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Volatility Transmission and Spillovers among Gold, Bonds and Stocks: An Empirical Evidence from Turkey

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ABSTRACT: This paper examines the volatility transmission mechanisms bivariately, between gold prices and alternatively, Turkish stock market and government bond indices. We employ the BEKK-GARCH model for evaluating the volatility linkages, as a robust technique. We investigate the period between June 2006 and November 2013, which infact, is a highly volatile period in the world economy, marked by the 2008 crisis. Our results confirm a bi-directional shock and volatility transmission between gold prices and Turkish stock market, whereas we document a uni-directional transmission from gold asset to Turkish government bonds. Based upon our BEKK-GARCH model corollaries, we design two hedged portfolios consisting of gold/stocks and gold/bonds. The optimal portfolio weights and hedge ratios are computed to signify that adding a portion of gold in bond and stock portfolios, enhances investment efficiency. Our empirical findings depict gold as a unique asset to reduce the portfolio risk especially in times of adverse market conditions in Turkey. Thus, our study conveys significant implications to international investors and portfolio managers in portfolio diversification and risk management.

Keywords: Gold; Stocks; Bonds; Portfolio Diversification
JEL Classifications: G01; G11; G15

1. Introduction

Since ancient times, gold has served as a means of exchange and storage of wealth. The price of gold is mostly related to economic and political instability, as it has no sovereign credit risk. Gold is a unique asset with safe haven and hedging properties, as it is weakly correlated with other financial investments (Lawrence, 2003; Capie et al., 2005; Hillier et al., 2006). Baur and Lucey (2010) adduce the safe haven property of gold in the US, UK and German stock markets, however for bonds, gold qualifies only as a hedge in Germany in their study. In the same vein, Baur and McDermott (2010) report gold as both a hedge and a safe haven investment asset in European and US stock markets.

There is a strand of literature investigating the links between macroeconomic forces and gold prices (Taylor, 1998; Christie-David et al., 2000; Worthington and Pahlavani, 2007). Lawrence (2003) asseverates that gold prices are not correlated with macroeconomic factors. Capie et al. (2005) evaluate gold as a hedge against exchange rate and discern a negative relation between gold returns and both the dollar/pound and the dollar/yen rates. Tully and Lucey (2007) beckon to the value of the US dollar as the main macroeconomic determinant of gold prices. Hammoudeh et al. (2010) adduce that gold acts as a hedge against exchange rate risk and past volatility of gold amplifies exchange rate volatility. Kim and Dilts (2011) aver a negative relation between gold prices and the value of the dollar. Sari et al. (2010) postulate the inflation hedging property of gold, as a safe haven especially when the dollar weakens against the euro.

A second branch of literature thoroughly investigates the association between gold and stock/bond markets (Sherman, 1982; Jaffe, 1989; Smith, 2002; Lucey et al., 2006; Michaud et al., 2006; Conover et al., 2007; Ratner and Klein, 2008). All of these studies meet at a common ground that gold is efficient in portfolio diversification. Davidson et al. (2003) posit that gold has either a positive or negative significant effect on most of the industries they investigate (22 world industries out of a sample of 24) in an attempt to signify gold "as an additional factor in international asset pricing models". Lucey et al. (2006) dissect the performance of gold when included in stock portfolios. Their sample consists a variety of stock indices over the period from 1988 to 2003. Their findings suggest that gold in a portfolio context raises return, reduces risk, measured in both variance and skewness. Hoang (2011) documents the enhancing role of gold investments in portfolio efficiency for French stock and bond portfolios between 2004 and 2009, underlying the superior outcome in stock portfolios.

In recent years, the research interest shifted more towards investigating the transmission processes between gold returns and financial markets. Do et al. (2009) surmise that gold returns are countercyclical in the Philippines and Vietnam equity markets, while they are procyclical in Indonesia, Malaysia and Thailand stock markets. Cohen and Qadan (2010) investigate the relation between gold prices and the VIX (Volatility Index), referred to as the "fear gauge". They document a bi-directional causality between gold and VIX returns at stable times, whereas there exists a uni-directional causality from gold prices to VIX at times of market fluctuations. Sumner et al. (2010) analyze the period over 1970 and 2009, concluding to a volatility spillover from innovations in stocks to the bond market. In their study, the spillover between gold-stocks and gold-bonds are negligible, probing the predictive power of gold price movements for stocks and bonds. Badshah et al. (2013) investigate the contemporaneous spillovers among the volatility indices for stocks, gold and euro-dollar exchange rate announced by the Chicago Board Options Exchange (CBOE), and they find out a strong unidirectional causal spillover from stocks to gold and exchange rate volatility, in addition to a bidirectional spillover between gold and exchange rate volatility. Miyazaki and Hamori (2013) detect a unidirectional causality in mean from S&P 500 index to gold over the period between 2000 and 2011. Chen and Lin (2014) examine the relation between gold and stocks for four different bear market periods; December 1968-May 1970; January 1973-December 1974; August 1987-October 1987; January 2000-October 2002. They reveal that gold acts as a good investment hedge only in two of the four bear market episodes, drawing attention to differing macroeconomic forces behind each episode. Moreover, they accentuate gold's hedging effectiveness only for small-cap stocks in nonbear markets. Arouri et al. (2013) evince that past gold shocks significantly affect the time-varying conditional volatility of stock returns in China and that gold can be used as an effective hedge for stock risk exposures.

The recent political disputes, the ongoing economic problems and the fast diffusion of contagion in global financial markets, force the investors to invest in safer assets to diversify their risk. Commodities such as oil and precious metals attract popular attention but gold proves to be the focus of all times. Turkey as an emerging market draws the attention of the international investors, where culturally, households put a special emphasis on gold investments. Thus the spillover mechanisms between the world gold market and Turkish stock and bond markets are of significant importance to these investors seeking hedging alternatives. In this study, we use the BEKK- GARCH model, in an attempt to bivariately analyze the volatility transmissions between gold-stocks and gold-bonds in the Turkish financial markets. A thorough understanding of the transmissions between these markets provides an accurate assay of portfolio allocation and hedging ratios. Therefore, we also compute the optimal weights and hedge ratios for portfolios of gold-stocks and gold-bonds based on our empirical results. The rest of the paper is organised as follows; the second part defines the methodology applied; the third part construes the data of the study; the fourth part expounds the empirical results; the fifth part explains the optimal weight and hedge ratio calculations and finally the sixth part discusses the conclusion.

2. Methodology

GARCH family models are widely used for modeling and forecasting volatility during the last two decades. For analyzing volatility spillovers between different time series multivariate GARCH specifications are applied such as the CCC-GARCH model of Bollerslev (1990) and the DCC-GARCH model of Engle (2002). Despite their simplicity in estimating the parameters, they do not allow to examine cross volatility spillovers. In Engle and Kroner's (1995) full-BEKK model, this shortfall is dispelled and the positive definiteness of the conditional covariance is obtained by a quadratic formulation of the parameters in the model structure. De Goeij and Marquering (2004) assert that the model is relatively frugal as the number of parameters is expanding linearly with the number of variables.

$$H_t = C'C + A'u_t u_t A + B' H_{t-1} B \quad (1)$$

where, *C, A*, and *B* are k×k matrices but *C* is the upper triangular and *H* is the variance-covariance matrix. The diagonal elements of matrix *A* assess the effects from past squared shocks on the current volatility while the non-diagonal elements measure the cross product influences of the lagged shocks on the current volatility. Similarly the diagonal elements of matrix *B* determine the effects from past squared volatilities on the current volatility and non-diagonal elements evaluate the cross product effects of the lagged covariances on the current volatility. The model above provides parsimonious cross market effects in the variance equation and ensures positive semi definiteness.
The following log-likelihood function is maximized,

$$L(\theta) = -T\ln(2\pi) - 1/2\sum_{t=1}^{T}(\ln|H_t| + \varepsilon_t^{'} H_t^{-1}\varepsilon_t) \quad (2)$$

where, θ is the parameter vector to be estimated and T is the number of observations. While modeling the BEKK-GARCH model, we use quasi maximum likelihood (QML) estimation method. It allows producing robust standard errors and yields consistent estimations even if normality assumption is violated. In addition, we perform simplex and BFGS algorithms to obtain initial conditions and the final estimates, respectively.

3. Data Analysis

We use the log returns of gold and bond prices in Turkish Liras along with the composite stock market index of Borsa Istanbul (BIST100) denominated in Turkish Lira on daily basis. All price data is the closing values. Gold prices are announced by Istanbul Gold Exchange (IGE) per troy ounce and extracted from the Turkish Central Bank website. 10-year government bond prices are from Bloomberg while BIST100 index is taken from Borsa Istanbul. The data covers the period from June 6, 2006 to November 29, 2013. The log returns are calculated as follows;

$$R_{t+1} = \log(P_{t+1}) - \log(P_t) \quad (3)$$

where, R_{t+1}, denotes return, P_t and P_{t+1} represent price at time t and price at time t+1, respectively.

The mean values of the returns are -0.05%, 0.04% and 0.07% for bonds, stocks and gold, respectively while the standard deviations are 1.65, 2.07, and 1.48 in the same order. In Turkey, gold investments generate the highest return at the lowest risk, measured in terms of standard deviation, while bond returns are very slightly negative, and stocks are the riskiest investments with considerably lower returns and higher unconditional volatility compared to gold. It can be seen that gold and bond returns are skewed to the right whereas BIST100 returns are skewed to the left.

Table1. Descriptive Statistics (%)

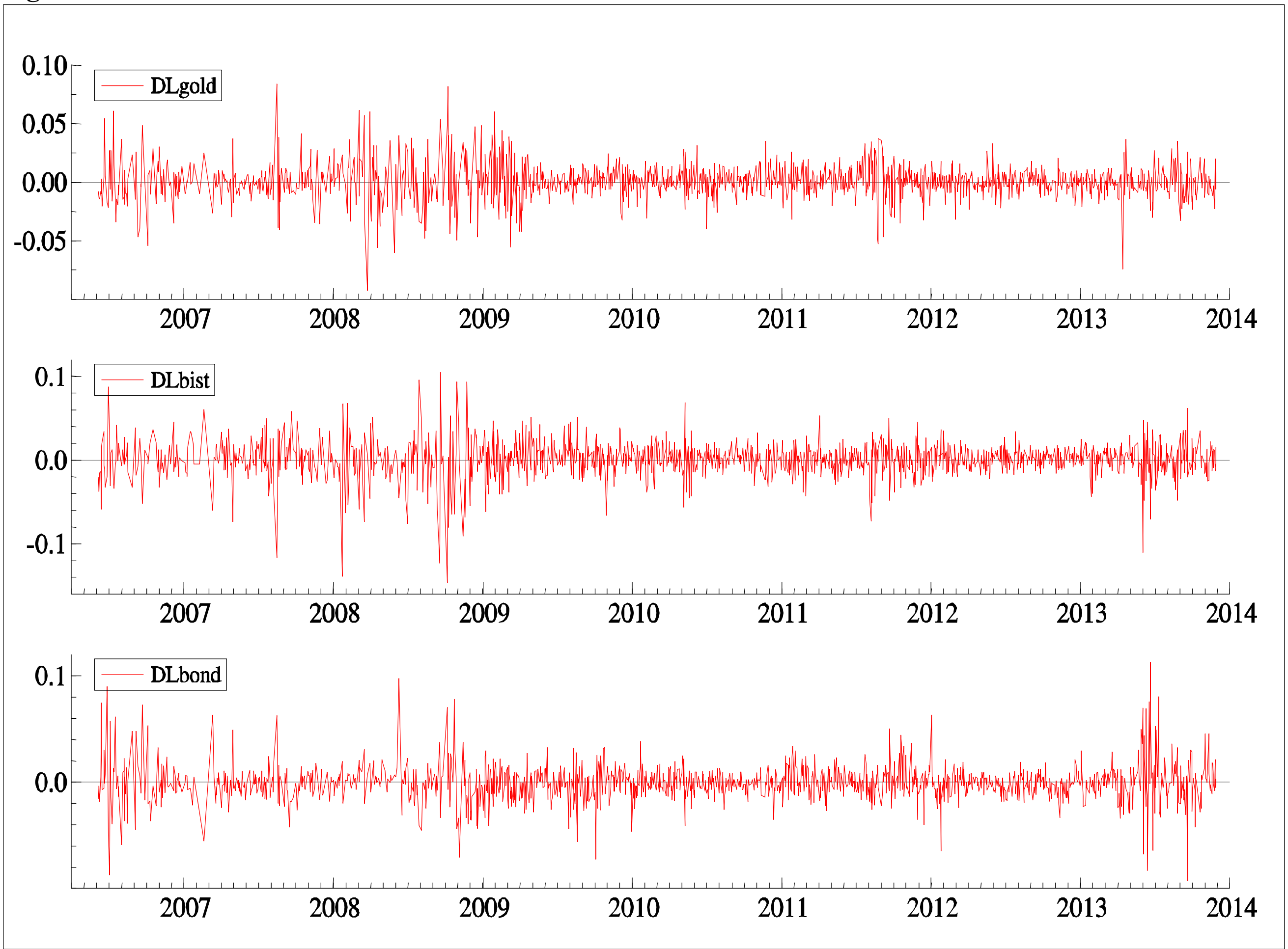
	Gold	BIST100	Bond
Mean	0.075	0.044	-0.050
Minimum	-9.258	-14.65	-9.255
Maximum	8.376	10.553	11.269
Std. Dev.	1.484	2.073	1.650
Skew.	0.079	-0.732	0.559
Kurt.	4.720	6.845	7.322
J-B	1527.3[a]	3355.1[a]	3619.7[a]
	(0.000)	(0.000)	(0.000)
ARCH (10)	21.405[a]	18.742[a]	21.699[a]
	(0.000)	(0.000)	(0.000)
Q (10)	37.364[a]	43.131[a]	34.348[a]
	(0.000)	(0.000)	(0.000)
Q2 (10)	418.979[a]	345.220[a]	387.000[a]
	(0.000)	(0.000)	(0.000)
ADF	-24.837[a]	-23.647[a]	-20.805[a]
	(0.000)	(0.000)	(0.000)

Notes: (a) denotes the statistical significance at the 1% level.

Moreover, excess kurtosis is computed for all the return variables (greater than 3), implying leptokurtic distributions which are more peaked around the mean with thicker tails compared to the normal distribution. The non-normality is also confirmed by the rejection of Jarque-Bera test statistics' null hypothesis at the 1% level significance. Typically, Ljung-Box tests up to 10^{th} lag indicate serial correlations on raw and squared data. ARCH (10) test results reveal that the variables contain significant ARCH effects. Finally, Augmented-Dickey-Fuller (ADF) test applied to the return variables provide the rejection of unit-roots. Therefore, the return data is in accord with GARCH-type modeling and further analysis.

Figure 1 presents the log-difference plot of the gold, BIST100 and 10-year government bond prices. Beginning by the mid of 2007, it can be seen that the returns in gold and stocks are highly volatile for about two years until the mid of 2009, a period marked by the sub-prime mortgage crisis in the world. From the graphs, the effects of volatility clustering can be traced for all of the variables featuring GARCH type models for volatility transmission analyses.

Figure 1. Return Plots



4. Empirical Results

Based on the results in Table 2, past own shocks (news) are significant for both gold-bonds and gold-stocks pairs. The past shocks of gold have the highest impact on its own current volatility in both models. The estimated cross error terms show that there is a significant and negative bi-directional shock transmission for gold-stocks pair. Past news in gold (stocks) negatively affects the current volatility of stocks (gold) substantiating the safe haven property of gold investments against stocks. From the table, it can be seen that there is a uni-directional shock transmission from gold to bond investments which is positive.

The estimated coefficients for the one lag conditional variance show that past own volatilities have significant impact on the current volatilities of the variables in both gold-stocks and gold-bonds pairs. The current volatility of bond returns are the most affected by own past volatility, while the current volatility of stocks is the least affected. In terms of cross conditional volatility terms, the results reveal that there is a bi-directional volatility transmission between gold and stocks. The past volatility in gold returns negatively affects the current volatility in stocks, while the volatility transmission is positive from stocks to gold. For the gold-bonds model, the cross coefficients delineate a uni-directional volatility transmission from gold to bonds which is negative. The results of the diagnostic tests based on standardized residuals depict no serial correlation and no remaining ARCH effects, reifying the BEKK-GARCH (1, 1) model adequate to capture the dynamics of volatility spillover between the series.

Table 2. VAR (1)- BEKK (1,1) MGARCH Results

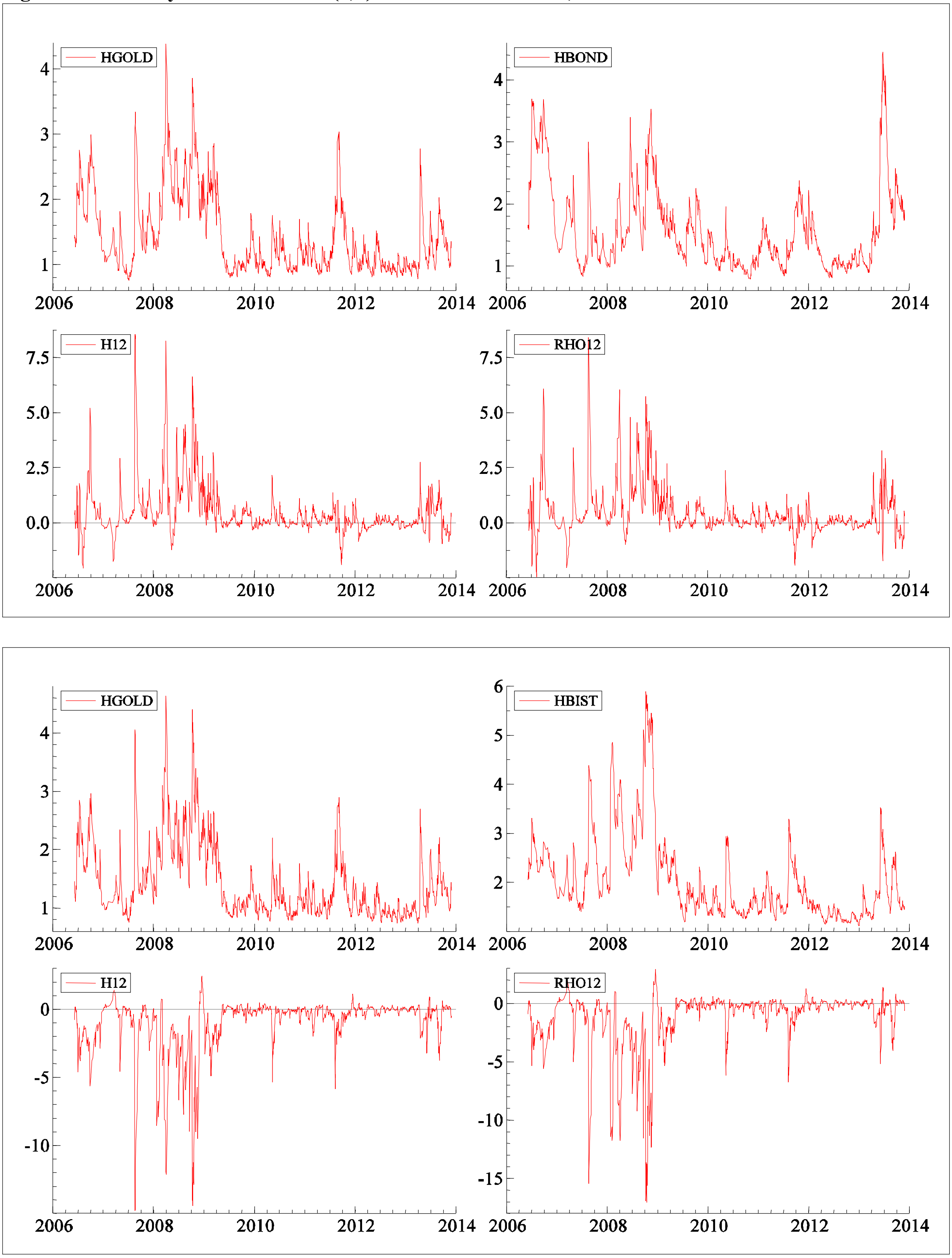
	Gold	Stocks	Gold	Bonds
Mean	0.030	0.164[a]	0.053[c]	-0,092[a]
	(0.261)	(0.000)	(0.060)	(0.004)
$(\varepsilon_{it-1})^2$	0.328[a]	-0,053[b]	0.344[a]	0.144[a]
	(0.000)	(0.036)	(0.000)	(0.000)
$(\varepsilon_{jt-1})^2$	-0,096[a]	0.268[a]	0.003	0.250[a]
	(0.000)	(0.000)	(0.696)	(0.000)
h_{it-1}	0.939[a]	-0,052[a]	0.926[a]	-0,059[a]
	(0.000)	(0.000)	(0.000)	(0.000)
h_{jt-1}	0.055[a]	0.934[a]	0.001	0.959[a]
	(0.000)	(0.000)	(0.644)	(0.000)
LL	-5.757.531		-5.408.134	
Q (10)	22.095[b]	16.535[c]	20.797[b]	53.839[a]
	(0.014)	(0.085)	(0.022)	(0.000)
Q^2 (10)	1.539	7.112	1.719	7.607
	(0.998)	(0.714)	(0.998)	(0.667)
ARCH (10)	0.142	0.696	0.164	0.881
	(0.999)	(0.728)	(0.998)	(0.549)

Note: Robust standard errors are in parentheses. (a) indicates 1% significance, (b) 5% significance, and (c) 10% significance levels. i represents gold, j stands for stocks in gold-stock bivariate model and it denotes bonds in the gold-bonds model.

Figure 2 represents the conditional variances, covariance and correlation plots. In general, volatility of gold and both the stock and the bond markets increase during periods of political and/or economic turmoil. The largest increase in conditional variances can be seen in the aftermath of 2008 sub-prime mortgage crisis. Other high volatility periods are the end of 2011 and the mid of 2013. The end of 2011 is marked by the European sovereign debt crisis which induced the collapse of financial institutions and high government debt in some European countries, while the debates about FED's monetary policy decisions blazed in the mid of 2013.

Figure 2 also provides a visual evidence of the "safe haven" or the "refugee" asset property of gold against stocks. Gold and stock returns are negatively correlated almost in all times and the negative correlation increases during the 2008 crisis. The correlation coefficient between gold and bond returns is mostly positive and considerably low between 2009 and 2012, substantiating the hedging property of gold investment against bonds.

Figure 2. Volatility Plots of BEKK (1,1) MGARCH for Gold, Bonds and BIST100



Note: HGOLD, HBOND and HBIST are the conditional variances of the series, H12 denotes the covariance, while RHO12 denotes the correlation between gold-bonds and gold-stocks in the second and fourth rows respectively.

5. Hedge Ratios and Optimal Portfolio Weights

In this section, we discuss about the connotations of our BEKK-GARCH model results on designing optimal portfolios of both gold-stocks and gold-bonds. We construct two hedged portfolios, firstly of gold and BIST 100 index, and secondly of gold and 10-year government bonds. The aim is minimizing the risk at the same expected return. Kroner and Ng (1998) propose the optimal holding weight calculations;

$$w_t^{ij} = \frac{h_t^j - h_t^{ij}}{h_t^i - 2h_t^{ij} + h_t^j} \tag{4}$$

and

$$w_t^{ij} = \begin{cases} 0, & if \;\; w_t^{ij} < 0 \\ w_t^{ij}, & if \;\; 0 \le w_t^{ij} \le 1 \\ 1, & if \;\; w_t^{ij} > 1 \end{cases} \tag{5}$$

where, for the first portfolio that is constructed of gold and stocks (BIST 100 index) the w_t^{ij}, denotes the weight of gold in a one-dollar portfolio of gold/BIST 100 index at time t; h_t^i, h_t^j and h_t^{ij} are the conditional volatility of gold returns, the conditional volatility of BIST100 index and the conditional covariance between gold and stock returns at time t. For the second portfolio, h_t^i, h_t^j and h_t^{ij} stand for the conditional volatility of gold returns, the conditional volatility of the government bond index and the conditional covariance between gold and bond returns at time t, respectively. We derive all the series from our BEKK-GARCH models.

Kroner and Sultan (1993) compute the optimal hedge ratios of a two asset portfolio in the following way;

$$\beta_t^{ij} = \frac{h_t^{ij}}{h_t^j} \tag{6}$$

where, B_t^{ij} indicates the amount of short position required in the gold market to hedge the one-dollar long position in the stock market.

Table 3 delineates the average values of optimal weights and hedge ratios for the portfolios. The results show that the optimal weight of gold in the gold/stocks portfolio is 0.585 and it is 0.523 in the gold/bonds portfolio according to our BEKK-GARCH models. This denouement implies that, to minimize risk at a given level of return, investors should hold more gold asset than either stocks or bonds in Turkish financial markets. The hedge ratio for the gold/bonds portfolio is 0.178, implying that one-dollar long position in Turkish government bonds should be shorted by 17.8 cents in the gold market. On the other hand, the hedge ratio for gold/stocks portfolio is -0.415, which means that one-dollar short position in Turkish stock market, should be longed by 41.5 cents in the gold market. This result is also substantiated by the high negative correlation coefficient between gold and stock returns. Overall, our findings corroborate the long-lived contemplation that gold is a unique asset to reduce the portfolio risk especially in times of adverse market conditions. In Turkish markets, adding a portion of gold in bond and stock portfolios, increases efficiency by lowering risk at the same expected return.

Table 3. Optimal Portfolio Weights and Hedge Ratios

	Gold/Stocks	**Gold/Bonds**
w_t^{ij}	0.585	0.523
β_t^{ij}	-0.415	0.178

6. Conclusion

This study investigates the shock and volatility transmission mechanisms between gold, and stock/bond markets in Turkey, applying bivariate BEKK-GARCH modeling for gold-stocks and gold-bonds pairs respectively over the period June 6, 2006 to November 29, 2013. Overall, we posit some significant shock and volatility transmissions at varying magnitudes. For the gold-stocks pair, we report a negative bi-directional shock transmission. These findings are also substantiated by the negative correlation between the two asset classes, highlighting the “safe haven” property of gold investments against stocks. There exists a bi-directional volatility transmission between gold and stocks, wherein, the one-lagged volatility in gold returns negatively affects the current volatility of stocks. However, the past volatility of stock market returns positively affects the current volatility of the gold asset. A plausible explanation for this outcome may come from Baur and McDermott's (2010) deliberation that the exceeding levels of uncertainty in stock markets impel the co-movement of gold with the stocks. Coudert and Raymond (2011) substantiate the above mentioned scholars in pointing out gold as a weak safe haven at times of increased stock market uncertainty. Hence, our results are in line with the discussion about gold's exhibiting a weak safe haven property at times of extreme stock market fluctuations, since the time span under investigation matches a highly volatile period in both the Turkish and global stock markets. Furthermore, our empirical findings suggest a uni-directional positive shock and negative volatility transmission from gold prices to the government bond index, which can be vindicated by investors' preference towards gold investments when interest rates decline. Traditionally, Turkish investors convert to holding gold asset at low interest yield episodes, since uncertainty about future inflation rates brings about negative real-interest return as an issue.

In order to assess the implications of our findings in portfolio management and hedging, we also compute the optimal weights and hedge ratios for the designed portfolios of gold-stocks and gold-bonds. Gold asset outweighs both the stocks and bonds in the optimal portfolios. The hedge ratio for the gold-stocks portfolio is negative (-0.415), implying a one-dollar short in Turkish stocks should be longed by 41.5 cents of gold investments, whereby, according to the hedge ratio for the gold-bonds portfolio, one-dollar long in Turkish government bonds should be shorted by 17.8 cents in the gold asset. Thus, we confirm gold as enhancive element for portfolio efficiency. Our results provide insights for investors and portfolio managers to effectively implement diversification and hedging strategies in the Turkish financial markets.

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