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Review Article

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Financial Contagion and Oil Crisis : A Factor Analysis

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Abstract

During the actual oil crisis, the Brent crude oil price has collapsed falling below 40$ .The paper tries to answer the following question : could the oil price crisis generate a financial contagion jump?. The financial contagion is intended to be the co-movements of stock market returns as resulting of a shock or crisis. The study period is composed of two sub periods ;a quiet period from 3/01/2012 to 01/08/2014 and turbulent period from 04/08/2014 to 25/05/2016.Raw data consists of daily stock market indexes prices of the FTSE 100 , SP 500, Nikkei, hang seng, DAX, CAC40, S&P/CITIC300, BSE Sensex 30, Bovespa, FTSE SOUTH AFRICA, FTSE SINGAPORE, IPC MEXICO, BURSATIL , S&P/ASX 200, Tadawul All Share, bahrain all share. The co-movements of the stock market returns are analyzed through a principal component analysis (PCA).The results revealed that the KMO index (Kaiser-Mayer-Olkin) is higher during the turbulent period than during the quiet one and that the proportion of variance explained by the first component during the turbulent period reached 35% while during the quiet one it represented only 26,7%.Regarding the component structure, for the turbulent period, three factors are able to replicate the stock markets indexes movements while for the quiet period four factors are required. These findings give more credit to the thesis supporting the linkage between cross correlation and financial contagion.

Keywords: Stock Market Returns, Component Analysis, Financial Contagion, Oil Crisis

1. Introduction

Several crises such as the subprime crisis, the global financial crisis, the 1987 US crash turned upside down the international stock markets. More recently, an oil crisis characterized by a price drawdown, as a consequence of both declining demand and stagnant production, affected negatively the stock markets remerging the financial contagion spectrum. What about financial contagion, is it financial linkage across stock markets or shock transmission from one market to another as a virus transmission? How financial contagion could be detected? Which indicators could be used to distinguish between interdependence and shock transmission? The scope of this paper is to test financial contagion resulting of the actual oil crisis applying a component analysis, for this purpose, moult indicators were computed, such as KMO, proportion of variance explained by the first component and number of pertinent factors for periods before and during the oil crisis, considered as quiet and turbulent periods. The paper is organized as follows, a first section will define the financial contagion concept and present a selected literature review about contagion tests based upon component analysis, then a second section will present the data and methodology, a third section is devoted to main results and a last section will review main findings and point out further researches.

1.1. Literature Review

According to Rigobon, contagion between stock markets is defined as shock transmission being stronger than expected on the basis of economic fundamentals (pure contagion), or as shock transmission having suddenly strengthened at times of financial crises (shift contagion) [1]. According to Forbes and Rigobon, contagion is a significant increase of cross market linkages after a shock [2]. Several approaches were implemented to evaluate the financial contagion such as random matrix theory (L. Sandoval Jr and others 2010), wavelett analysis, econometric techniques based upon ARCH and GARCH or copula approach [3-8]. The literature review will focus only on research based upon PCA (principal component analysis) technique testing for financial contagion subsequent to financial crisis.

According to L. Sandoval Jr a crisis is defined to be a crash of global stock markets [9]. The authors count the number of occurrence of major drops in order to identify major and minor crisis. They identified the following crisis; The crisis of 1987, the 1989 USA saving and loan crisis, 1997 Asian financial crisis, 1998 Russian crisis, 2000 and 2001 end of the dot-com bubble, and 2008 subprime mortgage crisis in the USA. Fuentes and Godoy examined the sovereign spread co-movements for 18 emerging market economies located in Asia, East Europe and Latin America from September 1997 to November 2002 (divided into eight periods) in the light of PCA analysis [10]. They proposed this taxonomy for the co-movements episodes, an extreme Coupling (when the Percentage of variance explained by first principal component is above 50%),a strong Coupling (when the Percentage of variance explained by first principal component is between 35-50%) and a weak coupling otherwise. Following this classification, five episodes of strong coupling were identified the Asian crisis, the Brazilian devaluation, the Russian default, the Turkish crisis and the Argentina default.

Silvestre and villar aims to detect financial contagion during the 2007 financial subprime crisis [11]. The data were composed of daily stock prices of 21 developed (OECD) countries during the 2004-2011 period. The period was divided into periods, a quiet one from 1 January 2004 to 31 july 2007 and a turbulent one from 1 august 2007 to 4 March 2011.The PCA analysis revealed differences between both periods in terms of number of relevant factors , three for the quiet one and two for the turbulent one and in terms of proportion of variance explained by the relevant factors, for the quiet one the proportion represents 69,8% while for the turbulent one it reaches 73,9%. M. Ramírez and C. Martínez tries to evaluate the event shock transmission among eight Latin American stock markets [12]. The daily data gathered through 1997 to September 2008 concerned stock market indexes for eight Latin American countries, exchange rates, short term interest rate and sovereign spreads. The authors identifies eight episodes, 4 positive shocks (NASDAQ crisis, Turkish devaluation, Argentina's debt default and Brazilian confidence crisis) and four negatives ones (Mexico's debt upgrade, Colombia's debt upgrade, Peru's debt upgrade and Brazil's debt upgrade). then they implement PCA analysis for the subsamples composed of periods before and after shocks. The level of the KMO indicator for the aftershock period appears to be higher than the cut-off point of 0,7 showing a great interdependence. The proportion of variance explained by the first component considered as an indicator of regional risk has been computed for the aftershock period for each episode. For positive shocks, the proportion of variance explained by the first component is higher than 50% (more than 70% for three episodes) while for negative shocks, the proportion ranges from 40% to 49%.Based upon the threshold proposed by Fuentes and Godoy, the authors conclude to the existence of financial contagion for positive shocks and not for negative shocks [10].

S Mollah and G Zafirov and AMM S Quoreshi wanted to test the presence of financial contagion during the global crisis [13]. The period of analysis was from September 1, 2008 to December 31, 2009. Daily data related to sixty-four MSCI indices were collected grouping nine regions. For each region, the proportion of variance explained by the first component (through PCA analysis) was calculated. The results showed that for the Pacific Asian , South America, North America, Western Europe, Eastern Europe And the Nordic regions, the proportion is greater than 50%, (the highest value of 82% is obtained for North America) while for the MENA, Africa and South and Central Asia the proportion falls below 50% (the lowest value of 32% for the MENA region).The study demonstrates disparity in shock transmission among developed, emergent and underdeveloped regions G. Merick , S. Lentz, W. Smeltz and I. Meric aims to study U.S., Latin American, European, and Australasian stock markets linkage during the post-crash period from October 8, 2007 to July 26, 2010 on a weekly basis [14]. Using a PCA technique, they found that the proportion of variance explained by the first component was 66.596%.Two components are able to replicate the whole world (with 74.344% proportion of variance), with a first component composed of U.S., European, ,Latin American, Australian, Japanese, and New Zealand stock markets while the second component groups Asian stock markets.

2. Data and Methodology

The data consists in daily closing prices of the following stock market indexes :FTSE 100, Standard and Poor's500, Nikkei, hang Seng, DAX, CAC40, S&P/CITIC300, BSE Sensex 30, Bovespa, FTSE SOUTH AFRICA, FTSE SINGAPORE, IPC MEXICO, BURSATIL, S&P/ASX 200, Tadawul All Share, Bahrain all share and Brent crude oil. They were extracted from the website fr.investing.com. Returns were computed using the relative difference between two consecutive days. The missing values are replaced by average values during the period. The study period ranges from 3/01/2012 to 25/05/2016.It has been divided into two sub periods :from 3/01/2012 to 01/08/2014 titled before the oil crisis and from 04/08/2014 to 25/05/2016 titled during the oil crisis. The PCA technique will be applied for both sub periods using SPSS software to display the results. The study attempt to analyze the correlations between Brent crude oil price and stock markets prices and to compare the pre and post oil crisis periods in terms of co-movements intensity. (coupling) The research hypotheses are the following:

H0: the oil crisis is considered as an extreme episode generating financial contagion
H1: KMO during the oil crisis is greater than the one before the oil crisis
H2: the number of component factors is lower during the oil crisis than before
H3: the proportion of variance explained by the first component factor is greater during the oil crisis than before

3. Results

3.1 Correlation Between Brent Crude Oil Price and Stock Market Returns

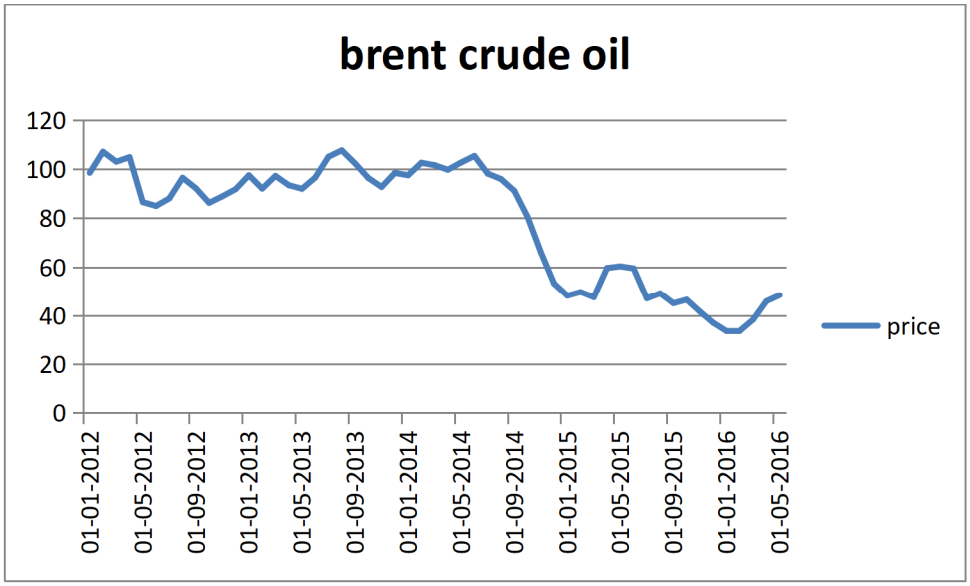

Figure 1: Brent Crude Oil Price During the Whole Period

The brent crude oil price evolution shows first a period of stability that lasts around September 2014 with a price of 91,16 $ and the drop will start since October 2014 , to reach in may 2016, 48,45 $.

market index	before oil crisis	during oil crisis
FTSE100	0,326*	0,334*
SP500	0,096*	0,249*
Nikkei	-0,035	-0,045
Hang Seng	0,057	-0,013
DAX	0,137*	0,152*
CAC40	0,258*	0,244*
SP Citi	0,032	0,034
BSE	0,026	0,151*
Bovespa	0,194*	0,083*
FTSE South Africa	0,171*	0,286*
FTSE Singapore	0,103*	0,092*
IPC Mexico	0,033	0,205*
Bursatil	-0,004	-0,063
Australia	0,011	0,064
Tadawul	0,011	0,063
Bahrein	-0,013	0,009
* :significant at 10% confidence level		

Table 1: Correlation Between Stock Market Index Return and Brent Crude Oil Return

Before the oil crisis,7 stock market indexes (FTSE100, SP500, DAX, CAC40, Bovespa, FTSE South Africa and FTSE Singapore) show a significant correlation with brent oil while during the oil crisis, this number increases to 9, adding BSE and IPC Mexico.

3.2. PCA Results Before the Oil Crisis (Quiet Period)

Only FTSE100,DAX, CAC40, FTSE SINAGPORE and FTSE South Africa seem to be correlated. Few correlation coefficients are higher than 0,5 .The factorization seems at first sight inadequate. (see appendix 1 for correlation matrix)

The PCA will now be applied to the following variables FTSE100 ,SP500, Nikkei , hang seng, DAX CAC40, SP/CITIC300, Bovespa, FTSE SOUTHAFRICA and FTSE SINGAPORE for the purpose to get higher KMO and significant factors.

Kaiser-Meyer-Olkin (KMO)	0,666	
sphericity test of Bartlett	Dof freedom	45
	Sig Bartlett	0

Table 2: KMO Index and Bartlett Test Quiet Period

The KMO increases but it remains a median value while the Bartlett test authorized the factorization

Component	Eigen value	% of variance	% cumulative variance
1	2,670	26,704	26,704
2	1,541	15,415	42,119
3	1,112	11,121	53,240
4	1,000	10,003	63,243

Table 3: Eigen values Quiet Period

The number of components is of four according to the eigenvalue criteria (cut off point 1) and the proportion of variance explained with four components equals 63,24% while the proportion of variance explained for the first component equals 26,7%

	1	2	3	4
FTSE100	0,823	0,096	-0,195	-0,077
SP 500	0,191	0,015	-0,4	0,826
Nikkei	-0,018	0,133	0,551	0,344
hang seng	0,42	0,349	0,464	0,016
DAX	0,704	-0,525	0,142	-0,03
CAC40	0,814	-0,398	-0,016	-0,06
SP/CITIC300	0,043	0,508	0,264	-0,153
Bovespa	0,098	0,566	-0,547	-0,247
FTSE SOUTH AFRICA	0,684	0,262	-0,032	-0,151
FTSE SINGAPORE	0,378	0,558	0,075	0,288

Table 4: Correlation Between Variables and Components Quiet Period

- Factor 1 is composed of FTSE SOUTH AFRICA, FTSE100,DAX and CAC40 (Europe and South Africa)
- Factor 2 is composed of FTSE SINGAPORE, Bovespa and S&P/CITIC300 (China, Singapore and Brazil)
- Factor 3 is composed of Nikkei (Japan)
- Factor 4 is composed of S and P 500 (USA)

3.3. PCA Results During the Oil Crisis (Turbulent Period)

The number of correlation coefficients higher than 0,5 is more important than before the oil crisis(see appendix 2 for correlation matrix)

	before the crisis	during the crisis
FTSE100/SP500	0,15	0,426
FTSE100/CAC40	0,586	0,799
FTSE100/DAX	0,406	0,639
FTSE100/FTSESA	0,56	0,638
FTSE100/FTSESINGAPORE	0,233	0,233
DAX/CAC40	0,74	0,811
DAX/SP500	0,066	0,303
DAX/FTSESA	0,269	0,415
DAX/FTSESINGAPORE	0,017	0,271
CAC40/SP500	0,1	0,357

Table 5: Selected Correlation Coefficients

For a selected number of cross-country correlation, the correlation during the crisis appears to be higher than before the crisis.

Kaiser-Meyer-Olkin(KMO)	**0,759**	
Bartlett"s test	Khi-deux test	1604,591
	freedom degree	45
	Signification	0

Table 6: KMO and Bartlett's test Turbulent Period

The KMO is close to 0,76, which depicts a good factorization level and it is validated by the Bartlett test (with a p value equals to 0).

Component	**Eigen value**	**%of variance**	**% cumulative variance**
1	3,504	35,042	35,042
2	1,538	15,380	50,422
3	1,087	10,866	61,288

Table 7: Proportion of Variance Explained by Components and Number of Components Turbulent Period

The number of factors retained according to the cut off eigen value point (of 1) is three. The total variance explained by the first component equals 35,042% and 61,288% for the three components.

	1	**2**	**3**
FTSE100	0,849	-0,328	-0,024
SP 500	0,473	-0,367	0,024
Nikkei	0,104	-0,051	0,854
hang seng	0,462	0,66	0,022
DAX	0,806	-0,138	-0,163
CAC40	0,903	-0,133	-0,129
SP/CITIC300	0,21	0,628	-0,398
Bovespa	0,328	0,481	0,238
FTSE SOUTH AFRICA	0,709	-0,142	0,028
FTSE SINGAPORE	0,464	0,419	0,311

Table 8: Correlation Between Variables and Components Turbulent Period

- Factor 1 is composed of FTSE100 DAX CAC40 and FTSE SOUTH AFRICA and SP500 (Europe, USA and South Africa)
- Factor 2 is composed of hang seng and S&P/CITIC300 (China)
- Factor 3 is composed of Nikkei (Japan)

indicators	**Before the oil crisis**	**During the oil crisis**
KMO	0,666	0,759
Number of factors	4	3
Proportion of variance explained by component 1	26,704%	35,042%
Cumulative variance for the first three components	53,24%	61,29%

Table 9: Interdependence Indicators Before and During the Oil Crisis

H1, H2 and H3 are validated due to higher KMO and proportion of variance explained by the first component and to lower number of relevant components during the oil crisis.

According to Fuentes and Godoy (2005) the proportion of variance explained by the first component during the oil crisis is between 35% and 50%, indicating a strong coupling rather than an extreme coupling, so the H4, presence of financial contagion during the oil crisis, is rejected

Factor	Before the oil crisis	During the oil crisis
Factor 1	Europe and South Africa	Europe, USA and South Africa
Factor 2	China, Singapore and Brazil	China
Factor 3	Japan	Japan
Factor 4	USA	

Table 10: Economic Signifiance of Factor

The oil crisis modifies the component structure, during the oil crisis, USA integrates the first component while before the oil crisis, it monopolizes a whole factor. During the oil crisis, the component structure is more concentrated.

4. Conclusion

The main findings of this research study are that both KMO, proportion of variance explained by the first component and number of pertinent factors play the role of financial contagion indicators. The proportion of variance explained by the first component during the oil crisis denotes that the oil crisis is just a strong coupling episode. The KMO during the oil crisis is close to 0,8 which points out good factorization level. The number of components is lower during the oil crisis than before offering also comprehensive factors. The conclusion about contagion presence after the oil crisis is not so obvious, whereas the stock market interdependence growth after the oil crisis is undeniable.

Regarding the rule highlighted by Fuentes and Godoy, three remarks have to be raised, first, The episode tautology (extreme, strong or weak coupling) must integrate other criteria such as the crisis intensity (minor or major), the region stock market indexes (developed, emergent and developing regions) and the type of assets (stock, bonds, commodities,…) second, others principal component indicators have to be added, third , the threshold has to be expressed in terms of difference between the quiet and the turbulent period.

Further researches are expected to test financial contagion during crisis from an investor perspective, considering that an investor must enter the stock market during quiet period and exit from it during turbulent period, joining in that the study conducted by M.Kritzman [15-26].

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Appendix 1: Correlation Matrix Before the Oil Crisis

	FTSE100	**sand 500**	**Nikkei**	**hang seng**	**DAX**	**CAC40**
FTSE100	1	0,15	-0,006	0,211	0,406	0,586
SP 500	0,15	1	-0,026	-0,012	0,066	0,1
Nikkei	-0,006	-0,026	1	0,053	-0,021	-0,072
Hang Seng	0,211	-0,012	0,053	1	0,139	0,194
DAX	0,406	0,066	-0,021	0,139	1	0,74
CAC40	0,586	0,1	-0,072	0,194	0,74	1
SP/CITIC300	0,05	-0,017	0,014	0,148	-0,082	-0,106
BSE Sensex 30	0,146	0,055	-0,003	0,059	0,247	0,318
Bovespa	0,215	0,013	-0,04	0,02	-0,2	-0,053
FTSE SOUTH AFRICA	0,56	0,037	0,029	0,227	0,269	0,334
FTSE SINGAPORE	0,233	0,122	0,041	0,297	0,017	0,095
IPC MEXICO	0,023	0,001	0,086	-0,014	0,168	0,089
BURSATIL	0	0,052	0,134	0,062	0,179	0,094
australia S&P/ASX 200	0,156	0,002	0,041	0,119	0,083	0,108
Tadawul All Share	0,024	-0,029	-0,081	-0,065	-0,049	-0,016
bahrain all share	0,022	0,002	-0,067	-0,025	0,029	0,065

	SP/CITIC300	**BSE Sensex 30**	**Bovespa**	**FTSE SAFRICA**	**FTSE SINGAPORE**
FTSE100	0,05	0,146	0,215	0,56	0,233
SP 500	-0,017	0,055	0,013	0,037	0,122
Nikkei	0,014	-0,003	-0,04	0,029	0,041
hang seng	0,148	0,059	0,02	0,227	0,297
DAX	-0,082	0,247	-0,2	0,269	0,017
CAC40	-0,106	0,318	-0,053	0,334	0,095
SP/CITIC300	1	-0,016	0,073	0,095	0,119
BSE Sensex 30	-0,016	1	-0,041	0,071	0,093
Bovespa	0,073	-0,041	1	0,145	0,149
FTSE SAFRICA	0,095	0,071	0,145	1	0,267
FTSE SINGAPORE	0,119	0,093	0,149	0,267	1
IPC	-0,128	0,065	-0,131	-0,055	-0,04
BURSATIL	-0,041	0,129	-0,221	-0,002	-0,022
SP/ASX 200	0,081	0,086	0,055	0,148	0,199

Tadawul All Share	0,019	-0,057	0,086	0,053	0,023
bahrain all share	0,054	-0,036	-0,005	0,021	0,005

	IPC MEXICO	BURSATIL	australia SP/ASX 200	Tadawul All Share	bahrain all share
FTSE100	0,023	0	0,156	0,024	0,022
SP 500	0,001	0,052	0,002	-0,029	0,002
Nikkei	0,086	0,134	0,041	-0,081	-0,067
hang seng	-0,014	0,062	0,119	-0,065	-0,025
DAX	0,168	0,179	0,083	-0,049	0,029
CAC40	0,089	0,094	0,108	-0,016	0,065
SP/CITIC300	-0,128	-0,041	0,081	0,019	0,054
BSE Sensex 30	0,065	0,129	0,086	-0,057	-0,036
Bovespa	-0,131	-0,221	0,055	0,086	-0,005
FTSE SAFRICA	-0,055	-0,002	0,148	0,053	0,021
FTSE SINGAPORE	-0,04	-0,022	0,199	0,023	0,005
IPC	1	0,103	0,01	-0,035	0,028
BURSATIL	0,103	1	0,117	-0,146	-0,078
SP/ASX 200	0,01	0,117	1	0,002	0,011
Tadawul All Share	-0,035	-0,146	0,002	1	0,664
bahrain all share	0,028	-0,078	0,011	0,664	1

Appendix 2 : correlation matrix during the oil crisis

	FTSE100	SP 500	Nikkei	Hang Seng	DAX
FTSE100	1	0,426	0,087	0,166	0,639
SP 500	0,426	1	0,038	0,017	0,303
Nikkei	0,087	0,038	1	0,022	0,031
hang seng	0,166	0,017	0,022	1	0,24
DAX	0,639	0,303	0,031	0,24	1
CAC40	0,799	0,357	0,045	0,318	0,811
SP/CITIC300	0,005	-0,044	-0,091	0,343	0,139
Bovespa	0,121	0,109	0,078	0,279	0,115
FTSE SOUTH AFRICA	0,638	0,256	0,061	0,234	0,415
FTSE SINGAPORE	0,233	0,079	0,092	0,42	0,271

	CAC40	SP/CITIC300	Bovespa	FTSE SOUTH AFRICA	FTSE SINGAPORE
FTSE100	0,799	0,005	0,121	0,638	0,233
SP 500	0,357	-0,044	0,109	0,256	0,079
Nikkei	0,045	-0,091	0,078	0,061	0,092
Hang Seng	0,318	0,343	0,279	0,234	0,42
DAX	0,811	0,139	0,115	0,415	0,271
CAC40	1	0,151	0,192	0,545	0,276
SP/CITIC300	0,151	1	0,207	0,046	0,093

Bovespa	0,192	0,207	1	0,164	0,223
FTSE SOUTH AFRICA	0,545	0,046	0,164	1	0,232
FTSE SINGAPORE	0,276	0,093	0,223	0,232	1