The Role of Gold as a Hedge and Safe Haven in Shariah-Compliant Portfolios

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26. August 2013

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ABSTRACT

The paper is the first attempt to evaluate the role of gold as a hedge (negative or low correlation with equities in normal market conditions) and safe haven (negative or low correlation in times of market turbulence) by using the daily data for gold and Shariah-compliant equities ranging from January 1996 to April 2013, and comparing between developed and emerging markets in time-frequency domain. Wavelet Coherence technique is applied to identify the best time-frequency for gold as a hedge, and MGARCH-DCC to find out the reaction of gold to unfavorable market conditions as a safe haven. The results tend to indicate that gold maintains its capacity as hedging instrument at higher time-scales, while during the financial crisis it demonstrated a weak form of safe haven by showing almost zero correlation with the Shariah-compliant equities.

Keywords: Gold, shariah-compliant equities, wavelet coherence, MGARCH-DCC

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1. INTRODUCTION

Historically, only the gold maintained its value during wars, upheavals, crisis periods, and changes of empires and governments (Hood & Malik, 2013). It is the most widely traded commodity in the world (Sari et al., 2009), which is demanded generally for two purposes: a) The «use demand», as an input in the production of jewelry, medals, coins, electrical components, etc.; b) The «asset demand», when the gold is demanded by governments, institutional and individual investors as an investment for the effective hedge against inflation and other uncertainty (Wang et al., 2011). Monetary market shows that gold is an ideal portfolio holding and an inflation hedge in view of uncertainty of world economy. It is included in the portfolios of most serious individual and institutional investors, who balance between soft assets such as stocks and physical assets such gold according to their strategies. Many central banks incorporate gold into both a currency basket used for exchange rate management purposes and a reserve asset portfolio for reducing the volatility and enhancing the risk/return balance.

Traditionally, gold is traded as an investment asset to hedge against inflation risk and increasing financial market risk; and besides that it can be used as a safe haven during market instability (Reboredo, 2013; Ibrahim, 2012; and Tully & Lucey, 2007).

As defined by Kaul & Sapp (2006), Baur & Lucey (2010), and Baur & McDermott (2010), an asset is a hedge if it is uncorrelated (weak form) or negatively correlated (strong form) with another asset or portfolio on average, while it is a safe haven if it is uncorrelated (weak form) or negatively correlated (strong form) with another asset or portfolio in times of extreme periods of stock market declines. Hence, the key difference between the two features is that a safe haven is required to hold the relationship under extreme market conditions, while a hedge must do so under normal circumstances (Reboredo, 2013).

However, such treatment is based on the assumption that gold is negatively or weakly correlated with other assets in continuous manner, which might not necessarily hold at all time-scales and periods.

Taking into account the significant role played by gold in portfolio diversification and its spectacular price fluctuations in recent years, especially after the global financial crisis, it is only natural for the investor to ask a question whether gold still can be treated as a hedge, and at which time scale the hedging property of gold becomes more meaningful. Moreover, what is the relationship between the gold and Shariah-compliant equities during the economic downturns - does the gold serve as a safe haven?

The paper evaluates the role of gold as a hedge and safe haven by using the daily data for gold and Shariah-compliant equities ranging from January 1996 to April 2013, and comparing between developed and emerging markets in time-frequency domain. Wavelet Coherence technique is applied to identify the best time-frequency for gold to behave as a hedge, and MGARCH-DCC to find out what was the reaction of gold to unfavorable market conditions as a safe haven. The results indicate that gold maintains its capacity as hedging instrument at higher time-scales, while during the financial crisis it demonstrated a weak form of safe haven by showing almost zero correlation with the Shariah-compliant equities.

The rest of the paper is laid out as follows: **Section 2** provides a brief overview of the existing empirical literature on the relationship between the gold and Shariah-compliant equities. In **Section 3**, we outline the methodology and describe the data. **Section 4** presents results, and **Section 5** concludes the paper.

2. LITERATURE REVIEW

The role of gold as a safe-haven asset with respect to stock market movements was analyzed by Baur and Lucey (2010), who showed that gold tended to hold its value in Germany, the UK and the USA when stock markets experienced extreme negative returns. In addition to that, Baur and McDermott (2010) showed that gold was both a hedge and a safe haven for major European and US stock markets but not for stock markets in Australia, Canada, Japan and some emerging markets. Ibrahim (2012) examined the linkage between gold and stock market returns from the Malaysian perspective, and variability of their relationships during the consecutive negative market returns. By applying the autoregressive distributed model to link the gold returns to stock returns with TGARCH/EGARCH error specification and using daily data from August 2001 to March 2010, he found that there is a significant positive but low correlation between the gold and once-lagged stock returns, and that the gold market surges when faced with consecutive market declines. Hiller et al. (2006) studied the role and effect of gold and other commodities on equity markets. They discovered that in the period between 1976 and 2004 the gold had a small negative correlation with the S&P500 index. In addition, it was found that portfolios which had been 5% to 10% invested in gold had better performance compared to portfolios with no gold. Likewise, Ziaei (2012) in his study using a panel GMM model and data set consisting of quarterly data for 8 East Asian countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Japan and South Korea) from 2006Q4 to 2011Q1, found that there is a significant negative relationship between gold and equity prices. Comparably, analyzing the effect of gold on the Hang Seng Index series with the application of GJR-GARCH model for the time horizon between 01/01/2002 and 31/08/2009, Garefalakis et al. (2011) uncovered that gold has a negative relationship with equity prices.

The study of Ghosh et al. (2004), after employing the cointegration regression technique on monthly gold price data ranging from 1976 to 1999, discovered that the price of gold rises over time at the general rate of inflation, and, thus, it is an effective hedge against inflation. However, in the short-run, the variations in real interest rate, gold lease rate, convenience yield, default risk, exchange rate and covariance of gold returns with other assets disturb the equilibrium relationship and generate short-run price volatility. Utilizing MGARCH-DCC method on daily observations covering the period between January of 1990 and June 2010, Ciner et al. (2013) reported that gold can be regarded as a safe haven against exchange rates in US and UK, which highlights its monetary asset role.

There is insufficient empirical evidence showing the multidimensional relationship between the gold and global Shariah-compliant equities comparing between developed and emerging economies assessing the role of gold in portfolio risk management. We believe that this study will fill the gap in the literature in this area by applying Wavelets Coherence and MGARCH-DCC analysis using the recent daily data. For academicians it would provide better insights of when and at which time horizon the gold can act best as a hedge. From the perspective of investors, this would provide a decision aid for making better asset allocation of one's portfolio.

3. DATA AND METHODOLOGY

3.1 Data

This study employs daily log returns on stock indices of Dow Jones Islamic Market (Developed and Emerging markets) and gold (S&P GSCI) expressed in USD ranging from January 1996 to April 2013. The data is obtained from the DataStream. The Table 1 shows the summary of data and methods applied.

Definitions of variables	*ISLD (diff log)*	*Dow Jones Islamic World Developed Market – Price Index*	*As a proxy for Shariah-compliant equities in the developed markets. Represents 1379 constituent companies. Price Index. [DJIWDD$]*
	ISLE (diff log)	*Dow Jones Islamic World Emerging Market – Price Index*	*As a proxy for Shariah-compliant equities in the emerging markets. Represents 1083 constituent companies. Price Index. [DJIWEM$]*
	GOLD (diff log)	*S&P GSCI Gold Spot – Price Index*	*As a benchmark for international gold prices. Measured in USD per troy ounce. [GSGCSPT]*
Methodology		*Wavelet Coherence and M-GARCH-DCC*	
Data	*Type:*	*Time Series*	
	Period:	*Daily (5 working days per week): from 02/01/1996 to 17/04/2013*	
	Obs:	*4512*	
	Source:	*DataStream*	

Table 1: Summary of data and methodology

The Shariah screening methodology: In this study we are using Dow Jones Islamic Indices as proxies for Islamic equities. According to Dow Jones requirements, the equities to be Shariah-compliant must pass through the following screening criteria:

1. *The qualitative screening approach* - any involvement in the following activities: alcoholic beverages; broadcasting & entertainment; conventional financial services; gambling; hotels; insurance; media agencies (except newspapers); pork-related products; restaurants & bars; tobacco; weapons & defense.
2. *The quantitative screening approach* - all of the following must be less than 33%:

   - The total debt divided by trailing a 24-month average market capitalization process;
   - Taking the sum of a company's cash and interest-bearing securities to be divided by the trailing 24-month average market capitalization;
   - Accounts receivables divided by the trailing 24-month average market capitalization.

According to Christie (1982), when the value of the stock declines, the financial leverage makes the stock riskier thus increasing the underlying volatility. Hence, we can notice that Islamic stock market indices are different from others in terms of intolerance towards the highly leveraged companies which probably makes these stocks more resilient in the face of market uncertainty.

3.2 Methodology

A. Wavelet: This method appears to be the most appropriate for the evaluation of hedging property of gold and identification of optimal time-scale at which market participants can gain maximum value from hedging.

The origin of wavelets can be traced back to Fourier analysis, which is the foundation of modern time-frequency analysis. Wavelets are localized in both the time and frequency domain and allow for analysis of time-frequency dependencies between two time series.

By looking at returns at shorter time scale, we are able to analyze the co-movement of assets at higher frequencies and at a longer time scale; we analyze the co-movement of asset returns at lower frequencies.

Basically, two types of wavelets exist, discrete wavelet transform (DWT) and continuous wavelet transform (CWT). DWT is useful for de-noising data and decomposing data whereas CWT is useful for extracting information and detecting data self-similarity. The application of discrete wavelet transform (DWT) is more common in the analysis of economic and financial data. This paper uses CWT to examine co-movement between the Shariah-compliant equities and gold.

The CWT $W_x(u,s)$ is obtained by projecting a specific wavelet ψ (.) onto the examined time series $X(T) \in I^2$ (*R*). CWT is defined as **(1a):**

$$W_x(u,s) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) dt$$

A wavelet has two control parameters, *u* and *s*; *u* is the location parameter that determines the exact position of the wavelet and *s* is the scale parameter that defines how the wavelet is stretched or dilated.

An important aspect of the wavelet transform is the ability to decompose and guarantee perfectly the reconstruction of the function $x(t)$ L^2 (*R*) **(2a)**:

$$x(t) = \frac{1}{C_\psi} \int_0^{\infty} \left[\int_{-\infty}^{\infty} W_x(u,s)\, \psi_{u,s}(t) du\right] \frac{ds}{s^2} \quad s > 0$$

The energy of the $x(t)$ is preserved by the wavelet transform, such that **(3a)**:

$$\|x\|^2 = \frac{1}{C_\psi} \int_0^{\infty} \left[\int_{-\infty}^{\infty} |W_x(u,s)|^2\, du\right] \frac{ds}{s^2}$$

Several types of wavelets exist, with different characteristics for different purposes. In the analysis of information on both amplitude and phase, the Morlet wavelet is a popular choice, which is defined as **(4a)**:

$$\psi^M(t) = \frac{1}{\pi^{1/4}} e^{i\omega_0 t} e^{-t^2/2}$$

where *S* is the central frequency of the wavelet and is set to 6.

To analyze co-movement between assets returns, we need to deploy wavelet coherence, a bivariate framework. Wavelet coherence will show the regions in which the two time series in time-scale space co-move but may not have high power. Wavelet coherence can be viewed as the local correlation, both in time and frequency, between two time series. This concept is particularly useful in analyzing the correlation between financial data during different regimes without having to sub-divide the data into different sample periods. Standard time series econometric methods analyze the time and frequency components separately but wavelet coherence allows three-dimensional analysis of time series data. We can simultaneously consider the time and frequency components, and the strength of the co-movement. Wavelet coherence is defined as follows **(5a)**:

$$R^2(u,s) = \frac{\left|S(s^{-1}W_{xy}(u,s))\right|^2}{S(s^{-1}\,|W_x(u,s|^2)\,S(s^{-1}\,\left|W_y(u,s\right|^2)}$$

where *S* is a smoothing operator; without smoothing, coherency is identically 1 at all scales and times. Smoothing is achieved by convolution in time and scale. $W_{xy}(u,s)$ is the cross wavelet power, and it uncovers the region in time-scale space in which the time series shows high common power.

Cross-wavelet power can be viewed as the local covariance between two time series at each scale. Cross wavelet power of two time series *x*(t) and *y*(t) is defined as **(6a)**:

$$W_{xy}(u,s) = W_x(u,s)\, W_y^*(u,s)$$

where $W_x(u,s)$ and $W_y(u,s)$ are continuous wavelet transforms of $x(t)$ and $y(t)$, respectively. The symbol * denotes a complex conjugate.

The wavelet coherence phase differences show the lead-lag relationships between the two time series. The wavelet coherence phase is defined as follows **(7a)**:

$$\phi_{xy}(u,s) = tan^{-1}\left(\frac{I\{S(s^{-1}W_{xy}(u,s))\}}{R\{S(s^{-1}W_{xy}(u,s))\}}\right)$$

where I and R are the imaginary and real parts, respectively, of the smooth power spectrum.

An arrow in the wavelet coherence plots represents the phase. A zero phase difference means that the two time series move together on a particular scale. Arrows point to the right (left) when the time series are in phase (anti-phase). When the two series are in phase, it indicates that they move in the same direction, and anti-phase means that they move in the opposite direction. Arrows pointing up by 90° mean that the first time series leads the second one, while arrows pointing down by 90° indicate that the second time series leads the first one.

Advantage of wavelet coherence method is that it can be used to identify structural breaks when a complete breakdown in correlation or a shift in the relevant frequency band occurs.

B. MGARCH-DCC: The multivariate GARCH-DCC model, introduced by Engle (2002), allows for the assessment of time-varying volatility and conditional correlations between the assets. This method is applied to assess the role of gold as a safe haven during the stock market crashes.

Dynamic Conditional Correlation (DCC) improves modeling flexibility by relaxing the assumptions about invariability of means and variances of variables and co-movements which is done by calculating a current correlation between the variables as a function of past realizations of both the volatility within the variables and the correlations between them. The link between variables can thus be seen to vary over time in a way that not only depends upon whether and to what degree the variables are moving in the same direction, but also takes account of the history of variance that each series has experienced. The DCC approach allows series to have periods of positive, negative, or zero correlation. Thus, both direction and strength of the correlation can be considered. When two series move in the same direction, the correlation increases and becomes positive. When they move in opposite directions, the correlation is decreased and may become negative (Lebo & Box-Steffensmeier, 2008). Thus, the estimates of dynamic correlation can be used to analyze how significant events impact on co-movement between the variables.

Assuming r_t as the vector composed of two return series, $r_t = (r_{1t}, r_{2t})'$ and denoting by A(L) the lag polynomial, we have **(1b)**:

$$A(L)r_t = \mu + e_t$$

where e_t is error-term vector.

The DCC model is based on the hypothesis that the conditional returns are normally distributed with zero mean and conditional covariance matrix $H_t = E[\, r_t r_t' \mid I_{t-1} \,]$.

The covariance matrix is expressed as follows **(2b)**:

$$H_t = D_t R_t D_t$$

where $D_t = diag[\sqrt{h_{1t}}, \sqrt{h_{2t}}]$ is a diagonal matrix of time-varying standard deviations issued from the estimation of univariate GARCH(1,1) process **(3b)**:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$$

and R_t is the conditional correlation matrix of the standardized returns ε_t, with $\varepsilon_t = D_t^{-1} r_t$ **(4b)**:

$$R_t = \begin{bmatrix} 1 & q_{12t} \\ q_{21t} & 1 \end{bmatrix}$$

The matrix R_t is decomposed into **(5b)**:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

where Q_t is the positive definite matrix containing the conditional variance-covariances of ε_t, and Q_t^{*-1} is the inverted diagonal matrix with the square root of the diagonal elements of Q_t **(6b)**:

$$Q_t^{*-1} = \begin{bmatrix} 1/\sqrt{q_{11t}} & 0 \\ 0 & 1/\sqrt{q_{22t}} \end{bmatrix}$$

The DCC(1,1) model is then given by **(7b)**:

$$Q_t = \omega + \alpha \varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1}$$

where $\omega = (1 - \alpha - \beta)\bar{Q}$.

Following Engle (2002), $\bar{Q}$ is treated as the second moment of ε_t, and is proxied by the sample moment of the estimated returns in large systems. However, the equality $\bar{Q} = E[\varepsilon_t \varepsilon_t']$ does not hold in the general case, and the interpretation of $\bar{Q}$ as well as its estimation are not straightforward.

The dynamic conditional correlations are finally given by **(8b)**:

$$\rho_{12t} = \frac{q_{12t}}{\sqrt{q_{11t} q_{22t}}}$$

According to Engle (2002), the estimation of this model is done using a two-step maximum likelihood estimation method, the likelihood function being given by **(9b)**:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(2\log(2\pi) + 2\log|R_t|| + \varepsilon_t' R_t^{-1}\varepsilon_t)$$

4. EMPIRICAL RESULTS

4.1 Preliminary results

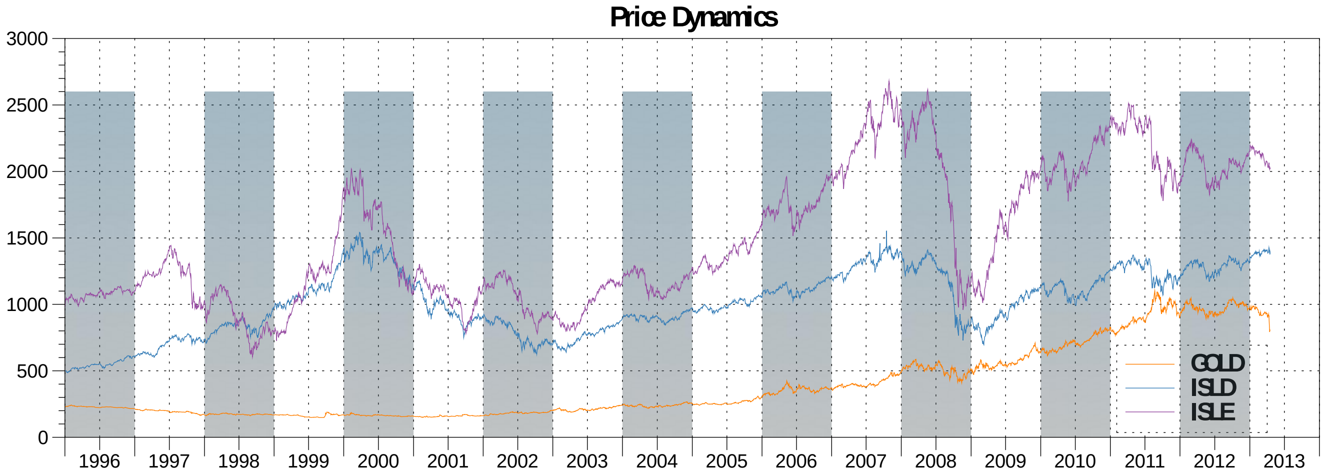

Figure 1: Price index dynamics of gold, crude oil and global Shariah-compliant stocks (normalized)

The Figure 1 shows gold and equities price index dynamics for the period from 1996 to 2013. Gold prices show steady growth starting from year 2001. Developing market equities seems to be relatively more stable than the emerging market, probably due to the better structure of the market in terms of regulations and trading strategies.

STATISTICS	*ISLD*	*ISLE*	*GOLD*
Mean	*0.000098*	*0.000069*	*0.000122*
Std. Dev.	*0.004856*	*0.005951*	*0.004743*
Return/Risk	*0.020181*	*0.011662*	*0.025722*
C.V.	*49.551020*	*85.749280*	*38.877049*
Skewness	*-0.322124*	*-0.346444*	*-0.105626*
Kurtosis	*12.070240*	*8.265646*	*10.472230*
Jarque-Bera	*15544 [0.00]*	*5302 [0.00]*	*10505 [0.00]*
Observations	*4512*	*4512*	*4512*

Table 2: Descriptive statistics
(- Significance at 1% level)*

The Table 2 provides descriptive statistics of returns series, defined as $r_t = \ln(P_t/P_{t-1})$, where P_t denotes the price index at time t. The mean returns for gold is relatively greater than for equities. The highest volatility is displayed by returns on equities of emerging markets. From the return-risk perspective, the most profitable ones are seem to be gold and equities of developed markets. The fat tail property of return series is apparent from the excess kurtosis of all assets, particularly in the case of gold and developed market stocks, hence indicating that observing extreme values is more expected. All asset returns are skewed to the left implying tendency towards negative returns. The Jarque-Bera test indicates that all the returns series are not normally distributed evidenced by the significance of the results at 1% level.

4.2 Empirical results

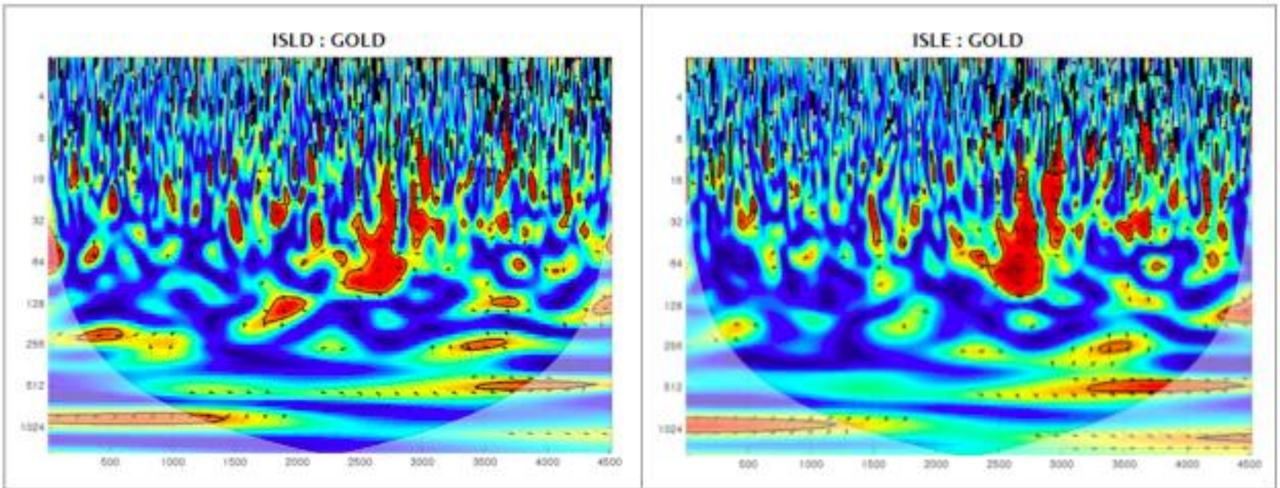

Figure 2: Wavelet Coherence outputs

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Figure 2: Wavelet Coherence outputs

The Figure 2 shows the multi-scale relationship between gold price returns (GOLD) and returns on equities from Islamic developed (ISLD) and emerging (ISLE) markets. Cold (blue) regions in the figure indicate low correlation, while hot (red) regions show high correlation between the pair of variables. Interestingly, both markets - developed and emerging - are almost similar in relationship with gold. Generally, the figures show the interrelation between gold and equities at low scales up to 64 days are inconsistent. According to Ghosh et al. (2004) in the short-run, the variations in real interest rate, gold lease rate, convenience yield, default risk, exchange rate and covariance of gold returns with other assets disturb the equilibrium relationship and generate short-run price volatility.

The strongest correlation is noticeable in the period between 2006-2008 for time-frequency 16-128 days. However, in the long-run - more than 100 days - the variables demonstrate very low correlations, indicating that gold is best in performing its role as a hedge in the low frequency time horizons, i.e. approximately 3-4 months. Basically, the result is supportive of the notion that gold can play a role as a financial variable that is important for stock market investors.

Parameters	Normal Distribution	t-Distribution	Volatility and Correlation		#
λ1_GOLD	0.95172 [0.000]	0.94204 [0.000]			
λ1_ISLD	0.92477 [0.000]	0.93069 [0.000]			
λ1_ISLE	0.90637 [0.000]	0.92234 [0.000]	Unconditional Volatility		Rank
λ2_GOLD	0.03662 [0.000]	0.04306 [0.000]	GOLD:GOLD	0.00475	1
λ2_ISLD	0.06679 [0.000]	0.06033 [0.000]	ISLD:ISLD	0.00486	2
λ2_ISLE	0.08306 [0.000]	0.06739 [0.000]	ISLE:ISLE	0.00596	3
(λ1 + λ2)_GOLD	0.98834 < 1	0.98511 < 1			
(λ1 + λ2)_ISLD	0.99156 < 1	0.99102 < 1			
(λ1 + λ2)_ISLE	0.98943 < 1	0.98973 < 1	Unconditional Correlation		Rank
Δ1	0.98306 [0.000]	0.98341 [0.000]	ISLD:GOLD	0.10337	1
Δ2	0.01371 [0.000]	0.01415 [0.000]	ISLE:GOLD	0.14276	2
MLE	54773.2	< 55235.1	ISLD:ISLE	0.53688	3
df	-	7.5 < 30			

Table 3: Volatility Parameters and Unconditional Volatilities & Correlations

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Table 3: Volatility parameters and unconditional volatilities and correlations

The Table 3 shows the results for MGARCH-DCC volatility parameters based on both assumptions of normal distribution and t-distribution. The greater Maximum Likelihood Estimate for t-distribution suggests that the return series are not normally distributed. Volatility parameters indicate non-persistence of asset volatility due to shocks (i.e. total of both lambdas for each variable shows the value less than 1, i.e. not IGARCH). Unconditional volatility estimates show that returns on gold is more stable compared to equities, and returns on equities from emerging markets are most volatile than that of developed markets. The unconditional correlation between returns on gold and equities of emerging markets is relatively stronger than linkages between gold and developed market returns.

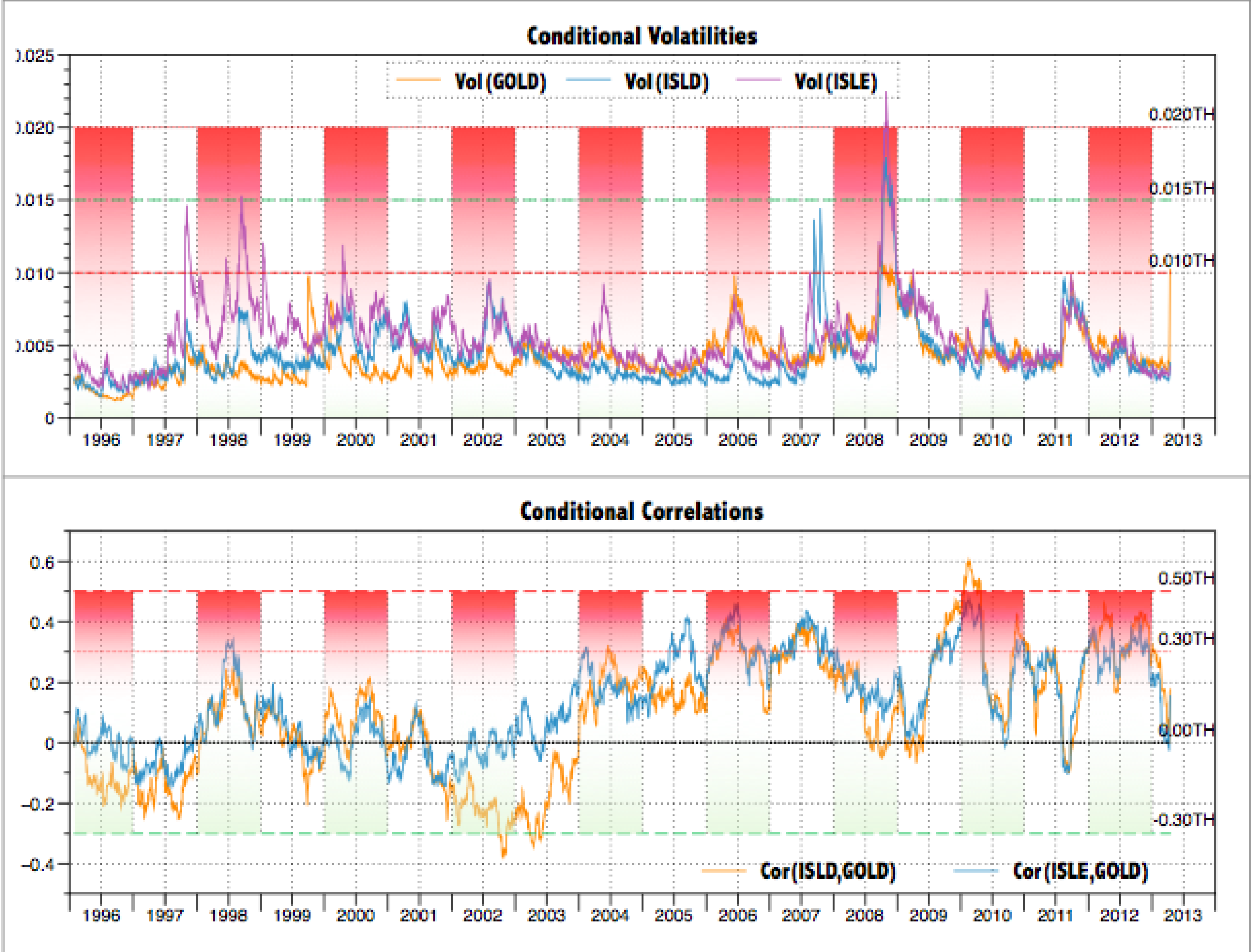

Figure 3: Conditional volatilities and correlations

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Figure 3: Conditional volatilities and correlations

The Figure 3 illustrates the conditional volatilities and correlations between the assets. Equities from emerging markets exhibit the highest variability of returns, while returns on gold are most stable; on average, gold is more correlated with equities of emerging markets, which is consistent with both unconditional estimates from Table 3.

Interestingly, since year 2005, the behavior of both equity markets is quite identical showing similar patterns of volatility and correlations with gold. In the periods of high volatility of stock markets, and particularly during the global financial crisis, their correlation with gold dropped almost to zero level, thus demonstrating a weak form of safe haven.

5. CONCLUSION

The objective of this paper was to evaluate the role of gold as a hedge (negative or low correlation with equities in normal market conditions) and safe haven (negative or low correlation in times of market turbulence) by using the daily data for gold and Shariah-compliant equities ranging from January 1996 to April 2013, and comparing between developed and emerging markets in time-frequency domain. Wavelet Coherence technique was applied to identify the best time-frequency for gold as a hedge, and MGARCH-DCC to find out the reaction of gold to unfavorable market conditions as a safe haven.

The results tend to indicate that gold maintains its role as a hedging instrument at higher time-scales - more than 100 days, and during the financial crisis and equity market instabilities it demonstrated a weak form of safe haven by showing almost zero correlation with Shariah-compliant equities of developed and emerging markets similarly.

Based on these results, we can infer that there are potential benefits of gold investment during periods of stock market slumps. From an academic perspective, the paper contributes to a better understanding of when and where gold can act as an inflation hedge and new application of threshold model. From the perspective of investors, this article provides a decision aid for making better asset allocation of one's portfolio.

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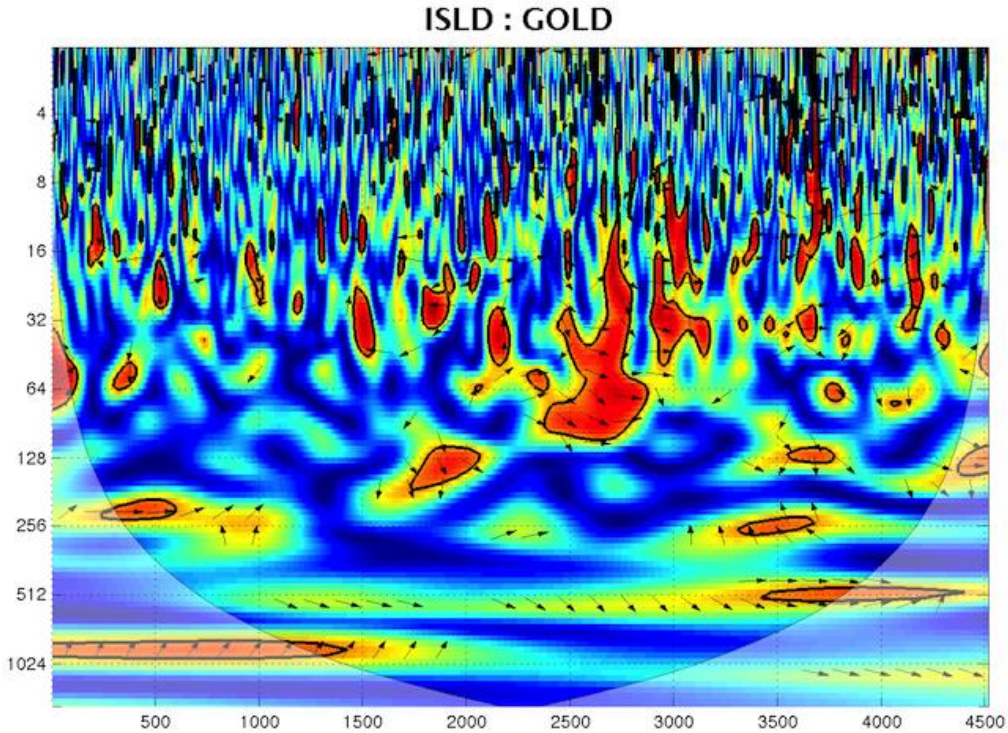

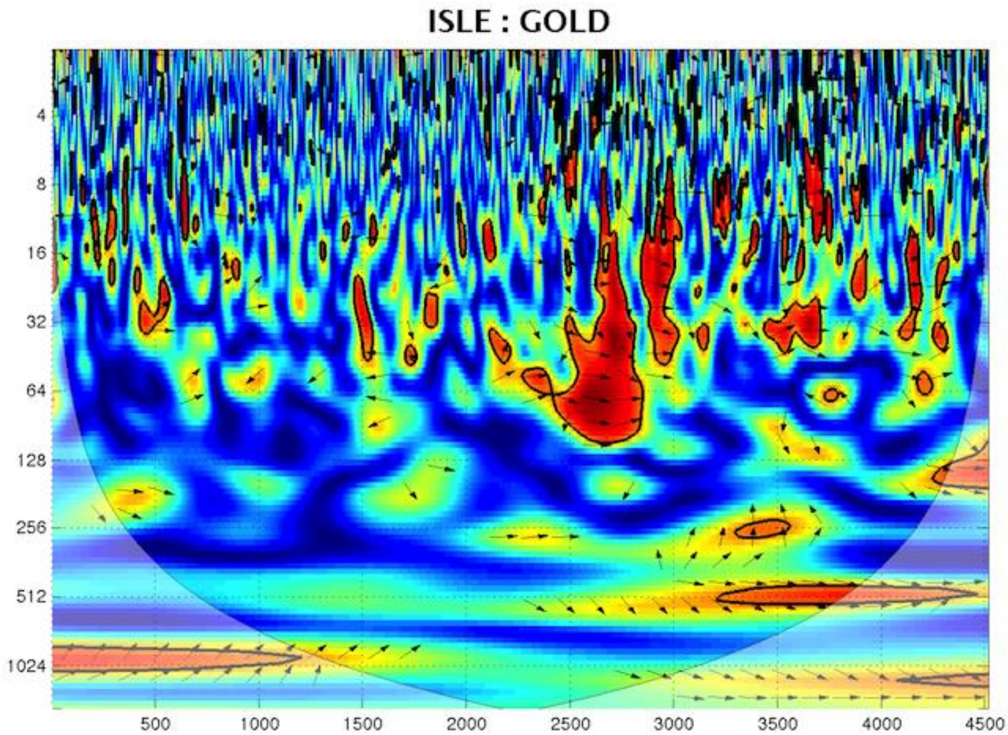

TABLE 1: MGARCH-DCC NORMAL DISTRIBUTION OUTPUT

Multivariate GARCH with underlying multivariate Normal distribution
Converged after 81 iterations

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Based on 4492 observations from 30-Jan-96 to 17-Apr-13.
The variables (asset returns) in the multivariate GARCH model are:
GOLD ISLD ISLE
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.

****

Parameter	Estimate	Standard Error	T-Ratio[Prob]
lambda1_GOLD	.95172	.0058320	163.1893[.000]
lambda1_ISLD	.92477	.0051223	180.5405[.000]
lambda1_ISLE	.90637	.0085007	106.6233[.000]
lambda2_GOLD	.036619	.0034748	10.5386[.000]
lambda2_ISLD	.066787	.0042780	15.6117[.000]
lambda2_ISLE	.083063	.0068859	12.0628[.000]
delta1	.98306	.0030097	326.6299[.000]
delta2	.013714	.0020638	6.6452[.000]

****

Maximized Log-Likelihood = 54773.2

****

Estimated Unconditional Volatility Matrix
4492 observations used for estimation from 30-Jan-96 to 17-Apr-13
Unconditional Volatilities (Standard Errors) on the Diagonal Elements
Unconditional Correlations on the Off-Diagonal Elements

****

	GOLD	ISLD	ISLE
GOLD	.0047521	.10337	.14276
ISLD	.10337	.0048642	.53688
ISLE	.14276	.53688	.0059563

****

For the time-varying conditional volatilities and correlations see the Post Estimation Menu.

TABLE 2: MGARCH-DCC t-DISTRIBUTION OUTPUT

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Multivariate GARCH with underlying multivariate t-distribution
Converged after 22 iterations

****

Based on 4492 observations from 30-Jan-96 to 17-Apr-13.
The variables (asset returns) in the multivariate GARCH model are:
GOLD ISLD ISLE
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.

****

Parameter	Estimate	Standard Error	T-Ratio[Prob]
lambda1_GOLD	.94204	.0072366	130.1773[.000]
lambda1_ISLD	.93069	.0067850	137.1692[.000]
lambda1_ISLE	.92234	.0086813	106.2446[.000]
lambda2_GOLD	.043065	.0048481	8.8828[.000]
lambda2_ISLD	.060327	.0055510	10.8678[.000]
lambda2_ISLE	.067390	.0069567	9.6870[.000]
delta1	.98341	.0034263	287.0142[.000]
delta2	.014145	.0024614	5.7465[.000]
df	7.4855	.36254	20.6475[.000]

****

Maximized Log-Likelihood = 55235.1

****

df is the degrees of freedom of the multivariate t distribution

Estimated Unconditional Volatility Matrix
4492 observations used for estimation from 30-Jan-96 to 17-Apr-13
Unconditional Volatilities (Standard Errors) on the Diagonal Elements
Unconditional Correlations on the Off-Diagonal Elements

****

	GOLD	ISLD	ISLE
GOLD	.0047521	.10337	.14276
ISLD	.10337	.0048642	.53688
ISLE	.14276	.53688	.0059563

****

For the time-varying conditional volatilities and correlations see the Post Estimation Menu.

Page 2

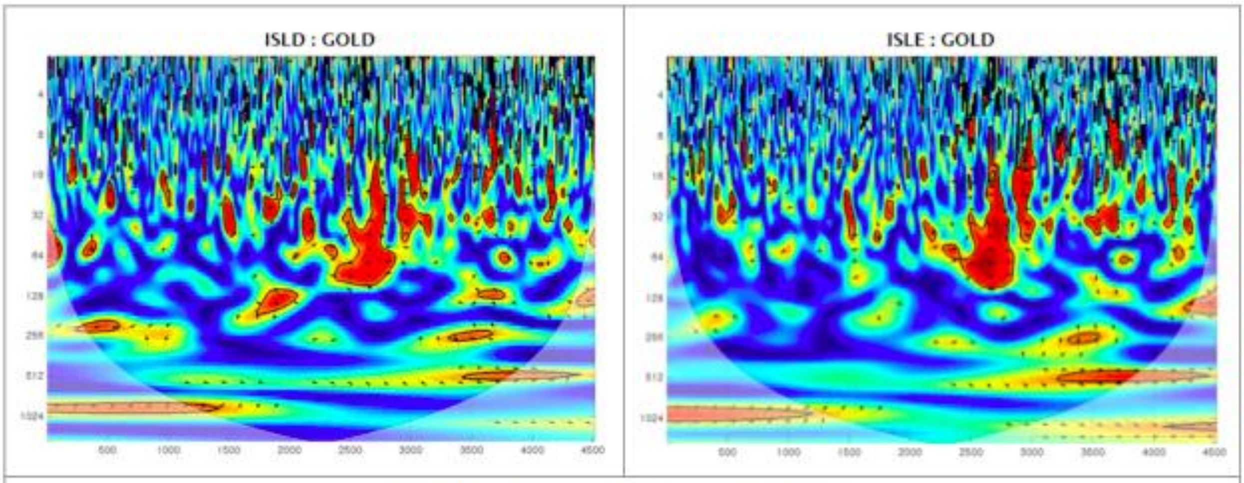

Figure 2: Wavelet Coherence outputs

Parameters	Normal Distribution	t-Distribution	Volatility and Correlation		#
λ1_GOLD	0.95172 [0.000]	0.94204 [0.000]			
λ1_ISLD	0.92477 [0.000]	0.93069 [0.000]			
λ1_ISLE	0.90637 [0.000]	0.92234 [0.000]	Unconditional Volatility		Rank
λ2_GOLD	0.03662 [0.000]	0.04306 [0.000]	GOLD:GOLD	0.00475	1
λ2_ISLD	0.06679 [0.000]	0.06033 [0.000]	ISLD:ISLD	0.00486	2
λ2_ISLE	0.08306 [0.000]	0.06739 [0.000]	ISLE:ISLE	0.00596	3
(λ1 + λ2)_GOLD	0.98834 < 1	0.98511 < 1			
(λ1 + λ2)_ISLD	0.99156 < 1	0.99102 < 1			
(λ1 + λ2)_ISLE	0.98943 < 1	0.98973 < 1	Unconditional Correlation		Rank
Δ1	0.98306 [0.000]	0.98341 [0.000]	ISLD:GOLD	0.10337	1
Δ2	0.01371 [0.000]	0.01415 [0.000]	ISLE:GOLD	0.14276	2
MLE	54773.2	< 55235.1	ISLD:ISLE	0.53688	3
df	-	7.5 < 30			

Table 3: Volatility Parameters and Unconditional Volatilities & Correlations

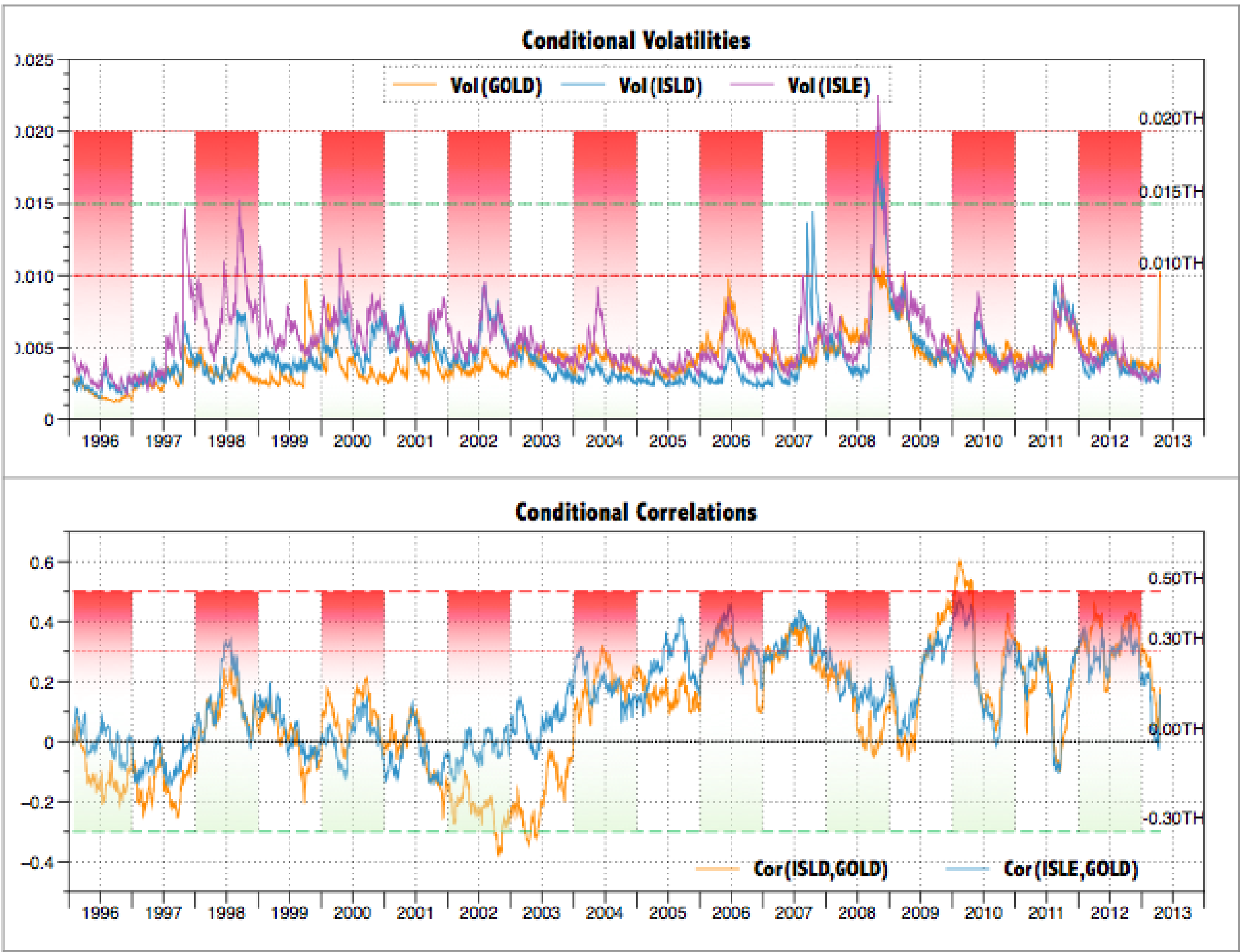

Figure 3: Conditional volatilities and correlations