A MATHEMATICAL MODEL FOR
FINANCIAL INNOVATION:
EMPIRICAL EVIDENCE FROM
FINANCIAL MARKETS

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A thesis submitted for the degree of
Doctor of Philosophy

Patras, May 2011
This thesis is dedicated to my family...
Acknowledgments

I feel deeply indebted to my supervisor professor, Costas Siriopoulos for his continuous support, encouragement, suggestions, discussions guidance and criticism throughout the undertaking of this thesis.

I am also grateful to professors George Androulakis and Thanasis Yannacopoulos who acted as advisors to this thesis, for the valuable input they provided.

I would like to notice the great support and advices I receive from professors D. Asteriou, I. Giannikos, Pilbeam K. and G. Pavlidis during the past four years that contribute a lot for this thesis.

Finally, I am deeply grateful to my parents and my sister for their faith, understanding and their endless support.
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**Abstract**

Financial innovation is an important research topic in modern economics. Financial innovation is an ongoing process where new financial products, services and procedures are created and it concerns important financial factors such as the regulatory restrictions, the relationship between financial innovation and the functionality of financial markets, the inefficiency of markets promoted by globalization and unexpected changes of economic status and financial intermediary.

The previous literature that deals with financial innovation is relatively constrained compared to the significance of the issue, which is a surprise considering the relative abundance of such research on other sectors of finance and economics.

The consequences of financial innovations concern the functional framework of capital markets, the microeconomic and the macroeconomic functional frameworks.

This thesis studies the influence of diffusion of financial innovation to market participants’ frictions and their values, through a theoretical, mathematical and empirical framework. We derive a novel measure of the influence of financial innovation to the market participants based on their correlation friction patterns. The main objective is to highlight a number of aspects and dimensions of this field.

In particularly, we aim to present: i) the theoretical framework on the role of financial innovation at the financial structure (the fundamental generating root causes and the effects on the function of financial markets, etc), and ii) the parameterization of the influence of financial innovation to market participants through a mathematical and econometric framework based on the participants’ minimum need for change, the diffusion rate and time parameter.

We undertake an extensive empirical analysis about the influence of introduction and diffusion of a financial innovation to market participants. The findings lead us to the conclusion that the parametric function, which is followed in order to show the influence of diffusion of financial innovation, has a statistically significant impact on returns and volatility of financial and economic indices.
Σύνοψη

Οι χρηματοοικονομικές καινοτομίες αποτελούν σήμερα ένα κρίσιμο πεδίο έρευνας στο οικονομικό γήγενσα. Η χρηματοοικονομική καινοτομία είναι μια τρέχουσα διαδικασία ανάδειξης νέων χρηματοοικονομικών προϊόντων/υπηρεσιών και διαδικασιών και αφορά βασικούς τομείς του χρηματοοικονομικού συστήματος όπως τους κανονιστικούς περιορισμούς που αντιμετωπίζει μια αγορά, τη λειτουργία των χρηματοοικονομικών αγορών και τη διαχείριση κινδύνου, τις αποσυνδικήσεις μεταβολές μεταβλητών και την χρηματοοικονομική διαμεσολάβηση.

Η προηγούμενη βιβλιογραφία και εμπειρική έρευνα των τελευταίων ετών που αναφέρεται στη χρηματοοικονομική καινοτομία είναι σχετικά μικρή σε σχέση με τη σημαντικότητα του ζητήματος, κάτι που αποτελεί έκτακτη λαμβάνοντας υπόψη την σχετική αφθονία παρόμοιων μελετών για άλλους τομείς της χρηματοοικονομικής.

Οι συνέπειες των χρηματοοικονομικών καινοτομιών είναι σημαντικές και αφορούν το λειτουργικό πλαίσιο των αγορών, το μικροοικονομικό πλαίσιο λειτουργίας των επιχειρήσεων και το μακροοικονομικό πλαίσιο λειτουργίας των επιχειρήσεων και του κράτους.

Αντικείμενο της διδακτικής διατριβής είναι η επίδραση της διάχυσης μιας χρηματοοικονομικής καινοτομίας στη διαμόρφωση των χρηματοοικονομικών τριβών της αγοράς. Ο κύριος στόχος είναι να αναδείξουμε μια σειρά πτυχών και διαστάσεων αυτού του πεδίου και, κυρίως: i) το θεωρητικό πλαίσιο του ρόλου των χρηματοοικονομικών καινοτομιών στο χρηματοοικονομικό περιβάλλον (τα θεμελιώδη γενεσιονικά αίτια και τις βασικές επιπτώσεις στη λειτουργία των χρηματοοικονομικών αγορών, κτλ) και, ii) την παραμετροποίηση της επίδρασης της χρηματοοικονομικής καινοτομίας στους συμμετέχοντες της αγοράς μέσα από ένα μαθηματικό και οικονομικό πλαίσιο βασισμένο στο ελάχιστο κατώτερο όριο ανάγκης για αλλαγή, στο ποσοστό διάχυσης, στις χρηματοοικονομικές τριβές μεταξύ των συμμετεχόντων της αγοράς και, του χρόνου.

Διεξάγοντας μια εκτεταμένη εμπειρική ανάλυση για την επίδραση της εισαγωγής και διάχυσης μιας χρηματοοικονομικής καινοτομίας στους συμμετέχοντες μιας αγοράς, τα ευρήματα της παρούσας διατριβής οδηγούν στο συμπέρασμα ότι η παραμετρική απεικόνιση που ακολουθείται για να δείξει την επίδραση της διάχυσης της χρηματοοικονομικής καινοτομίας έχει μια στατιστικά σημαντική επίπτωση στις αποδόσεις και τη μεταβλητότητα χρηματοοικονομικών και οικονομικών δεικτών.
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**Introduction**

Financial innovation is an important research topic in modern economics. Markets and organizations produce various new products and services in order to satisfy the investors’ demand. Financial innovation is an ongoing process where new financial products, services and procedures are created or/and standardized products are differentiated in order to response at the continuously changing economic environment. This running process has various periods of uncertainty. Thus, the purpose of the introduction of a financial innovation to market participants is the minimization of costs and the reduction of risk exposure.

The last years were a period of substantial change in financial products/services and processes. The previous literature that deals with financial innovation is relatively constrained compared to the size and significance of the issue. This is a surprise if we consider the relative abundance of such research on other sectors of finance and economics. We observe that the patterns of financial innovations are clearly not uniformed for markets in any periods of time. Furthermore, while much effort has been devoted to understand the characteristics of adopters and the impact of financial innovation to economic welfare, we know very few about how financial innovations are initially diffused.

The analysis of financial innovation is an issue with many angles. The theoretical framework of financial innovation process concerns the following factors:  i) the regulatory restrictions,  ii) the relationship between financial innovation and the functionality of financial markets,  iii) the market inefficiency promoted by globalization and unexpected changes in economic status and,  iv) the risk management issues.

Thus, we conclude on three main categories of financial innovations:  i) innovative asset securities (new bonds, new insurance products, new methods to evaluate risk, etc),  ii) innovative financial processes for transaction, trading and payment (information systems, ATMs, plastic cards, etc),  iii) innovative strategic management for financing
new investments (cash management strategies, innovative debt management strategies, merging, etc).

The consequences of financial innovations are observed in the financial structure of the markets, in the development of evaluated and pricing techniques, in risk management, etc. These consequences concern the functional framework of capital markets (risks, etc), the microeconomic functional framework (transactions costs, asymmetric information, etc) and the macroeconomic functional framework (monetary aggregates, etc) of markets.

Besides the determination of financial innovations, an important issue is the use of the econometric models for assessing the process of the introduction of a financial innovation. There is reluctance on the information we can derive from empirical diffusion models. This occurs because there is no systematic discussion about the diffusion process of financial innovation and the advantages of their properties. Thus, empirical models are often applied in a non-theoretical ad hoc manner, without deepening the way of modeling, without regarding the reliability of parameter estimation according to their uncertainty and without regarding the nature and the valuation of financial innovation.

Therefore, there is a shift in investors’ confidence for these models and moreover, they are reserved about the introduction of financial innovations in general. The shifts in expectations can be also even more because of the shock changes of relative variables such as interest rates or changes in macroeconomic conditions. The perception of investors for financial innovations can be change in a short time period. The current methodology does not capture this shift in investors’ confidence when financial innovation are disseminate to the markets.

This thesis studies the influence of diffusion of financial innovation to market participants’ frictions, through a theoretic mathematical and empirical framework. We derive a novel measure for the influence of financial innovation to market participants based on their correlation friction patterns. The main objective is to highlight a number of aspects and dimensions of this field through a theoretic mathematical framework.

Moreover, we present: i) the theoretical framework about the role of financial innovation in financial structure (the fundamental generating root causes and the effects on the function of financial markets, etc), and ii) the parameterization of the influence of financial innovation to market participants through a mathematical and econometric
framework based on the participants’ minimum need for change, the diffusion rate, the market frictions and, time parameter.

In particular, we present a parameterized diffusion factor where its elements are density or cumulative distribution functions with minimum boundaries (generalized univariate or multivariate Pareto family distributions) and they show market participants’ frictions which are created during the introduction of financial innovation or they show the financial innovation’s diffusion rate on market participants. This diffusion factor works as an endogenous or exogenous regressor factor that can be introduced to simultaneous models which measuring market participants’ values and their asymmetric volatilities. This lead us to the conclusion that the higher market frictions (stronger correlation patterns) are, the higher is the influence of the diffusion of financial innovation to market participants.

Motivated by these findings, we undertake an extensive empirical analysis and examine the relative simultaneous effects of specific diffused financial innovations such as the euro currency, the Euribor and information flow in Euro-zone governments’ bond yields, in implied volatility index and in Euribor index.

The results show that the diffusion factor has a statistically significant effect on the market participants’ values transitorily for the diffusion time period, but not permanently. Moreover, the diffusion factor has a significant influence on the estimated model coefficients, decreasing their bias and reducing significantly the model volatility. Hence, diffusion process of financial innovations seems to be a very important issue which drives market expectations and, eventually, the actual tendency of financial sector for the diffusion time. Therefore, it is very useful to measure the impact of financial innovation during the introduction.

The thesis contributes to the literature of financial innovations analysis in several ways. First, it derives an overall approach to the important role of financial innovations for the last decades. This approach recognizes the significant influences that financial innovations brought up in the financial system and presents a critical point of view of the results. Second, the approach followed in this thesis allows the examination of the relative simultaneous effects of introducing a financial innovation to market participants and their individual activities. Finally, the thesis undertakes a new comprehensive approach for the correlation between market participants’ frictions when a financial innovation is introduced to a market.

This thesis is organized as follows:
• In Chapter 1, we derive a scope for the notions of change, innovation, the adopters’ characteristics, innovation journey and diffusion models in a generally point of view. We present the previous analysis for these notions and we link the meaning of need for innovation into finance.

• In Chapter 2, we present the notion of financial innovations and their important role to the financial and economic structure. We undertake previous literature and we explain the significant importance of financial innovation in specific sectors despite the lack of empirical research, the availability of the data, etc.

• In Chapter 3, we present the most important categories of financial innovations the last twenty years, in main fields of financial and economic environment such as, derivatives, new monetary aggregates, innovative mortgages security prices, information and new financial instruments. The aim is to examine the role and the results of these financial innovations in financial markets within a critic point of view.

• In Chapter 4, we build a mathematical framework in order to model the influence of diffusion of financial innovation under specific assumptions. We use parametric distributions to capture the influence of diffusion of a financial innovation by market participants according to their correlation patterns (frictions). Finally, based on this framework, we build a diffusion influence factor among market participants.

• In Chapter 5, we apply the theoretic mathematical analysis in empirical implementations using data from various markets in order to study the diffusion, the impact and the results of financial innovations into market participants. We examine the relative simultaneous effects of specific diffused financial innovations such as the euro currency, Euribor and information flow on market participants such as the Euro-zone governments bond yields, implied volatility index, or Euribor future index. Thus, we introduce the diffusion factor in simultaneous mean and variance equations model in order to measure the diffusion of financial innovation on the variables of interest during diffusion time. The results show that our approach stands with a statistical significance about the influence of financial innovation in market participants, for the diffusion time period.

• Chapter 6 concludes the thesis and offers a summary and suggestions for further research. Finally, the references and the appendix follow.
1.1. Introduction

*Change* and *innovation* are basic elements of the business status quo. They are commonly considered phenomena of the present day even if in reality enterprises were always concerned about them. What has changed nowadays is their intensity. Moreover, change and innovation are not phenomena that preoccupy enterprises occasionally. In the contrary, they constitute the everyday elements of a company's status quo with different levels of importance like small changes or business practices or/and foundational changes and innovations that transform significantly the roles and responsibilities of people, the creation and development of groups, the formation of new products, processes, of new managerial models etc.

Enterprises are “born”, they develop, they mature and they “die” in the context of a *development process*. The patterns of reasoning that describe this process are two. According to the first one, change is understood as a process of precise *deterministic causation*. The second one is more realistic and complex because of its dynamics. The development process is influenced also by random events that can suddenly change the ex ante development course of an enterprise. What can change is either the firm’s historical context, or the broader generative factors that define in the whole the direction of its development process without though (and this is the main point of difference from the first one) pre-determining what will finally happen. So, change moves and develops in accordance with many particular components for each company and so the outcome of the development process of change cannot be pre-determined.

The overall consideration of development change should include the possibility of continuous and discontinuous change, unpredictability, in terms of unexpected factors (e.g., the entry of a new competitor in the market, a technological innovation), the impact of the reference point for every firm and that of general generative factors (e.g., broader macroeconomic forces that can't be controlled by the company). In the light of the above said, change is a dynamic process presented as a sequence of facts, that a company either influences actively by setting its own course, or is influenced when it is

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1 We are referring to the crucial concept of path dependency: the current situation of a company can be understood only if we take into account the conditions under which antecedent events occurred.
passively following or gets carried away by the current that the above interactive factors create.

During this dynamic process, the company is moving towards a specific direction defined by different events. This movement is necessary for its development that follows a precise development change plan. Nevertheless, future events and its interaction with other factors could change the direction of its development. The process of development change is a complex phenomenon that is not linear. The sum of forces that influence the development, their correlations, their exact order and grade of influence must be taken into consideration.

1.2. Change

The notion of change can be defined as the alterations in the form, the size, the product, the quality or generally in the situation of a company either of its different units, or as a whole, or in combination with other companies and organisations (networks, strategic coalitions etc.). It is obvious that according to the definition, change can be expressed in quantitative measurements. The estimation of the difference between two or more chronically distinct quantitative measurements or that of a number of dimensions shows if a company has transformed.

A basic distinction that must be made is that between the content and the process of change, that is to say the distinction between “what changes” and “how it changes”. The main coordinates relative to the content of change are the forces (e.g. competitive forces) and the interventions that appear within the company or that influence the final result of change. What is interesting about the process of change is the sequence of acts that shows the development of change in time. The distinction is simple as in reality the content and the process of change intermingle and the way in which each one of them alone influences the final result is not clear.

Change in the companies can occur in many different levels of analysis, including the product, the individual, the team, the company as a whole, the networks and coalitions as well as a branch of activity of the company. Because of the numerous levels of analysis and their differences, it is very important to define the level to which we refer to when we talk about the change in the characteristics or in the dimensions that we consider in order measuring the change for every given level.

Van de Ven & Poole (1995; 2004) put together a number of distinctive examples that present the combination and the level of changes:
• **Combination changes**: Changes that deal with the employees' mobility (hiring, promotions, dismissals) and the fluctuations of the resources' distribution within the units that constitute a company.

• **Structural changes**: They refer to the structural changes of the company's management, to the concentration of the decision making power, to the stereotyping of the rules within the organisation, to the control systems, to the balance/imbalance between the different units etc.

• **Functional changes**: Changes that have to do with the strategy (or the particular units' strategies), the procedures, the goals and the available products and services.

• **Limit changes**: Changes relative to purchases, merges, investments, consortia, strategic coalitions, the increase or decrease of activities, purchases, products and services in a certain territory.

• **Relation changes between the company's units**: Changes that refer to the variation of the working flow, the volume of communication, the range of cooperation and that of competition.

• **Performance changes**: Changes that show the efficiency (the level of the achievement of goals), the remuneration (the rate of optimisation of the resources for a specific outflow) and the general feeling of the members of the organisation (work satisfaction, quality of working life).

• **Environment changes**: Changes that deal with the direct environment within which the company moves like insecurity, complexity, heterogeneity, speed and volume of changes etc.

According to the above, it is clear that change effects many parts of the company's activity and thus requires, by definition, a complex and time consuming procedure, great capital, effort and at the same time, it is uncertain and risky. So, the range and volume of change varies.

A factor that could contribute to the understanding of the different types of change is the degree in which change is the result of a conscious, planned effort (*proactive*) or, in the contrary, a posteriori reaction to the environment (*reactive*). Nadler & Tushman (1989) used these elements and presented four types of change:

1. **Tuning**: A planned gradual change that aims at the improvement of the
organisation, of its functionality and profitability. However, tuning is not a reactive change in order to face a direct problem.

2. Adaptation: A gradual change reactive to external stimuli like, for instance, a new competitor, some changes in the markets’ needs new technologies etc. The company adapts each subunit in order to react to the external stimuli. Nevertheless, this reaction is not a sign of an overall effort to change.

3. Reorientation: Pre-planned dramatic change that is planned and implemented because of the forthcoming external changes, e.g. the reorientation of the greater public sector in account of the liberalisation of the market. The main elements are two: i) the company has the chance to prepare for the change, ii) the change is dramatic but an effort is made that aims at the company's continuity in time. The purpose of this type of change is to weaken the existing frame of reference, not to disintegrate it.

4. Recreation: The change of the company caused by “violent” changes and turbulences of the business environment that put in danger the existence of its actual form. It could be said that the company transforms and changes in such a way that could lead to its complete disintegration. Changes about the company's identity like for example changes in the processes and the products, changes of the company's headquarters, in the strategy, in the culture etc.

1.3. Innovation

Innovation is a change with economic or technological content. A simple definition of innovation is the following: Innovation is the embedment, the combination, the composition and the use of novel knowledge and technology for products, services and productive or administrative processes. Innovation refers to anything new, any breakthrough in the functioning and the products of a company.

For every organisation the idea of “new” reflects something different, refers to anything novel for the organisation itself and it doesn't matter if it has already been developed by others (OECD Publications, 1992). Economists use the word “innovation” in order to describe the shocks in economy (e.g. innovations in the monetary policy) as well as the reactions to these shocks.

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2 The definition in Greek enlightens the generality of its meaning: keno (new) + tomi (section) = the new section. Exactly like the Latin root of the word innovation: nova = new

It is crucial to signal the difference between *innovation* and *creativity*. Does a creative financial organisation foster innovation at the same time? On the other hand, is an organisation that creates innovation in processes or products and announces the use of creative approaches without though implementing them considered creative? The difference is important and realistic. Creativity generates new ideas and innovation puts them into practice. That is to say that by innovation we also mean their acceptance, their practical implementation and exploitation for the company's benefit.

The challenge for the financial directors is to create new ideas whenever the financial environment is in need of or demands such ideas, to canalise them within the limits of the company or to the market as innovations, taking the risk of how and if their practical implementation will lead to improved performances. In order for financial organisations to innovate they first have to overcome two obstacles that are the opposite sides of the same coin. The first one is the negative attitude towards innovations that is not uncommon as they are considered foreign and have to be declined because they oppose the traditional standards and thus they are risky. The second one is the level of versatility and persistence that is needed in order for the innovation to be accepted and applied in the market.

1.3.1. Categories of innovation based on their characteristics

An innovation can be classified in categories according to its properties and characteristics. These categories are either general or specific. This depends on the definition of the criteria that such a categorisation must satisfy. One classification of innovation, based on their characteristics and properties is the following.

At first, one can distinct innovations according to the activities that influence the innovation. In this way, we can distinct *Product Innovation* to *Process Innovation* and to *Innovation in Business Model*. *Product Innovation* identifies with the perception, the design and the introduction of a new product in the market. *Process Innovation* is of great importance for the competitiveness of a company or even of a certain unit. We come across such examples of innovation within the production process in the segments of industry and of technology. In many cases, innovation changes in the production process were beneficial in terms of the decrease in the production cost.

These two innovation categories are often interrelated in the sense that the

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4 There is a general reluctance to the trial of a new product or procedure irrelevant to how useless or useful and profitable it seems to be (Kaufman et al., 2004)
introduction of a new product in the market is feasible thanks to the innovative changes that are required during the production process that is to say to the company's physical assets. *Innovation in Business Model* is about the servitisation of the company's products that adds value to them. Servitisation is about the company's activities that refer to the conception, the inventiveness and the know-how of the market, its consumers’ needs as well as its own.

Another distinction of innovations that shows the grade of transformation is that between *Radical Innovation* and *Incremental Innovation*. *Radical Innovations* cause important and fundamental changes in the company's activities, they completely change its capabilities and transform its character but at the same time they increase uncertainty.

Shiller (2004) describes *radical innovation* as the development of new form of company or method that allows economic agents to manage *new classes of risks*. These new classes of risk could be organisational obstacles that are overcome with innovation, risks (like havocs) that influence the prices in the real estate sector, etc. *Incremental innovations* contain the sense of improvement and enhancement or even the exploitation of certain existing technologies and processes that a company has used or will use in the future. A *Radical innovation* is characterised and at the same time differs from *Incremental innovation* by four aspects: *i)* new performance standards, *ii)* improvement in respect of the performance features of “conventional” technology, *iii)* cost decrease, *iv)* change in the competition plan.

Another distinction of innovation is that between *Technical Innovation* and *Administrative Innovation*, in other words between the internal structure of the company and the technology it uses. *Technical innovation* refers to the technology used in order to create innovation and represents the production activities of a company. *Administrative innovation* refers to changes in the organisational structure, the administrative functions and the human resources of the company.

Finally, a further distinction from the point of view of the internal functionality and behaviour of the company is the following:

1. *Continuous Process Innovation*: The institution defines innovation as the ability and behaviour with a continuous change in the processes, new products and services.

2. *Discontinuous Innovation*: It refers to the case when the use existing services generate new innovative processes. This case of innovation has to do less with
the creation of new processes and more with their redefinition, in order to achieve something previously inconceivable. It is called discontinuous because of its nature as instead of a continuous and predictable procedure of gradual progress, it is characterised by unexpected leaps.

3. **Co-operational Innovation between organisations**: In this case we are talking about the deliberate business orientation towards other economic entities. It includes co-operations with other organisations, with the public, with non profit organisations etc. Moreover, it includes an opening to new ideas, possibilities and changes, etc. that are foreign to the organisation. An interesting case is a potential co-operation for the conciliation of competitive interests. The essential form of such an innovation is **merging**.

4. **Strategic Innovation that targets only to the new orientation of the organisation**: It is the possibility of the organisation to foresee totally new orientations as a means to long term profit. In this case, long term changes in the potential strategies are developed in order for the organisation to adapt better, sometimes even drastically, to the constantly changing business environment, to new situations and to customers' preferences.

The following graph represents the categories of innovation based on their characteristics:

*Figure 1.1.: Categories of innovation based on their characteristics*
In view of the constant competition and that of the huge and rapid development of the present economic situation, the different kinds of innovation reveal how difficult their classification is. Every economic institution has multiple processes, products and services that it re-adapts constantly in order to keep on the right track. So, there can't be a unique way to classify innovation in categories. The alternative solution suggested by Tufano (1995) is to adopt a functional approach for their classification, that is to say that innovations are classified according to their functionality.

1.3.2. Categories of the innovations' adopters

The groups of the innovations’ *adopters* -all of which constitute a social, economic or any other system with common characteristics- are many and they differ in terms of volume, of the time of adoption, of economic level etc. According to Rogers (1995), the groups of adopters are based on standard deviations from the mean of the normal curve. The groups are:

- **Innovators:** This group consists of individuals eager to try new things and to face the consequences of failure, who realise that they incur this risk. Generally, innovators are wealthy and can rectify all mistakes. Even though they are the ones, from the social and economic scale, who are the most exposed to risk, they also benefit the most from the innovation's success. These individuals don't have many innovation options and thus there aren't many available choices for investment. According to Rogers, this group represents 2.5% of the system members.

- **Early adopters:** They are educated and wealthy at the same time. They have gained social respect and make out from the mass. Compared to the rest, early adopters usually have the advantage of being updated and that of receiving information about innovations. According to Rogers, this group is 13.5% of the system members.

- **Early Majority:** This is the group formed by individuals who don't easily take a risk and who adopt an innovation somewhere near the mean of the normal curve of the innovation's diffusion rate. Generally, these individuals adopt the innovation later on and they belong to the average population in terms of education and wealth. According to Rogers this group is 34% of the system members.
- **Late Majority**: It's the group of people that has limited income and despise risk. They wait till innovation has been vastly adopted before they accept it. According to Rogers this group is 34% of the system members.
- **Laggards**: This term is given to those who are generally suspicious about new ideas and who often adopt an innovation after it has matured. They generally have a low income, they are of low social status and they often interact with others of the same background (friends, work associates etc.). According to Rogers they are 16% of the system members.

A classification of the groups in the population of a social system is presented in the following graph:

*Figure 1.2.: Innovation adopters’ categories*

The classification of the adopters of an innovation in groups is based on the common characteristics that some individuals share, in relation to the impact they get from innovation. Nevertheless, each one of them has his own dynamic behaviour that determines especially the time of adoption needed during the acceptance stage, according to the group they belong to. This dynamic behaviour doesn't differ much from the study of the human general behaviour. Thus, in order to interpret this dynamic behaviour, we have to combine the research results of many different sciences that study human behaviour.
Personal behaviour is the main characteristic of each individual who adopts, as individuals have neither the same needs nor the same grade (speed) of adoption. The following parameters play an important role:

1. **Motives**: It's the situation that makes individuals cover their needs. Motives are classified in accordance with the *prioritisation* of the individual's needs. Many times, different motives lead to the same needs and vice versa. The behaviour of an individual is not identical to his/her motives but depends on other factors like the environment, the motivational level, the existence of emotional motives, etc.

2. **Perception**: It's the way in which every individual interprets his/her environment. Perception is not limited to the passive acceptance and assimilation of the stimuli, but includes his/her judgement about the perceived stimuli. Perception starts from the stimulus that creates a feeling and thus it is actually perceived because of knowledge or memory. Knowledge or memory or even the combination of the two assists in order for a perceived stimulus to get to the stage of evaluation. During evaluation, the individual based on both the way he/she faces and senses life and situations and according to his nature and education will react to the perceived stimulus either in a positive or in a negative way. At this point, perception will have been activated.

3. **Attitude**: It's the way that an individual faces situations and depends on time and not only. We can distinguish two kinds of attitude towards an innovation: i) the habitual attitude of a person that highly determines the way he/she perceives a specific situation and thus an innovation and, ii) his/her attitude towards some innovations that is influenced by the amount of information that he considers reliable or unreliable. Attitude depends on many factors like the environment, experience, etc.

4. **Learning**: It is defined as the process that induces change in the past behaviour or that generates a new one in reference to an innovation. Learning occurs either through imitation or memorisation or understanding or education.

Rogers' theory is competent for the formation of a group of people that absorb an innovation. It is based though on three fundamental hypotheses.

   i. **The first fundamental hypothesis** is that the acceptance of an innovation is dyadic in respect of its result. People either adopt or don't adopt an innovation.

   ii. **The second fundamental hypothesis** is that there is a static (constant) ceiling
number of possible adopters of an innovation and that is either known to the researcher or he/she is capable of estimating it with relative precision. For most innovations though, this is not the reality. In other words, the ceiling number of the potential adopters of an innovation is dynamic. In real time, the dynamics of a population would surely conduce to a more precise adjustment estimation of the diffusion process.

iii. The third fundamental hypothesis of diffusion is that only one adoption per person is allowed. In reality, there are cases in which an individual adopts many times.

1.3.3. The innovation journey

Innovation is a change with economical and technological content. The dominating theory of the way a company develops and handles an innovation within its boundaries is that of Wheelwright & Clark (1993), a theory known as the development funnel. It's a gradual process that aims at the diminution of risk and at the resolution of problems that appear during the diffusion of innovation in the market that it targets. The figurative illustration of the development funnel is the following:

*Figure 1.3.: Development funnel*
Only a small percent of innovations manage to succeed the market, so it is required a standardized of procedure which minimize costs, mistakes, uncertainty and waste of sources.

1.3.4. Innovation as a journey

When an innovation is introduced in the market, the company enters the Innovation Journey (IJ) (Van de Ven et al., 2001). It is defined as the course of an innovation that grows, develops and is materialised by economic agents that are involved in transactions within the (evolving) institutional frame. The IJ demands a fair amount of time, it presupposes resources, and it contains uncertainty and risk and doesn't involve short term improvement innovations. Instead it refers to innovations that are part of a combined effort for development and profit. The periods of an innovation journey are:

1. **Initiation period**: To begin with, the idea of an innovation is created by the exposition of the company to multiple sources of external stimuli. With the passing of time, the stimuli of a company increase in terms of quantity, of variety and of content quality. Nevertheless, freedom of circulation of information\(^5\) within the economic environment is an indispensable condition. The beginning of the IJ is the realisation of the need for change that creates opportunities for new products or processes, e.g. change of the economic condition, new technological developments etc.

2. **Development period**: Its main characteristic is the complexity and uncertainty of the IJ. The lack of previous experience (as we refer to an innovation) leads to an endeavour to manage a controllable chaos. Because innovation is an uncertain process, it is impossible to know a priori which is the best alternative solution to every problem that occur.

3. **Implementation period**: During this period the implementation of innovation starts. This means that all the attention is focused on innovation, its entry in the market, the possible production on a large scale as well as its diffusion to potential receivers. The important element of this period is that the IJ hasn't come to an end yet, as there is constant need for readjustment, an element of absolute necessity for the product's smooth adaptation either in the market or

\(^5\)The circulation of ideas is connected to change and progress. Monopoly and stability in the propagation of ideas lead to entropy.
within the company's environment.

1.4. The economic environment

An innovation that is born and spread in a market or within a company owes its creation mostly to the economic and social environment that change rapidly and constantly. What changes though and why?

The period of time that most researchers recognise as being the most crucial turning point that led to the current special characteristics of the economic and social environment is the end of the 80's with the end of the Cold War. This initially political, catalytic fact elicited dramatic changes to the existing balance of powers that was established after the end of the World War II. Nevertheless, the consequences were not only political. They deal with the social and economic dimensions of the modern world. In the economic level, the collapse of real socialism and the parallel triumph of capitalism signified a series of mutual correlated impulses with great effect on an international level: the opening of the geographic markets, the dramatic raise of the volume of competition, the deregulation of markets, the free movement of capital, etc.

Parallel to this evolution, the technological revolution has led to what is often referred as the “technological era”. With the use of technology, information circulates in such a way that the traditional spatiotemporal limitations are abolished and the catalytic influence of technology on the economic and social life is obvious.

As a consequence to the above said, economy has transcended the industrial phase. This means that the creation of the value added price in economy in an international level has started to move away from the actual industrial production and from the circulation of goods and towards the circulation of information and the provision of advanced products and services. The shift of balance in economy has inevitable consequences for the produced products and services. It seems like the “ideal” low cost with maximum profit product and service is gaining ground.

The general evolution of horizontal technology (in the sense that is widely used) in every sector of the economic activity creates new markets while others fall in decadence. Generally, it creates a wave of demand for innovation, new products and processes that constitute the keystone for the creation of value added price. A side effect of these developments is the fragmentation of developed markets. Competition pushes companies to personalise their products and services in order to cover or/and create needs. With the use of modern technology, the recognition and satisfaction of needs with
a competitive cost and speed is finally possible.

The economic environment of a country is without doubt influenced by each domestic financial policy and depends on the international monetary situation as there isn't a nation with a closed economy. All financial institutions, wealthy or not, are influenced by the domestic fiscal and financial environment and the international economic environment and indices like oil prices, inflation, the unemployment rate, etc.

Nowadays, financial institutions function within a complex business environment that is constantly changing. Its rate of change is usually higher than the rate of change in a financial institution. Thus, each institution has to spot the main changes that happen in the financial world and to adjust to them in order to survive and evolve. Even if those changes create insecurity they also create opportunities for innovation that can yield profit if an institution is prepared for them.

In any case, the economic environment of a financial institution that pushes the institution towards innovation has three levels: the Macroeconomic level, the Intermediate level and the Microeconomic level.

1.4.1. The Macroeconomic level of innovation

The Macroeconomic level of a company includes coordinates of the general environment that the company belongs to like the economic, technological, political and the regulating or legal forces. Economy is perceived as the sum of related mechanisms within which are companies, universities and public research institutions as well as other supporting organisations that deal with the funding of companies and of innovations, the technical education -just to mention some- or that provide services for the support and transfer of technology The main characteristics of the Macroeconomic level are:

- **Complexity**, composition and the distribution of the economic institutions as well as the speed in which the economic environment changes. Another basic element is the mobility of the labour force and that of information. Mobility happens because of different reasons such as unemployment or in order to decrease costs etc., and affects the production of goods and services. The analysis of the flow of knowledge and information within the system is of crucial importance. An example is the communication and circulation of knowledge between Public Research Organisations and companies (e.g. information about technology, about the needs of the market etc.).
• The technological environment that changes rapidly as new products and services with advanced technology appear in the market. Not only is the production of new technologies a basic element but also the specialisation of the labour force in the new technologies is crucial. If not, technological development and specialisation would be out of balance.

• The regulation environment that is expressed through laws, presidential decrees and ministerial decisions. Thus, each government regulates the economic life (and not only) of a country. Regulations change constantly. Laws that affect the activity of companies are set for different reasons like to influence consumption, to protect consumers, to ban the production of some products or services of the private sector or to direct investments abroad. Factors like the fiscal frame, political encouragements of competition, the opening of the domestic market to international competition etc. create prospects for development and innovation. More specifically, policies that enforce the circulation of products, services and ideas between countries result to the increase of the competition pressure, in a national level, and to the quest for innovative practices, in the international market. The national regulation along with the European one makes the regulation environment difficult to comprehend.

• The state/nation is another factor that defines the national infrastructure and deals with broader issues that outline horizontal economy. Some of these issues are investments and the government support and funding of research, policies that deal with the capital tax on companies, availability of venture capital fund, and exposure to international competition, attraction of investments and domestic demand for innovation etc.

1.4.2. The Intermediate level of innovation

The Intermediate level examines the interrelations of companies with common characteristics. It's about company clusters that deal with similar or complementary activities or that congregates geographically. The term cluster is defined as the group of companies in close territorial proximity to one another that have similar activities, while they are interconnected with specific common or complementary characteristics.

Clusters attract a lot of attention because they show intense spillover effects of knowledge, experience and information that intensify innovativity and competition
between the members of the cluster. Indispensable factors that affect innovativity in a cluster are: i) the availability and quality of necessary inputs, ii) healthy competition between the companies and, iii) the right stimuli and support from the domestic market.

Inputs include human capital, an affective system of transfer and exchange of knowledge and financial capitals. Competitiveness deals with the rules, the motives, the pressure that is put on companies and that push them towards innovation. The intense domestic competition and the pressure put by important international competitors force companies to use innovation in order to become more competitive. Finally, innovativity will increase if the domestic demand motivates the cluster or each company separately with the right stimuli to constantly improve in order to cover the continually changing needs of the market.

1.4.3. The Microeconomic level of innovation

The Microeconomic level is described by the company’s special characteristics and its ability to innovate. The components of the Microeconomic level are in direct relation to the company and for this reason it has great control over them.

The direct business environment that is at the company's disposal is used for the attainment of its goals. This environment is the company's workforce, the technical and material structure that is composed by its equipment and facilities, its technological level and the funding that comes either from its capital stock or from loan capitals, in order to reach its goals.

Funding either consists of the company's resources (assets) or derives from organisations that invest on high risk innovations and expect high yield. Funding is the main financial source. The State could also play an important role by activating mechanisms such as the government guarantee, controls etc. Finally, the company's effective technical knowledge about crucial activities increases value added and its potential to innovate.

A company experiences innovation through its own direct level of reference that is activated by some mechanisms. The change the company experience is expressed through consecutive innovation processes until it completes its “life course” that is to say until the product “dies” or becomes standardised. Life courses start with a innovative boost, while the core idea of innovation is progressively gaining ground. During the initial phase, the criteria of measurement and evaluation of the innovation's utility are imprecise and incomprehensible. The market along with its participants and
the consumers will form the diffusion, acceptance and evaluation processes of the innovation.

Afterwards, the market begins to take shape, while the basic form of the innovative product is becoming known and is often standardised. In the mean while profit margins start to narrow. When the innovation matures, the difference between the competitors becomes less obvious and the need to lower the prices is inevitable. In this way, after all the attempts for improvement, innovation is meant to die and the product becomes a standardised one, if it is not withdrawn from the market as unprofitable.

The most “interesting” variable of this process is the variable of time. Even if every life circle has the same general characteristics, the speed in which each one of them progresses varies. Speed, in this case, can be seen in two different ways. On the one hand it's the speed of a company that innovates and on the other the speed with which the market absorbs the innovation.

In the first case, we are referring to the rate of change and of introduction of innovations in a company (introduction rate of new products, changes in the strategies etc.). In the second case, we are referring to the speed with which innovation gets absorbed by the market. Since markets have high speed change rates, because of the forces that act upon the macroeconomic level, what lie behind the absorbing rate is the intense worldwide competition and the demand for high quality in a competitive price.

1.5. The diffusion – Diffusion models of innovations

Diffusion is the process during which an innovation is accepted from the members of a target market (Rogers, 1995). Diffusion rate is the speed in which the innovation spreads from one adopter to the next potential one. A high diffusion rate means faster spreading and so better performance of the in view investments in innovation.

Diffusion Models are the models that were developed in order to show the level of diffusion of an innovation in accordance with a given group of expected adopters of a system, who share the same characteristics, expressed in a simple mathematical equation that shows the time that has passed since the innovation's introduction. The aim of a diffusion model is to describe the augmentation of the number of the members of a system that absorb in function with time. Thus, a diffusion model is a repetitive process that shows the theoretical explanation of the dynamic expression of the
diffusion process in terms of some specific, elementary and general characteristics.

Information about the characteristics of these models could be doubtful. This happens because there isn’t a systematic debate about the advantages of their properties. Thus, diffusion models are often applied ad hoc, without a theoretical basis and they lack in depth and process of reasoning. This is the present general situation. Despite vast literature, the diffusion of research results seems to be problematic. Consequently, just a few researchers have based their research on previous results and information, except if they have been working on the subject of diffusion of innovation for their own benefit.

The most widespread model is the Bass model. Several researchers have suggested different extensions of the Bass Model (1969), like the estimation of the parameter of the market's size with the use of external information, the estimation of the model's parameters with techniques of maximum likelihood or non-linear estimation processes, etc. Nevertheless, its first version is still in use today. Of course, recent researchers have taken into consideration the model's restrictions. In Appendix (Table 1) we present a survey of innovation diffusion models (Meade & Islam, 2006).

1.5.1. The Bass Model

Let’s assume that an innovation is available in one market with \( m \) consumers. If \( N(t) \) is the number of the members of a society that have already adopted the innovation and \( F(t) = N(t)/m \) is the cumulative number of the consumers that have already consumed divided by the total of the potential consumers. The number of the rest of the potential consumers will be \( [m - N(t)] \). We define \( dN(t)/dt \) the diffusion rate of the product in the market in time \( t \), \( p \) the coefficient of innovation (external influence) and \( q \) the coefficient of imitation. Bass (1969) suggested the model:

\[
\frac{dN(t)}{dt} = \left[ p + q \frac{N(t)}{m} \right] [m - N(t)]
\]

The above equation has been proved adaptable to many markets and products.

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6 Most Diffusion Models originate from different scientific areas like epidemiology, the process of life and death in populations, etc.

7 Bass F., 1969, "A new product growth model for consumer durables", Management Science, 15(5), pp:215–227. The Bass Model is the most known model of empirical research. The publicity of the Model in 1969 by Bass in Management Science has been the most cited in all science periodicals, until now, compared to any other research that has been published about the same subject.
The first part of the equation \( p \left[ m - N(t) \right] \) expresses the number of consumers who haven't been influenced by previous consumers (the innovators) and the second part \( \left[ q \frac{N(t)}{m} \right] \) expresses the consumers who have been influenced by others (the imitators). The mathematical solution of Bass model is the following:

\[
N(t) = mF(t) = \frac{m \left( \frac{p+q}{p} \right)^2 \exp \left( - \left( p + q \right) t \right)}{ \left[ 1 + \frac{q}{p} \exp \left( - \left( p + q \right) t \right) \right]^2 }
\]

By estimating the 1st derivation of the relation, we can estimate the time during which the rate of sales will be the maximum. The result is:

\[
t_{\text{max}} = \ln \left( \frac{q}{p} \right) \div \left( q + p \right)
\]

1.5.2. Flexible – Dynamic Diffusion Models

In virtue of the lack of flexibility of the fundamental diffusion model, there have been several attempts to develop flexible diffusion models based on two properties: the inflection point and symmetry. The most popular ones (Floyd Model, Sharif-Kabir Model, Jeuland Model, the NSRL Models, the NUI Models) are described in Table 2 along with their mathematical properties of the inflection point and of symmetry.

Flexible diffusion models allow the diffusion curve to be either symmetrical or non-symmetrical, and the inflection point changes according to the diffusion graph. As a result of their flexible nature, there is the possibility to classify the diffusion graphs as the diffusion curves reflect the properties of innovation. Despite their flexibility, when it comes to the construction of diffusion graphs, flexible models are also characterised by the restrictions imposed by the fundamental diffusion models.

In the case of dynamic diffusion models, the ceiling of potential adopters of an innovation is not constant. Thus, the diffusion process is dynamic and the estimations of the parameters of a diffusion model differ. For this reason dynamic diffusion models were introduced. Mahajan & Peterson (1978) suggested that a dynamic diffusion model,

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8 See Appendix, Chapter 1st, Table 2.
where the ceiling of potential adopters of an innovation $\bar{N}$, changes as time passes. More precisely, initially they suggested that $\bar{N}$ is a function of time:

$$\bar{N}(t) = f(S(t))$$

Where $S(t)$ is a vector with endogenous and exogenous variables that influences $\bar{N}$. Thus, if $f(S(t))$ can replace $\bar{N}$ in the equation of a diffusion model, like the Bass model, the result of a dynamic model will be:

$$\frac{dN(t)}{dt} = [a + bN(t)][f(S(t)) - N(t)]$$

Examples of this kind of variables that contain the socio-economic terms of a social system increase or decrease because of governmental actions, of efforts to influence the diffusion process (like advertisement), etc.

Mahajan & Peterson applied the dynamic diffusion model in the research about the diffusion of membership of the United Nations during the period 1945-1974. Because the number of countries in the word almost doubled up during this period the ceiling number of the countries that could potentially become members of the United Nations (the adopters) wasn't for sure static. Even if various variables (e.g. geopolitical) could influence the adoption, only the number of countries that exist each year, during the research period, was considered in order to define $\bar{N}$. Other similar flexible dynamic diffusion models have been developed by Chow (1967), Lackman (1978), Dodson & Muller (1978) as well as Sharif & Ramanathan (1981).

1.6. Condition for innovation

The quest for profit forces companies, households and economic agents to look for new or improved products, services, processes and forms or structures of companies that will decrease their production costs, will satisfy, in a great range, their customers' demand and will bring higher profits. Sometimes this quest is made through official Research & Development (R&D) programs or sectors of a company. Other times, it is a hazardous result of control processes or of the trial and mistake method.

Relative literature has aimed at the revelation of the conditions that encourage

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9 Appendix, Chapter 1, Table 3
important (or less important) trials to innovate and has focused on the five conditions that relate to innovation (Frame & White, 2009):

1. **Market power**: this factor is necessary in order for companies to bear fruit from an innovation. This happens because of: *i*) the free deliberation that relates to new ideas, *ii*) difficulties in the funding of risky investments in Research and Development (R&D) for the creation of a successful innovation.

2. **Enterprise size**: the bigger the size of a company the more the sales of a product that incorporates an innovation and thus, the higher the yield of the investment in innovation. A bigger size allows a company to adapt economies of scale for the R&D department which is needed to produce innovations for expanding in a broader field of activities and products receiving more innovation stimuli.

3. **Technological opportunities**: Technologies play a “double role”. They contribute subsidiary to the development of new innovations and at the same time, technologies are innovations that have a chain reaction as they further innovation.

4. **Appropriability**: information is a unique product that in the case of innovation is protected. In this way, the investor in innovation is protected as copying would deprive him of the prospective expectations and profit. Moreover, adequacy refers to the adaptation of innovation to the market's needs. These needs are dynamic, in the sense that if an innovation that is created to meet a market's need isn't launched on time, this need might cease to be and thus the innovation will be useless and the production costs will be huge.

5. **Product market demand conditions**: the size and the development of the market characterise and form the product, services and process demand conditions. Large markets have more efficient outcomes in successful innovation trials while an emerging market will likely attract more innovations and thus create more profits. Some other characteristics of a market could be the product price fluidity, the alterations in demand, the macroeconomic elements, the fiscal policy and regulations, etc.

It has to be mentioned that the above conditions are hypotheses. Scherer (1986) suggests that small or mid-sized companies of mediocre dynamics are probably fast innovators because of the competition pressure of the market, a pressure that is absent from the serene world of monopoly. If quest and success were constant, interrelated
phenomena then innovations would appear with a constant flow. Thus, flows of
innovation are not homogeneous in all companies and for every period of time (Cohen,
1995).

1.7. Conclusion

We've mentioned before that innovation takes multiple forms and has multiple
kinds of adopters (sometimes it's product or service innovation, etc. and some other
times it is introduced by markets, companies of any kind, industries, etc). Change and
innovation are the motive and the vehicle for organizations to lead themselves to the
future. During the last decade financial innovations seem to be very interesting.

There is a tight relation between innovation in a broader sense and financial
innovation. Innovation is a new product/service/process/company that includes the
sense of financial innovation that refers to a product/service/process/company in the
financial sector itself. However, all innovations of all kinds aim to make profit. Products
that are not directly financial become investments in order to be profitable. Such
products are, for instance, the new products (DVD players, barcodes, etc.), the new
processes (online systems for the purchase of products, improved production versions,
 chips, etc.) and the new forms of companies and organisations (MIS systems\textsuperscript{10},
etc.).

Innovation is around us, our credit cards in our wallets, the new financial reports
are published in the newspapers and ATMs where probably most of our cash is
distributed are in our everyday life. It's obvious that a specialised debate about the
foundation of financial innovation is necessary and useful (taking into account how
meaningful it is) as international publishing is relatively small (Frame & White, 2004).

\textsuperscript{10} A management information system (MIS) is a system or process that provides information needed to manage
organizations effectively. Management information systems are regarded to be a subset of the overall internal controls
procedures in a business, which cover the application of people, documents, technologies, and procedures used by
management accountants to solve business problems such as costing a product, service or a business-wide strategy.
Management information systems are distinct from regular information systems in that they are used to analyse other
information systems applied in operational activities in the organization. Academically, the term is commonly used to
refer to the group of information management methods tied to the automation or support of human decision making,
e.g. Decision Support Systems, Expert Systems, and Executive information systems.
CHAPTER 2
FINANCIAL INNOVATION (F.I.) – PREVIOUS LITERATURE

In the present economic reality, there is a broad range of different financial products, services processes and types of financial institutions. The last thirty years, the process of Financial Innovation is the main reason why a series of important changes and modifications happened to the financial instruments, to the financial structure and to company and financial institution practices.

The main reason for the development of the bank systems, especially in the U.S. and in Europe, is the creation, the emergence and the diffusion of financial innovations. The last few years, this process of financial innovation has been dynamically developed and has benefited from the simultaneous technological evolution. This led to the creation of new status quo in the international scenery, because of the modification or/and the re-planning of standardised products, ideas, instruments and processes.

2.1. Introduction

The basic function of the financial market is to facilitate and to expand the distribution of resources, in space and time, towards an uncertain environment and to channel society's savings towards the most prosperous investment opportunities with a counterbalancing risk. The financial system consists of the capital and money market and the stock exchange. Capital markets cover the spectrum of currency demand, income, equity markets, and derivatives markets and include all financial intermediaries like investment and commercial banks that constantly offer adaptable products and services. Capital and money markets allow money flow and give the opportunities for investment with some risk for the investors. They are the source of information that helps different sectors of the financial activity take centralised or decentralised decisions.

Developed economies differentiate between low-risk investors in the real economy and venture capitalists that are responsible for the financial risks of the investment. Thus, this differentiation between real and paper economy is due to the comparative advantage of the financial activities. The main characteristic of finance is time as uncertainty that generates risk, deals with the future. For investors that despise risk, these risks represent costs.

Financial institutions are a group of complex and dynamic relations and
correlations, internal (when it’s between them) or external (when they deal with the broader economic environment). Thus, the way they react in the markets doesn't simply reflect their own preferences. Preferences that are formed beget the need for new financial products.

The multiple different and complex characteristics of the financial system and of its participants render the introduction of new financial innovations necessary and constantly opportune.

2.2. Financial innovation

Financial Innovation is the process of creation, diffusion, analysis and pricing of the new financial products, services, technical functions and institution forms that are demanded. The analysis of a new financial innovation aims to mark its multidimensionality, to describe the reasons why the need to be introduced in the market is constantly increasing and to evaluate the economic repercussions of this activity.\(^\text{11}\)

The variety of financial innovations evinces the difficulty in their classification. We can classify them according to one characteristic. Such a classification, though, wouldn't be representative because: \(i\) each category wouldn't cover all the characteristics of an innovation and, \(ii\) most financial innovations could fall under more than one category. Therefore, the alternative classification adopted by most researchers\(^\text{12}\) has the functional approach. Frame & White (2004) classify financial innovation in the following categories: \(i\) new products and services, \(ii\) new procedures and, \(iii\) new forms of companies.

If the economic world functioned in “perfect markets” and markets were efficient with no information asymmetries, no risk, etc., financial innovations wouldn't be expedient but simple neutral changes. Various imperfections of the financial system urge financial institutions to discover and develop effective financial innovations for a more suitable adaptation to the economic environment. Thus, financial innovations are the utmost answers to different problems or changes that avert danger and help financial institutions maximise their profit.

Why is it though that we have so many new products? The common answer would be that markets are non-effective and thus financial innovations concur to the markets' effectiveness. This debate may reach an impasse. It is easy to say that markets

\(^{11}\) Tufano, 2003; Frame & White, 2004

\(^{12}\) Merton, 1992; Crane et al., 1995; Finnerty, 1988, 1992 & 2001
are not completely effective so the pricing of any financial innovation, from a tautological point of view, is not a problem. Thus, we have to look for the functions that financial innovations serve. Moreover, theoretical models and empirical studies are necessary in order to support the need and functionality of financial innovations.

The main changes that stimulate the appearance, development and function of financial innovations are the following\textsuperscript{13}.

2.2.1. Regulation and Taxes

Financial innovation could be an answer to taxation and regulatory constraints. If we think of taxes and regulations as imperfections, then higher taxation and the need to get around constraints will increase the flow of innovations\textsuperscript{14}.

Every country's fiscal policy intends to the conditioning of different income pro rata tax rates (individual household or business incomes, shares, capital gain, etc.). If a country doesn't change its fiscal policy for a certain time, the resulting equilibrium won't motivate innovation. When governments alter the existing fiscal structure, financial innovations are created in order to overcome difficulties created by the new fiscal framework. Hence, a new internal fiscal equilibrium is achieved and thus new innovation opportunities are presented. Change in the fiscal structure motivates and defines a “successful” innovation\textsuperscript{15}.

The second factor that inspires financial innovation is changes in the markets' regulatory framework. When constraints relax, market participants introduce new investment strategies, unattainable in the past when it came to profit or/and to the probable decrease of risk. On the other hand, when constraints are imposed or the existing ones become stricter, financial innovations that will be created will tend to be defensive mechanisms that aim to restore profitability or to decrease risk. They are activated because of the cost's increase that is the result of the adherence to a certain constraint. Thus, it is impossible to define \textit{a priori} a clearly positive or negative relation between the regulatory framework and the financial innovation.

The last few years, a deregulation is noticed in the financial markets. Because of this deregulation, a clear differentiation between financial institutions, commercial banks, saving and loan associations aren’t feasible. With the extension of deregulation

\textsuperscript{13} Campbell, 1988; Merton, 1992; Tufano, 2003

\textsuperscript{14} Santangelo & Tufano, 1997; Kollbrenner, 1995; Warren, 1993; Knoll, 1997 & 2001

\textsuperscript{15} Gergen & Schmitz, 1997
Academic discussion\textsuperscript{16} about the regulatory environment is intense and a fundamental question is still posed: if the regulatory environment is prolific and if it motivates or prevents the development of financial innovation.

\subsection*{2.2.2. Incomplete markets, Transaction and Marketing Costs}

A financial innovation has to satisfy the investors' demand for: market completion, capital concentration and circulation, conclusions about investment decisions and about opportunity extensions of the distribution and exchange of risk, risk counterbalance and capital transfer -in space and time- towards non effective markets\textsuperscript{17} where the involved market participants can neither transfer capital nor reduce or/and handle risk. Besides, financial models of innovation that are used as instruments should vaguely help sustain balance\textsuperscript{18}.

A financial innovation should succeed in reducing the cost of mediation and to facilitate transactions via a paying system that will reduce the involved parties' transaction and marketing costs. Many of the innovation processes of modern technology payments endeavour to minimise transaction costs. ATMs, cash cards, e-banking, etc., aim at surprisingly lower transaction costs.

Moreover, new company forms, like e-finance and e-commerce companies (OpenIPO, Ebay, B2B and B2C) or Microfinance institutes, for undeveloped countries, are innovations that intend to introduce new financial products and to reduce the costs of the involved parties, of issuers and of consumers.

\subsection*{2.2.3. Risk management, asymmetry information and agency costs}

Financial innovations are introduced in order to reduce risk, to minimize asymmetric information and agency costs. This is the \textit{feedback effect} of innovation and cost (Merton, 1992). The total cost reduction results to the narrowing of the profit margin. Thus, cost reduction covers also the cost of a new financial product.

Uncertainty in the international financial market has caused disorders but has also encouraged companies and intermediaries to innovate, by offering to their

\textsuperscript{16}White, 2000; Pouncy, 1998; Hu, 1989; Miller, 1991

\textsuperscript{17}Van Horne, 1985; Allen & Gale, 1988; Duffie & Rahi, 1995; Grinblatt & Longstaff, 2000; Ang & Cheng, 2005

\textsuperscript{18}Duffie & Jackson, 1989; Geanakoplos, 1990
customers’ new products to direct or even by advising them to take advantage of new risks (Calomiris, 2009). Through this process, financial organizations ameliorated their evaluation and the way they handle asset and investment risks, along with external risks. In this way, a financial institution handles more effectively risks (credit risk, interest rates risk, exchange risk rate, etc) with the help of financial instrument innovations. Such financial instruments were developed especially in the last few years, like foreign exchange futures, swaps and options, and other.

2.2.4. Macroeconomic conditions and globalization

Rising globalization and instability are phenomena that require the creation of financial innovations. Because of globalization, companies, investors and governments are exposed to new risks (e.g., exchange rates). Thus, financial innovations assist to the management of these risks. On the other hand, globalization gives room for more potential investors (Finnerty, 1992). Moreover, globalization allows investors to evolve horizontally and towards different groups and territories.

Macroeconomic instability can be considered the stimulus of innovation (Citanna & Schmedders, 2005). Because inflation and interests are unstable, new products are designed in order either reduce risk or protect economic agents from risk. A changing inflation and interest environment creates the demand for different types of products. Partly, a tendency for high asset negotiability is the result of interest mutability.

Changes in the level of economic activity could motivate financial innovations. During economic welfare, financial institutions are open to new ideas. Nevertheless, during economic recession the accent is on reduction of risk and liquidity. The change in economic activity affects not only the volume and the type of capitals that are needed, but also the financial institutions' attitude towards risk.

2.2.5. Underlying research and technology

The constant development of academic research and of technology is an important push for the creation of financial innovation or for their combination with different ones. A number of new forms of financial products, services and processes were created because the new assessment methods of security yields and their risk gained the trust of companies and managers. New methods for portfolio and shares management and for the assessment of secured stocks, new ways for transactions, new
means of managing risk and new evaluation techniques, facilitated evaluations and processes with the means of technological and IT innovations.

Technological progress, IT and telecommunication improvements brought and continue to cause changes in a series of products and services, prompting the realization of financial innovation ideas. Electronic capital transfers, ATMs, credit cards, prepaid cards and personal online transactions have surprisingly reduced transaction costs and have increased speed and accuracy.

2.2.6. Consequences of financial innovations

We have seen the main sectors of change that motivate financial innovation. It is also obvious that these sectors are characterized by interdependence. The degree of dependence can vary in quality and time and yet interdependence is a fact. Changes in one sector or innovation shocks induce small or big changes to other sectors. For instance, technological development brings on technological innovations that have application on the reduction of risk or to its evaluation, rendering the market more effective. We can't examine each section separately but only from a complementary point of view.

Merton (1992) analyses this phenomenon and says that changes are part of a spiral effect process. The multiplication of transactions (of new stocks or of the purchase of standardized stocks) renders possible the creation of new financial products that ameliorate the market's effectiveness in combination to technology. Thus, the transaction volume increases and investors and intermediaries trade in order to counterbalance their exposure to risk. Then, the increased volume of transactions reduces margin transaction costs and thus, new financial products, services and strategies become possible which, in their turn, increase the volume of transactions. The success of such purchases encourages investments and the creation of new additional purchases and investments. In this way, the degree of economic stability changes, macroeconomic conditions (employment, interests, etc.) alter and a constant spiral process is created.

The consequences of financial innovation are quite important. They are noticed especially in the financial structure and strategy, in the development of evaluation and management techniques of assets and of their revenue risks and in the competitive role

19 For instance a transaction that costs $1, it could cost $0.01 online (An evaluation of The Economist, May 20th 2000, “Online Finance Survey”, p:20)
of financial institutions. The consequences regard:

- **The markets' functional framework**: effective management of different stocks and their risks with the use of financial innovation instruments, the creation of financial instruments and practices of analysis of innovative products that are issued and negotiated in domestic and international financial markets, etc.

- **The companies' microeconomic functional framework**: decrease of transaction costs, dealing with asymmetrical information, effective systems of administration motives, expansion of the competition forms between financial institutions that issue national or international services, different non financial institutions (fund companies, mutual trust companies, et. al.) that have the potential to offer the required financial services and products, development of technological progresses in payment, service and information systems, effectiveness of the financial system (pricing, risk management with new complex instruments, etc), financial system stability (possibility to counterbalance risk and to access new markets and activities), change in the strategy of liquidity management, development of secondary purchases of negotiable stocks, etc.

- **The companies' and governments' macroeconomic functional framework**: financial innovations brought about changes in the modern macroeconomic analysis, in credit extension and credit quality, in the credit creation process, in monetary policy issues, in the banks' funding policy in the financial market, etc.

Consequently, within today's free financial system, the process of financial innovation broadens the forms of competition between financial institutions and the sphere of their activities.

3. Previous Literature

   During the last 35 years, important studies have been presented about the framework of financial innovation. In this section, we will present a review of the existing literature in the financial innovation, by using the framework of the survey analysis of Frame & White (2004)\(^{20}\). We created a framework of analysis of the

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\(^{20}\) Frame & White (2004; 2009f) studied the literature and with the basis of a categorization with broad criteria, they revealed the 25 most important empirical studies related to financial innovation, out of which fourteen study different phenomena while the rest are more general and refer to the same innovative products.
financial innovation literature that is based on the theoretical and empirical questions that the researchers posed, while we tried to present their limits and methodologies. The framework of the literature references about financial innovation is:

1. Studies that refer to the notion, the nature, the need and the design of financial innovations from a general point of view or that targeted a form of financial innovation.
2. The literature that refers to the empirical study of diffusion models of a financial innovation.
3. Studies that refer to the adopters' characteristics (investors, companies, consumers), of financial innovation.
4. Studies that describe the factors and the conditions of the economic environment that acts upon financial innovations.
5. Studies that refer to the results of the financial innovation and economic prosperity.
6. The literature of reviews about financial innovations of the last thirty years.

The division of the literature references is not absolute but was based on the main research question that is present in every study, without though being limited by it. For instance, some researches study new innovation products (e.g. credit cards) and some others make a combination as they present on the one hand, an innovation, from the point of view of the product, and on the other hand, its diffusion (e.g. Internet banking).

Literature references can also be divided according to the functionality of the financial innovation in two ways. On the one hand, it's the static functionality where a financial innovation is presented in a specific moment of time with a specific form and is the result of the current situation. On the other hand, it's the dynamic functionality where the financial innovation is the reflection of the economic and social changes that happen through time. In this case, a part of the financial innovation pre-existed (maybe in another form) and it just came into light in a certain moment, which proves that to some extend change could be predicted by historical information, while asymmetrical change will never be.

Thus, empirical research hypothesis can be examined on the strength of two characteristics: i) the empirical ones -the paper has data and a controlled hypothesis- and, ii) the innovative ones -the paper examines a financial innovation during the period
it was considered innovative. For instance, a study about ATMs that uses data from the 70's would be inappropriate in comparison to a study that examines data from the 90's. Using the above analysis framework, we present the relative literature about financial innovation.

2.3.1. The nature and design of financial innovations

The notion, the nature and the design of financial innovations was the study case for researchers especially during the 90's.

Wojnilower (1980) studied the nature of financial innovations under the effect of restrictive financial factors. He came to the conclusion that investors aim at the maximization of their portfolio return and not at getting around the constraints. Thus, new products must be designed with the principal of funding flexibility for the company.

Friedman et al., (1981) underlined that the aim of a financial innovation is to improve a company's ability to face risk, to reduce transaction costs and to go around administrative constraints that occur.

Silber (1975; 1978; 1981) developed a microeconomic model of a financial innovation based on the hypothesis that financial innovations are created in order to reduce the constraints imposed to companies. These constraints could be either within the company (self-appeared liquidity, etc.) or external (national regulatory infrastructure, demand and supply factors of financial products that are defined by the market, etc.). In 1983, the writer created a framework to understand the reasons why financial innovations appear. He points out the external factors that influence innovation (technology and legislative initiatives) and act within a regime of constraints but are independent to innovation. He came to the conclusion that innovations ameliorate economic welfare.

Miller (1986) says that if the secret generative mechanisms of the processes that produced new products in the previous years are understood, a basis can be formed in order to understand where we are heading to in the future. Economic cycles change the development rate of financial innovations according to the economic environment that is repetitively reformed in the future. Furthermore, Harris & Raviv (1989) examined and pointed out the important role of asymmetric information in the design of new securities and how they interact.

Allen & Gale (1991) focused on the constraints of short sales as the pricing
source for the securities' issuer. Moreover, Chen (1995) reported the intermediaries' characteristics that create new diverse securities and the fact that a financial innovation can be lucrative because it can reduce the cost of the market frictions and more precisely the short sales constraints. Pesendorfer (1995) shows that the extent to which intermediaries are involved (they convert standardized bonds to bonds adapted to their customers' needs) can be significantly limited by the process of balance of the financial innovation.

Duffie & Rahi (1995) described financial innovations and security designs for financial purchases from a theoretical and practical point of view. They concentrated basically on unprofitable purchases with possible asymmetrically informed participants. After they had referred to the relative literature about markets' balance, they created a united microeconomic framework with a Gaussian methodology that studied the impact of a financial innovation on risk sharing and on information aggregation between investors.

Ireland (1995) combined two basic ideas about the nature of financial innovation in an equilibrium monetary policy model: i) the process of a financial innovation is an endogenous factor and is considered an investing plan and, ii) the process of a financial innovation comes with an important initial cost that could complicate the relation between liquidity demand and floating interests. Thus, it is applied in econometric models of liquidity demand and tries to grasp the impacts of financial innovations by evincing that a theoretical liquidity demand model, when it is properly modified, can measure the otherwise unobserved data capacity. If the process of financial innovation includes significant but stable initial costs (because of the training that people had on the innovation or because of the market's reaction to the new security), then the decision about the innovation will be taken only if bargain costs exceed certain threshold levels.

Charupat & Prisman (1997) underlined that market frictions induce motives for the creation of financial innovations. By studying the arbitrage pricing approach, the design and the pricing of innovative bonds in markets with constraints on forward sales they noticed that the impact of the arbitrage pricing approach is uncertain and this, in turn, influences the design and the pricing of new bonds.

Other studies examine the design and sales problem of asset-backed securities that come from precise products (Boot & Thakor, 1993; DeMarzo & Duffie, 1999) or they focus on the design of financial innovations according to the investors' needs, on their pricing and on asymmetric information (Allen & Gale, 1989; Madan & Soubra,
Finally, in some cases, the financial institution is an innovator intermediary that plans profit based only on the transaction and service offer (Cuny, 1993; Hara, 1995; Ohashi, 1995).

Lately, Tadesse (2006) examined if the financial architecture of an economy is oriented towards a financial purchase or towards the banking sector and if this is an important factor for the long-term economic growth, especially for innovations and technology. The writer used data that cover a large number of countries and industries and focus on the advantages of the banking sector against purchases during the getting informed process. The results showed that financial architecture has an important impact on industrial activities on innovation and that the oriented investment design in the market has a positive impact on technological development, a fact that agrees with the theoretical approaches that want markets to have a comparative advantage in the identification and funding of new technologies.

His conclusions are important. Financial architecture is of great importance for the long term development as the choice of an appropriate architecture depends on the industrial infrastructure of a country. Moreover, from the point of view of public investment, at least in terms of its impact on innovation and technology, there doesn't seem to be a Pareto efficient of the financial architecture. Market doesn't always override banks and vice versa. Finally, taken into account a country's architecture, industries could achieve different innovation rates. Thus, financial architecture plays an important role in the formation of a country's industrial infrastructure and it partly imposes the rate of the country's technological development.

Lately, Plosser (2009) pointed out that financial innovation, led by developments and the financial and econometrics development, plays an important role in the economic thriving. However, the current crisis in the financial markets raises fundamental questions about the nature of financial innovations and their role in the decision making for the conservation of economic stability. The writer underlined these questions, focusing on the complexity of the formation of the economic risk and on decisions that target to decrease short term financial instability, market distortions and moral risk that could be the result of these policies.

2.3.2. The adopters of financial innovations and their motives

The adopters of financial innovations have various characteristics. Their main characteristic is that the users of a financial innovation don't necessarily belong to the
financial service sector and could compose the broader consumer group. The relative existing literature concentrates on two kinds of users of financial innovations: i) the users of e-banking transaction products (ATMs, debit cards, credit cards, electronic bill payment services) and, ii) the adoption of Internet banking by banks and Small Business Credit Scorings (SBCS).

Carrow (1999) and also, Bhattacharyya & Nanda (2000) studied investment bank motives to innovate, focusing on market shares. Their results showed that their motives are related to financial innovation that yields great direct profit.

Sullivan (2000) compared bank corporations that offer online transactions through their websites to those that don't have such a service, for the first trimester of 2000. His results show that the first ones have lower expenses, bigger profits and they are preferred by educated consumers of all ages.

From 1998 to 2002 four studies examined the case of Bank Holding Companies (BHC) and presented their results related to excess returns floating, to competition and to cash flow (Bhargava & Fraser, 1998; Fields & Fraser, 1999; Gande et al., 1999; Cornett et al., 2002).

Frame, Srinivasan & Woosley (2001) studied the portfolio's impact for commercial loans under $100,000 of the big bank corporations in 1997. The results show that the possibility of adoption of the diffusion process is inversely proportional to the number of the bank affiliates and proportional to the bank sectors. This shows the connection between the corporation's structure and the adoption of specific technologies.

In 2000, Mantel examined the reasons and the benefits from the use of electronic transactions and of debit cards for 1300 consumers based on their characteristics (gender, age etc.) and on the market's size. A year later, Mantel & McHugh (2001) expanded this study and examined innovation and competition of the specialised market in electronic transactions. That time, Stavins (2001) presented the consumers' characteristics that have a positive or negative impact on the adoption of electronic transaction systems.

Lang et al., (2003) analysed Internet banking data during the third trimester of 1999. By using Logit models, they found that the choice of a bank corporation to
adopt Internet banking relates to *Holding Company affiliation*\(^{21}\), to its geographical position in the cities and to high transaction costs. A large part of the services of banks that offer Internet banking is positively related to their size and to the time needed for online transactions.

Finally, Hayashi & Klee (2003) underline that the consumers pay for the services and products in different ways that depend partly on the consuming tendency that helps new technology adoption, partly on the need to use services and products and on the transaction's nature.

### 2.3.3. The conditions of the economic environment that encourage financial innovation

Research focuses basically on the changing factors and the conditions of the economic environment that influence the creation, the emergence and the diffusion of financial innovations.

Horib & Silber (1987) presented a linear programming model for a bank market that explained the course of *deposit shadow prices*\(^{22}\) between 1952 and 1970. The results showed that this kind of deposits was developed especially in 1961 and 1969 because during these years two important financial innovations emerged: *negotiable certificate of deposits and bank loan products*, respectively.

Van Horne (1984) believes that a financial innovation is possible to survive when it completes the markets: *i)* by reducing the intermediate costs of services and, *ii)* by realising an unfulfilled investors' wish for a certain type of security, that is exposed to lower unpredictable costs, making the market more effective. He highlights the changes in the economic environment that dictate the creation of financial innovations like inflection and interest instability, policy changes, and technological changes, the level of economic activity and academic research. To conclude, he believes that financial innovations will continue to thrive as long as markets become more competitive.

According to Ross (1989) demand and the supply of securities are functions of the players whose actions are limited by intermediation and policy rules. He created a microeconomic model where financial innovation appears to be the natural add of supply and demand to the players' limitations and to marketing cost.

\(^{21}\) The term refers to the organization or the portfolio company that controls corporation (a bank etc.) ether by holding the majority of shares or in another way that allows the control of the majority of the board of directors of the controlled company

\(^{22}\) The term refers to the price that is formed in the market in case of balanced economic conditions.
Merton (1992) underlines that the creation and the form of financial innovations depend on the general economic and institutional environment that shapes financial innovations and on other factors like complexity, technological availability, political decisions, economic mechanisms, etc. Given the technological development and the need for complete markets, the ground is fertile for a greater system development to face the issue of market regulation.

Lerner (2002) describes financial patenting of innovations that is to say of innovations that are patented with a certificate of innovation, between 1971 and 2000 (455 patents). He notes that the level of patents was mediocre but suddenly surged in 1998 after the State Street Decision\(^{23}\) that allowed business method patents. Lerner studied the activity of investment banks, awarded with patent certificates, and found that it is proportional to their size.

Later, Lerner (2005) expanded his initial research. He took into consideration the rareness of empirical studies and the fact that awarded financial patents were rarely used and he developed a measurement for financial innovations based on the Wall Street Journal. The analysis was similar to his previous study and focused on the institutions that relate to innovations by examining a number of hypothesis suggested in the literature\(^{24}\). His results showed that innovation generation is inversely proportional to the company's size, highlighting that small companies don't obtain their patent rights.

Finally, Citanna & Schmedders (2005) studied how the incompleteness rate and the structure changes in a financial market act upon asset price variability. They showed that asset price variability in markets that don't directly aggregate risk show zero variability and hence financial innovation that completes the market doesn't increase price variability.

2.3.4. Consequences of financial innovations on profitability and economic welfare

A big part of the literature examines the consequences of financial welfare, from the point of view of profitability, for a company or for the intermediary that introduces the financial innovation, as well as how it influences the socio-economic system that adopts it.

Sylla (1982) considers that during crisis periods of the credit system, new

\(^{23}\) http://www.law.cornell.edu/patent/comments/96_1327.htm

\(^{24}\) He followed Cardinal & Opler (1995) in Journal of Accounting and Economics
monetary policy models are introduced, forcing governments to examine the price and transaction mechanism.

Tufano (1989) gave two reasons why a company innovates. The first one is the creation of an effective monopoly in order for the new financial innovation to be sold in a higher price than its cost. The second one is to cover, with the introduction of the innovation, the bigger part of the marker. By examining a sample of fifty eight innovations between 1974 and 1986, Tufano realized that the latter reason happens more easily than the former. If the institution that promotes the innovation is an investment bank, it has the advantage of its experience and reputation among possible investors. Thus, according to Tufano, there will be a reputation about its profit and a lower cost as a result of its experience. Financial innovation advantages reduce in time, but they obviously do survive long enough to motivate investment banks to develop new products.

Varma & Chambers (1990) studied profits that relate to the announcement of OID issuing-original deep discount bonds. They found that OID announcements between March 1981 and June 1982 related to the positive response of share yields.

Flood (1992) examined two financial innovation cases: the Canadian coin futures that failed and the Market index a mutual fund that was successful. Both innovations had a common characteristic. They were both unnecessary, in the sense that their price followed the price level of other funds. The result was that having the choice between two unnecessary counterbalancing securities, investors preferred the one with lower liquidity and transaction costs. The conclusion was obvious but can't be generalised. As long as financial frictions, like transaction and liquidity costs, represent real capital channels, then successful financial innovations are the ones that in theory boost profit.

Merton (1992) posed the following question: how does a financial innovation contribute to the financial system performance, when it is strongly believed that financial innovation is nothing more than a bargain that helps to get around constraints and to ward off taxes without any social value? However, what Merton showed with the International stock return swaps is that it is possible to create a financial innovation in order to get around constrictions having nonetheless a social impact as it reduces social costs, by meeting precisely destined and socially friendly targets. He also mentioned that changes are part of a spiral process.

McConnell & Schwartz (1992) described the case of LYON (Liquid Yield
an Option Note, a zero-risk option, a callable convertible bond, that is to say a financial innovation issued in 1985 by Merrill Lynch and; Elul (1995) showed in his model that if markets are deficient enough, then welfare results, from the introduction of a new financial bond, can have arbitrary effects on the utility of economic agents.

Levine (1997) highlighted the relation between financial and economic developments as the level of financial development is an omen of economic growth, of capital accumulation and of technological change. Financial innovation hinges mainly on financial development. Levine explained the way in which the financial system acts upon economic growth and believes in a functional approach for the understanding of the role that the financial system plays in economic growth. This approach focuses on the frictions between the functions' development and their quality that originate from the financial system, especially from innovation.

Persons & Warther (1997) developed a dynamic model for the financial innovation adoption. During each period of time, the company decides whether to adopt or not an innovation of questionable value. The profit from each period's adaptation reveals information about the innovation's value. Moreover, the authors showed that social welfare is boosted, innovations are adopted by more companies and that intermediaries have a reason to motivate such adoptions.

Dow (1998) examined the yields, the liquidity and the costs that result from the introduction of an innovative bond in a cross market\textsuperscript{25} with two kinds of investors: those who are not informed about counterbalancing risk needs and those who are informed. Other factors like other share revenues, singular motives for future transactions, other innovation investors, etc. are not taken into consideration. By introducing a new security, investors that dislike risk can use the new market to counterbalance the positions they held before the new security's introduction with a liquidity shift in the market.

Generally, the availability of these counterbalancing bargains will affect the strategies with which investors channel their investments. The writer recommended the opening to new security purchases. He also considered that the general impact of the model is that a big part of the volume of transactions could be due to the consumers' counterbalancing needs -an interesting remark as there is a lack of information about the portfolio theory that explains the high transaction volume.

\textsuperscript{25} This term refers to the case in which a price offer from a stockbroker happens to be higher than the lowest price offering for the same security or vice versa.
Grinblatt & Longstaff (2000) studied the innovation of Treasury STRIPS and zero coupon bonds. They found that initially intermediaries created new STRIPS to render markets more effective, to take advantage of asymmetries in taxes and in logistics and to maintain portfolios in optimal liquidity.

Calvet et al., (2004) presented the introduction of a new financial innovation in an endogenous market with heterogeneous risks for revenues. In this case, new mechanisms are created like the diversification and the expectation to counterbalance investors' risks, price flows that are imposed by financial innovations and push towards new turnovers for the participants, etc. The introduction of new securities changes the participation share in the market, it reduces dividends' flow and in some cases it decreases risk premiums. Within multi-sector economies, financial innovations expand into markets via the choice of a differentiated portfolio and affect expected revenues.

Ang & Cheng (2005) examined if the market's effectiveness ameliorates for the securities, which are recently introduced to the Single Stock Futures Exchanges (SSF) established list. After they had determined the information related to the securities' price flows, the authors showed that the number of the unexplainable high revenues from price flows reduced for SSF companies compared to the period prior to their entrance. This reduction was proportional to the extension of the transaction activities in the SSF market. This article's contribution is important as it adds empirical data to the question if derivatives achieve a better market remuneration, while it's the first study about the SSF financial market.

DeYoung (2002; 2005) examined the case of Internet only-banks and demonstrated that their success depends on the transaction rate, the technological development and its effect on the economies of scale and on the powerful administrative organization and practice. Furthermore, Cheney & Rhine (2006) analyzed the important innovation of prepaid cards and underlined the consumers' advantages compared to the traditional bank transactions.

Later, Dynan et al., (2006) studied financial innovation as a stability factor for the economic activity. They tried to realize the effect of the financial innovation on consuming, the household investment activity and the business investment activity. Their results recommended that financial innovations contribute a great deal to the stability of the economic activity.

The Bank of England (2008) presented a macroeconomic model that included
constraints, government contracts and fixed capital externalities that are connected to the resale capacity of capitals during pressure. If a shock happens as a result of the changes during macro-economic instability and of developments in the financial markets, externalities could produce a systematic self-preserved economic crisis. The results showed that financial innovation and macroeconomic stability could render economic crisis in developed countries less possible than in the past, but with a greater higher effect.

*BIS* (2008) showed the positive influence that financial innovations have on the reduction of default rates in the short-term and underlined that the financial innovation impact on violation risk is possibly different that depends on the fixed investment opportunity and the debtor’s economic situation.

Lately, Gerardi *et al.*, (2010) developed an evaluation methodology about the impacts of the changes in the market of mortgage loans for households, based on the hypothesis that the higher the expectations of the income revenue of a household, the higher the wish to consume, ceteris paribus. They used data from the beginning of the 80’s and they showed that mortgage loan markets have become less imperfect because of securitization - that has played an important role. The above analysis is important because of the recent crisis in home loans that started in 2007. According to many, the main crisis reason is the changes in the mortgage loan market, while authentication became stricter and new mortgage products multiplied. The authors showed that the use of the secondary market and the innovative mortgage product diffusion happened much earlier (2001-2005) and fall to agree that securitization is responsible for the present crisis (not the diffusion of new mortgage products but the increase in loans) because the loan and crediting criteria loosened.

Finally, Calomiris (2009) examined the misrepresentations that gave an impetus to the latest crisis and suggested general reforms that would decrease distortion costs that relate to agency problems and credit risk. Some of the suggested reforms in the article are: the establishment of minimum capital requirement for big bank corporations, a credit rating agency, a supervisory regulation of macroeconomic numbers during calm periods in order to decrease capital requirements during recession, prevention measures for liquidity or for asset entries and for other possible macroeconomic risks.
2.3.5. The diffusion of a financial innovation

The research in this field deals with the way and the speed that a financial innovation is adapted by the market's or industry's participants or by a group of consumers it is addressed to.

Hannan & McDowell (1984; 1987) used information about ATMs adaptation by banks that they used in their previous research (Hannan & McDowell, 1984) and examined the reactions' nature of banks that face the competition impulses of the adaptation process. By using an exponential surviving model, they demonstrated that the adaptation of the competitive innovation will surely increase the decision possibility for adaptation. Moreover, the authors examined the diffusion and adaptation effect of the technological innovation as well as the interaction of the market's concentration during the presence of competition. Finally, they presented an example to show how evaluation process can be used for the control of other diffusion processes.

By using the same data, Saloner & Shepard (1995) found that the expected time for the ATMs adaptation in terms of the number of accounts and that of the accounts' forms will reduce because of network externalities.

Molyneux & Shamroukh (1996) examined the diffusion of the underwriting of junk bonds and note issuance facilities -NFIs for the periods 1978 to 1988 and 1983 to 1986, by using a diffusion model NUI. The authors found that external factors (like demand for change) play an important role in the junk bond underwriting diffusion. On the contrary, NIF underwriting diffusion seems to be motivated by current impulses. Moreover, the authors showed that if a bank adapts then products become more desired by other banks that in their turn might follow and thus adopters will increase.

Later, Gowrisankaran & Stavins (2004) examined network externalities for the automated clearing house electronic payments system (ACH) by using data from the trimester reports about adaptation and the use of ACH of each bank, and they underlined their importance in their results.

Akhavein, Frame & White (2005) studied small business credit scoring diffusion in the 90's. By using a hazard model they estimated that big bank corporations adapted this technology faster. With the use of a Tobit model, the authors first cross examined the results and then found that corporations with more business units adopt innovations

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26 It's a financial product that gives the right to a company to issue short-term securities that are underwritten by a bank.

27 With this system the participant banks execute electronic capital transfers without the use of checks.
earlier. The credit ability for small companies was also examined in the Federal Reserve Bank of Atlanta documents and more precisely by Frame et al., (2001) and also by Berger et al., (2001).

Finally, DeYoung et al., (2007) examined the impact that bank webpage and online transactions have on the effectiveness of the banks. They realised that the network adoption improved their effectiveness especially through the increased incomes that came from transaction services' costs. Their results show that banks use the Internet channel as a supplement and not as a substitute for the natural units.

2.3.6. Financial innovation survey

The great importance of financial innovation made some researcher present a survey on the existing literature about financial innovation, by introducing different criteria each time. The most important researches are mentioned below.

Finnerty (1992) created a list with more than sixty innovatory instruments, organised according to their category, the response (debit, preferred instruments, convertible financial instruments and common shares) and their reason of existence (risk distribution, liquidity rise, transaction cost decrease, tax decrease and regulatory constraints deviation).

Allen & Gale (1994) dedicated their whole research on financial innovation and embodied it in their book that has an extensive reference to the literature of researched on financial innovation. A similar survey on financial innovations is also presented by Crawford & Sen (1996).

Alcorta (1999) divided the factors that affect financial innovation diffusion into: i) macroeconomic factors (interest rate level, funding availability and product demand increase, etc.), ii) stable factors (quality, flexibility and productivity) and, iii) economic factors (labour cost, administration, etc.).

Frame & White (2004) presented an extensive reform of the financial innovation literature. The authors adopted broad criteria and found more or less twenty five empirical researches on the subject, most dated after 2000. Taking into consideration that some financial innovations are examined more than once in the studies, they showed that only fourteen single innovation phenomena are mentioned in the literature. An even more surprising fact is that only two studies analyse contemporary research hypothesis that deal with the conditions of the economic environment like regulations, taxes, market frictions, unstable macroeconomic conditions and edge technologies that
are the stimulus for financial innovation. The authors mentioned some hypotheses to explain why empirical researches on financial innovation are so few, compared to their importance, like the absence of accessible data, and suggested to financial agents to make data accessible to researchers.

Lately, Frame & White (2009) examined the technological changes and the financial innovations that the commercial banking has come across the last twenty five years. The authors examined the relative literature about different financial innovations that were defined as new products and services, as production processes and as organisational forms. They realised that the previous year formed a period of essential change for bank products, services and technologies. They also realised that even if a lot of effort is put in order to understand financial innovation consumers and their effects on the economic and social welfare, we currently know very little about how and why financial innovations are developed in the first place.

2.4. A critical point of view to the previous literature

During the last thirty years, financial innovation process has provided a wide range of innovative products, services and processes to the financial sector that broadened the participants' choices in the market and contributed to the general economic growth. The international environment is altering, competition in the financial service sector is stiffening and market participants are looking for new ways to optimise their transactions.

Literature that refers to financial innovation is relatively narrow and of limited ranges in relation to the complexity and the importance of the subject in question. By studying the literature relative to financial innovation, we realise that the last few years were a period of deep change from the point of view of products/services and processes. Moreover, while a great effort has been put to comprehend the adopters' characteristics and the effect of financial innovation on economic welfare, we don't know much about how and why innovations develop in the first place and we know even less about how they relate to one another and about the frictions between the participants/adopters and the market. On the one hand, it is important to understand the conditions that encourage financial innovation and yet, on the other hand, we notice that innovation currents and their adaptation time are not the same for all the contributing parts.

It's a shame that previous literature is characterised by the lack of empirical studies that examine the hypotheses or that provide a quantitative analysis of financial
innovations. It becomes even worse if we consider the number of similar articles in other financial sectors. This lack of information is mostly true about hypotheses that focus on the structuring terms that encourage an innovation and mainly on frictions and on the relations that are developed and influence diffusion and generally on the analysis of a financial innovation. The relatively few empirical studies focus mainly on innovation evaluation and on the adopters' characteristics and sometimes on a cross sectional basis or on the diffusion framework of innovations.

According to the above literature presentation in the subject of financial innovation, we highlight the crucial questions that rise from the relative literature:

- Most studies refer to the consequences of welfare and profit that result from the appearance of the financial innovation. About sixteen studies (half dated before 2000) present financial innovation results mostly in a macroeconomic level and in financial markets.
- Only seven studies present the conditions of the economic environment that encourage the appearance of a financial innovation. Six of them appeared before 2000 and refer to the general characteristics of the economic environment.
- Seven studies that appeared earlier than 2000 refer to the notion, the nature and the design of new financial products. After 2000, only three studies describe these notions, with the latest study (Plosser, 2009) posing the question about financial innovations' nature and their effects on the financial environment, especially because of the 2008 crisis. On the other hand, only six studies make a reference to research questions about financial innovation.
- Only three studies present a survey on previous literature. Two of them were completed before 2000 and used only the criterion of the functionality of financial innovations while the last one has broader criteria and presents an innovation survey from many points of view like diffusion, design, affective factors, etc.
- Only six studies present financial innovation diffusion models. Half of them are dated before 2000, refer to the same financial products (ATMs) and use to their empirical analysis the same data. The rest of them, that are more recent, refer only to the electronic transaction system and to the SBCS.
- Only two studies by the same writer (one is the continuation of the other) refer to the financial innovation patent.
• Most studies or parts of them refer to the direct and/or indirect consequences on the economic welfare. Moreover, most of them deal with new bank products and only a few of them refer to the issuing of securities.

• Only six studies are about two new financial institution forms and more precisely about Internet only banks and BHS. In addition, five studies evaluate the characteristics of dissimilated investors or consumers that use a financial innovation.

We reach the conclusion that empirical studies are just a few and of limited range when it comes to research hypotheses. We can't be sure about the reasons of the limited financial innovation literature, which is disproportionate to its huge and recognised value and its research interest while it is known as the workhorse of the financial system. Frame & White (2004) notify some of the reasons why literature is limited:

1. Research & Development department policies: Empirical research on innovation has been related to development attempts or to company extensions and to the design of new products. Thus, there is a shift away from financial research. On the other hand, financial institutions rarely have an R&D budget (even if they have IT budgets). Nevertheless, the lack and the shift from financial research are wrong, strategically speaking, as industrial development gives priority to financial development and resource rising.

2. Lack of financial data: Central banks collect and analyse micro-data. While financial innovations develop at full speed, micro-data and their analytical elaboration are especially useful and help central banks perceive the challenges they face for the preservation of economic stability (Noyer, 2007). Yet, there is a huge lack and/or access to historical (and not only) data that are widely used to finance and applied econometrics. These data come from financial institutions, bank products, etc. and could reveal the market's need for financial innovations. However, most data bases\(^{28}\) aren't accessible to researchers or require a huge cost. On the other hand, big organisations keep data of their activities but are only for personal use and are not published. Thus, when data are not accessible or/and are not for general use, they don't provide any useful information for

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\(^{28}\) Such data bases are: Centre for research in Securities Prices (CRSP), Standard & Poor’s, Compustat, Datastream, etc.
3. **Industrial organisation**: the biggest part of research about innovation originates from sectors or economic agents that relate to industrial organisation. In this way, research targets (directly or indirectly) to the industrial production and to the construction sector where **R&D** data and sales information are available. Thus, the volume of research activity in innovation is most probable to appear in companies with market power and firm size but that also have secret research activities.

4. **Patenting**: The characteristics of companies and of financial innovations vary a great deal. Sometimes, even certificates in financial innovations that don't have common characteristics are neither patented nor advertised. As a result, an empirical research in financial innovation that uses patents doesn't appear in Finance. Research must shed light on basic questions of the patent process like the possible production of additional financial innovations and the economics of financial innovation.

5. **Financial innovations as opportunist products with no continuation**: Quite often, financial innovations appear suddenly as a reaction of market participants to economic, tax and regulation environment changes with the form of opportunist products. Consequently, the new product is immediately standardized or/and doesn't present any research interest and it concludes its life span as it has served its purpose. Sometimes, even if it presents a research interest, the financial innovation doesn't follow a precise structural and developmental course. Certain periods appear to be more active than others, especially when there is financial freedom and **IT** boost during the relative financial activity. Stationary periods do make research more difficult.

### 2.5. Conclusions

In this chapter we have seen the concept and the important role of financial innovation to the financial and economic structure. Previous literature shows the significant importance of financial innovation in specific sectors despite the lack of empirical research, the availability of the data, etc.

Financial innovation has been developed in alternative fields of economic interest, such as technology, security prices, derivative products, etc. The significant role of financial innovation is more understandable in cases that financial innovations
create or develop in emerging markets. The interest should focus at the questing; if financial innovations achieve their goals.

In next chapter, we will present and examine the most important categories of financial innovations the last twenty years, in main fields of financial and economic environment such as, derivative market, new monetary aggregates, innovative mortgages, information and new financial instruments, The aim is to examine the role and results of financial innovations in these sectors within a critic point of view.
CHAPTER 3

THE MOST IMPORTANT FINANCIAL INNOVATIONS – PRESENTATION AND CRITIC

3.1. Introduction

Within the present economic environment, the needs and the demands of the capital market participants are rapidly changing. Through the use of cheaper, flexible financial instruments and that of new effective techniques to handle risk, financial innovation has significantly improved the financial system's effectiveness as it is a restructuring mechanism for the participants' capital structure.

Financial innovation process has influenced the market's framework, the companies' functional microeconomic framework, the structure and the nature of the competition operations of the international banking system, the national economic and financial policies and the monetary policy that governments implement. This is the result of Financial Engineering that brought forward new instruments and techniques for researchers in order to handle risk and to finance companies. The main clusters of financial innovation techniques that were developed are the following:

- **Innovations in securities** that influence the development of financial innovation instruments, which include consuming and financial applications for the companies. Such examples are guaranteed capitals, currency equivalents, new types of unit trusts, new insurance products, forward contracts, innovative instruments to manage risk, etc.

- **Financial process innovations** that deal with new ways to issue bonds, to trade securities, etc. Thus, transaction costs reduce, low cost information systems and technologies that promote transactions are used, etc.

- **New financial strategic solutions or forms or institutions** that help companies overcome cash flow or financial problems. Such examples are cash management strategies, innovative debt management strategies, different forms of customer and company funding, merges, etc.
Tables 1 and 2 in Appendix present analytically a grouping of clusters, in general, of financial innovations and clusters developed by the banking sector, respectively:

Table 1 and Table 2: Clusters of financial innovations

<table>
<thead>
<tr>
<th>Table 1: Clusters of Financial Innovations</th>
<th>Table 2: Clusters of Banking Financial Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer assets</td>
<td>New products and services delivery</td>
</tr>
<tr>
<td>Consumer credit and mortgage</td>
<td>Organizational functions process</td>
</tr>
<tr>
<td>Bank lending to business</td>
<td>Functional processes and benefit of joint services</td>
</tr>
<tr>
<td>Treasury securities and agencies</td>
<td>Various types of Banking Financial Innovations</td>
</tr>
<tr>
<td>Tax-exempt securities</td>
<td></td>
</tr>
<tr>
<td>Corporate bonds</td>
<td></td>
</tr>
<tr>
<td>Derivatives (futures and options)</td>
<td></td>
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</tbody>
</table>

In the next paragraphs, we will present the most important financial innovations that influenced radically the financial architecture of the financial system, that created emerging and secondary markets and/or that appeared because of the technological and IT developments. Moreover, we will critically reflect over the consequences of their emergence in the financial markets. The financial innovations that will be presented are: i) derivative assets, ii) monetary aggregates and monetary policy, iii) new business forms, iv) asset-backed securities, v) mortgage market and, vi) other financial innovation instruments.

3.2. Derivatives assets

In recent years, the development of derivative assets significantly influenced the financial system. Originally, they appeared in the U.S. markets in the beginning of the 70's as the result of the great fluctuations in the exchange rates, in the interest rates and in international transactions.

The result is the creation of financial products of which pay-offs depend on other product prices: the underlying assets. Underline assets could be interest rates, foreign exchange rates, equities, equity indices, commodities, insurance contracts, corporate securities, etc.

The derivative market has five main categories of underlying assets: i) the interest rate derivatives, ii) the foreign exchange derivatives, iii) the credit derivatives, iv) the commodity derivatives and, v) the equity derivatives. There are two groups of

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29 Appendix, Chapter 3rd, Table 1 and 2 (Fasnacht D., 2009, “Open Innovation in the Financial Services”, Springer Publ., p:60)
derivative contracts that are distinguished by the way they are traded in the market:

1. **Over The Counter (OTC) derivatives**: they are contracts that are traded directly between two parties, without another intermediary or an exchange. Such products are swaps, forward rate agreements, exotic options, etc. The OTC derivative market is the biggest one and it is mainly uncontrollable with respect to disclosure of information and exchanges between the parties, especially when banks and other big and complex financial institutions, like Hedge Funds, participate.

2. **Exchange Traded Derivative (ETD)**: they are derivative contracts that trade options with a short call position or a long call position or with futures. Such derivative exchanges compose a market where both parties exchange standardized predetermined contracts. Thus, a derivative exchange acts as an intermediary to all transactions and takes initial margin from both parties of the trade. The largest derivatives exchanges are, by number of transactions, the Korea Exchange (KOPSI Index Futures & Options), Eurex that contains a wide range of European products like interest rate and index products, and CME Group that was created by the merge of the Chicago Mercantile Exchange, the NY Mercantile Exchange and the Chicago Board of Trade in 2007.

The most important products that have been broadly developed lately in the financial markets are the financial futures\(^{30}\), credit derivatives\(^{31}\), certificates debt or receipts (GOU) and warrants.

Lately, large financial companies developed the so called weather derivatives (Golden *et al.*, 2007). It’s a type of a derivative that allows companies to hedge their exposure from unexpected weather conditions. More and more companies are influenced by weather conditions, especially their profits and installations. The U.S. Department of Energy\(^{32}\) estimates that 20% of the American economy is directly

\(^{30}\) There are five different categories of financial futures: i) currency futures, ii) interest rate futures, iii) stock index futures, iv) future options and, v) options on futures. With futures one can buy securities (mostly issued by the government), and cash flows, Eurodollars, gold as well as products like oil and soya. A futures contract obliges the holder to make or take delivery under the terms of the contract, whereas an option grants the buyer the right, but not the obligation, to establish a position previously held by the seller of the option. The underlying asset to a futures contract can be securities, merchandises, precious metals, etc. at a stated future date.

\(^{31}\) They are derivative of which the payments depend on the creditworthiness of the obligations of a third party (a company or a government). Credit derivatives allow companies to trade risks (in almost the same way they trade market risk), to diversify credit risk and to transfer it to a third party.

\(^{32}\) [http://www.energy.gov/](http://www.energy.gov/)
influenced by the weather as profits that come from most industries depend a great deal on weather conditions. Weather conditions have direct impact on agriculture production, on the demand of energy products, etc. while they have indirect impacts on retail companies, on entertainment, on constructions, on the tourist market etc.

For instance, the profits of an energy company depend on retail prices and the amount of sales of electricity that are influenced by weather conditions as they increase or decrease the demand for electricity. An especially warm winter could result to an excess in oil or gas stock to energy companies as households will use less energy to warm up.

The first OCT weather derivative deal, in 1997, created a weather risk management sector. In September 1999, the Chicago Mercantile Exchange (CME) introduced the exchange-traded weather futures, the first products of the kind.

The derivative market development is exploding and it shows from the following statistical data:

- The value of the Interest Rate Swaps and of other derivatives reached $450.000 billion or in other words it was eleven times the international GDP at the end of 2009, according to BIS. Ten years ago, their value was about $75 trillion, two and a half times the GDP.
- The credit default swaps (CDS) had grown more than five times the corporate bonds value, worldwide, by the end of 2009. Only three years ago, CDS purchases were 85 percent of the volume of corporate bonds. The CDS market is currently the most dynamic market in terms of liquidity and risk management and goes up to $32.600 billion.
- The value of commodity derivatives has grown from $400 billion in 1998 to $2.944 billion in 2010.
- According to BIS, the International Swaps and Derivatives Association (ISDA)
reports and the *British Bankers’ Association (BBA)*\(^36\), the *OTC* market turnover in June 2010 was $614.674 billion and has grown by $20.000 since 2006\(^37\) of which 67% are interest rate contracts, 8% are credit default swaps, 9% are foreign exchange contracts, 1% are equity contracts and 12% are other derivatives exchanges.

In the following table *OTC* derivatives by risk category and instrument are presented.

**Figure 3.1.: OTC Derivatives by Risk Category and Instrument**

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Amounts Outstanding in Billions of $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange contracts</td>
<td>49.196</td>
</tr>
<tr>
<td>Interest rate contracts</td>
<td>449.793</td>
</tr>
<tr>
<td>Equity linked contracts</td>
<td>6.591</td>
</tr>
<tr>
<td>Commodity contracts</td>
<td>2.944</td>
</tr>
<tr>
<td>Credit default swaps</td>
<td>32.693</td>
</tr>
<tr>
<td>Unallocated</td>
<td>73.456</td>
</tr>
</tbody>
</table>

*Source: BIS, (2010)*

Derivatives are mainly used in order to hedge risk from financial exchange loss, to represent the market's direction in the future towards an arbitrage profit and to transform the nature of assets or to change the nature of an investment in order to avoid loss for both parties, after a portfolio's trade.

The main reason to use derivative contracts is hedging\(^38\). With the use of a derivative, the risk (i.e. of a portfolio) shifts from higher to lower underlying asset risk. Minimizing the risk is actually accomplished through diversification that concentrates and distributes the risk of each and every financial instrument\(^39\). Finally, risk is minimised also with the use of *risk premia* that allow investors to reduce uncertainty for

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\(^36\) [www.bba.org.uk](http://www.bba.org.uk)

\(^37\) Appendix, Chapter 3, Figure 1.

\(^38\) The three main risks that relate to derivative contracts are: market risk, credit risk and operational risk.

\(^39\) Broad diversification in a huge number of different instruments could demand a huge number of small transactions for these instruments.
possible loss while conserving the financial benefits from assets. Such derivatives are called risk free assets, like options, that reduce transaction costs and allow investors to avoid trading singular securities or derivatives.

*OTC* derivative market was the innovative response of the international financial institutions to the growing needs of their clients for hedging. The *OTC* derivatives were also developed in order to take advantage of arbitrage opportunities in national debt markets.

On the other hand, derivatives can be used as a risk premium by different import/export companies, or by investment corporations that look for ways to extend their investment choices, to face exchange rate risks and interest rate flows, to the diversify of a security portfolio with minimum credit risk, to take advantage of the differences between the ongoing and forward contracts and upward, downward and steady market tends, etc.

Derivatives have other advantages as well like the possibility to directly convert positions to cash, the possibility to trade positions as much as one wishes to and the possibility to secure part or the whole value of the investors' portfolios. They also increase effectiveness, flexibility and market liquidity and they guarantee the fulfilment of trading obligations. Last but not least, they are the fastest and the simplest forward contracts with the lowest cost.

However, the disadvantages of derivative contracts are equally important. The complexity of some derivatives and their risk estimating methods boost insecurity. Moreover, because these new financial instruments are created and traded mainly during economic and financially thriving periods, we don't know how derivative markets would function during recession.

The huge growth of derivatives and the changes in the markets' structure could surpass the growth rate and the available analysis and process foundations of *risk management*. Especially in the case of credit derivatives, the gaps in the foundational management and the systems of risk management are more obvious.

On the other hand, the increasing use of derivatives generates new risks within the financial system. During the last few years, derivative innovations have been related to important financial losses like the collapse of *Barings (Queen’s bank)*, of the *Long-Term Capital Management* (a hedge fund of Myron Scholes and Robert Merton) and the Ernon collapse in 2002. The Long-Term Capital Management downfall is usually given
as an example of a financial crisis that is created because of a wrong estimation of derivative products.

A kind of risk is the one created by the *concentration* in some specific derivatives and markets. In the U.S, the twenty five most important banks of the country hold more than 90% of the total volume of derivative products while the first five hold 85%. Moreover, the best derivatives dealers hold more or less 30% of the international derivative market in national currency values, while some of the international financial institutions hold the biggest part of the rest of the market.

Nowadays, the role of financial derivatives is questionable when it comes to the potential advantages and disadvantages of derivatives in the financial system. Some consider derivatives to be the financial weapons of mass destruction that hide unknown risks while others believe derivatives to be the most important financial event and look forward to the creation of more complex ones as an essential step towards the development of a more flexible and effective financial system.

The recent exponential development of the derivatives market raises questions about the impact of financial derivatives on the financial system (Duffie & Zhu, 2009). The variability of the risks mentioned above could possibly cause flaws in the financial system. The main concern is that brokers' failure could lead to losses for the market's participants or/and a broker's exit from the market could result into lack of liquidity in the market.

**3.3. Monetary aggregates and monetary policy**

A crucial question for Central banks is rational understanding of the mechanisms with which the *monetary policy* transforms economy. The recent swift of the derivatives, of the hedge funds and of private bank corporations, as well as the introduction of the *euro* (maybe the most important financial innovation of the recent years) pose new challenges for Central Banks: they make the analysis and the implementation of the monetary policy more complex as they alter its transmission mechanisms and change the payment system. This new environment can expose financial stability in to danger. With the European monetary unification and the fact that financial institutions operate across borders and transactions, capital and products traffic freely within the *EU (European Union)*, the international and the European capital markets have come closer to their completion.

The role of the monetary policy is to secure stability of the purchasing power of
the euro in order to avoid market distortions because of inflation. It could be combined with the support of the sustainable economic growth. In order to propel economic stability, Central banks try to ensure the smooth function of the *payment system* and of markets, by taking the necessary measures that reduce the probability of problem transmission and of systemic risk.

The above two responsibilities of Central banks (*monetary policy and financial stability*) are interrelated. Financial instability has an impact on broader economy and the other way around as macroeconomic factors can sometimes influence financial stability. Therefore, because both targets are obvious, Central banks use monetary aggregates in order to achieve their goals.

Financial innovation is a challenge for development or/and the evaluation of *monetary aggregates*[^40]. When a financial innovation comes into light, instability signs of money supply appear and the financial behaviour of some economic agents alters. The role of the financial innovation in these cases is still unknown hence important and necessary for the possible interpretation of the money supply fluctuation and of inflation.

The introduction of a financial innovation induces two basic changes in the monetary policy mechanisms (Noyer, 2007) [^41]: changes in the business sector (i.e. the interest rate channel) and changes in the monetary policy decisions because of the total impact of the business channels. However, the volume of changes and the total impact of a financial innovation on the monetary policy of Central banks can't be exactly defined as it is influenced by other factors as well, like unemployment, inflation, globalization, etc.

Financial innovation encourages faster transmission and the embedment of information in the financial market rates, especially when information is about monetary policy decisions that come through the *interest rate channel*. Thus, it contributes to the asset management by reducing transaction costs and by facilitating arbitrage, hedging, funding and investment strategies. However, financial innovation demands bigger

[^40]: We refer to the measures of money supply as adopted by financial and monetary policies. Aggregates are categorized as *basic* and *secondary*. The basic aggregates are for instance the discount rate, the open market policy, changes in the percentage of the compulsory deposit rates. Secondary aggregates are instructions, recommendations and specific credit controls.

[^41]: Noyer describes during the last few years, there is a huge interest towards new exchange rate financial innovations. In recent years, two innovations that may have an impact on the interest rate elasticity of money demand have emerged. One takes the form of high-yielding and highly liquid deposits accessible via direct banking or internet accounts. The second, which is still marginal, consists in the introduction of so-called “retail derivatives”, which are usually short-term deposits with embedded derivatives tailored to the needs of investors.
leverage, which increases the interest rate impact that changes because of the Central bank. Other problems that appear with the introduction of financial innovation like the evaluation of difficulties, the lack of expertise of some traders, etc., are considered temporary.

In some cases though, financial innovations can put financial stability in danger. For instance, huge credit supply and demand could cause liquidity problems that lead to high leverage levels and financial instability. This results to an increase of systemic risk while the impact of financial innovation on credit propagates financial instability instead of reducing it, especially during stressful situations. At this point, Central banks should take the necessary measures in order to moderate the possibility of systemic risk.

Furthermore, new investors could appear whose choices influence systemic risk. Investors of the kind are hedge funders that take short-term capital loans to fund long-term investments. Their activities could be the source of systemic risk as they represent 40% of the stock exchange turnover and 25% of the purchase of credit derivatives turnover. They are also the main liquidity providers in most markets. The importance of hedge funds is great as they can increase liquidity in the banking system (a traditional instrument to manage crises that is used by Central banks) and to avoid instability successfully.

Financial instability, systemic risk and moral hazard increase as well, when the stabilising policies of the Central banks aren't rational. However, the evaluation of monetary policy interventions or/and of political ones, which aim at the abatement of short-term financial instability and at the possible risk of the market distortion, are not trivial. There is a huge debate going on about the relation between interventions that aim at the short-term financial instability abatement and the possible distortions of the financial market that could stem from them. Interventions in financial markets could provoke the rise of moral hazard and thus block a rational pricing policy.

The comprehension of financial and credit means, of rational monetary policy in financial markets and its impact on financial innovation are matters of great importance that could improve the market's effectiveness and thus, help all Central bank policy makers create a more effective monetary policy.

It is obvious that the smooth function of financial markets is a basic yet important element for the achievement of the Central bank goals. However, neither the size of the market shocks that create a disorder to the effective function of a market are obvious, nor are the moment when Central banks should intervene in order to re-
establishes market stability. The better understanding of this distinction is crucial for the definition of the appropriate monetary policy and instruments.

3.3.1. The Euro

Product, services, capital and employment markets, in accordance with the political decisions that are taken by the EU members, form a single market without borders. If a single market didn't exist, the adoption of a single currency would be sub-optimal. The introduction of the euro in the EU alone is an important financial innovation that had an important impact on the financial behaviour of all economic agents.

The most important motive for the euro introduction was the need to adopt a single product, service and workforce market and to adapt to the changing environment in Europe. The euro is a currency with many nations and thus, it builds up expectations for the gradual integration of all European countries in many levels.

The euro, as a common currency, has one more particularity in respect of the rest of the financial innovations. It is a financial innovation with political characteristics. Political exercise targets at the provision of public products and at the defence of the public good that differs in the sense that there is a territorial, a national and an international level.

With the introduction of the euro and the single monetary environment, the EU member states are capable of exercising common effective and appropriate policies in many levels, based on the principle of subsidiary, as it is put in the EU Treaty. This approach is very important for the international environment where many issues can't be appropriately solved in a regional or national level (environment, foreign policy for security, international financial stability). Moreover, a single currency increases the common trust between the member states that know they can exchange products and services without intermediary costs.

The introduction of the euro brought a new organisation for the payment settlement systems for bonds and equities. The European Central Bank (ECB) provides a thorough description of the payment system, and the settlement of securities to all EU member states. Moreover, the Bank for International Settlements (BIS) is the organisation where payment systems and settlement take place and it contributes to the enforcement of the financial market foundation and to the promotion of a healthy and efficient payment and settlement system.
Many studies, BIS and ECB studies included, deal with the systems and clusters of retail payment of the euro, the access criteria, timetables, the pricing policy, and other functional characteristics. Moreover, they emphasize on the completion of the payment systems with the help of innovation in the Euro-zone, like the Large Value Payment Systems (LVPS), the Single European Payments Area (SEPA) and system TARGET2.

Bech et al., (2008) highlighted the three tendencies observed in payment systems: 

1. more access to new systems that are not limited to one country or to one currency, maintaining their security and efficiency,
2. more use of LVPSs because of the extension of financial services, of changes and of the globalisation of financial institutions, and,
3. the development of Central banks and the evaluation of the systems according to international standards.

The new currency brought forward new prospects for investors, for the Member-States, for the labour market and, generally, it influenced the economic environment in its whole within and out of the Euro-zone. Price stability is the main target of the unitary monetary policy and in order to meet it, every Central bank had to secure a stability level for the exchange rate. Domestic stability is to a high extend the coordination of external stability. However, the question posed is whether the single currency really managed to eliminate most external sources of instability and to make monetary policy a Euro-zone issue.

Price stability leads to the secondary goal of Central banks that is the maintenance of financial stability. There is no doubt that the euro has proved to be efficient for the protection of the European economy and for the consequences of external or asymmetrical shocks. However, this is a complex matter because financial stability of all financial markets of the common currency is required. Because of globalisation, the limits of the markets and the limits of the responsibilities of the Central Bank don't overlap as the euro is used globally across the EU borders.

Because of the introduction of the euro and of the monetary policy by the ECB, all member states should function in an economic environment with low inflation or low inflation expectations and low interest rates. The overall low levels of inflation in

42 Kohlleppel, 2001; Lichter, 2001; Nieuwenhof, 2001; Humphrey, 2009
43 Bech & Soramki, 2001; Selgin, 2004; Rosati & Secola, 2005; Bolt & Humphrey, 2005; Holthausen & Rochet, 2006; Carbs-Valverde & Lipares-Zegarra, 2009
44 Finocchiaro, 2006; Saccomanni, 2007; Draghi, 2008; Kemppainen, 2008; Bolt & Schmiedel, 2009
45 De Séze, 2006; Bolt & Humphrey, 2005; ECB, 2009; Toledano, 2009
Europe since the introduction of the *euro* and the comparative low fluctuation of the inflation level of the member states is an important victory of the single currency that helps monetary policy makers meet their goals. Nevertheless, the question whether inflation managed to be kept in low levels (as we notice on the following graph), on the whole, for the member-states, during the *euro* period is yet to be answered.

*Figure 3.2.: Inflation rate (Euro-zone, 2000-2010)*

![Inflation rate graph](source)

After lifting internal borders, the workforce mobility within the *EU* is a crucial issue. Nowadays, a basic factor of financial life is the knowhow, which is easily and more quickly transferred from one region to the other. Thus, the need for the workforce mobility is still as urgent. However, flexibility of labour though is required. In other words, it is important for the employers to adapt as quickly as possible to the new skills and processes needed. Considering the need for flexibility in the labour market, the completion of the fundamental reforms of the labour market is very significant.

The unitary market allows investors the unique possibility to have access to a broader range of investment opportunities and to a longer list of securities. Within the Euro-zone and in the world at large, *euro-denominated banknotes* are promoted. During the last couple of years they have doubled and are now the most circulated banknotes worldwide.
The introduction of the *euro* has also directly affected the reduction of the exchange rate risk and has created a new unitary capital market. The so called home bias to asset holding has decreased the most, not only within the Euro zone, in comparison to the assets issued in other countries. This has globally increased the demand for *euro*-denominated financial assets.

At last, we have to underline the global debate concerning the need for further economic completion. Generally, there are still many obstacles to overcome before the overall completion of the European financial markets like, for instance, different regulation systems, various market practices and more precisely the heterogeneity of the present national market foundations and the lack of sufficient interrelations. One of the goals of the *EU* is to achieve a balanced sustainable development in the Euro-zone. Amelioration is already evident, but for better results many more heterogeneity symptoms have to be eliminated within the unitary European financial market.

### 3.4. New company forms

During the last two decades, new forms of financial institutions were created within the financial system. Their emergence and development was mainly due to the expansion of technology, to the creation and negotiation of new securities, products, services and purchases and to the complex relations between compatible organisations that led to the creation of new ones.
Holding companies are a new form of financial institutions that include: companies that share with another company part of the common ownership and administration; every organization that takes part in the issuing of (common) credit cards according to one (of the two) national banking card systems; subsidiaries of various, similar objects; group of companies of which 80% or more of the voting shares belong to one company; investment or portfolio companies; merging companies; auditing companies; proprietary or controlling companies\(^{46}\) that hold an important part of the voting shares of other companies and have the right to vote, etc.

The rapid increase of technology and of Internet users, created new forms of bank corporations: the Internet novo Banks. According to Delgado et al., (2007), in 2002 there were thirty five such companies in the EU and twenty in the U.S. The difference between them was that in the EU such companies were part of the administration and management of huge bank corporations while in the U.S. the general tendency was that of novo operations. This function of autonomy in the U.S. could explain the fact that afterwards most Internet novo Banks disappeared through winding-up proceedings or repurchase or closure or they were obliged to have physical presence.

Such cases of companies that are created as quickly as they disappear could represent what is known as “failed financial innovation of company”. Understanding the reasons why such companies failed, could help to the understanding of the aspects that give rise to successful financial innovations. DeYoung et al., (2000; 2005; 2008) showed that Internet Novo Banks are less profitable than traditional banks because of the small company size and of the limited number of the accounts.

Another form of corporations with fast expansion rates of their activities are the Monetary Financial Institutions (MFIs)\(^{47}\) that absorb or create with a consortium bank

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\(^{46}\) Proprietary companies are a widespread company form. They take part in the equity capital of other companies without normally having their own production activity. Their main activity is to hold and administrate other companies. Thus, their profit comes from dividends and other non-operating gains. If a proprietary company has a productive activity this is usually limited and the profit from this activity is respectfully limited. Moreover, it can participate to the equity capital of commercial industries and thus, it is considered a commercial industry as well. It has to be mentioned that proprietary companies are actively contributing to the equity capital of the companies they participate in as they contribute with their knowhow and experience to the amelioration of the effectiveness of their administration. They could also boost the stock value of a company that participates in the stock market by reflecting goodwill.

\(^{47}\) The sector ‘other financial institutions’ comprises all financial institutions with the exception of monetary financial institutions (banks, money market funds and monetary authorities), pension funds and insurance corporations. Examples are lease companies, venture capital and development capital companies, holdings exclusively engaged in managing and controlling a group of subsidiaries whose main function is financial intermediation and/or the provision of financial assistance, insurance intermediaries, securities brokers and stock exchange institutions.
security loans\textsuperscript{48}, by reducing the loan interest rate in the private sector. The number of M\textit{FIs} in the Euro zone is presented, by category, in the following table:

<table>
<thead>
<tr>
<th>Table 3 – Number of MFIs in the Euro zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>All MFIs</td>
</tr>
<tr>
<td>Central Bank</td>
</tr>
<tr>
<td>Credit institution</td>
</tr>
<tr>
<td>Money market fund</td>
</tr>
<tr>
<td>Other institution</td>
</tr>
</tbody>
</table>

\textit{Source: ECB (2010)}

The expansion of the \textit{MFI} s’ activity is referred in a specific part and represents more or less 10.5\% of the \textit{M3}\textsuperscript{49}.

3.4.1. Microfinance Institutions

\textit{Microfinance Institutions} (MFIs) provide financial services to low budget consumers or to countries with low \textit{GDP} that have limited or no access to broad bank products and relative services. MFIs provide a variety of high quality financial services\textsuperscript{50} like credits, savings, capital transfers, security, etc.

\textit{MFIs} can be national institutions (i.e. the agricultural credit cooperatives in China), institutions by a group of countries (i.e. consortia of credit help in West Africa), non-profit organisations (i.e. different \textit{NPOs} in Latin America), profit organisations (i.e. \textit{MFIs} in East Europe). Independently of their form, \textit{MFIs} have three common characteristics: \textit{i)} they know the market and provide simple and fast approval processes for loans, \textit{ii)} have low administration costs, \textit{iii)} they develop specific innovation techniques to secure loan returns, with high interest rate repayments and provide motives, supervision and offers for gradually bigger loans for the debtors.

Their main goals are the institutional (regulations and their application, the development of human resources, controlling, etc.) and the financial (rates and

\textsuperscript{48} They are loans to investors for holding of shares by stockbrokers, and loans from banks to stockbrokers for the coverage of the clients’ positions, or for lending shares from one stockbroker to another basically for the coverage of security sales that are not present in the latter’s portfolio.

\textsuperscript{49} Money supply is classified in the following indicators: MO=notes and coins, M1=MO+demand deposits, M2=M1+saving deposits and time deposits, M3=M0+M2+bonds and repos, M4+shortterm government securities, M$N=M4+foreign exchange deposits+mutual fund shares

\textsuperscript{50} Such activities are the needs of a lifetime (marriages, education, etc.), personal extraordinary needs (insurance, unemployment, etc.), destructions (floods, earthquakes, etc.) and investment opportunities (land purchase, entrepreneurship, etc.)
analogies of productivity, funds, analysis of the financial rates, financial administration and internal control, etc.) sustainability of the financial sector along with the debtors sustainability. Nowadays, with the use of different innovation processes\textsuperscript{51}, financial services can be provided to a number of developed countries and to low income consumers in a sustainable basis.

The most important sources of information and data about MFIs are the *MicroBanking Bulletin* that is published by Microfinance Information Exchange\textsuperscript{52}, the CGAP (Consulting Group to Assist the Poor)\textsuperscript{53}, the WSBI (World Saving Bank Institute)\textsuperscript{54} and the MCS (Micro Credit Summit)\textsuperscript{55}. At the end of 2009, 1084 MFIs were found, which served 74 million customers with loans up to $38 billion and deposits of $23 billion. It is estimated that about $250 billion is needed in order to cover all the needs of the undeveloped countries around the world. In the next graph, we see the total committed amount for Microfinance per territory, according to CGAP.

*Figure 3.4.: Total Committed Amount*

![Figure 3.4.: Total Committed Amount](source: CGAP (2010))

The regulatory framework within which MFIs function is of great importance for the development of their innovatitivity. On the one hand, MFIs should be able to function

\textsuperscript{51} A tactic that is adopted is that of the adoption of systems that encourage continuous ameliorations in products and services to serve a selected group of debtors.

\textsuperscript{52} Microfinance Information Exchange Inc; 2009, “MicroBanking Bulletin Issue”, 19, pp:49, \url{http://www.themix.org/}

\textsuperscript{53} \url{http://www.cgap.org/}

\textsuperscript{54} \url{http://www.wsbi.org/}

\textsuperscript{55} \url{http://www.microcreditsummit.org/}
freely and with such an interest rate that would oversubscribe their sustainability. On the other hand, though, the lack of rules makes most MFIs function on an unhealthy basis. Thus, the goal of a radical regulatory framework has two parallel components. The first is the formation of an effective and low-cost framework that ameliorates their model requirements, which function on a healthy basis and, at the same time, the second one is the encouragement of MFIs to adopt innovative processes, services and products, avoiding the constraints that debilitate their effectiveness, like the restrictive conditions in the use of fund and loans, etc.

Government interference plays an important role in the development of MFIs by forming the financial environment they act upon. And yet, governments should act as a supervisor for MFIs. Generally, experience has shown (McGuire & Conroy, 2005) that in most countries many practical difficulties that appear prevent MFIs from being introduced to severe regulations and where this happened, it didn't yield the expected results, especially within an environment with limited administration resources. The issue of regulation supervision and its application is crucial. A radical choice would be the establishment of an independent authority to direct MFIs, as long as it is truly independent. Another choice would be a process/method to define their revenue and that would refer to the MFI models, through self-regulation. Self-regulation can take many forms. It can alter form a voluntary ethical doctrine that MFIs agree upon to a severe license system that a supreme legal entity will supervise.

An MFI should respect the lowest level of a legal and sustainable function, transparency, functionality and processes that it serves. Apart from the above lowest levels, there is the performance rate for MFIs that examine mainly capital adequacy, asset quality, management, earning and liquidity. Moreover, performance and the submission of activity reports are indispensable, given that the sector is expanding. Comparative performance measurements should be created in order to evaluate and compare institutions and thus to encourage MFIs to ameliorate their performance. At the same time, performance models shouldn't discourage innovation and should focus on performance rather than on used processes.

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56 The most important performance indicators for MFIs are the number of active customers, the repayment rate: total collections during previous twelve months/amount due during previous twelve months plus amount past due, portfolio at risk: balance of loans 30 days past due/value of total loans outstanding, operating cost ratio: operating expenses/ average loans outstanding, operational self-sufficiency: operating income/ total operating expenses, financial self-sufficiency: operating income/adjusted total operating expenses, equity to asset ratio = total equity/total assets and current ratio = current assets/current liabilities. For a better analysis: www.cgap.org
Financial institutions are of great interest for the Microfinance sector. Banks have more advantages in comparison to autonomous MFIs, like big clusters, more access to accounts, better standards, bigger product variety, special saving products, etc.

The main reason why banks avert from Microfinance is interest rates. When debtors borrow, they usually address to profit making lenders where interest rates are really high\(^{57}\). Banks and MFIs should offer the possibility to provide alternative loans with lower interest rates and favorable conditions in order to prevent speculation.

However, Microfinance is an inherently costly activity and in order to survive, it has to charge higher interest rates for its services than other kinds of loans, services and other debtors have. This is a fact, regardless of the choices given by MFIs and banks. Systemic innovation, as a form to lift interest rate controls, is the main positive reason for banks to participate in Microfinance. Finally, it is important to find effective ways and models that decrease risks and that encourage innovation, avoiding, at the same time, speculation.

### 3.5. Asset-backed securities

*Asset-backed securities (ABS)* are innovative securities collateralized by a pool of underlying assets like credits, loans, regular payments, debentures, etc. ABS is an important element of short duration portfolios because of their average slow duration, of the credit evaluation of their issuing and of their revenue that is higher than that of treasury bills. Investors, apart from the satisfying revenue, participate in a market with high liquidity and low price fluctuation and they succeed in differentiating their investing portfolio. ABS issuers have advantages such as lower capital cost, fund flexibility through different money sources, more investors to start with and last but not least they are freed from the regulations on capital\(^{58}\).

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\(^{57}\) Robinson (2001) showed that in such cases of a typical lending in fourteen countries is Asia, in Latin America and in Africa, 76% of the lenders had imposed interest rates of more than 25%.

\(^{58}\) They are often repackaged several times, making it difficult to keep track of the original underlying assets. Repackaged securities are generally issued by *special-purpose vehicles (SPVs)* or *structured investment vehicles (SIVs)*, entities created solely for this purpose. ABS includes also the asset-backed funds. They are either insurance companies or national organizations that instead of placing their capital in savings accounts, they invest in assets, bonds or shares in order to succeed more profits but with higher risk.
3.5.1. Asset securitization

Asset securitization is lately used broadly by institutions and banks that supply the retail credit market with mortgages, credit cards and generally with consuming loans. Asset securitization has many steps. The first one is to sell a bunch of financial assets to an independent, healthy and legal organization that issues ABS. In this way the original asset holder gets cash by liquidating his position. However, because the seller is probably better informed about the ABS (who faces “adverse selection”), the buyer requires credit enhancement like a third-party guarantee, an over-collateralization or a guarantee with a Tranching priority of claims.

Apart from liquidity, asset securitization can be socially beneficial as long as it allows low cost loan issue or even privately beneficial for financial institutions or savings-banks that look for ways to regulate their capital positions (Thomas, 2001).

The most popular financial innovation in the level of asset securitization are the certificates of deposit, or collateralized loan obligations or structured debt securities, or collateralized debt obligations (CDOs) that show a huge development in international markets (Longstaff & Rajan, 2006).

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59 The term refers to the process through which loans (of a country or of a multinational company) are substituted by negotiable securities that are purchased by investors (banks or financial institutions). Securitization appears in practice in two ways: i) by the direct security issue, ii) by the issuing of necessary securities.

60 At the end of 2008, federally sponsored mortgage pools and privately arranged ABS issues (including private-label mortgage-backed securities) totaled almost $9.0 trillion of the $49 trillion in U.S. credit market debt outstanding. By contrast, at the end of 1990, these figures were $1.3 trillion and $13.8 trillion, respectively.

61 Tranche is the issue of a securities loan with several parts (tranches). Tranche CD is a medium term certificate of deposit that is issued in different amounts a time ($15 million to $30 million the issue). Tranching is a kind of a guarantee that includes the creating of two or more security types that are defined by the priority of claims. The original seller often retains the most junior (“equity”) security (the one with the lowest payment priority and thus the first absorption of losses) as a way of assuaging skeptical investors about the quality of the assets in the pool. However, sophisticated investors, such as hedge funds, sometimes also hold such positions.

62 Thomas (2001) presents empirical evidence that the stockholders of certain ABS issuers benefit from securitization.

63 Collateralized debt obligations (CDOs) are a type of structure ABS whose value and payments are derived from a portfolio of fixed-income underlying assets. CDOs securities are split into different risk classes, or tranches, whereby “senior” tranches are considered the safest securities. Interest and principal payments are made in order of seniority, so that junior tranches offer higher coupon payments (and interest rates) or lower prices to compensate for additional default risk. The types of CDOs can based on the underlying asset, such as collateralized loan obligation (CLOs backed primarily by leveraged bank loans), collateralized bond obligation (CBOs backed primarily by leveraged fixed income securities or collateralized synthetic obligations (CSOs backed primarily by credit derivatives), structure finance CDOs (SFCDOs backed primarily by structured products such as ABS and mortgage-backed securities), etc. Other types of CDOs includes CDOs types, such as commercial real estate CDOs (CRE CDOs backed primarily by commercial real estate assets), collateralized insurance obligations (CIOs backed by insurance or reinsurance contracts), etc.
Literature about CDOs refers mainly to the reasons of their appearance and their structure (Lucas et al., 2007), their risk evaluation and pricing (Glasserman & Suchintabandid, 2007) and their relation to systemic risk (Krahnen & Wilde, 2006) or to banks and their lending attitude (Goderis et al., 2007). Nevertheless, innovation generated more complexity. Investment banks promoted a series of specifically complicated and complex products like constant proportion debt obligations (CPDO) and re-securitisations of CDOs and ABSs that are called CDO squared and CDOs of ABS (Goodman, 2002; Glasserman & Suchintabandid, 2007).

The function of financial markets is a current issue that has been going on since last summer because of the turmoil of subprime mortgages that have had unexpected huge loss the last couple of years in the U.S. Many, if not all, of these mortgages were ABS and were sold to investors in tranches, possibly reflecting different risk characteristics. The risk spreading and the insecurity about the value of the underlying assets of the CDOs and generally of the ABS were not perceived by the market participants and academics that continued to believe that risk was reducing through differentiation. When those securities started to show exaggerated loss compared to the loss expected, given the initial credit ratings, worried investors started to doubt the ratings' validity.

While in many cases, complex ABS had been widely sold to a number of
investors, their complexity, by definition, made market participants have difficulties and their evaluation impossible. This happened because, to a large extent, underlying default rates presented great variability and also because it was difficult to define which financial institution was (and still is) exposed to these securities and to what extend (Plosser, 2009).

Therefore, investors were held back and thus the banks and different financial institutions have difficulties in selling these securities or in using them as collateral, in order to raise capital in short-term capital markets. Generally, a speedy risk spreading was observed while exchanges were going down or even freezing in some particular markets.

3.6. Mortgage market

Mortgages\textsuperscript{64} are a series of financial products that have dramatically changed the last two decades, especially in the U.S. The previous years (especially during the 80's), the norm were the fully amortising fixed-rate mortgages that requested from the client to have a good credit history or a safe (based on personal criteria) long-term income. The first big change came at the end of the 80's with the introduction of different adjustable rate mortgages (ARMs) which until then were not allowed by law in the U.S.

Since then, things have changed. Mortgage lending, as financial products, are negotiated in many forms as products and services or as investment opportunities. Such cases are the mortgages\textsuperscript{65}, the mortgages loss clause\textsuperscript{66}, the mortgages-backed securities, the mortgages certificates & notes\textsuperscript{67}, the mortgages life insurances, the amortized mortgages\textsuperscript{68}, the mortgages development, mortgages bonds, etc.

\textsuperscript{64}Mortgage is a conveyance, a debt instrument that is used as a security for the loan to the lender (the mortgagor). It can be a real property of the mortgagor that in case that it is not repaid in full the mortgagee will take possession of. In order to have a mortgage, the lien (the right of ownership) has to be recorded in the register of title documents. When the loan is paid in full the lien is voided.

\textsuperscript{65}They are long-term mortgage loans with periodic payments. They are issued by institutions and banks like Mortgage banks and building societies. In the U.S., most mortgage loans are offered by institutions like the Mutual Savings Banks and the Mortgage Banks.

\textsuperscript{66}It is a clause that protects the mortgagee from the damages generated by the mortgagor's actions. Without this clause the insurance would be cancelled. It is known as the New York Standard of the Union Loss Clause.

\textsuperscript{67}It's a promissory note that pledges usually mobile things. Such notes are issued, for example, to cover in total or partially the value of purchased products that are pledged afterwards to secure the payment.

\textsuperscript{68}A mortgage loan is repaid in periodical equal payments and consists of the principal and the interest. During the first few payments the larger portion of the payments goes toward the interest and as the loan is paid off towards the principal. Such mortgages are usually mortgages on real property.
By now all financial institutions can grant loans (i.e. real estate loans, loans for consuming purposes, etc.) with a lien, that is to say with a mortgage or a deed or even a down-payment. The mortgage credit is given when the lien is registered against the land, in order to minimize the risk of default and is provided to those who want to purchase a real estate, to those involved in the housing construction, to businessmen, etc.

The big development of mortgages created a secondary Mortgage market where mortgagors place mortgage-backed securities that represent their mortgages to the banks or to private parties; they pay the total amount and substitute the original mortgagee. In this way they have legal claim against the interest rate and the lien, in case it is not paid off within the deadline. The main elements of the secondary mortgage market are the representative mortgage-backed securities that become possessions of banks and of private agents and can be transferred to other purchasers.

The great development of the secondary mortgage market generated new financial ABS products with the mortgage being the underlying asset. A mortgage-backed security is a case of financial innovation that includes bundles of mortgages as full collateral. The most known of them are the Collateralized Mortgage Obligations (CMO)\(^69\) and the Stripped Mortgage-Pass-Though Securities\(^70\).

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\(^69\) CMO is a type of mortgage-backed security that creates separate pools of pass-through rates for different classes of bondholders with varying maturities, called tranches. The repayments from the pool of pass-through securities are used to retire the bonds in the order specified by the bonds’ prospectus. CMOs utilize cash flows of long maturity, monthly pay collateral to create securities with short, intermediate and long maturities and expected lives. This is done by using all the principal payment in the early periods to repay the short term security.

\(^70\) Stripped Mortgage Pass Though Securities uses mortgage-pass-through as collateral. There are two types of stripped mortgage-pass-through securities, one that pays interest only (IO-security) and one that pays principal only (PO-security). The purpose of stripping mortgages is to provide a way to trade the pre-payment risk inherent in mortgage loans and mortgage pass through securities. The holder of the PO-security benefits from the homeowners decision to prepay, while the IO-holder gains from the decision not to prepay. Since the pre-payment rate is negatively correlated with interest rates, the IO-security is an asset whose return is strongly positively correlated with interest rates. Hence the IO-securities moves the opposite direction from most fixed income securities which make it valuable for investors who want to hedge against interest risk.
In the beginning of the 80's, financial innovations became known as the reaction to the Mortgage Market crisis, a crisis milder than the current one yet similar. The main similarity is also the main reason of bankruptcy of domestic mortgages, caused by a macroeconomic shock. During the previous crisis, the problem was inflation and interest rate hazard that the mortgagees couldn't handle. Before the current crisis, wide variations of the interest rates between 1995 and 2005 didn't perturb the mortgage market. However, after 2005, the real estate price problem was added. Banks were neither ready for the market's collapse that followed after 2006 nor did they realise that interest rates were very high (Gerardi et. al., 2001).

3.6.1. Subprime mortgages

A financial innovation that is directly related to technological changes and the development of risk valuation methods are the subprime mortgages. They are lending to borrowers with a less-than-ideal record (i.e. with a FICO\textsuperscript{71} score below 620) and/or high leverage as it is estimated by the ratio of borrower debt to income (personal leverage) or

\textsuperscript{71}FICO is a publicly-traded corporation (under the ticker symbol FICO) that created the best-known and most widely used credit score model in the United States. Here is a percentage breakdown of a FICO score: 35% for Payment History, 30% for Debt Ratio, 15% for Length of Credit History, 10% for Types of Credit and 10% for Number of Credit Inquiries.
with the ratio of loan to value and they are based on risk estimation according to estimation models. Subprime mortgages usually have stricter conditions compared to other loans like higher interest rates and sanctions over payment failure. In 2008 subprime mortgages reached $1200 billion (Inside Mortgage Finance, 2009)72.

The subprime mortgages default in 2007 and 2008 has raised doubts about the social benefits of subprime mortgages and the way that these loans are funded and spread in the market. The question posed is whether this financial innovation has speculative characteristics as it is provided mostly to households and companies with blemished credit history.

Before the current crisis, many researchers tried to explain the characteristics of the subprime mortgage market as well as the consumers' profiles (Lax et.al., 2004), their creditworthiness, the interest rates and the requirements to pay-off the loans (Chomsisengphet & Pennington-Cross, 2006) the valuation and the subprime mortgages yields (Crews-Cuts &Van Order, 2005), the mortgage market integration (Chinloy & MacDonald, 2005), the models' estimation of prepayment, prepayment time and default (Mayer et al., 2010; Gerardi et al., 2010; Demyanyk &Van Hemert, 2008; Foote et al., 2008).

3.7. New financial instruments

Various financial consuming or commercial products, services, processes and instruments emerged in the financial sector as combinations of other standardised products. They covered all aspects of the consumer's world and they were created in order to serve the economic agents' demand (business and households) for credit, lower cost, money flows and social services. Such products/services are the Cash management accounts, life or health insurances (or pension insurance contracts), money market accounts, certificates, etc.

For instance, the variable life insurance is a financial product that targets the economic agents' demand for a social health insurance. They are a kind of a Mutual fund73 that is embodied in an insurance contract. The current yield and the redemption

72 http://www.imfpubs.com/
73 A Mutual fund is a collective investment scheme that is invested is a pool of corporate securities, commodities, options, stock bonds, other mutual funds etc. Its net income is divided in equal shares, equity positions that are issued by the Mutual Fund Management Company. This is the proof of participation of an investor in the Asset of the balance sheet. The investor that holds shares (units) is called unit-holder. The individual assets of the portfolio belong as a whole to different agents. In other words, a mutual fund is neither a legal person nor a company but has the status of a management product of an S.A. that is established by the Hellenic Capital Market Commission (HCMC)-the
value are directly related to this mutual fund that is contained in the contract. This new product combines several standardised assets and securities and reconstructs the payoffs in a financial way.

Many financial innovations of commercial products and services emerged in combination with the development of other sectors like technology, Internet and industrial products. These products are mainly the new payoff and account management systems that satisfies consuming demand, they transformed the retail financial and bank market and replaced money transactions by offering to consumers distant, around the clock services for all kind of transactions. Such products are the automatic teller machines (ATMs), credit and debit cards, Online banking, etc.

*Debit cards* are a kind of instrument-card of a pay-now type that are connected to a bank account with online (pin-based) transactions or/and offline (signature based) accounts. The use of debit cards allows the holders to transact without cash. According to the periodical *ATM & Debit News*\(^7\) of 2009, only in the U.S., the amounts transferred by debit cards reached $30 billion. The major part of research on debit cards concentrates in the demographic and the social characteristics of possible users that adopt the product (Stavins, 2001; Mantel & McHugh, 2001; Hayasi & Klee, 2003; Klee, 2006).

*Prepaid cards* are the type of pay-earlier cards that the owners bind beforehand an amount for future purchase of products and services. Credit cards are a pay-later instrument the owners of which pay-off products and services afterwards. These two kinds of cards are either open systems (i.e. Best Buy) or closed systems (i.e. VISA or MasterCard), they associate with the pay-off time, they are used mainly to pay bills or for capital transfer and the cardholder has the flexibility to pay-off products and services as he wishes to (Cheney & Rhine, 2006; McGrath, 2005).

The rapid Internet development pushed financial institutions to adopt online buy/sell transactions of products and services, along with the parallel development of their security level (DeYoung, 2005). Until 2007, about 80% of the commercial organisations and of the important commercial financial institutions had offered to their clients’ online services and products.

The main issue for institutions was to form an appropriate and handy online independent regulatory authority for the capital markets. Unit-holders are neither responsible for the S.A. management actions or defaults nor for the Trustee. According to the law a bank can be a Trustee. (Philippas N., 2010)

\(^7\) [http://www.acclaimsubscriptions.com/](http://www.acclaimsubscriptions.com/)
operating system for customer services that would satisfy the demand, while they had to understand the process with which technology and Internet would affect their effectiveness (DeYoung et al., 2007). The Online service introduction for institutions brought new innovations like new IT systems, special trained personnel, etc. whilst they secured lower transaction costs, higher profit and important changes in the “competition terrain” (Hernando & Nieto, 2007).

The development of the financial theory and of technology created new financial evaluation instruments of risk management. Three popular risk measurement and evaluation techniques are the Value and Risk (VaR), the Stress Testing and the Credit Scoring. In any case, the main idea is to determine the capital level that is required by the financial or the bank institution in order to face possible critical fluctuating situations, financial difficulties, etc.

Value at Risk (Jorion, 2001) is defined as the major loss likely to be suffered on a portfolio in a certain period of time and level of statistical importance, thus it describes an average level of the future yield or loss distribution during the period studied, assuming markets are normal and for a defined trust period. The last few years four credit risk evaluation models, based on the VaR measure, have been added. The following models are measurement instruments of the credit risk that have an additional function.

1. CreditMetrics of JP Morgan: It is based on the possibility for every debtor to jump from one credit risk situation to another or/and to a default condition in a determined period of time. Risk comes from either the change in the creditworthiness of a company, because of the asset value fluctuation or from the change of the time structure of the market interest rates.

2. Portfolio Manager of KMV: It estimates the expected default frequency for every debtor, independently from his creditworthiness. The possibility of a company to end up in a default condition depends on the change in the asset market value in relation to the level of the debt obligations in its capital structure (structural approach).

3. CreditRisk+ of Credit Suisse First Boston: The default possibility is considered to be following a distribution (i.e. Poisson) relevant to the company's activity domain. In other words it depends on external factors (reduced form approach) and not on the capital structure or, in other words, the company's value.
4. CreditPortfolioView of McKinsy & Co: This model estimates for every company one possibility of default as well as the possibility for its creditworthiness to change, in accordance with normally changing macroeconomic factors. Thus, it embodies the situation in the economy, whilst transition tables alter during the turnover in such a way that a higher possibility to upgrade during economic growth and the opposite (to downgrade during economic recession) are included.

**Stress testing** is a process of recognition and management of extreme situations that could lead to unexpected losses. Instead of using historical facts, a series of price scenarios are created in order to foresee a portfolio's yield. Control gives answers to questions about specific scenarios: in case of an unexpected situation, what will be the market's reaction be? Stress testing gives answers to the following questions: i) what is the portfolio's loss for a possible scenario, ii) which are the worst cases and, iii) what needs to be done in order to limit the loss during the worst scenarios.

The most important financial institutions use new technologies and methods that evaluate the credibility distribution of small companies that grant loans (Berger & Udall, 2006). Such a new technology is the Small Business Credit Scoring (SBSC) that uses statistical methods and analyses general consuming data and their combination with the relative limited historical data of the small company in order to foresee future credit revenue or default.

Research on this field is wide. The adoption of this method by bank institutions is analysed by Akhavein, Frame & White (2005). The way that SBSC influences their credit availability is analysed by Frame et al., (2001); Frame et al., (2004); Berger et al., (2005); and DeYoung et al., (2008). At last, Berger et al. (2007) study the frequency that small and medium sized banks use the SBSC.

Within the current financial crisis, a company's risk evaluation and credibility pose important questions. How effective are the existing risk evaluation methods in minimising the default or the model's uncertainty? Do those models capture the effects hidden between the lines in the statistical relations of the total shock effects? Are there enough instruments and methods to test these stress tests? Answering such

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75 Important literature references on stress testing are presented by Fender & Gibson (2001), Berkowitz (2000), Kuipec (2000) and, BIS (www.bis.org) and CEBS (http://www.c-ebs.org)
questions is a real challenge for the credit portfolio sector and for their dependence on the expected loss distributions.

CONCLUSION – PART 1

The evolution of financial innovation in recent years has had a tremendous contribution to the financial and economic sectors because it has expanded the options of market participants among many new financial products, services or processes.

The variety of financial innovations is considered as the response of market participants to many of the changes in the financial, fiscal and regulatory international system. It is also an answer to their continuous search for minimizing costs and finding more flexible financial instruments that can restructure the capital markets and address the risks posed, due to the rapid development of economic environment, technology, competition and globalization of markets.

Previous research has noticed the importance of financial innovations by covering several fields of research such as the nature of financial innovations, the economic environment that encourage the creation of financial innovation, the consequences of financial innovations, the adopters and the diffusion of financial innovation, etc. In particular, we presented the significant role of financial innovations in main sectors of financial structure such as the derivatives markets, the monetary aggregates, the financial instruments, the mortgages markets and information. Summing up, we can say that the continuous evolution of the global economic environment will remain and the need to create innovative financial products will always exist on the future.

However, key questions are remained about the characteristics of financial innovation and its diffusion. In next chapter, we will try to answer and analyze some research hypotheses questions into a theoretical and mathematical framework. These questions are concerned the nature of financial innovations, the role of market frictions in the development of financial innovations and give a mathematical framework about the influence of the diffusion of financial innovation to market participants.

The results of this analysis are very important because: i) they show the significant factors that create the need for innovation, ii) they explain why financial innovation should not be a temporary response to restrictions and overcome difficulties but they are truly created to complete markets and minimizes risks through new forms and techniques, iii) they give the structural characteristics of financial innovations that
different from plain occasional products and persist in time, \(iv\) they show how financial innovations smooth the market frictions that exist between market participants because of the dynamic financial structure and, \(v\) propose a modelling methodology about the influence of the diffusion of financial innovation to market participants.

Therefore, future research should move in two main areas: \(i\) the design, creation and diffusion of functional financial innovations and, \(ii\) the analysis of the factors that make the benefits of financial innovation last in time.
PART 2
CHAPTER 4
THEORITICAL APPROACH – RESEARCH HYPOTHESES

In this chapter, a structural framework for financial innovation is presented through a theoretical and a mathematical point of view. The chapter is divided in two sections. Section One presents the theoretical hypothesis framework and Section Two presents the mathematical framework for the influence of the diffusion of financial innovation to market participants.

In particular, at the 1\textsuperscript{st} section we examine the structural characteristics of the financial innovations and the role of market frictions in the development of financial innovations. In particularly, we examine the following research hypotheses concerning:

1. *The structural characteristics of a financial innovation based on a microeconomic framework.*
2. *The role of financial market frictions to the development of financial innovations.*
3. *The social value of financial innovation*
4. *The role of the regulation and state in innovative market activities*
5. *Conclusions of the section*

Furthermore, in order to model and demonstrate the above through a mathematical framework that shows the influence of the diffusion of financial innovation to market participants, at the 2\textsuperscript{nd} section we examine the following hypotheses:

1. The theoretical mathematical framework and the assumptions. In particular, we examine:
   - the diffusion process with Pareto distribution–Univariate and multivariate case
   - the diffusion process with compound GP distribution–Univariate and multivariate case
2. the introduction of the diffusion factor to econometric models and in particular:
   - introducing the diffusion matrix as exogenous factor on simultaneous equations model
• introducing the diffusion matrix as regressors factor to conditional variance-covariance equation

The results of this analysis will lead to important conclusions about the significant factors that create the need for innovation, the role of frictions at the creation of financial innovation and their structural characteristics and, finally, a model about the influence of the diffusion of financial innovation to market participants without being limited to the actual modelling of diffusion.
SECTION ONE

4.1. The structural characteristics of a financial innovation – Microeconomic framework

The previous years, financial innovation led to the substantial transformation of the capital markets worldwide by creating new investment opportunities. And yet, nowadays, financial innovations are blamed for being the main reason why the financial crisis was triggered again after many decades.

Financial innovations have particular characteristics that differ from the analogous industrial and technological innovations. Financial innovations influence the financial intermediation, which is the functional core of the financial sector. In other words, it helps moneys move from one investment or form of investment to a more profitable one. Thus, the main goal of financial innovations is the effective financial intermediation for companies and households. This goal is attained with the increase of liquidity, capital adequacy, funding, asset-based mortgages, the cost reduction of transactions, securitisation, etc.

Nowadays, the challenge is to reconsider financial innovations and to be able to distinguish a successful financial innovation from an unsuccessful occasional one.

4.1.1. What is considered a successful financial innovation?

Successful financial innovations are those of which the results have a constant character, that are resistant in time and continuously increase by encouraging or/and by creating a chain reaction (a new wave) of innovations even if the original change, which generated the initial need for the innovation to be created, is no longer standing.

A financial innovation is successful when it creates a productive way to use capital that in other cases wouldn't happen. In other words, a successful financial innovation adds value by making financial intermediation available to all economic agents (companies, households, intermediaries) that can effectively use it by reducing transaction costs and by making the market more attractive. Thus, we reach the conclusion that a financial innovation is successful when it differentiates beneficial financial intermediation from exaggerated intermediation.

A simple example of financial intermediation is savings banks. Households and companies place their savings to savings banks that, in turn, collect the money and offer savings account interest rates, while they lend with higher interest rates. Thus, households make profit through savings accounts and take loans to purchase goods and companies spread their activities through loans.
A financial innovation is not necessarily successful just because it exists or because it creates a new market (Plosser, 2009). Sometimes, financial innovations don’t manage to meet the expectations or/and have unpredicted negative consequences, because of the exaggerated financial intermediaries. In other words, they fail to pass the market test. Their failure costs investors and consumers. Such a case was the asset-based mortgages in the U.S. during the current crisis. Because of the excessive number of new loans, each and every consumer could buy a house.

However, their current value is less than their construction cost and the income increase expectations were not fulfilled. On the other hand, because of the creation of the new demand, in the market, for new houses because of new loans, the construction of new buildings was spectacular, which obviously means that there was a huge waste of money. What comes out from the above is that while asset-based loans are a beneficial innovation, we can’t easily argue for it because of the current phenomena of real estate bubble.

The radical regulatory framework about financial intermediation is partly blamed. Its structure should, on the one hand, discourage financial innovations that create exaggerated intermediation and, on the other hand, it should encourage innovations that provide financial services that consumers and investors are in real need of. Thus, a regulatory framework is successful when it can discern when a financial innovation promotes a beneficial and competitive financial intermediation. During the last few years, the financial mechanism allowed companies to create a variety of new products and securities as well as new financial evaluation instruments.

However, because a security is born, its survival and success in the market is not taken for granted. Many new products, like structured investments or SIVs\(^{77}\) may not survive or may take different forms. The message is that financial innovations are profitable with many economic and social benefits and yet this doesn't mean that every innovation will survive and pass the market tests within a rational regulatory framework.

The success of a financial innovation depends equally on another factor that is to

\(^{77}\) A structured investment vehicle (SIV) was an operating finance company established to earn a spread between its assets and liabilities like a traditional bank. The strategy of SIVs was to borrow money by issuing short-term securities, such as commercial paper and medium term notes and public bonds at low interest rates and then lend that money by buying longer term securities at higher interest rates, with the difference in rates going to investors as profit. Long term assets could include, among other things, residential mortgage backed securities, auto loans, student loans, credit cards securitizations and corporate bonds.
what extend investors trust its evaluation models. Complex portfolio valuation models, used by financial institutions, are the base for the pricing of assets and securities, according to their turnover. However, most investors (mainly those who trade asset-backed securities) know little about pricing models and risk models, their week points and potentials. So it's not only a matter of new financial products but of their financial valuation instruments as well. The new financial theory has developed various models in order for investors to have different information flow and different complexity degree and, thus, divergence is created in some new markets. This could be the case of liquidity problems or regulatory constrains for example.

Nevertheless, what really happens is that when models are relatively new and complex, the investors are shifting their confidence at them. The trust alterations can enforce mutability that is generated by the investors' shock when they realise that random mutable situations, like interest rates and macroeconomic conditions, possibly exist. This happens when reality has fundamental deviations from previous predictions. Part of the recent fuzz in the markets was due to the loss of the investors' confidence in evaluations that financial institutions gave about different assets and credit products. Thus, investor’s expectations are changing radically.

Another crucial problem is the incomplete or/and private (no free access) data bases that consequently give wrong estimations about models. For example, many financial institutions use risk models of asset based loans, based on private data that may not be trustworthy or, in many cases; these models don't include data of the last market declination in the 90's. Wrong estimations would possibly be less, if researchers had access to high quality data that covered multiple turnovers of the markets they were referring to.

The shift of the investors' confidence in valuation models of new products can take just a little time to happen and can cause instability to financial markets. The level of confidence in models about a new financial product depends, partially, on the level of effectiveness of the model, on the dependence and evaluation relation of the participants' frictions in the market during the diffusion process of the innovation and on time. Thus, the effectiveness of valuation models has to be improved in order to improve the interpretation of mutability and frictions between the market's participants.

The question posed lately is whether financial innovation processes have already come to the point of diminishing returns. The answer is that as long as financial innovations are created as the result of financial developments, financial innovations
will continue to be necessary financial tools in the future. Financial innovations will continue to thrive as long as capital markets will continue to evolve, transform and cause uncertainty. The attention of financial institutions will be constantly shifting towards more profitable financial products to offer in order to become more competitive. The range, the returns and the effectiveness of financial products/services will increase while technology will develop. The differences between depository institutions, investment banks, insurance banks and retailers, will be minimising.

Most financial institutions will adopt dynamic strategies in order to protect their liability by increasing their motives for further expansion of their transactions and this, in turn, will allow a more effective realisation of their strategies. Further differentiation of risk, less transaction costs and the reduction of asymmetrical information will contribute to a further improvement of financial strategies and investing activities (Pilbeam, 2011). This shift in combination with an information advantage will create more liquidity in the markets.

Moreover, there will be more demand for regulatory protection with emphasis on the investors' protection, on healthy collaborations between investors and companies, etc. The markets' extension, the decrease of transaction costs, the continuous development of technologies and information diffusion will facilitate the development of the financial services of companies by extending their financial perspective.

4.2. The role of financial market frictions in the development of financial innovations

Financial market frictions are defined as anything that perturbs (positively or negatively) financial intermediation and financial transactions in a market with two important consequences: i) force market participants to deviate from their market portfolios and, ii) make them expose to more or less risk than they would prefer to. The term “market portfolio” doesn't include only financial assets. It also includes real estate assets, human capital, investment timetables and everything directly or indirectly related to the above.

Financial market frictions generate costs that act on transactions and create insecurity to the market participants as they can't transform their portfolios without a cost. For example, an investor holding a suboptimal portfolio could lower his risk without sacrificing expected return or he could improve his expected return without accepting more risk by rebalancing his portfolio. However, rebalancing is costly or even
impossible in a financial market with frictions. It may pay to accept portfolio’s inferior combination of risk and expected return rather than to incur the costs of trading. The result is that he holds a part of the market portfolio.

There is a significant difference between financial frictions and market’s inefficiencies. Markets tend to be efficient even when the presence of financial frictions is enormous. Security prices reflect all the public information but not, necessary, all the private information. Securities pricing errors are not classified as market frictions. If a security pricing error exists, market participants make their choices and weigh their portfolios based on that pricing error. A short run behavior of security prices through time is affected by a variety of different sources of trading frictions such as order processing costs, inventory effects, information effects, etc.

4.2.1. Market Microstructure

Market microstructure is the financial architecture that characterizes a financial market, its financial intermediation and frictions. Market microstructure analyzes the costs of providing transaction services and the impact of such costs on the short run behavior of securities prices where; costs are reflected in the bid ask spread and the related measures (O’ Hara, 1995).

The major types of market structures are the continue call auction market and dealer market. Continuous markets are characterized by the bid and ask prices where trades can take place. The bid ask-spread reflects the difference between what buyers must pay and what sellers receive (Huang & Stoll, 1997). Bid ask-spreads vary widely depending on the nature of the market. In an actively traded stock market the spread is low per share. Under a specified market microstructure, a short run behavior of security prices through time is affected by a variety of different sources of trading frictions, such as order processing costs, inventory effects, information effects, etc.

For example, consider a stock investor who prefers an equal mix of stock and bonds. If stock prices rise while bond prices do not, then the portfolio becomes over weighted with stocks and is too risky for the investor. But selling some of the equities to reestablish the equal mix would trigger capital gains taxes. Because of this, the investor may choose to retain the unwanted risk exposure rather than incur a tax liability.

A pure auction market is the one in which investors (represented by a broker) trade directly with each other without the intervention of dealers. A call auction market takes place at specific time moments when the security is called for trading and the investors place orders at a specific moment according to specific rules. In real world, most markets started as call auction markets and later became continuous auction markets as trade volume is increasing. In a continuous auction market, investors are trade without taking into consideration resting orders placed earlier by other investors and the large number of brokers. Generally, traders in continuous markets are classified in a variety of ways such as, active or passive, liquidity or informed, individual or institutional, public or professional. Most markets are continuous (as NYSE and European markets). Electronic markets are also continuous markets (Hasbrouck, 2006).
Security prices with greater friction tend to have larger spreads and greater short run variability (Madhavan et al., 1997). In thin markets for risky assets, participants search for counter-parties directly because the fixed costs of capital investments (including communication and information) are too large to be offset by the lower marginal costs of each transaction if transactions are few. Transactions costs are lower in these high-volume markets\(^{80}\).

4.2.2. Previous literature in financial market frictions

Financial market frictions have been a subject of research interest the last years for the financial analysts, approaching general or individual subjects and types of frictions. Several studies focus at the research of financial innovations that were presented because of financing frictions and, reversely.

Levine (1997) analyses the link between financial innovation and market frictions and explains the way that financial system affects economic growth based on a functional approach. This approach examines frictions between development and quality of functions that the financial system provides, in particular through innovation. Previous important studies are those of Van Horne (1984), Flood (1992), Chen (1995) and, particularly, Ireland (1995) who is among the first that mention the threshold levels as the condition to innovate because of market participant’s frictions.

The analysis of risk premia equilibrium models in bond markets shows that the great volatility of interest rates and risk premia is linked to standard real business-cycle developments or/ and inflation expectations (Wachter, 2006; Ravenna & Seppala, 2007; Le et al., 2009; Bansal & Shaliastovich, 2009). Ashcraft & Schuermann (2008) identify seven key informational frictions\(^{81}\) that arise in the originate-to-distribute model. They also discuss how market participants work to minimize such frictions and speculate as to how this process fails.

\(^{80}\) As trading volume increases, markets evolve from direct search through brokered, dealer, and continuous auction markets. As trading volume increases, it begins to make sense to invest in capital and to acquire specialized knowledge about potential buyers and sellers to facilitate trading. If volume increases still further, or if risk decreases, brokers find it efficient to buy and sell on their own accounts. Although holding inventory is risky, if the asset value is sufficiently stable or if its liquidity is sufficiently high, then this risk is worth taking because holding inventory permits the dealer to make more trades in less time. For some assets, trading volume is so high that a continuous auction is possible.

\(^{81}\) These keys are: \(i\) Frictions between the mortgagor and the originator, \(ii\) Frictions between the originator and the arranger, \(iii\) Frictions between the investor and the credit rating agencies, \(iv\) Frictions between the asset manager and investor, \(v\) Frictions between the servicer and third-parties, \(vi\) Frictions between the servicer and the mortgagor and, \(vii\) Frictions between the arranger and third-parties.
There are studies that show the positive friction (contribution) of the increasing production on risk premia volatility in U.S. Treasury markets (Ludvigson & Ng, 2009) and swap markets (Joslin et al., 2009). The changing intensities of using interest rate swaps over the business cycle are likely to induce a strong link between financial frictions, credit availability, and swap rates. Moreover, market participants often express concerns about possible deterioration of the credit quality of bond insurers and financial intermediaries through higher risk premia and rates in swap markets (McCormick, 2008). Thus, risk premia in swap markets are likely to be informative regarding the importance of financial market frictions.

In conclusion, several studies of financial frictions show the follows:

- The link between the soundness of intermediaries’ balance sheets and risk premia in financial markets (Allen & Gale, 2005; Vayanos, 2004; He & Krishnamurthy, 2008).
- The deterioration in the capital and collateral positions of financial intermediaries during economic downturns affects their funding liquidity (Brunnermeier & Pedersen, 2008).
- The strong relationships between changes in bank lending conditions and future growth in aggregate real output (Lown & Morgan, 2006).
- The strong predictive content of credit spreads for future output (Gilchrist et al., 2009) has been attributed to links with expected corporate cash flows (Philippon, 2008) and cyclical variation in consumers default risk premia (Gomes & Schmid, 2009).
- Investors and investment advisers have inherent conflicts of interest because they have different goals as investors want maximum returns with minimum risk, and advisers want maximum profits with minimum effort (Tkac, 2004).

4.2.3. Classification of financial market frictions

The number of financial frictions is huge and can be classified in many different ways in relation to imperfect information, to the alignment of motives and goals, to liquidity, to the economy's articulation to facilitate economic activity, to dynamic systems, etc. Thus, there isn't only one way to classify frictions as there isn't a single way to classify financial innovations.

We can classify financial frictions in categories only by choice, without refusing
that a type of friction can belong to more than one category. By structuring financial frictions, we can create four basic categories: i) transactions costs, ii) taxes and regulations, iii) asset indivisibility and nontrade assets, iv) agency and information problems.

Transaction costs are probably the most familiar financial market friction. Advances in communications and data handling technology have reduced not only the costs of trade to a fraction of what they were just a few years ago but also the time needed to make trades. Together these forces probably more than offset an increase in the opportunity cost of time itself (Vayanos, 1998). We can categorize transaction costs as:

1. **The costs of trade in financial markets** include real expenditures of resources which have been declining with technological improvements. Over some periods these costs may have risen in real terms but the costs of communication and data analysis have fallen over time.
2. **The opportunity cost of time**: Trading requires time (time to search, to gather information, to find a trading partner and the time to make the trade itself). Minimizing these costs represents a profit opportunity. One partial solution is to automate the process by means (e.g., automatic electronic payments). Another example is dividend reinvestment plans, which let investors hold securities directly and automatically reinvest dividends (DeGennaro, 2003 and 2005).

Taxes and regulations is the second category of financial market frictions. Taxes and regulatory costs can be either explicit or implicit.

1. **Explicit taxes** can be pecuniary or non pecuniary. Corporations pay pecuniary taxes on income, which change prices and can even affect the medium of exchange. Investors can generate deductions to offset dividends earned in order to eliminate the tax on the dividends. Individuals pay income and capital gains taxes, and these payments surely affect their consumption decisions, their

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82 Vayanos (1998) builds a general equilibrium asset pricing model with transaction costs. He shows that a stock’s price may increase as transaction costs rise because an increase in transaction costs has two opposing effects on the stock’s demand. While investors buy fewer shares, they hold shares for longer periods, and either effect can dominate. Vayanos finds that realistic levels of transaction costs have very small effects on asset returns but large effects on investors’ trading strategies and turnover.
wiliness to work, their investment decisions and trades. Taxes can also be non pecuniary, paid in effort, time, and resources.

2. *Implicit taxes* can be capital requirements of insured banks, privately imposed regulations or restrictions (such as short-sale restrictions or underwriting contracts)\(^8\), pricing errors that arise from financial market friction, government-imposed regulations, compliances costs\(^8\) which affect portfolio allocations and trades, etc.

The influence of taxes and regulations is enormous. Managing and coping with them requires a considerably large investment; thousands of lawyers, accountants, and practitioners work daily to comply with taxes and regulations in the least costly way for firms and households.

*Asset indivisibility (or derivation)* is an important category of financial market frictions. If assets were infinitely divisible, then investors could hold an arbitrarily small portion of each asset. This practice would permit all investors and brokers, even the ones with little to invest, to hold the market portfolio of all investable assets. On the other hand, same investors or brokers could create infinite derivatives assets, because the divisibility of their underlying assets is infinite.

In fact, the minimum trading unit of assets is finite. This means that most investors must decide whether to hold the smallest trading unit of an asset or to omit it from their portfolios. The portfolios created in this way will not be invested in the same proportions as the market portfolio. This also depends on the volume of wealth of investors because a wealthy investor can hold a larger number of assets. Combined with trading costs (fixed and velocity ones) asset indivisibility is more difficult for investors with limited means of investing because their portfolios tend to lie further below the capital market line.

Another problem is the non-trading assets that generate multiple financial frictions because they are not tradable. This kind of assets (such as human capital or the capital

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\(^8\) Because underwriting contracts is costly, annuities are designed to be long-term investments, and issuers impose these fees to discourage customers from canceling the contracts after short periods. Otherwise, if investors hold such contracts for only short periods, transactions costs would harm the contract’s performance. In turn, this lower performance would make the contract less attractive to those who seek a low-cost, long-term investment. Still, these restrictions do limit trading because an investor wishing to abandon this annuity and invest the proceeds elsewhere might find it too costly to do so.

\(^8\) Financial Executives International (2005) surveyed 217 public companies with revenues averaging $5 billion and found that the costs of compliance averaged $4.36 million per firm (www.financialexecutives.org).
stock) tends to drive investors away from holding the market portfolio. We cannot say that if an asset begins to be traded, then market frictions will not be eliminated, but will be exchanged for another, less costly friction. After all, trading assets are also subject to financial market frictions.

Agency and information problems cause many financial frictions. Separation of ownership can lead to incentive problems, and financial contracts cannot handle them at zero cost. Conflicts of interest are also causing financial frictions. Imperfect information can lead to inaccurate credit decisions, in turn meaning that lenders miss some good loans and make some bad loans. Asymmetric information can also affect prices and prevent markets from clearing.

The information asymmetry can work either in favor of or against various groups. For example, management knows the correct value of the company but investors do not. Investors know that management knows and they know that management is issuing shares rather than borrowing or using cash to take on projects. This information problem can cause firms to forgo profitable projects and to issue more debt and hold more cash. As any contract is subject to information asymmetry and agency problems, these financial market frictions touch virtually every area of financial economics.

4.2.4. Do market participants belong to a network where frictions thrive?

With the term “network” we mean the connection or, in other words, the level of association of the network's participants that compose the network's nodes (Watt & Strogatz, 1998). We can make the hypothesis that each and every participant of the financial system (investors, consumers, markets, economies, etc.) belongs to one of those networks (or to separate networks with common characteristics) and the random movement (r) (to every direction) from one node (participant) to another is possible and depends on their in between financial friction (Philippas & Siriopoulous, 2009). The

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85 Palacios (2002) gives one explicit example for human capital contracts for financing higher education in the U.S.
86 This is Akerlof’s (1970) familiar “lemons problem (Longhofer & Peters, 2005)
87 Consider initial public offerings (IPOs). Investors usually have great difficulty valuing the new securities. Obviously, no recent market price is available, financial statements might be limited, and analysts rarely provide much coverage. In addition, the current owners know more about the company than potential buyers do. In the context of Akerlof’s lemons problem, the owners know whether the company is a good company or a bad company. In addition, they have incentives to overstate the company’s value. Investors are aware of the information problem, of course, so they assume that the company is bad and bid accordingly. In fact, unless the current owner of a good company is able to credibly certify that the company is good, he will not take a good company public. Without access to certification, the IPO market for good companies fails.
network's nodes are the participants and every connection between two nodes reflects their correlation. This network is represented at the figure below (Figure 4.1.):

**Figure 4.1.: The network nodes of market participants**

![Diagram](image)

The level of connectivity (movement) of such a network fluctuates from absolute normal \((r = 0)\) to absolute random \((r = 1)\), while the parameter \(r\) reflects the level of association, that is to say the time that a situation needs to travel from one node to another one which depends on the friction level. As all numeric values for the interval \([0, 1]\) can randomly occur, the fluctuation in the diffusion of a financial innovation shows the nodes' friction in relation to their association.

The higher a participant's friction level (who is subject to all the effects of a financial innovation) with another participant, within the network, the higher the level of insecurity that stems from the lack of knowledge about the financial innovation. In consequence, when the level of movement \(r\) fluctuates and thus frictions between the network participants are different and fluctuate, diffusion travels through the network with a different speed, perception and entropy (average level of uncertainty) without having the possibility to overcome a network's node either because no shorter path exists or because of the participant's importance.

The diffusion of a situation is more possible to happen faster between nodes that are more interrelated, as long as the frictions between them are not as strong and the
level of insecurity is low. For instance, the development of technologies that originate from constant capital investments gave the possibility to consumers to buy products on credit, in markets where initially they would have needed money to do so. In this way, the part of the financial system where credit cards are used is a network that changed the way to trade (money transactions decreased) and widened the transactions range (Ireland, 1995).

4.2.5. The economic significance of market financial frictions

The economic significance of financial frictions is enormous. Financial frictions can affect the financial decisions and the behavior of market participants. We can see evidence of the effect of frictions on the returns of investors’ portfolios and optimal holdings of risky assets, such as stocks, on financial indices and investment opportunities.

For example, the gap between the interest rates, at which consumers can borrow and lend, is a major source of profits for financial institutions and exists because intermediation (the linking of borrowers to lenders) entails costs to overcome information asymmetries. On the other hand, frictions can affect the investment opportunities, reduce investors’ utility and prompt investors to change their behavior and trade less (Lo et al., 2004).

Market frictions can affect risk-return trade-off of a given portfolio weights and have a substantial effect on portfolio rebalancing frequency. Different portfolio weights could depend on the fact that, in the presence of transaction costs, portfolio rebalancing becomes more costly. Finally, financial market frictions can affect the academic and empirical research on asset pricing, which is conducted within a framework of frictionless asset markets (agents do not face transaction costs and are not subject to short-selling constraints, when they formulate models to explain asset returns).

Therefore, we can say that market financial frictions is a set of market participants (it is created by them and depends on them) that can have an additional positive or a negative impact on them and is characterised by a dynamic attitude. More precisely:

1. Market financial frictions may create costs for the participants: by realising these costs, investors can understand the overall transaction costs and decide the way to handle them.\(^{88}\)

\(^{88}\) Constantinides (1984) show that the option to take defers capital losses or gains has a substantial value. The
2. *Market financial frictions may generate business opportunities*: costs are paid to an entity. Organisations with lower market friction costs have a comparative competition advantage (DeGennaro, 2003).

3. *Market financial frictions may transform in time*: the level of market frictions varies, changes, new ones are created and others disappear in time. This is more obvious in the banking sector where analysts deal with bigger and more complex banking products than the ones they used to deal with ten years ago. However, these difficulties are counterbalanced with the increase in the amount of information and the computing power they nowadays are armed with. Another basic element is the interest shift towards the quality of information rather than the quantity.

4. *Market financial frictions depend, partially, on the market's structure and its participants*: the market's structure depends on the risk of the assets that are traded and on the trade volume. The potential market size defines the equilibrium structure.

4.2.6. The value of information

Information is a unique innovative commodity by nature. When information is publicly known, it becomes a standardized commodity for any individual investor. All investors can experience any kind of information before knowing its value (Shapiro & Varian, 1999). The same piece of information can be consumed by any number of people without losing any of its benefits (Stiglitz, 2000).

The existence of uncertainty over the value of a traded commodity is in the nature of information markets. When investors adopt any piece of information, it becomes their asset, and therefore they do not have to buy more of it. For an efficient market, security prices fully reflect all available information effects. Prices reflect available information to such a degree that, the marginal profit of acquiring information and using it for trading is equal to the marginal cost (Fama, 1970).

Under a specified market microstructure, a financial time series in a continuous stock market (such as an index or a security price or an interest rate) can be denoted as

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89. Kane (2000) shows that regulators face a similar problem: The complexity and difficulty of resolving an undercapitalised institution increases with the size of the institution, and megamergers have the capacity to shift the political calculus of a resolution and all the financial market frictions that entails, enormously.
\[ Y_t, \ t = 1, 2, 3, \ldots \] In every time moment \( t \), the value of time series reflects the price level of financial series subject to an information set \( I \) subject to time \( t-1 \) \((I_{t-1})\). This information set is known but not necessary incorporated by the market traders.

Previous research has concentrated on exploring the importance of demand or supply of financial information and the unique characteristics of information at a theoretical level\(^{90}\). Other studies concentrate on information flow and in particular on firm-specific information or macroeconomic or market related information\(^{91}\).

During the last decade, all economic agents (investors and consumers) have been exploiting information from electronic and printed hardcopy press and particularly the Internet search volumes. This happens because the Internet is nowadays the main source of intermediation, promotion and consumption of information in financial markets\(^{92}\). A significant number of investors and consumers use the Internet as an information source and for overview. Information supply generates dynamic relationships among the investors and it is possible to diversify the investing interest because of the frictions that information creates.

The most common manner of searching any desired information is through the online search engines. The most famous one is Google Search Engine. Google search engine has developed a metric system to measure the “hits” (attention) of an individual or a group of investors. This system, called Google Trends Labs containing Google InSight for Search, measures the number of “hits” on a specific topic and can be categorized by country, subject of search and time, offering frequently publicly available data at no cost. Recently, empirical studies\(^{93}\) have shown that Google Trends Labs captures the individual investor’s attention, has a temporary effect on stock prices and can significantly predict daily realized volatilities of indices. They also construct the relative Financial Economics Attitude Revealed by Search (FEARS) index.

At the other hand, information is not always rationally evaluated or can be controlled. The information and the value of information are not absolute measurements because they depend on the way the information receiver understands a forecast. The value of information has a different impact on any investor with different inventory

\(^{90}\) Grossman & Striglitz, 1980; Allen, 1990;
\(^{91}\) Ederington & Lee, 1993; Mitchell & Mulherin, 1994; Berry & Howe, 1994; Ryan & Taffer, 2004;
\(^{92}\) Barber & Odean, 2001; Antweiler & Frank, 2004; Veldkamp, 2006;
\(^{93}\) Da et al. 2009a, 2009b & 2010; Vlastakis & Markellos, 2010;
Information asymmetry\textsuperscript{94} and information’s value asymmetries are market frictions and are always generated even though an increasing number of people is going to have easy access to all types of information, as a result of the technological advantages.

However, the demand for information still exists. Technology can give all types of investors’ access to all types of information in any market. However the problem is not eliminated because there are many conflicts of interest, as there is a variety of investors aiming at the same profits. A financial innovation can be introduced to market participants for reducing the asymmetric information and moral hazards problems and, furthermore, lead market to more completeness because financial innovation can distribute the information demand to bigger number of participant equally. However, the value of information flow has not the same influence to all the participants.

If we consider information as a financial innovation that can be publicly known, it is important to ask ourselves an arising question: if markets are not efficient and prices cannot fully reflect the available information, what rate of information do prices reflect? Does the value of a financial information is mispriced\textsuperscript{95}? If this happens, does this information trivialize financial assets?

It is an interesting question to what extent investors anticipate to announce news and where they get that information. Moreover, it is interesting to compare how volatility responds towards to information flow. It might be possible that a large part of volatility can be explained by the information flow and announcements news, because investors can already anticipate before the news is released and over or under reactions might be at stake. Additionally, risk management and derivative pricing can be ameliorated.

Previous literature examines how heterogeneous asset prices response to macroeconomic announcements and concentrate on information flow and particular on firm-specific information or macroeconomic or market related information. Some announcements have a strong impact on asset prices and others not. The common

\textsuperscript{94} Asymmetric information is a situation in which one party in a transaction has more or superior information compared to another one. This often happens in transactions where the seller knows more than the buyer, although the reverse can happen also. Potentially this could be a harmful situation because one party can take advantage of the other party’s lack of knowledge. Asymmetric information can lead an investor to two main issues: i) adverse selection which is an immoral behavior that takes advantage of asymmetric information before a transaction and, ii) moral hazard which is an immoral behavior that takes advantage of asymmetric information after the transaction.

\textsuperscript{95} Like Oscar Wilde noted: cynic men are those who know the price of everything and the value of nothing.
explanation is that timing matters—announcements released earlier in the cycle affect asset prices more.

Mitchell & Mulherin (1994) study the relation between the number of news announcements reported daily by Dow Jones & Company and aggregate measures of securities market activity including trading volume and market returns. They find that the number of Dow Jones announcements and market activity are directly related and that the results are robust to the addition of factors previously found to influence financial markets, news importance and major macroeconomic announcements, and non-information sources of market activity as measured by dividend capture and triple switching rating.

Berry & Howe (1994) present a measure of public information flow (news releases by Reuter's News Service per unit of time) to financial markets and use it to document the patterns of information arrival, with an emphasis on the intraday flows. They find that public information arrival is non constant, present seasonality and distinct intraday patterns. According to their findings the authors suggest a positive, moderate relationship between public information and trading volume but an insignificant relationship with price volatility.

Jones et al., (1998) and also Christiansen (2000) examine the response of Producers Price Index (PPI) and Employment (EMP) releases on Treasury bond market volatility. Their results indicate significant increases in bond market volatility on announcement days. This increase does not persist, as news is immediately incorporated in the prices.

Kuttner (2001) estimates the impact of monetary policy actions on bill, note, and bond yields, using data from the futures market for Federal funds to separate changes in the target funds rate into anticipated and unanticipated components.

Ryan & Taffer (2004) examine whether firm-specific information events drive economically relevant positive and negative stock price changes and trading volume and, so, the nature of such information. They find that a significant number of price changes and trading volume movements of companies can be readily explained by public domain information. Taking into account the magnitude of market response to different news releases, they also find that firms' formal accounting disclosures dominate within this domain.

Sager & Taylor (2004) examine the evidence regarding systematic patterns in the euro/dollar foreign exchange market on days when the Governing Council of the
ECB announces its interest rate decisions versus other days. The authors find strong evidence that the Governing Council policy announcements contain significant news content.

Goeij & Marquering (2005) analyses the impact of macroeconomic news announcements on the conditional volatility of U.S. Treasury bond returns. They find that announcement shocks have a strong impact on the dynamics of bond market volatility. The bond market incorporates the implications of macroeconomic announcement news faster than other information.

Sager et al., (2009) examine evidence of systematic patterns in exchange rate movements on Monetary Policy Committee’s days over the first decade of operation of the Monetary Policy Committee. They use a Markov switching framework that incorporates endogenous transition probabilities, which allows an interesting alternative characterization of macroeconomic news effects on the foreign exchange market. They find evidence for nonlinear regime switching between a high volatility, informed trading state and a low volatility, liquidity trading state.

Finally, Gilbert et al., (2010) define in a novel way the relevance or information content of a macroeconomic announcement as its ability to forecast decisions, to nowcast GDP growth and inflation, to investigate of what extent the information content. They find that timeliness and revision noise of macroeconomic announcements help explain the differential impact of news on asset prices. They also find that a significant fraction of the variation in price impact can be explained by differences in information content.

4.2.7. The connection between financial innovation, market frictions and information distribution

Financial innovations are created in order to reduce strong financial frictions between the market's participants. The attempt to smooth such frictions demands additional expenditures. Hence, the financial system will strengthen and the benefits of a financial innovation will be revealed.

The presence of market frictions prevents the market's potential from distributing the risks between its participants. Thus, the equilibrium in such markets is
no Pareto efficient\(^9\). In this way the possibility is given to innovative investors to enter the market to a pro-innovation equilibrium having in mind to introduce in Pareto securities.

The introduction of such securities can be considered an arbitrage chance for these investors (Citanna & Cass, 1998). When equilibrium is no Pareto efficient, pricing that maps a price on every possible requirement is not necessarily linear. Thus, market frictions can create deviations in equilibrium between the prices of a requirement and the price of a portfolio. This deviation may also appear in the equilibrium, as market frictions can make investors reluctant. In such cases, innovative investors must find profitable securities and take advantage of price deviations. This arbitrage chance is available only to innovative investors because of their potential to issue new bonds and of their advantage of handling friction costs at will, as they prevail over ordinary investors. Financial innovations will be linear combinations of the already existing financial instruments but with a better use.

In that case, financial innovation can continually remove items from the list of non-trading assets by introducing new instruments that render assets effectively tradable. It can also make assets more divisible and can derive them in new instruments. In some of these cases, bundling the assets reduces idiosyncratic risk. In addition, the innovation permits unbundling the assets’ risk and selling parts of it to investors who are better able to bear it (Degennaro & Robotti, 2007). Therefore, we can point out the followings:

The first point is whether financial intermediaries that innovate should be limited to specific market subsets (and thus to friction subsets). This limitation would impede the innovation process, as additional innovations that would be required in different markets may not be substantiated or considered or may even be delayed.

The second point is whether market participants identify the use of a financial

\(^9\) A Pareto improvement occurs when there is a change in the allocation of resources which makes one person better off but doesn’t make anybody else worse off. Pareto efficiency is said to exist when no other improvements can be made in the allocation of recourses to one individual without it casing a loss to others. A simple way of explaining Pareto efficiency would be to say that it refers to a situation where it is not possible to make one person better off without it necessitating other people being worse off. Pareto efficiency is not related to equity. Given a set of choices and a way of valuing them, the Pareto frontier or Pareto set is the set of choices that are Pareto efficient. The Pareto frontier is particularly useful in engineering: by restricting attention to the set of choices that are Pareto-efficient, a designer can make tradeoffs within this set, rather than considering the full range of every parameter. The idea of Pareto efficiency is often used in the real world. It provides justification for increasing the resources given to one group if doing so does not lower the resources of other groups. All though Pareto efficiency is not concerned with equity there are many who would see it as fair. When applying the concept to the real world there is often the idea of compensation; if a change causes a loss to one group they receive compensation so that there is no real loss (http://en.wikipedia.org/wiki/Pareto_efficiency).
innovation since the first moment of its appearance or/and whether they are all more or less equally uncertain (or share the same amount of information).

Kenneth Arrow (Nobel prize, 1972)\(^7\) said that the first thing we get to know (and then buy) about a product/service is the information regarding its value, which is often not possible to be known from the beginning because we don’t know the effectiveness of the product/service. Simultaneously, the buyers require collateral of minimal quality about this product/service. This means that the tradable product/service is adjusted because the offering quality is not determined from the beginning of the trade and more over because the failure cost is high. Both these issues lead any market to regulation. Furthermore, sellers and buyers have a social contract meaning that the seller follows ethical codes (deontology) and he does not deceive the buyers.

What happens is that market participants don't have the same information about the usefulness of the financial innovation that is introduced in the market by one participant. This can happen because there is a continuously distribution of asymmetry in information, and moreover, the participant who introduces the financial innovation set mispriced value according to the functionality that the innovation was created in the first place (they are sometimes diametrical opposites).

The contribution of the financial innovation is difficult to be measured and can't be instantly defined. The innovation is the one that adds value to the company. This is reflected in the company's share value, even though this value is not subjective as it is based on a group of imprecise hypothesis about the innovation's usefulness. It is the best possible scenario (having radical expectations) for the company's future as it combines and takes appropriate advantage of the objective value of the total influx used by the company.

Thus, the creator of the financial innovation takes the role of the investor who distributes the available resources, as well as that of a salesman who later resells it. Therefore, market participants adopt the innovation without having formed a personal opinion on it, just to be ahead of the game, to overcome current competition and as a respond to the conflict interest that the financial innovation caused with its introduction.

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\(^7\) Kenneth Joseph Arrow (born August 23, 1921) is an American economist and joint winner of the Nobel Prize in Economics with John Hicks in 1972. In economics, he is considered an important figure in post neo classical economic theory. Ken Arrow's impact on the economics profession has been tremendous. For more than fifty years he has been one of the most influential of all practicing economists. His most significant works are his contributions to social choice theory, notably "Arrow’s impossibility theorem" and his work on general equilibrium analysis. He has also provided foundational work in many other areas of economics, including endogenous growth theory and the economics of information (http://en.wikipedia.org/wiki/Kenneth_Arrow).
The third point is whether possible frictions and/or imperfections in the market will reduce the innovation's effectiveness. The answer is that there may be insufficient information or financial instruments that will satisfactorily measure the risk of a new financial instrument. In fact, information can alter or/and disappear when the creation of new financial instruments includes a number of contributing parts. If the contributing parts don't have a financial interest during the process and the diffusion of the new financial instrument, its innate risk may increase. So, it is important to be designed in such a way that it will create a constant need for its adoption and use.

Moreover, the more the contributing parts the more the valuation differences or contrasts that stem from the heterogeneity of the financial instruments that participants use. However, the point is not to eliminate different valuations but to combine them in order to succeed a constant evaluation and improvement of the financial innovation.

The fourth point is whether the introduction of any information can create new frictions in the market as well as the need for new innovations. The volume of information changes the status quo of the market structure and generates new financial frictions. A financial innovation indicates the reduction of asymmetric information and moral hazard problems, in order to make market more efficient, as the information demand can be equally distributed to more participants. This works as a wave of innovations. An innovative commodity, such as information, creates asymmetries, which need new financial ideas and processes to reduce costs.

Merton (1992) denotes that financial innovations are introduced to reduce risk and to minimize asymmetric information and agency cost as a result of feedback effect between cost and innovation. Duffie & Rahi (1995) describe the impact of a financial innovation to information aggregation and risk sharing among the investors using a Gaussian framework. They are focused on the design of securities prices at inefficient markets with asymmetrical informed participants. Tadesse (2006) states the advantages of bank sector versus markets that promoting innovations based on information sets.

However, since the links of markets are very strong, innovative shocks and information asymmetries of an individual market can diffuse, sometimes with high intensity, rapidly and easily in all the other linked markets. This depends also on the rate of the shock and the way that market participants, acting as a group, are adopting all available information. The increase of asset holding (that is generated from financial

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98 This is the Merton's feedback effect (see Chapter 2nd)
innovation) can provoke sensitive changes in investor’s portfolios with asset price booms-busts. Demand of credit is instigated because of the need for liquidity, which brings higher leverage and economic instability. The result is that systemic risk is increasing and the role of financial innovation is inversed because it does not reduce the economic instability, in particular in situations of crisis.

4.3. The social value of financial innovation

In February 2010, the magazine “The Economist” organised a voting debate with the title: “Financial Innovation: This house believes that financial innovation boosts economic growth”. One side argued for the positive impact of financial innovation on economic growth and was expressed by Levine Ross (Professor in Economics, Brown University), while the other side argued that the previous years the right forms of financial innovations were not created in such a way to help the financial sector and thus the economic growth and was expressed by Stiglitz Joseph (Professor in Economics, Columbia University).

Based on these two arguments, a voting was organised and gave a result of 45% for Prof. Stiglitz. It was observed though that: i) the voters were influenced by the recent crisis and, ii) the voting was not absolute in the sense that those who voted “YES” believed that financial innovation was not always useful while those who voted “NO” didn't always think that financial innovation was a bad omen for crises. We note that even the opinions of a broader group of consumers or of a non-specialist audience about the social value of financial innovations are divided.

The prevailing opinion during the latest period of the current crisis is that financial innovation is a investors’ and managers' mania with no radical expectations, who aim at occasional higher yields, lower risk, and it has no function at all but product differentiation. This aimless, expensive game creates potentially huge social costs that have two components: the first is an a priori misrepresentation of the available capital and the distribution of investment capitals and, the second one is an a posteriori excessive insecurity and a fluctuation of prices, when these expectations aren't realised.

Nevertheless, there are financial innovations that benefited outstandingly the economic activity, the markets and the households. Such cases are the mortgage market and the development of the derivatives market. Transactions costs in these markets

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99 www.economist.com/debate/overview/166
decreased and companies managed to counterbalance insecurity about exchange interest rates and product prices. Moreover, equally beneficial for households and companies is the creation of different types of products and services in the mutual funds market, in the real estate market, in the pension and insurance products, in annuity products, etc. As a whole, these innovations gave more chances to household and companies to create more effective and less risky portfolios.

At the end of the day, financial innovations influence society both positively and negatively. However, diversity characterises the opinions about the real impact of financial innovations on society's welfare.

4.3.1. Financial innovation's impact on society

In the literature, the methodology used to measure the impact of a financial innovation, there are analyses of precise examples that present either the positive (like the housing loan market\(^{100}\)) or the negative (tax avoidance or losses in income tax allowances) social impacts of a financial innovation. And thus, there are a number of arguments on how innovation leads or doesn't lead to complexity and on the good or bad business decisions and social expense that follow (Elul, 1995).

The most important argument against financial innovation is that it contributes to high levels of market instability with negative consequences like partial or general financial crises. Especially during the last decade, derivatives markets were the “battle field” of those who argued about the positive or negative impacts of innovation on social welfare and whether it aggravates emerging market crises.

Despite the researchers’ attempts to support their arguments, in any way, they can neither measure social welfare directly nor can they evaluate realistically the observed results. Moreover, taking into consideration the spiral form of innovations (successful innovations generate others) and their development process, it is extremely difficult to define the limits of a successful innovation in the sector of social welfare. To examine the a priori impacts of precise financial innovations in order to decide whether their a posteriori reasons of existence were necessary is a vain attempt.

An alternative way, in order to answer to the a priori questioning about how necessary a financial innovation is and to form an initial structure to the problem, could be by examine the significant role that this financial innovation plays in market

\(^{100}\) For instance, the first studies about the social impact of CMOs came to the conclusion that they helped households to buy residencies with loans (Hendershott & Shilling 1989 and also, Jameson et al., (1992).
completeness\textsuperscript{101}. Given that markets are not efficient, the hypothesis that an innovation gives to market participants many more choices (in terms of numbers) could be considered and thus, social welfare will be boosted by definition, caused by the existence of optimum Pareto.

Cittana & Cass (1998) and Turner (2005) developed models and different techniques to measure the impact of financial innovations on not efficient markets. Financial innovation induces Pareto optimality that aims at the income increase with the relative risk prevention. The results show that a Pareto optimal financial innovation is required, even if the existence of a new market is not necessary.

However, this can't be the rule as the addition of a new financial instrument can have arbitrary consequences on the usefulness of economic agents by changing their conditions for better or for worse. We could draw the conclusion that the impact of financial innovation on the demand and supply curves and on social welfare is a process with many evaluation parameters.

4.3.2. Why don't developing countries follow development?

The positive impact of a financial innovation on society is very important when it appears during the introduction of the innovation in developing economies or to consumers of low or no income, in combination with the rapid development of MFIs that we presented in Chapter 3\textsuperscript{rd}. This is a very important issue, especially for the current year, as 2010 is the European Year for combating poverty. For this reason, huge investments (i.e. the World Cup) took place in developing countries, like those in Africa.

The main question that is raised and is expressed in many sub-questions, is the following: why developing countries don't cope with the development of other countries notwithstanding the giant leap of financial innovations? Why are there so many differences in the countries' revenues while globalisation is constantly increasing? Finally, what does real development mean for developing countries and what do developed economies know about it? How can developing countries follow up?

The biggest part of research (Dieckmann, 2007; Brom, 2009; CGAP Publications, 2009; etc.) focuses on the parameters that preclude developing countries from catching up development? However, after all those years, the question and the situation remain the same.

\textsuperscript{101} An initial study of the subject is presented by Allen & Gale (1994) and, Duffie & Rahi (1995)
The dominant opinion is that the huge differences that appear between the financial markets of countries with obvious results in their revenues and productivity are due to the powerful relation that connects the development of financial markets between those countries with the macroeconomic development of each country (Banerjee & Duflo, 2008; Levine, 2005).

However, on the other hand, the macroeconomic relations and frictions that are formed within these economies are unexplored. Innovations and productive activities of domestic companies in the emerging markets are blocked by financial frictions (McGuire & Conroy, 2005). The lack of information about the dynamic aspects of productivity like innovation flows is surprising, especially for countries that are not OECD\(^{102}\) members.

In order to understand what is that defines changeability in the productivity level and hence in the revenues of these countries, we should try to better understand financial frictions that prevent companies from innovating and from being activated in sectors that would boost their productivity, like product export.

In fact, in developing countries, foreign companies tend to be more productive than the domestic ones and this gap in productivity doesn't seem to narrow in time (Estrin \textit{et al.}, 2009). Foreign companies embody faster and completely their technological superiority and hinder domestic ones, by using specific business ways (i.e. high cost), from importing and from adapting or adjusting technology and practices of high activity and productivity. Thus, financial frictions act upon investments as well as upon research and development that takes place in a microeconomic level in domestic companies (Hall & Lerner, 2009). Moreover, frictions tend to have impacts on the ability of a domestic company to export (Lucas, 1990; Greenaway \textit{et al.}, 2007).

Gorodnichenko & Schnitzer (2010) have showed that financial innovations of domestic companies (especially small companies) are strongly influenced by frictions. The productivity of domestic companies in emerging markets doesn't keep pace with technological development; service companies are more sensitive to restrictions because it is difficult to pawn their investments and innovations; and the public sector doesn't provide the best support to the service sector in order for companies to outweigh market financial frictions and to catch up with development.

Consequently, domestic companies don't ever keep up with foreign ones when it

\(^{102}\) http://www.oecd.org
comes to development. The dynamic financial frictions are negatively related to macroeconomic data of productivity and of commercial activity and thus they influence in a negative way exports and innovative activities that tend to decrease, while the restrictions imposed because of frictions increase. For this reason, the markets' completion doesn't help domestic companies or economic growth as a whole.

Frictions decrease when financial markets develop. As long as frictions delay the technological development and productivity, national and commercial policies should direct towards the constitution of regulations for credit markets and towards the creation of a strong banking sector (where there isn't one) that will be willing to give access to foreign funding for a wide range of financial products.

More precisely, we don't support the idea of an aimless liquidity boost for companies, without any control and careless funding choices. On the contrary, a radical strategy should be planned that will include a process of careful funding choices, improved information systems and a flexible regulatory framework. Moreover, restrictions make companies chose, because of complementariness, between innovation strategies and those of globalisation. Thus, domestic companies will derive similar benefits from emerging economies, from commercial freedom and from funding, and will gain an equally advanced position in the race of the increasing competition. Market completion results in boosting domestic companies, as desired, when it is accompanied by additional financial market reforms.

4.4. The role of regulations and the role of the state in innovative activities

Within the analysis of financial innovations, we should take into consideration frictions caused by the constant changes in the regulatory framework practices and in the management of commercial transactions of the financial system. Such governmental innovative activities are mainly regulations about groups of markets, market participants, institutions and the sectors of the economic activity; they are not always effective; they demand organisation and thus they need more time to be applied. National innovative activities can take place in financial markets in different ways (Greenspan, 2006):

1. By funding activities in open markets, the government functions in the market as every investor does, by following the same rules.
2. Acting as an innovative competitor, with direct or indirect funding and support of new financial products, markets, services, etc. like securitised mortgages,
index-linked bonds, all savers accounts, etc.

3. *Acting as a supervisory authority* for the application of law, by forming mainly independent authorities like the *Capital Market Commission*, or/and by acting as the lawmaking body that passes new laws and restrictions for the market participants, the products and services or even for the markets (uptick rules, margin requirements, circuit breakers and patents on products).

4. *Acting as an intermediary* that negotiates and represents domestic products/services to international agreements with other international markets and countries.

There is an important difference between the financial innovation action of a country and the financial innovation action of a company. The financial innovation action of a country is mainly composed by regulations about the foundation of the economic environment that the company lives in.

There is an obvious and tight interdependence of financial innovations, produced by private investors, and foundational and service innovations, created by the state, that sometimes ends up with their inevitable clash (Greenspan, 2006). When the state's financial innovation actions have unsuccessful results for the effectiveness of the financial system, intermediary high costs are created. These costs are: i) direct costs to participants, ii) price fluctuation and capital distribution costs, iii) costs that result from the asymmetrical capital transactions of the participants. Thus, this disproportion could, from time to time, put in danger the functionality of the financial system.

Thus, a basic question arises as to whether the state is really an innovative body. When the state issues financial innovation products, can they reduce the cost of state funding? Are new social benefits created in this way? Which should be the way to approach the issuing of regulatory and normative frameworks that are not limited to a single mind policy?

The dramatic increase in the number and in the complexity of transactions and the international connectivity of financial markets has created a macro systemic risk for state activity (Segoviano, 2008). Any changes that are made in practice, because of a state's innovation activity, imply a de facto further interdependence between institutions, markets and nations within the international financial system. This strong interdependence creates frictions in the economic (and political) agenda and raises questions such as how to secure the market's independence and where the limits of state
intervention or guarantees are put. If we take into account such macroeconomic hazards, the need to regulate the market will increase, considering that the technological development can't replace or even decrease this need.

The usual taken approach during the issuing, the amending or the adjustment of the regulatory framework that refers to the financial system, is the analysis and the adoption of those practices that aim at the amelioration of transactions within the limits of healthy competition. Another approach can yet be adopted: the functional regulation approach. According to this approach, the regulatory framework should be in line with the functionality of financial institutions in time and in space. Through this functional approach, financial institutions can offer services and develop horizontally, in a more efficient way, in time and space.

The functional approach of the regulatory framework gives the opportunity to institutions to differ in time, which means that their functions for a period of time and in different places or countries can alter. Moreover, institutions won't likely take part in a game of regulatory arbitrage where resources are wasted and therefore, the chances for rent-seeking and regulatory capture are reduced. Moreover, it can facilitate the necessary changes in institutional structures without the simultaneous requirement to review norms or regulatory bodies that impose this approach.

The perceived benefits of a shift towards a functional approach of the regulatory framework will be important. They will empower the coordination and the standardisation of the regulations in an international level. However, this will only come in force when the coordinated policies selected will be socially beneficial, otherwise the decrease of the regulatory differentiations won't give the best possible results.

4.5. Conclusions

From the above analysis of the financial innovation process, three conclusions are drawn about the role of financial market frictions to the development of financial innovations.

The first conclusion is that financial innovations, judging by the way they are created, symbolise the reaction of market participants (investors, financial institutions, investing banks, etc.), driven by profit and by the changes (frictions) in the economic, fiscal and regulatory international environment.

The second conclusion is that the needs and the demands of the market participants increase rapidly and the funding conditions and frictions transform
dynamically. Therefore, the financial innovation process provides a restructuring mechanism to the participants' capital structure with cheaper and more flexible funding instruments, as well as innovation techniques to effectively manage the risks they face.

The third conclusion is that the creation of financial innovation effects and will continue to do so: in the way that markets function; at companies in a microeconomic level; at the structure and the nature of the actions of a more and more competitive international banking system; at the economic and credit policies of countries and the monetary policy implemented by governments.

Even that the researchers, worldwide, have been studied the process of financial innovation; there is a lack of sufficient empirical analysis, particularly on the influence of diffusion of financial innovation. Research in the future should shed light on two basic matters of the process: the possible creation of additional financial innovations and the microeconomic framework financial innovations. Nevertheless, taking into consideration the structure of the financial system and the latest developments of the current crisis, special attention should be paid in partial aspects of the design, the introduction and the diffusion of a financial innovation in the market. More precisely:

New products should have a more transparent form and content. In this way, their use facility will ameliorate and they will be better understood and so they will have less information costs and hence they will be less prone to fluctuations in their profit expectations. The increasing stability of expectations can support market liquidity during recession periods, especially in secondary markets. Moreover, final investors should be able to demand, from the state, a more favourable regulatory framework, when it comes to collateral for securitisation, and more protection and risk distribution from the issuers.

On the other hand, big financial institutions (like banks) should publish more information and reports in order to ameliorate market transparency. Rating agencies should provide additional information about estimated securities' risks and stress the uncertainty level of their estimations. Last but not least, investment banks should continue to offer adjusted products that are in line with precise risks in order to have a corresponding counterbalance.
SECTION TWO

The analysis of the influence of financial innovation’s diffusion to market participants as a random phenomenon is our objective in the present section. In particular, we examine the diffusion of financial innovation at the market a non-deterministic event that may be single occurrences or evolve over time using parametric univariate or multivariate distributions\(^\text{103}\) with specific characteristics.

4.6. Introduction

We consider a market with a constant number \(m\) of market participants (firms and investors) symbolized as, \([i = 1,\ldots,m\text{ and } m > 1]\). We consider the following cases:

A) Every market participant has a minimum boundary of internal need for change and it is internally determined by each \(i\)-th participant. We assume that this minimum boundary is constant and well defined for each \(i\)-th participant. For example, if we consider that a new bond is introduced to the market by one participant, then the adoption by any other market participant depends on his minimum utility to adopt according to his costs and, furthermore, according to the competitive market pressure for adoption. Any \(i\)-th participant will adopt a financial innovation if his need of change exceeds his minimum boundary\(^\text{104}\). Let us assume that \(U = [u_i, \ i = 1,\ldots,m]\) represents the minimum boundary for the \(i\)-th market participant.

B) All market participants are connected in a unique group network that can vary from completely regular \((r = 0)\) to completely random \((r = 1)\)\(^\text{105}\). The nodes of this network are the market participants (firms and investors) and every link between two nodes represents the correlation frictions between two participants. We also assume that every market (network) can be divided into sub-markets (sub-networks) and that \(0 \leq r \leq 1\).

\(^{103}\) Parametric distributions can be used when the phenomenon theory applies to the particular problem or the particular distribution can be used for modelling the specific variable without actually having any theory to support.

\(^{104}\) Creating the boundary of internal need for change is comparable to the classical mechanism limits of collective and individual choice (Granovetter, 1978).

\(^{105}\) See: paragraph 4.2.4.
C) A financial innovation (as it is described in previous chapters) is introduced to the market. We can follow some of Rogers’ (1995) assumptions regarding innovation assuming that when a financial innovation is introduced to the market, then: \(i\) the financial innovation is independent of any other financial innovations that may be introduced at the same time and, \(ii\) every market participant can adopt the financial innovation per unit of the time period of study. However, Roger’s assumptions are not obligated.

D) We also consider that a financial innovation can be introduced to a market (or a sub-market) originating from two main sources: \(i\) from a market participant (e.g., a bank that issues a new note). This participant designs and promotes the innovation to the market. All the other market participants have the choice to either adopt (trade) or not this innovation, \(ii\) from an institutional organization or the government state. In that case the innovation is introduced to the market from an outside indirect participant. Examples of this kind can be the ECB macroeconomic announcements or a new government regulation framework (from EU or international one) regarding the domestic financial markets.

Sometimes an innovation must be absorbed and applied obligatorily by the market participants during a given adjustment time interval and in other cases it can be an innovation which any participant evaluates with his own tools (e.g., information about the market).

In any case, new financial frictions are created in the financial market during the introduction of a financial innovation. The number of adoptions shows the diffusion in time. The need for adoption is caused by the financial frictions which innovation creates among the market participants during time. The diffusion process depends on the diffusion rate which is attributed to the positive change for the specific participant. Since we have supposed a random access and various values of the diffusion speed of adoption, financial innovation also depends on the degree of correlation and the power of frictions among the market participants. As the need of a participant increases, the diffusion rate increases.

Moreover, as long as the degree of frictions with other participants is high, diffusion rate of other participants is also high. Consequently, the positive benefits of the introduction of financial innovation depend on the correlation frictions between
market participants. This tendency of diffusion can be derived from empirical data, beyond the time periods and the categories of financial innovations. However, the period during which this tendency appears varies a lot due to numerous factors. This happens, to a great extent, because of great changes that must be developed for the innovative processes. The need and the rate of adoption of a financial innovation constantly increase following the globalization of financial markets.

There are two significant questions to answer concerning the time of adoption and the diffusion process:

A) How the time of diffusion is determined? Who determines the time interval of diffusion and what are the factors that affect it?

When we examine the diffusion of an innovation, the adoption refers to the whole number of market participants. The diffusion rate determines the diffusion time. However, in the case of financial innovations, these conditions regarding adoption and time vary. That happens for several reasons.

First, it concerns the nature of financial innovation. For example, there is a significant difference between new market information or a new bank note, a new bond or a new service for mortgage introduced into the market. This difference concerns the degree of innovativeness.

Second, the market participant or the institutional organization, who introduce the financial innovation, can determine the time horizon of diffusion or the sub market the innovation refers to.

Third, there is a possibility that only a part of the market will participate in the adoption process of financial innovation. This does not mean that the financial innovation will be trivialized, vanish or not become a standardized product.

Finally, when financial innovation is determined and become obligatory for the whole market (or a sub-market), there is a specific (every time different one) time limit for a market participant’s adjustment and, therefore, a different rate of adoption (e.g., a regulation framework or the introduction of euro currency).
B) Do censored (left or right) observations exist according to adoption time?

The answer is yes, censored observations can exist before and after the time of study or else left and right observations out of sample.

Left censored observation can occur from the expectation (rumor) of a forthcoming financial innovation and can create financial frictions among the market participants before the introduction of the financial innovation. These frictions have many forms such as asymmetric information, mispriced pricing on stocks, or misevaluate inventory moves by large investment house or investment banks (e.g. UBS Bank). For example, if UBS Bank trades a large number of stocks on behalf of its clients, this movement can be interpreted as asymmetric information and can cause the front running phenomenon. However, this move by the investment bank does not necessarily mean that asymmetric information actually exists as it could just be a large number of orders which is distributed to a large number of clients.

Right censored observations can occur for two basic reasons: i) when the time of diffusion is misevaluated and, ii) when diffusion expands beyond the time of study as a result of the impact of innovation. Therefore, the phenomenon of heterogeneity occurs.

Under the above framework of assumptions we continue presenting the mathematical framework in order to model the influence of the financial innovation diffusion at market participants.

4.7. The mathematical framework of diffusion process

4.7.1. The diffusion process with Pareto distribution – Univariate and multivariate case

A financial innovation is introduced to market participants. Then, the \( i - th \) market participant will adopt the financial innovation because his need for change has exceeded its minimum boundary.

Let us consider the probability space \((\Omega, \mathcal{F}, P)\) and the random vector \(X = [X_i]\) which is the map from the aforementioned space into the \(n\)-dimensional Borel space \((\mathbb{R}_+^n, B^n)\) such as the \(i-th\) coordinate, \(i = 1, 2, \ldots, m\) of \(X\) is univariate Pareto

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106 Censored observations arise whenever the dependent variable of interest represents the time to a terminal event, and the duration of the study is limited in time. Censored observations may occur in a number of different sectors in economics. For example, we may study the "survival" of new businesses or the "survival" time of one company's products. (http://www.statsoft.com/textbook/survival-failure-time-analysis/)

107 http://www.ubs.com/
distribution. This random variable $X$ shows the $i$-th participant’s adoption of financial innovation in time $[t, t+h]$. Therefore, we can write (the Pareto probability of $X$ is greater than some number $x$):

$$
Pr(X_i > x_i) = \begin{cases} 
\left( \frac{u_i}{x_i} \right)^{k_i}, & x_i \geq u_i, \\
1, & x_i < u_i
\end{cases}, \text{ or else, } Pr(Z_i > z_i) = \begin{cases} 
e^{-k_i z_i} = a_i, & z_i \geq 0 \\
0, & z_i < 0
\end{cases}
$$

When; $Z_i = \log \left( \frac{X_i}{u_i} \right)$, $u_i$ is the minimum boundary of $i$-th participant and $k_i$ is a positive parameter.

We also consider another case of adoption (Shun-Chen, 2002) which refers to the probability of the $i$-th participant to create a need (caused by financial frictions) for adoption to another potential market participant $(i+s)-th$ in time $[t, t+h]$ because the adoption and influence of financial innovation has exceeded its minimum boundary:

$$
Pr(X_{i+s} > x_{i+s} / a_i) = \begin{cases} 
\left( \frac{u_{i+s}}{x_{i+s}} \right)^{k_{i+s}}, & x_{i+s} \geq u_{i+s} \\
1, & x_{i+s} < u_{i+s}
\end{cases}, \text{ or else, } Pr(Z_{i+s} > z_{i+s} / Z_i) = \begin{cases} 
e^{-k_{i+s} z_{i+s}} = \beta_i, & z_{i+s} \geq 0 \\
0, & z_{i+s} < 0
\end{cases}
$$

When; $Z_{i+s} = \log \left( \frac{X_{i+s}}{u_{i+s}} \right)$, $u_{i+s}$ is the minimum boundary of $(i+s)-th$ participant and $k_{i+s}$ is a positive parameter.

We thus have assumed that every market participant has a rate of "positive behavior" related to financial innovation and a rate to "cause" other "positive behaviors". These rates are symbolized as $a_i$, $\beta_i$ respectively.

The joint density probability function (JPDF) of the $i$-th market participant to adopt and create a need for adoption in time $[t, t+h]$ is given by:

$$
Pr(Z_i, Z_{i+s}) = Pr(Z_{i+s} / Z_i) Pr(Z_i) = \begin{cases} 
e^{-k_i z_i} e^{-k_{i+s} z_{i+s}} = e^{-kw} = a_i \beta_i = \lambda_i, & z \geq 0 \\
0, & z < 0
\end{cases}
$$

When: $kw = k_i z_i + k_{i+s} z_{i+s}$, $k = (k_i \ k_{i+s})$ and $w_i = (z_i \ z_{i+s})$.
When we examine a high dimensional dataset of the univariate Pareto distribution or a compound Pareto distribution, it is natural to ask for a multivariate extension. Indeed, research papers touch on various aspects of the multivariate distribution theory with applications in finance and risk management (Pfeifer & Nelehová, 2004; Malevergne et al., 2006; Furman & Landsman, 2009; Vernic, 2009; Furman & Landsman, 2009).

We can extend the JPDF for the \( i \)-th market participant that causes adoptions to all the other market participants in time \([t, t+h]\). Therefore we have:

\[
\Pr(Z_i, Z_{i+1}, \ldots, Z_{m-(i+1)}) = \Pr(Z_{i+1}, \ldots, Z_{m-(i+1)} \mid Z_i) \Pr(Z_i) =
\]

\[
e^{-k_i \sum_{s=1}^{m-1} e^{-k_{i+s} z_s}} = e^{-kw} = a_i \beta_{i+1} \beta_{m-(i+1)}, \quad z \geq 0, \quad 1 \leq s \leq m-1, \quad s \neq i
\]

\[
0, \quad z < 0
\]

When: \( kw = k_i z_i + k_{i+1} z_{i+1} + \ldots, \quad k = (k_i, \ldots, k_{i+s}) \) and \( w_i = (z_i, \ldots, z_{i+s}) \)

Using the Pareto cumulative distribution (PCD) we derive that the diffusion rate (spread) of the \( i \)-th market participant is given by:

\[
P(w) = \begin{cases} 
1 - e^{-kw} = 1 - \lambda, & w \geq 0 \\
0, & w < 0
\end{cases}
\]

If we assume that \( W_i(t) \) is the cumulative number of adoptions in time \([t, t+h]\) with the initial value \( W_{i=0}(i) = 0 \) then \( W_i(t) \) is a randomly selected participant, where \( 1 < i \leq m \). Based on the above cases, the probability for any participant at time \( t \) to adopt in time \([t, t+h]\) and to cause a positive adoption to others is: \( (a_i \beta_i / (m-1)) h \). The number of the remaining participants is \((m-i)\). Therefore, the cumulative probability \( W_i(t) \), which increases in the next phase, from \( i-th \) to \( (i+s)-th \) in time \([t, t+h]\) is:

\[
W_{m-(i+1)}(t) = (m-i) \left( a_i \beta_i / (m-1) \right) h
\]

Otherwise, \( W_{m-(i+1)}(t) = (m-i) \lambda_{m-i} h \), when \( \lambda_i = (a_i \beta_i) \)
Expected value and standard deviation of the distribution factor $W$, are $\mu_w=1/k$ and $\sigma^2_w=1/k^2$, respectively.

The increase of $W_i(i)$ can reach up to $m$. Therefore we have: $\max(W_i(i))=m$. We call $\lambda_i$ as the diffusion rate of $i-th$ participant and we consider that $W_i(i)$ is a stochastic variable. We can say that the process of diffusion $\{W_i(m), t \geq 0\}$ is found in the situation $i$ at time $t$, if $W_i(i)=i$. In order to compare different speeds under different conditions, we report the variations in the $\rho$ indicator defined as:

$$\rho = \frac{\sum_{i=1}^{m} \lambda_i}{\sum_{i=1}^{m} i}$$

Indicator $\rho$ allows us to compare different diffusions rates of different financial innovation by the same number of market participants.

4.7.2. The diffusion process with compound GP distribution–Univariate and multivariate case

Expanding the diffusion process analysis, we now present a compound Poisson G-Pareto distribution to model high grade events, such as the adoption of a financial innovation.

We consider the same assumptions of the previous paragraph. In particular, we examine the univariate compound distribution process of adoption for a market participant. We assume that the $i-th$ participant adopts the financial innovation (a high grade event) because the need for adoption has exceeded its minimum boundary, using a univariate continuous distribution for adoption ($GPD$) per time over certain threshold level (Poisson distribution). In this case, the $i-th$ participant does not create a need for adoption to another potential market participant $(i+s)-th$ in time $[t,t+h]$.

We afterwards examine the multivariate compound distribution process “causing adoption” to another market participant. We assume that the $i-th$ participant creates a need for adoption to another potential market participant $(i+s)-th$ in time $[t,t+h]$. Therefore, we extent the analysis and consider the multivariate case of adoption and frictions. A market participant adopts an event (financial innovation) and provokes
(multivariate) this behavior to another market participant (dual friction) by compounding the discrete distribution of adoptions per time over a certain threshold level (Poisson distribution) with the multivariate continuous distribution for adoption (GPD).

In any situation, *Maximum log-likelihood estimation* (MLE), *Compound Moment estimation* (CME) and *Probability-Weight Moment estimation* (PWME) are the most common applied estimation methods for the parameters of compound distribution process.\(^{108}\)

Using these assumptions we can: *i)* capture the rate of event (adoption) of the individual participant, *ii)* capture the significance of contribution of financial innovation for any participant, *iii)* examine the diffusion rate for any firm value (participant) by frictions and; *iv)* observe the behavior of the financial innovation and calculate probabilities explicitly because the structured dependence is determined by coefficients.

4.7.2.1.1. Poisson-Generalized Pareto (PGP) univariate distribution

Let \(M\) be a random variable (the number of an event in a given time) with their corresponding probability \(P(M = k) = p_k, \sum_{k=0}^{\infty} p_k = 1 \text{ and } k = 1, 2, \ldots\). Let \(\xi = [\xi_i]\) and \(n\) be random variables with distribution function \(S(x)\) and \(T(x)\), respectively. The formula of distribution function respect to \(\xi\) is written:

\[
F_\xi(x) = \sum_{k=0}^{\infty} p_k [S(x)]^k - p_0 [1 - T(x)]
\]

Let \(F_0(x) = \sum_{k=0}^{\infty} p_k [S(x)]^k\) where \(F_0(x)\) is the compound extreme value distribution composed of the distribution of \(M\), \(\xi\). We take under consideration that \(F_0(x)\) is monotone non-decreasing, right continuous and satisfies that: \(\lim_{x \to \infty} F_0(x) = 1\), \(\lim_{x \to -\infty} F_0(x) = p_0\).\(^{109}\) Different distribution functions of \(M\) and \(\xi\) gives different forms

\(^{108}\) The *mean square errors* (MSE) of estimators by PWME are much smaller than those estimators by CME and there is no significant difference between PWME and ML (Beirlant et al., 2004).

\(^{109}\) When \(p_0 > 0\) then \(F_0(x)\) is not a probability distribution. We can modify \(p_0\) in a small appropriate area to make \(F_0(x)\) satisfy the continuous of a distribution function. In practice, we focus on \(F_0(x)\) approaching so we don’t discuss the modification in detail.
of compound extreme value distributions. The most common form is Poisson-Gubel univariate distribution.

Assume random variable \( X \) that has \( c \times m \) observations \((\text{time} \times \text{observations})\) with distribution function \( H(x) \). If we suppose a given threshold \( u \) then observations that exceed \( u \) are called exceedances. We assume that the random variable \( M_u \) is the number of exceedances in any time moment with Poisson distribution \((\text{parameter } \lambda)\).

We regard that the underlying distribution \( H(x) \) is in the maximum domain of attraction so the distribution of excess is a Generalized Pareto Distribution \((\text{GPD})\). Then, we can write:

\[
H_u(x) = P(X - u \leq x / X > u) = 1 - \left(1 + \frac{x - \mu}{\sigma}\right)^{1/\gamma}
\]

When: \( x > u \) and \( \left(1 + \frac{x - \mu}{\sigma}\right) > 0 \)

For \( X > u \) the distribution of exceedances is given by:

\[
H_u(x) = P(X \leq x / X > u) = 1 - a \left(1 + \gamma \frac{x - \mu}{\sigma}\right)^{-1/\gamma}
\]

When: \( a = P(X > u) \)

(or else; \( H_u(z) = 1 - a \left(1 + \gamma z\right)^{-1/\gamma}, \; z = \frac{x - \mu}{\sigma} \))

Let \( \xi \) with distribution \( S(x) \) denotes the exceedances at any time period. If all observations are smaller than threshold \( u \), then \( \eta \) with distribution \( T(x) \) denotes the largest observation of the event in that time period. Let \( M \) be the random variable of events with Poisson distribution and parameter \( \lambda \) which denotes the number of exceedances in the time period respect to \( M_u \).

Because; \( P(\eta < u) = 1, \; p_0[1 - T(x)] = 0 \; \text{for } x > u \), the compound distribution is written:

\[
F(x) = \sum_{k=0}^{\infty} p_k [S(x)]^k = \exp\left[ -\lambda a \left(1 + \gamma \frac{x - \mu}{\sigma}\right)^{-1/\gamma} \right]
\]
Therefore, the Poisson-Generalized Pareto distribution of random variable $X$ is given by:

$$F(x) = \exp \left[ -\lambda a \left( 1 + \gamma \frac{x - \mu}{\sigma} \right)^{-1/\gamma} \right]$$

When: $a = P(X > u), \ x > u$ and $\left( 1 + \gamma \frac{x - \mu}{\sigma} \right) > 0$

or else: $F(z) = \exp \left[ -\lambda a (1 + \gamma z)^{-1/\gamma} \right], \ z = \frac{x - \mu}{\sigma}$

The probability density function (PDF) is given by:

$$f(z) = (F(z))' = \left( \exp \left[ -\lambda a (1 + \gamma z)^{-1/\gamma} \right] \right)' \Rightarrow$$

$$f(z) = \frac{\lambda a}{\sigma} \exp \left[ -\lambda a (1 + \gamma z)^{-1/\gamma} \right] \left(1 + \gamma z\right)^{-1/\gamma}$$

If we estimate the model using MLE, then the log-likelihood function is written as: $\ln L = \sum_{i=1}^{n} \ln \left[ f(x) \right]$. This formulation is called Poisson-Generalized Pareto compound extreme value distribution (Beirlant et al., 2004). For example in an empirical analysis, suppose we have a set of data (e.g., a currency exchange rate). The rate of return of investment in a financial innovation, such as a bond or a foreign exchange future currency, for a market participant is a random variable $X$ and the threshold $u$ is usually determined by the investor. Investors always expect to get more profit from that investment when they adopt the financial innovation because their need for adoption exceeds a certain predetermined value which is their threshold. Thus, investors pay more attention to the investment profits or losses when they adopt.

4.7.2.1.2. Poisson-Generalized Pareto (PGP) multivariate compound distribution

We now compound the discrete distribution with a multivariate continuous distribution of adoption and create a need for adoption. Each variable shows the rate to "cause" other "positive behaviors" to a potential market participant.
The multivariate compound distribution process is derived by compounding the discrete distribution of the number of data sampling over certain threshold level per time (Poisson distribution) into the multivariate continuous distribution (GPD).

Let \( M \) be a random variable with probability \( P(M = k) = p_k \) and \( k = 1,2,... \) as we mention before. Let \( (\xi_{11},...,\xi_{1m}), (\xi_{21},...,\xi_{2m}),... \) be independent and identically distributed random vectors (the observed successive causes for adoption) with joint density \( g(*) \). Then, we are interested to find the multivariate distribution of:

\[
(X_1,...,X_m) = (\xi_{11},...,\xi_{1m})^{110}
\]

We regard that \( G(x_1,...,x_m) \) is the multivariate continuous cumulative distribution. Therefore, the multivariate compound distribution is written (Coles & Tawn, 1994; Malevergne et al., 2006):

\[
F(x_1,...,x_m) = P(X_1 < x_1,...,X_m < x_m) \Rightarrow
\]

\[
F(x_1,...,x_m) = P\left(\bigcup_{i=1}^{\infty} \{X_1 < x_1,...,X_m < x_m\} \cap \{M = i\}\right) \Rightarrow
\]

\[
F(x_1,...,x_m) = \sum_{i=1}^{\infty} p_i P(X_1 < x_1,...,X_m < x_m, M = i) \Rightarrow
\]

\[
F(x_1,...,x_m) = \sum_{i=1}^{\infty} p_i p \left(\bigcup_{k=1}^{i} \{X_1 < x_1,...,X_m < x_m\} \cap \{\max_{1 \leq j \leq k}(\xi_{ij}) = \xi_{1k}\} \cap \{M = i\}\right) \Rightarrow
\]

\[
F(x_1,...,x_m) = \sum_{i=1}^{\infty} p_i p \left(\{\xi_{11} < x_1,...,\xi_{1m} < x_m, \xi_{i1} > \xi_{1j}, j = 1,2,...,M / M = i\}\right) \Rightarrow
\]

\[
F(x_1,...,x_m) = \sum_{i=1}^{\infty} p_i \int_{-\infty}^{x_1} \int_{-\infty}^{x_2} \cdots \int_{-\infty}^{x_m} \cdot \cdot \cdot \cdot G^{i-1}(u) \cdot g(u_1,...,u_m)du_1...du_m
\]

When, \( G^{i-1}(u) \) is the marginal distribution of \( G(x_1,...,x_m) \), \( g(u_1,...,u_m) \) is the density probability function.

The frequency of extreme events occurrence \( (m) \) can be fitted to Poisson distribution: \( P_i = e^{-\lambda} \frac{\lambda^i}{i!} \). Therefore, it can be transferred to the following form:

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110 The case \( N=0 \) should be neglected because extreme value of interest can occur outside the event when \( N=0 \).
The method can be obtained through estimation of parameters of marginal distributions and their dependent parameters by putting any type of extreme value family distributions on the density function \( g(u_1, \ldots, u_m) \) in the last equation. Some formulations from the extreme value family distributions can be:

A) The one way effect \( G\)-Pareto distribution, which can be formed as:

\[
G(z_1, z_2, \ldots, z_m) = \prod_{i=1}^{m} \exp\left[- \lambda \alpha \left[1 + \gamma_i z_i\right]^{1/\gamma_i}\right], \quad z_i = \frac{x_i - \mu_i}{\sigma_i}
\]

B) The Gumbel Mixed Distribution (GMD) (Gumbel, 1960), that can be formed as a multivariate extreme value with joint distribution:

\[
G(x_1, x_2, \ldots, x_m) = \prod_{i=1}^{m} G_i(x_i) \exp\left[-\theta \left[\sum_{i=1}^{m} \frac{1}{\ln(G_i(x_i))}\right]^{-1}\right],
\]

\[0 \leq \theta \leq 1, \quad \theta = 2\left[1 - \cos\left(\frac{\rho}{\sqrt{6}}\right)\right], \quad \rho: \text{correlation coefficient}\]

When, \( G_i(x_i) \) presents the marginal distribution functions for each random variables \( X_i, \ i = 1, \ldots, m \) respectively and have the form:

\[
G_i(x_i) = \exp\left[-\exp\left(-\frac{x_i - u_i}{a_i}\right)\right]
\]

C) The Nested-Logistic trivariate distribution, which can be formed as (Shi & Shengsheng, 1999):
\[
G(x_1, x_2, x_3) = \exp \left[-\left(\frac{1}{1+\gamma_1 \frac{x_1-\mu_1}{s_1}} + \frac{1}{1+\gamma_2 \frac{x_2-\mu_2}{s_2}} + \frac{1}{1+\gamma_3 \frac{x_3-\mu_3}{s_3}}\right)^b\right]
\]

Parameters \(\gamma_i, \mu_i, \sigma_i\) are the shape, location and scale parameters of marginal distributions \(G(x_i)\). The dependent parameters \(a, b\) can be obtained through Moment estimation:

\[
\hat{a} = \frac{\sqrt{1 - \rho_{1,3}} + \sqrt{1 - \rho_{2,3}}}{2} \quad \text{and} \quad \hat{b} = \frac{\sqrt{1 - \rho_{1,2}}}{\hat{a}},
\]

When; \(\rho_{i,j}\) are correlation coefficients.

Trivariate layer structure shows that the correlation between \(x_1\) and \(x_2\) is stronger than \(x_1\) and \(x_3\) and also \(x_2, x_3\).

**4.8. Introducing the diffusion factor to econometric models**

In this paragraph, we will build the diffusion matrix factor that shows the diffusion rates of each participant and are distributed in the above ways for a high dimensional dataset. Then, we will consider three cases. In the first case we will examine the effect of diffusion matrix as exogenous factor on the returns of market participants with a simultaneous equations model. In the second case we will examine the effect of the introduction of financial innovation as a regressor factor in the conditional variance equation.

**4.8.1. Building the diffusion matrix factor**

Let us consider the following probabilities:

\[
\begin{align*}
\Pr(z_i) &= p_{ii}(t) = 1 - e^{-k_i z_i} \quad \text{or} \quad \exp\left(-\lambda \alpha \left[1 + \gamma_i z_i\right]^{-\alpha / \gamma_i}\right) \\
\Pr(z_i, z_{i+s}) &= p_{i,i+s}(t) = 1 - e^{-k_i z_i} e^{-k_{i+s} z_{i+s}} \quad \text{or} \quad \exp\left(\sum_{i=1}^{i+s} -\lambda \alpha \left[1 + \gamma_i z_i\right]^{-\alpha / \gamma_i}\right)
\end{align*}
\]

Where, \(p_{ii}(t)\) symbolizes the adoption of the \(i-th\) participant and \(p_{i,i+s}(t)\) symbolizes the prompted rate for adoption to the \((i+s)-th\) participant, in time \([t, t + h]\). For a high dimensional dataset these probabilities can distribute with Pareto
distribution or compound Pareto distribution as we have showed above. These probabilities show the diffusion rate of the $i-th$ market participant to adopt and provoke adoption to another participant.

Furthermore, we consider the matrix $\Lambda_{(t,m)}$ where the columns are representing the market participants and the rows are representing the diffusion time moments $[t_1,t_2,...,t]$:

$$
\Lambda = \begin{bmatrix}
P_{11}^{(t_1)} & P_{12}^{(t_2)} & \cdots & P_{1m}^{(t_m)} \\
0 & P_{22}^{(t_2)} & \cdots & P_{2m}^{(t_m)} \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & P_{mm}^{(t)}
\end{bmatrix}
$$

We call this matrix $\Lambda$ the diffusion matrix of adoption for market participants and we regard some properties for this matrix:

A) The rows show the discrete time of adoption which varies among the market participants and depends on the expected time of adoption. Therefore, time frequency can be determined alternatively or can be Poisson distributed.

B) The columns are determined by the number of market participants that varies from $\min(i=1)$ to $\max(i=m)$. Diagonal elements show that any market participant adopts the financial innovation at next time step $t+h$ for two reasons: i) because his need for change has exceeded his minimum boundary and, ii) because financial frictions are generated by other participants (at least one with high correlation who has already adopted the financial innovation) and create a need to the next one provoking him to exceed his minimum boundary for change. The scale of adoption is random for any participant (random network). This means that every participant could be the next potential adopter.

C) We also have to notice the following:

1. All the elements of a random row (column) can be zero if a market participant does not participate in the diffusion process at any time moment during the diffusion. Then this participant (row and column) is excluded from the potential market size of adoption.

2. The matrix $\Lambda$ is triangle because when the $i-th$ market participant has adopted then the diffusion process is transferred internally to him. However, he continuous to provoke frictions to other participants to adopt the innovation.
3. Diagonal elements are not equal to zero\textsuperscript{111}. In that case we have $X_i = u_i$ so we assume that market participant does not participate in the diffusion process yet.

4. We consider the matrices $(\Lambda'\Lambda)_{\text{vecm}}$ and $P_{\text{vec}} = \Lambda(\Lambda'\Lambda)^{-1}\Lambda'$. The matrix $(\Lambda'\Lambda)$ is positive semi-definite and $\det(\Lambda'\Lambda) \neq 0$. The matrix $P$ is an identity, positive semi-definite, symmetrical and trajectory matrix\textsuperscript{112}.

4.8.2. The first case

In the first case we consider a simultaneous equations model of market participants and the introduction of a financial innovation. Therefore, we examine the effect of diffusion matrix as exogenous factor on the returns of market participants. The size of equations is equal to the potential (participated) number of participants that adopt the financial innovation. First, we analyze the theoretical framework for a simultaneous equations model and then we introduce the diffusion factor as exogenous matrix.

4.8.2.1. The simultaneous equations model

Simultaneous equations model are a system of equations that contains multiple endogenous and exogenous variables. For solving this system, we need to estimate a simultaneously specification for all the parameters. Simultaneous equations model are very useful because we can insert a number of exogenous and lagged endogenous variables at the right side of the equation. The exogenous (current or lagged) and lagged endogenous variables are called predetermined variables. The individual equations which apart the simultaneous equation system, are called structural equations.

A simultaneous model is \textit{complete} when the number of the structural equations is equal to the number of endogenous variables, so the endogenous variables can be solved in terms of the predetermined variables. We call a system of equations as a \textit{recursive system of equations} if the matrix of coefficients of the endogenous variables is triangular. Because of the property of triangular, in a recursive model there is unidirectional dependency among the endogenous variables. A \textit{simultaneous equation system} with $m$ linear equations has the form\textsuperscript{113}:

\textsuperscript{111} Appendix, proof A
\textsuperscript{112} Appendix, proof B, C, D
\textsuperscript{113} The term $X_{i,t}$ also includes the term $X_{-i,t}$. 

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\[ Y_{i,t} = Y_{i-1,t} c_i + X_{i,t} \beta_i + \varepsilon_{i,t} \]
\[ i = 1, 2, \ldots, m : \text{number of equations} \]
\[ t = 1, 2, \ldots, T : \text{number of time observations} \]

The open form of the system is written:

\[ Y_{1,t} = \sum_{i=2,m} c_i Y_{i-1,t} + \sum_{i=1,2,k} \beta_i X_{i,t} + \varepsilon_{1,t} \]
\[ Y_{2,t} = \sum_{i=3,m} c_i Y_{i-1,t} + \sum_{i=1,2,k} \beta_i X_{i,t} + \varepsilon_{2,t} \]
\[ \vdots \]
\[ Y_{m,t} = \sum_{i=1,2,m-1} c_i Y_{i-1,t} + \sum_{i=1,2,k} \beta_i X_{i,t} + \varepsilon_{m,t} \]

We symbolize: \( Y_{i,t} (m \times 1) \) is the dependent variable vector, \( X_{i,t} \) is the matrix of exogenous variables with \((k \times 1)\) vector for every \( i \) equation, \( Y_{i-1,t} \) \((n \times 1, \text{for each } i \text{ equation and } n < m)\) is the vector of all other endogenous variables which enter the \( i-\text{th} \) equation on the right side, \( \beta_i \) \((k \times 1)\) and \( c_i \) \((n \times 1)\) are the regression coefficients and \( \varepsilon_{i,t} \) \((m \times 1)\) are the error terms.

Putting all the endogenous lagged variables to the left side of the equation, we can write the \( m \) equations in the \textit{structural matrix form}:

\[ YC = XB + E \]

We note that:

- \( Y_{(r \times m)} \) is the matrix of the endogenous dependent variables which includes the matrices \( Y_{i-1,t} \) as sub-matrices, \( Y_{(r \times m)} = \begin{bmatrix} Y_{1,t=1} & \cdots & Y_{m,t=1} \\ \vdots & \ddots & \vdots \\ Y_{1,t} & \cdots & Y_{m,t} \end{bmatrix} \).

- \( C_{(m \times m)} \) is the coefficient matrix which refers to the correlation between the dependent variables (with ones on the diagonal and components of vector \( c_i \) (or zeros) at the other elements, \( \begin{bmatrix} 1 & c_2 & \cdots & c_m \\ c_1' & 1 & \cdots & c_m' \\ \vdots & \ddots & \ddots & \vdots \\ c_1^{(m)} & \cdots & \cdots & 1 \end{bmatrix} \).
• $B_{(k \times m)}$ the matrix of coefficients of exogenous variables that the components of vectors $\beta_i$ (or zeros), $B_{(k \times m)} = \begin{bmatrix} \beta_0 & \beta_1 & \ldots & \beta_m \\ \beta_0' & \beta_1' & \ldots & \beta_m' \\ \ldots & \ldots & \ldots & \ldots \\ \beta_{(k)} & \ldots & \ldots & \beta_{(k)} \end{bmatrix}$

• $X_{(r \times k)}$ is the matrix of all exogenous regressors from all equations (each $X_i$ is a $k_i$-columned sub matrix of $X$), $X_{(r \times k)} = \begin{bmatrix} X_{i,j=1} & \ldots & X_{i,k,j=1} \\ \ldots & \ldots & \ldots \\ X_{i,j} & \ldots & X_{i,k,j} \end{bmatrix}$

• $E_{(r \times m)}$ is the matrix of the error terms, $E_{(r \times m)} = \begin{bmatrix} \varepsilon_{1,j=1} & \ldots & \varepsilon_{m,j=1} \\ \ldots & \ldots & \ldots \\ \varepsilon_{1,j} & \ldots & \varepsilon_{m,t} \end{bmatrix}$

Matrix $C_{(m \times m)}$ has a non zero determinant, so we can use the invertible matrix $C^{-1}$ for the above system equation:

$$Y = XBC^{-1} + EC^{-1} = XW + V \text{ where } W = BC^{-1}, \ V = EC^{-1}$$

This is an OLS model and can be estimated. However, we have to make some assumptions before estimate the coefficient factor $\hat{W}$ of the decomposing factors $B$ and $C^{-1}$. The assumptions are:

1) $\text{rank}(X) = k$

2) Error terms are assumed to be identically and independent distributed, $E \sim N(0, \Sigma), \ Exp(E'E) = \Sigma$, where $\Sigma$ is a variance-covariance matrix.

3) The number of unknowns at the equation system should be less or equal to the number of equations ($k + n \leq m$, for each equation).

The common estimation methods for simultaneous equations models (Wooldridge, 2009) are the 2-Stage OLS method and the Limited information maximum likelihood (LIML).

A) Two-Stage OLS method is an equation-by-equation technique of two steps, where the endogenous regressors on the right side of each equation are being
instrumented with the exogenous regressors from all other equations: i) regressing $Y_{-i}$ on $X$ and obtain the predicted values $\hat{Y}_{-i}$ and, ii) estimating $c_i$ and $\beta_i$ with OLS regression of $Y_i$ on $\hat{Y}_{-i}$ and on $X_i$. For the $i-th$ equation on the system, we can write:

$$Y_{i,t} = Y_{-i,t}c_i + X_{i,t}\beta_i + \varepsilon_{i,t} = (Y_{-i,t} X_{i,t})\left(\begin{array}{c} c_i \\ \beta_i \end{array}\right) + \varepsilon_{i,t}$$

Then, the 2-StageLS estimator is given by:

$$\left(\begin{array}{c} \hat{c}_i \\ \hat{\beta}_i \end{array}\right) = \left\{ \begin{array}{l} (Y_{-i,t} X_{i,t})^\prime \left(XX\right)^{-1} X^\prime (Y_{-i,t} X_{i,t})^{-1} \left(Y_{-i,t} X_{i,t}\right)^\prime X^\prime Y_i \\ P(Y_{-i,t} X_{i,t})^{-1} \left(Y_{-i,t} X_{i,t}\right)^\prime P Y_i \end{array} \right.$$  

$$\left(\begin{array}{c} \hat{c}_i \\ \hat{\beta}_i \end{array}\right) = \left[ J_i^\prime P J_i \right]^{-1} J_i^\prime P Y_i$$

where $P = (XX)^{-1} X^\prime$, $J_i = (Y_{-i,t} X_{i,t})_{(n+k)}$

Matrix $J$ is the matrix of both endogenous and exogenous regressors in the $i-th$ equation and $P = (XX)^{-1} X^\prime$ is a projection matrix on the linear space spanned by the exogenous regressors of $X$.

B) The Limited information maximum likelihood (LIML) estimator is:

$$\left(\begin{array}{c} \hat{c}_i \\ \hat{\beta}_i \end{array}\right) = \left\{ \begin{array}{l} (Y_{-i,t} X_{i,t})^\prime \left(I - \lambda M_i\right)(Y_{-i,t} X_{i,t})^{-1} \left(Y_{-i,t} X_{i,t}\right)^\prime \left(I - \lambda M_i\right) Y_i \\ J_i^\prime (I - \lambda M_i) J_i^{-1} J_i^\prime (I - \lambda M_i) Y_i \end{array} \right.$$  

where $M_i = I - P = \left(I - X_i^\prime X_i\right)^{-1} X_i^\prime$, $J_i = (Y_{-i,t} X_{i,t})_{(n+k)}$ and $\lambda$ is the smallest characteristic root of the matrix:

$$\left(\begin{array}{c} \varepsilon_{i,t} \\ \varepsilon_{i,t} \end{array}\right)_{(n+k)} = \left[ \begin{array}{cc} Y_{i,t} & M_i (Y_{i,t} Y_{-i,t}) \end{array} \right]^{-1} \left[ \begin{array}{cc} Y_{i,t} & M_i (Y_{i,t} Y_{-i,t}) \end{array} \right]$$

When $\lambda = 1$, LIML estimator coincides to the 2-StageLS estimator.
4.8.2.2. The diffusion matrix as exogenous or endogenous factor on simultaneous equations model

A financial innovation is introduced to the market. Every $i-$th market participant has an internal minimum boundary of need for change, $u_i$. The diffusion matrix $\Lambda$ can be used as exogenous or endogenous factor on the simultaneous equations model in order to study the effect of diffusion of financial innovation on the returns of market participants. Therefore, the exogenous variable $X_{i,t}$ is replaced with the diffusion matrix of adoption $\Lambda_{i,t}$.

We can optional use a multiplicative dummy variable $I_t$ to restrict the analysis of the effects of financial innovation’s introduction on market participant returns in specific time for the simultaneous equations model. Therefore, the dummy variable has the formulation:

$$I_t = \begin{cases} 
0, & \text{financial innovation is not introduced} \\
1, & \text{financial innovation is introduced} 
\end{cases}$$

For the $i-$th equation on the system, we can write (general case):

$$Y_{i,t} = Y_{-i,t}c_i + \Lambda_{i,t}Y_t + \varepsilon_{i,t} = \left(\begin{array}{c} c_i \\
Y_t 
\end{array}\right) + \varepsilon_{i,t}$$

The equation shows that the effect of financial innovation during the diffusion differs at $\gamma$.

a) The 2-StageLS estimator is given by:

$$\begin{pmatrix} \hat{c}_i \\ \hat{\gamma}_i \end{pmatrix} = \left[ J_t'P_{J_t} \right]^{-1} J_t Y_i$$

where $P = \left( \Lambda \left( \Lambda' \Lambda \right)^{-1} \Lambda' \right)$, $J_t = \left( Y_{-i,t} \quad \Lambda_{i,t} \right)_{(ns+nk)}$

b) The (LIML) estimator is given by:

$$\begin{pmatrix} \hat{c}_i \\ \hat{\gamma}_i \end{pmatrix} = \left[ J_t'(I - \lambda M_t)J_t \right]^{-1} J_t'(I - \lambda M_t)Y_i$$
Matrix $J$ is the matrix of both endogenous and exogenous diffusion matrix in the $i-$th equation and $P = \left( \Lambda \left( \Lambda' \Lambda \right)^{-1} \Lambda' \right)$ is the projection diffusion matrix on the linear space spanned by the exogenous $\Lambda$. If we use the multiplicative dummy variable the:

$$Y_{i,t} = Y_{i,t-1} + I_{i,t-1} \gamma_i + \epsilon_{i,t} = \left( Y_{i,t} - I_{i,t-1} \right) \left( \begin{array}{c} \gamma_i \\ \epsilon_{i,t} \end{array} \right)$$

The estimation methods are the same. We can only notice that the projection diffusion matrix on the linear space spanned by the exogenous regressors of $I_{i,t-1}$ is given by: $P = \left( I' \Lambda \left( \Lambda' \Lambda \right)^{-1} \Lambda' \right)$.

4.8.3. The second case

In the second case we examine the effect on volatility of the introduction of a financial innovation to the market as a regressor factor in the conditional variance equation. First, we analyze the theoretical framework for the univariate and multivariate case of conditional variance–covariance equation(s) and then, we build the conditional variance model using the regressor factor of diffusion.

4.8.3.1. Regressors in the variance equation

Suppose an $AR(1)$ model. The equation is written:

$$R_i = \mu + aR_{i-1} + \varepsilon_i$$

suppose that: $\varepsilon_t \sim \text{N}(0, \sigma_i^2)$

Conditional variance equation is written as:

$$\sigma_i^2 = \sigma_0 + \sum_{j=1}^{q} \beta_j \sigma_{i-j}^2 + \sum_{i=1}^{p} a_i \varepsilon_{i-j}^2$$

Equation of conditional variance may be extended to allow for the inclusion of exogenous or predetermined regressors $z$, in the variance equation:

$$\sigma_i^2 = \sigma_0 + \sum_{j=1}^{q} \beta_j \sigma_{i-j}^2 + \sum_{i=1}^{p} a_i \varepsilon_{i-j}^2 + Z_i \pi$$
Note that the forecasted variances from this model are not guaranteed to be positive. You may wish to introduce regressors in a form where they are always positive to minimize the possibility that a single, large negative value generates a negative forecasted value.

We also require a basic distributional assumption about the conditional distribution of the error term $\varepsilon$. There are three assumptions commonly employed when working with GARCH models: Gaussian distribution, student’s $t$-distribution and the Generalized Error Distribution (GED). Given a distributional assumption, GARCH models are typically estimated by ML under the assumption that the errors are conditionally normally distributed. In addition to the standard GARCH specification, there is the flexibility to estimate several other variance models. These are the Integrated ARCH (IGARCH), Threshold ARCH (TARCH), Exponential ARCH (EGARCH), Power ARCH (PARCH) and Component GARCH. For each of these models, the user has the ability to choose the order, if any, of asymmetry. Let us consider TARCH model.

TARCH (Threshold ARCH) model was first introduced by Zakoïan (1994) and also by Glosten et al., (1993). The generalized specification for the conditional variance is given by:

$$\sigma^2_t = \sigma_0^2 + \sum_{j=1}^{q} \beta_j \sigma^2_{t-j} + \sum_{i=1}^{p} a_i \varepsilon^2_{t-i} + \sum_{k=1}^{r} \gamma_k \varepsilon^2_{t-k} I_{t-k}$$

Where $I_{t-k} = \begin{cases} 1, & \varepsilon_t < 0 \\ 0, & \text{otherwise} \end{cases}$

In this model, good news, $\varepsilon_{t-i} > 0$, and bad news, $\varepsilon_{t-i} < 0$, have differential effects on the conditional variance; good news has an impact of $a_i$, while bad news has an impact of $a_i + \gamma_i$. If $\gamma_i > 0$, bad news increases volatility, and we say that there is a leverage effect for the $i$-th order. If $\gamma_i \neq 0$, the news impact is asymmetric.

4.8.3.2. System Autoregressive Conditional Heteroskedasticity (System-ARCH)

The System ARCH estimator is the multivariate version of ARCH estimator. System ARCH is an appropriate technique when one wants to model the variance and
covariance of the error terms, generally in an autoregressive form. ARCH estimation uses ML method to jointly estimate the parameters of mean and variance equations.

Given a specification for the mean equation and a distributional assumption, all that we require is a specification for the conditional covariance matrix. System ARCH allows you to choose from the most popular multivariate ARCH specifications: Constant Conditional Correlation (CCC), the Diagonal VECH and the Diagonal BEKK. For example if we assume that $\varepsilon_t \sim GED$, then the ML for GARCH models is given by:

$$L = -\frac{1}{2} m \ln (2\pi) - \frac{1}{2} \ln (|V|) - \frac{1}{2} \varepsilon'_t V^{-1} \varepsilon_t$$

Assume now we have a system of equations for mean returns:

$$Y_1 = \mu_1 + \varepsilon_{1t}$$
$$Y_2 = \mu_2 + \varepsilon_{2t}$$
$$\ldots \text{etc}$$

Where $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \ldots) \sim N(0, H_t)$ and $V_t$ is the covariance matrix. We can use one of the three specification methods for the ARCH system. Then the conditional covariance matrix is given by:

$$V_t = \Omega + A \otimes \varepsilon_{t-1} \varepsilon'_{t-1} + B \otimes V_{t-1}$$

We analyze the technical form of the system ARCH model. Let us consider a system of $m$ equations with the stacked form:

$$\begin{bmatrix}
Y_1 \\
Y_2 \\
\vdots \\
Y_m
\end{bmatrix} =
\begin{bmatrix}
X_1 & 0 & \ldots & 0 \\
0 & X_2 & \ldots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \ldots & X_m
\end{bmatrix}
\begin{bmatrix}
\beta_1 \\
\beta_2 \\
\vdots \\
\beta_m
\end{bmatrix} +
\begin{bmatrix}
\varepsilon_1 \\
\varepsilon_2 \\
\vdots \\
\varepsilon_m
\end{bmatrix}$$

In matrix form we can write: $Y = XB + E$

When:

$$Y = \begin{bmatrix}
Y_1 \\
Y_2 \\
\vdots \\
Y_m
\end{bmatrix}_{(T \times m)}$$
$$X = \begin{bmatrix}
X_1 & 0 & \ldots & 0 \\
0 & X_2 & \ldots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \ldots & X_m
\end{bmatrix}_{(T \times \ell m)}$$
$$B = \begin{bmatrix}
\beta_1 \\
\beta_2 \\
\vdots \\
\beta_m
\end{bmatrix}_{(\ell m \times 1)}$$
$$E = \begin{bmatrix}
\varepsilon_1 \\
\varepsilon_2 \\
\vdots \\
\varepsilon_m
\end{bmatrix}_{(T \times m)}$$
When, $V_{(M_T \times M_T)}$ is the covariance matrix. Under distribution assumptions, the covariance matrix can be written for the stack form:

$$V = E(\varepsilon\varepsilon') = \sigma^2 (I_M \otimes I_T)$$

There are some interest cases. When the residuals are heteroscedastic and when correlated? Residuals can be heteroscedastic across the $m$ equations. There is also the possibility for residuals to be heteroscedastic and contemporaneously correlated. We assume the matrix $\Sigma_{(M \times M)}$ of contemporaneously correlated residuals where the $i, j$-th element is: $\sigma_{ij} = E(\varepsilon_i, \varepsilon_j)$ $\forall t$. We can have three cases:

1) If we have heteroscedastic residuals but not contemporaneously correlated residuals then $\sigma_{ij} = 0$ and the matrix is diagonal:

$$V = E(\varepsilon\varepsilon') = \text{diag}(\sigma_1^2, \sigma_2^2, ..., \sigma_M^2) \otimes I_T$$

2) If we have heteroscedastic residuals and contemporaneously correlated residuals then:

$$V = \Sigma \otimes I_T$$

3) If we have heteroscedastic, contemporaneously correlated and autocorrelated residuals then the general form is written as:

$$V = \begin{bmatrix}
\sigma_{11} \Sigma_{11} & \sigma_{12} \Sigma_{12} & \cdots & \sigma_{1M} \Sigma_{1M} \\
\sigma_{21} \Sigma_{21} & \sigma_{22} \Sigma_{22} & \cdots & \sigma_{2M} \Sigma_{2M} \\
\vdots & \vdots & \ddots & \vdots \\
\sigma_{M1} \Sigma_{M1} & \cdots & \cdots & \sigma_{MM} \Sigma_{MM} \otimes (M \times M)
\end{bmatrix}$$

When $\Sigma_{ij}$ is the correlation matrix for the $i, j$ equations.

There are several estimation methods which conclude to the estimators (when $V = \Sigma \otimes I_T$). For example:

- For the OLS estimation, the estimators are: $\hat{\beta}_{OLS} = (XX^{-1}XY$, $\text{var}(\hat{\beta}_{OLS}) = \hat{\sigma}^2 (XX^{-1})$. 

• For the Weight Least Squares (WLS) estimation, the estimators are:
\[
\hat{\beta}_{WLS} = \left( X \hat{V}^{-1} X ^{-1} \right) X \hat{V}^{-1} Y \quad \text{and} \quad \text{var} (\hat{\beta}_{WLS}) = \left( X \hat{V}^{-1} X ^{-1} \right) \text{ when}
\]
\[
\hat{V} = \text{diag} \left( \hat{\sigma}^2_{11}, \ldots, \hat{\sigma}^2_{MM} \right) I_r \quad \text{and} \quad \hat{\sigma}^2_{ii} \quad \text{is the residual variance estimations.}
\]

• For the SUR (Zellner, 1962) method, the estimators are:
\[
\hat{\beta}_{SUR} = \left( \left( X' \hat{\Sigma} \otimes I_T \right)^{-1} X' \left( \hat{\Sigma} \otimes I_T \right)^{-1} Y \right)
\]
where \( \hat{\Sigma} \) is the consistent estimate of \( \Sigma \).

• For the 2 Stage Least Square (TSLS) and the Weight-TSLS estimations, if we suppose the model: \( YC_j + XB_j + E_j = 0 \rightarrow Y_j = Z_j \delta_j + \varepsilon_j \) when \( Z_j = (Y_j' \quad X_j') \) and \( \delta_j = (C_j' \quad B_j') \), then the estimators are:
\[
\hat{\delta}_{2-LS} = \left( \hat{Z}_j' \hat{Z}_j \right)^{-1} \hat{Z}_j',
\]
\[
\hat{\delta}_{W-2LS} = \left( \hat{Z}_j' \hat{V}^{-1} \hat{Z}_j \right)^{-1} \hat{Z}_j' \hat{V}^{-1} Y.
\]

The specifications that we assume for the system ARCH are the followed:

A) Diagonal VECH

This is a restricted version of generalized multivariate VECH model of conditional covariance (Bollerslev et. al., 1988) with the formulation:
\[
V_t = \Omega + A \varepsilon_{t-1} \varepsilon_{t-1}' + B V_{t-1}
\]

The coefficient matrices \( \Omega, A, B \) are symmetrical \((n \times n)\) matrices and the operator \((\ast)\) is the element by element product. The coefficient matrices can be parameterized. The most common way is to allow the parameters in the matrices to vary without any restrictions (for example, parameterize them as indefinite matrices). In that case the model may be written in single equation format as:
\[
V_{g,j} = \Omega_{g} + A_{g} \varepsilon_{g,j-1} \varepsilon_{g,j-1}' + B_{g} V_{g,j-1}
\]

This model is the unrestricted version of Diagonal VECH. It does not ensure that the conditional covariance matrix is positive semi-definite. As Ding & Engle (2001)
summarized, there are several approaches for specifying coefficient matrices that restrict
to be positive semi-definite, possibly by reducing the number of parameters\textsuperscript{114}.

\textbf{B) Constant Conditional Correlation (CCC)}

Bollerslev (1990) specifies the elements $h_{ij,t}$ of the conditional covariance
matrix $V_t$ as follows:

$$h_{ij,t} = c_i + a_i e_{i,t-1}^2 + d_i I_{i,t-1} e_{j,t-1}^2 + b_i h_{ii,t-1}$$

$$h_{ij,t} = \rho \sqrt{h_{ii,t} h_{jj,t}}$$

Restrictions may be imposed on the constant term using variance targeting so
that: $c_i = \sigma_i^2 (1 - a_i - b_i)$ where $\sigma_i^2$ is the unconditional variance.

When exogenous variables are included in the variance specification, the user
may choose between \textit{individual} coefficients and \textit{common} coefficients. For common
coefficients, exogenous variables are assumed to have the same slope $g$ for every
equation. Individual coefficients allow each exogenous variable effect to differ across
equations:

$$h_{ij,t} = c_i + a_i e_{i,t-1}^2 + d_i I_{i,t-1} e_{j,t-1}^2 + b_i h_{ii,t-1} + \gamma_i X_{it} + g X_{2t}$$

\textbf{C) Diagonal BEKK}

\textit{Diagonal BEKK} was introduced from Engle & Kroner (1995). The equation has
the form:

$$V_t = \Omega \Omega' + A \varepsilon_{t-1} \varepsilon_{t-1}' A' + B V_{t-1} B'$$

Matrices $A, B$ can be restricted as diagonal matrices.

\textsuperscript{114} A way is to assume constants values for matrix $B = b(i')$, where $b$ is a scalar parameter and $i = [1 \ldots 1]$, or
the variance target restriction for matrix $\Omega = \Omega_0 (ii' - A - B)$ and $\Omega_0$ is the unconditional sample variance
of residuals. In both of these specifications, there is no insurance that the conditional covariance matrix is positive semi-
definite.
4.8.3.3. The diffusion matrix as regressor factor to conditional variance-covariance equation

A financial innovation is introduced to the market. Let us consider a random market participant who has an internal minimum boundary of need for change $u_i$. The diffusion matrix (the transposed version where we assume each column for the $i-th$ participant in time study) can be used as regressor factor to examine the asymmetric volatility in the conditional variance equation. Suppose an AR(1) model for the $i-th$ participant’s returns. The equation is written:

$$R_t = \mu + aR_{t-1} + \varepsilon_t$$

suppose that: $\varepsilon_t / \text{Inf}_{t-1} \sim N(0, \sigma_i^2)$

We symbolize:

- $R_t$: is the market participant returns.
- $(\varepsilon_t / \text{Inf}_{t-1}) \sim N(0, \sigma_i^2)$: the error term where $\text{Inf}_{t-1}$ is the information set for time moment $t-1$.
- $\sigma_i^2$: the conditional variance of unexpected returns, or else; the error term.
- $\mu, a$: the coefficients of the model.

We need to model the conditional variance. First, we can also use a dummy variable (Li & Engle, 1998) which shows the effects of financial innovation’s introduction on a market participant’s returns during time of diffusion in conditional variance equation. Moreover, we use a similar threshold GJR model (Glosten et al., 1993). This form of specification has two main goals: $i$) to capture the innovation effect on volatility and $ii$) to allow us assume a certain level of asymmetry on conditional variance. Volatility behaves asymmetrically after big shocks, such as the introduction (adoption) of a financial innovation. Therefore, big shifts on returns (prices) should be linked with these shocks. We can write for the conditional variance:

$$\sigma_i^2 = c_0 + c_1\sigma_{t-1}^2 + b_i\varepsilon_t^2 + I \sum_{j=1}^{m} \gamma_j P_{ij}^{(t-j-1)} + u_t$$

When:

- $I$ is the dummy variable in and we can write:
\[ I = \begin{cases} 0, & \text{financial innovation is not introduced} \\ 1, & \text{financial innovation is introduced} \end{cases} \]

- \( p_{ij}^{(t-1,\ldots)} \) is the element of the diffusion transpose matrix in time moments
- coefficient \( \gamma_i \) which is typically greater than zero (\( \gamma > 0 \)) because the diffusion of financial innovation (or else the need of change) will always be real in a random time moment.

Notice that the term \( p_{ij}^{(t)} \) has any of the form:

\[
p_{ij}^{(t)} = 1 - e^{-kw} \text{ or } \exp \left[ -\sum_{i=1}^{m} \lambda \alpha \left( 1 + \gamma_i z_i \right)^{-1/y_i} \right]
\]

The conditional variance equation contains a term that captures the pre-innovation effects and the post-innovation effects. The equation shows that the effect before and after the innovation is differs at \( \gamma \). When innovation is diffused (introduced) market participants need time to rebalance their portfolios because of the complexity of market and the correlation frictions. This is the time for calm of returns (Harris & Raviv, 1993).

### 4.8.3.4. The parameter of surprise

We can also examine the unexpected component during the introduction of financial innovation. Then, the difference (before and after) is the size of the shock for the unexpected return (Balduzzi et al., 2001). We suppose another dummy, such as:

\[
Z_{t-1}^{spr} = \begin{cases} 0, & \text{if it is not a suprise} \\ 1, & \text{if it is a suprise} \end{cases}
\]

Therefore, the model becomes:

\[
\sigma_t^2 = c_0 + c_1 \sigma_{t-1}^2 + (b_0 + b_1 Z_{t-1}^{spr}) \varepsilon_t^2 + I \sum_{j=1}^{m} \gamma_j p_{ij}^{(t-1,\ldots)} + u_t
\]
4.8.3.5. System of conditional variance equations – the multivariate case

Introduction and diffusion of financial innovation can generate multiple covariances of all the market participants with different diffusions. Let as assume that 
\( \varepsilon_i / I_{t-1} \sim N(0, V_t) \) where \( V_t = \begin{bmatrix} \sigma_{ij}^2 \end{bmatrix} \). Then, we can write:

\[ \sigma_{ij,t}^2 = c_{ij,0} + c_{ij,1} \sigma_{ij,t-1}^2 + \left( b_{ij,0} + b_{ij,1} Z_{ij,t-1}^{im} \right) \varepsilon_i^2 + \gamma I \Lambda_{ij,t-1} \mu + u_t \]

This is a generalization of modeling the asymmetric volatility which allows several terms of asymmetric conditional variances and covariance. Under a distribution assumption of specification as it mentioned before, we can estimate the conditional covariance matrix.

In empirical implementations, it is expected that the use of regressors will have a significant importance to the parameters estimation of asymmetric volatility. In particular, we expect that asymmetric volatility will be reduced in that case and, on the other hand the estimated parameters will be more accurate, more efficient and standard deviation of parameters will be reduced significantly. That should occur because investors will rebalance their portfolios during the time of adoption. Hence, financial innovations seem to be a very powerful tool to systematically drive market expectations and, eventually, the actual evolution of the real economy. Therefore, it is very useful to measure the impact of financial innovation on investors’ policy.

4.9. Conclusions

In this section, we build a mathematical framework in order to model the influence of diffusion of financial innovation under some assumptions. We use some parametric distributions like G-Pareto and a compound process of G-Pareto and Poisson distributions, to capture the adoption of a financial innovation from a market participant and the influence that this adoption has to other market participants by creating a diffusion influence matrix among market participants.

Thus, we introduce the diffusion matrix in simultaneous equations model and multivariate volatility models in order to measure the diffusion of financial innovation on dependent interest variables during time.

In the next chapter, we will apply the above theoretical mathematical analysis in empirical implementations using data from various sources in order to study the diffusion, the impact and the results of financial innovations into market participants or
indices. The aim is to present a proposal of how financial innovations drive market frictions and expectations and, eventually, the actual evolution of the real economy, through our approach.
CHAPTER 5
EMPIRICAL ANALYSIS

In the present chapter, we perform several different empirical applications in different interest areas in order to show the significance of the above mathematical methodology. The chapter is structured as follows. First, we present a proxy in order to define the variables of interest and the financial innovations that related to these variables. Furthermore, we present the description of the variables and the data samples that we will use at the following empirical analyses.

We divine the following empirical analysis in three parts. At the first part, we examine the influence of the euro (through €/$ exchange rate\textsuperscript{115}) and Euribor (3-month) introduction on Euro-zone governments’ bond yields. At the second part, we analyze the effect of €/$ exchange rate on the implied volatility index (VIX) and on Euribor and, at the last part, we measure the influence of information flow on implied volatility index (VIX) and on Euribor. Finally, the summary of our findings follows on each part.

5.1. The influence of the diffusion of €/$ exchange rate and Euribor (3-months) on EMU (1999) Government Bond Yields (10-years) rates

The Euro-zone is the Economic and Monetary Union (EMU) of EU member states countries that sharing the same currency (euro) and the same monetary policy. Nowadays, the number of the EU member states is sixteen countries\textsuperscript{116}. Eleven of these countries adopted the euro currency in 1999 by qualifying the agreement convergence criteria. The countries, that adopted euro in 1999, are showed at the following table:

\textsuperscript{115} The exchange rate between two currencies specifies how much one currency is worth in terms of the other. It is the value of a foreign nation’s currency in terms of the home nation’s currency. The foreign exchange market is one of the largest markets in the world. The spot exchange rate refers to the current exchange rate (http://en.wikipedia.org/wiki/Exchange_rate)

\textsuperscript{116} These member states are (2010): Austria, Belgium, Finland, France, Germany, Greece, Cyprus, Ireland, Italy, Luxembourg, the Nederlands, Portugal, Malta, Spain, Slovakia and Slovenia. There are also third microstates countries that have adopted euro with special agreements to the EU as Montenegro, Monaco, San Marino, Vatican City, etc.
### Table 5.1.: Euro-zone (1999)

<table>
<thead>
<tr>
<th>Country</th>
<th>Date of adoption</th>
<th>Previous currency</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>01/01/1999</td>
<td>Portuguese escudo</td>
<td>200.482</td>
</tr>
<tr>
<td>Spain</td>
<td>01/01/1999</td>
<td>Spanish peseta</td>
<td>166.386</td>
</tr>
<tr>
<td>France</td>
<td>01/01/1999</td>
<td>French franc</td>
<td>6.56</td>
</tr>
<tr>
<td>Italy</td>
<td>01/01/1999</td>
<td>Italian lira</td>
<td>1.936</td>
</tr>
<tr>
<td>Ireland</td>
<td>01/01/1999</td>
<td>Irish pound</td>
<td>0.787</td>
</tr>
<tr>
<td>Belgium</td>
<td>01/01/1999</td>
<td>Belgian franc</td>
<td>40.34</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>01/01/1999</td>
<td>Dutch guilder</td>
<td>2.203</td>
</tr>
<tr>
<td>Germany</td>
<td>01/01/1999</td>
<td>German mark</td>
<td>1.95</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>01/01/1999</td>
<td>Luxembourgian franc</td>
<td>40.33</td>
</tr>
<tr>
<td>Austria</td>
<td>01/01/1999</td>
<td>Austrian schilling</td>
<td>13.76</td>
</tr>
<tr>
<td>Finland</td>
<td>01/01/1999</td>
<td>Finnish markkas</td>
<td>5.945</td>
</tr>
</tbody>
</table>

Source: ECB (2009)

The monetary policy of all member countries in the *Euro-zone* is designed and managed by *ECB*. *Euro-zone* is represented politically by its finance ministers, known collectively as the *Euro Group* and is presided over by a president.

A debt security issued by a government to support government spending, most often issued in the country's domestic currency. Government debt is money owed by any level of government and is backed by the full faith of the government. Federal government bonds[^117] in Europe and U.S. include savings bond, Treasury bond, Treasury inflation-protected securities, etc. Before investing in government bonds, investors need to assess several risks associated with the country. Lending to a national government in the country's own sovereign currency, government bonds, are free of credit risk, because the government can raise taxes or simply print more money to redeem the bond at maturity. But this does not mean risk-free.

*Euribor[^118]* is the rate at which Euro interbank term deposits are offered by one prime bank to another prime bank within the *EMU* zone. The choice of banks quoting for *Euribor* is based on market criteria. These banks are of first class market standing and they have been selected to ensure that the diversity of the euro money market is adequately reflected, thereby making *Euribor* an efficient and representative benchmark.

A strict *Code of Conduct[^119]* sets out rules covering: *i)* the criteria used to determine which banks may belong to the *panel of banks[^120]*, *ii)* the obligations of the

[^117]: [http://www.investopedia.com](http://www.investopedia.com)
[^118]: [http://www.euribor-ebf.eu](http://www.euribor-ebf.eu)
[^120]: [http://www.investopedia.com](http://www.investopedia.com)
panel banks and, iii) the tasks and the composition of the Steering Committee, which is responsible for overseeing Euribor. Thomson Reuters\textsuperscript{121} has been chosen as the screen service provider responsible for computing and also publishing Euribor.

Since its launch, Euribor has become a reality on the derivatives markets and is the underlying rate of many derivatives transactions, both OTC and exchange-traded. European banks considered that the introduction\textsuperscript{122} in 1999 of the single currency made it necessary to establish a new interbank reference rate within the EMU.

For the purpose of this part of empirical analysis, we set the variables of harmonized government bond yields rates for the EMU eleven countries that adopted the euro in 1999, and the variables of €/$ exchange rate variable and Euribor 3M after 1999. This dataset contains eleven variables presenting the harmonized government bond yields rates (10Y) of EMU for the period 1980M01 to 2010M08 (a total of 368 monthly observations) and the variables of €/$ exchange rate and Euribor 3M for the period 1999M01 to 2010M08 (140 monthly observations).

Table 5.2., (Appendix) presents the descriptive statistics of all the variables. We can see on Table 5.3., where the average of bond yields means for all countries is 7.07% with a range (4.28%).

<table>
<thead>
<tr>
<th>Mean</th>
<th>Stand. Error</th>
<th>Range</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.07%</td>
<td>0.4295</td>
<td>4.28%</td>
<td>5.19%</td>
<td>9.48%</td>
</tr>
</tbody>
</table>

An interest conclusion can be export from the graphs of EMU bond yields (see Figure 5.1., Appendix). During the introduction of euro and Euribor 3M (1999-2001) all series of bond yields have a common increasing trend for short period. This led us to the conclusion that the introduction of euro and Euribor 3M as financial innovations has an effect on government bonds.

We also test the individual Granger causality between each variable of government bond yields and the variable of euro and Euribor (Table 5.4., Appendix)

\textsuperscript{120} Panel Banks: The contributors to Euribor are the banks with the highest volume of business in the euro zone money markets. The panel of banks contributing to Euribor consists of 44 banks: i) banks from EU countries participating in the euro from the outset, ii) banks from EU countries not participating in the euro from the outset and, iii) large international banks from non-EU countries but with important euro zone operations.

\textsuperscript{121} www.thomsonreuters.com

\textsuperscript{122} Euribor history: i) on 15\textsuperscript{th} December 1997, the European Banking Federation and the Financial Markets Association announces the progress of Euribor development, ii) on 27\textsuperscript{th} May 1998, it is announced that the list of Euribor Reference Banks is published and, iii) Euribor was first published for value on 4\textsuperscript{th} of January 1999.
according to the null hypothesis \((H_0: \text{euro or Euribor does not cause Granger causality to each country})\). The results show that the null hypothesis is accepted at the majority of the cases.

Finally, we test the stationary of all time series (government bonds yields, euro and Euribor) with the ADF test specification. The results show (Table 5.5, Appendix) that the null hypothesis \((H_0: \text{time series variable has a unit root})\) is accepted at the 1% and 5% level of significance for all cases.

Thus, we determine three transformations for each financial innovation’s variable: the minimum boundary Pareto distribution (variable \(p_1^{(\text{Exr or Eur3M})}\)), the G-Pareto distribution (variable \(p_2^{(\text{Exr or Eur3M})}\)) and the compound process of Poisson G-Pareto distribution (variable \(p_3^{(\text{Exr or Eur3M})}\)) on a simultaneous equations model we showed at paragraph (4.8.2.2.), using as the minimum boundary the minimum value of each series.

At this equation model we have eleven times series presenting the government bond yields for the EMU countries, two common exogenous variables (the 1st difference stationary times series of €/$ exchange rate and Euribor3M), the diffusion factor \(\Lambda\) (with lags if necessary) and a dummy variable (=0 before introduction of innovation and =1 after introduction of innovation) for the diffusion factor. The transformed variables can be used as the instrumental variables for the system.

We use a simultaneous equation model with specific AR(1) term for each equation and four common exogenous variables for all the equations: the 1st difference time series of Euribor 3M and €/$ exchange rate and their transformed diffusion factor each time. Table 5.6., presents the results of the estimation:

### Table 5.6: Estimation results-Government bond yields

<table>
<thead>
<tr>
<th>System</th>
<th>C</th>
<th>AR(1)</th>
<th>(p_1^{\text{min}})</th>
<th>(p_2^{\text{pere}})</th>
<th>(p_3^{\text{pore}})</th>
<th>(D(\text{euro}))</th>
<th>(D(\text{Euribor}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>4.01</td>
<td>0.951</td>
<td>0.02</td>
<td>0.43</td>
<td>1.30</td>
<td>0.479</td>
<td>0.126</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.02)</td>
<td>(0.43)</td>
<td>(0.222)</td>
<td>(0.85)</td>
<td>[0.018]</td>
<td>[6.99]</td>
</tr>
<tr>
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<td>[3.46]</td>
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</tr>
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</tr>
<tr>
<td></td>
<td>(0.3)</td>
<td>(0.028)</td>
<td>(0.222)</td>
<td>(0.13)</td>
<td>[3.46]</td>
<td>[6.99]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[13.29]</td>
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<td></td>
</tr>
<tr>
<td>Finland</td>
<td>3.915</td>
<td>0.961</td>
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<td>--</td>
<td>--</td>
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<td>$p_2^{\text{euro}}$</td>
<td>$D(\text{euro})$</td>
<td>$D(\text{Euribor})$</td>
</tr>
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<td>(0.028)</td>
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<tr>
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<tr>
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<td>(0.027)</td>
<td>--</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>System</th>
<th>$C$</th>
<th>$AR(1)$</th>
<th>$p_3$</th>
<th>$p_3^{\text{exchrate}}$</th>
<th>$p_3^{\text{euro}}$</th>
<th>$D(\text{euro})$</th>
<th>$D(\text{Euribor})$</th>
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</thead>
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<tr>
<td>Austria</td>
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<td>Belgium</td>
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<td>(0.0281)</td>
<td>(0.827)</td>
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<td>(0.0289)</td>
<td>(3.385)</td>
<td>(3.52)</td>
<td>(0.0181)</td>
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<td>0.94</td>
<td>(0.0281)</td>
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<td>Nederlands</td>
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</tr>
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<td>Luxemburg</td>
<td>4.016</td>
<td>(0.404)</td>
<td>0.96</td>
<td>(0.027)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Country</td>
<td>Mean</td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td>AR(1) Coefficient</td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td>AR(1) Coefficient</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>-------------</td>
<td>-------------</td>
<td>------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Finland</td>
<td>3.924</td>
<td>(0.407)</td>
<td>[9.62]</td>
<td>0.962</td>
<td>(0.0288)</td>
<td>[33.42]</td>
<td>--</td>
</tr>
<tr>
<td>France</td>
<td>3.949</td>
<td>(0.315)</td>
<td>[12.52]</td>
<td>0.951</td>
<td>(0.0311)</td>
<td>[30.56]</td>
<td>--</td>
</tr>
<tr>
<td>Spain</td>
<td>4.247</td>
<td>(0.266)</td>
<td>[15.81]</td>
<td>0.941</td>
<td>(0.0281)</td>
<td>[35.44]</td>
<td>--</td>
</tr>
<tr>
<td>Portugal</td>
<td>4.729</td>
<td>(0.596)</td>
<td>[7.92]</td>
<td>0.968</td>
<td>(0.026)</td>
<td>[36.52]</td>
<td>--</td>
</tr>
<tr>
<td>Italy</td>
<td>4.359</td>
<td>(0.248)</td>
<td>[17.53]</td>
<td>0.939</td>
<td>(0.027)</td>
<td>[33.57]</td>
<td>--</td>
</tr>
<tr>
<td>Ireland</td>
<td>4.845</td>
<td>(0.0759)</td>
<td>[6.37]</td>
<td>0.974</td>
<td>(0.022)</td>
<td>[42.08]</td>
<td>--</td>
</tr>
<tr>
<td>Nederlands</td>
<td>3.907</td>
<td>(0.368)</td>
<td>[10.59]</td>
<td>0.959</td>
<td>(0.03)</td>
<td>[31.06]</td>
<td>--</td>
</tr>
<tr>
<td>Germany</td>
<td>3.8</td>
<td>(0.311)</td>
<td>[12.19]</td>
<td>0.945</td>
<td>(0.034)</td>
<td>[27.75]</td>
<td>--</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>4.026</td>
<td>(0.42)</td>
<td>[9.57]</td>
<td>0.962</td>
<td>(0.027)</td>
<td>[34.73]</td>
<td>--</td>
</tr>
</tbody>
</table>

The results confirm the influence of exogenous diffusion factor of financial innovation to market participants’ government bond yields at all the cases. Moreover, it appears that the AR(1) individual coefficients for each equation is statistical significant and have similar values for all the cases. This means that the estimated parameters of lag term are consistently steady among the government’s bond yields for each member country. Furthermore, we occur that the standard deviations of all the AR(1) coefficients are also floating within the same values at all the systems. Therefore, there is a significant existence of strong forecast-ability for government bond yield curves. This is very attractive issue from the vantage point of active bond trading and the vantage point of credit portfolio risk management.

At the other hand, the common regressors of €/$ exchange rate and Euribor3M are significant for the system for all the cases. This lead us to the conclusion that the variables of €/$ exchange rate and Euribor 3M have their significant importance on the forecast-ability of government bond yield curves.

Nevertheless, the diffusion exogenous diffusion factor is also statistical significant for all the cases following a common trend and similar values (positive coefficient rate for $p^\text{ex} \text{diff}$ and negative coefficient rate for $p^\text{exrate}$). These coefficients values are the diffusion rates in any case for the restricted diffusion period for time.
Moreover, values of diffusion factor represent the financial frictions between the financial innovations. The above results lead us to the conclusion that the exogenous diffusion factor (the diffusion rates) of financial innovations is statistically significant without take into consideration the distribution function we use, according to our approach. Overall, the results presented in this case, confirm our approach that reported in the previous section and show the significant relationship between the diffusion rates for the specific diffusion time period and, the market participants, and in our case, government bond yield curves for the EMU (1999).

5.2. The influence of the introduction of euro currency on VIX index and Euribor (3-months) interest rate.

VIX\textsuperscript{123} is the ticker symbol for the Chicago Board Options Exchange Market Volatility Index, a measure of the implied volatility of S&P500 index options, referred to as the fear index or the fear gauge. It represents one measure of the market’s expectation of stock market volatility over the next 30 day period. The VIX is calculated and disseminated in real-time by the Chicago Board Options Exchange. It is a weighted blend of prices for a range of options on the S&P500 index\textsuperscript{124}.

A high VIX is not necessarily bearish for stocks. VIX is a measure of market perceived volatility in either direction, including to the upside. In practice, when investors anticipate large upside volatility they are unwilling to sell upside call stock options unless they receive a large premium. Option buyers will be willing to pay such high premiums only if similarly anticipating a large upside move. The resulting aggregate of increases in upside stock option call prices raises the VIX just as does the aggregate growth in downside stock put option premiums that occurs when option buyers and sellers anticipate a likely sharp move to the downside. When the market is believed as likely to soar as to plummet, writing any option that will cost the writer in the event of a sudden large move in either direction may look equally risky.

For the purpose of this part of empirical analysis, we set the variables of VIX, Euribor 3M as market participants. This dataset contains two variables with daily frequently observations referring at the period 01/03/1995 – 12/31/2009 (a total number of 3776 daily observations).

\textsuperscript{123} http://www.cboe.com
\textsuperscript{124} VIX has replaced the older VXO which was a measure of implied volatility calculated using 30 day S&P100 index at-the-money options.
Table 5.7. (Appendix) presents the descriptive statistics and Figure 5.2. (Appendix) presents the graphs of the variables. During the introduction of euro currency (1999-2001) the VIX has a steady behavior with low values. This led us to the conclusion that the introduction of euro has stabilized the fear index for a time period.

We also test the individual Granger causality between the variables (Table 5.8., Appendix) according to the null hypothesis ($H_0: each\ variable\ does\ not\ cause\ Granger\ causality\ to\ another$). The null hypothesis is accepted and the phenomenon of precedence appears: VIX causes Euribor 3M and Euribor 3M causes VIX.

Finally, we test the stationary of all time series with the ADF test specification. The results show (Table 5.9., Appendix) that the null hypothesis ($H_0: time\ series\ variable\ has\ a\ unit\ root$) is accepted at the 1% and 5% level of significance for the majority of the cases and is rejected for VIX. Therefore, we transform endogenous time series at stationary series using 1st difference transformation.

Thus, we determine three transformations for each market participant variable: the minimum boundary Pareto distribution (variable $p_1^{(VIX\ or\ Eur3M)}$), the G-Pareto distribution (variable $p_2^{(VIX\ or\ Eur3M)}$) and the compound process of Poisson G-Pareto distribution (variable $p_3^{(VIX\ or\ Eur3M)}$) on a simultaneous equations model we showed at paragraph (4.8.2.2.). At this simultaneous equations model we have two endogenous variables (VIX and Euribor3M), the diffusion factor $\Lambda$ for the endogenous variables, the common variable of €/$ exchange rate for both equations and a dummy variable (=0 before introduction of euro and =1 after introduction of euro) for the diffusion factor. The transformed variables can be used as the instrumental variables for the system. Table 5.10., presents the results of the estimation:
Table 5.10: Estimation results - VIX and Euribor3M

<table>
<thead>
<tr>
<th>System</th>
<th>C</th>
<th>AR(1)</th>
<th>p_{VIX}</th>
<th>p_{EUR3M}</th>
<th>D(euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(VIX)</td>
<td>0.06</td>
<td>-0.114</td>
<td>-0.105</td>
<td>0.035</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.04)</td>
<td>(0.01)</td>
<td>(0.007)</td>
<td>(0.05)</td>
</tr>
<tr>
<td></td>
<td>[2.01]</td>
<td>[-6.04]</td>
<td>[-8.53]</td>
<td>[4.86]</td>
<td>[-1.36]</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[5.99]</td>
<td>[3.72]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System</th>
<th>C</th>
<th>AR(1)</th>
<th>p_{VIX}</th>
<th>p_{EUR3M}</th>
<th>D(euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(VIX)</td>
<td>0.05</td>
<td>-0.115</td>
<td>-0.186</td>
<td>0.053</td>
<td>-0.081</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.02)</td>
<td>(0.011)</td>
<td>(0.058)</td>
</tr>
<tr>
<td></td>
<td>[-2.03]</td>
<td>[-6.03]</td>
<td>[-8.58]</td>
<td>[4.87]</td>
<td>[-1.37]</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.019)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[6.04]</td>
<td>[3.74]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System</th>
<th>C</th>
<th>AR(1)</th>
<th>p_{VIX}</th>
<th>p_{EUR3M}</th>
<th>D(euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(VIX)</td>
<td>-0.13</td>
<td>-0.114</td>
<td>-0.282</td>
<td>0.076</td>
<td>-0.0801</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.018)</td>
<td>(0.033)</td>
<td>(0.016)</td>
<td>(0.0589)</td>
</tr>
<tr>
<td></td>
<td>[-3.61]</td>
<td>[-6.048]</td>
<td>[-8.37]</td>
<td>[4.66]</td>
<td>[-1.36]</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[-6.11]</td>
<td>[3.77]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results confirm the existence of the influence of endogenous diffusion factor of VIX and Euribor 3M to market participants at all the cases. The AR(1) individual coefficients for each equation are statistical significant and have similar values for all the cases. As we occur from the previous paragraph, the estimated parameters of lag term are consistently steady among variables of interest (VIX and Euribor 3M) and the standard deviations of all the AR(1) coefficients are also floating within the same values at the systems. Furthermore, we see that the common regressor of €/$ exchange rate is significant for the system for all the cases with a similar value.

We can see that the diffusion endogenous diffusion factor is also statistical significant for all the cases following a common trend and similar values (positive coefficient rate for $p_{VIX}^i$ and negative coefficient rate for $p_{EUR3M}^i$). These coefficients values are the diffusion rates of endogenous adoption for the variables of interest in any case according to the restricted diffusion period for time. Moreover, we can occur that these values of diffusion factor represent the internal financial frictions which are smoothed during the diffusion time. This lead to the conclusion that when the diffusion factor is consider to be endogenous (the diffusion caused by the introduction of financial
innovation on market participants) the coefficients are showing the diffusion rate of financial innovations’ adoption and they are statistically significant without take into consideration the distribution function we use.

Overall, the results presented in this case, confirm our approach for the endogenous case that reported in the previous section and they show the significant relationship between the diffusion matrix factor and the returns of market participants that shift the values of interest variables and, in our case, VIX and Euribor 3M.

5.3. Measuring the influence of diffusion information flow from ECB and Thompson Reuters released news on Euribor (3-months) index

The European Central Bank (ECB) is the central bank for Europe's single currency, the euro. The ECB’s main task is to maintain the euro’s purchasing power and thus price stability at EMU. The ECB’s statements have a unique institutional characteristic of announcing its policy rate decisions and explaining its monetary policy stance. In order to communicate with the public effectively and address the informational needs of various target groups such as politicians, academics, the press and financial market participants, ECB uses various instruments such as the Monthly Bulletin, the Testimony to the Committee on Monetary Affairs of the European Parliament, etc.

We examine information flow and announcements’ effect on financial markets by adopting the following framework. Information flow and announcements are able to affect prices returns through their bias statements and this effect can be generating from the innovativeness of information. During the period, market participants’ start processing and analyzing the news with different toolbox and rate of interest. Since announcements or institutional reports are not quantitative data, the ranking of statements can be in good news and bad news according to investor’s individual interest.

The aim is to determine the impact of information flow. For that reason, we will use the SVI data from Google Trends Labs. Google Trends Labs service provides data for any keyword the user inputs. The SVI data is quantitative data that capture the demand of information. SVI data are derived from the number of searches for the specific keyword, divided by the total number of queries at the point in time and scaled to the highest value, for the requested period so that is the highest value at the sample is 100.
We make the following assumptions: i) SVI captures individual investor attention and demand for information in sample time period, ii) financial markets and market participants immediately react to information news (this means that the news is not only statistically and economically significant, but also quantitatively important), iii) all market participants are connected to a network with full access to public information (Google Search Engine).

We consider “ECB” and “Reuters” as the search keywords because they are connected to Euribor (3-months). These datasets include some noise by people searching, but we assume that is random noise without any systematic influence. We use the specific keywords for some reasons. The first main reason is that the keywords give the official website on the top and therefore, brings the best result. People may search the keyword for reasons other than investment, but there are not any other different ways to spell them. At the other hand, when investors search for information, they often use the common talk able name for any announcements or relevant news.

The main goal is to examine how this information can be properly diffuse through a probability algorithm. The purpose of the algorithm is to establish the possible existence of scaling, either normal or anomalous, in the most efficient way as possible without altering the data with any form of de-trending. The existence of scaling implies the existence of a pdf(x,t) that scales according to a distribution.

Let us consider the information flow as a time series call $X_i$, $i=1,2,...,t$. For any given time $t$, we can find $t-i+1$ sub-sequences defined by: $X_i^s$, $s=0,...,t-1$. For any of these sub-sequences we can build a diffusion trajectory. This trajectory can be express as: $X(t) = \sum_{i=1,2,...} X_i^s$. At each time $t$, we use a pdf(x,t) that will be evaluate the moment entropy of this diffusion process. We can partition the time into intervals and to use the number of these cells to determine the probability $p_i$ on the $i$-th cell at time $i$.

For every $i$-th time cell, any market participant has a minimum boundary of previous information entropy $u_{i-1}$ which is the previous information set. Therefore, we can assume that any news (information) introduced to time $i$-th has a probability that exceed its previous information (means its minimum boundary).
The Shannon-Khinchin axioms\textsuperscript{125} allow us to define as the lack of information about the measure of an event $i$ that occurs with a probability $p_i$ the following indicator: $b_i = -\ln p_i$. We observe that if an event occurs with a probability $p=0$ there is a total lack of information about that event and; if an event occurs with a probability $p=1$ we possess all the available information.

Finally, if we have a long series of observations where the events $i=1,2,...,n$ occur with a probability distribution $\{p_i\}$, the four Shannon-Khinchin axioms uniquely determine the entropy of the system as the average of the lack of information $b_i$ about each events that is: $S(p) = c \sum_{i=1,2,...} p_i b_i$. The positive constant $c$ is undetermined and is chosen to be one by convention. Thus, we can determine the moment diffusion entropy of the system as the average of the lack of information $b_i$ about each news events for time interval that is: $(sp)_i = p_i b_i$, $i=1,2,...$

For the purpose of this part of empirical analysis, we set the variables of \textit{Euribor 3M} and the \textit{SVIs} for keywords \textit{ECB} and \textit{Reuters}. This dataset contains three variables with weekly frequency observations referring at the period 2004W01 to 2010W08 (a total of 349 weekly observations). \textit{Table 5.1.}, (Appendix) presents the descriptive statistics and \textit{Figure 5.3.} (Appendix) shows the graphs of all the variables.

We also test the individual \textit{Granger causality} between the variable of \textit{Euribor 3M} and \textit{SVIs} indices (\textit{Table 5.12.}, Appendix) according to the null hypothesis ($H_0$: \textit{Euribor does not cause Granger causality to SVIs indices}). The results show that the null hypothesis is accepted at the majority of the cases. The null hypothesis is rejected and the phenomenon of precedence appears: \textit{Euribor 3M} causes \textit{SVI} of \textit{Reuters}.

Finally, we test the stationary of all time series with the \textit{ADF} test specification. The results show (\textit{Table 5.13.}, Appendix) that the null hypothesis ($H_0$: \textit{time series variable has a unit root}) is accepted at the 1% and 5% level of significance for \textit{Euribor 3M} and is rejected for \textit{SVIs} indices. Therefore, we transform all variables to stationary time series using $1^{st}$ difference transformation.

Thus, we determine the moment diffusion entropy of information flow $(sp)_i = p_i b_i$, $i=1,2,...$ for \textit{ECB} and \textit{Reuters} released information news, using three

\textsuperscript{125} The four Shannon-Khinchin axioms for the $S(p)$ function are: \textit{i}) continuity, \textit{ii}) maximality, \textit{iii}) additivity and, \textit{iv}) expandability (Khinchin, 1957; Shannon & Weaver, 1963)
transformations for the \( \text{pdf}(x,t) \) (the probability \( p_i \)): the minimum boundary Pareto distribution (regressor variable: \( sp_1^{(ECB \text{ or } Reut)} \)), the G-Pareto distribution (regressor variable: \( sp_2^{(ECB \text{ or } Reut)} \)) and the compound process of Poisson G-Pareto distribution (regressor variable: \( sp_3^{(ECB \text{ or } Reut)} \)), as regressors variables to the model we showed at paragraph 4.8.3.3.: 

\[
\sigma_i^2 = c + c_1 \sigma_{i-1}^2 + b_1 \left( \text{resid}_i \right)^2 + \sum_{k=1}^{\infty} \gamma_k sp_{i,i-k}^{(ECB \text{ or } Reut)} + u_i
\]

This is an ARMA(1,1)- GARCH (1,1) with the moment diffusion entropy and its 1st lag when needed. Table 5.14., presents estimation results for the extent GARCH(1,1) with regressors model.
Table 5.1: Estimation results - Euribor3M and Information flow

<table>
<thead>
<tr>
<th>Equation</th>
<th>Mean equation</th>
<th>Variance equation</th>
<th>Information flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>AR(1)</td>
<td>MA(1)</td>
</tr>
<tr>
<td>D(Euribor)</td>
<td>[0.008 (0.003)]</td>
<td>[0.931 (0.01)]</td>
<td>[-0.632 (0.04)]</td>
</tr>
<tr>
<td>D(Euribor)</td>
<td>[0.002 (0.003)]</td>
<td>[0.937 (0.02)]</td>
<td>[-0.6 (0.06)]</td>
</tr>
<tr>
<td>D(Euribor)</td>
<td>[0.0053 (0.0052)]</td>
<td>[0.931 (0.02)]</td>
<td>[-0.541 (0.07)]</td>
</tr>
<tr>
<td>D(Euribor)</td>
<td>[0.009 (0.008)]</td>
<td>[0.944 (0.02)]</td>
<td>[-0.724 (0.07)]</td>
</tr>
<tr>
<td>D(Euribor)</td>
<td>[0.009 (0.009)]</td>
<td>[0.944 (0.03)]</td>
<td>[-0.721 (0.07)]</td>
</tr>
<tr>
<td>D(Euribor)</td>
<td>[0.009 (0.009)]</td>
<td>[0.936 (0.01)]</td>
<td>[-0.65 (0.04)]</td>
</tr>
</tbody>
</table>

This table presents the estimated coefficients for the independent variables in each equation of the system equation. We symbolize the standard errors of coefficients with ( ) and the z-statistic with [ ]. According to the descriptive statistics, we set:

\[ u_{ECB} = 0.29 \text{ and } u_{Reu} = 0.12 \]
Overall, in both cases, we can see that that the introductions of information flow regressors have a significant effect to the estimated coefficients for Euribor 3M with the same trend (positive rate \( sp_i^{(t)} \) and negative rate \( sp_i^{(t-1)} \) for ECB and, positive rates \( sp_i^{(t+1)} \) for Reuters). In particular, we can see that asymmetric volatility reduces and at the other hand. That occurs because investors use all the information entropy flow they can have. The results show strong and economically relevant evidences that ECB and Reuter’s communication impacts Euribor futures prices transitorily but also, sometimes permanently during time according to the information entropy they can have. Hence, central bankers’ and financial released news web pages seem to be a very powerful tool to systematically drive market expectations and, eventually, the actual evolution of the financial markets and real economy.

5.4. Summary

This chapter studied the influence of diffusion of financial innovation to market participants using the methodology approach form chapter 4th. The main results are the following:

We studied the influence of introduction of financial innovation to market participants considering three transformations for the diffusion factor: the minimum boundary Pareto distribution, the G-Pareto distribution and the compound process of Poisson G-Pareto distribution. In order to examine different cases, we consider three cases with of market participants that adopted different kinds of financial innovation: the EMU (1999) government bond yields for the introduction of euro with exogenous diffusion factor, the VIX and Euribor (3M) for the introduction of euro with endogenous diffusion factor and the Euribor (3M) for the information flow and released financial news using technology.

We found that there is a significant influence between the introduction of financial innovation and market participants that is expressed by the diffusion factor during the diffusion selected time period. Overall, the results demonstrate that using the proposed methodology, the diffusion factor has a significant effect on market participants in terms of mean returns and historical asymmetric volatility. Interestingly, this effect is robust for any case of transformed diffusion factor and shows that the influence of introduction financial innovation diminishes the bias of coefficients and volatility.
CHAPTER 6
CONCLUSIONS AND FURTHER RESEARCH DIRECTIONS

6.1. Summary

This thesis has studied the important role of financial innovations and their relationship to financial markets and market participants’ frictions.

At the beginning of this thesis, we introduce the notions of change and innovation as the basic elements of the business status quo. We present how change and innovation are dynamic processes presented as a sequence of facts. Furthermore, we present the groups of the innovations' adopters and their differences in terms of volume, time of adoption, economic level, etc., and moreover the levels of the economic environment of a financial institution that pushes the institution towards innovation.

Going further on this thesis, we introduce the notion of financial innovation and we present their varieties, the main changes that stimulate their appearance and their consequences at the financial system. Adopting broad criteria, we present the research literature of financial innovations for the last thirty years and we make a critic on it.

Following up, we examine the significant role of financial innovation in main fields of financial and economic environment such as, derivative market, new monetary aggregates, innovative mortgages, information and new financial instruments, within a critic point of view.

Furthermore, concerning the role of market frictions in the development of financial innovations, we analyze some research hypotheses questions with a theoretical framework. These questions are concerned the structural characteristics of the financial innovations and the role of market frictions in the development of financial innovations.

In order to demonstrate the above theoretical framework through a mathematical one that shows the influence of the diffusion of financial innovation to market participants, we build a diffusion matrix regressor which analyzes the influence of an introduction of a financial innovation to market participants. The study case of diffusion process uses a univariate or a multivariate form of probability distributions. This analysis leads us to important conclusions about the role of frictions and also, leads us to an approach for the influence of the diffusion of financial innovation to market participants.
Finally, we study this approach in several ways within econometric models in order to examine its significance on the estimation of asset returns and their asymmetric volatilities when a financial innovation is introducing to a market.

In particular, we examine four empirical implementations which are presenting the influence of the *euro* (through €/$ exchange rate) and *Euribor* introduction on Euro-zone governments’ bond yields, the effect of €/$ exchange rate on the implied volatility index (*VIX*) and on *Euribor* and, at last, the influence of information flow on *VIX* and *Euribor*. Overall, the results are quite important because they demonstrate strong evidences that the diffusion matrix regressor has a positive influence to the estimated coefficients of the models, decreasing their bias and reducing significantly the model volatility. That lead us to the conclusion that the mean square error is diminishing with our estimation approach. Hence, diffusion of financial innovations seems to be a very powerful tool to systematically drive market expectations and, eventually, the actual evolution of the real economy.

### 6.2. Directions for future research

This thesis has taken some basic steps towards the understanding the influence of market frictions on the diffusion of financial innovation to market participants. Possible directions for future research could include some important limitations in our analysis, such as:

A significant change occurs to the financial structure of the market. A formal model would facilitate this change as the difference between the previous and the post situation with breakeven point the introduction of financial innovation. We can examine the possibility to record pre-determine alternative factors that influence the diffusion of financial innovation. For example, we can take into consideration the possible long-run economic growth advantages to adopting legal and policy changes that create one type of financial structure rather than another.

Analyzing the financial innovation, there is not distinction between successful and not successful characteristics of financial innovation. The introduction of financial innovations is connected with the average increasing efficiency and the changes. However, it should be interesting to examine how these changes are distributed and which are the systematic differences between the counterparties that introduce financial innovations.
Another important field of future research is to examine the factors that determine the possibility of a firm to participate to the financial innovation process. The process of financial innovation has offered numerous financial innovation products and processes to the business and financial sectors, by multiplying the choices of the market participants and by contributing to a general economic growth of a country. While the international environment alters and competition becomes more and more harsh in the sector of financial services, market participants look for new ways to put transactions through in a more efficient way.

It is very interesting issue to examine why economies or firms at similar stages of development have different looking financial systems and need different financial innovations. This case study should examine the evidences that some financial organizations or financial sectors are more innovative than others.

Many retail investors lack sophistication regarding financial products, but choose to participate in the market. Over time, investors learn but are required to keep abreast of developments in the market as they occur. Such changes are endogenously induced by producers of financial market, and must be taken into account when government-sponsored educational initiatives are implemented.

The adoption of a financial innovation can be an internal process for a firm by analyzing the impact of “good news” in time of diffusion. This firm has an internal minimum boundary need for change and can be the pre-determine lower value of the firm which is: i) the weight average of short and long term liabilities, ii) the value of the firm, iii) the functionality of the firm. Before the introduction of the financial innovation to the market, firm has an initial value. Firm value can change during time as the result of changes in economic environment, random or scheduled ones.

This kind of change can be the introduction of financial innovation to the market where the innovation process for the firm holds on for time $t$. Jump-diffusion models (Kou, 2002) can be used to model this internal process and measure the asset pricing of the firm. The jumps show the influence of financial innovation during diffusion time according to frictions between the firm and the introduction of financial innovation to the market.

Finally, the analysis presented in this thesis can easily be extended to include and compare different classes of assets, indices and financial innovations.
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Websites


References for the Diffusion Survey (Appendix)


**APPENDIX**

**CHAPTER 1**

**TABLE 1: INNOVATION DIFFUSION MODELS (SYRVEY)**

<table>
<thead>
<tr>
<th><strong>The diffusion of a single innovation in a single market</strong></th>
<th><strong>The use of explanatory variables in the diffusion model</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chatterjee &amp; Eliashberg (1990)</td>
<td>Kalish (1985)</td>
</tr>
<tr>
<td>Goldenberg, Libai, Solomon, Jan &amp; Stauffer (2000)</td>
<td></td>
</tr>
<tr>
<td>Bemmaor &amp; Lee (2002)</td>
<td></td>
</tr>
<tr>
<td>Teng, Grover &amp; Guttler (2002)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Estimation of the Bass model</strong></th>
<th><strong>The diffusion of a single innovation in a single market</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>--------</td>
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</tr>
<tr>
<td>Venkatesan &amp; Kumar (2002)</td>
<td>They use a genetic algorithm as the tool for finding a minimum sum of squares to forecast the adoption of mobile telephones across seven European countries.</td>
</tr>
<tr>
<td>Goswami &amp; Karmeshu (2004)</td>
<td>They use simulated annealing to fit a random coefficients version of the Bass model.</td>
</tr>
<tr>
<td>Boswik &amp; Franses (2005)</td>
<td>They use financial econometrics to propose a new stochastic error process for the Bass model to capture heteroscedastic errors and a tendency for the data to revert to the long-term trend.</td>
</tr>
</tbody>
</table>

**Use of diffusion models with little or no data**

<table>
<thead>
<tr>
<th>(1998)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Puttis</td>
<td>He found that the use of seasonally adjusted quarterly data leads to greater forecasting accuracy than the use of annual data but found no further advantage with monthly data.</td>
</tr>
<tr>
<td>Lee, Boatwright &amp; Kamakura (2003)</td>
<td>They describe an application of the hierarchical Bayes procedure for forecasting sales of recorded music, pre-launch.</td>
</tr>
<tr>
<td>Bass, Gordon, Ferguson &amp; Githens (2001)</td>
<td>They prepared a pre-launch forecast of subscriptions to satellite television over a 5-year horizon.</td>
</tr>
</tbody>
</table>

**Modeling constrained diffusion**

<table>
<thead>
<tr>
<th>(1991)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jain, Mahajan &amp; Muller</td>
<td>They propose an adaptation to the Bass model where there is a third category introduced of waiting applicant. This model is fitted to data describing the diffusion of fixed line telephony in Israel.</td>
</tr>
<tr>
<td>Ho, Savin &amp; Terwiesch (2002)</td>
<td>They look at managing demand for new products in the presence of supply constraints.</td>
</tr>
</tbody>
</table>

**Modeling the diffusion of multiple sub-categories**

<table>
<thead>
<tr>
<th>(1993)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahajan, Sharma &amp; Buzzell</td>
<td>They make a model about the effect of a new entrant to an expanding market.</td>
</tr>
<tr>
<td>Givon, Mahajan &amp; Muller (1995)</td>
<td>They used a model for the diffusion of software where the sales of legal copies are known but the sales of pirated software are not and in 1997 they extended their work to brands of the same software products and found that piracy rates differed significantly between brands.</td>
</tr>
<tr>
<td>Kim, Chang &amp; Shocker (2000)</td>
<td>They make a model competition between products that fulfill the same function.</td>
</tr>
<tr>
<td>Shocker, Bayus &amp; Kim (2004)</td>
<td>They discussed a range of other formulations for the interaction between the diffusions of related sub-categories of products such as prey–predator models.</td>
</tr>
</tbody>
</table>

**Model selection and forecasting**

<table>
<thead>
<tr>
<th>(1993)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>He used nine variations of growth curves to forecast forty-six data sets.</td>
</tr>
<tr>
<td>Gottardi &amp; Scarso (1994)</td>
<td>They compared the forecasting accuracy of ARIMA models with a selection of diffusion models.</td>
</tr>
<tr>
<td>Meade &amp; Islam (1998)</td>
<td>They classified twenty-nine diffusion models into three classes according to the timing of peak diffusion in relation to introduction and saturation.</td>
</tr>
<tr>
<td>Bewley &amp; Griffiths (2003)</td>
<td>They modeled the penetration of the compact disc (CD) in sound recording in twelve countries. They use the Bass model and versions of the flexible logistic.</td>
</tr>
<tr>
<td>Bemmaor &amp; Lee (2002)</td>
<td>They compared the one to three steps ahead forecasting performance of the Bass model and the Gamma-shifted Gompertz (G-SG) model using twelve products and services.</td>
</tr>
<tr>
<td>Bewley &amp; Griffiths (2003)</td>
<td>They use bootstrapping to generate prediction intervals for their CD penetration forecasts.</td>
</tr>
<tr>
<td>Gutierrez, Nadiri &amp; Sanchez (2005)</td>
<td>They formulate a stochastic version of the Gompertz that allows them to provide confidence intervals for their out-of-sample forecasts.</td>
</tr>
</tbody>
</table>

**Modeling of diffusion across several countries**

<table>
<thead>
<tr>
<th>(1991)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Takada &amp; Jain</td>
<td>They used the Bass model for a cross-sectional analysis of the diffusion of</td>
</tr>
</tbody>
</table>
They modeled the innovativeness of the different nations, measured by patent applications in the US in terms of variables including income (GDP), research expenditure, and levels of international trade.

They studied the effect of lead-lag on international diffusion of innovations.

They modeled the diffusion of pharmaceutical drugs with the logistic model using data from 15 countries.

They compared several formulations of the parameters of the Bass and Gompertz models as functions of national variables for the diffusion of three telecommunication products.

They develop a multinational Bass model which incorporates both simultaneous effects and lead-lag effects.

They used a hierarchical Bayesian framework to estimate their pooled cross-sectional models.

They used a logistic as the basis for modeling the diffusion of telecommunications within the European Union.

They examine the factors influencing the cross-country diffusion of the internet.

He uses a similar approach to Gruber and Verboven to model the diffusion of mobile telephones in Finland.

They forecast the consumption of natural gas in Spain.

<table>
<thead>
<tr>
<th>Model</th>
<th>Value of flexibility</th>
<th>Symmetry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floyd</td>
<td>0.33</td>
<td>Symmetrical or non symmetrical</td>
</tr>
<tr>
<td>Sharif &amp; Karib</td>
<td>[0.33, 0.5]</td>
<td>Symmetrical or non symmetrical</td>
</tr>
<tr>
<td>Dodson &amp; Jeyland</td>
<td>[0, 0.5]</td>
<td>Symmetrical or non symmetrical</td>
</tr>
<tr>
<td>NUI (Non Uniform Influence)</td>
<td>[0, 1]</td>
<td>Symmetrical or non symmetrical</td>
</tr>
<tr>
<td>NSRL (Non symmetric Responding Logistic)</td>
<td>[0, 1]</td>
<td>Symmetrical or non symmetrical</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model</th>
<th>Description (dynamic cause)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chow (1967)</td>
<td>Number of adoption is affected from a technological or a pricing change.</td>
</tr>
<tr>
<td>Lackman (1978)</td>
<td>The model is based on the increasing corporate profits sales. The profit variable is considered to show that users are shifting to new products when their efficiency is high.</td>
</tr>
<tr>
<td>Peterson &amp; Mahajan (1978)</td>
<td>Multidimensional Diffusion models</td>
</tr>
<tr>
<td>Mahajan &amp; Peterson (1979)</td>
<td>Dynamic Diffusion models of time and space</td>
</tr>
</tbody>
</table>


### TABLE 1: FINANCIAL INNOVATIONS

#### CONSUMER ASSETS

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money-Market Mutual Funds, Funds of Funds</td>
<td>Shares of a diversified portfolio of short-term money-market securities offering chequing privileges</td>
<td>Evolved in 1974 in response to rising money-market rates</td>
</tr>
<tr>
<td>6-month Money-Market Certificates</td>
<td>26-week time deposits in minimum denomination of $10,000 at banks and thrifts. Ceiling rate is indexed to Treasury bills of comparable maturity. Minimum denomination was lowered to $2500 in January 1983</td>
<td>Authorized in June 1978 in response to high money-market rates</td>
</tr>
<tr>
<td>Small Saver Certificates</td>
<td>Time deposits with no minimum denomination earning variable yield based on the yield of Treasury securities of comparable maturity offered by commercial banks and thrifts. Original maturities range from 1 1/2 to 4 years depending on date of issue</td>
<td>Authorized in July 1979 in response to high money-market rates</td>
</tr>
<tr>
<td>All Savers' Certificates</td>
<td>One-year maturity savings certificate issued by depository institutions between October 1981 and December 1982 with annual yield of 70%. Of the average yield of 52-week Treasury bill. A maximum of $100 ($200 joint) of interest income was tax-exempt</td>
<td>Legislated in October 1981 to stimulate household saving and promote flow of funds through thrifts</td>
</tr>
<tr>
<td>91-day Money-Market Certificates</td>
<td>Initially, time deposits with minimum denomination of $7500 issued by depository institutions. Ceiling rate indexed to 91-day Treasury bill. In January 1983, minimum denomination was reduced to $2500</td>
<td>Authorized in May 1982 in response to high money-market rates</td>
</tr>
<tr>
<td>Ceiling-free Certificates</td>
<td>Time deposit with original maturity in excess of 2 1/2 years if issued on or after 1st April 1983 or original maturity of at least 1/2 years if issued on or after 1st May 1982 with no minimum denomination</td>
<td>Beginning in 1974 available only to consumers not covered by pension plans. Authorized for all consumers in December 1981 to encourage personal savings</td>
</tr>
<tr>
<td>NOW Accounts</td>
<td>Savings accounts permitting unlimited Negotiable Orders of Withdrawal (NOW) earning a Regulation Q ceiling rate. Essentially an interest bearing cheque account; for consumers only</td>
<td>First authorized in New England in 1974 and became nationally Available by 1980</td>
</tr>
<tr>
<td>Money-Market Deposit Accounts</td>
<td>Deposit with cheque privileges requiring an initial and average balance of $2,500 but not subject to interest rate restriction or minimum maturity</td>
<td>Authorized in December 1982 in response to high interest rates and continuing flows of funds into money-market mutual funds</td>
</tr>
<tr>
<td>Super-NOW Accounts</td>
<td>Ceiling-free NOW accounts with minimum balance requirement</td>
<td>Interest rate ceiling removed on NOW accounts with balances in excess of $2,500. Authorized in</td>
</tr>
</tbody>
</table>

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127 Fundamental reasons of financial innovation’s creation: i) regulations and legal factors, ii) interest rate volatility, iii) tax advantages, iv) reducing transaction and agency costs, v) accounting benefits or increasing liquidity, vi) risk-sharing, vii) price volatility, viii) improvements in technology and, ix) other factors (e.g. academic research).
January 1983, in response to continued high interest rates and flows of funds into money market mutual funds

<table>
<thead>
<tr>
<th>IRAs and Keoghs</th>
<th>Tax deferred retirement savings instrument</th>
<th>Authorized in March 1982 in response to high money-market rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Broker) Cash-Management/ Sweep Accounts</td>
<td>Sweep accounts offer automatic transfer of NOW account or demand deposit funds above some minimum level from accounts at depository institutions into interest-bearing investments such as Money-Market Mutual Funds or Retail RPs. Cash Management Accounts are similar, but in addition offer credit lines, debit cards and a larger portfolio of securities, are available from nonbank institutions (i.e. brokerage firms)</td>
<td>Banks began offering sweep accounts in 1981 in response to losses of consumer deposits to Money-Market Funds. Nonbank firms had been offering cash-management accounts in response to high interest rates</td>
</tr>
</tbody>
</table>

| Financial Processes (Debit and prepaid cards, Self registration, Discount brokerage, Electronic transfer funds, automated clearing houses, ATMs, Direct public sale of securities, point of sale terminals, CMA, Clearing House Interbank Payment System, Online Banking, etc.) | Financial Processes are services for consumer or companies’ transaction and management. | Reducing transactions costs and improved the payment system at the sale points. |

| Tuition futures | Tuition futures is a college finance technique that involves a guarantee of stable tuition rates in return for payment years in advance | Prepaid tuition programs create value for purchasers. Considering how this value is created is important because it points out some clear directions in setting prices for these benefits |

### CONSUMER CREDIT AND MORTGAGES

<table>
<thead>
<tr>
<th>Variable Rate Mortgages</th>
<th>A mortgage loan which provides for the adjustment of its interest rate as market interest rates change</th>
<th>Initiated in the early 1970s, but not a significant force until the mid-to-late-1970s, to protect lenders from interest rate volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Rate Consumer Installment Loans</td>
<td>A consumer installment loan which provides for the adjustment of its interest rate as market interest rates change</td>
<td>Initiated in the late 1970s, to protect lenders from interest rate volatility</td>
</tr>
<tr>
<td>Equity Access Accounts (e.g., variable life insurance)</td>
<td>Like a second mortgage, allows consumers to use equity acquired in their homes at a market rate of interest. These loan-like investments are packaged for sale to pension funds and life insurance companies</td>
<td>Inflation resulted in large real estate capital gains</td>
</tr>
<tr>
<td>Mortgage Pools and the Secondary Mortgage Market (Mortgage pass through securities, collateral mortgage obligations)</td>
<td>Mortgages are packaged and sold in the secondary market. The selling institution often services these mortgages</td>
<td>The secondary market was developed to enhance the liquidity of mortgage. By packaging and selling (mostly fixed rate) mortgages in the secondary market, banks and thrifts may increase</td>
</tr>
<tr>
<td>CMOs, letter of credit, etc.)</td>
<td>mortgage originations</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>Bonds Linked to home mortgages</td>
<td>Pools of mortgages used as collateral for bonds</td>
<td>Tax advantages to issuer</td>
</tr>
</tbody>
</table>

**BANK LENDING TO BUSINESS**

<table>
<thead>
<tr>
<th>Fee-type services at commercial Banks</th>
<th>Fees for services such as cash management, data systems and loan commitments have to a large extent been replacing the more traditional compensating-balance arrangements</th>
<th>High interest rates (and high opportunity cost on non-interest-bearing business chequing balances) have prompted corporations to demand explicit fees for bank services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Pricing Options at Commercial Banks</td>
<td>Banks have been offering a wider array of pricing terms on bank loans, including spreads over the prime rate, the LIBOR rate and the CD rate. The options are usually specified in loan commitment agreements. The borrower may alter the pricing option at various intervals depending on market conditions</td>
<td>The use of multiple pricing options has been spurred by volatile interest rates and by increasing price competition from foreign banks</td>
</tr>
<tr>
<td>Rime/CD Option in Syndications</td>
<td>Pricing option for loan participants</td>
<td>Attract US regional</td>
</tr>
<tr>
<td>Floating Rate Loans and Below-Prime Lending</td>
<td>The interest rate on these loans adjusts daily as with rime-based loans or periodically as with LIBOR or CD-based loans. Banks often charge discounts from the prime rate to their best loan clients</td>
<td>Interest rate volatility has stimulated the use of floating rate loans</td>
</tr>
<tr>
<td>Credit Extendedly to US Residents by Foreign Branches of US Banks</td>
<td>These are loans booked at the foreign offices of US banks and are typically funded in the Euro-dollar market and priced over LIBOR. These loans grew rapidly in the late 1970s</td>
<td>State tax advantages, reserve requirements, and change in the spread between the prime rate and LIBOR have all contributed</td>
</tr>
<tr>
<td>Growth of US Branches and Agencies of Foreign Banks</td>
<td>The number and size of these institutions have grown rapidly during the 197s and early 1980s. They have competed vigorously with domestic banks, particularly in the market for mid-sized corporate borrowers</td>
<td>The breadth of the US loan market attracted this banks, along with the increasing ability to rise and move funds internationally</td>
</tr>
<tr>
<td>Correspondent Networks and Loan Syndications</td>
<td>Better communication, data management, and other services have led to greater reliance on correspondent networks for syndications and loan participations</td>
<td>Lending constructions and recent merger and acquisitions activity have contributed to the formation of larger loan syndicates (including foreign banks) organized through the correspondent networks</td>
</tr>
<tr>
<td>Leasing by Banks and Bank Holding Companies</td>
<td>Banks and bank holding companies purchase capital equipment to take advantage of investment tax credits and accelerated depreciations. This equipment is leased to corporations</td>
<td>This type of leasing began in the 1960s and grew more popular in the 1970s. The recent Economic Recovery Tax Act provided greater incentives for leasing arrangements</td>
</tr>
<tr>
<td>Samurai and Shogun Leases</td>
<td>Long-term leasing finance for capital goods exports</td>
<td>Initiated by Japanese Government to reduce particularly sensitive trade surpluses</td>
</tr>
<tr>
<td>Loan Production Offices and Asset-</td>
<td>These facilities make loans to business, often providing working capital. The loans are</td>
<td>Circumvent interstate banking restrictions by establishing bank</td>
</tr>
</tbody>
</table>
| Based Finance Companies | usually secured by inventories accounts receivable or other such assets | related loan offices in more than one state
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>International Banking Facilities</td>
<td>The federal Reserve Board permitted the establishment of IBFs beginning in December 1981s. These facilities conduct deposit and loan business with foreign residents, including foreign banks. IBFs are not subject to reserve requirements or interest rate ceilings and are exempt from insurance coverage and assessments imposed by the FDIC.</td>
<td>To enable domestic banks to compete more effectively with foreign banks for international business</td>
</tr>
<tr>
<td>Pricing Caps</td>
<td>Automatic change in basis of loan pricing when difference between relevant interest rates crosses threshold</td>
<td>Protect borrower and/or lender against unusual relative rate developments</td>
</tr>
<tr>
<td>ECU Loans- SDR Loans</td>
<td>Ready-made diversification</td>
<td>Exchange rate volatility</td>
</tr>
<tr>
<td>Multicurrency Clauses</td>
<td>Affords borrower flexibility to choose denomination at draw-down</td>
<td>Exchange rate volatility</td>
</tr>
<tr>
<td>Sub-Participation in Syndicated Credits</td>
<td>Options to put loans to underwriters</td>
<td>Broaden market by making syndicated credit more liquid</td>
</tr>
<tr>
<td>Bullet Credits</td>
<td>Syndicated credit with all principal paid at maturity</td>
<td>Increase flexibility for borrowers</td>
</tr>
<tr>
<td>Contractual Linkage to Access to IMF Resources</td>
<td>Syndicated credit contingent upon IMF programmed being in place</td>
<td>Enforce policy conditions</td>
</tr>
</tbody>
</table>

**TREASURY SECURITITES AND AGENCIES**

| Variable Rate Saving Bonds | The new floating rate savings bonds tie their yield to the 5-year Treasury securities. The Treasury also guarantees a minimum rate of return on these bonds | High and volatile interest rates made the old fixed rate savings bonds unattractive to investors |
| Adjustable Rate Federal National Mortgage Association Securities | Since early 1983, Federal National Mortgage Association has added adjustable rate graduated payment and growing equity mortgages into the securities they issue | The increased popularity of new forms of mortgages and the reduced supply of conventional fixed rate mortgages led to the change |
| Carter Bonds | The Treasury issued these bonds in 1979. They were denominated in foreign currency | The bonds were part of President Carter's program to boost the US dollar |

**TAX-EXEMPT SECURITIES**

| Municipal Bond Funds | Similar to the stock mutual funds, these funds enable small investors to diversify their tax-exempt portfolio and to improve the liquidity of their holding | 1976 legislation allowed the dividends on these bond funds to exempt from Federal income taxes. Investors' increasing interest in tax-free income helped the growth of the industry |
| Deep Discount Municipals Bonds | These municipals bonds carry a law coupon and are issued at a discount from par | High and volatile interest rates made conventional fixed rate bonds less attractive to investors |
| Insured Municipal Bonds | These Bonds carry insurance issued by several private organizations. Both the principal and interest are guaranteed | The deteriorating financial position of many municipalities led them to purchase insurance in order to reduce their cost of financing |
| Tax-exempt Unit Trusts with put Options | These unit trusts carry put options issued by commercial banks. Investors have the option to sell the bonds back to the bank at par value, | High and volatile interest rates |
thus guaranteeing them against any default or market risk

<table>
<thead>
<tr>
<th><strong>CORPORATE BONDS</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECU Bonds-SDR Bonds</strong></td>
<td>Ready-made diversification</td>
<td>Relative Interest rate and exchange rate volatility</td>
</tr>
<tr>
<td><strong>Currency Put Attached to Bonds (Dual currency bonds, Eurocurrency bonds, etc.)</strong></td>
<td>Option to convert bond proceeds into another currency at a predetermined exchange rate</td>
<td>Proxy for medium term option market</td>
</tr>
<tr>
<td><strong>Original Issue Deep-Discout Bonds</strong></td>
<td>Bonds that have coupon payments giving yield below market rate of return</td>
<td>Response to level and volatility of interest rates; postponement of tax payments</td>
</tr>
<tr>
<td><strong>Zero Coupon Bonds</strong></td>
<td>No coupon payment; appreciation from discount value to par</td>
<td>Response to level and volatility of interest rates; postponement of tax payments</td>
</tr>
<tr>
<td><strong>Variable Rate Bonds and Notes</strong></td>
<td>Interest rates periodically adjusted to reflect market rates</td>
<td>Lessens bondholder’s exposure to volatility of interest rates</td>
</tr>
<tr>
<td><strong>Commodity Linked Bonds</strong></td>
<td>Principal is convertible into a fixed quantity of a commodity</td>
<td>Lessens bondholder’s exposure to volatility of inflation and interest rate; helps corporations raise funds in risk exposure high interest rate period. Also acts as a proxy for medium term forward market for commodities</td>
</tr>
<tr>
<td><strong>Bonds with Warrants</strong></td>
<td>Bonds sold with options to purchase additional debt or equity at a fixed price or yield</td>
<td>Partially hedges bondholder’s risk associated with volatile interest rates and inflation</td>
</tr>
<tr>
<td><strong>Stripped Bonds</strong></td>
<td>Coupon payments and final payment of principal separated and sold separately</td>
<td>Response to level and volatility of interest rates</td>
</tr>
<tr>
<td><strong>Bonds with put Options</strong></td>
<td>Bonds that can be sold back to the corporation at a fixed price</td>
<td>Lower risk exposure from volatility of interest rates</td>
</tr>
<tr>
<td><strong>Interest Rate Swap Agreements</strong></td>
<td>An exchange by two or more parties of a mix of fixed and variable payment streams</td>
<td>Scarcity of bank names in fixed rate bond markets. Also used by domestic US banks and thrifts to better match asset and liability reprising; spurred by volatile interest rates</td>
</tr>
<tr>
<td><strong>Retractable or Extendable Notes/Bonds</strong></td>
<td>Allows holder to extend or shorten maturity of bond/notes</td>
<td>Reduces risk from interest rate volatility</td>
</tr>
<tr>
<td><strong>Drop-lock Bond</strong></td>
<td>Floating rate note carrying a high minimum coupon automatic conversion to fixed rate if interest rate falls below minimum</td>
<td>Reduces risk from interest rate volatility</td>
</tr>
<tr>
<td><strong>Floating Note Convertible to Fixed Rate Note</strong></td>
<td>Specifies dates when holder can convert to predetermined fixed yield</td>
<td>Reduces risk from interest rate volatility</td>
</tr>
<tr>
<td><strong>Caterpillar Issues (roller issues)</strong></td>
<td>Fixed rate security with option by issuer or holder to call or put at par at predetermined rates or accept a new fixed rate bond at a new interest rate</td>
<td>Reduces risk from interest rate volatility</td>
</tr>
<tr>
<td><strong>Partly-Paid Issues</strong></td>
<td>Bondholder initially puts up 10-30 per cent of principal and balance 6 months later</td>
<td>Helps manage interest rate, liquidity and exchange rate risks</td>
</tr>
</tbody>
</table>
**FINANCIAL FUTURES AND OPTIONS**

<table>
<thead>
<tr>
<th>Financial Futures on Cash Market Instruments (US Treasury Bills, US Treasury Notes, US Treasury Bonds, GNMA Certificates Domestic CDs, Three-month Eurodollar Deposits, Pound sterling Canadian dollar, Japanese yen, Mexican peso, Swiss franc and, Deutsche franc)</th>
<th>Commitments to buy or sell the given cash market instrument at a specified time and place in the future. The price is established when the contract is made</th>
<th>These contracts have evolved in part owing to increased interest rate and exchange rate volatility. Most were introduced in the last five years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark Financial Futures on Stock Market Indexes (Value Line Index, S&amp;P 500 Index, S&amp;P 100 Index and NYSE Composite Index)</td>
<td>These contracts are tied to price movements in the given stock market index. The contract is settled by cash at a specified time and place in the future. The price is established when the contract is made</td>
<td>These contracts have evolved owing to increased price volatility in the stock market. They have all been introduced since the beginning of 1982</td>
</tr>
<tr>
<td>Options on Financial Futures and contracts (Us Treasury Bonds, S&amp;P 500 Index, NYSE Composite Index and Value Line Index)</td>
<td>These Instruments allow the buyer to buy or sell the given futures contract, if he wishes at given date in the future. A premium is paid for the option</td>
<td>These contracts have evolved owing to increased price volatility in these indexes. The loss on an option is limited to the premium price</td>
</tr>
<tr>
<td>Options on Indexes (stock index futures, interest rates futures, interest rate swaps, Major Market Index, AMEX Market Value Index, S&amp;P 100 Index and S&amp;P500 Index)</td>
<td>These contracts are tied to price movements in the given index. They are settled in cash if the difference between the settlement price and the strike price leads to a profit; otherwise the contract expires with no settlement</td>
<td>These contracts have evolved owing to increased price volatility in these indexes. The loss on an option is limited to the premium price</td>
</tr>
<tr>
<td>Offshore Financial Futures Markets</td>
<td>More flexibility in instruments and time zones</td>
<td></td>
</tr>
<tr>
<td>Option on Foreign Currencies (foreign currency futures, currency swaps, pound sterling, Canadian dollar, Deutsche Mark, Japanese yen and Swiss Franc)</td>
<td>These instruments allow the buyer to buy or sell the given currency if he wishes, at a given date in the future. A premium is paid for the option</td>
<td>Relative interest rate and exchange rate volatility</td>
</tr>
</tbody>
</table>

**TABLE 2: BANKING FINANCIAL INNOVATIONS**

<table>
<thead>
<tr>
<th>Category</th>
<th>Financial Innovation</th>
<th>Year (decade) of adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>New products and services delivery</td>
<td>Bond (Eurobond)</td>
<td>1960s (1963)</td>
</tr>
<tr>
<td></td>
<td>Credit cards</td>
<td>1969</td>
</tr>
<tr>
<td></td>
<td>Junk bond</td>
<td>1970s</td>
</tr>
<tr>
<td></td>
<td>Convertible bonds</td>
<td>1970s</td>
</tr>
<tr>
<td></td>
<td>Money market deposits</td>
<td>1970s</td>
</tr>
<tr>
<td></td>
<td>Money market mutual funds</td>
<td>1970s</td>
</tr>
<tr>
<td></td>
<td>NOW accounts</td>
<td>1970s</td>
</tr>
<tr>
<td></td>
<td>Collateralized mortgage</td>
<td>1970s</td>
</tr>
<tr>
<td></td>
<td>Derivatives</td>
<td>1970s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Various types of Banking Financial Innovations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockbox system</td>
</tr>
<tr>
<td>Treasury work station</td>
</tr>
<tr>
<td>Lobby automation-video banking</td>
</tr>
<tr>
<td>One-stop banking</td>
</tr>
<tr>
<td>Online financial management system</td>
</tr>
<tr>
<td>Personal banker</td>
</tr>
<tr>
<td>Open architecture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functional processes and benefit of joint services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated teller Machines, ATMs</td>
</tr>
<tr>
<td>Home banking</td>
</tr>
<tr>
<td>Electronic fund transfer</td>
</tr>
<tr>
<td>Branch automation</td>
</tr>
<tr>
<td>Transaction portal</td>
</tr>
<tr>
<td>Internet banking</td>
</tr>
<tr>
<td>Mobile banking – GSM and WAP services</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organizational functions process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk management systems</td>
</tr>
<tr>
<td>Automated voice response systems</td>
</tr>
<tr>
<td>Automated check</td>
</tr>
<tr>
<td>Computerized loan document Generation</td>
</tr>
<tr>
<td>Discount brokerage services</td>
</tr>
<tr>
<td>High-speed image processing of check</td>
</tr>
<tr>
<td>High-speed image processing of office documents</td>
</tr>
<tr>
<td>Truncation of check handling process</td>
</tr>
<tr>
<td>Telephone banking</td>
</tr>
<tr>
<td>Automated mortgage origination</td>
</tr>
<tr>
<td>Centralized loan application process</td>
</tr>
<tr>
<td>Customer information file</td>
</tr>
<tr>
<td>Electronic trading of shares</td>
</tr>
<tr>
<td>Loan tracking system</td>
</tr>
<tr>
<td>Profitability analysis by customer</td>
</tr>
<tr>
<td>Straight through process</td>
</tr>
<tr>
<td>Customer needs-based segmentation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organizational functions process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Management Account</td>
</tr>
<tr>
<td>Certificate of deposit</td>
</tr>
<tr>
<td>Mortgage-backed securities</td>
</tr>
<tr>
<td>Adjustable rate mortgage</td>
</tr>
<tr>
<td>Variable rate mortgage</td>
</tr>
<tr>
<td>Self-directed IRA accounts</td>
</tr>
<tr>
<td>Sweep &amp; asset management accounts</td>
</tr>
<tr>
<td>Debit cards</td>
</tr>
<tr>
<td>All in one account</td>
</tr>
<tr>
<td>Direct payroll deposit</td>
</tr>
<tr>
<td>Structured products</td>
</tr>
<tr>
<td>Credit derivatives</td>
</tr>
<tr>
<td>Exchange-traded fund, ETF</td>
</tr>
<tr>
<td>Trackers saving accounts</td>
</tr>
<tr>
<td>Weather derivatives</td>
</tr>
</tbody>
</table>
CHAPTER 4

A) Poisson distribution

If the discrete random variable $X$ is a Poisson distributed then the probability of exactly $X$ occurrences that arrive in a system, when the expected number of occurrences is a rate parameter $\lambda$, is given by:

$$X \sim P(\lambda) \iff f(x) = \frac{e^{-\lambda} \lambda^x}{x!}, \quad E(X) = \text{var}(X) = \lambda$$

Poisson distribution is applied to systems with large number of possible events.

B) Pareto Distribution

The Pareto distribution is used to describe the allocation of wealth among individuals or it shows the way that a larger portion of the wealth of any group is owned by a smaller percentage of the people of a group.

The probability density function (PDF) graph shows that the possibility or fraction of the population that owns a small amount of wealth per person is rather high and then decreases steadily as wealth increases. This distribution is not limited to describe wealth or income but in many situations in which equilibrium is found in the
distribution of the small to the large. For example, it can be used to show the
standardized price returns on individual stocks.

B.1) Definition for Pareto distribution

If $X$ is a random continuous variable with a Pareto distribution then the
probability that $X$ is greater than some number $x$ ($x \in [u, \infty]$) is given by:

$$P(X > x) = \begin{cases} 
\left(\frac{u}{x}\right)^a, & \text{for } x \geq u \\
1, & \text{for } x < u 
\end{cases}$$

Scale parameter $u$ is the positive minimum possible value of $X$ and $a$ is a
positive shape parameter.

The cumulative Pareto distribution for a random variable with the parameters $u$
and $a$ is:

$$F_X(x) = \begin{cases} 
1 - \left(\frac{u}{x}\right)^a, & \text{for } x \geq u \\
0, & \text{for } x < u 
\end{cases}$$

By differentiation, the probability density function is:

$$f_X(x) = \begin{cases} 
a \frac{u^a}{x^{a+1}}, & \text{for } x \geq u \\
0, & \text{for } x < u 
\end{cases}$$

We have the following properties for Pareto distribution:

- **Expected value**: $E(X) = \frac{au}{a-1}$, $a > 1$

- **Variance**: $\text{var}(X) = \left(\frac{u}{a-1}\right)^2 \frac{a}{a-2}$, $a > 2$

- **Entropy**: $H = \ln \left(\frac{a}{u}\right) - \frac{1}{a}$

- **Conditional distribution**: the conditional probability distribution of a Pareto-
distributed random variable given the event that is greater than or equal to a
particular number $u^* (>u)$ is a Pareto distribution with the same shape
parameter $a$ and minimum the bounder $u^*$. 

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• **Relation to exponential distribution:** if $X$ is Pareto distributed with parameters $u$ and $a$ then $Y = \log\left( \frac{X}{u} \right)$ is exponential distributed with intensity $a$. Equivalently, if $Y$ is exponential distributed with intensity $a$ then $X = ue^Y$ is Pareto distributed.

• **Characterization theorem:** suppose that $X_i$, $i = 1, 2, \ldots$ are independent identically distributed variables whose probability distribution is supported on the interval $[u, \infty)$. Suppose for all $n$ the variables $\min(X_1, \ldots, X_n)$ and $(X_1 + \ldots + X_n) / \min(X_1, \ldots, X_n)$ are independent. Then the join distribution is the Pareto distribution.

If we assume that variable is bounded we have, respectively: If $X$ is a random variable with a bounded Pareto distribution then the *cumulative Pareto distribution* for variable $X$ that is greater than some number $x$ ($u \leq x \leq l$) with the parameters $u$ and $a$ is given by:

$$F_X(x) = \frac{1 - u^a x^{-a}}{1 - \left( \frac{u}{l} \right)^a}$$

- The **probability density function** is: $f_X(x) = \frac{au^a x^{-a-1}}{1 - \left( \frac{u}{l} \right)^a}$

- The **Expected value** is: $E(X) = \frac{u^a}{1 - \left( \frac{u}{l} \right)^a} \left( \frac{a}{a-1} \right) \left( \frac{1}{u^{a-1}} - \frac{1}{l^{a-1}} \right)$

- The **variance** is: $\text{var}(X) = \frac{u^a}{1 - \left( \frac{u}{l} \right)^a} \left( \frac{a}{a-2} \right) \left( \frac{1}{u^{a-2}} - \frac{1}{l^{a-2}} \right)$

**B.2) Parameter estimation for Pareto distribution**

The **likelihood function** for the Pareto distribution with parameters $u$ and $a$ for the sample variable $X = \{x_1, \ldots, x_n\}$ is given by:
\[ L(a,u) = \prod_{i=1}^{n} a \frac{u^a}{x_i^{a+1}} = a^na \prod_{i=1}^{n} \frac{1}{x_i^{a+1}} \Rightarrow \]
\[ L(a,u) = n \ln a + na \ln u - (a+1) \sum_{i=1}^{n} \ln x_i, \text{ where } \hat{u} = \min x_i \]

Maximizing the above equation the MLE parameters are:
\[ \hat{a} = \frac{n}{\sum_{i}(\ln x_i - \ln \hat{u})}, \quad s^2 = \frac{\hat{a}^2}{n} \]

C) Generalized Pareto Distribution

Generalized Pareto Distribution (GPD) has three parameters: the location parameter \( \mu \in (-\infty, \infty) \), the scale parameter \( \sigma \in (0, \infty) \) and the shape parameter \( \gamma \in (-\infty, \infty) \). Suppose that \( x \) is a random variable and support that:
\[
\begin{cases}
x \geq \mu \ (\gamma \geq 0) \\
\mu \leq x \leq \mu - \sigma / \gamma \ (\gamma < 0)
\end{cases}
\]

The cumulative distribution function (CDF) is given by:
\[
F_{(\gamma,\mu,\sigma)}(x) = \begin{cases}
1 - \left( 1 + \frac{\gamma(x - \mu)}{\sigma} \right) ^{-\frac{1}{\gamma}} , & \text{for } \gamma \neq 0 \\
1 - \exp \left( \frac{x - \mu}{\sigma} \right) , & \text{for } \gamma = 0
\end{cases}
\]
or else;
\[
F_{(\gamma,\mu,\sigma)}(z) = 1 - \left( 1 + \gamma z \right) ^{-\frac{1}{\gamma}}, \quad z = \frac{x - \mu}{\sigma}
\]

The probability density function is given by:
\[
f_{(\gamma,\mu,\sigma)}(x) = \frac{1}{\sigma} \left( 1 + \frac{\gamma(x - \mu)}{\sigma} \right) ^{-\frac{1}{\gamma} - 1} = \frac{\sigma^{\frac{1}{\gamma+1}}}{[\sigma + \gamma(x - \mu)]^{\frac{1}{\gamma+1}}}
\]
or else \( f_{(\gamma,\mu,\sigma)}(x) = \frac{1}{\sigma} \left( 1 + \gamma z \right) ^{-\frac{1}{\gamma+1}} \)

We can also support that the Expected value is \( E(x) = \mu + \frac{\sigma}{1-\gamma}, \quad (\gamma < 1) \) and the variance is \( \text{var}(x) = \frac{\sigma^2}{(1-\gamma)^2 (1-2\gamma)}, \quad (\gamma < 1/2) \).
D) Definitions

Counting process \( N(t), t > 0 \) is a stochastic process that keeps the count of a number of events that have occurred up to time \( t \). Obviously, \( N(t) \) is non-negative, non-decreasing and integer-valued for all \( t > 0 \). The difference \( N(t) - N(s) \) equals the number of events in the time interval \([s, t], s < t\). \( N(t) \) denotes the number of adoptions of market participants in time \([t_0, t] \).

We consider a sequence of independent and identically distributed random variables \( T_i \) with cumulative exponential distribution function \( F(T_i \geq y) = e^{-\lambda y} \) and rate \( \lambda \) and we assume that \( T_n = \sum_{i=1}^{n} T_i \). We call Poisson process the right continuous process \( N_t = \sum_{n \geq 1} I_{t \geq T_n} \). In any time moment \( t \), \( N_t \) is Poisson distributed with rate parameter \( \lambda t \) such as: \( P[N_t = n] = e^{-\lambda t} (\lambda t)^n / n! \).

A Poisson process is a counting process that has the desirable additional properties that the number of events in disjoint intervals is independent and that the number of events in any given interval depends only on the length of that interval, and not on its particular position in time\(^{129}\).

Compound Poisson process is a generalized consideration of Poisson process where the time intervals between the jumps are exponential distributed and the size of the jumps are distributed randomly. If we consider the sequence of independent and identically distributed random variables \( \{Y_i\}_{i \geq 1} \) distributed with random \( f \), then the process \( X_t = \sum_{i=1}^{N_t} Y_i \) is called Compound Poisson process.

E) Proofs

Matrix \( \Lambda_{(r \times m)} \) is representing the market participant’s diffusion in time:

\[
\Lambda = 
\begin{bmatrix}
    p_{11} & p_{12} & \ldots & p_{1m} \\
    0 & p_{22} & \ldots & p_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    0 & 0 & \ldots & p_{mm}
\end{bmatrix}_{(r \times m)}
\quad \text{and} \quad
\Lambda' = 
\begin{bmatrix}
    p_{11} & 0 & \ldots & 0 \\
    p_{12} & p_{22} & \ldots & 0 \\
    \vdots & \vdots & \ddots & \vdots \\
    p_{1m} & p_{2m} & \ldots & p_{mm}
\end{bmatrix}_{(m \times m)}
\]

\(^{129}\) http://onlinelibrary.wiley.com
A) The trivial case of \( X_i = u_i \) makes the diagonal element equals to zero

**Proof**

If \( X_i = u_i \) then we have:

\[
p_{ii}^{(t)} = \begin{cases} 1 - \exp(-kz_i), & \text{with } z_i = \log \left( \frac{X_i}{u_i} \right) = \log(1) = 0 \Rightarrow \\ \exp \left[ -\lambda a \right] \\ \end{cases}
\]

Therefore, market participant doesn’t participate to the diffusion process, yet.

B) We determine that: \( |\Lambda| = tr[\Lambda] \neq 0 \).

**Proof**

The matrix is triangle so; \( |\Lambda| = tr[\Lambda] \). Moreover, we have that:

\[ |\Lambda| = tr[\Lambda] = \sum_{i=1}^{m} p_{ii}^{(t)}. \]

According to proof (A), there is no possibility to have all probabilities of diagonal elements equal to zero. So; \( |\Lambda| = tr[\Lambda] \neq 0 \).

C) The formulation of matrix \( (\Lambda'\Lambda)_{(m\times m)} \)

**Proof**

We consider the matrix \( (\Lambda'\Lambda)_{(m\times m)} \). Calculating matrix \( (\Lambda'\Lambda) \) we get:

\[
\Lambda'\Lambda = \begin{bmatrix}
  p_{11}^{(t)} & 0 & \ldots & 0 \\
p_{12}^{(t)} & p_{22}^{(t)} & \ldots & 0 \\
\vdots & \ddots & \ddots & \vdots \\
p_{m1}^{(t)} & \ldots & p_{mm}^{(t)} & 0
\end{bmatrix}
\begin{bmatrix}
p_{11}^{(t)} & p_{12}^{(t)} & \ldots & p_{1m}^{(t)} \\
p_{21}^{(t)} & p_{22}^{(t)} & \ldots & p_{2m}^{(t)} \\
\vdots & \ddots & \ddots & \vdots \\
p_{m1}^{(t)} & \ldots & p_{mm}^{(t)} & 0
\end{bmatrix}
\Rightarrow
\]

\[
\Lambda'\Lambda = \begin{bmatrix}
p_{11}^2 & P_{11}p_{12} & \ldots & P_{11}p_{1m} \\
P_{11}p_{12} & p_{22}^2 + p_{12}^2 & \ldots & P_{12}p_{1m} + p_{22}p_{2m} \\
\vdots & \ddots & \ddots & \vdots \\
P_{1m}p_{11} & P_{1m}p_{12} + p_{2m}p_{22} & \ldots & p_{1m}^2 + \ldots + p_{2m}^2
\end{bmatrix}
\]

The diagonal elements are positive so \( tr(\Lambda'\Lambda) > 0 \) and, therefore, the matrix is positive semi-definite and has \( \det(\Lambda'\Lambda) \neq 0 \).
D) Consider the matrix $P_{(re)} = \Lambda (\Lambda' \Lambda)^{-1} \Lambda'$. Then, matrix $P$ is an identity

$\left(P^2 = P\right)$ symmetrical ($P = P'$) and trajectory matrix ($P \Lambda = \Lambda$).

Proof

1. $P^2 = P \Rightarrow P^2 = \left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\right)\left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\right) = \left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\right) = P$

2. $P' = \left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\right)' = \left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\right) = P$

3. $P \Lambda = \left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\right)\Lambda = \left(\Lambda (\Lambda' \Lambda)^{-1} \Lambda'\Lambda\right) = \Lambda$

CHAPTER 5

Table 5.2.: Descriptive statistics of EMU (1999) harmonized Government bond yields, Euribor 3M and €/$ exchange rate

<table>
<thead>
<tr>
<th></th>
<th>AUSTRIA</th>
<th>BELGIUM</th>
<th>FINLAND</th>
<th>FRANCE</th>
<th>GERMANY</th>
<th>IRELAND</th>
<th>Euribor 3M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>6.3835</td>
<td>7.22</td>
<td>6.8068</td>
<td>7.42577</td>
<td>5.1948</td>
<td>6.1614</td>
<td>3.0638</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>6.595</td>
<td>6.78</td>
<td>5.32</td>
<td>6.44</td>
<td>4.83</td>
<td>5.39</td>
<td>3.1144</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>11.44</td>
<td>13.88</td>
<td>13.54</td>
<td>17.05</td>
<td>9.0667</td>
<td>10.77</td>
<td>5.1841</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>2.77</td>
<td>3.03</td>
<td>2.62</td>
<td>2.68</td>
<td>2.37</td>
<td>3.04</td>
<td>0.6528</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>2.006</td>
<td>3.0303</td>
<td>3.2638</td>
<td>3.5811</td>
<td>1.5808</td>
<td>2.0844</td>
<td>1.2659</td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
<td>0.2428</td>
<td>0.6029</td>
<td>0.7311</td>
<td>0.9021</td>
<td>0.6276</td>
<td>0.4771</td>
<td>-0.1177</td>
</tr>
<tr>
<td><strong>Kurtosis</strong></td>
<td>2.1382</td>
<td>2.2703</td>
<td>2.0335</td>
<td>2.9689</td>
<td>2.4689</td>
<td>1.8223</td>
<td>2.1733</td>
</tr>
<tr>
<td><strong>Jarque-Bera</strong></td>
<td>15.295</td>
<td>34.821</td>
<td>48.439</td>
<td>18.5773</td>
<td>25.368</td>
<td>4.309</td>
<td></td>
</tr>
<tr>
<td><strong>Obs</strong></td>
<td>368</td>
<td>357</td>
<td>272</td>
<td>357</td>
<td>240</td>
<td>265</td>
<td>140</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>ITALY</th>
<th>LUX</th>
<th>NEDER LANDS</th>
<th>PORTUGAL</th>
<th>SPAIN</th>
<th>Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>9.4874</td>
<td>6.0099</td>
<td>5.5878</td>
<td>8.4845</td>
<td>9.1045</td>
<td>1.1846</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>9.48</td>
<td>5.955</td>
<td>5.4</td>
<td>5.625</td>
<td>9.11</td>
<td>1.2173</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>21.44</td>
<td>9.9</td>
<td>9.19</td>
<td>17.09</td>
<td>18.11</td>
<td>1.5759</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>3.29</td>
<td>2.65</td>
<td>2.56</td>
<td>3.19</td>
<td>3.09</td>
<td>0.8525</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>5.0547</td>
<td>1.8301</td>
<td>1.6317</td>
<td>4.5911</td>
<td>4.6279</td>
<td>0.1959</td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
<td>0.5287</td>
<td>0.2279</td>
<td>0.4657</td>
<td>0.4706</td>
<td>0.2529</td>
<td>-0.0776</td>
</tr>
<tr>
<td><strong>Kurtosis</strong></td>
<td>2.1944</td>
<td>1.7738</td>
<td>2.3027</td>
<td>1.5149</td>
<td>1.5713</td>
<td>2.01789</td>
</tr>
<tr>
<td><strong>Jarque-Bera</strong></td>
<td>26.289</td>
<td>21.961</td>
<td>16.527</td>
<td>38.129</td>
<td>34.164</td>
<td>5.7669</td>
</tr>
<tr>
<td><strong>Obs</strong></td>
<td>357</td>
<td>308</td>
<td>293</td>
<td>296</td>
<td>357</td>
<td>140</td>
</tr>
</tbody>
</table>
Figure 5.1.: Graphs of harmonized Government Bond Yields (10Y) rates of EMU (1999), €/$ exchange rate and Euribor 3M

Table 5.4.: Pair wise Granger Causality Tests (Lags: 1) of EMU (1999) harmonized Government bond yields, Euribor 3M and €/$ exchange rate

<table>
<thead>
<tr>
<th>Pairwise Granger Causality Tests, (Lags: 1), Sample: 1980M01 2010M08</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>This table presents Granger causality tests between euro or Euribor and individual country in the sample. The table shows the F-statistics and the F critical value for two alternative hypotheses, corresponding to each variable Granger causing the other.</td>
<td></td>
</tr>
<tr>
<td>Null Hypothesis: (Fc=3.84)</td>
<td>F-Statistic</td>
</tr>
<tr>
<td>EUR3M does not Granger Cause AUSTRIA</td>
<td>0.83</td>
</tr>
<tr>
<td>AUSTRIA does not Granger Cause EUR3M</td>
<td>1.95</td>
</tr>
<tr>
<td>EURO does not Granger Cause AUSTRIA</td>
<td>0.79</td>
</tr>
<tr>
<td>AUSTRIA does not Granger Cause EURO</td>
<td>0.366</td>
</tr>
<tr>
<td>EUR3M does not Granger Cause BELGIUM</td>
<td>0.68</td>
</tr>
<tr>
<td>BELGIUM does not Granger Cause EUR3M</td>
<td>1.89</td>
</tr>
<tr>
<td>EURO does not Granger Cause BELGIUM</td>
<td>0.68</td>
</tr>
<tr>
<td>BELGIUM does not Granger Cause EURO</td>
<td>0.58</td>
</tr>
<tr>
<td>FINLAND does not Granger Cause EUR3M</td>
<td>2.62</td>
</tr>
</tbody>
</table>
Table 5.5: Unit Root Tests of EMU (1999) harmonized Government bond yields, Euribor 3M and €/$ exchange rate

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept</th>
<th>Critical value t-stat (1%)</th>
<th>Critical value t-stat (5%)</th>
<th>Intercept and trend</th>
<th>Critical value t-stat (1%)</th>
<th>Critical value t-stat (5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1.09</td>
<td>3.44</td>
<td>2.86</td>
<td>3.08</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Belgium</td>
<td>1.31</td>
<td>3.44</td>
<td>2.86</td>
<td>3.01</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Italy</td>
<td>1.35</td>
<td>3.44</td>
<td>2.86</td>
<td>2.83</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Spain</td>
<td>1.2</td>
<td>3.44</td>
<td>2.86</td>
<td>2.60</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Germany</td>
<td>1.74</td>
<td>3.44</td>
<td>2.86</td>
<td>3.23</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>1.31</td>
<td>3.44</td>
<td>2.86</td>
<td>3.10</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Finland</td>
<td>0.72</td>
<td>3.44</td>
<td>2.86</td>
<td>2.44</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Portugal</td>
<td>1.62</td>
<td>3.44</td>
<td>2.86</td>
<td>2.46</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>France</td>
<td>1.3</td>
<td>3.44</td>
<td>2.86</td>
<td>2.2</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Ireland</td>
<td>1.55</td>
<td>3.44</td>
<td>2.86</td>
<td>2.01</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Nederlands</td>
<td>0.59</td>
<td>3.44</td>
<td>2.86</td>
<td>2.53</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>Euro</td>
<td>1.26</td>
<td>3.47</td>
<td>2.88</td>
<td>2.67</td>
<td>4.02</td>
<td>3.44</td>
</tr>
<tr>
<td>Euribor</td>
<td>1.7</td>
<td>3.47</td>
<td>2.88</td>
<td>2.03</td>
<td>4.02</td>
<td>3.44</td>
</tr>
</tbody>
</table>

This table presents ADF unit root tests results for all the variables. The test were conducted for two specifications, intercept and, intercept and linear trend. The null hypothesis for ADF is the existence of a unit root test so time series are stationary for two significant levels, 1% and 5% (absolute values). A star denote when null hypothesis is rejected.
Table 5.7.: Descriptive statistics of VIX, Euribor 3M and €/$ exchange rate

<table>
<thead>
<tr>
<th></th>
<th>VIX</th>
<th>Euro</th>
<th>Euribor 3M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>21.489</td>
<td>1.171</td>
<td>3.263</td>
</tr>
<tr>
<td>Median</td>
<td>20.3700</td>
<td>1.202</td>
<td>3.289</td>
</tr>
<tr>
<td>Maximum</td>
<td>80.8</td>
<td>1.599</td>
<td>5.468</td>
</tr>
<tr>
<td>Minimum</td>
<td>9.89</td>
<td>0.852</td>
<td>0.749</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>8.921</td>
<td>0.195</td>
<td>1.11</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.901</td>
<td>0.039</td>
<td>0.066</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>9.271</td>
<td>2.05</td>
<td>2.04</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>84.63.471</td>
<td>104.58</td>
<td>107.32</td>
</tr>
<tr>
<td>Obs</td>
<td>3776</td>
<td>2767</td>
<td>2761</td>
</tr>
</tbody>
</table>

Figure 5.2.: Graphs of VIX, Euribor 3M and €/$ exchange rate

Table 5.8.: Pairwise Granger Causality Tests (Lags: 1) of VIX, Euribor 3M and €/$ exchange rate

Pairwise Granger Causality Tests (Lags: 1), Sample: 01/03/1995 – 12/31/2009
This table presents Granger causality tests between euro and individual country in the sample. The table shows the F-statistics and the F critical value for two alternative hypotheses, corresponding to each variable Granger causing the other.

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>EURO does not Granger Cause EUR3M</td>
<td>0.07</td>
</tr>
<tr>
<td>EUR3M does not Granger Cause EURO</td>
<td>2.18</td>
</tr>
<tr>
<td>EURO does not Granger Cause VIX</td>
<td>0.11</td>
</tr>
<tr>
<td>VIX does not Granger Cause EURO</td>
<td>6.2</td>
</tr>
<tr>
<td>VIX does not Granger Cause EUR3M</td>
<td>99.8</td>
</tr>
<tr>
<td>EUR3M does not Granger Cause VIX</td>
<td>8.81</td>
</tr>
</tbody>
</table>

Table 5.9: Unit Root Tests of VIX, Euribor 3M and €/$ exchange rate

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept</th>
<th>Critical value t-stat (1%)</th>
<th>Critical value t-stat (5%)</th>
<th>Intercept and trend</th>
<th>Critical value t-stat (1%)</th>
<th>Critical value t-stat (5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX</td>
<td>3.93</td>
<td>3.43*</td>
<td>2.86*</td>
<td>3.94</td>
<td>3.96</td>
<td>3.41*</td>
</tr>
<tr>
<td>Euro</td>
<td>0.38</td>
<td>3.43</td>
<td>2.86</td>
<td>3.15</td>
<td>3.96</td>
<td>3.41</td>
</tr>
<tr>
<td>Euribor 3M</td>
<td>0.49</td>
<td>3.43</td>
<td>2.86</td>
<td>0.25</td>
<td>3.96</td>
<td>3.41</td>
</tr>
</tbody>
</table>

Table 5.11.: Descriptive statistics of Euribor 3M and SVIs Indices

<table>
<thead>
<tr>
<th></th>
<th>EUR3M</th>
<th>Reuters SVI</th>
<th>ECB SVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.735</td>
<td>23.206</td>
<td>63.243</td>
</tr>
<tr>
<td>Median</td>
<td>2.207</td>
<td>22</td>
<td>62</td>
</tr>
<tr>
<td>Maximum</td>
<td>5.419</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.644</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Std. Dev.</td>
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<td>6.894</td>
<td>13</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.209</td>
<td>5.194</td>
<td>0.4</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.906</td>
<td>50.421</td>
<td>3.389</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>19.932</td>
<td>34271.57</td>
<td>11.53</td>
</tr>
<tr>
<td>Obs</td>
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<td>349</td>
</tr>
</tbody>
</table>

Figure 5.3.: Graphs of SVIs indices
**Table 5.1:** Pair wise Granger Causality Tests (Lags: 1) of VIX, Euribor 3M and SVIs

Indices

<table>
<thead>
<tr>
<th>Null Hypothesis (Fc=3.84)</th>
<th>F-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUR3M does not Granger Cause REUT</td>
<td>4.32</td>
</tr>
<tr>
<td>REUT does not Granger Cause EUR3M</td>
<td>0.98</td>
</tr>
<tr>
<td>ECB does not Granger Cause EUR3M</td>
<td>0.07</td>
</tr>
<tr>
<td>EUR3M does not Granger Cause ECB</td>
<td>1.46</td>
</tr>
</tbody>
</table>

**Table 5.12.:** Pair wise Granger Causality Tests (Lags: 1) of VIX, Euribor 3M and SVIs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intercept</th>
<th>Critical value t-stat (1%)</th>
<th>Critical value t-stat (5%)</th>
<th>Intercept and trend</th>
<th>Critical value t-stat (1%)</th>
<th>Critical value t-stat (5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euribor 3M</td>
<td>0.6</td>
<td>3.44</td>
<td>2.86</td>
<td>0.78</td>
<td>3.98</td>
<td>3.42</td>
</tr>
<tr>
<td>SVI ECB</td>
<td>4.06</td>
<td>3.44*</td>
<td>2.86*</td>
<td>4.07</td>
<td>3.98*</td>
<td>3.42*</td>
</tr>
<tr>
<td>SVI Reuters</td>
<td>7.65</td>
<td>3.44*</td>
<td>2.86*</td>
<td>9.41</td>
<td>3.98*</td>
<td>3.42*</td>
</tr>
</tbody>
</table>