CORRELATION OF DJIA, DAX AND BET INDEXES UNDER NORMAL CIRCUMSTANCES AND DURING A FINANCIAL CRISIS SITUATION

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Abstract:

Up until the 80's, financial crises were considered to be limited to the level of capital markets (therefore individual), without any systemic implications. In the 90's however we witnessed important financial crises: The European Monetary System, (1992), the crisis in Mexico (1994-1995), Asia (1997-1998), Russia (1998), Brazil (1999), Argentina (2001) and the most important crisis since World War 2, the financial crisis that took off in the United States in 2007. The intensification effect of the globalized economy led to a higher degree of commercial and financial integration of states all over the world. Thus, gradually, local financial crises propagated to the level of the world financial system.

Relevant in that regard are several difficult episodes that had a powerful effect on the capital market, especially after the 80's: the crisis of the European Monetary System, (1992), the Tequila crisis (Mexico 1994-1995), the Asian crisis (1997-1998), the Russian crisis (1998), the crisis in Brazil (1999), the crisis in Argentina (2001).

Keywords: crisis, risk, Markovity model, Johansen test, Granger

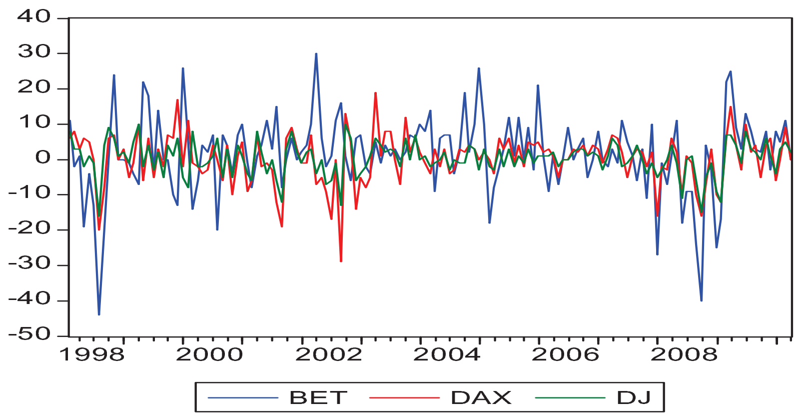
The consequences of those financial crises were not limited to the capital markets of the countries where they began, as they spread rapidly to world markets – an effect known in literature as ***contagion***.

Several important reasons are being mentioned in order to study the phenomenon of international propagation of financial shocks.

First of all, the ***contagion*** phenomenon can have significant implications on the administration of financial portfolios, mainly as to the international diversification of risk.

Secondly, the importance of studying this phenomenon is strengthened by the trend towards integration that describes world financial markets. The technological revolution, corroborated with the liberalization of international financial markets led to a significant increase in international capital flow, which has made it possible for shocks to be propagated at a worldwide level. Last but not least, research on the ***contagion*** phenomenon is important in order to identify the role and efficiency of interventions made by international financial institutions in a crisis situation. We have used the MetaStock database to extract the course of the Dow Jones (United States), DAX 30 (Germany) and BET (Romania) indexes. We have calculated the monthly yields of those indexes since 1998 until 2010 (148 observations). We have tried to evaluate the importance of ***contagion*** effects on capital markets, using econometric methods, ranging from correlation to co-integration tests. We have also tried to prove that during the most severe financial crisis since World War 2, the degree of market correlation becomes higher. We have use the E-Views econometric software.

Graph 1– monthly yields of Dow Jones, DAX 30 and BET indexes



The graph showing the course of the three indexes indicates that the Romanian market - defined in our analysis by the BET index – experienced wider fluctuations than the American or the German markets.

The correlation matrix

	BET	DAX	DJ
BET	**1.000000**	**0.304010**	**0.304419**
DAX	**0.304010**	**1.000000**	**0.798272**
DJ	**0.304419**	**0.798272**	**1.000000**

A high degree of correlation is noticeable between the Dow Jones and DAX between 1998 and 2010 (80%). The low degree of correlation between the BET and DAX or the BET and Dow Jones indexes is explained by the specific course of the BET index over the past decade (a degree of undervaluation in the beginning of the interval, significant acceleration in the years before the 2007 onset of the crisis and a severe decline afterwards). As it will become apparent further on, during the crisis, the degree of correlation between the BET index and the Dow Jones and DAX indexes grew significantly.

The Kolmogorov-Smirnov test

It is a test recommended for ordinal variables, when the hypothesis of normal distribution is not plausible or when the variables are numeric but the samples are small and information about distribution is absent. It applies to $2 \times n$ incidence tables, the ones with two rows and *n* columns.

The test is based on statistics calculated in several steps, which is compared with theoretical statistic that is not derived from tables, but is calculated by the following formula:

$$D_t = K\sqrt{\frac{n_1 + n_2}{n_1 \cdot n_2}}$$

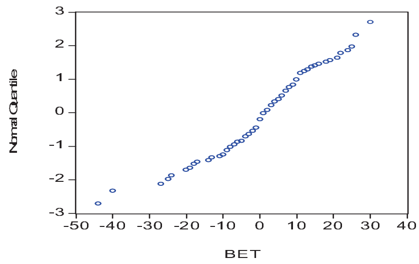
With n_1 and n_2 being the volumes of samples and K being a constant which depends on the desired ceiling of significance. The values of K are detailed in the following table:

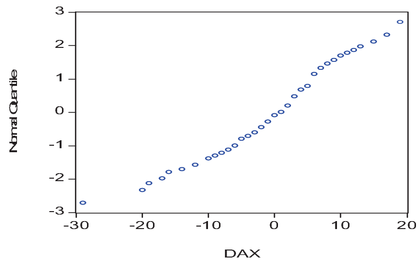
Values of the K coefficient for the calculation of the theoretical threshold of the Kolmogorov-Smirnov test

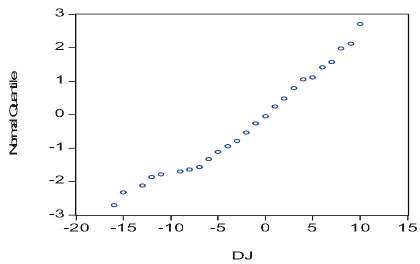
Significance ceiling	Ceiling value of p	Value of K
Significance (S)	0,95	1,36
High significance (HS)	0,99	1,63
Very high significance (VHS)	0,999	1,95

The following steps will be carried out:

- Classes will be set, as in making a histogram, by dividing the difference between the maximum and minimum value in the two data series, into equal segments
- Relative frequencies will be calculated for each class for each of the two data series
- Relative cumulated frequencies will be calculated for both data series
- Differences will be calculated between relative cumulated frequencies of the two series, for each class
- The largest difference will be chosen between the ones calculated at the previous step. This is the statistic of the test
- The theoretical statistic of the test will be calculated, the equivalent of the threshold value that is extracted from tables at the other tests. That statistic is D_t, given above.
- If the statistic of the test is higher than the theoretical one, the difference is significant otherwise it is not significant. The next step in the analysis is to implement the (non – parametrical) Kolmogorov – Smirnov test. The results are presented in the graph below:

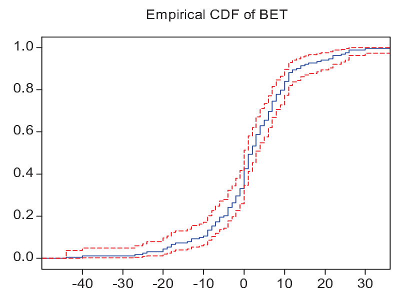


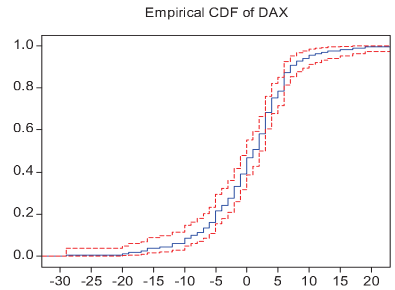


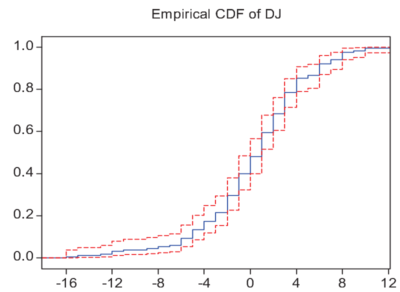


We notice a close (similar) distribution of yields expressed by the Dow Jones, DAX 30 and BET indexes during the analyzed period. If the distributions of series on both axes coincide, the graphs should have a linear trend. It is clearly noticeable that all three graphs indicate that BET, DAX and DJ follow the normal distribution.

Graphs of the type QQ (Quantile – Quantile) for the three stock exchange indexes are placed approximately in a straight line, except for the left end, which is bent downwards. The QQ tyoe graphs which follow liniar trends in the middle zone, while bending in the middle area, but they bend upwards at the left end and downwards şi în at the right end are an indicator of the fact that the distribution is leptokurtic and has a thicker tail than in the case of a normal distribution.







If the grapsh bends downwards at the left end nad upwards at the right end, it means that distribution is platikurtic and has thinner tails than in the case of the normal distribution.

The representation of the three indexes leads to the conclusion that they are platikurtic.

Notable differences outline the different fluctuations degrees of those indexes. That confirms the saying „***…When America sneezes, Europe catches a cold and the rest of the world dies of pneumonia…***". One can see that a variation of the Dow Jones index brings about a higher fluctuation of the German index DAX 30 and an even higher fluctuation of the BET index (when the Dow Jones indexes dropped by 16%, the DAX 30 index lost 30%, while the BET index declined over 40%). In order to identify the existing relationship between the three indexes we have used the Granger causality test, as well as the Johansen co-integration test.

The Johansen co-integration test

The discovery that countless time series of the macroeconomical variable type can have a unit root contracticted the theory of non-stationary time series. Engle and Granger (1987) showed that a liniar combination of two or several non-stationary time series can be a stationaary series. If indeed this liniar combination exists, then the component non-stationary series are said to be co-integrated. The stationary liniar combination is called the co-integration equation, and is interpreted as a relation of long term balance between variables.

The aim of co-integration tests is to find out wether a group of non-stationary series are co-integrated or not. Eviews assumes co-integration tests based on auto-regressive vectors (VAR), starting from the methodolgy developed by Johansen (1991, 1995a). Considering an auto-regressive vector of the order p:

$y_t = A_1y_{t-1} + \dots + A_py_{t-p} + Bx_t + \varepsilon_t$, where y_t is the k size vector of non-stationary variables I(1), x_t is the size d vector of exogen variables, and ε_t este is the innovative vector. Thus the equation can be rewritten as follows:

$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + å_t$, where:

$\prod = \sum_{i=1}^{p-1} A_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$

The theory states that if the matrix of $\prod$ coeficients has the rank $r < k$, matrixes α and β of sizes k x r, of r rank each, so that $\prod = \alpha\beta'$ and $\beta' y_t$ is I(0) – a zero degree integrated, r is the number co-integration relations (co-integration rank) and each column of β is the co-integration vector. The elements of the α vector are called adjustment parameters.

Johansen's Model consists of an estimation of the $\prod$ matrix starting from an auto-regressive vector without a restricted auto-regressive vector and the testing of the possibility to reject restriction enforced by the reduction of $\prod$ matrix rank reduction.

The results of the Johansen co-integration test are presented in the tables below:

Sample(adjusted): 1998:04 2010:04
Included observations: 145 after adjusting endpoints
Trend assumption: Linear deterministic trend
Series: BET DAX DJ
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.441187	176.5435	29.68	35.65
At most 1 **	0.317155	92.16217	15.41	20.04
At most 2 **	0.224396	36.84643	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 3 co-integrating equation(s) at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.441187	84.38131	20.97	25.52
At most 1 **	0.317155	55.31574	14.07	18.63
At most 2 **	0.224396	36.84643	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 3 co-integrating equation(s) at both 5% and 1% levels

Unrestricted Co-integrating Coefficients (normalized by b'*S11*b=I):

BET	DAX	DJ
-0.075887	-0.102769	0.404222
0.064223	0.148017	-0.041733
0.071500	-0.294334	0.328840

Unrestricted Adjustment Coefficients (alpha):

D(BET)	4.585432	-5.586877	-2.357205
D(DAX)	-1.661444	-3.826045	1.879751
D(DJ)	-2.570538	-2.437943	0.014809

1 Co-integrating Equation(s): Log likelihood -1422.633

Normalized co-integrating coefficients (std.err. in parentheses)

BET	DAX	DJ
1.000000	1.354243	-5.326642
	(0.43087)	(0.64743)

Adjustment coefficients (std.err. in parentheses)

D(BET)	-0.347974
	(0.07850)
D(DAX)	0.126082
	(0.05187)
D(DJ)	0.195070
	(0.03339)

Log likelihood -1394.975

2 Co-integrating Equation(s):

Normalized co-integrating coefficients (std.err. in parentheses)

BET	DAX	DJ
1.000000	0.000000	-11.99024
		(1.18846)
0.000000	1.000000	4.920531
		(0.70214)

Adjustment coefficients (std.err. in parentheses)

D(BET)	-0.706783	-1.298193
	(0.09150)	(0.16585)
D(DAX)	-0.119640	-0.395573
	(0.05986)	(0.10850)
D(DJ)	0.038497	-0.096684
	(0.03866)	(0.07007)

The first part of the results report on the number of cointegration relationships. The technique provides two statistics: the Trace Statistic and Maximum Eigenvalue. Their conclusions are presented at the bottom of each table, so each test indicates that there are three relations of co-integration between indexes.

The following two tables are vectors β and α, and the last two indicate the coeficients of the co-integration equations.

A conclusion of this test is that the three indexes are co-integrated via three co-integration equations, thus producing one stationary series.

The Granger causality test

Correlations do not necessarily imply relations of ausality. There are countless meaningless corelations, such as the one between salaries in the educational system and the consumption of alcohol. Granger's aapproach (1969) on the x-y causality consists of seing how much of y's current values can be explained by former values of y and, if by adding delayed values (by various lag intervals) of x, the relation can be improved. It is said that y has a Granger causality related to x, if x helps in estimating the value of y or, in other words, if those coefficients of x's delayed values are significant from a statistic point of view. One should keep in mind that the statement „y has a Granger causality with x" does not mean that y is the effect of the result of x. Also the Granger causality test works both ways, meaning that y has a Granger causality with x and x has a Granger causality with y.

The starting regressions are:

yt = α0 + α1yt-1 + … + αiyt-i + β1xt-1 + … + βix-i + εt

xt = α0 + α1xt-1 + … + αixt-i + β1yt-1 + … + βiyt-i + ut, for all analysed variable pairs. For the caluclated F, the Wald Statistic is used, with a null hipothesys:

β1 = β2 = … = βi = 0 for each equation.

The null hipothesys is that y does not have a Granger causality with x, for the first regreesion, and x does noot have a Granger causality with y, for the second regresie.

The results of the test are included in the table below:

Pairwise Granger Causality Tests

Sample: 1998:02 2010:04
Lags: 2

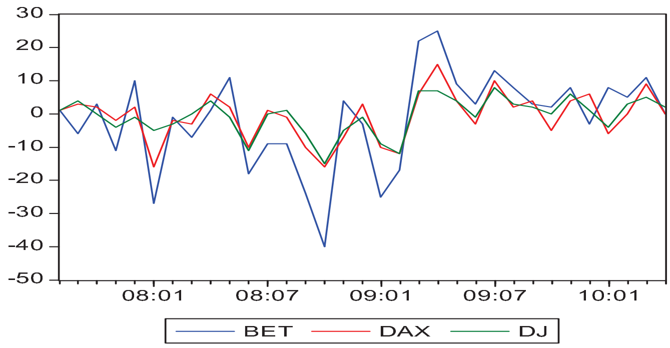
Null Hypothesis:	Obs	F-Statistic	Probability
DAX does not Granger Cause BET	145	0.26636	0.76655
BET does not Granger Cause DAX		1.07904	0.34273
DJ does not Granger Cause BET	145	2.16455	0.11863
BET does not Granger Cause DJ		0.48383	0.61745
DJ does not Granger Cause DAX	145	1.68844	0.18855
DAX does not Granger Cause DJ		0.31703	0.72883

As for the causality relation between DAX and BET, the null hypotheses will be accepted, as the errors assumed by rejecting the null hypothesis are very large (77% and 34% respectively). Therefore, BET does not have a Granger causality with DAX, nor the does DAX have a Granger causality in relation with BET.

The causality between DJ and BET works only one way, according to the results of the test, meaning that the American market is the cause of events on the Romanian market. The error committed by rejecting the hypothesis of non-causality between DJ and BET is 11%. Thus, by accepting a level of confidence of 90% (89%, more precisely), one can conclude that BET has a Granger causality in relation to DJ, but not the opposite.

When talking about DJ and DAX, the null hypotheses cannot be ruled out, so there are no relations of causality between the two indexes, according to this test.

Subsequently, we applied the same methods for the period between August 2007 - April 2010.



The correlation matrix

	BET	DAX	DJ
BET	1.000000	0.824211	0.807312
DAX	0.824211	1.000000	0.890824
DJ	0.807312	0.890824	1.000000

It is noticeable that during the economical-financial crisis, the degree of correlation between markets grew significantly. The course of the BET index became more correlated with those of the Dow Jones and DAX 30 indexes during that period.

The Johansen co-integration test

Sample: 2007:08 2010:04
Included observations: 33
Trend assumption: Linear deterministic trend
Series: BET DAX DJ
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.665167	61.39240	29.68	35.65
At most 1 **	0.367684	25.28636	15.41	20.04
At most 2 **	0.265001	10.16026	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 3 co-integrating equation(s) at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.665167	36.10604	20.97	25.52
At most 1 *	0.367684	15.12610	14.07	18.63
At most 2 **	0.265001	10.16026	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 3 co-integrating equation(s) at the 5% level
Max-eigenvalue test indicates 1 co-integrating equation(s) at the 1% level

Unrestricted Co-integrating Coefficients (normalized by b'*S11*b=I):

BET	DAX	DJ
0.169616	-0.438293	0.034473
0.081042	0.360654	-0.622209
0.086647	-0.158701	0.203134

Unrestricted Adjustment Coefficients (alpha):

D(BET)	3.271803	-2.322873	-7.470042
D(DAX)	5.175537	-1.373740	-2.240646
D(DJ)	3.535456	0.758215	-2.049483

1 Co-integrating Equation(s): Log likelihood -301.0270

Normalized co-integrating coefficients (std.err. in parentheses)

BET	DAX	DJ
1.000000	-2.584026	0.203241
	(0.40807)	(0.50778)

Adjustment coefficients (std.err. in parentheses)

D(BET)	0.554951
	(0.48680)
D(DAX)	0.877856
	(0.19645)
D(DJ)	0.599671
	(0.15607)

2 Co-integrating Equation(s):	Log likelihood	-293.4639
Normalized co-integrating coefficients (std.err. in parentheses)		
BET	DAX	DJ
1.000000	0.000000	-2.691791
		(0.28772)
0.000000	1.000000	-1.120357
		(0.10506)
Adjustment coefficients (std.err. in parentheses)		
D(BET)	0.366702	-2.271763
	(0.53316)	(1.60985)
D(DAX)	0.766525	-2.763847
	(0.21219)	(0.64068)
D(DJ)	0.661118	-1.276112
	(0.17086)	(0.51590)

The co-integration test for the crisis period indicates the presence of three co-integration equations both for the critical level of 5%, and for 1% , according to the Trace Statistic, and the Maximum Eigenvalue Statistic suggest the existence of three co-integration equations for the critical level of 5%, and an equation for 1%.

The Granger causality test

Pairwise Granger Causality Tests

Sample: 2007:08 2010:04
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
DAX does not Granger Cause BET	33	0.80365	0.45775
BET does not Granger Cause DAX		6.13101	0.00619
DJ does not Granger Cause BET	33	0.56619	0.57405
BET does not Granger Cause DJ		2.33066	0.11581
DJ does not Granger Cause DAX	33	3.22331	0.05497
DAX does not Granger Cause DJ		0.30916	0.73654

The Granger causality test suggest that DAX and DJ are caused by BET. Also, there are relations of causality between DJ and DAX, in the sense that the German market is influenced by the American market.

It is remarkable that the causality relations are more pronounced in situations of crises on the considered markets, so the three stock market indexes are involved in Granger-type relations of causality, either in one way, or the other. (according to results provided by outputs, the causality is not mutual in this case).

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