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How Important is the Contagion Effect for the Romanian Capital Market?

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Summary:

Significant turbulences occurring in the world capital markets, starting with 2007, emphasized the presence of contagion between the markets, with consequent spillover of the volatility from one market to the other. The contagion effect between different markets is of great interest for a broad range of economists, as the concept became more popular after the most recent financial crisis.

In this article, we aim to assess the proportion of the volatility of the Romanian capital market's returns that is due to the interaction with 10 other capital markets around the world, by using a methodology proposed by Diebold and Yilmaz (2008). We calculate volatility indexes for daily, weekly and monthly data, in order to capture the impact the developed capital markets have on less developed capital markets.

The obtained results confirm the role the financial contagion plays in the spreading of volatility among different countries, especially from the more developed to the less developed markets. In the case of the Romanian capital markets, the more developed capital markets have a major impact on the volatility of returns, as shown by corresponding part of the spillover index, with the contagion effect being most revealed by using monthly data (with a value of 68.88%), then weekly data (49.24%) and, in the daily data case, the index has the lowest value (34.32%).

This result confirms the need for an international stance on the supervising the financial markets in the European Union, in order to monitor and take preemptive actions that consolidates the markets' resilience to shocks. In the Romanian capital market case, it is shown the need to start a reform that lead to strengthen its place as a financing venue for the Romanian companies, especially considering the perspective of the Capital Markets Union process intended to be initiated starting early 2019.

Key words: capital market, contagion risk, volatility

JEL Classification: C13, C22, C58, D53, G01, G15

1. Introduction

After the current account liberalization and the integration in the global financial system, the turbulences occurred in developed capital markets tend to have a direct and indirect effect on less developed stock markets. This was seen especially in the aftermath of the global financial crisis that started in US in 2007, apparently as a local crisis *(generated by the problems in a*

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part of the credit sector), but whose effects impacted almost every stock market in the world. The tensions in the capital markets evolved to liquidity black-holes and large outflows from the less developed markets (that offered more attractive returns), such as the emerging and frontier markets, toward the developed ones. The medium term effects generated by the financial crisis occurred in 2007 that lead to reshaping the local financial systems, the regulatory framework and the economic theories in the financial field emphasize the need to study the shocks' transmission mechanisms.

Due to globalization, the presence of shocks in the developed stock markets has effects on less developed markets, such as the generalized increased volatility of listed companies' shares. Considering the increased volatility of the listed companies' shares, mainly due to massive inflows *(that lead to soaring prices)* and outflows *(that lead to plunging prices)*, the markets' integration facilitates the turbulences' migration toward less prepared markets, where – generally – the effects are much stronger than in the developed markets.

The recent financial crisis, especially the one that started in 2007, showed the direct connection between the integration degree of local financial markets in the global financial sector and the impact generated by a global crisis' occurrence. So, as the markets become more integrated in the global financial system, the effects induced by a shock are almost identical mainly in the markets of the same type *(developed, emerging or frontier markets)*. A reason for this behavior is the homogenous structure of active institutional investors on the respective markets *(as for example, the pension funds, closed-end funds, open-end funds etc.)*, that follow rules and apply similar mechanisms for diversification and risk reduction.

We shall consider the differences between the interdependence between the markets and the contagion phenomenon. Forbes and Rigobon (2002) state that interdependence occurs when the markets' comovement does not increase significantly after a shock, despite the high level of correlation between the markets. As for contagion, the markets' comovement is increasing when a shock is present on the financial markets.

An alternative definition of contagion is given by Reinhart and Rogoff (2009), as contagion being the phenomenon of occurrence of immediate effects in a number of countries following an event. Furthermore, Reinhart and Rogoff (2009) consider two types of contagion, the „slow-burn" spillover and the „fast and furious" phenomenon, depending on the speed and intensity of this process.

In order to measure contagion, Rigobon (2001) analyzed the techniques developed so far and proposed two different methods, intended to solve the problems identified in using thse methods *(for example, the conclusions from the analyzed techniques might be biased when the data suffers from heteroskedasticity or there are some omitted variables).*

Kaminsky and Reinhart (1998) analyzed different theories and contagion, following the approach and definition provided by Eichengreen, et. al. (1996). Specifically, contagion is a case when the news about a crisis burst in one country lead to an increase in the probability of a crisis' occurrence at home.

Helleiner (2011) emphasized the connection between the degree of financial contagion and the overall stance of an economy: its presence is felt especially in countries whose financial systems where vulnerable to shocks (like real estate bubbles, financial excess and so on).

Moreover, the impact generated by the turbulences from the developed markets depends also on the characteristics of the local economy. This is the result of local capital market's openness degree toward the global financial system, the active institutional investors' structure and the independence of the monetary and financial authorities.

Considering these aspects, it is necessary for the financial and monetary authorities from each country *(as it is the case of member states of the European Union)* to develop and implement adequate and targeted measures, with the aim of controlling the causes and effects of the turbulences that are present on financial markets and, ultimately, to improve the citizens' trust in the stability and resilience of the global financial system. This goal is pursued by the European Commission and financial authorities from the European Union *(such as the European Central Bank, European Securities and Markets Authority, European Insurance and Occupational Pensions Authority)*, in order to reshape the legal framework with the markets' stability aim and to facilitate the economic growth. Moreover, the Capital Markets Union project, intended to be done starting 2019, aims to consolidate the financing channels for European companies and, therefore, create new jobs and foster the economic growth. Considering this, it is necessary that the national authorities operating in less developed stock markets *(such as Romania or Bulgaria)* analyze the perspective of the Capital Markets Union and design the measures needed to consolidate the local markets and improve their competitive advantages.

In this article, using the methodology proposed by Diebold and Yilmaz (2008) to outline the contagion effect, we define a static spillover index, whose evolution shows the impact the turbulences from the developed and emerging markets have on selected and analyzed capital markets, including the Bucharest Stock Exchange. We use the daily, weekly and monthly returns of the main indices from the 11 selected markets, in order to emphasize the impact the developed markets' volatility of returns has on the less developed markets.

2. The Theoretical Basis of Contagion on the Financial Markets

The study of the contagion involves the use of statistical and econometric tools and techniques, in order to develop models aimed to outline the connections between the financial markets within the global financial system.

Together with the globalization, the negative effects of the turbulences occurred in developed countries became present in the emerging and developing countries, by different transmission mechanisms (foreign exchange markets, trading, banking etc.). One major model on speculative attacks in foreign exchange markets is the one developed by Krugman (1979), that show how inconsistencies between domestic conditions and an exchange rate commitment leads to the collapse of the currency peg. In the case of an expansionary monetary policy, the rising balance-of-payments deficit is financed by expending central bank's reserves, until a level that attracts a speculative attack (eliminating the authorities' remaining foreign assets). Once the central bank's reserves are depleted, the exchange rate peg is abandoned, and the currency depreciates. The Krugman model proves that a condition for the central bank to maintain a currency peg is the existence of an adequate level of foreign reserves.

This approach was later expanded by the literature on speculative bubbles and sun-spot equilibriums that provide new perspectives on the causes of currency crisis. In Obstfeld (1986), the main hypothesis is that the pre- and post-crisis governmental policies are set arbitrarily and, when an attack occurs, the government will assume an expansionary policy *(this being the major limitation of this model)*. This limitation was overcome by models proposed by other authors, such as Bensaid and Jeanne (1993), or Obstfeld (1995), De Kock and Grilii (1994), obtaining that it is optimal to maintain the currency peg under some circumstances and to abandon it under some other conditions.

The case of contagion was analyzed in Willman (1988) and Goldberg (1993), who consider the impact the foreign events have on the real exchange rate and domestic competitiveness. Gerlach and Smets (1995) analyzed the attack on the Swedish Krona, after the fall of the Finnish Markka in 1992, finding that a successful attack on one exchange rate leads to its depreciation and a trade deficit for the second country (that become a target for the next speculative attack).

Contagion in currency crisis was analyzed also in Buiter et al. (1996), considering the spreading of a crisis in N+1 countries, where N countries are peripheral to the remaining country *(currency in each of the N countries being pegged to the currency of the last country)*.

Also, starting from the two broad types of contagion that are identified in the literature (fundamental-based contagion and "pure" contagion), there were developed a broad range of models trying to capture the contagion effect and the spreading mechanisms. For example, fundamental-based contagion (that refers to the transmission of shocks across national borders as a consequence of the financial or real linkages) is analyzed in Van Rijckegem and Weder (1999, 2000). In both papers, authors consider the mechanisms of the currency crisis in the case of the Mexican, the Asian and the Russian crisis *(the "ground zero" countries, namely each being the first country that experiences a balance of payment crisis)*. Van Rijckegem and Weder (1999, 2000) examine the lending bank as a transmission channel for the financial crisis, ignoring the actions of other financial actors, like hedge funds, institutional investors or mutual funds. The authors found that the spillovers through common bank lenders are important in the spreading of the Mexican and Thai financial crisis, considering 11 creditor countries and 30 emerging countries during the 1994-1998 time frame. In the 1999 article, Van Rijckegem and Weder considered the aggregated data for the studied countries, while in the 2000 article, the authors considered the disaggregated flows, by creditor and emerging market country.

Considering five waves of speculative attacks *(in 1971, 1973, 1992, 1994-1995 and 1997)*, Glick and Rose (1999) emphasized that the currency crises tend to spread along regional lines, while the macroeconomic factors do not consistently help in explaining the cross-country incidence of speculative attacks. One reason for these findings is the geographic proximity that facilitates international trades between the neighboring countries.

A different method was the one proposed by Diebold and Yilmaz (2008), that applied the autoregressive vector concept (VAR), defined by Sims (1980). With the model he proposed, Sims actually eliminated one of the main problems arising from the data series analysis, namely the selection of endogenous and exogenous variables. In a VAR model, all variables are considered as endogenous variables *(such that the preliminary step in the classical models, the selection of endogenous and exogenous variables, was eliminated)*.

Taking this into consideration, the main advantage of VAR models is the fact that it solved the difficult problem arising from a large data set, such as the selection of the dependent and independent variables. As such, when applying the VAR model, it is not necessary to identify from the beginning the dependent variable and the independent variables, therefore solving this uncertainty problem *(also known in the economic literature as the identification problem)*.

In order to study the economic phenomena, the VAR model is widely used to find the relations between various variables that can explain the respective phenomena. Armeanu, Pascal and Cioacă (2014) used these concepts for analyzing the contagion effects considering a number of six European countries. Moreover, the relationships between the returns of the developed capital markets and the Romanian capital market were also studied in Armeanu et al. (2012; 2013), finding the major impact that volatility from the former have on the later market. For example, using the daily returns of the main indices of the Istanbul Stock Exchange and Bucharest Stock Exchange, for the October 1st, 2011-October 1st, 2012, Armeanu et al. (2012) found a relation of cointegration, as well as a positive relationship between the returns (1% growth on Istanbul Stock Exchange determines 0.25% growth on the Bucharest Stock Exchange). But the influence intensity between the markets was found to be rather low, creating an advantage for selecting an international portfolio of financial securities from these emerging markets and an advantage for reducing systematic risk through diversification.

In Armeanu et al.(2013), the contagion phenomenon was analyzed for the Romanian and PIIGS (Portugal, Ireland, Italy, Greece and Spain) capital markets, considering the main economic and social events occurred during 2008-2014. In this respect, the contagion spreading effects were analyzed, as well as the markets' reaction to shocks and their persistence and intensity. It was proved that Italy and Spain are the most sensitive to the financial shocks, the former causing the largest spillover and the latter being the most affected by the spillover generated by the shocks in the other markets. Also, a dynamic spillover index as defined and used to assess the behaviour of the markets to various shocks. It was proved that the Lehman Brothers collapse and the sovereign debt crisis generated contagion in all the analyzed markets, inducing the most severe shocks (their spreading was generalized, affecting mainly the countries with weaker economies and with inefficient policies).

3. Methodology and Data

In order to assess the contagion effect, the relevant literature in the financial markets contains a broad range of models used in this respect. Glick and Rose (1999) start with a linear regression that estimates the indicator variable used to assess whether a country was attacked in a given episode *(a binary variable)* considering the importance of the trades with the "ground zero" country and a set of macroeconomic control regressors. The analysts used the maximum likelihood estimation of the binary probit model, with the null hypothesis being the coefficient of the trade variable being equal to zero *(a null hypothesis meaning that a trade contagion effect is present)*.

For each of the Mexican, Thai and Russian crisis episodes, Van Rijckegem and Weder (1999) expand the model proposed by Glick and Rose (1999), using a regression that also includes the competition for funds variable. The main problem of the models developed by Van Rijckegem and Weder (1999) was the fact that the results were dependent on the choice of crisis indicator, being more consistently significant for a binary crisis indicator than for a market pressure index.

In Van Rijckegem and Weder (2000), the equation analyzed by the authors, using the panel data regression, tries to assess the loss that the banking system from a creditor country faces in the event of a crisis in a borrower country. As such, a proxy is used, defined by the share of a creditor country's banking system exposure to a borrower country, as a share in the total lending of the respective creditor to developing countries. One weakness of the estimated model is the data used (based on BIS data), that captures only the o-balance sheet positions, although the banks use hedging instruments that are parts of off-balance sheet positions.

An alternative approach was proposed by Engle, Ito and Lin (1990), that uses GARCH model in order to capture the heteroskedasticity across intra-daily market segments *(namely, the impact of news in one market on the time path of per-hour volatility in other markets)*.

Diebold and Yilmaz (2008) provide an alternative way for measuring the contagion effect, by defining a spillover index, based on the variance decomposition of the forecasted errors from VAR models, using a Cholesky factorization. The main advantage of this model is its simplicity and straightforwardness, as well as the capacity to capture a broad range of information into a single measure of spillover occurring between different markets during a crisis.

The autoregressive vectors developed by Sims (1980) follow an asymptotic distribution, and for the largest part of the tested hypothesis, the number of degrees of freedom associated with this Chi-square distribution is not largely different from the number of degrees of freedom of the calibrated distribution *(as a consequence, the interpretation of the results of F-statistic tests' is difficult to make)*.

Once developed more VAR models, we apply statistical tests in order to assess its validity, using some economic hypothesis (that lead to a reduction in the number of models that were developed, with better results for the users).

In a VAR model, the variables' past values are considered, in order to find the possible relations between the current and past values *(evaluating the impact the past values have on the current value of the studied variables)*.

So, Sims and Watson (2001) show that, for a univariate autoregressive vector, the model consists in a single linear equation, where the current values of a variable are explained by its past values. Generalizing this approach and considering that the model is linear, for an autoregressive vector with n components, the model is a linear relation of the past values of the variable and the past and current values of the other (n-1) variables. The authors present 3 forms of the VAR model, namely the reduced form VAR, the recursive VAR and the structural VAR, each having differences and particularities. In the reduced VAR model, each variable is given by a linear relation of the variable' s past values and the past values of the other variables and an error term that is uncorrelated with them. In the recursive VAR model, each equation's error terms are uncorrelated with other equation's error terms. This can be done by including in the model of some current variables as endogenous variables (regressors). Estimation of each regression's components is done using the least square method, and the obtained results have error terms that are not correlated within equations. It is important to stress that the results are dependent on the order we choose to insert the variables in the VAR model. This reveals the importance of the selection step of the variables considered in the model. In the structural VAR model, the economic theory is used in order to find the order to select the variables, considering the causality relations between the variables *(such that the number* *of structural VAR models depends on the goals followed by the researcher)*.

These theoretical concepts are used mainly to test the Granger causality relations between the studied variables, to construct Impulse-Response Analysis and to make the variance decomposition of the forecasted errors. The Granger causality tests show the impact the past values of a variable are useful to predict the values of a different variable. So, if the p-value associated to the F-statistic is less than the chosen significance level, then the independent variable's past values explain the future values of the dependent variable.

The variance decomposition of the forecasted errors is an indicator that shows the percentage from the forecasted error's variance that is given by the occurrence of a shock within a time interval *(such that this indicator has an interpretation that is almost similar to the one associated to R^2 for the estimated error, in a given time interval)*. As a consequence, the variance decomposition provides clues on the relative importance of each event that influence the variables studied in the VAR model.

The obtained results from the VAR models must be cautiously analyzed and used with complementary methods, in order to derive adequate conclusions. For example, in the case of strong persistent variables, the use of Impulse-Response Analysis can lead to unuseful conclusions *(as the errors' variance can be abnormal)*. The same happens when the structural changes in the analyzed variables are not considered when applying the VAR model.

Moreover, it is necessary to note that the selection order in a VAR model is important for the analysis of the relationship between the considered variables. Therefore, an economic reasoning might be used for the selection order considered, such that the proposed model to be useful *(beside the statistical testing of its validity)*.

The VAR model with N variables proposed by Diebold and Yilmaz is used to define the spillover index, as the sum of individual contributions to the estimated errors' variance, determined by some shocks on each of the analyzed assets.

For example, we derive the spillover index formula for a stationary VAR model with two variables and one lag. This model can be written as $x_t = \Phi x_{t-1} + \varepsilon_t$, where $x_t = \begin{pmatrix} x_{1,t} \\ x_{2,t} \end{pmatrix}$ and Φ is a (2x2) matrix.

Considering a stationary model, then the representation in moving average of the VAR model is $x_t = \Theta(L)\,\varepsilon_t$, where $\Theta(L)$ is the inverse of the matrix $(I-\Phi L)$.

If we denote with Q_t^{-1} the unique Choleski decomposition matrix of the covariance matrix of the error terms ε_t, $A(L) = \Theta(L)\,Q_t^{-1}$ and $u_t = Q_t\,\varepsilon_t$, then we obtain $E(u_t u_t') = I$. The previous equation can be rewritten as $x_t = A(L)u_t$.

Starting with this model, the optimal estimation *(derived from a Wiener-Kolmogorov linear optimization process)* for the next period is given by the relation $x_{t+1,t} = \Phi x_t$, in which the error vector is given by:

$$e_{t+1,t} = x_{t+1} - x_{t+1,t} = A_0 u_{t+1} = \begin{bmatrix} a_{0,11} & a_{0,12} \\ a_{0,21} & a_{0,22} \end{bmatrix} \begin{bmatrix} u_{1,t+1} \\ u_{2,t+1} \end{bmatrix}$$

So, the covariance matrix is given by $E(e_{t+1,t}e'_{t+1,t}) = A_0A'_0$, and the variance of the forecasted errors for the next period is equal to $a_{0,11}^2 + a_{0,12}^2$ for x_{1t} variable and, respectively, equal to $a_{0,21}^2 + a_{0,22}^2$ for x_{2t} variable.

Therefore, for each variable, the variance of the forecasted error has been divided in components that are specific to the shocks occurred on the two variables. Moreover, it can be defined *own part of variance* for asset x_i as the percentage from the variance of the forecasted error for the next period determined by the shocks on the x_i variable *(in the previous case,* $a_{0,11}^2$

for x_{1t} and $a_{0,22}^2$ *for x_{2t})*. Also, it can be defined cross part of variance for x_i asset as being the percentage from the variance of the forecasted error determined by the shocks on x_j variable (with i≠j)

Therefore, for a VAR model with two variables and one lag, the contagion is estimated by $a_{0,12}^2$ *(this is the contribution the shocks on the x_{1t} variable have on x_{2t} variable)* and $a_{0,21}^2$ *(the contribution the shocks on the x_{2t} variable have on x_{1t} variable)*. It can be defined the total spillover as being given by the relation $a_{0,11}^2 + a_{0,12}^2$ *(that sum up the total effect of contagion between the two assets)*. In order to ease the interpretation of this number, it is usually transformed to an index, by dividing it by the total variance of the forecasted error, obtaining the spillover index.

Because the total variance of the forecasted error is equal to $a_{0,11}^2 + a_{0,12}^2 + a_{0,21}^2 + a_{0,22}^2$ = trace ($A_0A'_0$), then the definition of the *spillover index* is given by:

$$S = \frac{a_{0,11}^2 + a_{0,12}^2}{\text{trace}\,(A_0A_0')}\;100.$$

Generalizing this formula, for a VAR model with N-variables of order p, it can be obtained the spillover index formula (for the next period):

$$S = \frac{\sum_{i,j=1_{i\neq j}}^{N} a_{0,ij}^2}{trace(A_0\,A_0')}.100$$

For a VAR model with N-variables of order p and H-future periods, the spillover index formula is given by:

$$S = \frac{\sum_{h=0}^{H-1}\sum_{\substack{i,j=1\\ i\neq j}}^{N} a_{h,ij}^2}{\sum_{h=0}^{H-1} trace(A_h A_h')}.100$$

The methodology proposed by Diebold and Yilmaz can be used in various sectors and domains, such the time series for returns and volatilities, in order to find the causes of the volatility present on the capital markets.

These concepts will be used for data for the January 1st, 2007-September 15th, 2016 time frame, representing the main indices of Romania and other 10 countries, with developed capital markets *(France, Germany, United Kingdom, Austria and US)*, *emerging capital markets (Czech Republic, Greece, Poland and Hungary)* and frontier markets (Romania and Bulgaria), using the MSCI classification *(available mid-September 2016)*. As such, we use the closing values of the main indices from 11 capital markets: DJIA (US), FTSE 225 (United Kingdom), CAC40 (France), DAX30 (Germany), ATX (Austria), PX (Czech Republic), ATHEX (Greece), WIG20 (Poland), BUX (Hungary), SOFIX (Bulgaria) and BET (România), available on Thomson Reuters, www.stooq.com and on the official web-sites of the market operators and were used to calculate the daily, weekly and monthly returns of the analyzed markets.

Furthermore, the daily, weekly and monthly returns were afterwards analyzed using VAR models and variance decomposition, in order to define a spillover index. The choice for different data frequency intends to capture the potential delay in the occurrence of the effects of contagion *(by lengthening the time interval)*, as well as isolating the effects of increased volatility present during the crisis episodes in the daily returns *(that may not last for a longer period)*.

We choose the returns of the developed capital markets *(France, Germany, United Kingdom, Austria and US)* because the turbulences from these markets are supposed to have a large impact on less developed countries. In this cluster, the Austrian capital market is present, as the Romanian financial sector is significantly influenced by the Austrian companies, that have large presence in the banking industry, as well as in the non-banking financial industry *(especially in the capital market, where the largest fund manager and two out of the top 5 financial intermediaries are subsidiaries of Austrian companies)*.

In order to capture the regional stance of the contagion effect, we choose the emerging markets from the Central and Eastern Europe *(Czech Republic, Greece, Poland and Hungary)*, the returns that are obtained on these markets being a driver for the investors in finding investing opportunities in the region. Also, in the Romanian capital market operate intermediaries that are owned by companies from these countries, a fact that facilitates the spreading of the possible negative events between these markets. Moreover, the selection of these capital markets is also based on their importance in the European financial systems, with the Polish capital market being by far the most developed, followed by the Greek, Czech and Hungarian capital markets.

4. The Results

We start with the daily returns for the 11 analyzed countries. So, considering the daily returns for each index in the analyzed time frame, we use the Granger causality tests *(for each pair of the daily returns series)*, of lag 2, in order to capture the causality relations, considering also the past values of the variables.

In Table 1 are presented a part of these results, being emphasized the relation of the BET index with the other 10 indices.

Table 1. Pairwise Granger Causality Tests for selected indexes (01.01.2007-15.09.2016)

Null Hypothesis:	Obs	F-Statistic	Prob.
DJIA does not Granger Cause BET	2532	210.398	3.E-85
BET does not Granger Cause DJIA		1.49813	0.2237
FTSE does not Granger Cause BET	2532	39.8035	1.E-17
BET does not Granger Cause FTSE		2.92872	0.0536
DAX does not Granger Cause BET	2532	53.3704	2.E-23
BET does not Granger Cause DAX		2.09874	0.1228
CAC40 does not Granger Cause BET	2532	40.8252	4.E-18
BET does not Granger Cause CAC40		0.79771	0.4505
ATX does not Granger Cause BET	2532	50.3549	4.E-22
BET does not Granger Cause ATX		0.90415	0.4050
WIG20 does not Granger Cause BET	2532	32.7124	9.E-15
BET does not Granger Cause WIG20		0.88840	0.4114
ATHEX does not Granger Cause BET	2532	13.5200	1.E-06
BET does not Granger Cause ATHEX		0.20786	0.8123
BUX does not Granger Cause BET	2532	20.6590	1.E-09
BET does not Granger Cause BUX		0.34060	0.7114
PX does not Granger Cause BET	2532	23.1861	1.E-10
BET does not Granger Cause PX		3.23226	0.0396
SOFIX does not Granger Cause BET	2532	3.12541	0.0441
BET does not Granger Cause SOFIX		4.85706	0.0078

Source: www.bvb.ro, own calculation

Table 2. Unrestricted Cointegration Rank Test for selected indexes, lag interval in first difference 1 to 4 (01.01.2007-15.09.2016)15.09.2016)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.027165	303.0814	285.1425	0.0072
At most 1	0.023525	233.4310	239.2354	0.0885
At most 2	0.016166	173.2245	197.3709	0.4033
At most 3	0.014789	132.0062	159.5297	0.5629
At most 4	0.011223	94.32454	125.6154	0.7684
At most 5	0.009403	65.78164	95.75366	0.8461
At most 6	0.005587	41.88790	69.81889	0.9136
At most 7	0.004788	27.71765	47.85613	0.8257
At most 8	0.003522	15.57867	29.79707	0.7415
At most 9	0.002620	6.656554	15.49471	0.6179
At most 10	8.28E-06	0.020948	3.841466	0.8848

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.027165	69.65042	70.53513	0.0603
At most 1	0.023525	60.20648	64.50472	0.1214
At most 2	0.016166	41.21835	58.43354	0.7471
At most 3	0.014789	37.68166	52.36261	0.6402
At most 4	0.011223	28.54290	46.23142	0.8552
At most 5	0.009403	23.89374	40.07757	0.8319
At most 6	0.005587	14.17025	33.87687	0.9871
At most 7	0.004788	12.13898	27.58434	0.9270
At most 8	0.003522	8.922116	21.13162	0.8387
At most 9	0.002620	6.635606	14.26460	0.5331
At most 10	8.28E-06	0.020948	3.841466	0.8848

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

From this table, the probability values indicate that, except for Bulgaria, the Romanian capital market is not in a causality relation with any other capital market *(BET does not Granger cause any of the other 9 capital markets)*. Moreover, from the Table 1 we can find that is rejected the null hypothesis that the 10 analyzed capital markets does not Granger cause the BET index *(with the only exception being Bulgaria, but the probability level being less than 5%)*. We can conclude that the Romanian capital market is influenced by the other 10 capital markets (including the ones that are European Union's members). In the Bulgaria case, neither of the hypotheses cannot be rejected, meaning there are some causality relations that are not statistically significant.

Using the conclusions derived from the Granger causality tests, we can say that the US market has a significant influence over the other markets, as it is rejected every null hypothesis of DJIA not being in Granger causality relation.

Considering the importance of each analyzed capital market within the global financial system, we construct a VAR model for the 11 time series, the selection order being DJIA, FTSE, DAX, CAC40, ATX, WIG20, ATHEX, BET, BUX, PX and SOFIX for 2 lags, using daily, weekly and monthly data. In order to find the number of lags to consider, we performed the test for lag order selection, obtaining that the Schwartz information criterion and Hannan-Quinn information criterion suggest lag 1, but the Final Prediction error and the Akaike information criterion suggest lag 6. Considering the variance decomposition for lag 1, the results obtained are not useful in developing the spillover index, as - for each decomposition - the components corresponding to the remaining variables in the VAR model (that are included after the variable that is analyzed) are equal to zero (so, no sign of contagion, mainly due to the calculus of the VAR components). An alternative is to consider the variance decomposition for lag 6, but, in order to have results that are affected by the most recent events, we shall consider the variance decomposition of lag 2 (the differences in variance decomposition for lag 2 and lag 6 being marginal, in terms of the aim of the decomposition: to capture the contagion effect).

Before proceeding to find a VAR model, we use the Johansen cointegration test in order to find whether the selected indices are cointegrated. The results, for 4 lags in the first difference, are presented in Table 1, showing divergent results: the trace test indicates the presence of a cointegrating equation, while the Maximum Eigenvalue indicates no cointegration equations. We will continue with the unrestricted VAR *(considering the results from the Maximum Eigenvalue test)*, the implication of the results of Trace test being analyzed in a future research.

Source: own calculation

In each of the 3 cases, the VAR model is stable, as can be seen from the fact that all eigenvalues are less than one in absolute value *(graphically represented in Figure 1, where the daily data are on left side, weekly data on center and monthly data on right side)*.

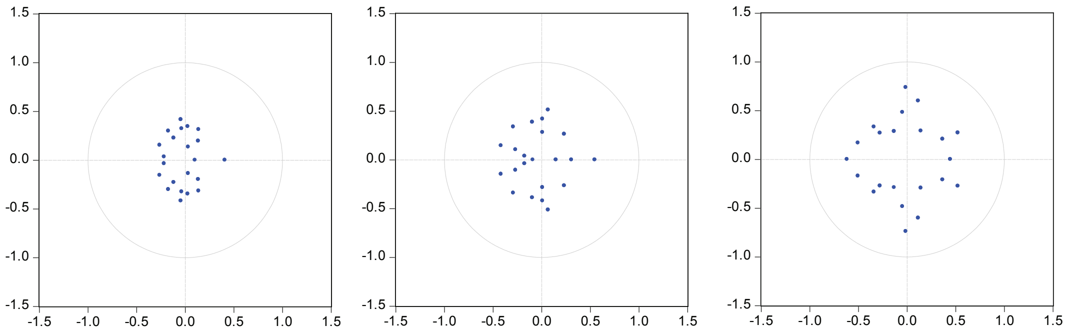

Fig.1. Inverse Roots of AR Characteristic Polynomial (daily returns-left, weekly-center, and monthly-right)

Source: own calculation

Applying the VAR Granger Causality test on the daily returns time series, we found that the returns of the US, French and Austrian capital markets have influence on the daily returns' volatility of the BET index from the Bucharest Stock Exchange (the results being presented in Table 3).

Table 3. VAR Granger Causality/Block Exogeneity Wald Test (01.012007-26.08.2016)

Dependent variable: BET

Excluded	Chi-sq	df	Prob.
DJIA	291.0020	2	0.0000
FTSE	1.686876	2	0.4302
DAX	0.512708	2	0.7739
CAC40	13.65241	2	0.0011
ATX	12.47026	2	0.0020
WIG20	3.654004	2	0.1609
ATHEX	2.820635	2	0.2441
BUX	0.303831	2	0.8591
PX	1.016233	2	0.6016
SOFIX	5.744818	2	0.0566
All	468.0143	20	0.0000

Source: own calculation

Using the methodology proposed by Diebold and Yilmaz, we make the variance decomposition of the forecasted errors of the VAR model for the daily data of the 11 time series. The result we obtained was used to calculate the spillover index for daily returns, which reveals the impact the external and internal factors have on the contagion effect.

From the Table 4, we found that, for Romania, the shocks on the external markets explain 34.32% of the volatility of the Romanian capital market, the largest contributors being the US and UK markets and, also, but less important, being the capital markets from Austria, Poland and Germany. This situation is due to the fact that largest investors on the Romanian capital market are foreigners *(especially investors from the US, the UK, Austria and Poland)*, as well as to the fact that retail investors are sentiment driven investors *(the evolution on the developed markets having an impact on the decisions adopted by the retail investors and, considering the poor liquidity, this drives to large swings in prices and therefore in amplified volatility)*. We also found that the Romanian capital market's influence on the other analyzed markets is a marginal one, only of 7.46%, the largest impact being identified on the capital markets of Bulgaria, the Czech Republic and Hungary *(smaller than the Bucharest Stock Exchange, in terms of market capitalization)*.

The data from the Table 4 show that the most exposed capital markets to external shocks are the French, the German, the Austrian, the Czech, the Polish and the Hungarian markets, that receive from the other countries 87.82%, 70.41%, 68.46%, 63.68%, 46.39% and, respectively, 46.17% of the shocks, the largest part from the shocks occurred in the developed markets, such the US and the UK markets.

When we consider a single index for the collected data, we find that 46.36% of the variance of the forecasted errors is due to the contagion effect, as measured by the spillover index. This value reflects the interaction of every analyzed market with the global financial system and the occurrence, in this time interval, of the global financial crisis, that lead to an increase in the volatility of the prices *(data volatility and the way we construct the VAR model partially explain the statistically identified relations from Table 4)*.

Source: own calculation

In the Romanian case, the largest contribution to the daily returns' volatility is derived from the developed capital markets (US and UK markets) and the main capital markets in the Central and Eastern Europe, such as the Austrian and the Polish capital markets. The contribution of the Austrian capital market can be explained by the listing on the Bucharest Stock Exchange of two large issuers that are also traded on

Table 4. The spillover index for daily returns (01.01.2007-15.09.2016)

	US	United Kingdom	Germany	France	Austria	Poland	Greece	Romania	Hungary	Czech Republic	Bulgaria	Contribution from the other markets
US	97.80515	0.209605	0.147917	0.615521	0.029549	0.004833	0.255236	2.08E-05	0.150595	0.776144	0.005429	2.19485
United Kingdom	40.29816	57.0946	1.018672	1.008005	0.011056	0.003222	0.261058	0.178649	0.00094	0.118038	0.007601	42.9054
Germany	45.76294	22.62085	29.5855	1.390601	0.0079	0.001513	0.243083	8.21E-02	0.018341	0.28423	0.00292	70.4145
France	45.33409	27.73445	14.27794	12.17104	0.002303	0.023255	0.27654	0.042922	0.016633	0.117552	0.003286	87.82896
Austria	36.2761	24.66542	5.300769	1.688682	31.53401	0.018263	0.287312	0.000713	0.173815	0.052898	0.002017	68.46599
Poland	24.29902	16.19329	2.841232	1.374104	1.436384	53.60986	0.043331	0.036547	0.011815	0.100477	0.053935	46.39014
Greece	12.54636	10.73973	1.194138	0.820586	1.554485	1.147416	71.31504	0.183705	0.067768	0.288027	0.142743	28.68496
Romania	21.15065	6.189753	1.041355	0.307689	3.788497	1.22466	0.587659	65.68	0.010861	0.000778	0.018102	34.32
Hungary	22.73456	10.38321	2.62204	1.906605	2.269819	4.88174	0.190332	1.010708	53.82963	0.019435	0.151918	46.17037
Czech Republic	28.48452	17.28085	1.075358	1.102772	7.616908	4.442948	0.716831	1.849753	1.008851	36.31081	0.110393	63.68919
Bulgaria	10.79103	1.105027	0.257346	0.266022	0.988762	0.283062	0.086454	4.079729	0.015738	1.044203	81.08263	18.91737
Contribution to the other markets	287.6774	137.1222	29.77677	10.48059	17.70566	12.03091	2.947836	7.464872	1.475357	2.801782	0.498344	509.9817
Total Contribution	385.4826	194.2168	59.36227	22.65163	49.23967	65.64077	74.26288	73.14487	55.30499	39.11259	81.58097	1100
												46.36198

the Wiener Boerse (from the energy and banking sectors). The Romanian capital market is also influenced by the evolutions on the Polish capital market, the largest capital market in the Eastern and Central Europe, where are present large institutional investors, that allocate some of their funds for investments in the issuers listed on the Bucharest Stock Exchange.

Source: own calculation

Using a similar reasoning for the weekly data, we obtain the data from the Table 5, according to which 49.24% of the weekly returns' volatility for the Romanian capital market is explained by the other analyzed capital markets. The most important effect is induced by the US, the UK, the Austrian and the Polish markets (as in the previous case). On the other hand, the impact of the volatility of weekly returns from the Romanian capital market on the other analyzed markets reduced from the value obtained from the daily data (to 6.29%). The largest impact of the turbulences present on the Romanian capital market can be seen on the Bulgarian and Czech stock markets, that are characterized by a smaller market capitalization than the Romanian capital market. Also, the contagion effect is due to the presence of same type investors, mainly not so large ones, as the low liquidity of these markets inhibit the investments on these markets.

The spillover index calculated on the basis of weekly data shows that 54% of the variance of the forecasted errors is determined by the presence of the contagion phenomenon. The largest impact is due to the turbulences occurring in the developed capital markets, such as the US, UK, German and French capital markets, and to a lesser extent by the capital markets from the Central and Eastern Europe.

Table 5. The spillover index for weekly returns *(01.01.2007-15.09.2016)*

	US	United Kingdom	Germany	France	Austria	Poland	Greece	Romania	Hungary	Czech Republic	Bulgaria	Contribution from the other markets
US	97.69738	1.441157	0.392615	0.014837	0.0051	0.24559	0.091851	0.063359	0.001077	0.027726	0.019307	2.30262
United Kingdom	49.63924	48.2884	0.007336	0.43389	0.056935	0.026147	0.060623	0.561549	0.628114	0.077799	0.219975	51.7116
Germany	53.55648	16.4892	28.75302	0.439765	0.028476	0.123737	0.235253	0.360455	0.00054	0.007016	0.006046	71.24698
France	58.00669	16.68494	14.90093	9.619243	0.011222	0.046417	0.113979	0.403255	0.021495	0.151094	0.040732	90.38076
Austria	46.60962	24.54714	4.41067	0.558297	22.57853	0.005313	0.319047	0.432544	0.134605	0.360167	0.04406	77.42147
Poland	35.83017	9.281871	4.454108	0.010883	2.612817	47.45551	0.004132	0.058164	0.175742	0.091198	0.0254	52.54449
Greece	21.57031	10.60476	1.672818	0.806846	4.711889	0.837031	58.52625	0.450563	0.384227	0.03274	0.402561	41.47375
Romania	30.45915	8.237782	1.380139	0.233332	7.145197	1.456037	0.275407	50.75096	0.012161	0.030491	0.019341	49.24904
Hungary	32.9397	7.186535	3.656261	0.366435	2.697203	5.997984	0.099161	0.350549	46.66634	0.008774	0.031061	53.33366
Czech Republic	38.99766	16.17909	3.240102	0.220479	10.88473	3.700983	0.17115	1.141068	0.653404	24.79519	0.016151	75.20481
Bulgaria	14.50659	5.089547	0.388317	1.140368	4.461231	0.128973	0.628443	2.447897	0.227374	0.181536	70.79973	29.20027
Contribution to the other markets	382.1156	115.742	34.5033	4.225132	32.6148	12.56821	1.999046	6.269403	2.238739	0.968541	0.824634	594.0694
Total Contribution	479.813	164.0304	63.25632	13.84438	55.19333	60.02372	60.5253	57.02036	48.90508	25.76373	71.62436	1100
												54.00631

Furthermore, we consider the monthly data representing the returns of the 11 selected indices, and we obtain the results presented in Table 6, following a similar approach.

The obtained result, using monthly data, show that the volatility of monthly returns of the Romanian capital markets is influenced in 68.88% proportion by the volatility experienced by the other countries, the largest effects being given by the US and UK markets. Also, it is present and an important part that is due to turbulences from the main capital markets from Central and Eastern Europe, such as the Austrian and Polish ones.

On the other hand, the volatility of monthly returns from the Romanian capital market has an impact of 26.11% on the other analyzed capital markets *(of the total volatility)*, that is significantly larger than those obtained for daily and weekly data. The most affected countries are those from the region, Romania being an exporter of volatility toward smaller capital markets (those from Bulgaria, Czech Republic and Hungary). But the Romanian capital market's potential of influencing the volatility in the developed markets is still low, even the calculated values might indicate such a possibility *(these values can be explained by the presence on the Romanian capital markets of some US and UK institutional investors that operate according to their global strategies)*.

Table 6. The spillover index for monthly returns (01.01.2007-15.09.2016)

	US	United Kingdom	Germany	France	Austria	Poland	Greece	Romania	Hungary	Czech Republic	Bulgaria	Contribution from the other markets
US	86.55635	3.852398	0.001762	0.120399	0.046295	1.848524	1.061457	4.280741	0.151779	0.001209	2.079089	13.44365
United Kingdom	50.97495	40.40246	0.017184	0.000133	1.815108	0.092362	1.913109	2.302047	0.856302	0.02097	1.605378	59.59754
Germany	58.31097	4.511037	31.19352	0.164632	0.937974	0.374459	2.145491	0.466215	0.857161	0.051666	0.986872	68.80648
France	56.56101	9.067327	13.82504	13.28195	0.129185	1.345309	2.253939	0.818875	0.000145	0.006682	2.710542	86.71805
Austria	43.79279	21.93266	2.526307	1.515887	24.73725	0.506628	1.271501	1.130636	0.021647	0.29157	2.273136	75.26275
Poland	40.76509	9.697108	2.681126	0.51158	3.954095	30.93201	2.720238	2.136654	3.73E-05	0.591189	6.010872	69.06799
Greece	29.18424	11.39767	2.576379	3.329243	6.440194	0.025905	42.47381	0.240342	0.094705	0.544148	3.693364	57.52619
Romania	44.02116	9.284879	0.334648	1.607622	7.152081	3.583322	0.796201	31.11397	0.383416	0.326289	1.396406	68.88603
Hungary	43.62835	5.634467	3.716662	2.306489	4.446345	3.116263	6.231662	2.729753	26.40472	0.013324	1.771968	73.59528
Czech Republic	43.07591	13.71067	3.194193	1.938496	12.64219	2.586113	3.23754	2.899717	0.124372	14.45693	2.133873	85.54307
Bulgaria	27.17922	14.6733	0.489464	0.458216	5.108441	0.652585	0.099187	9.11132	2.277276	3.252591	36.6984	63.3016
Contribution to the other markets	437.4937	103.7615	29.36277	11.9527	42.67191	14.13147	21.73033	26.1163	4.76684	5.099638	24.6615	721.7486
Total Contribution	524.05	144.164	60.55629	25.23465	67.40916	45.06348	64.20414	57.23027	31.17156	19.55657	61.3599	1100
												65.61351

Source: own calculation

Using monthly data, the spillover index shows that 65.61% of the variance of forecasted errors are determined by the presence of the contagion phenomenon, the largest impact being associated with the turbulences that are present on the developed capital markets, such as the US, UK, German and French, and to a lesser extent on the capital markets from the Central and Eastern Europe. It can be seen that the US capital market has the largest impact on the other capital markets, with the largest effects on the German, French and UK capital markets, that are developed and where operate a large number of institutional investors. The London Stock Exchange has the largest impact on the French and Polish capital markets, revealing the close ties of the later to the UK capital market (as the Warsaw Stock Exchange is the leading trading venue in the Eastern and Central Europe).

Considering the Eastern and Central European capital markets, for the analyzed time frame, the Polish capital market has the largest impact on the Romanian, Hungarian and Czech Republic capital markets. Also, the Wiener Boerse has the largest impact on the Czech Republic, Romanian, Bulgarian and Hungarian capital markets, revealing its importance in the region.

5. Conclusions

Using data from the January 1st, 2007-September, 15th, 2016 time interval, for 11 capital markets from developed countries (USA, United Kingdom, France and Germany) and from the Central and Eastern Europe (Austria, Poland, Greece, Romania, Hungary, Czech Republic and Bulgaria), we analyzed the presence of the contagion phenomenon and their induced effects. In this regard, we used a VAR model for daily, weekly and monthly data that explains the Romanian capital market's returns in relation with the other markets. In order to study the contagion effect, we used the methodology proposed by Diebold and Yilmaz (2008), by constructing a spillover index for each of the VAR models considered *(corresponding to the daily, weekly and monthly data)*.

We obtained that the volatility of the daily, weekly and monthly returns of the Romanian capital market are determined by the volatility present on the most mature capital markets (the US and UK capital markets), as well as on the most important capital markets from the Central and Eastern Europe, namely Austrian and Polish ones.

By calculating the spillover index for different frequency data, we obtained that the contagion effect is most revealed using monthly data (with a value of 65.61%), then weekly data (with a value for the spillover index being equal to 54.00%) and, in the daily data case, the index has the lowest value (the value for the spillover index being 46.36%).

Because the obtained results show connections between the Central and Eastern Europe capital markets and the developed markets, they are of interest for a large spectrum of users (supervisory authorities, institutional investors, researchers, etc.), interested in finding the contagion effects on the stability of capital markets. These results are the starting point for the assessment of the capital markets from the Eastern and Central Europe, considering their exposure to the shocks occurred on more developed markets. Moreover, the result confirms the need for an international stance on the supervising of financial markets in the European Union, in order to monitor and take preemptive actions that consolidate the markets' resilience to shocks.

Also, this result shows the need to start the reform on the Romanian capital market, in order to strengthen its place as a financing venue for the Romanian companies, especially considering the perspective of the Capital Markets Union process intended to be initiated starting early 2019. In order to have the preconditions for enjoying the full benefits of the Capital Markets Union, it is necessary that the less developed capital markets, such as the Romanian capital market, are prepared to compete with the more developed capital markets, by having in place the proper functioning mechanisms and institutions *(common to the European Union member states)*. But more important is that the less developed countries find, define and develop mechanisms that foster the competitive advantages over the more developed countries.

References

Armeanu, D. S., Dinică M. C., Burcă, A. M., Negru, A. and S. I. Cioacă, 2012. Correlation of DJIA, DAX and BET indexes under normal circumstances and during a financial crisis situation. Internal Auditing& Risk Management, 7(3), pp.23-36.

Armeanu, D. S., Doia, C. A., Hăncilă, M. and Cioacă, S., 2013. The analysis of the correlation intensity between emerging market during economic crisis. Romanian Statistical Review Supplement, 61(2), pp.307-318.

Armeanu, D. S., C. E. Pascal, S. I. Cioacă, 2014. Managing contagion risk during economic, financial and political shocks. Proceedings of the 8th International Management Conference "Management challenges for sustainable development", November 6th-7th, 2014, Bucharest, pp.1148-1157.

Bensaid, B., O. Jeanne, 1997. The instability of fixed exchange rate systems when raising the nominal interest rate is costly. European Economic Review, Vol.41 (8), pp.1461-1478.

Buiter, W., G. Corsetti, P. Pesenti, 1996. Financial Markets and International Monetary Cooperation. Cambridge: Cambridge University Press

De Kock, G., V. Grilii, 1993. Fiscal policies and the choice of exchange rate regime. Economic Journal 103, pp.347-356.

Diebold F. and Yilmaz, K., 2008. Measuring financial asset return and Volatility Spillovers, with application to global equity markets. Available: www.nber.org/papers/w13811 [Accessed September 26th, 2016]

Eichengreen, B., A. Rose, C. Wyplosz, 1996. Contagious Currency Crises. Available: http://www.nber.org/papers/w5681.pdf [Accessed September 26th, 2016]

Engle, R., T. Ito, L.W. Lin, 1990. Meteor showers or heat waves? Heteroskedastic intra-daily volatility in the foreign exchange market. Econometrica vol.58(3), pp.525-542.

Forbes K., R. Rigobon, 2002. No Contagion, Only Interdependence: Measuring Stock Market Comovements. The Journal of Finance, LVII(5), pp.2223-2261.

Gerlach, S., F. Smets, 1995. Contagious speculative attacks. European Journal of Political Economy 11, pp.5-63.

Glick, R., A. Rose, 1999. Contagion and trade: why are currency crisis regional. Journal of International Money and Finance, V.18.

Goldberg, L., 1993. Predicting exchange rate crises: Mexico revisited. Journal of International Economics

Helleiner, E., 2011. Understanding the 2007-2008 Global Financial Crisis: Lessons for Scholars of International Political Economy. The Annual Review of Political Science. [Online] 14, pp.67-87. Available: doi: 10.1146/annurev-polisci-050409-112539 [Accessed September 26th, 2016]

Kaminsky, G., C. Reinhart, 1998. On Crises, Contagion, and Confusion. Available: http://home.gwu.edu/˜graciela/HOME-PAGE/RESEARCH-WORK/WORKING-PAPERS/contagion.pdf [Accessed September 26th, 2016]

Krugman, P., 1979. A Model of Balance of Payments Crises, Journal of Money, Credit and Banking, 11, pp.311-325.

Obstfeld, M., 1986. Rational and Self-Fulfilling Balance of Payments Crises. American Economic Review 76, pp.72-81.

Obstfeld, M., 1995. International Currency Experience: New Lessons and Lessons Relearned. Brookings Papers on Economic Activity 2, pp.119-220.

Reinhart, C., K. Rogoff, 2009. This time is different. Eight centuries of financial folly. New Jersey: Princeton University Press, Princeton

Rigobon, R., 2001. Contagion: How to measure it? Available: http://www.nber.org/papers/w8118.pdf [Accessed September 26th, 2016]

Sims, C., 1980. Macroeconomics and reality. Econometrica, 48(1), pp.1-48.

Stock, J., M. Watson, 2001. Vector Autoregressions, Journal of Economic Perspectives, 15(4), pp.101-115.

Van Rijckeghem, C., B. Weder, 1999. Sources of contagion: finance or Trade? Available: https://www.imf.org/external/pubs/ft/wp/1999/wp99146.pdf [Accessed February 16th, 2017]

Van Rijckeghem, C., Weder, B., 2000. Spillovers through banking centers: A panel data analysis. Available: https://www.imf.org/external/pubs/ft/wp/2000/wp0088.pdf [Accessed February 16th, 2017]

Willman, A., 1988. The collapse of the fixed exchange rate regime with sticky wages and imperfect substitutability between domestic and foreign bonds. European Economic Review 32, pp.1817-1838.