6. EUROPEAN STOCK MARKETS CORRELATIONS IN A MARKOV SWITCHING FRAMEWORK

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Abstract

The growing correlations in global markets during negative shocks generated theoretical and policy debate for the concept of contagion. Acknowledging the different forms of contagion, this paper investigates this phenomenon throughout the last financial crisis at the global scale. In the line with the related studies, we use the narrow definition of contagion - a considerable increase in stock market comovement as a response to a shock affecting one country (or a group of countries). We applied the DCC GARCH setting to compute the daily correlations for a time lapse beginning in 2000 and closing in 2015 to verify contagion in 49 stock indices. After that we calibrate a Markov switching analysis with two states on the series of correlations for each country with all the set of other countries. We identified the moments when regime switches happen in the same time and we found different patterns in the dynamics of these simultaneous changes.

Keyword: contagion, European stock markets, dynamic conditional correlations, GARCH, Markov switching models

JEL Classification: G01, G15, C58

I. Introduction

Globalization brings relatively high correlations and an increase in investment opportunities. In the last years, we witness a remarkable growth in international economic integration, stated in both commercial and financial flows. Economic studies have examined the causes and superventions of this ascension in international integration. At the beginning of the 21st century, the potential for international diversification is very small as against other periods from the stock market's past.

The issue of contagion came into notice in the last years on the strength of intense correlations in world markets bound by negative shocks. There is also evidence that the diversification benefits erode during turbulent market conditions.

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In the economic literature there is a standing disaccord about the notion of contagion, but, predominantly, financial contagion pertains to relations on the short term, entailed by non-fundamentals (the debate regarding the international financial contagion was described by Lupu (2012)). For instance, Karolyi and Stulz (1996) enlighten that irrespective of fundamentals' development, when exhilaration for stocks is driven from one to other markets, contagion appears. Forbes and Rigobon (2001) phrased contagion as spreading of additional shocks evidenced in excess to those determined by fundamentals. Nonetheless, the narrow definition of contagion is utilized in most of research studies, understanding by this term an important growth in cross-market linkages when a shock occurs in one country (or group of countries). We can say that contagion appears when the external shocks occur and lead a set of countries to indulge contemporary speculative attacks and financial crises.

Hitherto, the spreadingly body of research dedicated to contagion has been centered on passages of financial crises. Contagion first appeared in financial language in financially tumultuous decennium of the 1990s when many policy makers and writers in financial journalism accepted that financial contagion exists.

Usually, in the academic research are measured the *comovements* in stock prices, sovereign spreads, exchange rates and capital flows from one country to another, particularly when the market is going down and about crises. Another focus of academic research is to identify the channels of contagion, or the paths by which these turbulences globally disperse.

As Marashdeh and Shrestha (2010) mentioned, market integration represents a case when the movability of stocks portfolios, the transaction costs, the legislative limitations or the custom duties for trade are not inconveniences. Also there is evidence that political coordination and enduring economic linkages between those countries by implication can bind their stock markets. In the same time, the development of stock markets boosts the level of integration among them (Masih and Masih, 2002 and Choudhry et al., 2007).

At the regional level, the *integration of capital markets* may promote the integration process in other economic domains. For instance, the harmonization of stock market settlement and trading mode may improve the regional integration in other policy sectors like accounting standards, corporate governance, fiscal and legislative issues (Okeahalam, 2001).

The objective of this study is to identify the moments when correlations change states according to the Markov switching framework. The identification of changes in correlations determined by large negative returns is the main tool for signalling the contagion phenomenon in the literature. In order to provide a broader perspective on the properties of contagion, especially in terms of impact on portfolio diversification, we use the Marko switching algorithm to identify the way in which the correlations tend to change states in the same time, by analyzing the series of state probabilities. The patterns observed in different samples show one important property of contagion – the tendency for correlations to switch states in clusters around large negative shocks.

These findings can produce information for the necessities identified by policy makers to increase the stability of financial markets by identifying precautionary measures for investors exposed to international portfolios.

The remainder of the paper is organized as follows. The next part reviews the economic literature on capital market correlations. Section III includes a presentation of our methodology and data. The fourth section brings into prominence the empirical results, followed by our conclusions in Section V.

II. Literature Review

In economic literature, there are some studies that try to explain what can drive the correlation of stock markets. For example, based on a Ricardian model, Roll (1992) convincingly showed that the economic integration may conduct to an inferior correlation of asset returns if, for example, it is consociated with higher sectorial specialization. Few years letter, Heston and Rouwenhorst (1994) argued that *country effects* including *monetary, fiscal, legislative, and cultural dissimilarities* defend the comovements between stock markets and not the differences in country specialization. A higher correlation of stock returns can be also driven by *greater flows of capital throughout countries*, together with *international arbitrage*, as mentioned by Dumas et al. (2003), which concluded that *financial integration* is a better explanation. Bracker, Docking and Koch (1999) considered that *bilateral trade* and the *macroeconomic and linguistic determinants* are a cause of international stock market comovement, while countries that are in the same geographical areas incline to have a bigger comovement of stock markets than countries that are faraway. Appreciable comovements are displayed by the couples of national stock market indices with semblable industrial structure.

An increasing number of papers (Karolyi and Stulz, 1996; Bracker, Docking and Koch, 1999; Connolly and Wang, 1998 and 2002) investigated the fundamental determinants behind stock market linkages and have suggested that international comovements are *not* totally conditioned by *public information on macroeconomic fundamentals*. Some of the remaining comovements can be explained by *private, non-observable information*.

There is considerable academic research that neatly indicates that correlations incline to increase when countries become *increasingly integrated* (Longin and Solnik, 1995; Bekaert and Harvey, 2000; Baele, 2005, and Baele and Inghelbrecht, 2010). Tavares (2009) examined how *economic integration* impacts the international comovements of stock returns, in both, emerging and developed markets. The results show that the correlation of asset returns is enhanced by the bilateral trade intensity and decreased by the volatility of exchange rate, the export differences, and the output growth's dissymmetry.

As documented in many research papers, it is presumable that the cross-country correlations of returns may as well *change across regions*. Books and del Negro (2002) suggested that this correlation is higher for Europe while other studies concluded that it is increasing in East Asia (Larrain and Tavares, 2003) and in Latin America (Heaney et al., 2002). Using a country-industry and country-style portfolios like the base portfolios, Bekaert et al (2009) sewed up that there is no confirmation for an ascending trend of returns' correlations, apart from the European stock markets. Another interesting finding is that big value stocks are stronger correlated across countries comparing with small value stocks, and the inequality has boosted over time.

Several studies particularly focused on the correlation and integration between European stock markets. Studying the *degree of convergence* among three important European stock markets (England, France and Germany), using a recursive common stochastic trends analysis, Rangvid (2000) evidenced that the level of convergence among European stock markets has intensified particularly in the last two decennary. In his study, Pascual (2003) investigated *long-run comovements* in the stock markets of France, UK and Germany stock markets applying cointegration techniques and found evidence of raising integration in the case of the French equity market, but not in the case of British and German markets. Using three different methods, Aggarwal, Lucey and Muckley (2004) observed no evidence of *increasing cointegration* amid several European stock markets.

A growing body of research has examined the special case of Central and Eastern European countries and the results suggest that these markets perform unconformably to developed markets. First studies that specified these differences are Divecha, Drach and Stefek (1992), Harvey (1995), Barry, Peavy III and Rodriguez (1998), as well as Bekaert et al. (1998). The literature evidenced some sameness empirically demonstrated: low correlations with developed markets and between emerging markets, high volatility, high long-term returns, and more variability in the predictability power as compared to the returns of the stocks traded in the developed markets. At the same time, it is more plausible that the emerging markets experience shocks generated by exchange rate devaluations, regulatory modifications, and political crises.

Pajuste (2002) observes that Central and Eastern European capital markets are quite *different in respect with their own correlations with European Union capital markets*. While the Czech Republic, Hungary and Poland display stronger correlations amidst them and with the European Union market, Romania and Slovenia show an inexistent or even negative correlation with the European Union capital market. Analyses in this area are performed by Horobet and Lupu (2009) and Lupu and Lupu (2009) providing evidence for the existence of *consistent statistical features of these linear dependences* by means of various techniques – cointegration and Granger causality tests on the one hand and dynamic conditional correlations estimated at the begining of the crisis on the other hand.

Harrison B., R. Lupu and I. Lupu (2010) identified in their paper the *statistical properties* of Central and Eastern European stock market dynamics. The paper investigates the stock market indices of ten emerging countries from Central and Eastern European region over the period between 1994 and 2006, evidencing the stationarity of these indices' returns and determining some common features of these markets taken as a whole.

There are different approaches and methodologies used to measure contagion – cross-markets correlation coefficients (the most straightforward approach to test for contagion), ARCH and GARCH models, conintegration techniques, direct estimations of particular transmission mechanisms, etc.

This paper extends the current literature by using a new methodology that identifies the problems faced by international investors when they aim at diversifying their portfolios. The clustering of same moment shifts in correlations and their scale represents the contribution to the field.

III. Data and Methodology

3.1 Methodology

In order to provide a basic analysis of the dynamics of linear connections for the financial assets in our sample, we use the specification of Christoffersen (2003) used to model the conditional covariances and conditional correlations under the standard DCC-GARCH model. The standard specification for the changing covariance mimicking the dynamics of a standard GARCH model is:

$$\sigma_{ij,t+1} = \omega_{ij} + \alpha R_{i,t} R_{j,t} + \beta \sigma_{ij,t}$$

Where i and j count for the assets, $R_{i,t}$ is the return of asset i at moment t, and ω, α, β are the coefficients that govern the dynamics of these covariances. In order to keep the setting of the GARCH model in which the modelled variance has a long-term average, the DCC-GARCH model allows for the existence of a long-term mean in the dynamics of the covariance by enforcing

$$\sigma_{ij} = \omega_{ij} / (1 - \alpha - \beta)$$

Which allow for a *fixed effects* – like phenomenon by keeping the same α and β. From this specification we can develop the dynamics of the correlations since

$$\sigma_{ij,t+1} = \sigma_{i,t+1} \sigma_{j,t+1} \rho_{ij,t+1}.$$

Therefore $\rho_{ij,t+1}$, the dynamic correlation coefficient between assets i and j is

$$\rho_{ij,t+1} = \sigma_{ij,t+1} / (\sigma_{i,t+1} \sigma_{j,t+1}).$$

$$\rho_{ij,t+1} = \frac{\omega + \alpha R_{i,t} R_{j,t} + \beta \sigma^2_{ij,t}}{\sqrt{(\omega + \alpha R^2_{i,t} + \beta \sigma^2_{i,t})(\omega + \alpha R^2_{j,t} + \beta \sigma^2_{j,t}}}$$

where at the denominator we have the dynamics of the variances modelled according to the standard GARCH specification. If we consider the noise in the dynamics of the GARCH equation as being the value of the returns after we filter them by the GARCH equation, then a model for these standardized returns is

$$q_{ij,t+1} = \bar{\rho}_{ij} + \alpha \left(z_{i,t} z_{j,t} - \bar{\rho}_{ij} \right) + \beta \left(q_{ij,t} - \bar{\rho}_{ij} \right).$$

We used the DCC-GARCH model[2] to compute correlations across all returns for the whole sample period. This consisted in the computation of all the pairs of the 49 countries in our sample (1176 estimations) for the whole set of 4772 common daily log-returns.

These correlations were divided in two samples: one that covers all the period from the beginning of the sample (January 2000) until September 14th 2008 and the other one from September 15th 2008 until the end of the sample (February 2015).

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[2] *The estimation was developed by the use of the MFE Matlab package developed by Professor Kevin Sheppard.*

Each pair of correlations was analyzed for regime shifts in order to acknowledge possible contagion phenomena. Using the Markov-Switching algorithm we computed the regime shifts for all possible pairs and for each of the two periods. Comparisons for the values of these switches are presented in the results section.

Financial crises may determine dramatic breaks in the behavior of many economic time series (Jeanne and Masson, 2000; Hamilton, 2005) or abrupt changes in government policy (Hamilton, 1988; Davig, 2004). Abrupt changes are also an important feature of the series of financial asset returns.

The Markov state switching models allow for the estimation of probabilities for the changes among a certain number of states that are considered as known by the researcher. If we assume a process like

$yt = \mu St + \epsilon t$

where $St = 1..k$ and ϵ_t follows a Normal distribution with zero mean and variance given by σ^2_{St}, then we allow for the possibility of the variable to move from one state to another.

Our analysis consists in the identification of changes in the means of a series of correlations between any possible pair of assets that could be constructed by combining the 49 financial indexes. To this end we consider the existence of two possible states for these dynamics and we estimate[3] the transition probabilities for these two states (i.e. the probability for the series to be in state 1 and, therefore, the probability for the series to be in state 2 at a certain moment in time; their sum is 1 as we assume that the series can only be in one of the two states).

3.2 Data

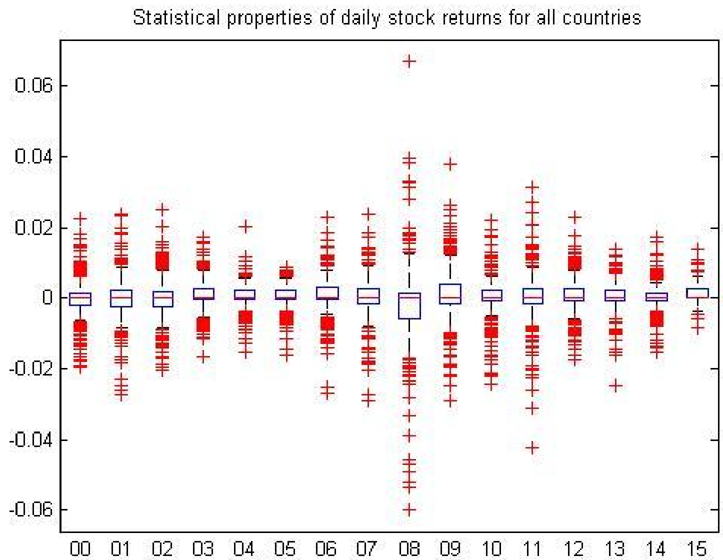
We are using daily data for a series of stock market indexes collected from January 2000 until February 2015. The countries covered in this analysis are Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Czech Rep., Denmark, Finland, France, Germany, Greece, Hungary, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Luxemburg, Malaysia, Mexico, Netherland, New Zealand, Norway, Pakistan, Philippine, Peru, Poland, Portugal, Romania, Russia, Singapore, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States of America, Venezuela. The set of countries is chosen so that we provide a comprehensive analysis at the global level by analyzing the countries with liquid capital countries.

A brief representation of the statistical properties for our data across the years is exhibited in Figure 1 below. We notice that the largest dynamics were recorded during 2008 as a result of the crisis inception, followed by 2011 and 2009. We also mention that for 2015 the chart shows the dynamics for only the two months of this year.

[3] The estimation is realized by the use of the MS_Regress algorithm developed by Marcelo Perlin.

Figure 1

A Boxplot for yearly distribution of daily stock market log-returns for all countries in the sample



IV. Results

The Markov-switching algorithm with two states was applied on the series of correlations for all pairs of national stock market indexes. The procedure generated a set of transition probabilities for each state at each moment in time.

Our objective is to identify and produce a measurement of the moments when these regime switches were simultaneous. This section presents results for different periods and for several groups of countries.

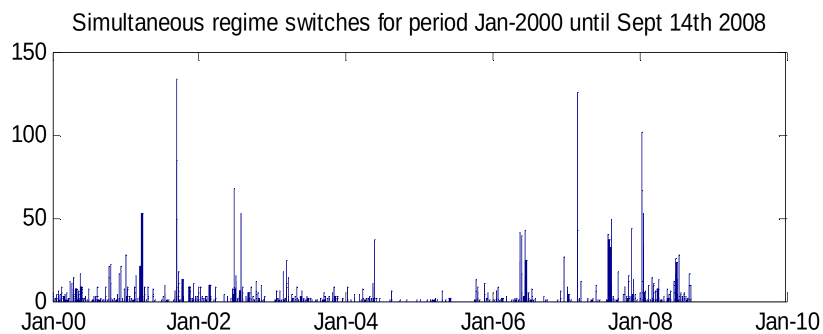
Our choice for the identification of the regime switches moments consisted in the measurement of the changes in the dynamics of the state probabilities from one period (one day) to another. Considering the first series of such probabilities, we assume that a change larger than 60 percentage points from moment *t* to moment *t+1* would be sufficient to acknowledge the shift from one state to another.

Based on these findings and in close keeping with the contagion stylized fact, we then consider the extent to which these estimated changes in the series of correlations tend to appear in the same time. Under the contagion framework, an increase in correlations should be triggered by the manifestation of crises. The tendency for the shifts in correlations to be produced in the same time would be a proof of spillover effects and it generally provides evidence on the strength of shocks that arise in the dynamics of stock market returns.

The simultaneous changes in regimes are accounted for by identifying the moments when more than one series of correlations exhibit large movements in the dynamics of state probabilities from one moment to another. The following charts present these changes both at the global and regional levels in two instances: the sample was divided into “period before the crisis”, which is considered to be the time frame from the beginning of our sample until the 14th of September 2008 and the “period during the crisis” that is covered by the dynamics of stock returns from 15th of September 2008 until the end of the sample, i.e. February 2015. We mention that when the analysis was performed on a sub-sample of countries, only the correlations among the respective countries were considered. For instance, in the case of Western European countries, we show the dynamics of the simultaneous changes identified for all the correlations that are possible by combining pairs of only these countries, we do not show the connections of these countries with the rest of the world. These connections are presented in an aggregated manner in the first charts that contain the analysis of the simultaneous regime switches for all countries.

Figure 2

Dynamics of simultaneous regimes switches – All Countries



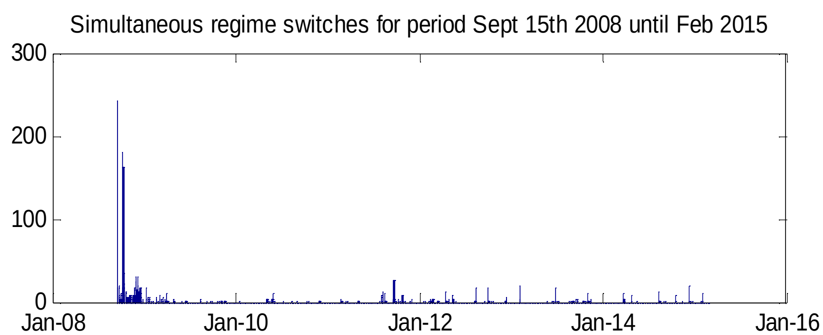
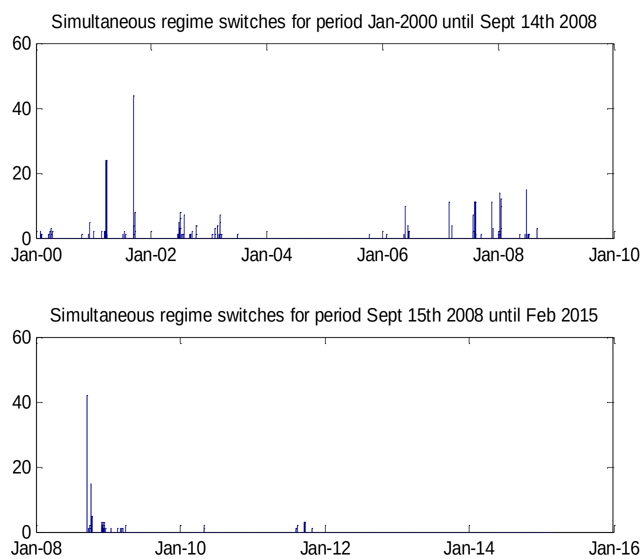


Figure 2 shows the dynamics of the simultaneous regime switches identified for the whole sample of stock market indexes in the two periods – before and during the crisis. We notice first the fact that the number of simultaneous shifts was very large around the 15th of September 2008, the moment that triggered the financial crisis. The scales for the two charts are different, the large columns in the lower chart stand for 200 – 250 correlations shifting in the first part of the sample, which prove the existence of an important change at the beginning of the second sample and showing a lower number of simultaneous shifts in the following moments, similar to the sizes of the columns in the upper chart. Since 49 countries (i.e. 49 different stock indexes) are taken into account, we mention that there are 1176 unique pairs that can exist with these assets. A set of 200 – 250 simultaneous shifts account for about 17 – 21% of the possible correlations. We can consider that the upper chart tends to show the usual or regular shifts, with very few exceptions, while the lower chart shows the dynamics in regime changes in correlations during the crisis phenomenon.

We notice a large number of simultaneous changes around 2002 as well as in 2007. If the first one is likely to be connected to the internet bubble bursting, the second one is largely generated by the sub-prime crisis. There are 18 countries in the sample of Western European countries, which generate 153 possible pairs for the estimation of correlations. The large values of approximately 50 pairs shifting regimes in the same time for the two moments account for approximately 33% of all possibilities.

Figure 3

Dynamics of simultaneous regimes switches – Western European Countries

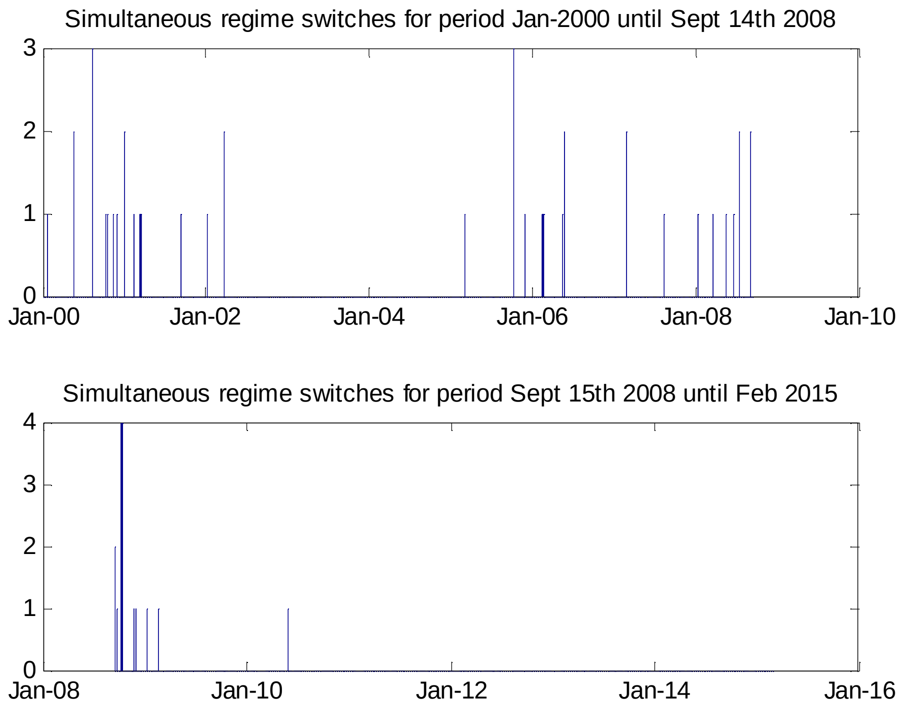


Similar dynamics are acknowledged when observing the simultaneous regime shifts in the correlations for stock indexes in Western European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherland, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, and United Kingdom). In this case, we can also see that the number of simultaneous changes is similar in the internet bubble with the one happening in the 2008, which triggered the financial crisis.

In the case of the Eastern European (Czech Republic, Hungary, Poland, Romania) countries, first we need to specify that we are accounting for only four countries, therefore a number of 6 unique pairs. Given the small number of such pairs, we can conclude that 75% of the possible pairs reacted in the same time as a result of the crisis and about 50% for the other similar situations. The Eastern European countries tend to react in a block to radical changes generated by large returns.

Figure 4

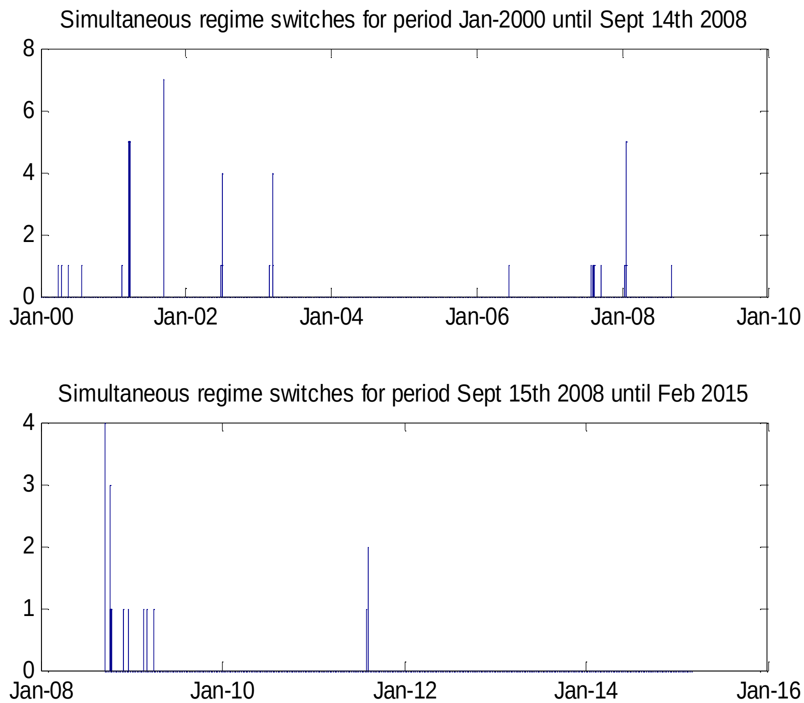
Dynamics of simultaneous regimes switches – Eastern European Countries



Reactions seem to have a lower extent of spillover in the case the G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom, and United States of America). Out of a total of 21 possible correlations, we acknowledge a large level of simultaneity in the regime changes at the internet bubble and to a smaller extent at the 15^{th} of September. However, we need to mention that the time lag between the countries in this sample may generate a bit of diffusion of the reaction to such events. We notice large numbers of simultaneous shifts after the 15^{th} of September, which could be interpreted by the fact that the countries trading with a time lag to US markets marked the shift in the consecutive days, which also proves the existence of important regime switches that could be considered simultaneous.

Figure 5

Dynamics of simultaneous regime switches – G7 Countries



We also took as a separated group the case of the developing countries other than the ones in Eastern Europe (Argentina, Brazil, Chile, China, Colombia, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Pakistan, Philippine, Peru, Russia, Singapore, Sri Lanka, Taiwan, Thailand, Venezuela), so that we could understand their tendency to react to shocks. We included 20 countries in this set, which account for 190 possible correlations. The Figure 6 shows the simultaneity of regime switches in the series of correlations for all these pairs. We observe that in the upper chart that exhibits the statistics for the first time sample we can see approximately 20 simultaneous regime changes during the internet bubble (which account for almost 11% of the possibilities) and about 30 (almost 16%) for the situations around the 15th of September. We also notice the same situation as in the case of the G7 countries, i.e. the fact that these 20 countries trade at different hours and the time lag between their trading sessions might generate reactions in consecutive days. We notice that the changes after the 15th of September (in the lower chart) are quite significant (they tend to cluster around the value of 30 for a few days), which is in close connection with this fact

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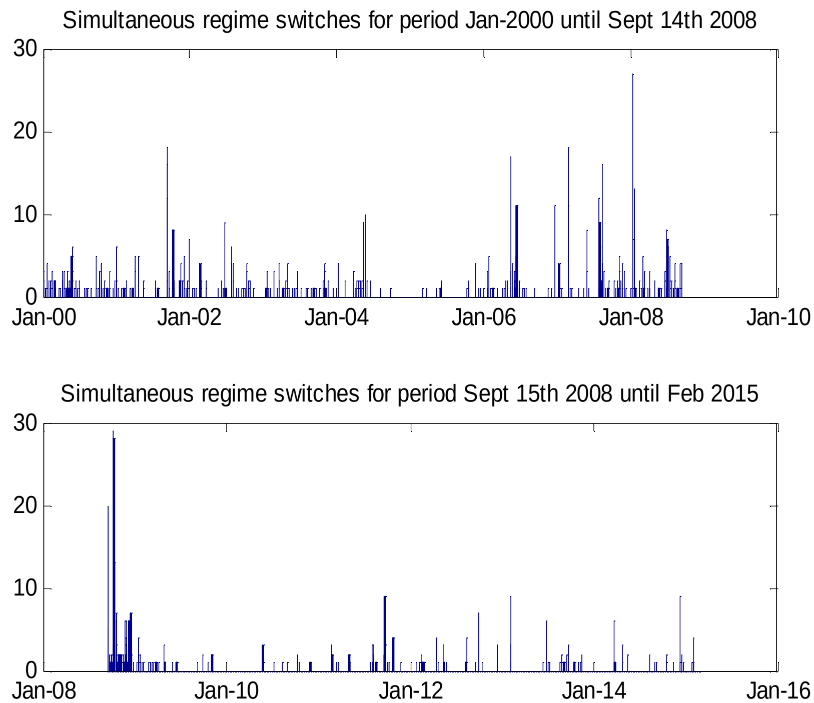
Figure 6

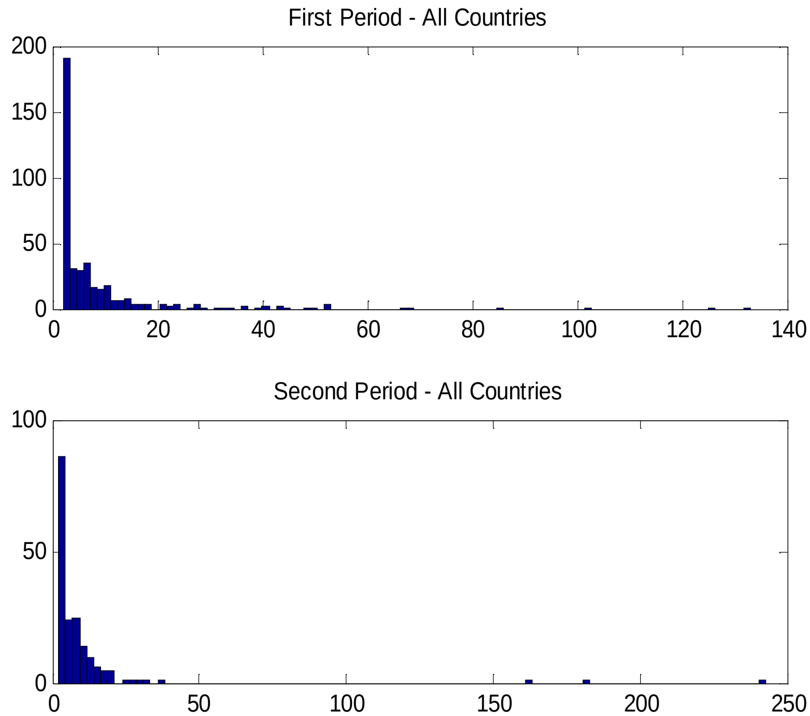
Dynamics of simultaneous regime switches – Developing countries except European



Another possible way to observe the tendency for the markets to exhibit contagion is to build a histogram of the moments in time when we can see the simultaneous regime shifts. The following chart exhibits the number of such moments as time passes, when the sample is divided in the same two sub-samples. If most of the changes are rather individual, since the histograms tend to exhibit large probability mass in the left part, we can see that the simultaneous changes to which a lot of assets participate are quite frequent. Comparing the upper chart with the lower one, we see that a much larger number of simultaneous changes is acknowledged after 15th of September 2008, and we know that these large numbers are identified in the neighborhood of this particular day. The different scale of these two charts is a proof of contagion by itself as it is also a picture of the regular and irregular dynamics of the correlations for stock market indexes at the global level. If the individual changes are quite often, and could manifest rather randomly, the set of changes that happen in the same time is sporadic and may impact the performance of global portfolios, by reducing their diversification effect. The large number of simultaneous changes is not usually clustered in these histograms. This means that once the returns for a set of assets achieved large levels of correlation (i.e. linear dependence) they tend to keep these levels of a while. Their return to the previous levels, in case it is achieved, is either a very long process or it would take a large amount of time to be achieved. Therefore, the regime switches are mostly persistent after a large shift takes place simultaneously for a large number of financial indexes.

Figure 7

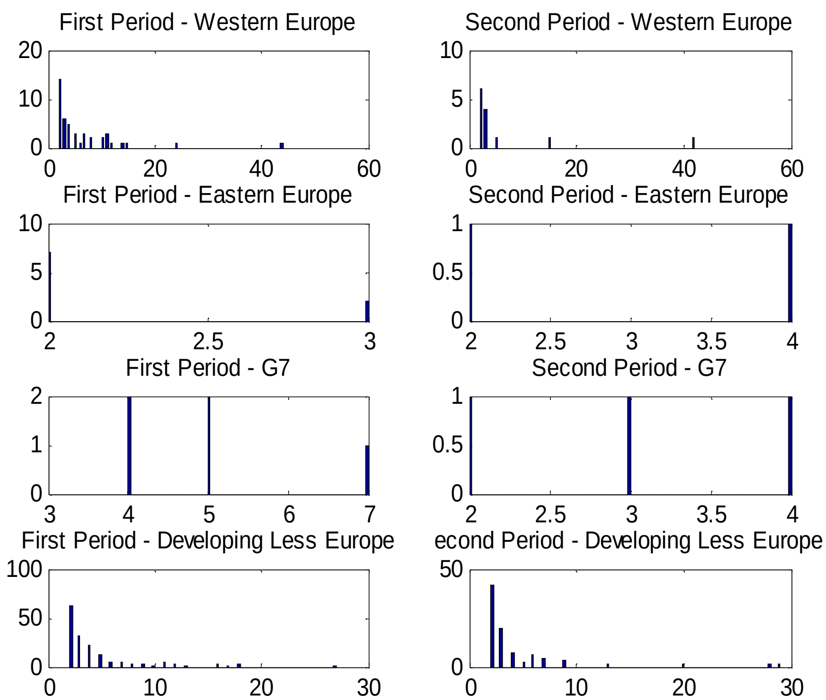
Histograms – all countries



The Figure 8 shows the histograms for each region and for the two different sub-samples. When comparing these charts, we notice that Western European indexes tend to change regimes quite often, and when they do the tendency is to exhibit independent changes in their correlations. The picture for both the Western Europe and the developing countries less Eastern Europe is quite similar to the one for all the countries. One cause could be the fact that in these two cases we are dealing with a rather larger number of countries, hence a large number of possible correlations too. In the case of Eastern Europe, the four countries in our analysis tend to react almost similarly to changes in correlations. We remind here the fact that each sample contains only correlations of the respective countries among themselves and not with the rest of the sample.

Figure 8

Histograms – each region



V. Conclusions

On the account of the rapid transmission of initial country-specific shocks to other economies, the puzzle of the financial contagion drew the attention of many researchers in the last decade.

The events triggering the financial crises after 2000 showed that deepening and understanding the subject of financial contagion is necessary for policy makers to improve the management of the crises and to avoid their future spreads.

Our analysis consists in the computation of the correlations for all the pairs of the countries in our sample (49 countries) for the period starting in January 2000 until February 2015. The correlations were allowed to have a dynamics in keeping with the GARCH properties of the returns in our sample.

Next we analyzed the changes in the values of the correlations by means of a Markov switching model with two states. The results show that there is significant difference in the values of the two states estimated by the model, the state with the higher correlations tends to be kept for longer periods of time in the last part of our sample, which is a prove of contagion realized on the national capital markets.

An investigation of the connection between these simultaneous changes and macroeconomic factors could provide interesting features for the construction of global portfolios by identifying the factors that could impact their performance as a function of possible diversification benefits.

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