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ARE ISLAMIC EQUITY MARKETS "SAFE HAVENS"? EXPLORING THE CONTAGION EFFECTS BETWEEN METAL FUTURE MARKETS AND MALAYSIAN ISLAMIC BONDS USING DCC-FIGARCH DURING THE RECENT GLOBAL FINANCIAL CRISIS OF 2008

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ABSTRACT

This paper examines the time-varying conditional correlations between seventeen metal future markets and Malaysian *Islāmic* bonds. We apply twelve sixvariate dynamic conditional correlation (DCC) FIGARCH models in order to capture potential contagion effects between the markets for the period 2007-2011. Empirical results reveal contagion during the under investigation period regarding the twelve sixvariate models, showing potential volatility transmission channels among the markets and implying that the *sukūk* bonds are not a safe haven during bearish times without portfolio diversification strategies. Findings have crucial implications for policymakers who provide regulations for the above derivative markets and for investors who invest long-term in *Islāmic* bonds.

JEL Classification: C58, C61, E44, G10, G20

Key words: DCC-FIGARCH, Metal futures, *Ṣukūk*, Financial contagion, *Islāmic* finance

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1. INTRODUCTION

Volatility transmission channels in *Islāmic* equity markets have motivated empirical researchers to study the contagion in *Islāmic* bond markets on derivative markets such as future markets during major global crises. The Global Financial Crisis of 2008 has led researchers to explore and discover potential spillovers among various financial and derivative markets, previously unexplored. This paper investigates the volatility spillover effects and the contagion effects (positive dynamic condition correlations) among major metal future markets and Malaysian *Islāmic* bonds (Narayan and Phan, 2019; Ahmed and Elsayed, 2019; Trabelsi, 2019; Gupta and Marfatia, 2019; Umar, 2017; Aloui, Hammoudeh, and Hamida, 2015; Mosaid and Boutti, 2014; Saiti, Bacha, and Masih, 2014; Rusgianto and Ahmad, 2013; Andersson et al., 2008) for the period 2007-2011. We answer whether *Islāmic* bond markets are safe havens during major crises by taking into consideration the contagion with the under investigation metal future markets. The recent global financial crisis has made assets with low correlations attractive for investors regarding the systematic risk protection. We extend the correlation analysis of Forbes and Rigobon (2002) by considering the Dynamic Conditional Correlation Fractionally Integrated GARCH (DCC-FIGARCH) of Engle (2002).

The main objectives of this paper are to address the following questions which are under-researched in the literature. Do Dynamic Conditional Correlations (DCCs) among those seemingly unrelated metal futures markets and *Islāmic* bonds (Zin et al., 2011; Karim, Kassim, and Arip, 2010) exist? Are those DCCs volatile? How do those DCCs evolve over time? Are there contagion effects in important periods of major crisis? Based on DCCs, do we observe interdependence? Are the under investigation *sukūk* bond markets save havens during the recent global financial crisis?

The paper is organized as follows: Section two presents the literature review. Section three describes the model and the data. Section four considers the empirical results, while Section five concludes.

2. LITERATURE REVIEW

The current literature explores the potential spillover effects among *Islāmic* financial assets and conventional equities (Metadjer, Benbakhti, and Boulila, 2020; Hassan, Hoque, and Gasbarro, 2019; Erdogan, Gedikli, and Cevik, 2018; Shahzad et al., 2018a; Abdullah, Saiti, and Masih, 2016; Nagayev et al., 2016; Mensi, Hammoudeh, and Kang, 2015a; Mensi et al., 2015b). Metadjer et al. (2020) analyse the volatility transmission among *Islāmic* and conventional financial markets. They use daily prices. By applying a bivariate BEKK-GARCH(1,1) model, they show the existence of volatility transmission among the markets. Hassan et al. (2019) explore the volatility linkage between *Islāmic* indexes and oil for BRIC countries. They find evidence that the volatility error forecast variance of all five indexes comes from spillover but is much lower compared to volatility spillover between conventional indexes and oil. Shahzad et al. (2018a) use ARMA-FIGARCH models for the period 2005-2015, to show existence of volatility spillover effects between the *Islāmic* stock markets of the world, Canada, Japan, USA, UK and *Islāmic* financial stocks (daily data). Erdogan et al. (2018) use the causality-in-variance test to reveal evidence of volatility spillovers from the *Islāmic* stock market to the foreign exchange market only in Turkey for the period 2013-2019. By using an MGARCH-DCC model, Nagayev et al. (2016) show correlations between commodity markets and the Dow Jones *Islāmic* market world index throughout the January 1999–April 2015 period. Abdullah et al. (2016) find that the Philippine *Islāmic* stock index is less correlated with crude oil during the period from 2007-2014. Mensi et al. (2015a) show time-varying linkages of the Saudi stock market with major commodity futures markets including WTI oil, gold, silver, wheat, corn and rice. They use a bivariate DCC–FIAPARCH model for the period 2005-2014. Mensi et al. (2015b) find linkages between the Sharia-compliant stocks and gold, by using a vine copula approach for the period 2005 to 2014.

Studies have investigated the relationship between *Islāmic* equities and *Islāmic* commodity markets (Shahzad et al., 2018b; Nagayev et al., 2016).

Shahzad et al. (2018) found time-varying dynamic correlation between the *Islāmic* Market World index, the *Islāmic* indices of the US, the UK, and Japan and the *Islāmic* Financials sector index and crude oil prices for the period 1996 to 2015. Nagayev et al. (2016) found time-varying correlations between commodity markets and the *Islāmic* Equity Index for the period January 1999 to April 2015.

To the best of our knowledge, this is the first paper considering potential spillover effects between metal future markets and *Islāmic* bonds.

3. MODEL AND DATA DESCRIPTION

3.1 THE SIXVARIATE DCC-FIGARCH MODEL

To study the time varying conditional correlations between the markets, we describe the dynamics of market logarithmic returns by their first lagged returns, as follows:

(1) $y_t = \mu + \varepsilon_t$, with $t = 1,...,T$. ε_t is the standardized residual such that:

(2) $$\varepsilon_t = \sqrt{h_t}u_t, \text{ where } \varepsilon_t \sim N(0, H_t) \text{ and } u_t \sim N(0,1)$$

where

$h_t =$ the univariate conditional variance matrix
$u_t =$ the standardized error
$H_t =$ the multivariate conditional variance matrix

The FIGARCH(*p,d,q*) model (Baillie, Bollerslev and Mikkelsen, 1996) is expressed as follows:

(3) $$h_t = \omega[1 - b(L)]^{-1} + \{1 - [1 - b(L)]^{-1}\Phi(L)(1 - L)^d\}\varepsilon_t^2$$

where ω is mean of the logarithmic conditional variance, $\Phi(L) = [1 - a(L) - b(L)](1 - L)^{-1}$ is lag polynomial of order p and $(1 - L)^d$ is fractional difference operator. Additionally, $b(L)$ and $a(L)$ are autoregressive polynomials of order p and q so that: $b(L) = 1 - \sum_{k=1}^{P} b_k L^k$ and $a(L) = 1 + \sum_{l=1}^{q} a_l L^l$.

The variance-covariance matrix of the residuals (Engle 2002) is defined as follows:

(4) $$H_t = D_t R_t D_t$$

D_t is the conditional variance matrix given by:

(5) $$D_t = diag\left(h_{11t}^{\frac{1}{2}} \ldots h_{NNt}^{\frac{1}{2}}\right)$$

R_t is the condition correlation matrix of $N \times N$ dimension, and is defined as follows:

(6) $$R_t = (\rho_{iit}) = diag(q_{11,t}^{-\frac{1}{2}} \ldots q_{NN,t}^{-\frac{1}{2}})Q_t diag(q_{11,t}^{-\frac{1}{2}} \ldots q_{NN,t}^{-\frac{1}{2}})$$

where the $N \times N$ symmetric positive definite matrix $Q_t = (q_{ii,t})$ is given by:

(7) $$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha u_{t-1}u_{t-1}' + \beta Q_{t-1},$$

$\bar{Q}$ is the $N \times N$ unconditional variance matrix of u_t, and α and β are nonnegative scalar parameters, satisfying $\alpha + \beta < 1$.

The parameters of the DCC-FIGARCH model are estimated by using the Full Information Maximum Likelihood (FIML) method with student’s t-distributed errors as follows:

(9)

$$\sum_{t=1}^{T}\left[log\frac{\Gamma\left(\frac{\nu+k}{2}\right)}{[\nu\pi]^{\frac{k}{2}}\Gamma\left(\frac{\nu}{2}\right)\nu-2^{\frac{k}{2}}} - \frac{1}{2}\log\left(|H_t|\right) - \left(\frac{k+\nu}{2}\right)log\left[1+\frac{\varepsilon_t{}'H_t{}^{-1}\varepsilon_t}{\nu-2}\right]\right]$$

where *Γ(.)* is the Gamma function, *k* is the number of equations, and *ν* is the degrees of freedom.

3.2 DATA DESCRIPTION

In this paper, we use daily data for 17 metal future and Malaysian *Ṣukūk* markets: NYM-PLATINUM CONTINUOUS - SETT. PRICE, CMX-HIGH GRADE COPPER CONT. - SETT. PRICE, CMX-SILVER 5000 OZ CONTINUOUS - SETT. PRICE, LME-LEAD CONTINUOUS - SETT. PRICE, DGCX-GOLD CONTINUOUS - SETT. PRICE, RF BPAM SUKUK 1-3Y IDX - TOT RETURN IND, RF BPAM SUKUK 3-7Y IDX - TOT RETURN IND, RF BPAM BNM SUKUK 3M-1Y IDX - TOT RETURN IND, RF BPAM CORP SUKUK IDX - TOT RETURN IND, RF BPAM GVT SUKUK 1-3Y IDX - TOT RETURN IND, RF BPAM GVT SUKUK 3-7Y IDX - TOT RETURN IND, RF BPAM GVT SUKUK 3M-1Y IDX - TOT RETURN IND, RF BPAM GVT SUKUK 7+Y IDX - TOT RETURN IND, RF BPAM GVT SUKUK IDX - TOT RETURN IND, RF BPAM LIQUID SUKUK 5 IDX - TOT RETURN IND, RF BPAM QUASI GVT SUKUK 3-7Y IDX - TOT RETURN IND and RF BPAM QUASI GVT SUKUK 7+Y IDX - TOT RETURN IND. The period of observation starts on 16th February 2007, and ends on 5th October 2011, one month after Standard & Poor's downgraded America's credit rating from AAA to AA+ (6 August 2011) for the first time since 1941 and one day after the S&P 500 faced a decline of 21.58% for last time after GFC. All prices have been extracted from Datastream® Database. For each market we use 1209 observations. Market logarithmic returns generated by $r_t = log\ (p_t)\ - log(p_{t-1})$, where p_t is the price of CDS spread on day t.

In Tables 1, 2, 3, 4, 5 and 6 we see the summary statistics for the market logarithmic returns. DGCX-GOLD_CONTINUOUS_-_SETT._PRICE exhibits the highest mean value (0,00031489). Based on the highest std. deviation (0.012487) values, LME-LEAD_CONTINUOUS_-_SETT._PRICE presents the largest fluctuations among all the markets. Additionally, all market returns are negatively skewed, except the cases of RF_BPAM_BNM_SUKUK_3M-1Y_IDX_-_TOT_RETURN_IND,RF_BPAM_GVT_SUKUK_7+Y _IDX_-_TOT_RETURN_IND and RF_BPAM_QUASI_GVT_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND. Furthermore, we observe that all market returns show excess kurtosis. In addition, Jarque-Bera statistic results indicate the rejection of the null hypothesis of normality for all market returns. ADF (Dickey and Fuller 1979) test results reject the null hypotheses of unit root at 1% level, showing that the daily market logarithmic returns are appropriate for further testing.

TABLE 1
Summary Statistics of the Daily Market Logarithmic Returns

	NYM-PLATINUM_CONTINUOUS_-_SETT._PRICE	CMX-HIGH_GRADE_COPPER_CONT._-_SETT._PRICE	CMX-SILVER_5000_OZ_CONTINUOUS_-_SETT._PRICE
Mean	6.842e-005	5.7065e-005	0.00027232
Minimum	-0.041707	-0.050245	-0.084768
Maximum	0.069579	0.050996	0.053672
Std. Deviation	0.0077048	0.0099042	0.01083
Skewness	-0.090561	-0.17655	-0.88420
t-Statistic	1.2860	2.5071	12.557
p-Value	0.19843	0.012172	3.6615e-036
Excess Kurtosis	8.8699***	2.4009***	6.1481***
t-Statistic	63.032	17.062	43.690
p-Value	0.00000	2.8696e-065	0.00000
Jarque-Bera	3958.4***	296.17***	2058.2***
p-Value	0.00000	4.8775e-065	0.00000
ADF Test	-19.57***	-20.9202***	-19.7957***

Note: downloaded from Datastream Database

TABLE 2
Summary Statistics of the Daily Market Logarithmic Returns

	LME-LEAD_CONTINUOUS_-_SETT._PRICE	DGCX-GOLD_CONTINUOUS_-_SETT._PRICE	RF_BPAM_SUKUK_1-3Y_IDX_-_TOT_RETURN_IND
Mean	1,5761e-005	0.00031489	7.3158e-005
Minimum	-0.057093	-0.027838	-0.003733
Maximum	0.055881	0.04234	0.0037019
Std. Deviation	0.012487	0.0058269	0.00060851
Skewness	-0.18431	-0.17346	-0.50362
t-Statistic	2.6174	2.4633	7.1519
p-Value	0.0088592	0.013766	8.5610e-013
Excess Kurtosis	1.5328***	4.5917***	8.8061***
t-Statistic	10.893	32.630	62.579
p-Value	1.2471e-027	1.5485e-233	0.00000
Jarque-Bera	125.00***	1066.4***	3951.0***
p-Value	7.1913e-028	2.7530e-232	0.00000
ADF Test	-20.0239***	-20.3989***	-18.0612***

Note: downloaded from Datastream Database

TABLE 3
Summary Statistics of the Daily Market Logarithmic Returns

	RF_BPAM_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_BNM_SUKUK_3M-1Y_IDX_-_TOT_RETURN_IND	RF_BPAM_CORP_SUKUK_IDX_-_TOT_RETURN_IND
Mean	7.066e-005	4.4911e-005	8.8942e-005
Minimum	-0.0045339	-0.0010516	-0.0041346
Maximum	0.0037467	0.0020192	0.0040344
Std. Deviation	0.00064881	0.00012668	0.00044708
Skewness	-0.68673	2.8329	-1.1453
t-Statistic	9.7522	40.230	16.264
p-Value	1.8058e-022	0.00000	1.7756e-059
Excess Kyrtosis	10.371***	59.668***	24.914***
t-Statistic	73.696	424.02	177.05
p-Value	0.00000	0.00000	0.00000
Jarque-Bera	5503.6***	1.8067e+005***	31480.0***
p-Value	0.00000	0.00000	0.00000
ADF Test	-17.6917***	-14.7669***	-15.0659***

Note: downloaded from Datastream Database

TABLE 4
Summary Statistics of the Daily Market Logarithmic Returns

	RF_BPAM_GVT_SUKUK_1-3Y_IDX_-_TOT_RETURN_IND	RF_BPAM_GVT_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_GVT_SUKUK_3M-1Y_IDX_-_TOT_RETURN_IND
Mean	6.3848e-005	9.9665e-005	6.8422e-005
Minimum	-0.0065031	-0.0034828	-0.0045182
Maximum	0.0055586	0.0031393	0.0037317
Std. Deviation	0.00067193	0.00043971	0.00064444
Skewness	-0.73531	-0.12946	-0.72526
t-Statistic	10.442	1.8385	10.299
p-Value	1.5938e-025	0.065986	7.0913e-025
Excess Kurtosis	21.137***	14.910***	10.533***
t-Statistic	150.20	105.95	74.850
p-Value	0.00000	0.00000	0.00000
Jarque-Bera	22577.0***	11183.0***	5685.2***
p-Value	0.00000	0.00000	0.00000
ADF Test	-17.8444***	-16.5772***	-17.7203***

Note: downloaded from Datastream Database

TABLE 5
Summary Statistics of the Daily Market Logarithmic Returns

	RF_BPAM_GVT_SUKUK_7+Y_IDX_-_TOT_RETURN_IND	RF_BPAM_GVT_SUKUK_IDX_-_TOT_RETURN_IND	RF_BPAM_LIQUID_GVT_SUKUK_5_IDX_-_TOT_RETURN_IND
Mean	9.0721e-005	7.2874e-005	7.1308e-005
Minimum	-0.0036794	-0.004182	-0.0042998
Maximum	0.0036746	0.0037118	0.0050544
Std. Deviation	0.00044991	0.00062147	0.00061634
Skewness	0.17199	-0.62187	-0.012304
t-Statistic	2.4425	8.8312	0.17473
p-Value	0.014587	1.0359e-018	0.86129
Excess Kurtosis	20.698***	9.6413***	15.683***
t-Statistic	147.09	68.514	111.44
p-Value	0.00000	0.00000	0.00000
Jarque-Bera	21552.0***	4752.6***	12369.0***
p-Value	0.00000	0.00000	0.00000
ADF Test	-15.1005***	-17.8395***	-17.5464***

Note: downloaded from Datastream Database

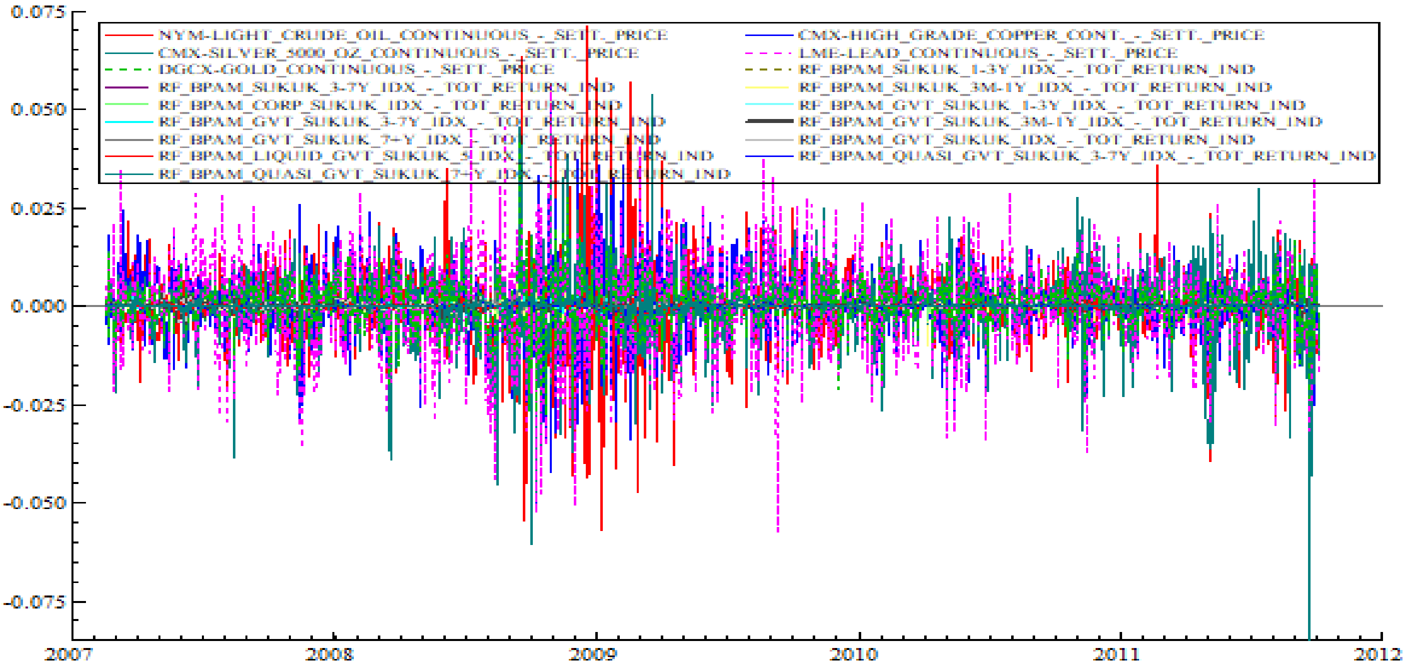
TABLE 6
Summary Statistics of the Daily Market Logarithmic Returns

	RF_BPAM_QUASI_GVT_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_QUASI_GVT_SUKUK_7+Y_IDX_-_TOT_RETURN_IND
Mean	7.6052e-005	9.5025e-005
Minimum	-0.0051022	-0.010678
Maximum	0.0065467	0.0095786
Std. Deviation	0.00055232	0.0010464
Skewness	0.90058	-0.41773
t-Statistic	12.789	5.9322
p-Value	1.8883e-037	2.9896e-009
Excess Kurtosis	36.771***	26.597***
t-Statistic	261.31	189.01
p-Value	0.00000	0.00000
Jarque-Bera	68163.0***	35611.0***
p-Value	0.00000	0.00000
ADF Test	-17.1442***	-16.5838***

Note: downloaded from Datastream Database

In Figure 1, we plot the actual series of all market logarithmic returns. The visual inspection of logarithmic returns provides a clear view of the trend for all markets. The graphs indicate the presence of heteroskedasticity rationalizing the use of the dynamic conditional correlations in the multivariate FIGARCH(1,d,1) framework.

FIGURE 1
Actual Series of the Logarithmic Returns of the Markets



4. EMPIRICAL RESULTS

This section is divided into four subsections. First, in section 4.1, the results from the DCC-FIGARCH(1,d,1) model are described. Second, section 4.2 presents the estimates of average correlations. Third, section 4.3 provides an explicit economic analysis based on dynamic conditional correlations (DCCs), while in section 4.4, we present the diagnostic tests.

4.1 RESULTS OF THE DCC-FIGARCH(1,d,1) MODEL

TABLE 7
Estimates of Univariate FIGARCH (1,d,1) Model

	NYM-PLATINUM_CONTINUOUS_-_SETT._PRICE	CMX-HIGH_GRADE_COPPER_CONT._-_SETT._PRICE	CMX-SILVER_5000_OZ_CONTINUOUS_-_SETT._PRICE
constant (μ)	0.000245*	0.000407*	0.000723**
t-Statistic	1.380	1.734	2.588
p-Value	0.1680	0.0832	0.0098
constant (ω)	0.687211**	3.213905*	0.036844*
t-Statistic	2.153	1.462	1.484
p-Value	0.0315	0.1441	0.1381
d-Figarch	0.853906***	0.430093**	0.458978**
t-Statistic	10.98	2.914	2.313
p-Value	0.0000	0.0036	0.0209
ARCH (a)	0.133657*	0.215736**	0.444432***
t-Statistic	1.798	2.417	3.082
p-Value	0.0724	0.0158	0.0021
GARCH (b)	0.899229***	0.57559***	0.713147***
t-Statistic	103.5	3.640	4.993
p-Value	0.0000	0.0003	0.0000

Note: downloaded from Datastream Database

TABLE 8
Estimates of Univariate FIGARCH (1,d,1) Model

	LME-LEAD_ CONTINUOUS _- _SETT._PRICE	DGCX-GOLD_ CONTINUOUS _- _SETT._PRICE	RF_BPAM_SUK UK_1-3Y_IDX_- _TOT_RETURN_ IND
constant (μ)	0.000284	0.000352**	0.0000891***
t-Statistic	0.8579	2.384	7.128
p-Value	0.3911	0.0173	0.0000
constant (ω)	0.042232*	0.643278*	0.003660*
t-Statistic	1.579	1.647	1.538
p-Value	0.1147	0.0998	0.1244
d-Figarch	0.429396***	0.670316***	0.582602***
t-Statistic	3.548	4.296	6.050
p-Value	0.0004	0.0000	0.0000
ARCH (a)	0.382870***	0.115474*	0.791247***
t-Statistic	4.389	1.284	6.801
p-Value	0.0000	0.1995	0.0000
GARCH (b)	0.726910***	0.769180***	0.858902***
t-Statistic	9.597	7.727	11.58
p-Value	0.0000	0.0000	0.0000

Note: downloaded from Datastream Database

TABLE 9
Estimates of univariate FIGARCH (1,d,1) model

	RF_BPAM_SU KUK_3- 7Y_IDX_- _TOT_RETURN _IND	RF_BPAM_BNM_ SUKUK_3M- 1Y_IDX_- _TOT_RETURN_I ND	RF_BPAM_CO RP_SUKUK_I DX_- _TOT_RETUR N_IND
constant (μ)	0.0000831***	0.0000281**	0.0000961***
t-Statistic	6.393	2.125	7.532
p-Value	0.0000	0.0338	0.0000
constant (ω)	0.035095**	0.0001687**	0.022481*
t-Statistic	2.113	2.398	1.057
p-Value	0.0348	0.0166	0.2906
d-Figarch	0.493628***	0.917064***	0.159071*
t-Statistic	7.058	9.461	1.818
p-Value	0.0000	0.0000	0.0693
ARCH (a)	-0.579136***	0.026092	0.627434**
t-Statistic	-3.669	0.2376	2.227

TABLE 9 *(continued)*

	RF_BPAM_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_BNM_SUKUK_3M-1Y_IDX_-_TOT_RETURN_IND	RF_BPAM_CORP_SUKUK_IDX_-_TOT_RETURN_IND
p-Value	0.0003	0.8122	0.0261
GARCH (b)	-0.499465**	0.883307***	0.525054*
t-Statistic	-2.867	26.12	1.832
p-Value	0.0042	0.0000	0.0672

Note: downloaded from Datastream Database

TABLE 10
Estimates of Univariate FIGARCH (1,d,1) Model

	RF_BPAM_GVT_SUKUK_1-3Y_IDX_-_TOT_RETURN_IND	RF_BPAM_GVT_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_GVT_SUKUK_3M-1Y_IDX_-_TOT_RETURN_IND
constant (μ)	0.0000821***	0.0001011***	0.0000841***
t-Statistic	6.676	7.674	6.734
p-Value	0.0000	0.0000	0.0000
constant (ω)	0.001618***	0.0004029***	0.030760**
t-Statistic	3.126	4.184	2.047
p-Value	0.0018	0.0000	0.0409
d-Figarch	1.352398***	1.183265***	0.493893***
t-Statistic	9.288	15.59	7.399
p-Value	0.0000	0.0000	0.0000
ARCH (a)	-0.049630	-0.128517*	-0.556928***
t-Statistic	-0.3254	-1.512	-3.773
p-Value	0.7449	0.1308	0.0002
GARCH (b)	0.964206***	0.968885***	-0.465627**
t-Statistic	68.29	151.4	-2.900
p-Value	0.0000	0.0000	0.0038

Note: downloaded from Datastream Database

TABLE 11
Estimates of Univariate FIGARCH (1,d,1) Model

	RF_BPAM_GVT_SUKUK_7+Y_IDX_-_TOT_RETURN_IND	RF_BPAM_GVT_SUKUK_IDX_-_TOT_RETURN_IND	RF_BPAM_LIQUID_GVT_SUKUK_5_IDX_-_TOT_RETURN_IND
constant (μ)	0.0001111***	0.0000841***	0.0000821***
t-Statistic	7.413	6.704	6.676
p-Value	0.0000	0.0000	0.0000
constant (ω)	0.014120*	0.041658**	0.0016618***
t-Statistic	1.643	2.495	3.126
p-Value	0.1006	0.0127	0.0018
d-Figarch	0.377846***	0.502477***	1.352398***
t-Statistic	4.885	6.699	9.288
p-Value	0.0000	0.0000	0.0000
ARCH (a)	-0.577149***	-0.559626**	-0.049630
t-Statistic	-3.977	-2.888	-0.3254
p-Value	0.0001	0.0039	0.7449
GARCH (b)	-0.405165**	-0.495464**	0.964206***
t-Statistic	-2.400	-2.261	68.29
p-Value	0.0166	0.0239	0.0000

Note: downloaded from Datastream Database

TABLE 12
Estimates of Univariate FIGARCH (1,d,1) Model

	RF_BPAM_QUASI_GVT_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_QUASI_GVT_SUKUK_7+Y_IDX_-_TOT_RETURN_IND
constant (μ)	0.0000871***	0.0001101***
t-Statistic	6.195	5.623
p-Value	0.0000	0.0000
constant (ω)	0.002971*	0.004895**
t-Statistic	1.660	2.496
p-Value	0.0972	0.0127
d-Figarch	0.809664**	1.225779***
t-Statistic	2.213	8.037
p-Value	0.0271	0.0000
ARCH (a)	0.373508*	0.122938

TABLE 12 *(continued)*

	RF_BPAM_QUASI_ GVT_SUKUK_3-7Y_IDX_-_TOT_RETURN_IND	RF_BPAM_QUASI_GVT_SUKUK_7+Y_IDX_-_TOT_RETURN_IND
t-Statistic	1.066	0.5527
p-Value	0.2865	0.5805
GARCH (b)	0.855576***	0.967492***
t-Statistic	6.297	101.6
p-Value	0.0000	0.0000

Note: downloaded from Datastream Database

Table 7 to 12 report estimated values for mean equation and univariate FIGARCH(1,d,1) model. Mean equation exhibits significant μ value for all markets except the case of LME-LEAD_CONTINUOUS_-_SETT._PRICE. Based on FIGARCH, our findings show the existence of long memory for most markets (0<d<1) and that RF BPAM GVT SUKUK 1-3Y IDX - TOT RETURN IND, RF BPAM GVT SUKUK 3-7Y IDX - TOT RETURN IND, RF BPAM LIQUID SUKUK 5 IDX - TOT RETURN IND and RF BPAM QUASI GVT SUKUK 7+Y IDX - TOT RETURN IND have no long memory (d>1). In addition, all the ARCH (*a*) and GARCH (*b*) terms are highly significant except for the ARCH (*a*) term of RF BPAM BNM SUKUK 3M-1Y IDX - TOT RETURN IND, RF BPAM GVT SUKUK 1-3Y IDX - TOT RETURN IND, RF BPAM LIQUID SUKUK 5 IDX - TOT RETURN IND and RF BPAM QUASI GVT SUKUK 7+Y IDX - TOT RETURN IND.

Figure 2 plots the behavior of conditional variances for all markets. By conducting a visual exploration, we observe that all markets exhibit strong ups and downs over time. Additionally, we observe large spikes in September 2008 revealing the effects of global economic crises.

Tables 13 to 16 report the results of the twelve sixvariate DCC model estimations. The DCC model results show significant α and β parameters, indicating strong ARCH and GARCH effects, suggesting empirical evidence that the markets are integrated. In addition, we provide the estimates of the degrees of freedom (v) and of the log-likelihood.

FIGURE 2
Conditional Variances of the Univariate GARCH (1,1) Model

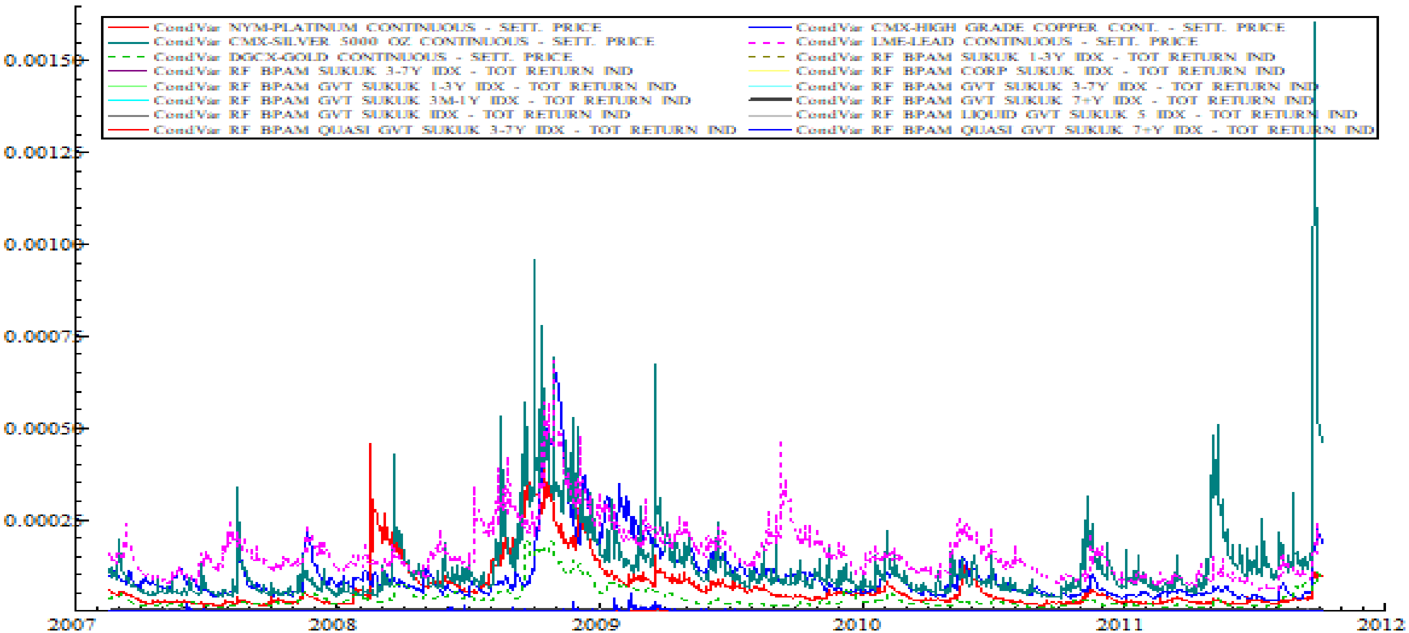
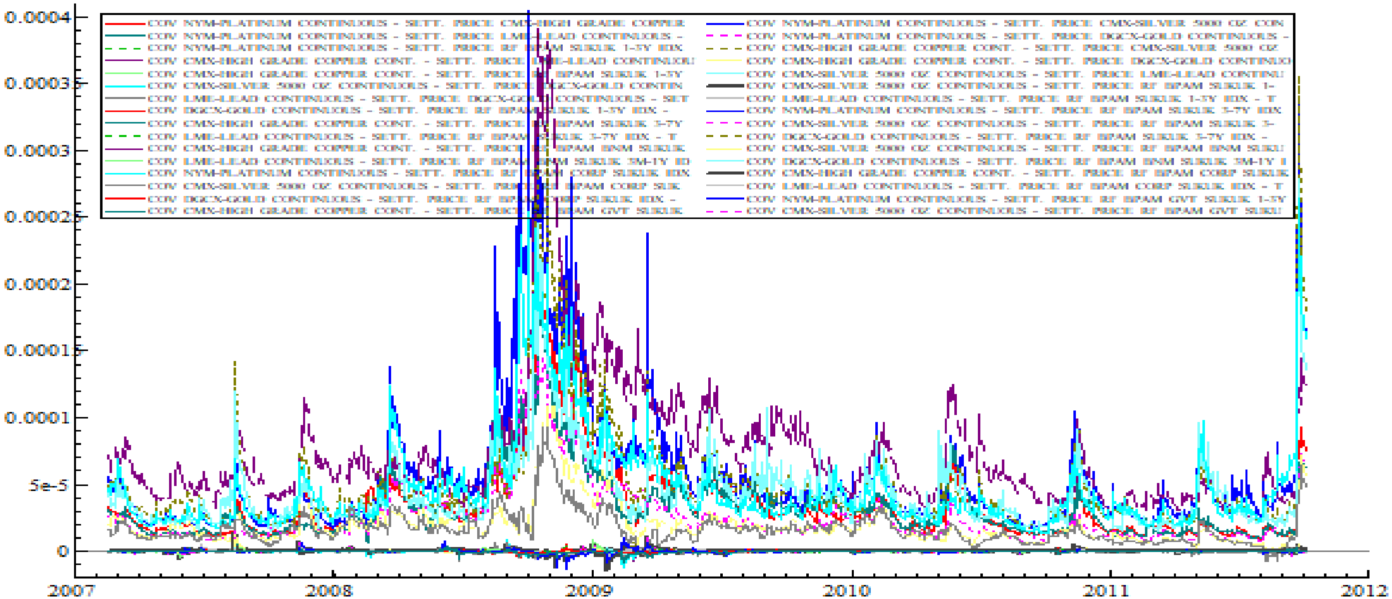


FIGURE 3
Conditional Covariances of the Bivariate DCC-GARCH (1,1) Model



In Figure 3 we graph the conditional covariances. Results suggest positive values for the most conditional covariances, while for some market pairs, conditional covariances present negative prices.

TABLE 13
Estimates of he Sixvariate DCC-FIGARCH (1,d,1) Model, Degrees of Freedom, Log-Likelihood

	PLATINUM-COPPER-SILVER-LEAD-GOLD-SUKUK_1-3Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-SUKUK_3-7Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-BNM_SUKUK_3M-1Y
alpha (α)	0.027900***	0.027411***	0.026686***
t-Statistic	5.829	5.749	5.891
p-Value	0.0000	0.0000	0.0000
beta (β)	0.894857***	0.896451***	0.911243***
t-Statistic	45.83	46.35	51.18
p-Value	0.0000	0.0000	0.0000
degrees of freedom (df)	6.743013***	6.664999***	5.579965***
t-Statistic	14.26	14.58	17.52
p-Value	0.0000	0.0000	0.0000
log-likelihood	29685.535	29671.343	31649.446

Note: downloaded from Datastream Database

TABLE 14
Estimates of the Sixvariate DCC-FIGARCH (1,d,1) Model, Degrees of Freedom, Log-likelihood

	PLATINUM-COPPER-SILVER-LEAD-GOLD-CORP_SUKUK	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_1-3Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_3-7Y
alpha (α)	0.028822***	0.027218***	0.024999***
t-Statistic	6.030	5.479	5.145
p-Value	0.0000	0.0000	0.0000
beta (β)	0.900485***	0.901666***	0.911781***
t-Statistic	48.51	44.40	44.40

TABLE 14 *(continued)*

	PLATINUM-COPPER-SILVER-LEAD-GOLD-CORP_SUKUK	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_1-3Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_3-7Y
p-Value	0.0000	0.0000	0.0000
degrees of freedom (df)	5.112184***	6.008224***	5.902076***
t-Statistic	18.27	15.48	16.04
p-Value	0.0000	0.0000	0.0000
log-likelihood	30133.711	29735.273	30227.304

Note: downloaded from Datastream Database

TABLE 15
Estimates of the Sixvariate DCC-FIGARCH (1,d,1) Model, Degrees of Freedom, Log-Likelihood

	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_3M-1Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_7+Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK
alpha (α)	0.027153***	0.026288***	0.027516***
t-Statistic	5.760	5.515	5.896
p-Value	0.0000	0.0000	0.0000
beta (β)	0.897064***	0.904885***	0.896806***
t-Statistic	46.68	46.84	47.44
p-Value	0.0000	0.0000	0.0000
degrees of freedom (df)	6.759783***	5.685455***	6.684407***
t-Statistic	14.36	17.21	14.48
p-Value	0.0000	0.0000	0.0000
log-likelihood	29679.650	30182.048	29669.039

Note: downloaded from Datastream Database

TABLE 16
Estimates of the Sixvariate DCC-FIGARCH (1, d, 1) Model, Degrees of Freedom, Log-Likelihood

	PLATINUM-COPPER-SILVER-LEAD-GOLD-LIQUID_GVT_SUKUK_5	PLATINUM-COPPER-SILVER-LEAD-GOLD-QUASI_GVT_SUKUK_3-7Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-QUASI_GVT_SUKUK_7+Y
alpha (α)	0.027218***	0.024804***	0.027878***
t-Statistic	5.479	5.169	5.364
p-Value	0.0000	0.0000	0.0000
beta (β)	0.901666***	0.908472***	0.898987***
t-Statistic	44.40	44.45	41.73
p-Value	0.0000	0.0000	0.0000
degrees of freedom (df)	6.008224***	5.198483***	5.284416***
t-Statistic	15.48	18.47	17.71
p-Value	0.0000	0.0000	0.0000
log-likelihood	29735.273	30049.448	29210.908

Note: downloaded from Datastream Database

TABLE 17
Estimates for the Average Correlations of the Sixvariate DCC-FIGARCH (1,d,1) Model

	Coefficient	t-Statistic	p-Value
PLATINUM-COPPER	0.483722***	16.25	0.0000
PLATINUM-SILVER	0.700087***	38.73	0.0000
PLATINUM-LEAD	0.368109***	11.17	0.0000
PLATINUM-GOLD	0.609988***	26.92	0.0000
PLATINUM-SUKUK_1-3Y	0.023563	0.6245	0.5324
COPPER-SILVER	0.506797***	18.52	0.0000
COPPER-LEAD	0.609039***	27.18	0.0000
COPPER-GOLD	0.387408***	12.27	0.0000
COPPER-SUKUK_1-3Y	0.017078	0.4906	0.6238
SILVER-LEAD	0.362812***	11.41	0.0000
SILVER-GOLD	0.767261***	48.36	0.0000
SILVER-SUKUK_1-3Y	0.054737*	1.483	0.1383

TABLE 17 *(continued)*

	Coefficient	t-Statistic	p-Value
LEAD-GOLD	0.272763***	8.163	0.0000
LEAD-SUKUK_1-3Y	-0.021623	-0.6667	0.5051
SUKUK_1-3Y-GOLD	0.078951**	2.070	0.0387
SUKUK_3-7Y-PLATINUM	0.020599	0.5500	0.5825
SUKUK_3-7Y-COPPER	0.023083	0.6580	0.5107
SUKUK_3-7Y-SILVER	0.054085*	1.483	0.1382
SUKUK_3-7Y-LEAD	-0.025934	-0.7925	0.4282
SUKUK_3-7Y-GOLD	0.080818**	2.141	0.0325
BNM_SUKUK_3M-1Y-PLATINUM	-0.001874	-0.05051	0.9597
BNM_SUKUK_3M-1Y-COPPER	0.037690*	1.045	0.2961
BNM_SUKUK_3M-1Y-SILVER	0.018551	0.5189	0.6039
BNM_SUKUK_3M-1Y-LEAD	0.017507	0.4839	0.6286
BNM_SUKUK_3M-1Y-GOLD	0.052675*	1.438	0.1507
CORP_SUKUK-PLATINUM	-0.039119	-0.8823	0.3778
CORP_SUKUK-COPPER	-0.025773	-0.6407	0.5219
CORP_SUKUK-SILVER	-0.010618	-0.2592	0.7956
CORP_SUKUK-LEAD	-0.001450	-0.03598	0.9713
CORP_SUKUK-GOLD	0.023871	0.6062	0.5445
GVT_SUKUK_1-3Y-PLATINUM	0.018432	0.4450	0.6564
GVT_SUKUK_1-3Y-COPPER	0.013261	0.3573	0.7209
GVT_SUKUK_1-3Y- SILVER	0.012743	0.3240	0.7460
GVT_SUKUK_1-3Y-LEAD	0.004133	0.1223	0.9027
GVT_SUKUK_1-3Y-GOLD	0.035982	0.9216	0.3569

Note: downloaded from Datastream Database

TABLE 18
Estimates for the Average Correlations of the Sixvariate DCC-FIGARCH (1,d,1) Model

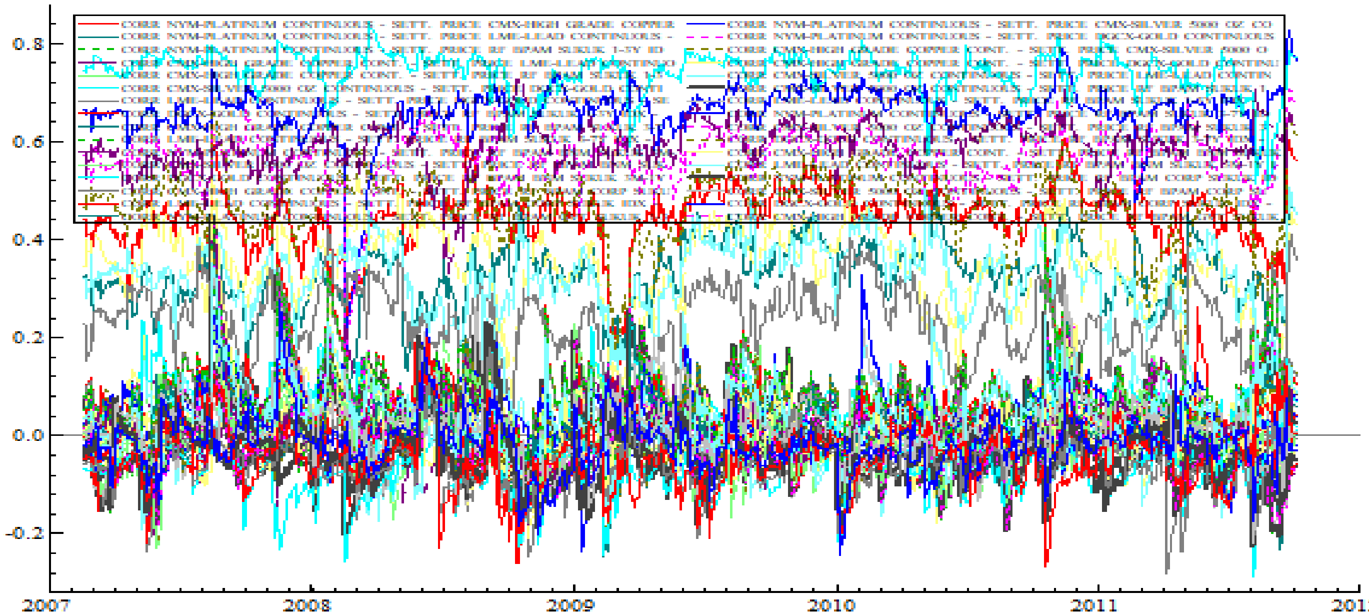
	Coefficient	t-Statistic	p-Value
GVT_SUKUK_3-7Y-PLATINUM	0.000667	0.01716	0.9863
GVT_SUKUK_3-7Y-PLATINUM	-0.010252	-0.2643	0.7916
GVT_SUKUK_3-7Y-SILVER	0.000613	0.01683	0.9866
GVT_SUKUK_3-7Y-LEAD	-0.007121	-0.1947	0.8457
GVT_SUKUK_3-7Y-GOLD	0.018818	0.5075	0.6119

TABLE 18 *(continued)*

	Coefficient	t-Statistic	p-Value
GVT_SUKUK_3M-1Y-PLATINUM	0.018107	0.4847	0.6280
GVT_SUKUK_3M-1Y-COPPER	0.021017	0.6028	0.5468
GVT_SUKUK_3M-1Y-SILVER	0.053827*	1.479	0.1394
GVT_SUKUK_3M-1Y-LEAD	-0.025589	-0.7870	0.4314
GVT_SUKUK_3M-1Y-GOLD	0.077693**	2.060	0.0397
GVT_SUKUK_7+Y-PLATINUM	0.009614	0.2502	0.8025
GVT_SUKUK_7+Y-COPPER	0.006457	0.1867	0.8519
GVT_SUKUK_7+Y-SILVER	0.013616	0.3820	0.7025
GVT_SUKUK_7+Y-LEAD	0.010917	0.3169	0.7513
GVT_SUKUK_7+Y-GOLD	0.020101	0.5637	0.5731
GVT_SUKUK-PLATINUM	0.020984	0.5598	0.5757
GVT_SUKUK-COPPER	0.016659	0.4825	0.6295
GVT_SUKUK-COPPER	0.051406*	1.394	0.1634
GVT_SUKUK-LEAD	-0.025561	-0.7923	0.4283
GVT_SUKUK-GOLD	0.079539**	2.107	0.0353
LIQUID_GVT_SUKUK_5-PLATINUM	0.018432	0.4450	0.6564
LIQUID_GVT_SUKUK_5-COPPER	0.013261	0.3573	0.7209
LIQUID_GVT_SUKUK_5-SILVER	0.012743	0.3240	0.7460
LIQUID_GVT_SUKUK_5-LEAD	0.004133	0.1223	0.9027
LIQUID_GVT_SUKUK_5-GOLD	0.035982	0.9216	0.3569
QUASI_GVT_SUKUK_3-7Y-PLATINUM	-0.027038	-0.6765	0.4988
QUASI_GVT_SUKUK_3-7Y-COPPER	0.017163	0.4425	0.6582
QUASI_GVT_SUKUK_3-7Y-SILVER	0.017469	0.4602	0.6454
QUASI_GVT_SUKUK_3-7Y-LEAD	0.007425	0.2138	0.8307
QUASI_GVT_SUKUK_3-7Y-GOLD	0.021598	0.5745	0.5658
QUASI_GVT_SUKUK_7+Y-PLATINUM	-0.068744*	-1.725	0.0847
QUASI_GVT_SUKUK_7+Y-COPPER	-0.039227*	-1.120	0.2632
QUASI_GVT_SUKUK_7+Y-SILVER	-0.056689*	-1.547	0.1222
QUASI_GVT_SUKUK_7+Y-LEAD	-0.019109	-0.5667	0.5710
QUASI_GVT_SUKUK_7+Y-GOLD	-0.045430*	-1.322	0.1865

Note: downloaded from Datastream Database

FIGURE 4
Dynamic Conditional Correlations of the Bivariate DCC-GARCH (1,1) Model



4.2 ESTIMATES OF AVERAGE CORRELATIONS

Tables 17 and 18 present the estimated average correlations of the sixvariate FIGARCH(1, d, 1)-DCC model. We observe that the most average correlations among metal futures markets are statistically significant and positive. In addition, results show that most average correlations among *Islāmic* bonds are not statistically significant.

4.3 ECONOMIC ANALYSIS OF DYNAMIC CONDITIONAL CORRELATION COEFFICIENTS

We proceed with the sixvariate FIGARCH(1, d, 1)-DCC estimation, using market logarithmic returns, illustrated graphically in Figure 4. The dynamic conditional correlation coefficient (DCC coefficient) estimates aim to give us a much clearer view of contagion effects.

As depicted in Figure 4, all the DCC coefficients are positive in sub-periods and extreme volatile, implying contagion effects and a less reliable correlation in guiding portfolio decision. Additionally, some pairs of markets present positive and persistently high DCCs during the most period, foreshadowing interdependence phenomenon; see for instance, Forbes and Rigobon (2002), and specifically the pairs of metal futures markets: silver-gold, platinum-gold, platinum-silver, platinum-copper, copper-silver, copper-lead, platinum-lead, copper-gold and silver-gold. Furthermore, we can clearly see the effects of major economic events considering the picks and troughs in the figure, i.e. (1) the Lehman Brothers bankruptcy (15/9/2008), (2) the USA presidential election (4/11/2008), and (3) when Standard & Poor's credit rating agency downgraded the credit rating of the USA from AAA to AA+ (5/8/2011).

TABLE 19
Diagnostic Tests and Information Criteria

	PLATINUM-COPPER-SILVER-LEAD-GOLD-SUKUK_1-3Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-SUKUK_3-7Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-BNM_SUKUK_3M-1Y
$x^2(12)$	3066,3**	3120,1**	5294,2**
p-Value	0,0000	0,0000	0,0000

TABLE 19 *(continued)*

	PLATINUM-COPPER-SILVER-LEAD-GOLD-SUKUK_1-3Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-SUKUK_3-7Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-BNM_SUKUK_3M-1Y
Hosking^2 (50)	1702.04	1686.18	1592.79
p-Value	0.9472115	0.9708656	0.9998077
Li-McLeod^2 (50)	1707.87	1692.35	1599.96
p-Value	0.9354658	0.9629831	0.9996880
Akaike	-49.106766	-49.085904	-52.363622
Schwarz	-48.906766	-48.883250	-52.160968

Note: downloaded from Datastream Database

TABLE 20
Diagnostic Tests and Information Criteria

	PLATINUM-COPPER-SILVER-LEAD-GOLD-CORP_SUKUK	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_1-3Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_3-7Y
$x^2(12)$	4694.8**	3424.2**	3922.2**
p-Value	0.0000	0.0000	0.0000
Hosking^2 (50)	1567.25	1690.46	1659.32
p-Value	0.9999703	0.9655565	0.9909520
Li-McLeod^2 (50)	1576.29	1695.80	1666.48
p-Value	0.9999409	0.9578762	0.9873879
Akaike	-49.852048	-49.191836	-50.007132
Schwarz	-49.649394	-48.989182	-49.804478

Note: downloaded from Datastream Database

TABLE 21
Diagnostic Tests and Information Criteria

	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_3M-1Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK_7+Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-GVT_SUKUK
$x^2(12)$	3066.9**	3541.5**	3105.1**
p-Value	0.0000	0.0000	0.0000
$Hosking^2$ (50)	1721.32	1696.05	1704.46
p-Value	0.9008017	0.9571641	0.9425610
$Li\text{-}McLeod^2$ (50)	1726.72	1701.58	1710.23
p-Value	0.8836851	0.9480751	0.9301688
Akaike	-49.099668	-49.932142	-49.082086
Schwarz	-48.897014	-49.729488	-48.879432

Note: downloaded from Datastream Database

TABLE 22
Diagnostic Tests and Information Criteria

	PLATINUM-COPPER-SILVER-LEAD-GOLD-LIQUID_GVT_SUKUK_5	PLATINUM-COPPER-SILVER-LEAD-GOLD-QUASI_GVT_SUKUK_3-7Y	PLATINUM-COPPER-SILVER-LEAD-GOLD-QUASI_GVT_SUKUK_7+Y
$x^2(12)$	3424.2**	5957.0**	4688.5**
p-Value	0.0000	0.0000	0.0000
$Hosking^2$ (50)	1690.46	1640.71	1771.38
p-Value	0.9655565	0.9964536	0.6681947
$Li\text{-}McLeod^2$ (50)	1695.80	1647.39	1775.12
p-Value	0.9578762	0.9949764	0.6450560
Akaike	-49.191836	-49.712425	-48.322963
Schwarz	-48.989182	-49.509771	-48.120310

Note: downloaded from Datastream Database

4.4 DIAGNOSTIC TESTS, HYPOTHESIS TESTING AND INFORMATION CRITERIA

Hypothesis testing results and information criteria are exhibited in Tables 19 to 22, $x^2(12)$ statistic results suggest that the null hypothesis of no spillovers is rejected at the 1% significance level. In addition, Ljuing-Box test results (Hosking 1980; McLeod and Li 1983) provide evidence of no serial autocorrelation, suggesting the absence of misspecification errors of the estimated MGARCH model. Furthermore, AIC and SIC information criteria are provided for our model.

5. CONCLUSIONS

In this article, we study the volatility transmission among metal futures markets and Malaysian *Islāmic* bonds using daily data for the period 2007 – 2011. We apply twelve sixvariate DCC-FIGARCH(1, d, 1) framework. To the best of our knowledge no empirical study has attempted to analyze the volatility effects among the under investigation metal futures markets and *sukūk* bonds in order to quantify and measure potential contagion effects. The empirical results answer the major research questions.

Using the FIGARCH-DCC model, we find evidence of significant and extremely volatile dynamic conditional correlations for all the pairs of markets. More importantly, we find positive and negative correlation in sub-periods, supporting that the investors (Pension funds, hedge funds and insurance companies) dealing can get diversification benefits and face non-important losses during bearish times. Contagion during bearish time-periods of the recent global financial crisis of 2008 shows that *sukūk* markets are not a safe haven without diversification strategies from the futures metal markets. Policy makers, who provide regulations for the metal futures markets, should examine possible strategies that take into account the spillovers of the above markets during future crises. By examining the evolution of dynamic conditional correlations, we conclude that it is safe to hold portfolio in Malaysian *Islāmic* bonds and metal futures markets, showing that the *Islāmic* bond markets are safe havens during a major global crisis.

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