The Informational Content of Unconventional Monetary Policy on Precious Metal Markets

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Abstract

This paper investigates the informational content of unconventional monetary policies and its effect on commodity markets adopting a non-linear approach for modeling volatility. The main question addressed is how the Bank of England, Bank of Japan and European Central Bank's announcements concerning monetary easing affect two major commodities, gold and silver. Our empirical evidence based on daily and high frequency data suggests that relevant information cause ambiguous valuation adjustments as well as stabilization or destabilization effects. Specifically, there is strong evidence that the Japanese Central Bank strengthens the precious metal markets by increasing their returns and by causing stabilization effects in contrast to the ECB which has opposite results mainly due to the heterogeneous expectations of investors within these markets. These asymmetries across Central Banks' effects on gold and silver risk-return profile imply that the ECB unconventional monetary easing informational content opposes its stated mission adding uncertainty in precious metals markets.

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Introduction

Recently there has been a debate in the literature regarding the relationship between conventional monetary policy conduct and commodity prices dynamics. Among others Christiano et al. (2005), Mallick and Sousa (2012), Sousa (2010) and Jawadi et al. (2015) provide empirical evidence supporting the view of a strong negative impact of monetary contractions on the aggregate commodity price index. This argument is also underlined by Belke et al., (2010a, 2010b, 2014) according to which global liquidity and low interest rate regimes are valuable indicators of commodity price inflation. While, Lastrapes and Selgin (2001) argue that the relationship between precious metal prices and monetary policy was weakened after the mid-nineties. However, Hammoudeh et al., (2015) identify positive impact of U.S. monetary policy contraction on the aggregated commodity prices over the pre financial crisis period, though their findings are commodity-sector specific. The precious metals' reaction is more elastic leading to prices fall on impact, but then turns to a positive one between two and six quarters, highlighting their role as financial instruments. In this direction Batten et al. (2010) argued that precious metals cannot be considered as a single asset class, due to the fact that among the precious metals only the volatility of gold is affected by monetary variables.

Over the last two decades, forming inflation expectations via monetary policy announcements has been a typical strategy for a central banker in developed countries. Central bank communication has been a useful tool in forming these expectations. Frankel and Hardouvelis (1985) are among the first who document a relationship between monetary policy news and commodity prices. According to Frankel's (1986) theoretical model, it is expected that news about US monetary policy, such as (unexpected) interest rate changes, play an important role in commodity prices. In this line, Hayo et al., (2012) provide evidence that expected target rate changes and communications decrease commodity volatility, whereas target rate surprises and unorthodox measures increase it. Nevertheless, the intensity of such

results is found to be medium during the recent crisis. Monetary policy communication is found to dampen commodity spot prices according to Tai et al. (2014). Moreover, Hove et al. (2015) argue that volatility in emerging economies' market commodities is effectively confronted, if the Central Bank targets on CPI inflation. By focusing on China's economy Klotz et al. (2014), indicate a positive causality from exchange rate volatility to industrial metals price uncertainty. Additional evidence is found on Papadamou and Markopoulos (2014) who reveal a unidirectional volatility transmission from the British Pound and Euro currencies to gold and silver precious metals. Moreover, Khalifa et.al (2011) investigated the relationship between the returns of precious metals and concluded that the normality assumption of precious metals' distributions is not valid and that high frequency data (intraday) could provide better forecasts compared with lower frequency data (daily). Furthermore, Baur et.al (2014) concluded that there is a close relationship between gold and silver returns on the long term which is affected significantly during distress periods. Finally, Narayan et.al (2013) and Batten et.al (2013) underline the importance of using commodities within profitable trading strategies, though the performance of these strategies could be affected significantly during distressed periods as was the case within the recent financial crisis.

The first research hypothesis of our paper is the examination of potential effects of Central Banks' announcements on gold and silver returns using daily and intraday data. Our second research hypothesis focuses on the examination of potential stabilization or destabilization effects of Central Banks' announcements on gold and silver volatility series using, again, daily and intraday data. Finally, we examine the dynamics of the correlation between gold and silver returns due to Central Banks' announcements using both daily and intraday data.

The main contribution of our study to the existing literature lies in the evaluation of the effects of the unconventional monetary policy announcements on the risk-return profile of the precious metals and

on their correlation dynamics by utilizing daily and intra-day frequency data. While there is an increasing number of papers recently focusing on the effect of quantitative easing on bond and currency markets[1] little has been done concerning the role of unconventional monetary policy announcements on precious metals' markets. This paper tries to fill this gap adding to existing literature on the interaction between monetary policy and commodities by focusing on two precious metals, gold and silver, which are attractive assets in a typical asset allocation strategy.

Our empirical evidence suggests that the effect that the informational content of unconventional monetary policy has on the precious metals markets is country specific. The Bank of Japan affects positively metals' returns dampening their volatility, in contrast to the European Central Bank which causes destabilization effects mainly due to the heterogeneous expectations of investors within these markets. These findings imply that the ECB unconventional monetary easing informational content opposes its stated mission adding uncertainty in precious metals markets. The rest of the paper consists of the data and the econometric methodology, the presentation of the empirical findings and a concluding discussion of the paper.

[1] As far as unconventional monetary policy effects on markets are considered, firstly, there is a pure negative effect on bond yields according to a number of studies (see among others Gagnon et al., 2011; Krishnamurthy & Vissing-Jorgensen, 2011; Christensen and Rudebusch, 2012; Breedon *et al*., 2012; Kapetanios *et al*., 2012; Joyce & Tong, 2012). Joyce *et al.* (2012) support the view that unconventional monetary easing works through the portfolio substitution channel, affecting thus asset prices and investment decisions. According to Steeley and Matyuskin (2015) quantitative easing can also significantly affect bond market volatility in case of UK. Secondly, announcements about monetary easing policies can reduce significantly country's currency and affect its variability as shown in a GARCH framework by Kenourgios et al., (2015a; 2015b). Thirdly, a series of papers indicates that there is a pass through mechanism of unconventional monetary policy to the real economy (Cecioni et al., 2011; Joyce et al., 2011; Peersman, 2011; Chen et al., 2012; Shibamoto & Tachibana, 2013; Lyonnet & Werner, 2012). The alterations caused on credit (Darracq-Paries & De Santis, 2015), by central banks via a specific program can also influences spending and income, and consequently asset prices and inflation rate.

Data and Research Methodology

For the purposes of our analysis we use prices for the two major commodities, that is gold and silver on a daily[2] and on an intraday (hourly) frequency. The sample period under investigation spans from January 2009 to July 2015 covering a period[3] where unconventional monetary policy actions are undertaken by the Bank of England, the Japanese Central Bank, and the European Central Bank, afterwards the global financial crisis. The role of interest rates as an effective monetary policy tool was diminished through the recent financial crisis leading Central Banks to act as lenders of last resort providing liquidity into the markets by directly purchasing assets (Quantitative Easing) and shifting from short term to long term funding to banks (Credit Easing).

The announcements which are examined in this study relate to the following actions: (i) the enhancement of monetary easing by the Japanese Central Bank, (ii) the increases of the size of asset purchase program by the Bank of England, and (iii) the long-term refinancing operations (LTROs) with allotted amount greater than 100 billion Euro by the European Central Bank. Following previous research by Kenourgios et al., (2015) we tested a series of announcements by each central bank covering the monetary easing strategies. More specifically these include but not limited to the following: a) announcement declaring the enhancement of monetary easing by the BoJ, b) announcements stating the size of asset purchases by the BoE and c) the long-term refinancing operations' (LTROs) announcements by the ECB with allotted amount greater than 100 billion Euro.[4]. These announcements are captured by time dummies that consider several lead-lag structures. The first one (DQE1 [0,+1]), considers the day (hour) of the announcement plus one day (hour) ahead and similarly the other time dummies account for different lead-lag effects spanning to 2 days (hour) before the announcement until

[2] The daily data are London fix prices provided by KITCO company at http://www.kitco.com/gold.londonfix.html
[3] Sample period for the intraday frequency covered a narrowed period from 1/1/2010 to 26/3/2012 due to data availability by Dukas copy database that was the provider of our intraday data.
[4] Time of unconventional policy announcements are identified by their sites (see for details also Kenourgios et al., 2015a).

3 days (hour) post the announcement (DQE2A [-2, +1], DQE2B [-1, +1], DQE3 [0, +3] and DQEALL [-2, +3]). The time lags selected for the purposes of our analysis offer a case sensitive tool for capturing a wide range of lead–lag responsiveness. Precisely, while in some cases the one day (hour) lag suffices in identifying the structural change, in some other cases a longer time window is needed. Overall, our conclusions are drawn using all the extracted information based on all of time windows comprehensively.

The time series of the gold and silver prices on a daily (panel A) and intraday (panel B) frequency are illustrated on Figure 1 of the appendix. Daily prices of gold and silver seem to exhibit a common pattern which is weakened when intraday frequency of the series is considered for and especially for specific sub-periods such as that of the first quarter of 2011. Several descriptive statistics are reported on Table 1 of the appendix for the gold and silver series on a daily and intraday frequency. It seems that the prices of silver are more volatile and leptokurtic than those of gold while both of them exhibit a negative skewness. The 5^{th} and 10^{th} order autocorrelation of the time series and the squared series indicate an autocorrelation structure highlighting the necessity of time-varying volatility specifications in the methodology part.

A preliminary analysis of the time series is conducted with respect to the stationarity of series on levels and first differences. Table 2 of the appendix refers to the examination of the stationarity of the series according to the Augmented Dickey Fuller, the Phillips-Perron and the KPSS tests for the daily and intraday Gold and Silver series on levels and 1st log differences. Panel A refers to the daily gold series, panel B, to the daily silver series while panels C and D of this table correspond to the analysis utilizing intraday prices of gold and silver. Undoubtedly the series on levels exhibit a unit root which diminishes when first log differences are used.

The investigation of the effect that the unconventional monetary policy announcements of Central Banks have on the risk-return profile of commodity prices is conducted by employing conventional conditional heteroskedasticity models and linear filters for the mean equation. The time dummies that account for lead-lag effects are incorporated in our methodology both in the mean and the variance specifications. The mean equation focuses on the five structural breaks and accounts for potential autocorrelation structures by application of the Newey-West consistent estimators:

$$r_{it} = a_{0,i} + b_i \cdot DQE_{k,l} + \varepsilon_{ti} \quad (1)$$

where *k* stands for the 5 different timing schemes, i.e. DQE1, DQE2A, DQE2B, DQE3 and DQEall, and *i* for the three Central Banks and consequently the three currencies, i.e. the Great Britain Pound, the Japanese Yen and the Euro. The significance and the sign of the time dummies' coefficients would dictate the effect that the unconventional monetary policy announcements have on the two major commodities' returns.

According to our methodology the residuals of the mean equation follow a zero-mean Generalized Error Distribution (GED) where the tail parameter is λ (λ>0) with time varying volatility as shown below:

$$\varepsilon_{it} \left| \Omega_{t-1} \right. \sim GED_{\lambda}(0, h_t) \quad (2)$$

where $\varepsilon_{i,t}$ is a 1xT vector of the residuals of the mean equation of the *i* commodity (gold or silver). This is based on the information set available until t-1 (Ω_{t-1}) and is assumed to follow a zero mean distribution with a time varying variance h_t as shown below:

$$h_t = c_0 + a_1 \cdot \varepsilon_{t-1}^2 + b_1 \cdot h_{t-1} \quad (3)$$

We employ the GED distribution with parameter λ in the analysis of the volatility (univariate and multivariate) accounting for potential non-normalities.

Furthermore, possible effects of unconventional monetary policy announcements are examined through the incorporation of the relevant time dummies, on the volatility specification:

$$h_t = c_0 + d_{k,l} \cdot DQE_{k,l} + a_1 \cdot \varepsilon_{t-1}^2 + b_1 \cdot h_{t-1} \quad (4)$$

where *k* stands for the 5 different timing schemes similar to the mean equation. The significance and the sign of the coefficients of the time dummies would dictate the stabilization / destabilization or neutral effect that the unconventional monetary policy causes on the two major commodity markets.

Any asymmetric outcome of the unconventional monetary policy effects on the risk-return profile of the two commodities would leave space for arbitrage opportunities. In this line, it is expected that the correlation between the two commodities would exhibit potential structural breaks underlying the necessity for active risk management. Therefore after identifying possible effects on the risk-return profile, cross correlations between gold and silver markets are investigated around the unconventional monetary easing announcements by using the multivariate conditional volatility model of Engle and Kroner (1995). The full BEKK model with a linear filter on the mean equation is described by the following equations:

$$\mathbf{R}_t = \boldsymbol{\mu} + \mathbf{B}_1 \cdot \mathbf{R}_{t-1} + \mathbf{B}_2 \cdot \mathbf{R}_{t-2} + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t \left| \boldsymbol{\Omega}_{t-1} \right. \square \; GED_{\lambda}(\mathbf{0}, \mathbf{H}_t) \quad (5)$$

where $\mathbf{R}_t$ is a 2xT vector of the returns of the two commodities, $\boldsymbol{\mu}$ is the unconditional mean vector of the returns of the two series, $\mathbf{B}_j$ contains the coefficients of the two autoregressive terms and $\boldsymbol{\varepsilon}_t$ is the vector of residuals. The latter, based on the information set available until t-1 (Ω_{t-1}) is assumed to follow a zero mean distribution with a time varying variance covariance matrix $\mathbf{H}_t$. The volatility specification of the covariance matrix is the following:

$$\mathbf{H}_t = C_0^{'} C_0 + A^{'} \boldsymbol{\varepsilon}_{t-1} \boldsymbol{\varepsilon}_{t-1}^{'} A + B^{'} \mathbf{H}_{t-1} B \quad (6)$$

where C_0 is a symmetric matrix with the constant term of the volatility specification, while A and B are non-symmetric matrices the elements of which represent the flow of information and the persistence along with the spillovers of volatility, respectively. This quadratic parameterization of the covariance matrix is positive definite. The augmented form of this model can be illustrated in the following equations:

$$\begin{aligned}\mathbf{H}_t = C_0^{'}C_0 + &\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}^{'} \begin{pmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 \end{pmatrix} \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \\ &+ \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix}^{'} H_{t-1} \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix}\end{aligned} \tag{7}$$

$$\begin{aligned} h_{11,t} &= c_{11} + \alpha_{11}^2\varepsilon_{1,t-1}^2 + 2\alpha_{11}\alpha_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}^2\varepsilon_{2,t-1}^2 + \beta_{11}^2 h_{11,t-1} + 2\beta_{11}\beta_{21}h_{12,t-1} + \beta_{21}^2 h_{22,t-1} \\ h_{22,t} &= c_{22} + \alpha_{22}^2\varepsilon_{2,t-1}^2 + 2\alpha_{22}a_{12}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{12}^2\varepsilon_{1,t-1}^2 + \beta_{22}^2 h_{22,t-1} + 2\beta_{22}\beta_{12}h_{21,t-1} + \beta_{12}^2 h_{22,t-1} \\ h_{12,t} &= c_{12} + \alpha_{11}\varepsilon_{1,t-1}^2 a_{12} + \alpha_{11}\varepsilon_{1,t-1}\varepsilon_{2,t-1}a_{22} + \alpha_{12}\varepsilon_{1,t-1}\varepsilon_{2,t-1}a_{21} + a_{22}\varepsilon_{2,t-1}^2 a_{21} \\ &\quad + \beta_{11}h_{11,t-1}^2\beta_{12} + \beta_{11}\beta_{22}h_{1,t-1}h_{2,t-1} + \beta_{12}\beta_{21}h_{1,t-1}h_{2,t-1} + \beta_{22}h_{22,t-1}^2\beta_{21} \end{aligned} \tag{8}$$

The models are estimated, using the quasi maximum likelihood estimator. The relationship between the two commodity series could be represented through the correlation coefficient which is time varying according to the estimated BEKK conditional variance-covariance matrix:

$$\rho_{12,t} = h_{12,t} / \sqrt{h_{12,t}h_{22,t}} \tag{9}$$

The effects that the unconventional monetary policy announcements have on the relationship of the two commodities could be examined through the examination of the relevant dummies on a linear filtration of the time series. Specifically, the first log-differences of the conditional correlation is allowed to follow a linear filter, i.e. an AR(1) model which incorporates the relevant dummies for unconventional monetary policy :

$$\Delta\log\left(\rho_{12,t}\right) = z_0 + z_1\Delta\log\left(\rho_{12,t-1}\right) + d_{k,l}DQE_{k,l} + u_t \tag{10}$$

Empirical Findings

The effect of monetary easing announcements of the three Central Banks on the risk-return profile of Gold series using daily data is presented in Table 3 of the appendix. Regarding the mean equation, it is shown that the Japanese Central Bank's announcements cause positive effects on gold returns in contrast to those of ECB which dampen gold returns. It seems that investors in case of an announcement by a BoJ identify a credible policy of reducing the value of yen leading them to a more value safe gold market. BoE decisions in contrast influence investors in a different manner, driving silver returns upwards. However, the ECB announcements in contrast to each clear defined preference on a strong Euro signal general worries on markets leading to a general sell off. With respect to the risk profile of gold series, it seems that there is no significant effect and consequently the unconventional monetary policy announcement does not stabilize nor destabilize gold prices. Similarly, the effect of the announcements on the return and volatility of Silver using daily data is presented in Table 4. As can be seen, the announcements of the Bank of England increase silver returns while announcements of the European Central Bank cause a destabilization effect on this particular market. Announcements from the BoJ do not have a significant effect on this commodity's variance. From our findings, we can infer that UK investors seem to see silver as a financial asset that can be used as a hedging tool to a possible British pound undervaluation, while ECB announcement in contrast to its mission adds uncertainty in that market.

Given that many times daily data frequency may not reveal significant dynamic reactions, we proceed to analyzing hourly data. According to our findings significant stabilization and destabilization effects are present on the two major markets. Specifically, for the case of the Gold market the intraday analysis, as presented at Table 5, suggests that ECB announcements decrease the returns of gold market and cause a destabilization effect. In contrast, the Japanese Central market stabilizes the gold market. For the case

of the silver market the results are presented at Table 6, revealing a reduction of returns for the case of ECB and a stabilization effect for the case of the Japanese Central Bank. Therefore, generally speaking we can say that intraday investors since ECB announcements react nervously in both gold and silver market by seeing these commodities as another financial assets, while BoJ's announcements can be characterized as more credible given their calming effect on those markets.

Regarding the correlation dynamics between the two markets, the results exhibit high heterogeneity with respect to the data frequency, the Central Bank and the timing scheme under examination. According to Table 7, the announcements from the BoJ tend to increase the correlation dynamics of the two commodities while those from the ECB tend to decrease the correlation dynamics between the two series, when daily data are used. Therefore, monetary easing announcements by the former implies that investors treat gold and silver similarly in their portfolios leaving less space for diversification among them while in the ECB announcement the results are the opposite.

In the case of the intraday frequency, Table 8, reads out a dampening effect of the correlation between the two series when the ECB and the BoE make announcements relevant with monetary easing, implying significant diversification benefit between gold and silver for short term traders.

Our results in a nutshell are presented in Table 9. Undoubtedly, there is heterogeneity in the transmission channel of the unconventional monetary policy impact on the precious metals. In the case of the ECB announcements investors' expectations are characterized by heterogeneity among gold and silver markets. This is apparently captured by the dampening of the correlation between the returns of the two metals and the increment of their volatility. In contrast for the case of the BoJ, investors seem to share homogenous expectations which are illustrated in the stabilization effects for both metals.

From this analysis it seems that the ECB announcements diminish the risk-return profile of gold and silver for both daily and intraday data, though the reduction of their correlation could be beneficial in a

portfolio perspective. Specifically, with respect to the first research hypothesis (returns) it seems that ECB announcements on either daily or intraday frequency data, have a negative effect on gold returns. However, the positive effect of BoJ announcements on gold returns is detected only for daily frequency data. Similarly, ECB announcements reduce silver returns only when using intraday data. Using daily data, however, a positive effect on silver returns is captured only due to the BoE announcements. Regarding the second research hypothesis (risk) it is found that by considering the intraday data frequency, BoJ announcements cause stabilization effect on gold and silver returns, oppositely to the destabilization effect of the ECB case for gold (intraday data) and silver returns (daily data). Finally, with respect to the third research hypothesis (correlation) it is found that the correlation between gold and silver returns is reduced for both data frequencies in the case of ECB announcements, although this is observed only for high frequency data when the BoE announcements are considered. In contrast the BoJ announcements affect positively the abovementioned correlation, which is observed when using daily data only.

It seems that the increase of gold after a monetary easing announcement by BoJ implies that gold plays a crucial role as a safe-Heaven asset for Japanese investors, in contrast to the UK case where silver seems to be the precious metal that attracts most investors during an easing announcement. Moreover, the reduction of the correlation between gold and silver could be beneficial for diversification purposes allowing for more efficient trading strategies by including both precious metals in the commodities' portfolio.

Conclusions

This paper examines the effect of unconventional monetary policy announcements by three major central banks (BoE, BoJ, ECB) on the risk-return profile of gold and silver markets and their time varying

correlation. By investigating these effects on different data frequency (daily & intra-daily) we shed light on the potential relationship between the informational content of monetary policy and investors' reactions on precious metal markets.

According to our findings there is heterogeneity in the transmission channel of the unconventional monetary policy impact on the precious metals. In the case of the ECB announcements investors' expectations are characterized by heterogeneity among gold and silver markets. This is apparently captured by the dampening of the correlation between the returns of the two metals and the increment of their volatility. In contrast, for the case of the BoJ, investors seem to share homogenous expectations which are illustrated in the stabilization effects for both metals.

Our results have several interesting implications for investors and policymakers. Metal markets' investors should consider the country specific impact of monetary easing announcements. A Central Bank with consistent record in monetary easing, like the BoJ, implies currency devaluation and can offer short-term calm down effects on precious metal markets, leading investors to treat gold and silver as safe assets for their portfolio strategies. However, a Central Bank with low frequency of monetary easing would potentially increase the uncertainty of investors' expectations in precious metal markets. Therefore even tangible assets with a hard store of value, such as precious metal commodities, may also be subject to fluctuations in financial markets. Overall, this paper underlines the importance of precious metals which can be treated both as financial assets and as safe investments depending on the information content concerning unconventional monetary policy decisions.

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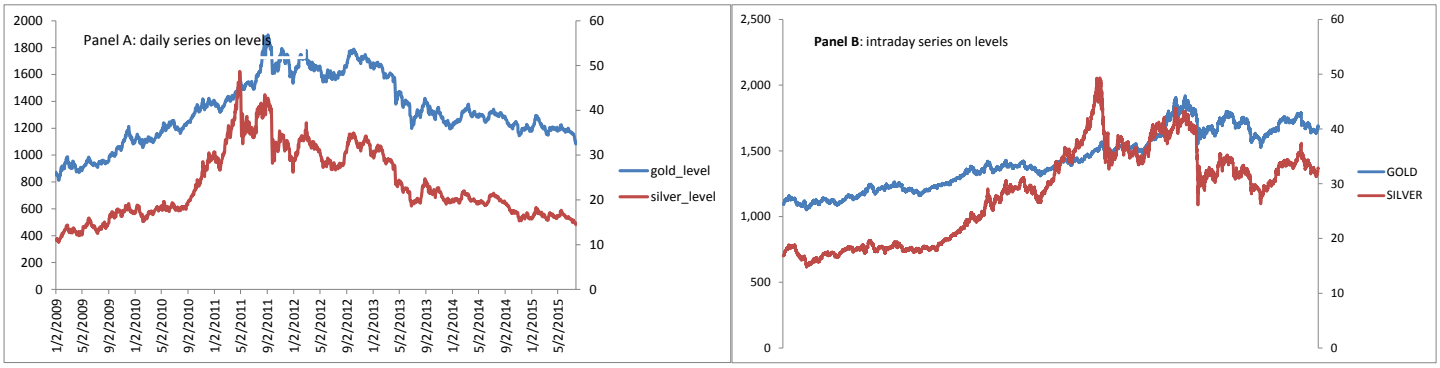
Appendix

List of Figures

Figure 1. Daily (Panel A) and Intraday (Panel B) Gold and Silver prices on level

Panel A **Panel B**



List of Tables

Table 1. Descriptive Statistics

Descriptive Statistics for Gold and Silver series on levels and 1st log differences

panel A: daily data	gold		silver	
	level	1st diff	level	1st diff
# observations	1657.0	1656.0	1657.0	1656.0
average	1339.0	0.0	23.3	0.0
standard deviation	246.9	0.0	7.8	0.0
skweness	0.1	-0.6	0.6	-0.5
kurtosis	-0.8	6.4	-0.7	8.7
JB	50.0	2930.5	134.9	5281.6
	0.000	*0.000*	*0.000*	*0.000*
Q2(5)	8203.7	29.3	8084.4	454.9
	0.000	*0.000*	*0.000*	*0.000*
Q2(10)	16259.4	55.2	15861.0	554.3
	0.000	*0.000*	*0.000*	*0.000*
ARCH(5)		24.0		318.9
		0.000		*0.000*
ARCH(10)		39.2		349.5
		0.000		*0.000*

Descriptive Statistics for Gold and Silver intraday series on levels and 1st log differences

panel B: intraday data	gold		silver	
	level	1st diff	level	1st diff
# observations	12792	12791	12792	12791
average	1429.637	0.000	28.249	0.000
standard deviation	222.066	0.002	8.425	0.005
skweness	0.154	-0.309	0.038	-0.890
kurtosis	-1.174	11.035	-1.187	19.146
JB	785.2	65098.9	754.0	197044.9
	0.000	*0.000*	*0.000*	*0.000*
Q2(5)	63922.6	1464.3	63870.0	2411.1
	0.000	*0.000*	*0.000*	*0.000*
Q2(10)	127766.1	1604.1	127572.0	2697.7
	0.000	*0.000*	*0.000*	*0.000*
ARCH(5)		947.4		1561.4
		0.000		*0.000*
ARCH(10)		958.5		1605.0
		0.000		*0.000*

Table 2. Stationarity tests

Panel A

Unit Root & Stationarity Tests: Augmented Dickey Fuller, Phillips-Perron and KPSS tests for the daily Gold series on levels and 1st log differences

Panel A: Gold	ADF Unit Root Test		PP Unit Root Test		KPSS Stationarity Test	
	levels	1st diff	levels	1st diff	levels	1st diff
T-Statistic	-1.357	-29.484	-1.251	-37.578	12.833	0.032
Sig Level	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val
1%	-3.969	-3.969	-3.969	-3.969	0.216	0.216
5%	-3.415	-3.415	-3.415	-3.415	0.146	0.146
10%	-3.129	-3.129	-3.129	-3.129	0.119	0.119

Panel B

Unit Root & Stationarity Tests: Augmented Dickey Fuller, Phillips-Perron and KPSS tests for the daily Silver series on levels and 1st log differences

Panel B: Silver	ADF Unit Root Test		PP Unit Root Test		KPSS Stationarity Test	
	levels	1st diff	levels	1st diff	levels	1st diff
T-Statistic	-1.652	-31.294	-1.697	-45.965	18.232	0.035
Sig Level	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val
1%	-3.969	-3.969	-3.969	-3.969	0.216	0.216
5%	-3.415	-3.415	-3.415	-3.415	0.146	0.146
10%	-3.129	-3.129	-3.129	-3.129	0.119	0.119

Panel C

Unit Root & Stationarity Tests: Augmented Dickey Fuller, Phillips-Perron and KPSS tests for the intraday Gold series on levels and 1st log differences

Panel C: Gold	ADF Unit Root Test		PP Unit Root Test		KPSS Stationarity Test	
	levels	1st diff	levels	1st diff	levels	1st diff
T-Statistic	-2.702	-81.233	-2.678	-112.582	19.917	0.037
Sig Level	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val
1%	-3.964	-3.964	-3.964	-3.964	0.216	0.216
5%	-3.413	-3.413	-3.413	-3.413	0.146	0.146
10%	-3.128	-3.128	-3.128	-3.128	0.119	0.119

Panel D

Unit Root & Stationarity Tests: Augmented Dickey Fuller, Phillips-Perron and KPSS tests for the intraday Silver series on levels and 1st log differences

Panel D: Silver	ADF Unit Root Test		PP Unit Root Test		KPSS Stationarity Test	
	levels	1st diff	levels	1st diff	levels	1st diff
T-Statistic	-1.266	-80.692	-1.295	-116.341	107.783	0.075
Sig Level	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val	Crit. Val
1%	-3.964	-3.965	-3.964	-3.964	0.216	0.216
5%	-3.413	-3.413	-3.413	-3.413	0.146	0.146
10%	-3.128	-3.128	-3.128	-3.128	0.119	0.119

Table 3. The effect of monetary easing announcements on mean return and volatility of gold by using daily data across BoE, BoJ and ECB.

RISK - RETURN PROFILE OF DAILY GOLD RETURNS

This table presents the effect of the monetary easing announcmenets on mean return (%) and volatility (%^2) of gold by using daily data across GBP, JPY and EURO

			Bank of England						Japanese Central Bank					European Central Bank				
mean equation	**intercept**	0.021	0.021	0.018	0.020	0.022	0.018	0.016	0.022	0.016	0.012	0.018	0.020	0.026	0.022	0.022	0.028
		0.349	*0.380*	*0.468*	*0.393*	*0.342*	*0.475*	*0.501*	*0.369*	*0.473*	*0.584*	*0.455*	*0.428*	*0.297*	*0.356*	*0.312*	*0.249*
	DQE1		-0.287					0.172					0.071				
			0.383					*0.273*					*0.728*				
	DQE2A			0.263					-0.020					-0.189			
				0.272					*0.858*					*0.220*			
	DQE2B				0.076					0.112					-0.069		
					0.758					*0.352*					*0.689*		
	DQE3					-0.201					0.215 *					-0.091	
						0.352					*0.070*					*0.632*	
	DQE_all						0.200					0.043					-0.234 *
							0.345					*0.666*					*0.074*
volatility equation	**c**	0.028 **	0.028 **	0.028 **	0.027 **	0.028 **	0.028 **	0.028 **	0.028 **	0.028 **	0.027 **	0.028 **	0.028 **	0.029 **	0.028 **	0.028 **	0.028 **
		0.000	*0.001*	*0.001*	*0.001*	*0.000*	*0.002*	*0.001*	*0.001*	*0.001*	*0.000*	*0.001*	*0.000*	*0.001*	*0.001*	*0.001*	*0.001*
	a	0.059 **	0.060 **	0.059 **	0.059 **	0.059 **	0.059 **	0.059 **	0.059 **	0.059 **	0.058 **	0.059 **	0.061 **	0.061 **	0.060 **	0.060 **	0.061 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	b	0.918 **	0.917 **	0.918 **	0.918 **	0.918 **	0.918 **	0.918 **	0.918 **	0.918 **	0.919 **	0.918 **	0.914 **	0.914 **	0.915 **	0.916 **	0.914 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	DQE1		-0.156					-0.013					0.055				
			0.187					*0.834*					*0.507*				
	DQE2A			-0.031					-0.004					0.027			
				0.677					*0.878*					*0.549*			
	DQE2B				-0.064					-0.006					0.030		
					0.459					*0.864*					*0.624*		
	DQE3					-0.091					-0.010					0.022	
						0.217					*0.777*					*0.731*	
	DQE_all						-0.028					-0.004					0.014
							0.611					*0.856*					*0.710*
# obs		1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656
log likelihood		5283	5284	5284	5283	5284	5284	5284	5283	5284	5285	5283	5283	5284	5283	5283	5285
Q2(5)		0.306	0.299	0.295	0.293	0.301	0.291	0.319	0.302	0.321	0.317	0.310	0.333	0.350	0.334	0.326	0.348
		0.998	*0.998*	*0.998*	*0.998*	*0.998*	*0.998*	*0.997*	*0.998*	*0.997*	*0.997*	*0.997*	*0.997*	*0.997*	*0.997*	*0.997*	*0.997*
Q2(10)		2.465	2.305	2.410	2.364	2.313	2.396	2.456	2.452	2.456	2.461	2.447	2.537	2.574	2.538	2.529	2.586
		0.991	*0.993*	*0.992*	*0.993*	*0.993*	*0.992*	*0.992*	*0.992*	*0.992*	*0.991*	*0.992*	*0.990*	*0.990*	*0.990*	*0.990*	*0.990*
ARCH(5)		0.303	0.296	0.292	0.290	0.299	0.289	0.316	0.299	0.318	0.314	0.307	0.330	0.347	0.331	0.323	0.346
		0.998	*0.998*	*0.998*	*0.998*	*0.998*	*0.998*	*0.997*	*0.998*	*0.997*	*0.997*	*0.998*	*0.997*	*0.997*	*0.997*	*0.997*	*0.997*
ARCH(10)		2.415	2.259	2.362	2.317	2.268	2.347	2.404	2.403	2.404	2.408	2.397	2.487	2.521	2.487	2.478	2.533
		0.992	*0.994*	*0.993*	*0.993*	*0.994*	*0.993*	*0.992*	*0.992*	*0.992*	*0.992*	*0.992*	*0.991*	*0.991*	*0.991*	*0.991*	*0.990*

DQE1 [0, +1]
DQE2A [-2, +1]
DQE2B [-1, +1]
DQE3 [0, +3]
DQEall [-2, +3]

Table 4. The effect of monetary easing announcements on mean return and volatility of silver by using daily data across BoE, BoJ and ECB.

RISK - RETURN PROFILE OF DAILY SILVER RETURNS

This table presents the effect of the monetary easing announcmenets on mean return (%) and volatility (%^2) of silver by using daily data across GBP, JPY and EURO

		Bank of England							Japanese Central Bank					European Central Bank				
mean equation	**intercept**	-0.012	-0.010	-0.025	-0.020	-0.011	-0.025	-0.020	-0.010	-0.015	-0.022	-0.012	-0.012	-0.006	-0.008	-0.011	-0.005
		0.799	*0.838*	*0.643*	*0.708*	*0.833*	*0.638*	*0.695*	*0.855*	*0.770*	*0.664*	*0.812*	*0.809*	*0.910*	*0.862*	*0.826*	*0.932*
	DQE1		-0.654					0.338					0.090				
			0.333					*0.308*					*0.874*				
	DQE2A			1.060 **					-0.057					-0.271			
				0.029					*0.816*					*0.451*			
	DQE2B				0.949					0.078					-0.191		
					0.113					*0.776*					*0.671*		
	DQE3					-0.261					0.307					-0.060	
						0.614					*0.252*					*0.893*	
	DQE_all						0.898 **					-0.006					-0.297
							0.038					*0.977*					*0.349*
volatility equation	**c**	0.265 **	0.273 **	0.273 **	0.269 **	0.273 **	0.272 **	0.261 **	0.266 **	0.265 **	0.258 **	0.266 **	0.255 **	0.246 **	0.249 **	0.261 **	0.253 **
		0.002	*0.002*	*0.003*	*0.002*	*0.003*	*0.002*	*0.004*	*0.003*	*0.003*	*0.003*	*0.002*	*0.001*	*0.003*	*0.002*	*0.001*	*0.001*
	a	0.100 **	0.102 **	0.101 **	0.100 **	0.102 **	0.101 **	0.099 **	0.100 **	0.100 **	0.098 **	0.100 **	0.094 **	0.092 **	0.093 **	0.095 **	0.093 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	b	0.848 **	0.845 **	0.844 **	0.846 **	0.846 **	0.845 **	0.849 **	0.847 **	0.848 **	0.851 **	0.848 **	0.851 **	0.855 **	0.853 **	0.849 **	0.852 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	DQE1		-0.843					0.087					1.682 **				
			0.192					*0.804*					*0.045*				
	DQE2A			0.307					-0.004					0.760 *			
				0.544					*0.983*					*0.082*			
	DQE2B				0.195					0.034					1.044 **		
					0.716					*0.894*					*0.035*		
	DQE3					-0.624					0.025					1.148 *	
						0.179					*0.915*					*0.051*	
	DQE_all						0.150					-0.015					0.638 *
							0.711					*0.918*					*0.061*
# obs		1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656
log likelihood		4046	4047	4049	4047	4047	4048	4047	4046	4046	4047	4046	4049	4049	4049	4049	4049
Q2(5)		2.330	2.208	2.449	2.410	2.201	2.401	2.394	2.320	2.345	2.404	2.336	2.336	2.097	2.083	2.133	2.092
		0.802	*0.820*	*0.784*	*0.790*	*0.821*	*0.791*	*0.792*	*0.803*	*0.800*	*0.791*	*0.801*	*0.801*	*0.836*	*0.838*	*0.830*	*0.836*
Q2(10)		3.961	3.865	4.147	4.060	3.833	4.078	3.998	3.962	3.972	4.014	3.961	3.961	3.668	3.669	3.692	3.663
		0.949	*0.953*	*0.940*	*0.945*	*0.955*	*0.944*	*0.947*	*0.949*	*0.949*	*0.947*	*0.949*	*0.949*	*0.961*	*0.961*	*0.960*	*0.961*
ARCH(5)		2.230	2.109	2.355	2.314	2.102	2.308	2.292	2.220	2.244	2.302	2.235	2.235	1.995	1.981	2.029	1.990
		0.817	*0.834*	*0.798*	*0.804*	*0.835*	*0.805*	*0.807*	*0.818*	*0.814*	*0.806*	*0.816*	*0.816*	*0.850*	*0.852*	*0.845*	*0.851*
ARCH(10)		3.775	3.682	3.949	3.866	3.649	3.883	3.811	3.776	3.786	3.823	3.776	3.776	3.504	3.504	3.525	3.498
		0.957	*0.961*	*0.950*	*0.953*	*0.962*	*0.952*	*0.955*	*0.957*	*0.957*	*0.955*	*0.957*	*0.957*	*0.967*	*0.967*	*0.966*	*0.967*

DQE1 [0, +1]
DQE2A [-2, +1]
DQE2B [-1, +1]
DQE3 [0, +3]
DQEall [-2, +3]

Table 5. The effect of monetary easing announcements on mean return and volatility of gold by using intraday data across BoE, BoJ and ECB.

RISK - RETURN PROFILE OF INTRADAY GOLD RETURNS

This table presents the effect of the monetary easing announcmenets on mean return (%) and volatility (%^2) of gold by using intraday data across GBP, JPY and EURO

		Bank of England							Japanese Central Bank					European Central Bank			
mean equation	**intercept**	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.009 **	0.009 **	0.009 **	0.009 **	0.009 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	DQE1		-0.181					0.028					-0.195				
			0.275					*0.332*					*0.121*				
	DQE2A			-0.154					0.002					-0.057			
				0.125					*0.932*					*0.441*			
	DQE2B				-0.213					0.001					-0.150		
					0.188					*0.977*					*0.104*		
	DQE3					0.062					0.026					-0.147 **	
						0.653					*0.365*					*0.021*	
	DQE_all						-0.018					0.007					-0.084 *
							0.864					*0.752*					*0.095*
volatility equation	**c**	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.008 **	0.007 **	0.007 **	0.008 **	0.008 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	a	0.232 **	0.232 **	0.232 **	0.232 **	0.232 **	0.232 **	0.234 **	0.234 **	0.234 **	0.233 **	0.233 **	0.218 **	0.216 **	0.217 **	0.220 **	0.219 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	b	0.661 **	0.661 **	0.661 **	0.661 **	0.661 **	0.661 **	0.658 **	0.657 **	0.657 **	0.660 **	0.659 **	0.673 **	0.676 **	0.675 **	0.669 **	0.671 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	DQE1		0.063					-0.009 **					0.127 **				
			0.272					*0.025*					*0.008*				
	DQE2A			0.029					-0.007 **					0.054 **			
				0.232					*0.000*					*0.012*			
	DQE2B				0.041					-0.007 **					0.077 **		
					0.211					*0.002*					*0.007*		
	DQE3					0.051					-0.002					0.049 **	
						0.150					*0.624*					*0.004*	
	DQE_all						0.032					-0.003 *					0.032 **
							0.170					*0.088*					*0.001*
# obs		12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791
log likelihood		60072	60078	60078	60079	60077	60077	60074	60075	60074	60073	60073	60089	60080	60085	60096	60089
Q2(5)		8.110	8.104	8.113	8.119	8.116	8.108	8.185	7.884	8.021	8.149	8.050	7.677	7.612	7.625	7.811	7.784
		0.150	*0.151*	*0.150*	*0.150*	*0.150*	*0.150*	*0.146*	*0.163*	*0.155*	*0.148*	*0.154*	*0.175*	*0.179*	*0.178*	*0.167*	*0.169*
Q2(10)		18.535 **	18.358 **	18.402 **	18.365 **	18.354 **	18.348 **	18.319 **	17.846 *	18.102 *	18.528 **	18.287 *	19.741 **	19.908 **	19.884 **	19.455 **	19.564 **
		0.047	*0.049*	*0.049*	*0.049*	*0.049*	*0.049*	*0.050*	*0.058*	*0.053*	*0.047*	*0.050*	*0.032*	*0.030*	*0.030*	*0.035*	*0.034*
ARCH(5)		8.305	8.297	8.305	8.312	8.308	8.300	8.387	8.080	8.219	8.346	8.247	7.886	7.812	7.831	8.031	8.000
		0.140	*0.141*	*0.140*	*0.140*	*0.140*	*0.140*	*0.136*	*0.152*	*0.145*	*0.138*	*0.143*	*0.163*	*0.167*	*0.166*	*0.155*	*0.156*
ARCH(10)		19.907 **	19.709 **	19.756 **	19.715 **	19.702 **	19.694 **	19.662 **	19.126 **	19.413 **	19.898 **	19.626 **	21.287 **	21.473 **	21.450 **	20.967 **	21.093 **
		0.030	*0.032*	*0.032*	*0.032*	*0.032*	*0.032*	*0.033*	*0.039*	*0.035*	*0.030*	*0.033*	*0.019*	*0.018*	*0.018*	*0.021*	*0.020*

DQE1 [0, +1]
DQE2A [-2, +1]
DQE2B [-1, +1]
DQE3 [0, +3]
DQEall [-2, +3]

Table 6. The effect of monetary easing announcements on mean return and volatility of silver by using intraday data across BoE, BoJ and ECB.

RISK - RETURN PROFILE OF INTRADAY SILVER RETURNS

This table presents the effect of the monetary easing announcmenets on mean return (%) and volatility (%^2) of silver by using intraday data across GBP, JPY and EURO

		Bank of England							Japanese Central Bank					European Central Bank				
mean equation	**intercept**	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **	0.020 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	DQE1		0.016					0.029					-0.216 *					
			0.962					*0.554*					*0.051*					
	DQE2A			0.020					-0.005					-0.031				
				0.919					*0.905*					*0.675*				
	DQE2B				-0.124					-0.008					-0.110			
					0.603					*0.859*					*0.197*			
	DQE3					0.372 *					0.029					-0.189 **		
						0.090					*0.586*					*0.012*		
	DQE_all						0.167					0.006						-0.077
							0.254					*0.878*						*0.174*
volatility equation	**c**	0.026 **	0.026 **	0.026 **	0.026 **	0.026 **	0.026 **	0.027 **	0.027 **	0.027 **	0.027 **	0.027 **	0.026 **	0.026 **	0.026 **	0.026 **	0.026 **	0.026 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	a	0.204 **	0.204 **	0.204 **	0.204 **	0.204 **	0.204 **	0.207 **	0.207 **	0.207 **	0.205 **	0.206 **	0.203 **	0.204 **	0.203 **	0.202 **	0.203 **	0.203 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	b	0.713 **	0.713 **	0.713 **	0.714 **	0.714 **	0.713 **	0.709 **	0.708 **	0.709 **	0.712 **	0.710 **	0.715 **	0.714 **	0.714 **	0.716 **	0.715 **	0.715 **
		0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	DQE1		0.082					-0.046 **					0.015					
			0.404					*0.000*					*0.700*					
	DQE2A			0.087					-0.033 **					0.002				
				0.261					*0.000*					*0.930*				
	DQE2B				0.053					-0.038 **					0.002			
					0.377					*0.000*					*0.938*			
	DQE3					0.009					-0.018					0.023		
						0.870					*0.144*					*0.257*		
	DQE_all						0.043					-0.020 **						0.009
							0.458					*0.003*						*0.486*
# obs		12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791	12791
log likelihood		50729	50730	50730	50730	50732	50731	50732	50734	50732	50730	50732	50731	50729	50730	50733	50730	
Q2(5)		7.784	1.962	1.967	1.963	1.963	1.964	2.000	2.004	2.007	1.982	1.994	1.961	1.961	1.953	1.928	1.944	
		0.169	*0.854*	*0.854*	*0.854*	*0.854*	*0.854*	*0.849*	*0.849*	*0.848*	*0.852*	*0.850*	*0.854*	*0.854*	*0.856*	*0.859*	*0.857*	
Q2(10)		19.564 **	6.774	6.736	6.780	6.809	6.750	6.537	6.396	6.475	6.693	6.565	6.840	6.805	6.819	6.784	6.795	
		0.034	*0.747*	*0.750*	*0.746*	*0.743*	*0.749*	*0.768*	*0.781*	*0.774*	*0.754*	*0.766*	*0.740*	*0.744*	*0.742*	*0.746*	*0.745*	
ARCH(5)		8.000	1.988	1.993	1.989	1.989	1.990	2.028	2.032	2.035	2.009	2.021	1.988	1.987	1.980	1.954	1.970	
		0.156	*0.851*	*0.850*	*0.851*	*0.851*	*0.851*	*0.845*	*0.845*	*0.844*	*0.848*	*0.846*	*0.851*	*0.851*	*0.852*	*0.855*	*0.853*	
ARCH(10)		21.093 **	6.977	6.938	6.984	7.013	6.953	6.740	6.597	6.677	6.897	6.768	7.047	7.010	7.024	6.987	6.999	
		0.020	*0.728*	*0.731*	*0.727*	*0.724*	*0.730*	*0.750*	*0.763*	*0.756*	*0.735*	*0.747*	*0.721*	*0.725*	*0.723*	*0.727*	*0.726*	

DQE1 [0, +1]
DQE2A [-2, +1]
DQE2B [-1, +1]
DQE3 [0, +3]
DQEall [-2, +3]

Table 7. The effect of monetary easing announcements on correlation dynamics between gold and silver returns by using daily data.

DAILY 1st diff CORRELATION DYNAMICS

This table presents the coefficients of the structural changes of the intradaily correlation between GOLD and SILVER accounting for QE dummies across GBP, JPY and EURO

c	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.989	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*	*0.989*
AR(1)	-0.140 **	-0.140 **	-0.140 **	-0.140 **	-0.140 **	-0.140 **	-0.141 **	-0.141 **	-0.141 **	-0.143 **	-0.142 **	-0.139 **	-0.135 **	-0.140 **	-0.139 **	-0.140 **
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
DQE1_GBP		-0.003														
		0.806														
DQE2A_GBP			-0.004													
			0.763													
DQE2B_GBP				-0.002												
				0.889												
DQE3_GBP					-0.003											
					0.801											
DQE_GBP						-0.004										
						0.759										
DQE1_JPY							0.012 *									
							0.077									
DQE2A_JPY								0.010								
								0.149								
DQE2B_JPY									0.011							
									0.123							
DQE3_JPY										0.013 *						
										0.063						
DQE_JPY											0.011					
											0.123					
DQE1_EUR												-0.002				
												0.840				
DQE2A_EUR													-0.030 **			
													0.001			
DQE2B_EUR														0.006		
														0.536		
DQE3_EUR															0.007	
															0.466	
DQE_EUR																-0.021 **
																0.019

DQE1	[0, +1]
DQE2A	[-2, +1]
DQE2B	[-1, +1]
DQE3	[0, +3]
DQEall	[-2, +3]

Table 8. The effect of monetary easing announcements on correlation dynamics between gold and silver returns by using intraday data.

INTRADAY 1st diff CORRELATION DYNAMICS

This table presents the coefficients of the structural changes of the intradaily correlation between GOLD and SILVER accounting for QE dummies across GBP, JPY and EURO

c	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.940	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*	*0.940*
AR(1)	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013
	0.148	*0.148*	*0.149*	*0.144*	*0.147*	*0.148*	*0.148*	*0.150*	*0.149*	*0.146*	*0.145*	*0.147*	*0.150*	*0.148*	*0.135*	*0.149*
DQE1_GBP		0.000														
		0.937														
DQE2A_GBP			0.001													
			0.903													
DQE2B_GBP				-0.014 **												
				0.026												
DQE3_GBP					-0.007											
					0.300											
DQE_GBP						-0.005										
						0.402										
DQE1_JPY							0.000									
							0.980									
DQE2A_JPY								-0.003								
								0.258								
DQE2B_JPY									-0.001							
									0.573							
DQE3_JPY										-0.001						
										0.711						
DQE_JPY											-0.004					
											0.139					
DQE1_EUR												-0.004				
												0.218				
DQE2A_EUR													0.002			
													0.522			
DQE2B_EUR														-0.001		
														0.760		
DQE3_EUR															-0.006 *	
															0.068	
DQE_EUR																0.000
																0.963

DQE1	[0, +1]
DQE2A	[-2, +1]
DQE2B	[-1, +1]
DQE3	[0, +3]
DQEall	[-2, +3]

Table 9. Comprehensive Table of key findings

	Gold		Silver		Gold and Silver
	Mean process	**Volatility**	**Mean process**	**Volatility**	**Correlation**
Daily	+BoJ, -ECB		+BoE	+ECB	+BoJ, -ECB
Intra-Day	-ECB	-BoJ, +ECB	-ECB	-BoJ	-BoE, -ECB