversion and Incentive Effects, *The American Economic Review 92 (5),* 1644-1654

Huang, C., and R. H. Litzenberger (1988), *Foundations for Financial Economics,* Prentice – Hall

Hull, C. L. (1952), *A Behavior System,* Yale University Press

Levy J. S. (1992), An Introduction to Prospect Theory, *International Society of Political Psychology 13 (2),* 171-186

Lintner, J. (1965), The valuation of Risk assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets, *Review of Economics and Statistics 47(1),* 13-37

Kahneman, D. and A. Tversky (1979), Prospect Theory: An analysis of decision under risk, *Econometrica 47,* 263-291

Kahneman, D. and A. Tversky (1984), Choices, Values and Frames, *American Psychologist 39 (4),* 341-350

Kahneman, D. and M. W. Riepe (1998), Aspects of Investor Psychology: beliefs, preferences, and biases investment advisors should know about, *Journal of Portfolio Management 24(4),* 52-65

Kahneman, D. (2002), A perspective on Judgment and Choice, *American Psychologist 58 (9),* 697-720

Kalai, E. and D. Samet (1985), Monotonic Solutions to General Cooperative Games, *The Econometric Society 53 (2),* 307-327

Kindleberger, C. P. and R. Z. Aliber (2005), *Manias, Panics and Crashes: A History of Financial Crises,* Palgrave Macmillan

Koenigs, M. L., R. Young, D. Adolphs, F. Tranel, M. Cushman, M. Hauser and A. Damásio (2007), Damage to the prefrontal cortex increases utilitarian moral judgments, *Nature 446,* 908-911

Laury, S. K., and C. A. Holt (2000), Further reflections on Prospect Theory, *Discussion Paper,* Georgia University Press

Liu, Q. and F. Song (2001), The Rise and Fall of Internet stocks: Should Financial Analysts be Blamed, *SSRN Working Paper Series*

Loewenstein, G. F. (1988), Frames of Mind in Intertemporal Choice, *Management Science 34 (2),* 200-214

Lucas, R. (1978), Asset Prices in an Exchange Economy, *Econometrica 46,* 1429-1445

Luce, R. D. and H. Raiffa (1957), *Games and decisions,* Wiley, New York

Madrick, J. (2000), When Greenspan speaks and the stock market doesn't listen, the loss of credibility is dangerous, *New York Times,* March 16

Markowitz, H. (1952), Portfolio Selection, *The Journal of Finance 7(1),* 77-91

Marino, V. (2000), A Technology tide in Europe lifted International Funds, *New York Times,* April 9

Maslow, A. H. (1943), A Theory of Human Motivation, *Psychological Review 50 (4),* 370-396

Mayr, E. (1988), *Toward a New Philosophy of Biology – Observations of an Evolutionist*, Harvard University Press, London

McDonald, R. and D. Siegel (1986), The Value of waiting to invest, *The Quarterly Journal of Economics,* 707-726

McDougall, W. (1909), *An Introduction to Social Psychology,* Methuen & Co., London (2nd Edition)

Michel-Kerjan, E., and P. Slovic (2010), *The Irrational Economist, Making decisions in a dangerous world,* Public Affairs, New York

Morgenson, G. (2000), Investing longtime best bet is being trampled by the bulls, *New York Times,* January 15

Morgenson, G. (2000), The FED has no surprises and the market has a reason to rally, *New York Times*, March 22

Morgenson, G. (2000), Buying on margin becomes a habit, investors turn to credit in a bull market, *New York Times*, March 24

Morgenson, G. (2000), At Waterloo, a Technology Stock's retreat, *New York Times,* April 16

Morgenson, G. (2000), Forces of nature, immutable truths, *New York Times,* April 02

Nash, J. F. (1950a), Equilibrium points in n-person games, *Proceedings of the National Academy of Sciences of the United States of America 36 (1),* 48-49

Nash, J. F. (1950b), The bargaining problems, *Econometrica 18 (2),* 155-162

Nash, J. F. (1951), Non-cooperative games, *Annals of Mathematics 54(2),* 282-295

Nash, J. F. (1953), Two person cooperative games, *Econometrica 21 (1),* 128-140

Norris, F. (2000), Nasdaq market at 5000: Volatility as way of life, *New York Times,* March 10

Norris, F. (2000), A hard fall as a highflier revises figures, *New York Times,* March 21

Norris, F. (2000), Modigliani's message: it's a bubble, and bubbles will burst, *New York Times,* March 31

Norris, F. (2000), Market Place: In only a few weeks Nasdaq falls 25,3% from its pinnacle, *New York Times,* April 13

Mossin, J. (1966), Equilibrium in a Capital Asset Market, *Econometrica 34 (4),* 768-783

Odean, T. (1998), Are investors reluctant to realize their losses, *Journal of Finance 53 (5),* 1775-1797

Oppel Jr., R. A. (2000), Dell Computer profit that meets lower forecast, *New York Times,* February 11

Pachur, T. and R. Hertwig (2006), On the Psychology of the recognition heuristic: Retrieval primacy as a key determinant of its use, *Journal of Experimental Psychology: Learning, Memory and Cognition 32,* 983-1002

Read, D. (2001), Is time-discounting hyperbolic or subadditive?, *Journal of Risk and Uncertainty 23*(1), 5-32.

Read, D. (2003), Intertemporal Choice, *Working Paper LSEOR 03.58*

Ross, S. (1976), The Arbitrage Theory of Capital Asset Pricing, *Journal of Economic Theory 13,* 341-360

Rubinstein, M. (1976), The Valuation of Uncertain Income Streams and the Pricing of Options, *Bell Journal of Economics and Management Science 7,* 407-425

Schoolman, J. (2000), Dow makes a comeback, profit-takers give Nasdaq small loss, *New York Daily News,* February 29

Schultz, P. and M. Zaman (2000), Do the individuals closest to internet firms believe they are overvalued?, *Journal of Financial Economics 59(3), 347-381*

Seo, Y., S. Cho and X. Yao (2000), The impact of payoff function and local interaction on the N-Player Iterated Prisoner's Dilemma, *Knowledge and Information Systems 2,* 461-478

Selten, R. (1965), Spieltheoretische behandlung eines oligopolmodells mit nachfragetragheit, *Zeitschrift fur die gesamte Staatswissenschaft 121* (2), 301-324

Selten, R. (1975), Reexamination of the perfectness concept for equilibrium points in extensive games, *International Journal of Game Theory 4 (1),* 25-55

Selten, R. and R. Stoecker (1986), End behavior in sequences of finite Prisoner's Dilemma Supergames, a learning theory approach, *Journal of Economic Behavior and Organization 7,* 47-70

Shapley, L. S. and M. Shubik (1954), A method for evaluating the distribution of power in a committee system, *American Political Science Review 48 (3),* 787-792

Sharpe, W. (1964), Capital Asset Prices: A theory of Market Equilibrium, *The Journal of Finance 19(3),* 425-442

Shefrin, H. and M. Statman (2000), Behavioral Portfolio Theory, *Journal of Financial and Quantitative Analysis 35 (2),* 127-151

Shelley, M. K. (1993), Outcome Signs, Question Frames and Discount Rates, *Management Science 39*(7), 806-815

Schelling, T. C. (1956), An essay on bargaining, *American Economic Review 46 (3),* 281-306

Schelling, T. C. (1960), *The strategy of conflict*, Harvard University Press, Cambridge

Shiller, R. (1982), Consumption, asset markets, and macroeconomic fluctuations, *Carnegie Rochester Conference Series on Public Policy* (17), 203-238

Shiller, R. J., and A. E. Beltratti (1992) Stock prices and bond yields: Can their comovements be explained in terms of present value models? *Journal of Monetary Economics* (30), 3-51

Shiller, R. (2000), *Irrational Exuberance,* Princeton University Press, Chichester, West Sussex

Skinner, B. F. (1989), Review of Hull's Principles of Behavior, *Journal of the experimental analysis of behavior 51 (2),* 287-290

Simon. H.A. (1955), A behavioral model of rational choice, *Quarterly Journal of Economics 69*, 99-118

Sornette, D. (2003), *Why Stock Markets Crash: Critical Events in Complex Financial Systems*, Princeton University Press

Steel, P. and C. J. König (2006), Integrating theories of motivation, *Academy of Management Review 31 (4),* 889-913

Thaler, R. (1981), Some empirical evidence of dynamic inconsistency. *Economics Letters*, *8*, 201-207

Thaler, R. (1985), Mental Accounting and consumer choices, *Marketing Science 4*, 199-214

Thaler, R. and E. J. Johnson (1990), Gambling the house money and trying the break even: The effects of prior outcomes on risky choice, *Management Science 36 (6),* 643-660

Thaler, R., A. Tversky, D. Kahneman and A. Schwartz (1997), The effect of myopia and loss aversion on risk taking: an experimental test, *Quarterly Journal of Economics*, 647-661

Thaler, R. (1999), Mental Accounting Matters, *Journal of Behavioral Decision Making 12*, 183-206

Tversky, A. and D. Kahneman (1974), Judgment under uncertainty: Heuristics and Biases, *Science 185(4157),* 1124-1131

Tversky, A. and D. Kahneman (1986), Rational choice and the framing of decisions, *Journal of Business 59 (4),* 251-278

Vanberg, V.J. (2004), The rationality postulate in economics: its ambiguity, its deficiency and its evolutionary alternative, *Journal of Economic Methodology 11(1),* 1-29

Volz, K.G., L.J. Schooler, R. Schubotz, M. Raab, G. Gigerenzer and D.Y. Von Crammon (2006), Why you think Milan is larger than Modena: neural correlates of Recognition Heuristic, *Journal of Cognitive Neuroscience 18*, 1924-1936

Von Neumann, J. (1928), Zur Theorie der Gesellschaftsspiele, *Mathematische Annalen 100 (1),* 295-320

Von Neumann, J. and O. Morgenstern (1953), *Theory of games and economic behavior,* (3rd Edition), Princeton University Press

White, E. N. (1990), The Stock Market Boom and Crash of 1929 Revisited, *The Journal of Economic Perspectives 4(2),* 67-83

White, E. N. (2004), Bubbles and Busts: The 1990s in the mirror of the 1920s, *NBER Working Paper No. 12138*

White, E. N. (2009), Lessons from the Great American Real Estate Boom and Bust of the 1920s, *NBER Working Paper No. 15573*

Other references

EconStats
http://www.econstats.com/

Federal Reserve Economic Data
http://research.stlouisfed.org/fred2/

Measuring Worth
http://www.measuringworth.com/

New York Daily News
http://www.nydailynews.com/

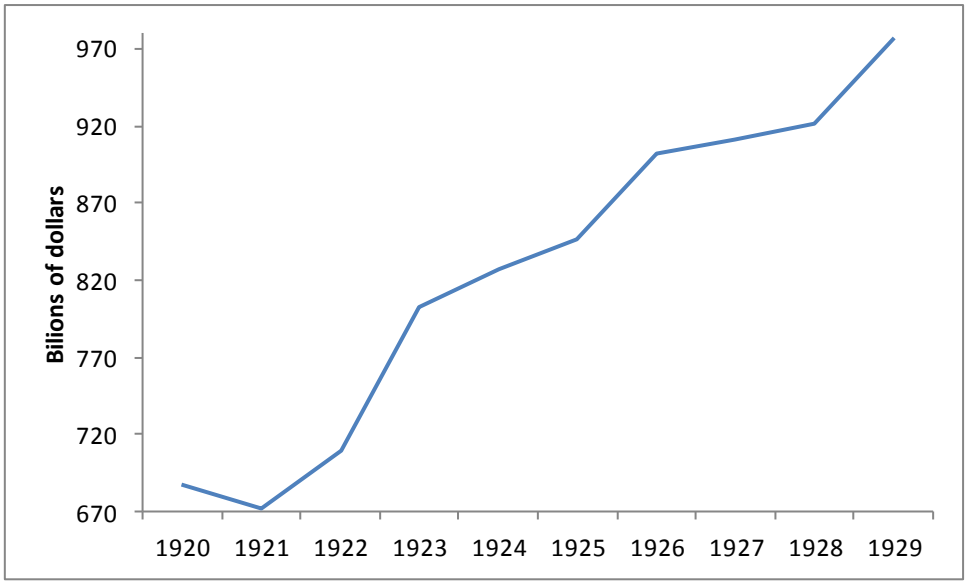
Robert Shiller Homepage
http://www.econ.yale.edu/~shiller/

Yahoo Finance
http://finance.yahoo.com/

The New York Times
http://www.nytimes.com/

Annexes

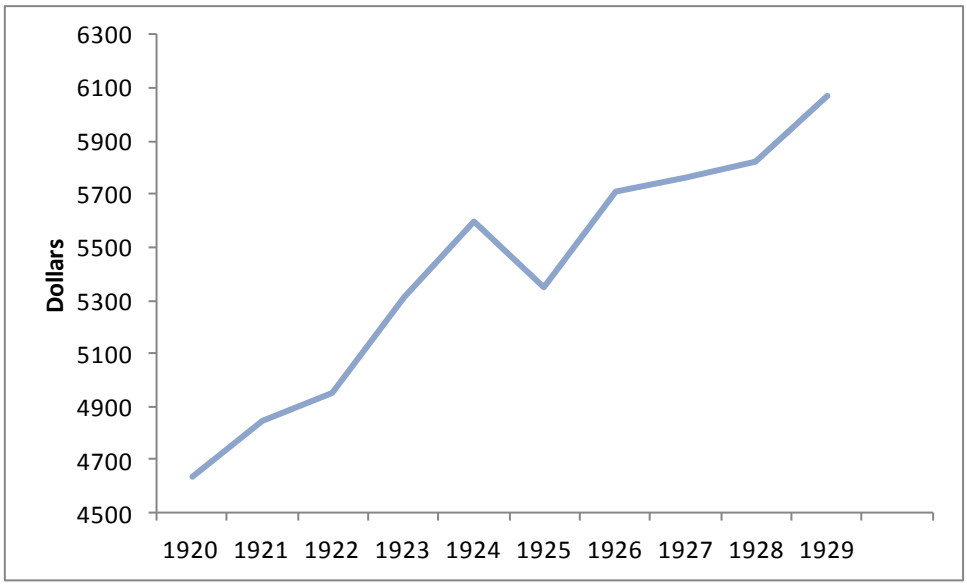
1.



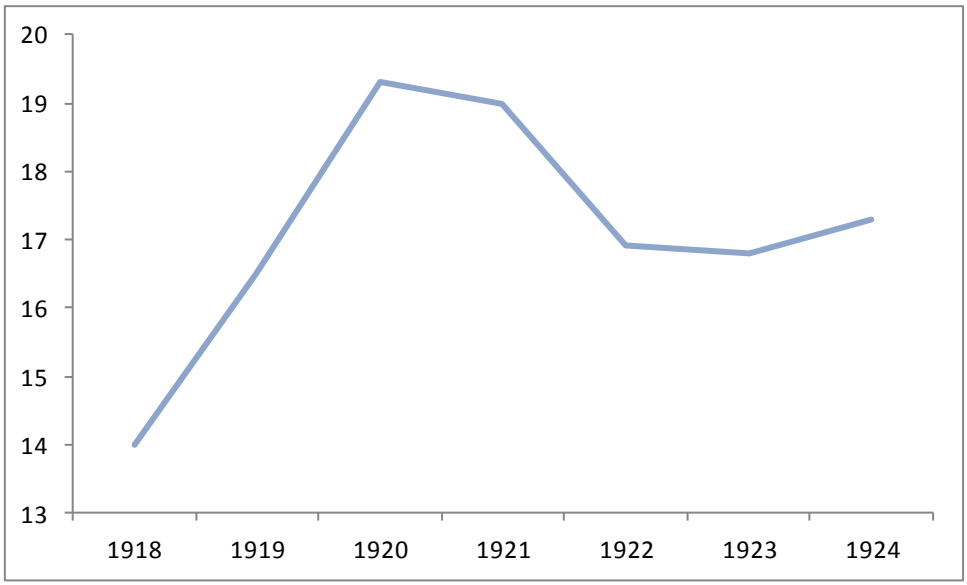
Annex 1.1. The evolution of the United States of America Real Gross Domestic Product between 1920 and 1929 in 2005 dollars (Measuring Worth: http://www.measuringworth.com/)

	Industrial Production Index											
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Set	Oct	Nov	Dec
1920	55.892	55.892	54.822	51.881	53.218	53.753	52.415	52.683	50.811	48.671	44.660	41.986
1921	39.579	38.777	37.707	37.707	38.777	38.509	38.242	39.579	39.846	42.253	41.718	41.451
1922	43.056	44.928	47.334	45.730	48.137	50.543	50.543	49.474	52.148	55.090	57.497	59.101
1923	57.764	58.566	60.438	61.775	62.578	62.043	61.508	60.438	59.101	58.834	58.834	57.497
1924	58.834	59.903	58.834	56.962	54.555	52.148	51.346	53.218	55.090	56.427	57.497	59.101
1925	60.973	60.973	60.973	61.508	61.241	60.706	62.310	61.241	60.438	62.845	64.182	64.985
1926	63.915	63.915	64.717	64.717	64.182	64.984	65.252	66.054	67.124	67.124	66.856	66.589
1927	66.322	66.856	67.659	66.054	66.589	66.322	65.519	65.519	64.450	63.112	63.113	63.380
1928	64.717	65.252	65.787	65.519	66.322	66.857	67.659	68.996	69.531	70.868	72.205	73.542
1929	74.612	74.344	74.612	75.949	77.286	77.821	78.891	78.088	77.554	76.216	72.472	69.263
1930	69.263	68.996	67.926	67.391	66.322	64.450	61.508	60.171	59.101	57.497	56.159	54.822

Annex 1.2. The USA Industrial Production Index between 1920 and 1930, index 2007=100, seasonally adjusted (Federal Reserve Economic Data: http://research.stlouisfed.org/fred2/)

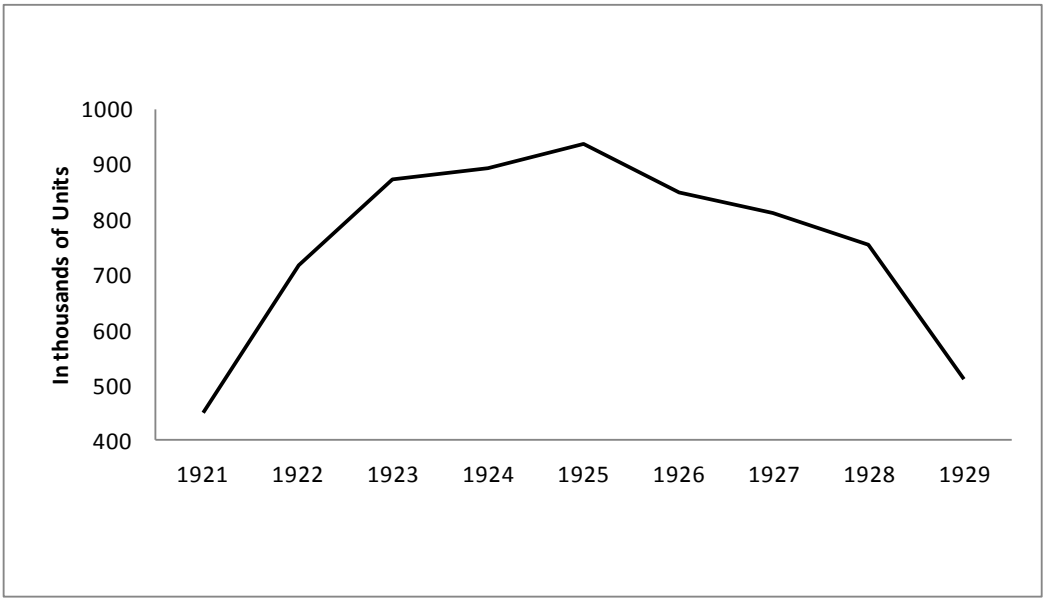


Annex 1.3. The evolution of the United States of America Real *per capita* Consumption between 1920 and 1929, annual data, in 2005 dollars (Shiller homepage: http://www.econ.yale.edu/~shiller)

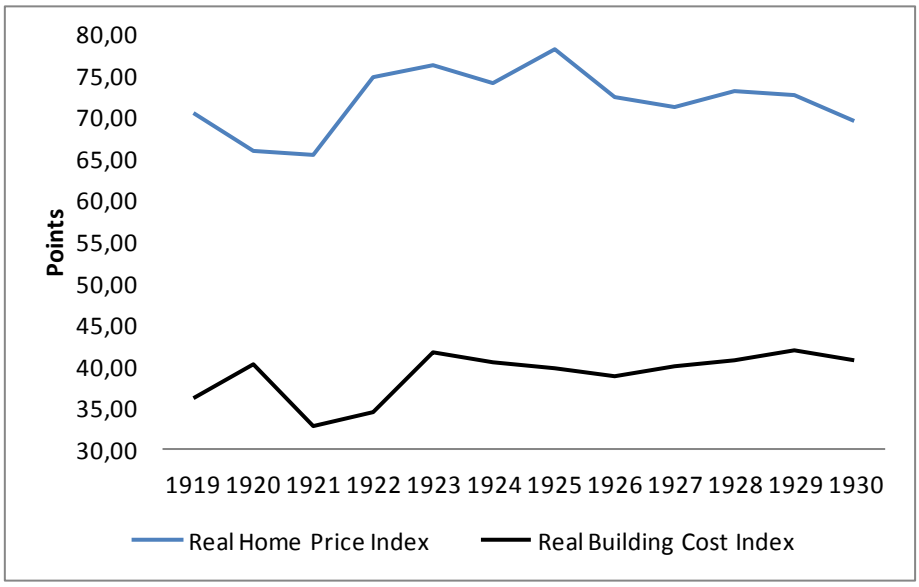


Annex 1.4. USA Consumer Price Index between 1918 and 1924, index 1987=100 (Shiller homepage: http://www.econ.yale.edu/~shiller)

2.

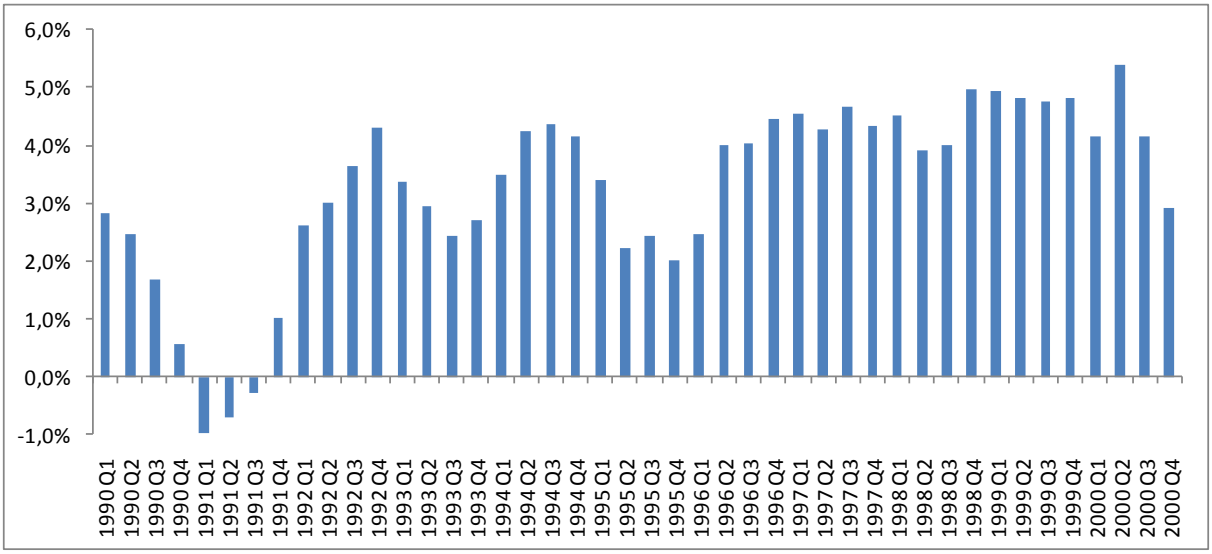


Annex 2.1. Number of housing starts on USA between 1921 and 1929, 10^3 scale (Shiller homepage: http://www.econ.yale.edu/~shiller)

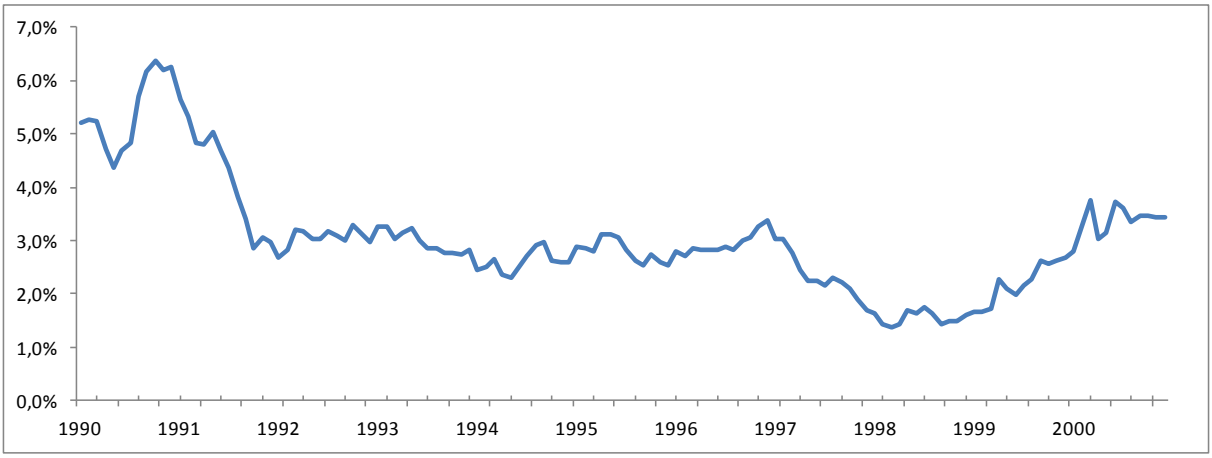


Annex 2.2. Real Home Price Index and Real Building Cost Index between 1919 and 1930 on USA, index 1987=100 (Shiller homepage: http://www.econ.yale.edu/~shiller)

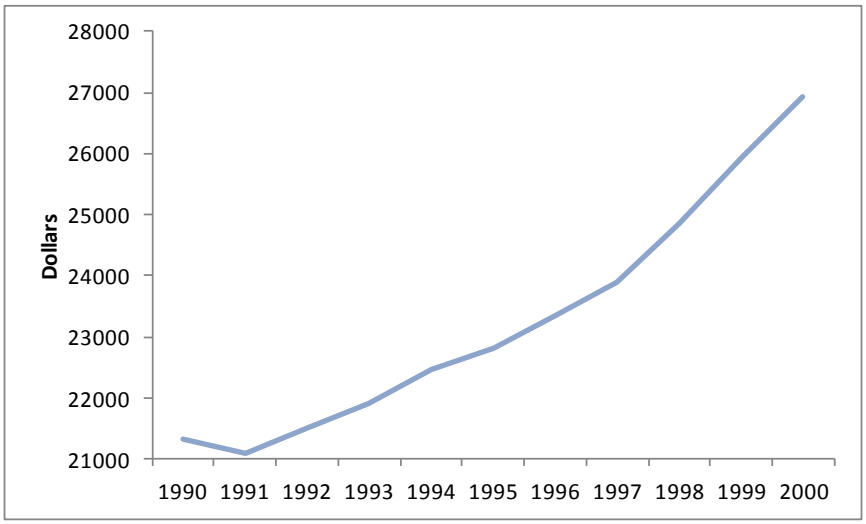
3.



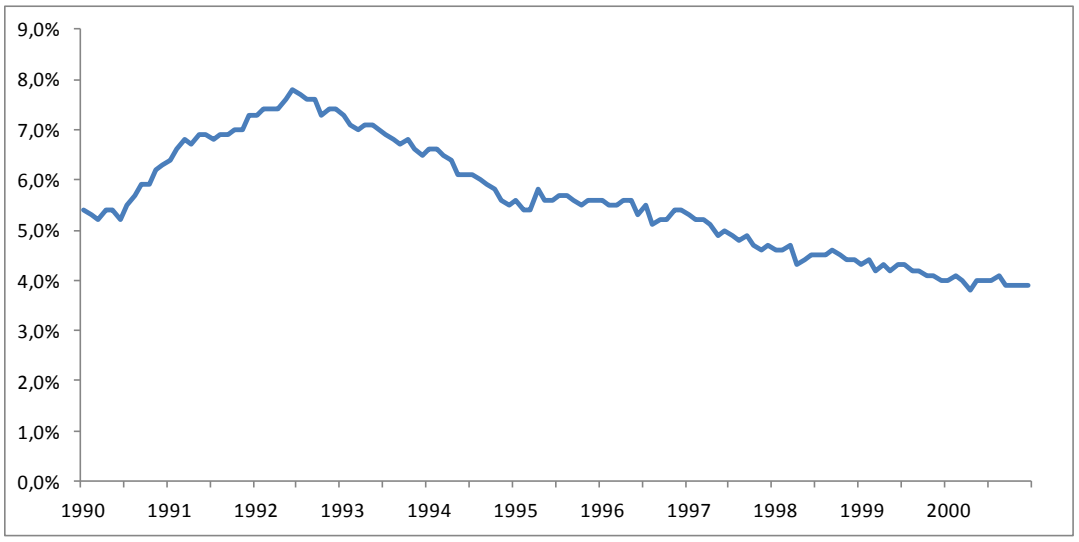
Annex 3.1. Real USA Gross Domestic Product between 1990 and 2000, quarterly data, % change from the homologous period, seasonally adjusted (Federal Reserve Economic Data: http://research.stlouisfed.org/fred2/)



Annex 3.2. USA Inflation Rate between 1990 and 2000, monthly data, seasonally adjusted (Federal Reserve Economic Data: http://research.stlouisfed.org/fred2/)



Annex 3.3. The evolution of the United States of America Real *per capita* Consumption between 1990 and 2000, annual data, in 2005 dollars (Shiller homepage: http://www.econ.yale.edu/~shiller)



Annex 3.4. USA Unemployment Rate between 1990 and 2000, monthly data, seasonally adjusted (Federal Reserve Economic Data: http://research.stlouisfed.org/fred2/)