Journal of Money, Investment and Banking
ISSN 1450-288X Issue 22 (2011)

http://www.eurojournals.com/JMIB.htm

A Volatility Spillover among Sector Index of International Stock Markets

Imen Kouki
Assistant Professor, Finance
Higher Institute of Management, Tunis & LAREQUAD, Tunisia
E-mail: imen_kouki@yahoo.fr

Nizar Harrathi
Assistant Professor of Quantitative Methods
Faculty of Economic Sciences and Management of Nabeul & LAREQUAD, Tunisia
E-mail: nharrathi@gmail.com

Mahfuzul Haque
Associate Professor of Finance, Scott College of Busines
Indiana State University, Terre Haute, IN 47809, USA
E-mail: mahfuzul.haque@indstate.edubstract

Abstract

This study investigates volatility spillover for 5 sectors, namely; banking, financial service, industrial, real estate and oil between international stock markets focusing on two zones. The first zone includes developed market excluding North America, emerging markets and North America. The second zone includes Japan, Australia, developed European markets and North America. The volatility spillover is examined estimating a VAR-BEKK model. We also examine the constant and dynamic of conditional correlation in different sectors. The main result supports the hypotheses of constant conditional correlation. The dynamic conditional correlation (DCC) provides evidence of cross border relationship within sectors. We do find evidence of integration of some sectors through the volatility. Investor who forms his/her portfolios by diversification process may find it of interest- beneficial for forming an accurate asset pricing models.

Keywords: Sector, Volatility, Transmission, Causality in variance, Multivariate GARCH, Conditional correlations.
JEL Classification Codes: G01, G11 G15.

1. Introduction

In recent years, the information technology revolution has had a tremendous impact on the structure of financial markets with the quick diffusion of information and the substantial deregulation and harmonization which led to increasing free flow of capital across markets that has fostered integration (Gallo & Otrando, 2007). Cross listing of securities is another driver that fostered the market integration since a shock occurred in one market is quickly transmitted to the others. This leads to spillovers from one market to other markets and causes the linkages between stock markets around the world to be stronger and the study of volatility linkage as well as volatility to be more important.

Spillover and contagion can alter the correlations between financial markets. Furthermore, at the time of financial crises, the cross-border contagion may have significant consequences for financial stability.

There are extensive literatures on volatility spillover between financial markets. Indeed, the multivariate GARCH and its various extensions (for example VAR-BEKK) have been widely used to examine the co-movement and the transmission of the volatility between index financial markets. Up to this point, not much attention has been given on the detection of the volatility spillover between sector indexes among financial markets. Simply put, no significant work has been undertaken to study the volatility transmission mechanism among the sector returns of national or international financial markets. Extant in the literature, we find two principal streaks; the first research area investigates the transmission of shocks among stock prices and stock return, while the second path study the time path of volatility in stock prices and stock returns. The first one, originally used by Kasa (1992), focuses on the study of the co-movements between different international financial markets, is based on the cointegration analysis. But the second one focuses more on the persistence and transmission of volatility from one market to other markets by using the autoregressive conditional heteroscedasticity (ARCH) to model time variant conditional variances. Our study combines elements of the both the lines of research by examining the volatility and shock transmission mechanism among five international sector indexes.

The objective of this study is to empirically investigate the volatility spillover of each sector across financial markets. We examine the hypothesis; since there is spillover volatility across financial market on the world, co-movement should be transmitted between indexes of each sector among international financial market. We apply the econometric technique proposed by Engle and Kroner (1995) by a VAR-BEKK model for five sectors, namely, Banking, Financial Service, Industrial, Real Estate and Oil between the International financial markets with the analysis primarily focused in two zones. The first zone (hereafter referred as the first zone) comprised of the Developed Markets (DM) excluding North America (NA), Emerging Markets (EM) and North America. The second zone (hereafter referred as the second zone) includes Japan (JA), Australia (AU), Developed European Markets (DEU) and North America. We also examine the constant and dynamics of conditional correlation in different sectors

Our study is distinct in the sense as it considers volatility spillover among five different sectors of international market encompassing both the developed and the emerging markets, and find integration of some sector through the volatility. Therefore an investor, who chooses his/her portfolios by diversification process, may find it beneficial for developing a correct asset pricing models, forecasting volatility in sector return with the hypothesis of volatility spillover and transmission of risk information, thereby enhancing the understanding of the equity markets.

The paper is organized as follows. Section 2 presents the main contributions of the literature. Section 3 presents the specific model. Section 4 discusses the dataset and the methodology. Section 5 and 6 reports the empirical results of volatility spillover, and presents the results of CCC and the dynamic conditional correlation (DCC) models. A discussion of the results is presented in section 7 while section 8 concludes the study.

2. Literature Review

There is a large body of literature which focuses on the volatility spillover of different markets over time, using a multivariate GARCH model. Christiansen (2007) examined mean and volatility spillover effects from both the US and Europe into the individual European bond markets and found negligible mean-spillover but volatility spillover effects was substantial. Wongswan (2006) studied the information transmission from the U.S. and Japan to the Korean and Thai equity markets and concluded that there is a large and significant association between developed market and emerging market equity volatility at short time horizons. Hassan and Malik (2007) estimated the mean and conditional variance among different US sector indexes and found significant transmission of shocks

and volatility among different sectors. Harris and Pisedtasalasai (2006) investigated return and spillover effects between the FTSE100, FTSE250 and FTSE Small Cap equity. They found that volatility transmission mechanism between large and small stocks in the UK is asymmetric.

Recent literature on Middle East and North Africa (MENA) market volatility uses univariate GARCH models and examines volatility behavior at the market index level. Hammoudeh and Li (2008) examined sudden changes in volatility for five Gulf Cooperation Council (GCC) stock markets at the market index level, using the iterated cumulative sums of squares (ICSS) algorithm, and analyzed their impacts on the estimated persistence of volatility. They found that most of these stock markets are more sensitive to major global events than to local and regional factors. Zarour and Siriopoulos (2008) used the univariate CGARCH to investigate the existence of volatility composition into short run and long run components. Malik and Hammoudeh (2007) examined the volatility and shock transmission mechanism among US equity, Gulf equity and global crude oil markets within a multivariate GARCH framework. They found significant transmission among second moments. They are able to document that Gulf equity markets are the recipients of volatility from the oil market. Hammoudeh, Yuan and McAleer (2009) examined the dynamic volatility and volatility transmission in a multivariate setting using the VAR(1)–GARCH(1,1) model for three major sectors, namely, Service, Banking and Industrial/or Insurance, in four GCC's economies (Kuwait, Qatar, Saudi Arabia and UAE). The results suggested that past own volatilities matter more than past shocks and there are moderate volatility spillovers between the sectors within the individual countries, with the exception of Qatar.

Another strand in the literature focuses on the transmission of news between cross-listed equities in order to examine the validity of the information that is transmitted with this kind of dataset. Cappiello, Engle and Sheppard (2006) extend the basic Dynamic Conditional Correlation model of Engle (2002) to study the correlations of global equity and bond returns by allowing for more flexible dynamic dependencies in the correlations and asymmetries, as well as switches, in the correlations across regimes. Li and Majerowska (2008) examined the linkages between the emerging stock markets and the developed markets using the BEKK parameterization of MGARCH. They found evidence of returns and volatility spillovers from the developed to the emerging markets implying that foreign investors may benefit from risk reduction by adding emerging markets' stocks to their portfolio. Koulakiotis and *al* (2009) used the multivariate GARCH-BEKK modeling approach to examine the transmission of news (both volatility and error) between portfolios of cross-listed equities within three European financial regions. They found that the Finnish and Danish portfolios of cross-listed equities are the main transmitters of volatility relative to the Swedish and Norwegian portfolios of cross-listed equities. Indeed, the Paris, Amsterdam and Brussels stock exchanges are the major exporters of volatility and error to the portfolios of cross-listed equities traded on the Milan and Madrid stock exchanges.

3. Model Specification

In this study, we use the vector autoregression (VAR) framework with one lag[1] to analyze interrelationship among returns index for each sector: The mean equation is given by:

$$Z_t = \Pi + \Gamma Z_{t-1} + \varepsilon_t \varepsilon_t \backslash I_{t-1} \curvearrowright N(0, H_t) \tag{1}$$

Where Z_t is a *k*1* vector of daily return index at time t, π is a *k*1* matrix of constants and Γ is a *k*k* matrix of parameters of lagged returns index. ε_t is a *k*1* vector of random errors representing the innovation at time t with a *k*k* conditional variance-covariance matrix H_t and I_{t-1} represents the market information at time t-1.

The multivariate GARCH and its various extensions have been widely developed in the parameterization of conditional cross- moments. Different classes of MGARCH models haves been proposed. They differ in the characterization of the conditional variance matrix of a stochastic vector

[1] The AIC lag selection criterion is used.

process. Engle and Kroner (1995) proposed a BEKK model that can be viewed as a restricted version of the VECH model. The BEKK (1,1) model has the following form:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}'A + G'H_{t-1}G \tag{2}$$

Where C is a $k*k$ lower triangular matrix of constants, A and G are $k*k$. The diagonal parameters in matrices A and G measure the effect of own past shocks and past volatility of market i on its conditional volatility. The off-diagonal elements in matrix $A(a_{ij})$ and $G(g_{ij})$ measure respectively the cross-market effects of shock spillover and the cross effect of volatility spillover.

Recently, MGARCH model uses conditional correlation. Bollerslev (1990) introduced a class of multivariate GARCH model with the assumption that the conditional correlations are constant (CCC). However, the assumption of Bollerslev's (1990) model may not be supported in many empirical studies. In order to make the conditional correlation matrix time-variant, (Tse and Tsui 2002; Engle 2002; Engle and Sheppard 2001) proposed a generalization of the CCC model[2], by making the conditional correlation matrix time-dependent. This model is known as the dynamic conditional correlation (DCC). The DCC approach guarantees that the time dependent conditional correlation matrix is positive for each point in time.

The dynamic conditional correlation (DCC) of Tse and Tsui (2002) has the following form:

$$H_t = D_t R_t D_t \tag{3}$$

$$R_t = (1-\theta_1-\theta_2)R + \theta_1\psi_{t-1} + \theta_2 R_{t-1} \tag{4}$$

Where D_t defined as in equation.5, R s a symmetric $k\times k$ ositive definite parameter matrix with unit diagonal elements, ψ_{t-1} the $k\times k$ orrelation matrix of the past P tandardized residual $(\hat{\varepsilon}_{t-1}\ldots\hat{\varepsilon}_{t-P})$ A necessary condition to ensure the positivity of ψ_{t-1} s $P \geq k$ θ_1 d θ_2 e non-negative scalar parameters satisfying $\theta_1+\theta_2<1$ Moreover, Engle (2002) proposes different dynamic conditional correlation model. The DCC model of Engle, the covariance matrix is decomposed as follows:

$$H_t = D_t R_t D_t\ . \tag{5}$$

Where Q_t a symmetric $k\times k$ ositive definite matrix containing the conditional covariance of standardized residuals given by:

$$Q_t = (1-\theta_1-\theta_2)Q_0 + \theta_1\eta_{t-1}\eta_{t-1}' + \theta_2 Q_{t-1} \tag{6}$$

Where Q_0 s the unconditional covariance matrix of $\eta_t\,\eta_t$ defined as in Eq. 5, θ_1 d θ_2 e non-negative scalar parameters satisfying $\theta_1+\theta_2<1$ θ_1 presents the impact of last shocks on a current conditional correlation and θ_2 ptures the impact of the past correlation. If θ_1 d θ_2 e statistically significant, the conditional correlations are not constant. Engle (2002) shows that the likelihood function can be written as:

$$L(\theta) = -\frac{1}{2}\sum_{t=1}^{T} log\left(2\pi + 2log\left|D_t\right| + log\left|R_t\right| + \eta_t' R_t^{-1}\eta_t\right) \tag{7}$$

4. Data Description

The daily data, collected from DataStream, covers the period from January 01, 2002 to October 10, 2009 has 2028 observations. We collected data of five sectors daily indices, namely bank, real estate, industrial, financial service and oil, with the analysis focused on two zones. The first zone includes developed market (DM) excluding North America (NA), emerging markets (EM) and North America.

---

[2] See more details in Bauwens *et al* (2006)

The second zone is defined by Japan (JA), Australia (AU), Developed European markets (DEU) and North America.

Table N°1 & graph N°1.1[3] summarizes the descriptive statistics for the daily return index[4]. We find DM, EM, NA, JA and AU, in the oil sector gives the greatest average return relative to the others sectors. The industrial sector of DEU yields the greatest returns. In terms of risk, we find banking sector for NA and DEU has the highest, but the oil sector has the highest risk for DM and EM. For the two later markets, sector historical risk is commensurate with return. However, the financial service sector is the most risky for JA and AU**.**

[3] We represent only graphics of Bank sector. The others graphics are not reported but available from the authors.
[4] The return is measured as the first log difference of sector indices.

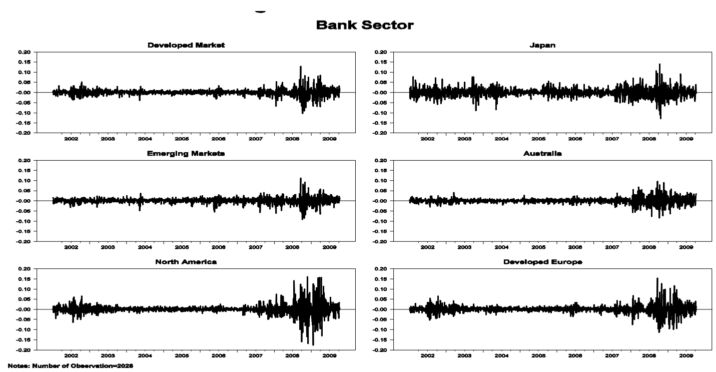
Zarour, B. and Siriopoulos, C. P. 2008, Transitory and permanent volatility components: The case of the Middle East stock markets. *Review of Middle East Economics and Finance, volume 4, pp. 1-14.*

Table N 1: Descriptive Statistics of stock returns

	Bank Sector						**Financial service Sector**					
	MD	**EM**	**NA**	**JA**	**AU**	**DEU**	**MD**	**EM**	**NA**	**JA**	**AU**	**DEU**
Mean	0,00009	0,00007	-0,00015	-0,00013	0,00016	-0,00004	0,00009	0,00025	-0,00009	-0,00047	0,00041	0,00019
Std, Dev,	0,015	0,014	0,023	0,0207	0,0141	0,019	0,015	0,015	0,021	0,022	0,021	0,014
Skewness	-0,14	-0,397	0,144	0,096	0,21	0,095	-0,301	-0,489	-0,126	-0,071	-0,58	-0,246
Kurtosis	9,883	8,717	14,499	0,434	6,758	10,314	4,2191	4,728	11,087	3,607	9,26	8,159
Jarque-Bera	8257,489*	6472,265*	17764,367*	1599,531*	3872,524*	8989,040*	153,407*	1968,994*	10388,351*	1100,947*	7356,4551*	5643,088*
ARCH-LM	99,737*	198,270*	69,989*	81,117*	111,474*	84,028*	106,387*	119,872*	74,844*	68,978*	162,736*	77,395*
L,B *Q*(10)	75,811*	86,401*	58,064*	30,646*	46,980*	46,358*	68,263*	75,380*	42,858*	28,575*	21,413*	50,158*
	Industrial Sector						**Real Estate Sector**					
Mean	0,00029	0,00068	-0,00003	0,00002	0,00003	0,00032	0,0003	0,00032	0,00009	0,00012	0,00003	0,00031
Std, Dev,	0,013	0,001	0,014	0,017	0,012	0,015	0,012	0,014	0,021	0,02065	0,01646	0,01225
Skewness	-0,377	-0,69	-0,258	-0,285	-0,481	-0,203	-0,489	-0,532	-0,258	-0,019	2,533	-0,454
Kurtosis	5,317	5,694	5,684	6,966	5,262	6,267	6,317	8,75	13,542	3,453	10,316	5,528
Jarque-Bera	2436,394*	2899,730*	2752,038*	4126,091*	2417,376*	3331,652*	3451,833*	6567,303*	15512,065*	1007,341*	901143,591*	2651,653*
ARCH-LM	176,052*	113,025*	96,696*	203,125*	57,182*	81,150*	185,492*	53,324*	129,633*	137,425*	2,121***	83,338*
L,B *Q*(10)	88,455*	77,409*	17,944*	35,367*	24,733*	47,710*	73,159*	139,752*	83,018*	55,582*	43,721*	39,104*
	Oil Sector											
Mean	0,00034	0,00084	0,00041	0,00013	0,00054	0,00028						
Std, Dev,	0,016	0,016	0,018	0,019	0,016	0,017						
Skewness	-0,213	-0,738	-0,634	-0,368	-0,387	-0,07						
Kurtosis	9,837	12,772	10,923	4,954	5,704	9,692						
Jarque-Bera	8189,759*	13963,058*	10214,737*	2119,293*	2799,230*	7936,472*						
ARCH-LM	126,880*	99,951*	159,666*	156,354*	152,674*	104,751*						
Ljung Box-*Q*(10)	72,870*	96,893*	51,305*	35,355*	16,395*	76,511*						

Notes: *,* and ***, denotes the levels of significance of 1%, 5% and 10% respectively, Ljung Box-Q(10) is the statistic for serial correlation.

Figure 1.1: Index Return



In order to identify if the index return is integrated or stationary, we conduct the unit root test. All the tests[1] findings indicate a rejection of the zero hypotheses that returns have a unit root in the favor of the hypotheses of the stationary. We also study the short run relationship between different index return through Granger and VAR model. First, the result of Granger causality test show that index sectors return of each market is caused by the other index returns. However, the Granger causality doesn't provide the strength of interrelationship. Therefore, the study of the volatility interdependence and cross-correlation are examined by the VAR framework. The lag length of endogenous variable is based on AIC criterion. The results[2] show that returns are correlated by their own past returns and the lags of the returns of the other sectors. Hence, there exists a conditional return spillover between different sectors. This result confirms the Granger causality.

5. Volatility Spillover

In this section, we examine the estimated result of time-varying variance-covariance by the BEKK (1, 1) model. The main results of the equation N°1 and N°2 are presented in tables N°2 and N°3, for each sector and zone.

Table N 2: Estimates Results of VAR (1)

	Bank		***Financial Service***		***Industrial***		***Real estate***		***Oil***	
	G1	***G2***	***G1***	***G2***	***G1***	***G2***	***G1***	***G2***	***G1***	***G2***
a_{11}	-0,083*	0,064*	0,047	0,039**	-0,014	-0,065*	0,075*	0,069*	-0,224*	-0,081*
a_{12}	0,068*	-0,065**	0,019	-0,036**	0,048**	-0,022	0,0632	0,014	0,115*	0,036
a_{13}	0,307*	-0,224*	033*	0,309*	0,424*	0,231*	0,251*	0,213*	0,412*	0,207
a_{14}		0,206*		0,346*		0,402*		0,253*		0,393*
a_{21}	-0,036*	-0,028*	1,309 10-3	-0,015	0,032	-0,063*	0,047**	-0,005	-0,095*	-0,034**
a_{22}	0,144*	-0,023	0,062**	-0,014	0,087*	-0,026	0,131*	-0,01	0,121*	-0,089*
a_{23}	0,226*	0,221*	0,281*	0,140*	0,388*	0,096*	0,182*	0,035	0,293*	0,215**
a_{24}		0,056		0,466*		0,330*		0,039*		0,406*
a_{31}	0,066	0,031	6,596 10-3	-0,001	-0,054**	0,014	-0,006	-0,032*	0,008	0,001
a_{32}	-0,072*	-0,014	5,67810-3	0,015	0,0188	-0,002	0,01	-0,017	-0,005	0,043**
a_{33}	-0,052**	-0,062*	-0,044	-0,061*	-0,00007	-0,11*	0,004	0,037*	-0,015	-0,279*
a_{34}		0,034***		0,262*		0,371**		0,142*		0,438*
a_{41}		0,013		-0,004		-0,016		-0,025*		-0,003*
a_{42}		-0,001		-0,056*		-0,039***		0,008		-0,024
a_{43}		0,324*		0,0082*		0,009		0,066*		-0,01
a_{44}		-0,112*		-0,074*		-0,038***		-0,044**		-0,008

[1] Results are not reported but available from the authors.
[2] Results are not reported but available from the authors.

Table 3: Estimates Results of multivariate GARCH: VAR(1)-BEKK(1,1), CCC and DCC

	Bank		***Financial Service***		***Industrial***		***Real estate Sector***		***Oil Sector***	
	G1	**G2**	**G1**	**G2**	**G1**	**G2**	**G1**	**G2**	**G1**	**G2**
Estimates parameters of BEKK(1,1) Model										
a_{12}	-0,021	0,001	0,112*	0,028**	0,158*	-0,077*	-0,029	0,078*	-0,183*	-0,02
a_{13}	-0,203*	-0,016***	-0,038***	0,004	-0,039	0,068*	0,063**	0,004	0,098*	-0,005
a_{14}		-0,008		0,001		-0,026*		-0,015		0,018
a_{21}	0,099*	0,046**	0,004	-0,006	0,003	-0,044***	0,119*	0,035*	0,127*	-0,034
a_{23}	0,02	0,079*	0,005	-0,002	-0,075*	-0,006	-0,013	0,077*	-0,033	0,069**
a_{24}		0,042**		0,085*		0,014		-0,029		-0,025
a_{31}	0,157*	-0,013	0,058*	0,132*	0,139*	-0,150*	-0,038**	0,02	0,066*	0,281*
a_{32}	0,113*	-0,021	0,056*	0,198*	0,151*	-0,184*	0,01	1,434*	0,146*	0,226*
a_{34}		0,032		-0,099*		0,006		-0,004		-0,042
a_{41}		0,048***		0,043*		0,065**		-0,003		0,145*
a_{42}		0,014		-0,048**		0,051**		0,489*		-0,041**
a_{43}		-0,04		0,090*		0,187*		0,147*		0,003
g_{12}	0,008	0,0004	-0,036*	-0,007**	-0,070*	-0,135*	-0,003	0,012**	0,204*	-0,134*
g_{13}	0,125*	0,001	0,004	-0,001	0,038*	-0,175*	0,001	-0,0003	-0,131*	0,102*
g_{14}		0,003		0,001		0,068*		0,002		0,106*
g_{21}	-0,053*	-0,008	-0,018***	0,009***	-0,032*	0,052***	-0,015*	0,026***	-0,152*	0,271*
g_{23}	-0,004	-0,011***	0,0002	0,002	0,022*	-0,076*	-0,002	-0,017	0,081*	0,341*
g_{24}		-0,00001		-0,019*		0,028**		0,043*		0,056***
g_{31}	-0,060*	0,012**	-0,004	-0,072*	0,003	0,399*	0,015*	-0,037*	0,082*	0,133*
g_{32}	-0,017*	0,008	-0,004	-0,047*	-0,002	0,212*	0,0001	0,051*	-0,048*	-0,320*
g_{34}		0,005		0,019*		-0,012		0,089*		-0,031
g_{41}		-0,024*		0,007*		-0,244*		-0,012*		-0,153*
g_{42}		-0,008		0,018*		-0,096*		-0,025*		0,136*
g_{43}		-0,001		-0,060***		0,023***		-0,051*		0,029
LLR	19568,107	24343,456	18423,152	23387,84	19552,77	25192,779	19342,2	24359,891	18746,445	23964,713
AIC	-19,281	-23,969	-18,151	-23,026	-19,266	-24,808	-19,058	-23,986	-18,47	-23,595
Constant Conditional Correlation: The CCC Model										
r_{12}	0,627*	0,247*	0,545*	0,262*	0,607*	0,275*	0,506*	0,102*	0,582*	0,264*
r_{13}	0,446*	0,087*	0,298*	0,199*	0,407*	0,265*	0,210*	0,138*	0,580*	0,198*
r_{32}	0,315*	0,074*	0,296*	0,406*	0,277*	0,178*	0,190*	0,334*	0,467*	0,195*
r_{41}		0,176*		0,113*		0,151*		0,049**		0,148*
r_{42}		0,222*		0,141*		0,112*		0,143*		0,146*
r_{43}		0,482*		0,432*		0,510*		0,300*		0,580*
LLR	19568,208	24419,51	18379,15	23404	19496,31	25219,759	19341,89	24242,447	18823,315	24080,14
AIC	-19,293	-24,068	-18,119	-23,066	-19,222	-24,858	-19,069	-23,893	-18,558	-23,733
Dynamic Conditional Correlation: The DCC Model										
θ_1	0,022*	0,011*	0,013*	0,011*	0,014*	0,009*	0,016*	0.009*	0,012*	0,006*
θ_2	0,975*	0,987*	0,985*	0,986*	0,982*	0,988*	0,982*	0.990*	0,985*	0,993*
LLR	19606,789	24419,776	18440,682	23408,44	19539,84	25215,393	19356,75	24322.393	18859,585	24070,841
AIC	-19,332	-24,072	-18,181	-23,074	-19,266	-24,858	-19,085	-23.976	-18,594	-23,728

Notes: Standard errors, constants, aij and gii are omitted to save space, *,**,*** represent the levels of significance of 1%, 5% and 10% respectively, LLR and AIC represent the log likelihood ratio and Akaike Information Criterion.

The existence of any causal relation among variance and covariance included in H_t imply that the off-diagonal coefficients of $A(a_{ij})$ and $G(g_{ij})$ are statistically significant. In fact, a_{ij} and g_{ij} respectively measure the effect of the own and cross past shock and past conditional volatility of the other markets. The most important feature of the BEKK model is that it can explain causality relation among both variance and covariance. The results of estimated BEKK are shown in table N°3.

5.1. Bank Volatility Spillover

As shown in table N°3, the coefficients a_{ij} are significant, except $a_{12}$and $a_{23}$for the first zone, a_{13}, a_{21}, a_{23} and a_{12}, a_{14}, a_{41}, a_{42} and a_{32} the second zone. Hence, we note a significance and negative effect of cross shock of DM on NA return, JA and AU on NA and AU on DEU and NA return, there is a cross shock between NA and DEU with a positive effect of cross shock is noted from EM to DM, NA to both DM and EM. Finally, for the second zone, the shock of AU sector influences positively the volatility of JA, DEU and NA. .

For the cross effect of volatility spillover, we find for the first zone a bidirectional effect between NA and DM, the conditional volatility of NA affect negatively the volatility of DM. This later affects positively the NA volatility. However, there is unidirectional effect between EM and DM, and EM and NA. Hence, we note that the volatility EM and NA bank sector have, respectively, a negative effect on DM and EM volatility. These results show that both shock and volatility of NA bank sector affect the volatility of DM and EM, thus confirming the hypothesis that information risk from NA bank sector plays a dominant role in the transmission of information.

However, the transmission of information of EM on NA has no effect, supports the hypothesis of low impact of this market on NA. While the DM affects the NA bank sector, confirms the hypothesis of integration of two sectors. Finally, we note, transmission of information from EM to DM. This result shows how the emerging bank system can influence the developed bank and that investors have to integrate the information risk of EM banks in their portfolio decision.

For the second zone, the results are interesting. In fact, the information risk of NA bank affect positively the volatility and only for JA bank, while the volatilities of DEU and AU are not influenced by the conditional volatility of NA. Also, the conditional volatility of DEU bank affects the volatility of JA bank. These results show the important role played by NA and DEU bank on the integration of information on the volatility of JA bank**.** However, there is no cross spillover between DEU volatility and NA volatility. The two markets are closely integrated, only by their shock and not by the cross volatilities.

5.2. Financial Volatility Spillover

The results show a bidirectional shock spillover between DM and NA, DEU and NA, while for NA and AU it is opposite. We find a unidirectional shock spillover from DM and NA to EM, from JA and DEU to AU and from DEU and NA to JA. For the volatility spillover, we find, for the first zone a bidirectional between DM and EM. However, the NA financial service has no information risk impact on the two markets. This result confirms the integration of EM with DM in the financial sector in term of volatility. For the second zone, the bidirectional causality in volatility spillover is shown between DEU and NA and NA and AU. Consequently, there is a strong integration of each of the two markets in the financial sectors. However, there is unidirectional volatility spillover from JA to AU, from DEU and NA to JA. The later result shows that the JA financial sector is influenced by NA and DEU and is susceptible to volatility from these markets and in his tour JA financial volatility influence the volatility of AU.

5.3. Industrial Volatility Spillover

Here we find a bidirectional shock spillover between EM and NA and unidirectional shock spillover from DM to EM and from NA to DM. The strong connection between EM and NA industrial sector may be explained by the importance and the degree of integration of this sector on the economic

condition of emerging. However, the service sector like bank and financial are not well developed and still weak and not integrated with developed market. For the volatility spillover, we note the information risk of NA industrial sector can influence neither DM nor EM. This explains the weakness of industrial sector of NA and the information risk from this sector don't play a dominant role of the transmission of information to DM and EM industrial. This result is confirmed by the presence of volatility spillover from DM and EM to NA industrial sector. However, the DM and the EM industrial sector are highly integrated because there is a bidirectional volatility spillover. This result confirms the strong interdependence between DM and EM industrial sector. Also, the EM industrial plays a dominant role of the transmission of information to DM. For the second zone, we note bidirectional volatility between the four markets. Hence, a strong integration of the industrial sector of the four markets in terms of volatility. So, investors have to take account of information risk from all markets in their portfolio decision. However, for the shocks spillover, we find only the bidirectional between, JA and AU, JA and DEU and JA and NA.

5.4. Real Estate Volatility Spillover

For the first zone, we find a weak integration between the three markets. In fact, for the volatility spillover, only DM real estate sector is affected by EM and NA. While for the shock spillover a bidirectional effect between DM and NA and unidirectional from EM to DM. The impact of information risk and shock of NA real sector on the volatility transmission of DM can be explained by the spread of subprime crisis of 2006-2007 in the world. However, the transmission and the contagion from EM to DM can be explained by the increase of real estate investment on EM markets. For the second zone, we note the dominance of NA on the other markets. Hence, volatility spillover of NA is transmitted to DEU, JA and AU markets. This can be explained again by the subprime crisis. However, there is bidirectional volatility spillover between DEU and NA and between JA and AU. It confirms the strong integration of real estate of the two markets and JA and AU volatility are affected by the European conditional volatility.

5.5. Oil Volatility Spillover

For this sector, we note a strong integration between markets of different zone. In fact, we find for the bidirectional shock and volatility spillover between markets. This result is explained by the higher volatility of oil price during this period and hence reinforces the integration of the market.

6. Constant and Dynamic Conditional Correlation

As expected all constant conditional correlations (CCC) are positive (table N°3). This reflects a simultaneous growth between different zones in each sector. We note, expect for the oil sector in the second zone, the CCCs are below *0.6*, showing different advantages and varying role played by each sector in the integration between different markets. As a matter of fact, for each sector, we note that high correlation is between DM and EM, DEU and NA. On the other hands, the lowest correlation is noted in real estate sector. The correlation is between *0.25* and *0.5*, reflecting a lower integration in this sector, despite of the subprime crisis.

Next, we investigate the interdependence among different markets of each sector using the DCC approach (table N°3). We focus only in the significant event of the global financial crisis of 2008.

We plot the dynamic correlations across financial markets within each sector (graph N°2.1)[1]. Theses correlations reflect the agent's behavior in the sector depending on the state of the economy. First, there is a dynamic correlation over the period and across market for each sector. In fact, we find, at least the coefficient θ_1 orθ_2 or the two coefficients is positively significant. Most series show an effect of the financial crisis 2008.

[1] We represent only graphics of Bank sector. The others graphics are not reported but available from the authors.

Figure 1.1: Index Return

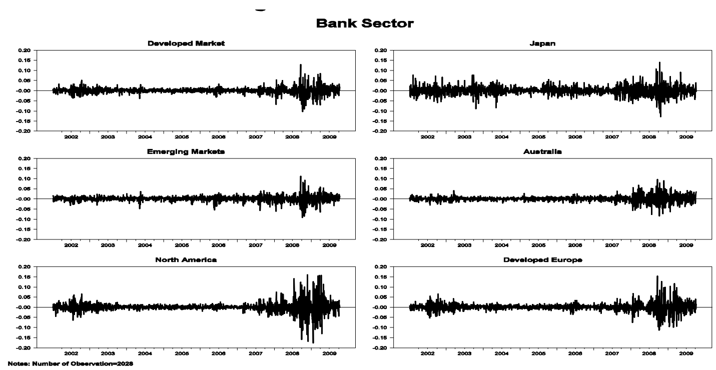
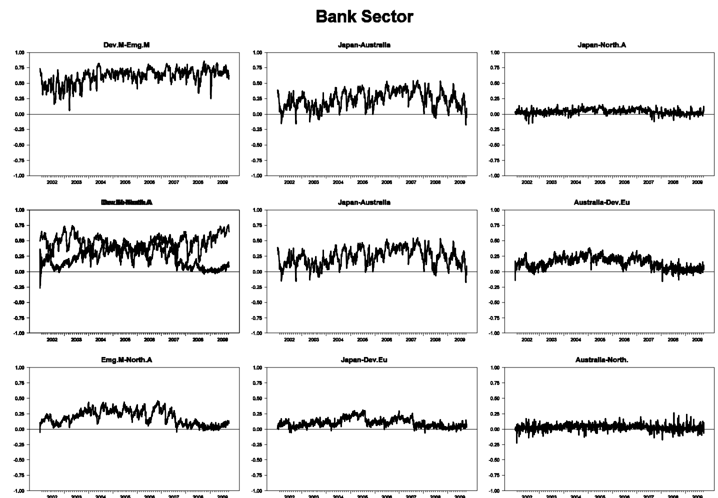


Figure 2.1: Dynamic Coditional Correlation



The correlation of the bank sector in DM and NA, and DM and EM is dynamic and positive throughout the sample period. The positive relationship became strong during the financial crisis between DM and EM. The correlation reached the peak level is about *0.8*. At the beginning of 2009, the correlation is decreased to reach *0.2* followed by an increase. However, the correlation between DM and NA wasn't affected at the beginning by the crisis. In fact, the correlation is still low and approximately equal to zero. But it increases at the beginning of 2009, but still very low. The correlation between NA and EM was the lowest during the crisis, comparing to the sample period. We note an independence between the two markets, as the correlation is zero. For the second zone, the correlation is very low between different markets, except between DEU and NA. For the others, the correlation, during the crisis is near zero, showing that integration has been decreased by the crisis. However for DEU and NA, was high before the crisis, the peak is *0.7*. The correlation decreased at *0.2*, just before the beginning of the crisis and increase quickly to 0.6 at the end of 2008. The correlation is still growing up in 2009. This strong correlation shows the high degree of integration of these two markets. For the financial service sector, the correlations are dynamic and positive for the first zone. We note that the crisis reinforces the integration between the three markets. In fact, the correlation between EM and DM reach its peak at the beginning of the financial crisis in September 2008, which is about *0.8*. While the correlation of NA with EM and DM is approximately zero at the beginning of 2008 and increases with the financial crisis. However, the correlation is less than *0.6*. So, the crisis reinforces the integration of the financial sectors of these markets. For the second zone, we note that the crisis was a factor for the increase in the correlation of NA with DEU and between JA and AU. In

fact, at the beginning of the crisis, the correlation of JA and AU reached its peak level (around *0.6*). While for NA and DEU, there are two periods of higher level of correlation. The first reach its peak at the beginning of with the subprime crisis and the second with the global financial crisis. The correlations are respectively *1* and *0.8*. Also, the correlation is very volatile for these markets. The correlation of NA and AU is very low throughout the sample period. It is less than *0.25*. Especially with the financial crisis, the correlation is negative. However, for JA with NA and DEU and AU with DEU, the crisis has a negative effect on the integration. In fact, with the crisis, the correlation is lowest throughout the sample period and near zero. The crisis has reinforced the integration of the first zone and between EM and DM for the industrial sector. In fact, the correlation has reached the peak during the crisis, above *0.8*. For DM and NA, the correlation is lowest throughout the sample period. Also, the correlation of NA and EM is very low; less than *0.25*. So the crisis is not a factor of integration for industrial sector of these two markets. For the second zone, we note that during the financial crisis, the correlation is the lowest for AU with NA DEU and JA and JA with DEU and NA. The correlation is almost zero. However, the correlation between NA and DEU increases during the financial crisis and is about *0.7*. Hence, the crisis is a factor of integration of industrial sector of DEU and NA.

For the real estate sector, the correlation is very volatile for the all the zones. We note that during the financial crisis, the correlation is the lowest for DM with NA, and is approximately zero. However, the correlation reached the peak at the beginning of 2007. This can be explained by the effect of subprime crisis with a lag. The same feature is noted for the correlation between EM and NA. For DM and EM, the correlation is high throughout the sample period. For the second zone, there is no correlation between AU and NA, JA and DEU and JA and NA. However, for JA and AU, the correlation reached the pick at the beginning and by 2009, the correlation is stationary and near zero. For DEU and NA, the correlation is low just before the financial crisis and is about (*-0.1*). With the crisis, the correlation increases and reaches *0.3*. And for AU and DEU, the correlation reached its peak at the beginning of the crisis, around *0.8* but dropped quickly to zero.

Finally, the oil sector is characterized by a higher volatility of his price during the sample period. This volatility is noted on the correlation between different markets. Hence, the correlation is dynamic, positive and very volatile for all zones. However, with the crisis, the correlation decrease and reaches the zero value for some markets.

7. Discussion

The analysis of the results by sector shows that the international financial markets are not integrated in all the sectors. Mainly, we find three highly integrated sectors: bank, real estate and oil. This integration can be explained by the crisis of these sectors faced. Banking, real estate and oil sectors had been affected respectively by financial, subprime and oil crisis. However, the financial service and industrial sectors are less integrated.

A potential investor can minimize the risk of his/her portfolios by diversifying in these two sectors. Hence, the diversifications of international portfolios are associated with the type of the sectors; therefore the investor can take into account the type of the sector on his/her portfolios decision. Another feature of our result shows the importance of the risk information of emerging market on the transmission of the volatility, especially in the industrial and real estate sectors.

On other hand, the DDC is significant, showing that the conditional correlation is not constant. However, we find the financial crisis of 2008 is not a factor of the integration and correlation for the oil sector and for the real estate of the first zone. Therefore, the crisis can be considered as a factor of integration between NA and DE for the different sectors, except oil between EM and DM. Also, the financial crisis reinforces the correlation of financial sector of the first zone.

8. Conclusion

Using VAR-BEKK model to examine volatility spillover among five different sectors of international market encompassing both the developed and the emerging markets, we find that the linkage between international financial markets depends on the type of the sector. Evidence of high integration is found between some sector through the volatility like the banking; real estate and oil, while the financial service and industrial are less integrated. An investor, therefore, who chooses his/her portfolios by diversification process, may find it beneficial for developing a correct asset pricing models, forecasting volatility in sector return with the hypothesis of volatility spillover and transmission of risk information, thereby enhancing the understanding of the equity markets. For future research, this study can be extended in several ways. An extension of BEKK model incorporating for the asymmetric features of volatility spillover to examine the contagion effect of the financial crisis on the volatility spillover and to perform the volatility spillover among sectors of each market. Also, using models' results, we can compute and analyze the optimal weights and hedge ratios for two-sector portfolio holdings between international indices.

Reference

[1] Bauwens, L., Laurent, S. and Rombouts, J.K.V. 2006, Multivariate GARCH models: a survey. *Journal of Applied Econometrics*, volume 21, pp. 79-109.

[2] Bollerslev, T. 1990, Modeling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. *Review of Economics and Statistics*, volume 72, pp. 498-505.

[3] Cappiello, L., Engle, R.F. and K. Sheppard, 2006, Asymmetric dynamics in the correlations of global equity and bond returns. *Journal of Financial Econometrics*, volume 4, pp. 537-572.

[4] Christiansen, C. 2007, Volatility-Spillover Effects in European Bond Markets. *European Financial Management*, volume 13(5), pp. 923-948.

[5] Christodoulakis, G.A. and Satchell, S.E. 2002, Correlated ARCH: modeling the time-varying correlation between financial asset returns. *European Journal of Operations Research*, volume 139, pp. 351-370.

[6] Elder, J. 2003, An impulse-response function for a vector autoregression with multivariate GARCH-in-mean, *Economics Letters*, Volume 79, N°1,pp 21-26.

[7] Engle, R.F. 2002, Dynamic conditional correlation: a simple class of multivariate generalized autoregressive conditional heteroskedasticity models, Journal *of Business and Economic Statistics*, volume 20, pp. 339-350.

[8] Engle, R.F. and Kroner, K.F. 1995, Multivariate simultaneous generalized ARCH. *Economic Theory*, volume 11, pp. 122-150.

[9] Engle, R.F. and Sheppard, K. 2001, Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH, *NBER Working Paper* Series, 8554.

[10] Gallo, G. M. and Otrando, E. 2007, Volatility transmission across markets: A multi-chain Markov switching model. *Applied Financial Economics*, volume 17(8), pp. 659-670.

[11] Hammoudeh, S.M, Yuan, Y. and Michael McAleer,M. 2009, Shock and volatility spillovers among equity sectors of the Gulf Arab stock markets. *The Quarterly Review of Economics and Finance*, volume 49(3), pp. 829-842.

[12] Hammoudeh, S.M. and Li, H. 2008, Sudden changes in volatility in emerging markets: The case of Gulf Arab stock markets. *International Review of Financial Analysis*, volume 17, pp. 47–63.

[13] Harris R.D.F and Pisedtasalasai, A. 2006,Return and Volatility Spillovers between Large and Small Stocks in the UK. *Journal of Business Finance and Accounting*, volume 33(9-10), pp. 1556-1571.

[14] Hassan, S.A. and Malik, F. 2007, Multivariate GARCH modeling of sector volatility Transmission. *Quarterly Review of Economics and Finance,* volume 47, pp. 470-480.

[15] Kasa, K. 1992, Adjustment costs and pricing-to-market theory and evidence. *Journal of International Economics*, volume 32(1-2), pp. 1-30.

[16] Koulakiotis. A, Dasilas. A and Papasyriopoulos, N. 2009, Volatility and error transmission Spillover effects: Evidence from three European financial regions. *The Quarterly Review of Economics and Finance*, volume 49(3), pp. 858-869.

[17] Li, H., and Majerowska, E. 2008, Testing stock market linkages for Poland and Hungary: A multivariate GARCH approach. *Research in International Business and Finance*, volume 22, pp. 247-266.

[18] Malik F. and Hammoudeh, S.M. 2007, Shock and volatility transmission in the oil, US and Gulf equity markets. *International Review of Economics and Finance*, volume 16, pp. 357-368.

[19] Tse, YK. and Tsui, AKC. 2002, A multivariate GARCH model with time-varying correlations. *Journal of Business and Economic Statistics*, volume 20, pp. 351-362.

[20] Wongswan, J. 2006, Transmission of information across international equity markets. *Review of Financial Studies*, volume 19(4), pp. 1157–1189.