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PhD Thesis

ABSTRACT

EMPIRICAL INVESTIGATIONS OF STOCK MARKET INTERCONNECTIONS

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'THE ONLY THING THAT IS CONSTANT IS CHANGE. '

HERACLITUS OF EPHESUS

Acknowledgments

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KEY WORDS
Integration, interdependence, spillover effects, contagion effects, international portfolio diversification, MGARCH models, MS-DCC, Markov processes.

INTRODUCTION

In the last decades we witnessed a number of financial and monetary crises, which have been ensued and propagated through capital markets, with regional and global consequences around the world. Among the examples we find the shock known as Black Monday from 1987; the so called lost decade of Japan 1990; Black Wednesday from 1992; the Mexican peso crisis (also known as Tequila effect) from 1994; Asian Crisis (or Asian Flu) that began in 1997; the Russian Crisis (also called Russian Cold) from 1998; the Brazilian Crisis (otherwise Brazilian Sneeze) from 1999; Dotcom Crisis (alias Nasdaq Rach) from 2000; Argentinean crisis from 2001, and of course, the present crisis, which began in 2007, also known as the Suprime Mortgage Crisis, Banking Crisis, Sovereign Debt crisis or just the Global Financial Crisis. (Kindleberger and Aliber, 2005) from the dawn of the civilization until 1997, identified a total of 39 local and global economic crises, all crossing the borders of a single country. Similarly (Reinhart and Rogoff, 2009) between 1800 and 2008 identify in 138 countries a total number of 783 banking crises. Over the past century the number of crises rose with 300%, and this number is only referring to banking crises. (Reinhart and Rogoff, 2009) together with (Kindleberger and Aliber, 2005) in hundreds of pages present an exhaustive analysis of the crises within the last hundred of years, along with the classification of these in types of crises. The single most important lesson that can be drawn is that crises have come to be part of the daily balance of the markets, and as (Reinhart and Rogoff, 2009) argue, no crisis is unique or purely isolated.

Currently we still experience the effects of a globally expanded crisis, which is considered to be the direct consequence of globalization and financial liberalization, crisis that has magnified the volatility and the propagation on a global scale. Such manifestations of increased frequency shocks, which are always unexpected by the market participants, are summarized by Friedrich von Hayek in the following manner *'The curious task of economics is to demonstrate to men how little they really know about what they imagine they can design'*.

Various factors have contributed to the integration of markets, such as the increase of cross-border capital flows, technological innovations in communication and transactions, and the introduction of innovative financial products. Globalization also played a crucial role in the integration of stock markets. The term '*globalization*' causes strong and controversial opinions across the world, views about the real or perceived 'international economic integration' (Kali and

Reyes, 2007). The increase of the economic and financial integration that has characterized the last half-century has been associated with spectacular economic growth and the move out of poverty for large parts of the world (Sachs and Warner, 1995). But, in the same time globalization is frequently criticized, the majority's perception being that the benefits and costs of economic integration were not evenly distributed around the world (Stiglitz, 2002). It is considered that the phenomenon of globalization lead to the increase of volatility transmission around the stock markets and to the propagation and contagion of economic and financial crises (Forbes, 2001; Bekaert et al., 2010).

Lawrence Summers, former President of Harvard University and U.S. Secretary of the Treasury, affirmed in an interview: *'Contagion has become very much a phenomenon, and it's a phenomenon of globalization'*. Transmission of shocks between stock markets is an observed and experienced phenomenon by millions of people, and with the increasing integration the simultaneous fall of the markets around the world becomes more and more likely, as noticed in the light of the current financial crisis. Some, like (Prasad et al., 2003), consider that instability is the direct result of integration, and wonder if it would have been better if it was avoided from the start. But, in the same time they point out that with economies becoming financially more integrated, the income per capita tends to increase. So through globalization and market integration we reached benefit with drawbacks. (Prasad et al. 2003) outline that a definite link between financial integration and economic welfare can't be drawn, as long as economic and political stability, as well as the stability of capital flows are not considered. Paul Samuelsson in a few words expounded the whole dilemma surrounding globalization: '*Globalization presumes sustained economic growth. Otherwise, the process loses its economical benefits and political support'*. Thus, as long as growth and stability dominates the economic scene, the conections between markets are not taken into consideration because their real effects are not perceived by the investors. In the moment when an external or a common shock occurs, integration of stock markets becomes more visible and more painful for market participants.

Through this work we attempted to address the issue of stock market interconnections and its main types, from the point of view of the current economic environment, in the context of diversified and dynamic mechanism of market economy. The motivation of choosing this theme resides in the necessity of an in-depth analysis of the interconnections between financial markets

in the light of the recent crisis, simultaneously with the transmission of contagion and spillover effects between markets.

It appears that these shocks are more frequent and devastating than originally considered, from where arises the need to include them in models that are designed to capture the simultaneous movements of markets. This theme seems to come to attention every time after a crisis has shook the markets and contagion effects were present. There are numerous papers, where each, by a specific approach attempts to explain *why* markets behave in this way, what would be the *causative factors*, *how* could this happen, and what was misspecified in the previous models. We know that in the year 2013, in Romania, we record the sixth consecutive year from the beginning of the crisis. Everyones projection, or maybe just the pessimists, indicate and describe o world characterized by high levels of unemployment and inflation, a banking system full of cracks and governments struggling with deficits. But how do we get here? As we know, globalization and liberalization of markets led to stock market integration and created the connections between markets, with frequent spillover and contagion effects. Or these effects were present in the markets, and globalization only emphasized them? What distinguishes contagion effects from spillover effects? Do markets walk together hand by hand, and when one stumbles, the others, from a sense of solidarity, decide to fall with it? Why do we need to know how they will fall? Which is the degree of interdependence before and after? Which market will decide to betray the others, and will flee from the fear arising from the possibility to fall into the abyss itself? More importantly can a market escape from the imminent disaster, without being chained together with the contaminated markets? As mentioned all papers are preoccupied with the question *why*? So why is there the need from a new paper, which embraces the perpetual question, turns it on all its sides, just to finally reach the undeniable conclusion, that interconnections between markets represent tangled spider webs, unfolded and rebuild day by day. Where at the beginning of our analysis we assume certain hypothesis, and after we are severely punished for our naivety, we blame the initial assumptions and unpredictability, the abnormal evolution of markets, the existence of informational asymmetries, the so known speculative bubbles, excessive risk exposure or greed. We argue that we are not living in a perfect world, and because of this we build stylized models. Afterwards we try to catch the wind, and so begins the long and agonizing process through which various test and methodologies are caried on in order to verify and reassert the original question. Why do markets tend to integration and what causes contagion

transmission between them? Which factors are accountable for influencing the risk of contagion, and how can we control them? We deceive ourselves in thinking we are the masters of our own models, where in the end everything becomes uncertainty, a certainty interval with a confidence level. Why should we not accept that we live in an imperfect world, which we do not fully understand, and instead of trying to create a perfectly stylized miniature world, we could try to adapt to the existing one and learn its essential features. As pointed out the analysis in the domain of stock market interconnections is focused especially on the questions *why* and *when* again? The essential question, *how usually,* was overlooked because it was presumed that the probability that a crisis will shake again the financial system is practically zero. A crisis is shown as an event of six sigma $\mu - 6\sigma$, so the probability that a shock would arise is equal with 1 in 506.797.346, or once in every 1.338 million years, with a probability of 99,999.999.8027% that this kind of events will never occur again, and a probability of 0,000.000.1973% recurrence[1]. For example Black Monday from 1987 was a 25-sigma event, where the S&P 500 index fell in one day with 20%. Such events should never occur again. But we don't need to search very far, in 2007 we witnessed a new crisis, which has been labelled a 25-sigma event, where the chairman of Goldman Sachs David Viniar stated: *'We were seeing things that were 25-standard deviation moves, several days in a row'.*[2] The case of the *Weekly Letters - Harvard Economic Society*, published in 16 November 1929 became famous, which emphasized with the highest conviction at that time: *'A severe depression like that of 1920-1921 is outside the range of probability'.* The publication ceased to exist because of the Great Depression from 1929. Maybe the moment has come for us to realise that the questions until now were impossible to answer, but instead we can try to differentiate steady times from the ones characterized by financial stress, and we can try to outline the manipulating strings of the markets, but without presuming that we can master the prediction of these and their full analysis.

The purpose of this research is the analysis of the detection, estimation and monitorization of the interconnections between markets. We developed a qualitative analysis for the identification and differentiations of the conceptual approaches wich surround stock market connections, namely the phenomenon that are considered interdependencies and integration, as well as the

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[1] (Taleb, 2007); (Dowd et al., 2008).
[2] *Financial Times*, August 13, 2007.

transmission channels that operate between the markets. On the other hand, a quantitive analysis of interconnections between markets has been developed, to which the whole financial system is exposed, together with the estimation of separate regimes that incorporate the effects of interdependence, as contagion. We estimated on different data sets, changing the initial values, several processes by changing regimes. We concluded that the results of the models converged, which confirmed the robustness of our estimates. The main results are presented for different data sets, focusing on the general characteristics of the models, and not on the specificities.

To achieve out aim, we focused our attention on the following specific objectives, namely the analysis of the conceptual differences *interdependence, integration, contagion and spillover effects.* We have addressed the identification of the channels of transmission between markets, and the classification of these based on the interconnections between the markets, together with a model that outlines the relationship between markets and regions in different states. Considering all these aspects, this work aims to identify the general trend of the linkages between stock markets, and the frequency of shifting from one state to another. One of the most sensitive and slippery issues in this paper will be linked to the problem of induction. It is impossible for us to consider all the markets, all the investors, and to make sure that we took into account all the possible scenarios. In this case we will encounter the problem of induction, also known as Hume's problem, introduced by David Hume, but mentioned first time in ancient philosophy by the Pyrrhonian sceptic Sextus Empiricus. He has pointed out that the process of drawing conclusions based on observations, namely inductive reasoning from particular to general, and observing only certain features of the phenomenon of the process is wrong. Some variables or causalities can be omitted, and so the general conlusion that is reached is just a particular event in a whole string of possible events. So an universal rule can't be established from an incomplete set of particular instances. Within this work we choose to follow critical rationalism, introduced by Karl Popper. Critical rationalism represents a part of the epistemological philosophy that claims the belief that reasoning, from the angle of empirical knowledge, can't play an explicit rigorous demonstrative function, but instead one of rational criticism. According to this view a single deviation is sufficient to invalidate a hypothesis, which remains true until it is disannulled. Popper's theory can be summarized as: *'Science may be described as the art of systematic over-*

simplification — the art of discerning what we may with advantage omit. [3].

The research methodology consists in estimating and monitoring of the connections between the markets and regions, by including contagion effects in the model. Our analysis is divided in three parts, where the first part contains the visualization of the connections between markets, within regions, together with their dynamics. In this methodology we proposed a DCC model for estimating the connection dynamics, followed by models with Markov switches on bivariate linkages. The second part of the analysis is focused on the connections between regions, by adopting the methodology developed by (Billio and Caporin, 2005) for estimating an MS(S)-DCC model. This model implies a DCC model which evolves in different states following a Markov process, which again is driven by a transition matrix with S different regimes. The third part of the study contains the connections that are established between the stock market from Romania with the aggregate markets from Continental Europe, North America and Asia. The estimation of each part of this study was developed in three phases, in the first step we extracted the common observed factors of the markets, in the second step we eliminated the effects of volatility on the markets, while the third phase contained the actual estimation of the model. By extracting the common factors we removed the direct effects of common shocks, after which we eliminated the shocks introduced by the volatility, only to obtain the pure correlation structure between the markets. The reason for choosing this methodology lays in the requirements encountered in estimating the correlations between markets, namely observable and unobservable common factors, periodicity, frequent shocks transposed into multiple regimens, together with more common shocks than predicted by the normal distribution. This meant the identification of a model that could capture periodic changes, reflect interdependence, but also be able to include drastic shifts from one regime to another when contagion and spillover effects were present on the market.

Going into depth on the issues of international diversification and connections between markets, in the first part of chapter one of the thesis, it is presented the history of international diversification and relationships between markets is presented. We encounter the concept of diversification in the Old Testament and in the Talmud, together with the works of Shakespeare. So the concept of international diversification is not new, since the early days people raised the

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[3] (Popper, 1982; pp. 44)

question of the sudden appearance of negative events that would have been able to destroy all initial expectations. The recommendation was that any goods or investment shall be divided into several directions, with the reasoning that a misfortune can't hit all investments at once. But with the apparition of the portfolio theory (Markowitz, 1952, 1952b, 1959) we can speak of the embodiment of this concept, in which diversifying is presented as a way of risk reduction. The next two parts of the first chapter include approaches of the theoretical literature regarding stock market integration. We present the most important definitions of stock market integration, interdependence and contagion, pointing out nuances that distinguish one form of linkage from another.

In chapter two the mechanisms of transmission between markets are presented, which are divided into two categories, namely those corresponding to interdependent markets, and those transmitted between in the markets by investors. In the case of interdependent markets, we speak about spillover effects which run through common shocks, real and financial linkages. On the other hand, if no connections can be identified between the markets, than the transmission of contagion is solely the result of investor's behaviour. This is true contagion, which is transmitted through investors and the portfolios they hold on multiple international markets. So responsible for transmitting spillovers effects are the market participants, and in this category we present rational contagion, which can be divided into informational effects and domino effects. Irrational contagion, on the other hand, results from the underlying motivations on the base of investors behavior, where information is not processed according to the rational Bayesian model, where there is no rational foundation behind the investors decision.

Chapter three is dedicated to the empirical approaches of the connections between markets, from the perspective of primordial works, together with the empirical model that we consider in our research. In the literature there are four established methodologies for analyzing the connections between markets, namely Correlation tests, Cointegration tests, ARCH and GARCH models, respectively Factor models. We start by highlighting the challenges to which a model concerned with stock market connections has to face. We present the evolution of the multivariate GARCH models and Markov processes, which lead to the apparition of the MSDCC model. The last section of chapter three contains the description of our implemented model to capture the interconnections between stock markets and regions.

Chapter four includes in the first part the implementation of the first model within 40 stock markets, while the second part consists in the analysis of connections within 6 regions, while the third part consists on the visualization of the linkages between Romania with the aggregate markets from Continental Europe, North America and Asia.

The final goal of this thesis is to help to clarify the concepts of interdependence, integration, spillover effects and contagion. We presented a quantitative model that is able to capture and identify different states of the markets, together with transmission effects between these. This paper proposes a methodology that is appropriate for visualizing the connections between markets, allowing international portfolio to adapt to these realities, facilitating the understanding of the linkages that are contoured between the stock markets. This paper addresses individual investors, analysts together with portfolio managers, banks, insurance companies, market authorities, and all stock market participants who are concerned with international risk management.

Synthesis of chapter 1

STOCK MARKET INTERCONNECTIONS – CURRENT CONCEPTUAL APPROACHES

The first chapter, entitled *Stock market interconnections - current conceptual approaches* presents the concepts related to the integration of market, respectively the transmission mechanisms between these. According to Markowitz's portfolio theory, we know that by choosing proportions of various assets, investors can create a portfolio which is designed to protect investors in the case of an adverse shock in the market. So the volatility of a portfolio is a function of individual volatilities and the correlations of the component asset pairs. According to this rationalisation, an investor can reduce its portfolio risk by holding combinations of assets that are not positively correlated. As himself Henry Markowitz states, '*Diversifying sufficiently among uncorrelated risks can reduce portfolio risk toward zero'* (Wall Street Journal, Interview 3, November 2008). So an investor can't include assets from integrated or highly dependent markets. The optimal markets are those which share reduced and stable connections, in the case of an adverse shock they should react in different ways, otherwise all the benefits of diversification were to be cancelled. This means that if between markets contagion effects can be

found, international diversified portfolios aren't able to fulfil their initial purpose. In a nutshell, investors can protect their portfolios from individual risks present on a single market, by including various assets from other markets that cancel the particular country risks. But if they are exposed to the same sources of risks, no diversification strategy can attain investor's protection.

In the same vein, (Tobin, 1958) introduces the mutual fund *separation theorem*, due to which investors' attention moves from asset selection to diversification through portfolio structure. (Sharpe, 1964) proposes its own capital asset pricing model, in which the concept of the correlation coefficient is explained. The model itself illustrates the relationship between the return of and asset and market. It is considered that through diversification the specific risk can be eliminated from the portfolio, so only systematic risk will remain. If international diversification is taken into account, and the markets are not entirely interdependent, this risk can be removed up to a certain level also.

(Lintner, 1965) reaches a similar conclusion, but insists that if assets do not possess distinctive features; diversification is not effective, since there is not a unique component that can be eliminated through diversification. Investing in a single active would become, in this case, equal with the investment in an efficient portfolio. Sharpe believes that diversification can eliminate all risks specific to an industry, or asset-specific risk, leaving only the market risk.

Moreover (Lintner, 1965) agrees that market risk is equal to systemic risk, only that he believes that all risk can't be avoided, since they are present from the beginning in all the assets. Here it is where international diversification shows its effects: if markets were fully integrated, the global factor would already be incorporated into the systemic risk of each asset, so it would not matter if investors would diversify international their portfolio or would just invest in the local market.

Even if on a first look these models seem differnet, their approaches are substantially similar regarding in the diversification and its importance in portfolio management. Despite the multiple approaches, one common feature is namely noticed that diversification is essential for portfolio management. (Grubel, 1968) took a step further and introduced the concept of international diversification, considering for the first time the possibility that investors allocate their portfolio in different stock markets in different countries, rather than just allocating their investment in one market in multiple sources. (Grubel, 1968) suggests that when countries are exposed to

peculiar shocks, some of the local stock market specific risks can be diversified on other markets in other regions.

(Levy and Sarnat, 1970) continue the research on international portfolio diversification, being the first ones to underline the hazards of stock market integration. Thus, international diversification of portfolios would allow investors to build superior portfolios in terms of risk and return, only if the markets show no common movements. But when markets become integrated, and contagion is present on the markets, the whole reasoning behind international diversification is undermined.

As shown, the specific risk is diversified, while the market risk, that risk that characterizes the entire financial system, remains undiversifiable. We can view the financial system from a global point of view, but also it can be country related, or be shaped according to a specific region. Global systemic risk is not diversifiable, since it shares common sources of risk in all the markets, according to the definition of (Bekaert and Harvey, 1995). Therefore, stock markets are integrated to a certain level, and if they are exposed to common shocks, they will tend to behave similarly. As we have seen in the case of the financial crisis in 2007, with a market fall, the other stock markets adopted a similar behavior. But as highlighted, just some of the markets are integrated, large majorities are interdependent and a few are segmented. But what are integrated markets? As stated in Bekaert and Harvey (1995) stock markets are completely integrated if assets with a specific risk have the same expected rate of return, regardless of the market on which they are traded. So the expected return in one market is explained as the exposure of investors to a common global factor. In such a vision, if markets are segmented, the covariance of a specific market and global market can't fully explain the return obtained on that market. So, in integrated markets the expected returns are similar, because the investors expose themselves to the same risk. But if markets are segmented than returns will vary, because the sources of risk are different in each market. Stock market integration can be regarded as a high and constant level of interdependence.

An investor can't diversify its portfolio in integrated or highly dependent markets. Optimal markets are those that are independent and are characterized by stable connection, which reacts differently in the case of market shocks. Even if an investor would choose markets with weak dependencies, if they are hypersensitive to global or regional movements, the effects of international portfolio diversification are cancelled out. In conclusion investors can protect their

portfolios by allocating their investments across multiple markets, which do not suffer from spillover and contagion effects, and most of all are not integrated.

So an important aim is to identify the existing connections among markets, and their reaction to shocks. In order to figure out a way to protect investors from the disrupting wave, first we have to think to assay the tsunami and its timing. Similar to a tsunami, also in the case of stock markets, we can have numerous causes which all have the same effect: trembling and wiping away everything. But in the case of markets, the game of hide and seek becomes a little bit more complex. Why? In the case of a tsunami we need an initial force, such as earthquakes or underwater explosions, which generates an immense energetic wave that disturbs the equilibrium. In the case of the markets, the problem is that there are two directions, one is related to the rising level of interdependence between markets, toward integration, which can be viewed an extreme state of interdependence. In this case, more frequent and indefatigable shock transmissions make part of the actual equilibrium of markets, as in Forbes and Rigobon (2002). In this case, before and after a shock, as the crisis in 2007, the linkages should not show significant variations, there is only interdependence, no contagion. Forbes and Rigobon (2002) consider that contagion is only true contagion if there is no dependence between the markets prior to the shock. In this case contagion is a pronounced increase in the dependence of the markets. If two markets share a high degree of correlation during periods of stability, and after the shock the co-movement between them shows no significant increases, even if they are highly linked one to another, this phenomenon can't be regarded as contagion, rather than interdependence.

The second direction considers contagion outside of the actual general system. Contagion becomes the disease of it, in other words an epidemic of the markets. Thus the channels of transmissions become of crucial importance in studying the linkages between stock markets. In this case markets become slowly integrated, but can never reach full integration, so in the case of a shock they show the signs of contagion from one market to another, as in Corsetti, Pericoli and Sbracia (2001). According to this view, if a shocks occurs, some comovements between markets are the implications of interdependence between them. This shock can be caused by global and regional factors, such as housing bubble, imprudent mortage lending, global financial imbalances, securitization, lack of transparency and shadow banking system, complex financial instruments with questionable risk management models or excessive leverage. So the rise of

volatility of asset prices in one market can be expected to be correlated to the rise of volatility in other markets, due to the international transmission mechanism. But if contagion occurs, the degree of transmission is very high, above what can be predicted when the mechanism of international transmission is constant, and is it propagated by irrational investor behavior and panic. Contagion is viewed as a break in the parameters governing the correlation system.

Synthesis of chapter 2

TRANSMISSION MECHANISM OF CRISES BETWEEN STOCK MARKETS

Another step in our analysis consisted in the classification of the different transmission mechanism, based on the main directions pointed out by theoretical literature, a compendium can be found in Figure 1. The principal criterion of classification is the cause propagating the shock. Chapter two – *Transmission mechanism of crises between stock markets* presents mechanism that operated between markets, and can be divided into channels which act in interdependent markets with spillover effects, and channels where the market are segmented, so the linkages are attributed to investors behaviour. In this case, contagion flows through investors and the portfolios they hold.

In interdependent markets we can have three possible channels, namely common shocks, trade linkages together with competitive devaluations, and finally financial linkages. These channels are the effect of different connections between markets. In the channel of common shocks (Calvo and Reinhart, 1996) include major increases in the global or US interest rates, (Moser, 2003) points out changes in commodity prices, recessions in major industrial countries and exchange rate changes between major currencies, (Corsetti et al., 1999), together with (Radelet and Sachs, 1998i; 1998ii) include in the goup of common shock triggers significant changes in the exchange rate, while (Chunan et al., 1998) consider that slowdowns in the US or global industrial production or changes in the ratings of developed countries constitute also global factors.

Through trade linkages, such as bilateral change between two countries, a crisis can also be exported into other markets. In this case, if the income of a country decreases, it leads to a reduction in demand for imports, and this is equivalent with the reduction of exports of other countries. In a scenario like this, the balance of payments and other fundamental variables are

affected. (Kaminsky and Reinhart, 2000) together with (Van Rijckeghem and Weder, 1999a; 1999b) consider that trade linkages are subordinated to other factors in the transmission of crises.

Competitive devaluations, as shown by (Corsetti et al., 1999), describe a situation where a crisis has the effect of currency depreciation in one country. So the exports of other countries are altered, by making the exports of the depreciated currency country more attractive. In this case the other countries will be inclined to depreciate their own currency also, for competitive reasons, and so a wave of depreciations is perceptible on the markets. Usually the final amount of total depreciations exceeds the necessary depreciations allowed by the equilibrium, and this constitutes contagion. These linkages are found significant (Eichengreen and Rose, 1998a; 1998b); (Glick and Rose, 1998), together with (Forbes, 2000; 2001), while (Masson, 1998); together with (Baig and Gooldfajn, 1999) believe that these are not central in shock transmission consider that trade linkages are subordinated to other factors in the transmission of crises.

 The last linkage in dependent markets is the financial one, where (Claessens and Forbes, 2004) suggest that these may be constructed from foreign direct investment, reduction in trade credit, or changes in other capital flows between countries.

(Rigobon, 2002) considers that financial linkages can be associated with all the institutions which are necessary for the functioning of financial markets. (Van Rijckeghem and Weder, 1999a; 1999b) consider the common bank lender effect, where one country is hit by a shock, and if a bank has high exposure on the affected market, probably it will suffer major losses. This has the direct consequence that it will meet margin calls, or will readjust its risk exposures, reduce lending on other markets for the purpose of restoring the capital asset rations, and so the crisis in transported in the other markets also (Kaminsky and Reinhart, 2000) suggests that banking institutions play an extensive role in the transmissions of shocks, while (Kaminsky et al., 2001) together with (Broner et al., 2004) emphasize the importance of mutual fund in crisis propagation. (Claessens and Forbes, 2004) consider that similar employed VAR (Value-at-Risk) model can produce similar behavioural patterns and decision.

In the second case of transmission mechanism, there are no dependences between countries, the catalyst of common collapse is represented by investor's behaviour. As it was pointed out by (Devenow and Welch, 1996), this can be classified as a rational or irrational reaction to an external event.

Thus the distinction between these two categories is made by motivations that lie behind the decisions of investors, or the barriers which determined that the information on which they based their expectations is incomplete. The models shaped around the behavior of investors can be divided into rational models of forced contagion, namely irrational models where market participants do not always behave according to rational Bayesian model type.

Figure 1. Transmission mechanism between stock markets
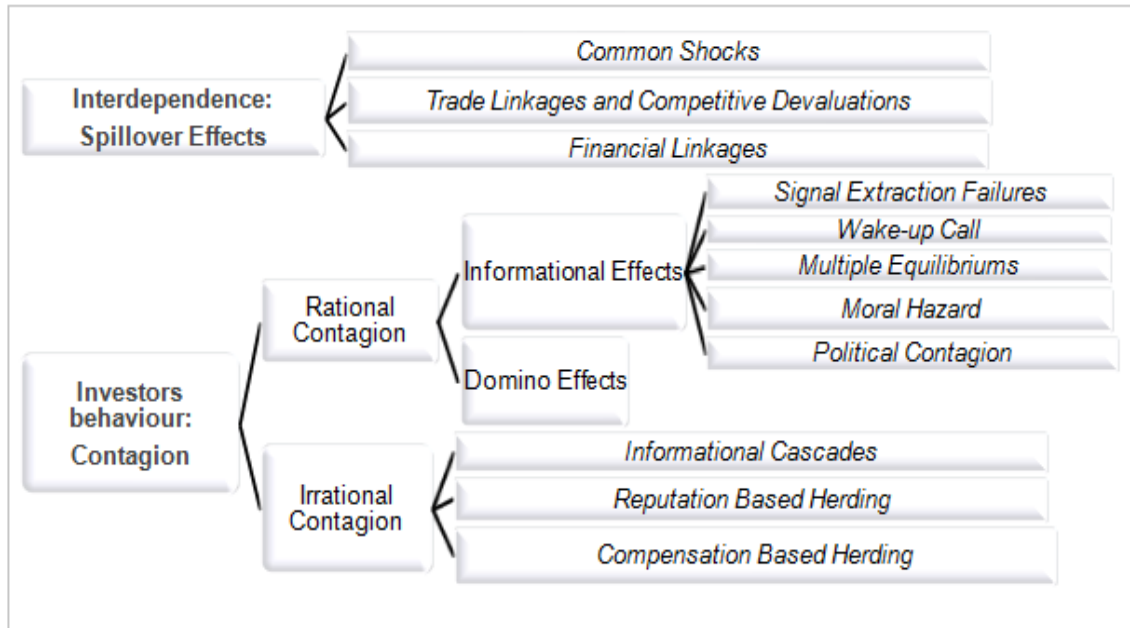
Source: (Own processing)

Rational or forced contagion, is one that is influenced by external events, outside the reach of investors, such as the existence of asymmetric information and multiple equilibriums. Due to market imperfections investors seem to behave irrationally, but they are acting rationally based on correct signals. In the case of irrational contagion agents completely ignore the signals coming from rational decisions, and choose to join the general movement of the market.A rational reaction to an event can be also called forced contagion, which, in (Moser, 2003) vision can be divided into informational effects and domino effects. (Moser, 2003) believes that we can speak about informational effects in transmitting a contagion, when a shock in a single market forces investors to update and change their expectations regarding the other markets. On the other hand domino effects are propagated through indirect financial linkages. (Bikhchandani and Sharma, 2000) see forced contagion as a false herding behaviour, as opposed to pure herding investors take decisions based solely on their own private information.

Informational effects can be divided in *(i) Signal Extraction Failures*, as discussed by King (King and Wadhwani, 1990), where the transmission of crisis is attributed to the misinterpretation of the behaviour of other investors from the market. (Moser, 2003) considers that these effects can appear from the mistaken view of investors about fictional interdependence between markets, or the hypothesis that similar markets will tend to behave similar, in other words the lump together hypothesis. Another informational effects is the so called *(ii) Wake-up call* which is introduced by (Goldstein, 1998); and refers to the case when a shock in a market forces investors to update correctly their initial mistaken believes. The third element in informational effects is represented by the *(iii) Multiple Equilibriums*, which is referred to as expectations interaction by (Moser, 2003), market coordination problem by (Claessens and Forbes, 2004) together with (Marshall, 1998); and political contagion by (Drazen, 2000). This contagion is similar to a mental contagion, where each investor would choose the best option, only if the others would proceed similar. The best decision would be not to sell, and so asset prices would remain stable. The worst decision, which is pareto optimal, refers to the belief that everybody will sell, and so they all start selling, which causes assets prices to decline. Since we discuss a sequential process, the trigger variable becomes of primordial importance, which determines investors to change their expectations about the likelihood of a crisis. (Diamond and Dybvig, 1983) propose the model of bank runs, while (Obstfeld, 1986) discusses self-fulfilling speculative attacks. (Marshall, 1998) together with (Chang and Velasco, 1998) apply these models in international context, where liquidity needs are a sufficient condition for crises to be triggered. *(iv) Moral Hazard*, which is addressed by (Dooley, 1997) model, discusses the possibility when international investors are convinced that in times of major turbulences central banks will intervene and calm the spirits. *(v) Political Contagion* is another form of informational effect in transmitting contagion, which is discussed by (Drazen, 2000); and by (Moser, 2003) with the term membership contagion, by (Dornbush et al., 2000) as contagion deriving from the changes in the rules of the game.

In the second category of rational contagion we find the so called domino effects, related to which (Valdés, 1997) discusses a contagion model related to wealth effects. These contain liquidity shocks, but which are pure shocks, so they do not start from stock markets. The effect of a liquidity shock is the reduction of wealth, which in turn forces market participants to reduce their exposure on stock markets. A similar approach is incorporated by (Calvo, 1999); together

with (Kyle and Xiong, 2001) and (Goldstein and Pauzner, 2004) models.

The second category of contagion transmission, as an irrational reaction to an event, is also discussed by Keynes (1936), with the well know term 'following the herd'. (Bikhchandani and Sharma, 2000) suggest that the main reason for herd behaviour is the presence of imperfect information on markets, together with concern for reputation and unfair market compensation structures. (Hirshleifer and Teoh, 2003) suggest that payoffs or network externalities, sanctions upon deviants, preferential interactions, direct communication and observational influences are the possible sources of herding. There are different viewpoints, but a classification of herding could be perceived as (i) informational cascades as considered by (Bikhchandani et al., 1992;1998) together with (Bannerjee, 1992). These occur when an investor, noticing the actions of other investors, chooses to make the same decision, regardless of his private information and personal opinion. (ii) Reputation Based Herding models are discussed by (Scharfstein and Stein, 1990); (Trueman, 1994); (Devenow and Welch, 1996); (Prendergast and Stole, 1996); (Graham, 1999) and (Welch, 2000), where portfolio managers choose herding, because they believe that in this case it is less likely to obtain sub optimal results compared to the other participants. (iii) Compensation Based Herding is discussed in the models of (Dow and Gordon, 1995); (Maug and Naik, 1996); together with (Admatiti and Pfleider, 1997) where investors are rewarded externally according to the achieved performances. So investors will be stimulated to copy the herd behaviour, because they want to reach at least the average level of performance. So, instead of encouraging investors to achieve superior performances, outside incentives will only move investors closer to herding, this because they choose to copy the movements of others, and obtain medium benefits, instead of the risk of obtaining nothing.

In this chapter we classified the possible propagation mechanisms between stock markets. These can be divided into channels acting in independent markets, throught shocks that are perpetuated by spillover effects, respectively mechanisms that operate in independent markets, where the linkages can be attributed to the behavior of investors.

Synthesis of chapter 3

MODELS REGARDING STOCK MARKET INTERCONNECTIONS

Chapter three, entitled *Models regarding stock market interconnections* covers the main methodologies used in the empirical literature to identify the possible regimnes that can characterize stock markets and the effects of transmission between them. As Rigobon (2002) states, the main problem of the empirical literature of contagion and interdependence, and the changes between the two states is that the measurable events are more rare that the number of possible hypothesis. So the only aspect on which everybody agrees is that there is no unanimously accepted definition of contagion and interdependence, or a single model to test it. This discrepancy has lead to different econometric models employed to identify the connections between markets. There are mainly four distinctive techniques that explore and try to capture the linkages between markets, which are differentiated according to the implemented methodology and tested assumptions, which in turn are derived from the definition of possible states between markets.

The first investigates the relationships between stock markets using *correlation coefficients*. These tests verify if the correlation structure presents significant changes in time, but also and during pre- and post-crisis periods. The second type of methodology examines the *cointegration vectors* between the stock indices, for capturing over longer periods of time the changes in the interlinkages between markets, considering that if markets are cointegrated, they are part of the same system. As stated earlier through international portfolio diversification gains can be achieved, if different markets are not integrated. On the other hand, if integration between markets is indubitable, international diversification may have only a limited potential. Third approach involves the *univariate and multivariate general autoregressive conditional heteroscedasticity models* for estimating the variance-covariance structure between the markets. The fourth approach uses *factor analysis* to investigate the relationships between markets, while addressing the integration of markets through the factors leading to integration, together with the influences that lead to the increase of interdependencies. We have presented the different approaches, as discusses earlier, including the main relevant studies and findings.

The second part of the third chapter presents the evolution of MGARCH models, along with the

advantages and limitations that characterizes them. MGARCH models are divided into three categories, namely *(i) models generalized from univariate standard GARCH models*, (*ii*) *models created from linear combinations of univariate GARCH models*, respectively *(iii) models resulted from nonlinear combinations of univariate GARCH models*. We present the characteristics of these models, each new category of models being introduced to correct the limits of the previous ones. Also we presented the specifics of the Markov processes together with the MSDCC model, which is the final result of combining MGARCH models with Markov processes.

The last part of chapter three focuses on implementing the empirical models to our data, and the description of these, in three parts: (i) *empirical models regarding the analysis of connections within regions, between stock markets*. We test the integration and causality between markets within each region, and then implement a DCC model in each region, between markets to view the connections that are contoured between them, and their dynamics. The last part of the methodology tests the stability of the connections on bivariate correlation structures, to see if there are significant changes from the perspective of the investor who is concerned with international diversification. The second part of the empirical investigation focuses on (ii) *MS(S)-DCC model for identifying the connections between regions of stock markets*. We present an MGARCH model with Markov switches, the MS(S)-DCC model, and applied it to multiple market sets, to see if the results converge and if they confirm the robustness of the estimates. This model is chosen because it meets the necessary requirements of testing and estimating the interconnections between markets, namely frequent changes in interdependence, constant state of market integration, together with spillover and contagion effects, characterized simultaneously by structural breaks of the governing parameters of the process. The third part of the implemented methodology refers to (iii) *the connections of the Romanian stock market with the stock markets in Continental Europe, North America and Asia*. To view these linkages we applied six different models from MGARCH models (CCC, DCC, ADCC, BEKK, RCC and RARCH), followed by an MS-DCC model. The first objective is to view correctly the real connections between markets and to verify if the estimates of the different models are robust. Another objective is to observe the degree of interdependence between the Romania stock market with the other regions, since the connections between Romania and the emerging markets in Europe are tested in the first part of the chapter.

Synthesis of chapter 4

## EMPIRICAL INVESTIGATIONS REGARDING STOCK MARKET INTERCONNECTIONS

Chapter four, entitled *Empirical investigations regarding stock markets*, is concerned with the identification of the connections between markets, namely integration, interdependence and market segmentation, together with spillover and contagion effects. In this work we adopted the definitions suggested by (Bekaert and Harvey, 2002) in terms of market integration, together with the proposal made by (Forbes and Rigobon, 2002) regarding the difference between spillover and contagion effects between markets. In the financial literature three main approaches arise in describing the relationships between markets. The first group of studies measures stock market integration by using a single criterion, namely the law of one price. This was introduced by (Tamir, 1972) and tries to explain assets price level through the influence of a global market. At the base of this lies the CAPM, which states that a common asset pricing model should be able to explain the different price levels of assets on different markets. This type of integration can be viewed as *integration through prices.* The second view of integration was introduced by (Feldstein and Horioka, 1980), and, in order to determine stock market integration the impact of barriers to capital mobility is measured. Formally it can be viewed as *capital-flow integration*, since it is connected to the mobility capital between stock markets. The third approach compares the evolution of stock markets in order to observe their degree of integration. *Risk integration* defines integration from the point of view of mutual risk factors in asset returns, where these features are rather global than national specific. We address risk integration through our analysis, so two markets are integrated if there is a point that causes a clear break from one state to another, and if in the moments of shock, regardless of the nature of the shock, they do not depart one from another.

Regarding contagion, we adopt (Bekaert et al., 2005b) definition of contagion, where contagion is regarded as an excess correlation during crisis periods, much higher as it could be explained by the normal transmission mechanisms between markets. Excess correlation overall represents high interdependence and integration of markets. We consider interdependence as a stable state of dependence between markets, which is not affected by external shocks, as given by the

definition of (Forbes and Rigobon, 2002). In our vision integration is an extreme and stable state of interdependence.

Figure 2. Theoretical model of interaction between regions
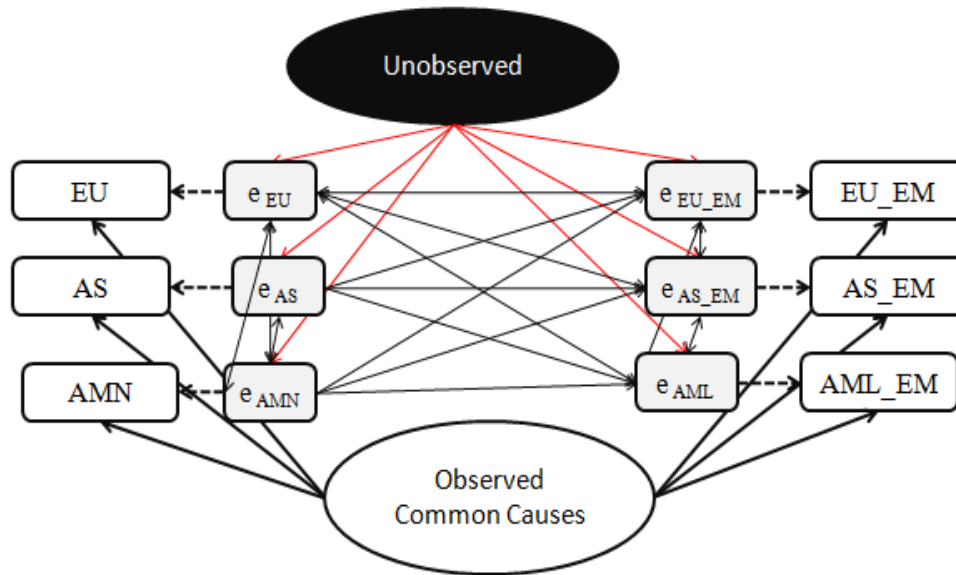
Source: (Own processing)

We chose this methodology because we believe that the analysis of the determinants of market connections would be a difficult and sensitive task, especially due to the factors that may be omitted. The identification, quantification and implementation in one model of all the factors responsible for transmission of spillover and contagion effects across markets would become a Sisyphean task. For these reasons we chose to concentrate on the connections that are established between markets, namely *interdependence/integration/segmentation* and the transition between these moments *spillover/contagion*. Contagion is defined as a sudden, frequent change in the correlation structure between markets during periods of financial stress, due to observable or latent factors. As a conclusion of the previous chapters, the only common ground in the literature is that there is no consent in the definition and approach of contagion, neither in the means of testing it. The only shared view on which everybody agrees is that the markets all in constant change, with shocks that are shifting the linkages. In such a case we propose a model that can include multiple regimes, without making any judgments about the effects that are creating the shock or the type of transmission mechanism that interrupts the periods of stability.

Our empirical model was presented in chapter three, and so our analysis is also divided into three

main parts. The first part focuses on individual markets, and the linkages between these within the same region. The second part of the study is concerned with the connections between the six regions of the world, represented in Figure 2. The regions behave like micro-systems that are influenced by common observed and latent regional causes and shocks.

The main question is related to the extraction of these latent variables from the correlation structure that governs the system. The third part of the analysis identifies the relationship between the Romanian stock market together with the aggregate markets in Continental Europe, North America and Asia.

Thus obtaining a clean correlation structure in all the three parts of the analysis, we can identify the variables that govern the process, which are not subject to constraints between certain levels of states, but are capable to illustrate the true dependence structure between the markets. So instead of trying to find answers to the question what causes shocks and contagion movements, we choose to visualize the direct connections between the markets and their characteristics, so that these observations could be actively implemented in international portfolio allocation by the market participants.

In the first part of the chapter we analyzed the nature of linkages between the 40 stock markets in the last decade, between the developed and emerging stock markets in Europe, Asia, Asia Pacific and America. We addressed two main questions: first, what is the degree of dependence of the stock markets? And second, how is the pattern of linkages changing, are the relationships between the markets intensified over time and headed towards a higher degree of integration?
The conclusion that can be drawn is that the 40 markets are not fully integrated, but show signs of dependence. We identify linear causal links between markets that are not integrated, where the developed markets from Europe influence directly the emerging markets from Europe, which in turn influence the market groups from Asia and Asia Pacific.

As there are no co-integration relationships between the markets, we applied a four-lag VAR model to filter out the dependencies due to the common causes, and then we stabilized the returns through a GJR-GARCH model for the variance equation. In the volatility series we observe simultaneous increases, which indicate the existence of contagion effects, as defined by (Corsetti et al., 2011). This volatility structure indicates spillover effects arising through the direct transmission of shocks, but not because of the linkages between the markets. On the

obtained series DCC modelld we built on a regional level, with dynamic correlation coefficients within regions, together with the estimation of the parameters which govern the different systems. In total we obtained for the 40 stock markets 187 series of conditional time-varying correlation.

The developed markets in Europe present high interdependencies towards integration, the emerging markets from Europe are characterized by weak and medium connections, the markets from Asia and Asia Pacific show signs of medium towards high linkages, while the majority of the stock markets from America present high dependencies, where CO is the only country that is characterized by weak dependencies, being almost segmented from the markets in the region.

The slowest reactions to shocks can be observed in the emerging markets in Europe, which recommend them as markets to be considered in international portfolio diversification. They are followed by the Asian and American markets, and eventually by the developed markets from Europe.

In the two-state Markov model on the correlation series, some of the markets confirm the existence of two different regimes, but these two states differ only in absolute values. Viewed in terms of portfolio diversification, the differences between the two states become insignificant. This hypothesis confirms the stability of inter market connections within the same regions. Most markets show a slight increase in dependencies, towards integration.

In the second part of our analysis we adopted the MS(S)-DCC model, a methodology proposed by (Billio and Caporin, 2005), and applied it to multiple market sets. We choose the MS(S)-DCC model, because it incorporated our previous findings, and applied it to the major geographical and economically divided stock markets. We answered the following questions: if volatility increases, the interdependence between the markets tends to rise also? By analyzing the different volatility periods along with the mobile conditional correlation coefficients we can conclude that these are not decisively affected by the level of volatility. Once the volatility effects were filtered out, we have seen that the correlation coefficients tend to rise, depending mainly of past levels and on the existence of shocks within the markets. The markets tend to move to higher levels of interdependence once a shock shifts the parameters of the model. From a high dependence state the markets can shift only to a reduced one, but only after a new shock. Also from our model we can conclude that the linkages are persistent between the markets, while different regimes

respond with specific speed to shocks on the market.

The second part of the analysis concentrated on the connections between 6 regions, namely developed and emerging Europe, developed and emerging Asia, together with North and South America. We conclude that a two state model is suitable for all linkages, where a regime is characterized by low to medium dependencies, while the other describes a state where the markets seem to be integrated or highly dependent. According to the transition probabilities the model persists in average 12 weeks in the low independence regime, and 18 weeks in the high one. In the period between 1995 and 2003 the first state is the dominant one, while from 2003 the second state, with the high interdependence, takes over, with short comebacks of the state with low and medium dependencies. Regarding the parameters governing the process, the two states are distinguished manly by the speed by which they respond to shocks, while the high interdependence state is characterized by a greater instability, while the persistence tends to be similar in both.

The emerging markets from Europe, Asia and America are not fully integrated, instead they share an average interdependence. From mid-2003 the market moved into a permanent state of high interdependence, being more influenced by past correlation than market shocks. The developed and emerging markets in Europe are characterized by a stable connection, the first state persists on average 204 weeks, while the second lingers 273 weeks. Between 1995 and 1999 the state with high dependencies dominates the markets, between 2000 and 2005 these are linked by medium interdependencies, just to be fortified from mid-2005. The stability between the two regions during the shock of 2007 indicates a rejection of the hypothesis of contagion between markets.

The results regarding the connections between the emerging and developed regions within Asia also indicate the existence of two states, one which is characterized by weak dependencies, which is replaced in 2004 by a high dependence structure. The weak dependence linkages indicates moderate responses to shocks in the markets, which is consistent with independent markets and lack of spillover effects. In the year 2005 the Asian markets become vulnerable to shocks, with fortified linkages.

The markets in South America from 2003 become integrated with the markets in North America, while prior to 2003 they were characterized by medium dependencies.

The developed and emerging markets, both in Europe and Asia are characterized by two possible states, one defined by medium and low dependencies, while the other shows signs of integration and high dependencies. The regime of high dependencies is characterized by fast responses to shock, while the low correlation structure presents slow responses.

The connections between the markets of Europe and America suffer from constant variations, with a regime governing the process around 3 months, which induces instability in the internationally diversified portfolios. The two states different in terms of correlation coefficients, a state is delimited with integrated markets, while the other presents signs of weak and very weak dependencies. Thus there is a condition that is favorable for portfolio diversification between the regions of Europe and America, while the other state cancels all benefits of this. The regime containing the high correlation coefficients is driven by a process that responds instantaneously to shocks.

The connections between the Asian and American markets are driven by two distinct regimes, each ruling on average 5 months. A state is characterized by weak dependencies, while the other includes highly dependent and almost integrated markets. Also in this case the regime containing the high correlation coefficients is driven by a process that responds immediate to shocks.

We would like to mention that we estimated several versions of these models, changing the initial values of the correlation matrixes, the unconditional probabilities and the parameters driving the dynamics of the correlation structure. Although the initial values were different, the final estimates of the parameters and the smoothed state probabilities of models converged, which confirmed the robustness of the estimates.

The final part of the third chapter consists of applying MGARCH models, so we can visualize more clearly the correlation structure, together with the spillover and contagion effects during the crisis in 2007 for the Romanian stock market. The final estimates of all the MGARCH models converge, and indicate a low dependence structure of the Romania markets with the markets from Continental Europe, North America and Asia. Applying the model MS-DCC we can observe that the markets under the study are governed by two different states. Until 2007 we could have considered Romania a segmented market, after which we could notice an increase of the interdependencies. From the perspective of international portfolio diversification Romania is a country that should be considered to be included in the portfolio, but only if the markets are in

the low dependence structure. It is important to note that while MGARCH models would indicate increasing inter-dependencies from weak to medium, and the elimination of the effects of international portfolio diversification through time, the MS-DCC model shows that these dependencies are not permanent, and there is always a possibility that the markets will return to the weak dependence structure.

CONCLUSIONS

The objective of this paper is to identify the connections between markets, namely integration, interdependence, and with spillover and contagion effects in 40 stock markets. The conclusion that can be drawn is that the 40 markets are not fully integrated, but shows signs of variable dependencies. The developed markets from Europe are integrated, while the emerging markets in Europe, Asia and Asia Pacific and America are characterized by stable, medium linkages during calm periods, but in periods of crisis they are characterized by spillover and contagion effects. Over time connections between markets show slight increases, but not high enough to cause breaks in transmission mechanisms. The second objective was to detect ex-post, estimate and monitor the interconnections within 6 regions. We estimated several processes governed by variable regimes, and we concluded that the results converge. The linkages between region shows larger swings than the interconnections within regions. More specifically, states with low dependencies and states with high dependencies govern the markets. The third part of the analysis focused on the market in Romania, and the linkages that shape between this and the three major regions of the world.

The general conclusions which can be drawn based on the empirical investigations is that common shocks are not responsible for the increasing dependencies between markets. In the model of individual markets, as well as in the model within regions, after the direct shocks were removed, the correlation structure between the markets presented insignificant variations to the state were these effects were not filtered. Another observation is related to the interconnections between markets during periods of high volatility. By analyzing the mobile correlation coefficients mobile along with periods of high volatility, we can conclude that volatility does not affect significantly the correlation structure evolution in time. Also, once the volatility effects

were filtered out, the correlation coefficients tend towards integration. The dependency structure of the correlation is influenced significantly by the level of past correlation, but also by shocks that can not be explained by the model. These result are consistent with that of (Rigobon and Forbes, 2002), who points out that there is no contagion between markets, but only inter-dependencies, after the correlation structure is corrected for the effects of volatility. Markets tend to become more interconnected and integrated, but in average this condition is not a permanent state between markets. These results confirm the effects of spillover between markets, but not contagion, since all the markets show signs of significant dependencies.

Our analysis is consistent with the result indicated by (Billio and Caporin, 2005), suggesting that periods of low correlation between markets are followed by increases in the parameters of shocks in the correlation structure, and not in the coefficients of past correlation. But unlike (Billio and Caporin, 2005), in the state where reactions are more intense to shocks, the unconditional dependencies increase, which would seem to eliminate the effects of international diversification. But the connections between certain regions are stable, with long regimes shifts, while within regimes the markets shows no breaks, which is favourable for effective international diversification. Our results indicate discontinuities in the transmission mechanisms between regions, but not between the individual markets.

We conclude by pointing out that this research is relevant to investors who desire to allocate their investment in several sources, thus protecting themselves from unwanted market movements. This paper is intended to help clarify the concepts of interdependence, integration and segmentation, as well as the transmission mechanism between them, contagion and spillover effects. This analysis serves to determine the interconnections between individual markets within region, as well as linkages between regions. This paper proposes a methodology that is suitable for visualizing the characteristics of the connections between markets, allowing international portfolio to adapt to these, in the meantime facilitating the understanding of the interconnections between stock markets.

References (selection)

■   Akerlof A. George and Shiller Robert J., (2010), *Identity Economic - How Our Identities Shape Our Work, Wages, And Well-Being*, Princeton, New Jersey, US.

■   Amadi Amir A. and Bergin Paul R., (2008), *Understanding international portfolio diversification and turnover rates*, Journal of International Financial Markets, Institutions and Money, Vol. 18, No.2, pp.191-206

■   Ang Andrew and Chen Joseph, (2002), *Asymmetric Correlations of Equity Portfolios,* Journal of Financial Economics, No.63, pp.443-494.

■   Arouri Mohamed El Hedi and Foulquier Philippe, (2012), *Financial Market Integration: Theory and Empirical results*, Economic Modelling, Vol. 29, pp. 382-394.

■   Baur Dirk G. and Lucey Brian M., (2012), *Flights and contagion – An empirical analysis of stock-bond correlations*, Journal of Financial Stability, Vol. 5, pp. 339-352.

■   Bauwens Luc, Laurent Sebastien and Roumbouts Jeroen V.K., (2006a), *Multivariate GARCH Models: A Survey*, Journal of Applied Econometrics, Vol. 21, pp.79-109.

■   Beine Michel, Cosma Antonio and Vermeulen Robert, (2010), *The Dark side of global integration: Increasing tail dependence,* Journal of Banking and Finance, Vol. 34, pp. 184-192.

■   Beirne John and Gieck Jana, (2012), *Interdependence and Contagion in Global Asset Markets*, Working Paper Series No. 1480, October 2012, European Central Bank.

■   Billio Monica and Caporin Massimiliano, (2005), *Multivariate Markov switching dynamic conditional correlation GARCH representation for contagion analysis*, Statistical Methods & Applications, Vol. 14, pp. 145-161.

■   Billio Monica and Caporin Massimiliano, (2010), *Market linkages, variance spillovers, and correlation stability: Empirical evidence of financial contagion*, Computational Statistics and Data Analysis, Vol. 54, pp. 2443-2458.

■   Billio Monica, Caporin Massimiliano and Gobbo Michele, (2003*), Block Dynamic Conditional Correlation Multivariate GARCH models*, GRETA Working Paper, No. 03.03.

■   Billio Monica, Caporin Massimiliano and Gobbo Michele, (2004*), Flexible Dynamic Conditional Correlation Multivariate GARCH for Asset Allocation*, GRETA Working Paper, No. 04,03.

■   Billio Monica, Getmansky Mila, Lo Andrew W. and Pelizzon Loriana, (2010b), *Measuring Systemic Risk in the Finance and Insurance Sectors*, MIT Sloan School of Management Working Paper, No. 4774-10.

■   Bollerslev Tim, (2010), *Glossary to ARCH (GARCH),* Volatility and Time Series Econometrics: Essays in Honor of Robert F. Engle, Chapter 8, pp.137-163. Oxford University Press.

■   Caporin Massimiliano, (2003), *Variance (Non-) Causality: A Bivariate GARCH-type model*, GRETA Working Paper, No. 03.08.

■   Caporin Massimiliano, Pelizzon Loriana, Ravazzolo Francesco and Rigobon Roberto, (2013), *Measuring Sovereign Contagion in Europe*, NBER Working Paper Series, Working Paper No. 18741.

■   Corsetti Giancarlo, Pericoli Marcello and Sbracia Massimo, (2011), *Correlation Analysis of   Financial Contagion,* în Kolb Robert W., (2011), *Financial Contagion: The Viral Threat to the wealth of Nations*, John Wiley&Sons.

■ Desmoulins-Lebeault Francois and Kharoubi-Rakotomalala Cecile, (2012), *Non-Gaussian diversification: When size matters*, Journal of Banking and Finance, Vol. 36, pp. 1987-1996.

■ Dungey Mardi and Yalama Abdullah, (2010), *Detecting Contagion with Correlation: Volatility and Timing Matter*, Centre for Financial Analysis and Policy Cambridge, Working Paper No. 35.

■ El Hedi Aroudi Mohamed and Foulquier Philippe, (2012), *Financial market integration: Theory and empirical results*, Economic Modelling, No. 29, pp. 382-394.

■ Engle Robert F. and Granger C.W. J., (1987*), Co-Integration and Error Correction: Representation, Estimation and Testing*, Econometricc, Vol. 55, No. 2, pp. 251-276.

■ Engle Robert F. and Kroner F. Kenneth, (1995), *Multivariate Simultaneous Generalized Arch*, Econometric Theory, Vol. 11, No. 1, pp. 122-150.

■ Engle Robert F. and Sheppard Kevin, (2001), *Theoretical and Empirical properties of Dynamic Conditional Correlation Multivariate GARCH*, University of California, San Diego, Discussion paper 15.

■ Engle Robert F., (1982), *Autoregressive Conditional Hetersoscedasticity with Estimates of Variance of United Kingdom Inflation*, Econometrica, Vol.50, No.40, pp.987-1007.

■ Engle Robert F., (2002), *Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models*, Journal of Business& Economic Statistics, Vol. 20, No. 3, pp. 339-350.

■ Engle Robert F., (2009), *Anticipating Correlations – A New Paradigm for Risk Management*, Princeton University Press.

■ Fama Eugene F., (1968), *Risk, Return and Equilibrium: Some Clarifying Comments*, The Journal of Finance, Vol. 23, No. 1, pp. 29-40.

■ Făt Codruța Maria, Dezsi Eva, (2012), *A Factor Analysis Approach of International Portfolio Diversification: Deos it Pay Off?* , Proceedings of the EMQFB International Conference - Emerging Markets Queries in Finance and Business 2012, Procedia Economics and Finance, indexat în ScienceDirect (în curs de publicare).

■ Gallo Giampiero M. and Otrando Edoardo, (2008), *Volatility spillovers, interdependence and comovements: A Markov Switching approach*, Computational Statistics & Data Analysis, Vol. 52, pp. 3011 – 3026.

■ Hafner Christian M., (2009), *Causality and forecasting in temporally agregated multivariate GARCH processes*, Econometrics Journal, Vol. 12, pp.127-146.

■ Hamilton James D. and Susmel R., (1994), *Autoregressive conditional heteroskedasticity and changes in regime*, Journal of Econometrics, Vol. 64, pp. 307-333.

■ Hamilton James D., (1994), *Time Series Analyisis,* Princeton University Press, New Jersey.

■ Kaminsky Graciela L., Reinhart Carmen M. and Vegh Carlos a., (2003), The *Unholy Trinity of Financial Contagion*, Journal of Economic Perspectives, Vol.17, No. 4, pp.51-74.

■ King Mervyn A. and Wadhwani Sushil, (1990), *Transmission of Volatility between Stock Markets*, Review of Financial Studies, Vol. 3, No, 1, pp. 5-33.

■ Kolb Robert W., (2011), *Financial Contagion: The Viral Threat to the wealth of Nations*, John Wiley&Sons.

■ Longin Francois M. and Solnik Bruno, (2001), *Extreme Correlation of International Equity Markets*, The Journal of Finance, Vol. 56, No. 2, pp. 649-676.

■ Longstaff Francis A., (2010), *The Suprime credit crisis and contagion in financial markets*, Journal of Financial Economics, Vol. 97, pp. 436-450.

■ Markowitz Harry, (1952b), *Portfolio Selection*, The Journal of Finance, Vol. 7, No.1, pp. 77-91.

■ Moser Thomas, (2003), *What is International Financial Contagion,* International Finance, Vol.6, No.2, pp.157-178.

■ Noureldin Diaa, Shephard Neil and Sheppard Kevin, (2012), *Multivariate Rotated ARCH Models,* Economic Papers 2012-W01, Economics Group, Nuffield College, University of Oxford.

■ Otranto Edoardo, (2005), *The Multi-chain Markov Switching Model, Journal of Forecasting*, Vol. 24, pp. 523-537.

■ Pelletier Denis, (2004), *Regime switching for dynamic correlations*, Journal of Econometrics, Vol. 131, pp. 445-473.

■ Reinhart Carmen M. and Rogoff Kenneth S., (2009), *This Time is Different Eight Centuries of Financial Folly*, Princeton University Press, Princeton, New-Jersey, US.

■ Rigobon Roberto, (2002), *International Financial Contagion : Theory and Evidence in Evolution*, The Research Foundation of Association for Investment Management and Research, Charlottesville, Virginia.

■ Stiglitz Joseph E., (2010), *În cădere liberă-America, Piața liberă și Prăbușirea Economiei Mondiale*, Ed. Publica, 2010

■ Taleb Nassim Nicholas, (2007), *The Black Swan-The Impact of the Highly Improbable*, Random House, New-York.

■ Trenca Ioan, Dezsi Eva and Petria Nicolae, (2011), *Basel III: Countercyclical Capital Buffer Proposal – The Case of Romania*, Revista Economică, Vol. 6 (59), No. II/2011, pp.352-362, ISSN 1582-6260.

■ Trenca Ioan, Simona Mutu and Dezsi Eva, (2011), *Advantages and limitations of VAR models used in managing market risk in banks*, Finanțe-provocările viitorului (Finance- Challenges of the Future), Vol. 1, No. 13, pp. 33-43.

■ Trenca Ioan and Dezsi Eva, (2012), *Financial Contagion on the Romanian stock market*, Finanțe-provocările viitorului (Finance- Challenges of the Future), Vol. 1, No. 14, pp. 27-36.

■ Trenca Ioan, Petria Nicolae and Dezsi Eva, (2013), *Linkages between the stock markets of Eastern Europe*, Revista Economica (data acceptării 22/4/2013, în curs de publicare).

■ Trenca Ioan, Petria Nicolae and Dezsi Eva, (2013), *AN INQUIRY INTO CONTAGION TRANSMISSION AND SPILLOVER EFFECTS IN STOCK MARKETS*, Analele Universitatii din Oradea Stiinte Economice (data acceptării 27/4/2013, în curs de publicare).

■ Trenca Ioan and Dezsi Eva, (2013), CONNECTIONS BETWEEN THE EUROPEAN STOCK MARKETS, Revista de Studii și Cercetări Economice Virgil Madgearu (data acceptării 20/5/2013, în curs de publicare).

■ Treynor Jack L., (1962), *Toward a Theory of Market Value of Risky Assets*, Manuscript nepublicat, apărut în - Treynor Jack L., (2007), *Treyor on Institutional Investing*, John Wiley & Sons, Hoboken, New Jersey, Partea a treia 47-64.