FINANCIAL CONTAGION ON THE ROMANIAN STOCK MARKET

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1. Introduction

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'. During the past 30 years the world faced a new era of global economies and capital markets, various factors contributing to this aspect, namely the increase of cross-border capital mobility, technological innovations in communications and transactions and the introduction of innovative financial products. So the increased globalization of the world economy and liberalization has a specific impact of the behaviour of national stock markets and the linkages between them, as demonstrated by simultaneous fall of the markets around the world. The spread of crises, or contagion was heavily researched during several other episodes of financial distress, and, as we all have noticed, in the light of the current financial crisis, the notion of contagion, has once again become a controversial topic.

Our main question is related to the behaviour of the Romanian stock market from the point of view of financial contagion from the global world market. But in order to be able to characterize the specific stock market movements during the crisis, first we need to define contagion and to see which is the best approach capturing it.

Forbes and Rigobon (2002) define market contagion as a 'significant increase in cross-market linkages after a shock to one country or a group of countries'. According to this definition, if two markets share a high degree of correlation during periods of stability, and after the shock the comovement between them shows no significant increases, even if they are highly correlated one to another, this phenomenon can't be regarded as contagion, rather the markets are integrated. Bekaert, Harvey and Ng (2005) consider that contagion can be described as an excess of correlation between markets, more than it can be explained by economic fundamentals.

Corsetti, Pericoli and Sbracia (2001) regard contagion as 'structural breaks in the parameters of the underlying data generating process'. According to this view, if a shock occurs which is 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 and excessive leverage, some comovement across markets are the implications of interdependence. 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 behaviour and panic.

Pericoli and Sbracia (2003) summarize the wide variety of meanings of contagion as follows: (1) 'Contagion is a significant increase in the probability of a crisis in one country, conditional on a crisis occurring in another country', (2) 'Contagion occurs when volatility spills over from the crisis country to the financial markets of other countries', (3) 'Contagion is a significant increase in co-movements of prices and quantities across markets, conditional on a crisis occurring in one market or group of markets', (4) '(Shift-) contagion occurs when the transmission channel is different after a shock in one market', (5) 'Contagion occurs when co-movement cannot be explained by fundamentals'.

As we can observe there isn't a consensus regarding the definition of contagion, but also the evidence of financial contagion is not conclusive in the existing literature. Some researchers find an increase of correlation after a crisis, as Baig and Goldfajn (2000); Chiang, Jeon and Li (2007). Others conclude that in the presence of crises, no contagion effect can be detected, as Forbes and Rigobon (2002), affirm 'no contagion, only interdependence' is observable, while others, like Bekaert, Harvey and Ng (2005); Corsetti, Pericoli and Sbracia (2005), find contagion as interdependence between markets.

Baig and Goldfajn (2000) test for the evidence of contagion between five Asian markets, during the East Asian crises, using correlations and VARs. They find evidence of cross-border contagion both in the currency as in the equity markets.

Chiang, Jeon and Li (2007) use a dynamic conditional-correlation model in nine Asian markets and they consider that a contagion effect can be identified during the Asian crisis. Also they observe that an increase of correlation after the initial shock and a shift in variance during the period of the crisis, facts that reduce the benefits of international portfolio diversification.

Forbes and Rigobon (2002) use unconditional cross-market correlation coefficients for testing contagion during the 1987 U.S stock market crash, 1994 Mexican peso devaluation and 1997 East Asian crisis. Their findings suggest that there is a high level of market co-movemnet during the crises, interdependence, but no contagion.

Bekaert, Harvey and Ng (2005), found no evidence of additional contagion during the Mexican crisis, but their results suggest that during the Asian crisis a meaningful increase in correlation is observable in the stock markets.

As one can notice, there is no settled meaning for contagion in finance, neither a standardized approach, but even so, it is crucial to understand how financial distress spreads between stock markets. In this study we use the third definition given by Pericoli and Sbracia (2003) employing a 3 states MS-VAR.

2. Methodology

Our paper takes as mentioned, as approach, in identifying the contagion effect between the markets the increase in cross-country correlations of returns during financial turbulences.

First we analyze the unconditional correlations in the pre-crisis period and after, in order to get a general sense of the behaviour of the markets, and establish the number of states, after which we apply a Markov-switching VAR.

The logic behind this analysis is the following: the unconditional correlations can show possibly an increase of the interdependence between markets and determine the number of states, while the conditional correlations subtracted from the MSVAR can identify the contagion effect between markets. In this sense we explain the evolution of the Romanian stock market in parallel with the world stock market evolution, where for each state we define a correlation matrix, to see how the Romanian stock market is regime dependent. From the logarithmic rates of return the covariance was estimated:

$$Cov(Z_A, Z_B) = \frac{1}{T} * \sum_{t=1}^{T} \left(R_{A,t} - \overline{R}_A\right)\left(R_{B,t} - \overline{R}_B\right)$$

Where T represents the number of observations, $R_{A,t}$ and $R_{B,t}$ the logarithmic yields of the two indices A and B, and $\overline{R}_A$ and $\overline{R}_B$ being the averages of A and B. Thus two indices which have a positive covariance tend to fluctuate in the same direction. But to have comparability between data the correlation coefficient was calculated, which is given by the following relationship:

$$\rho_{AB} = \frac{Cov(Z_A, Z_B)}{\sigma_A * \sigma_B} \qquad (2)$$

Where σ_A and σ_B represent the standard deviation of the index A, respectively B. The correlation coefficient can be found within the interval [-1; 1], a close value to -1 symbolizes strong negative correlation, while one close to 1 a strong positive correlation. If the correlation coefficient takes a value close to 0, then we deal with a lack of correlation, which means that the two markets tend to evolve independently, with no relationship linking them.

But why use a Markov-switching process in order to investigate the relationships during crises? These models are mostly used is mechanism where an unobservable, or a state variable, governs the behaviour of the phenomenon, and where there are constant shifts in the parameters that describe the dynamics of the process, in our case the Romanian market behaviour.

The Markov switching models were introduced by Hamilton (1989) as a tool for dealing with endogenous structural breaks in the series.

We choose a MS-VAR, where S denotes the number of regimes, so that $S_t = \overline{1,k}$.

$$Y_t = A(S_t) \cdot Y_{t-1} + e_t \qquad (3)$$

$$e_t \sim \mathrm{N}\left(0, \Omega(\mathrm{S_t})\right) \qquad (4)$$

$$\Omega(\mathrm{S_t}) = \begin{pmatrix} \sigma^2_{1,S(t)} & \sigma_{1,2,S(t)} \\ \sigma_{1,2,S(t)} & \sigma^2_{2,S(t)} \end{pmatrix} \qquad (5)$$

In this process $Y_t = [Y_{RO} \quad Y_{World}]^T$ is a 2x1 vector of stock market indices, A a vector of parameters, while T stands for the transpose, S_t represents the switches. e_t follows a Normal distribution with a zero mean and a variance of $\sigma^2_{1,S(t)}$, and the covariance between the two markets is $\sigma^2_{1,2,S(t)}$.

This model describes a switching mechanism, where there are k states, and this means that there will be k values for $A(S_t)$, $\sigma^2_{1,S(t)}$ and $\sigma^2_{1,2,S(t)}$.

For a Markov regime switching model the transition states are stochastic, not deterministic. This is a real and valid assumption about the governing forces of the stock markets. The dynamics between the switching processes is driven by a transition matrix, where the probabilities control the switching from one state to another.

$$P = \begin{bmatrix} p_{11} & \cdots & p_{1k} \\ \vdots & \ddots & \vdots \\ p_{k1} & \cdots & p_{kk} \end{bmatrix} \quad (6)$$

Where p_{ij} from the row i, column j controls the probability of a switch from state j to state i. For example this means the probability to switch from state 2 to state 1 between the time t and t+1 will be given by p_{12}, while the probability of staying in state 2 is illustrated by p_{22}. In other words p_{12} indicates the probability that the model will be in first state at time t+1 if at the moment t it was in the second state. In our model the transition probabilities are assumed to be constant. The MS-VAR is estimated by maximum likelihood using Hamilton's filter and iterative algorithms. In our methodology the calculation of the covariance matrix is performed using the first partial derivatives of log likelihood. This method approximates the Hessian matrix with the gradient vector. See Hamilton (1994) for more details in the calculation of standard errors.

3. Descriptive analysis of the employed variables

The statistical data used in this study consist of the weekly stock index closing prices of the Romanian stock market, captured by the BET denominated in US dollars index and the MSCI World Index. The latest is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed markets also in US dollars. The MSCI World Index as the Bet Index was extracted from DataStream. The sample period is between 19 September, 1997 to 03 March 2012, totalling 758 weekly observations for each series. Although the sample period covers only a period of 15 years, it allows us to capture the recent financial crisis. The returns R_t are calculated by taking the logarithm of the ratio of two consecutive weekly closing prices P_t and $P_{t-1}: R_t = \ln(P_t / P_{t-1})$. From now on these series will be used- RRo and RWorld where these represent the variation of the logarithmic daily financial series in two consecutive days.

Figure no. 1. Indices normalized at 100 with base on 19/09/1997

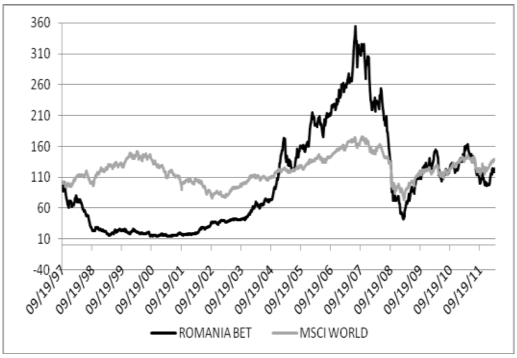


Table no. 1. Distributional statistics of returns

	RO	World
Mean	0.0003	0.0004
Median	0.0016	0.0027
Maximum	0.2172	0.1164
Minimum	-0.3116	-0.2238
Std. Dev.	0.0506	0.0261
Skewness	-0.8457	-1.0863
Kurtosis	7.655	11.604
Jarque-Bera	777.825***	2487.173***

Denotes ***-1% significance level

Table 1 contains statistical information about the data. The distribution is skewed to the left, wich illustrates that in most markets the negative shocks are more frequent than the positive ones and the pdf is leptokurtic. As pointed out by the Ljung-Box test the returns exhibit significant autocorrelation (Table no. 2).

Table no. 2. Autocorrelations of returns

	RRo	**RWorld**
AC_5	0.068	0.030
AC_{10}	-0.019	-0.012
AC_{20}	0.004	0.016
AC_{36}	0.027	-0.010
PAC_5	0.041	0.033
PAC_{10}	-0.033	-0.007
PAC_{20}	-0.012	0.023
PAC_{36}	0.013	-0.024
$L\text{-}B_5$	32.560 (0.000)***	5.283 (0.382)
$L\text{-}B_{10}$	38.988 (0.000)***	19.322 (0.036)**
$L\text{-}B_{20}$	47.384 (0.001)***	33.040 (0.033)**
$L\text{-}B_{36}$	70.376 (0.000)***	46.334 (0.116)

Denotes ***-1%, ** -5% significance level

Where, AC_k is the autocorrelation function at lag **k;**

PAC_k is the partial autocorrelation function at lag **k**;

$L\text{-}B_m$ is the Ljung-Box_m statistics test that assesses the null hypothesis that a series exhibits no autocorrelation for m lags, against the alternative that some autocorrelation coefficient ρ_k, k=1,..., m is nonzero. The test statistic is: $Q = T \cdot (T+2) \cdot \sum_{k=1}^{m} \left(\rho_k^2 / (T-k)\right)$, where T is the sample size, m is the number of the autocorrelation lags and ρ_k, is the sample autocorrelation lag at lag k. Under the null hypothesis the asymptotic distribution of Q is chi-square with k degrees of freedom.

In Figure 1. The evolution of the Romanian stock index and the MSCI World index can be observed. It is very clear only from the evolution that the two variables are characterized by a three states regime. In the first period the World market outperforms constantly the Romanian market, until the beginning of year 2005, when the World market index falls below the performance of BET. The third period begins with 2008, where the two series converge and are characterized be a high degree of correlation. As we can notice in Table 3, during the whole period the correlations are at a level of 0.376, so we could conclude that the Romanian market, being an emergent market is correlated only at a mild level with the world markets, and so investors can benefit from diversification. But if we take one step further with our inquiry, than we realize that the three periods that we observe are characterized by three different degrees of correlations. In the first period, between 1997 and 2004 the correlation is very low, almost as the two markets are evolving independently. In the second period, between 2005 and 2007, which captures the evolution of the two indices until the beginning of the financial crisis we can identify an increase in the correlation, up until 0.472. The third period exhibits the most aggressive relationship between the two, with a correlation coefficient equal to 0.702.

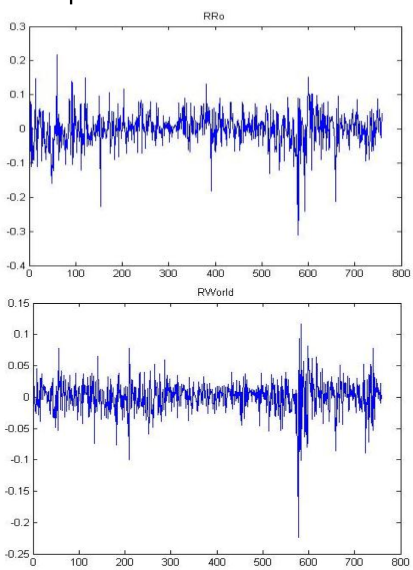
Consequently we define three states, (1) a high correlation state, (2) a low correlation state, and a (3) no- or possibly a negative correlation state. In such a case contagion between the markets is a reality if and only if during the financial turmoil the smoothed probabilities show an unusual increase towards high correlation state from the other two. On the other hand, if the switching behaves usual, not favouring one state over the other that we can speak only about an increase in the linkages between markets, integrated markets as Forbes and Rigobon defined (2002) it, but no contagion can be distinguished in the real sense.

Table no. 3. Unconditional correlations of returns

	RRo - RWorld
Total period	0.376 / (11.159) / [0.000]***
I.	0.009 / (0.174) / [0.862]
II.	0.472 / (7.340) / [0.000]***
III.	0.702 / (14.607) / [0.000]***

Where () represent the t-statistic, while [ ] the Probability |t|=0.
Denotes ***-1% significance level
I. represents the sample between 19/09/1997 and12/31/2004
II. represents the sample between 07/01/2005 and 28/12/2007
III. represents the sample between 01/04/2008 and 30/03/2012

Figure no. 2. Returns of the indices (19 September 1997 - 03 March 2012).



In Figure no. 2 we can observe the evolution of the returns of the two indices, which indicate clearly the effects of the financial crisis on the stock market. Both of the markets show the most extreme movements at the fourth quarter of the year 2008, and as we can see, it seems that the two are highly correlated.

4. Empirical findings

As stated before we employ a 3 state Markov-switching VAR with 2 lags:

$$\begin{bmatrix} Y_{Ro,t} \\ Y_{World,t} \end{bmatrix} = \begin{bmatrix} \mu_{Ro,s} \\ \mu_{World,s} \end{bmatrix} + \begin{bmatrix} \beta_{1,Ro,s} \\ \beta_{1,World,s} \end{bmatrix} \cdot \begin{bmatrix} Y_{Ro,t-1} \\ Y_{World,t-1} \end{bmatrix} + \begin{bmatrix} \beta_{2,Ro,s} \\ \beta_{2,World,s} \end{bmatrix} \cdot \begin{bmatrix} Y_{Ro,t-2} \\ Y_{World,t-2} \end{bmatrix} + \begin{bmatrix} \beta_{3,World,s} \\ \beta_{3,Ro,s} \end{bmatrix} \cdot \begin{bmatrix} Y_{World,t-1} \\ Y_{Ro,t-1} \end{bmatrix} + \begin{bmatrix} \beta_{4,World,s} \\ \beta_{4,Ro,s} \end{bmatrix} \cdot \begin{bmatrix} Y_{World,t-2} \\ Y_{Ro,t-2} \end{bmatrix} + e_t$$

In Table 4. the coefficients of the model can be found, while Table 5. contains the characteristics of each regime regarding the joint behaviour of indices. In our system three regimes characterize the model, with the following states:
State 1 - Medium volatility Romania, Low volatility the World market and a positive medium significant correlation.
State 2 - Low volatility Romania, Low volatility the World market and a negative medium significant correlation.
State 3 - High volatility Romania, Medium volatility the World market and a positive medium significant correlation.

In opposition to the theoretical model, the MSVAR didn't identify a high correlation regime, only a negative and two medium positive states, with different degrees of volatility between them. This is a surprising fact, but it seems to confirm that the Romanian stock market isn't fully integrated with the world market. This supports international portfolio diversification, but only if contagion isn't transmitted thought the markets. In this sense Masson (1998) defines contagion as 'monsoonal effects', where he considers that major economic shifts in industrial countries can initiate crises in emerging countries, so a common shock, while 'spillovers' are considered to be a consequence of the interdependence among countries. In this view, pure contagion is associated with changes in investor's expectations that are not related to a country's macroeconomic fundamentals, as As Engle (2009) indicates, the channels of contagion, next to the fundamentals, are found within the behavior of investors, and can be traced to the portfolios that they trade within multiple markets. He affirms 'When one emerging market has a financial crisis, often this affects many emerging markets even though they are not economically connected. The link is hypothesized to run through portfolios'. The model didn't outlined a state where a real contagion could take place, a monsoonal effect from the world market, but the third state would seem the most suitable to characterize a contagion in the broad sense, so a spillover effect.

Table no. 4. Markov-switching VAR coefficients

Variable	State 1	State 2	State 3
$\mu_{Ro,s}$	0.006 (0.002) [0.001]***	-0.005 (0.003) [0.109]	-0.010 (0.009) [0.283]
$\mu_{World,s}$	0.005 (0.000) [0.000]***	-0.002 (0.002) [0.223]	-0.006 (0.006) [0.338]
$\beta_{1,Ro,s}$	0.069 (0.049) [0.157]	0.301 (0.062) [0.000]***	-0.183 (0.147) [0.214]
$\beta_{1,World,s}$	0.002 (0.027) [0.926]	-0.025 (0.037) [0.493]	-0.034 (0.072) [0.648]
$\beta_{2,Ro,s}$	0.003 (0.051) [0.957]	0.301 (0.054) [0.000]***	-0.016 (0.136) [0.907]
$\beta_{2,World,s}$	-0.068 (0.026) [0.008]***	0.082 (0.036) [0.024]**	0.129 (0.097) [0.182]
$\beta_{3,World,s}$	-0.200 (0.097) [0.040]**	-0.028 (0.129) [0.827]	0.379 (0.234) [0.106]
$\beta_{3,Ro,s}$	-0.119 (0.054) [0.027]**	0.041 (0.073) [0.571]	-0.008 (0.123) [0.948]
$\beta_{4,World,s}$	0.071 (0.101) [0.478]	0.209 (0.113) [0.064]*	0.278 (0.285) [0.329]
$\beta_{4,Ro,s}$	-0.036 (0.052) [0.487]	0.274 (0.069) [0.000]***	-0.160 (0.143) [0.266]

Denotes ***-1%, ** -5%, * 10% significance level
Where () represent the (Standard Error), while [ ] the [P value].

Figure no. 2. Evolution of the variables according to the Markov-switching VAR

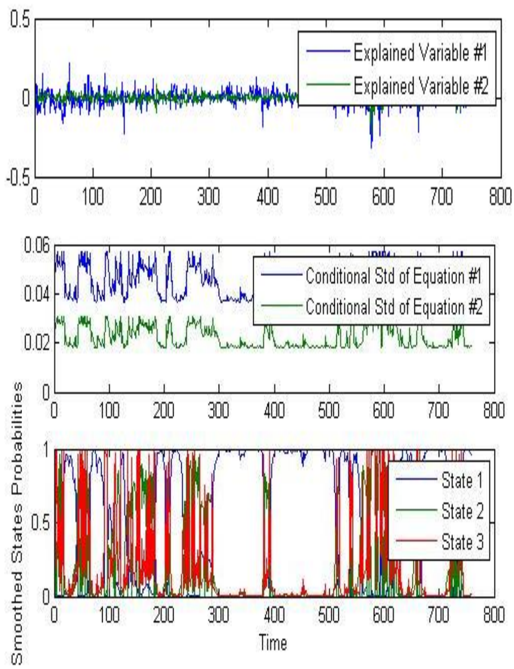


Table no. 5. Variance and Covariance matrix

	V_{RRo} / Sd_{RRo}	V_{RWorld} / Sd_{RWorld}	Covariance /Correlations
State 1	0.00124/	0.00029/	0.00019/

	0.03521 (0.00009) [0.000]***	0.01703 (0.00002) [0.000]***	0.31684 (0.00003) [0.000]***
State 2	0.00071/ 0.02665 (0.00014) [0.000]***	0.00029/ 0.01703 (0.00006) [0.000]***	-0.00015/ -0.33507 (0.00007) [0.040]**
State 3	0.00712/ 0.08438 (0.00106) [0.000]***	0.00191/ 0.04370 (0.00018) [0.000]***	0.00177/ 0.47997 (0.00043) [0.000]***

Denotes ***-1%, ** -5%, * 10% significance level
Where () represent the (Standard Error), while [ ] the [P value].

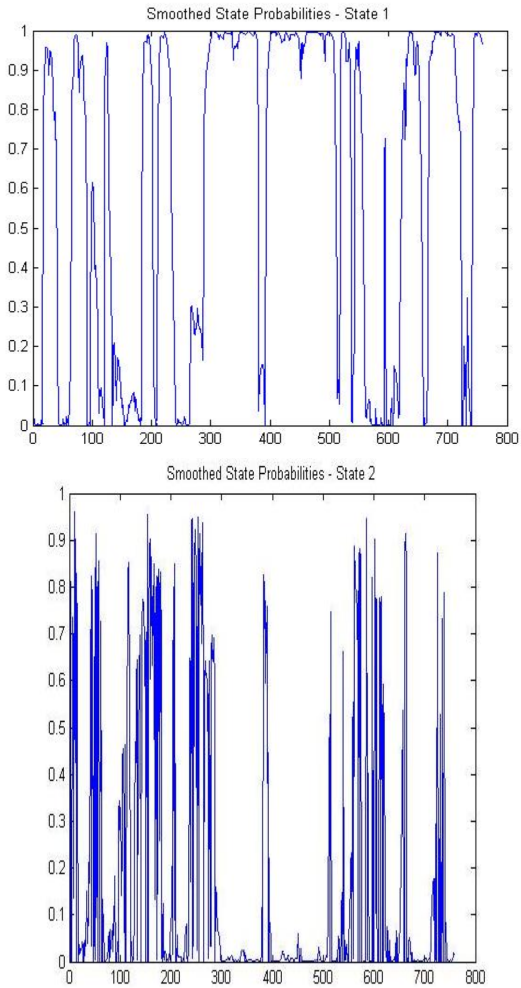
The next step is to verify the transition probability matrix and the behaviour of the smoothed probabilities during the financial turmoil. In Table 6., which contains the Transition probability matrix, we can observe that p_{11}, p_{22}, p_{33} prevail and are highly significant. The most probable for the model is to stay in State 1, if in the previous time moment was also in State 1, and this state will persist on average for $1/(1-p_{11})$ = 26.09 weeks. The probabilities p_{22} and p_{33} are analogous, the second stage will persist on average for 2.36 weeks, while the third for 2.03 weeks. Also the switching from the second and the third states are closely related, with a similar p_{32} and p_{32}, namely the probability of switching from a low volatility state with negative correlation to a high volatility state and positive correlation is the same. This fact could indicate a contagion between the markets. But in order that the switching from a low correlation state to a high one to be recognizable as contagion, this phenomenon should dominate the time period of the financial crisis.

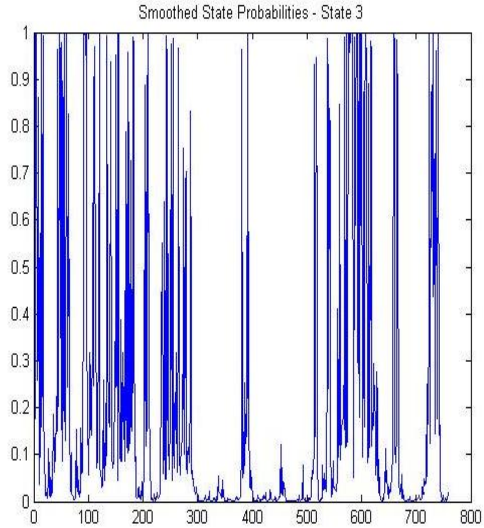
Table no. 6. Transition probability matrix

	State 1	State 2	State 3
Expected Duration of Regimes	26.09 weeks	2.36 weeks	2.03 weeks
State 1	p_{11}=0.962 (0.045) [0.000]***	p_{12}=0.000 (0.033) [1.000]	p_{13}=0.117 (0.055) [0.033]**
State 2	p_{21}=0.012 (0.018) [0.511]	p_{22}=0.576 (0.090) [0.000]***	p_{32}=0.376 (0.084) [0.000]***
State 3	p_{31}=0.026 (0.019) [0.174]	p_{32}=0.424 (0.097) [0.000]***	p_{33}=0.508 (0.084) [0.000]***

Denotes ***-1%, ** -5%, * 10% significance level
Where () represent the (Standard Error), while [ ] the [P value].

Figure no. 3. Evolution of the Smoothed State Probabilities





In Figure 3. we can observe the evolution of the smoothed state probabilities, and as we can notice, during the financial crisis no unusual movements can be detected. The smoothed probabilities of all the three regimes are at approximately the same level, with no state dominating the system. According to this no financial contagion can be detected from the world market to the Romanian stock market.

5. Conclusions

In the light of globalization and liberalization of the world markets, the behaviour of national stock markets and the linkages between them have been undergoing thought fundamental changes, as demonstrated by the simultaneous fall of the markets around the world during the recent crisis. The spread of crises, or contagion was heavily researched during several other episodes of financial distress, and, as we all have noticed, the notion of contagion, has once again become a controversial topic.

We examine the behaviour of the Romanian stock market from the point of view of financial contagion from the global world market. Our paper takes as mentioned, as approach, in identifying the contagion effect between the markets the increase in cross-country correlations of returns during financial turbulences, so we employ the third definition given by Pericoli and Sbracia (2003).

Our analysis is based on 3 states MS-VAR model from 1997 to 2012. The results suggest a system with the firts state characterized by medium volatility of the Romanian stock market, low volatility of the World market and a positive medium significant correlation between the two. The second state is defined by a negative medium significant correlation with low volatility of the Romanian and World market. The last state distinguish itself by high volatility of the Romanian stock market, medium volatility the World market and a positive medium significant correlation between them. The evolution of the smoothed state probabilities during the financial crisis show no unusual movements that could indicate contagion, only comovement due to integrated markets. The linkage between the Romanian and the world market is time-varying, from no dependence in can evolve towards a durable relationship in times of medium and high volatility.

As a result no real contagion can be identified during the financial crisis to the Romanian stock market, no 'monsoonal effects' only 'spillovers' due to the integrated markets, our findings are similar to the conclusions of Forbes and Rigobon (2002).

The presence of interdependence between the Romanian and world stock market has important consequences for international portfolio diversification, this linkages could imply that the potential gain for attaining superior portfolios by diversification is limited, possibly eliminated.

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