Do Precious Metals Markets Influence Stock Markets? A Volatility Approach

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Abstract

This paper investigates the nature of volatility spillovers between stock returns and precious metals returns for the G-7 countries over the 1995-2006 period. We divide our sample into a number of sub periods, prior to, during and after the Asian crisis, with the objective to provide a wide analysis of the behaviour of these two markets taking into account the effects of the Asian crisis; we use EGARCH modelling which takes into account whether bad news has the same impact on volatility as good news. The results show that there is no evidence of volatility persistence from stock returns to precious metals returns, but overall the results are significant in the other way around. In terms of volatility spillovers effects, the main findings are that there is evidence of volatility spillovers running in a bidirectional way in almost all the cases. And finally, the results from asymmetric spillover effects show that negative news have a stronger impact in these financial markets than positive news.

Keywords: Stock Returns, Precious Metal Returns, EGARCH modeling, Volatility Persistence, Volatility Spillovers and Asymmetric Spillovers.

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1. Introduction

Precious metals are of particular interest as they are important stores of value and monetary assets. In particular, gold has been a key component of global monetary reserves for trading and currency hedging (Capie, Mills and Wood, 2005). Precious metals are used in many industrial activities; they can be used in the manufacturing process in jewellery, as well as an investment and reserve of value assets. In the current situation, where financial markets are facing increasing depreciation in their assets, precious metals are bound to play an increasing role as options in modern portfolios.

Precious metals have been generally ignored by investors in the construction of their portfolios, but this trend seems to start changing. Precious metals are gaining in importance as investment opportunities a situation that has started to unfold since the US dollar began to depreciate against the Euro. In addition, there has been a growing interest in the precious metals markets by agents that incorporate metals in the production process (such as many metallurgic companies) and also by the jewellery industry, where metals like gold, platinum and silver are clearly dominant. These characteristics imply that the demand in these markets have been raising and becomes stronger.

The variability of commodities, exchange rates and stock prices has been widely investigated for many years due to its implications for the participants involved in these markets. Special attention has been paid by the investors and the hedgers that attempt to offset their exposures and risks from theses markets, must adjust their hedge ratios in accordance with the movement of these main financial markets, while on the other hand speculators rely on price volatility in order to generate business opportunities that allow them get profits and at the same time provide liquidity to the markets.

The aim of the current paper is to extend the research in this area by using a GARCH (EGARCH) analysis to model stock returns and precious metals returns volatility spillovers. We focus our attention on the use of EGARCH estimation of volatility spillovers between the major financial markets represented by the G-7 economies (Canada, France, Germany, Italy, Japan, UK and US) and the precious metals markets (gold, platinum and silver). We attempt to address the gap in the literature in this area by conducting an in-depth analysis of the relationship between these two financial markets. The current evidence has not focused on the analysis of spillovers

between the two types of markets. Therefore, we analyse the relationship between these two variables in the major stock markets in order to provide evidence in the area. The remaining of the paper is set out of as follow: section 2 presents the literature review, and it brings both the theoretical and empirical evidence on the nature of linkages between stock markets and precious metals markets, section 3 describes the methodology that is used to assess the nature of volatility spillovers between stock and precious metals markets; section 4 presents our empirical results, and section 5 concludes the paper.

2. Literature Review

There is an extensive literature analysing volatility spillovers in stock markets; however, the interaction between stock markets and precious metals markets has received far less attention. It is well known that the price of various natural resource products is of high importance in both policy and business circles (Bernard, et al., 2005). Therefore the main objective of this article is to provide an analysis of the interaction existing between the major financial markets represented by the G-7 (Canada, France, Germany, Italy, Japan, UK and US) and precious metals markets (gold, platinum and silver) based on GARCH (EGARCH) techniques. The motivation for this research is that precious metals markets could represent an important option for investors in order to diversify their investment strategies and portfolios.

Engle (1982) recognised that, in certain series, there are periods in which volatility was high and others in which it was low. He saw this volatility clustering as a time-varying conditional variance. He developed and applied ARCH modelling which dispenses with such an assumption. Afterwards, Bollerslev (1986) formulated the GARCH model, by allowing the variance of a series to be decomposed into unconditional and time conditional components. These models are capable of identifying periods of relative tranquillity and volatility. Through the use of GARCH (p,q) models many analyses have provided evidence of the success of these techniques in the analysis of financial markets spillover effects. The reason for using this particular technique is derived from the characteristics of our series. The characteristics of the stock returns and of the precious metals returns show that all the series are highly leptokurtic (non-normal series), a feature that has been commonly recognised in the analysis of these kinds of time series. The literature brings evidence that the ARCH family models have been proved successful in

analysing volatility effects in these series, indicating that a GARCH (EGARCH) analysis will be the most efficient way to study these financial markets .As the time series of the precious metals returns and stock markets returns follow the typical distributions that allow the use of GARCH techniques we decided to implement the EGARCH modelling in our analysis; this asymmetric model allows negative shocks to behave differently from positive shocks. The main advantage of an EGARCH model is that it overcomes the problem of the standard ARCH/GARCH models where symmetry is imposed on the conditional variance.

Taylor (1998) investigates precious metals (gold, platinum and silver) reactions against inflation. He tested the hypothesis that precious metals act as short-run and long-run hedges against inflation. He focused his analysis on the period before 1939 and around the second OPEC oil shock in 1979. During no other period could precious metals be used to hedge inflation. His analysis notices that the belief that precious metals (in particular gold) have always acted as hedges against inflation until very recently is completed unfounded. He found that there have been particular periods during the last 80 years when precious metals have been used as a short-run hedge against inflation, but they could not be used to hedge inflation around the first oil crisis in 1973/74 or during the last ten years. Since he found a cointegrated relationship between metal prices and the level of CPI with the help of a VAR model, it can be inferred that precious metals can be used as a long-run inflation hedge.

Mills (2003) investigated the statistical behaviour of daily gold price data from 1971 to 2002. He found that the phenomenon of volatility prices scaling with long-run correlations is important. He found that gold returns are characterised by short-run persistence and scaling with a break point of 15 days. Daily returns are highly leptokurtic with multi-period returns only recovering gaussianity after 235 days.

Aggarwal and Lucey (2005) examined the existence of psychological barriers in a variety of daily and intraday gold price series. They analysed three data sets: daily gold prices from the official London AM fix over the period 2/11/1980-31/12/200, daily data from COMEX for cash and futures gold for the period 2/11/1982-28/11/2002, high frequency data set supplied by UBS London over the period 28/08/2001-09/01/2003. They found evidence that psychological barriers at the 100's digits (price levels such as $200, $300, etc) do exist in daily gold prices, while the evidence is weaker for high frequency data for gold. They also found significant evidence of changes in conditional means around psychological barriers.

Bernard, Khalaf, Kichian and McMahon (2005) analysed the aluminium price series with daily, weekly and monthly frequencies. They used three econometric specifications that cover: i) random-walk models with ARCH or GARCH effects, ii) Poisson-based jump-diffusion models with ARCH or GARCH effects and iii) mean reverting models that allow for uncertainty in equilibrium price. Their results showed that in the case of high frequency (daily and weekly) data, the mean-reverting model with stochastic convenience yield outperforms to a large extents. All other competing models for all forecast horizons, within the class of non-mean reverting GARCH processes analysed for the same frequencies models with jumps or asymmetries fare best, yet the latter remain dominated by the mean reverting models. With monthly data, the mean-reverting model still fares well in comparison with the random-walk GARCH class.

Xu and Fung (2005) examined patterns of across-market information flows for gold, platinum, and silver futures contracts traded in both the U.S and Japanese markets. They analysed daily data for gold, platinum and silver futures contracts traded in U.S and Japan over the period from November 1994 to March 2001. Their results indicate that pricing transmissions for precious metals contracts are strong across the two markets, but information flows appear to lead from the U.S market to the Japanese market in terms of returns. There are strong volatility spillover feedbacks effects across both markets and their impacts appear to be comparable and similar. They also found evidence that intraday pricing information transmission across the two precious metals futures markets is rapid, as offshore trading information can be absorbed in the domestic market within a trading day.

Batten and Lucey (2006) analysed the volatility structure of gold, trading as a futures contract on the Chicago Board of Trade using intraday (high frequency) data from January 1999 to December 2005. They used GARCH modelling and the Garman Klass estimator. They found significant variations across the trading days consistent with microstructure theories, although volatility is only slightly positively correlated with volume when measured by tick-count.

Fernandez and Lucey (2006) analyzed the implications for portfolio management of accounting for conditional heteroskedasticity and structural breaks in long-term volatility. They based their analysis in PGARCH models fitted to the return series. They used weekly data of the Dow Jones Country Titans CBT municipal bond, spot and futures prices of commodities for the period 1992-2005. They also applied their procedure to artificial data generated from distribution functions. They conclude that

neglecting GARCH effects and volatility shifts may lead to overestimating financial risk at different time horizons.

Watkins and McAleer (2006) analysed data on 3-month futures contracts for aluminium, aluminium alloy, copper, lead, nickel, tin and zinc. They estimated various long-run models using daily London Metal Exchange price data for the period 1 February 1986 to 30 September 1998. They found that in most of the samples considered for the seven metals markets, the test for cointegration determined the existence of one statistically significant long-run relationship among the futures price, spot price, stock level and interest rate. They also found that the risk premium and carry models usefully are applied to each of the LME metals markets over different time periods.

Tully and Lucey (2006) investigated the macroeconomic influences on gold using the asymmetric power GARCH model (APGARCH). They examined cash and futures prices of gold and significant economic variables over the 1983-2003 period, paying special attention to two periods, around 1987 and in 2001, the year of the equity market crashes. Their results suggest that the APGARCH model provides the most adequate description for the data, with the inclusion of a GARCH term, free power terms and unrestricted leverage effect terms. They also found that the gold cash and futures data over a long period confirmed the US dollar is the main macroeconomic variable which influences gold.

Wolfle (2006) used a dataset of 19 commodities and two stock indices (S&P 500 and Dow Jones) daily data covering the period from December 31, 1999 through May 31, 2006. He applied GARCH procedures to analyse his time series. In general he found strong evidence of interdependence among commodities. He found that Dow Jones and S&P500 Index do not spillover to commodities. The Dow Jones Index reacts on innovations for coffee and soybeans. Information transmissions between stock and commodity markets are rejected which means that commodity and stock markets are not interdependent, which supports the use of commodities to diversify risk in stock portfolios.

Hiller, Draper and Faff (2006) investigated the role of precious metals in financial markets by analysing daily data for gold, platinum and silver from 1976 to 2004. They include the S&P 500 Index as a proxy for stock market returns from the US investors' perspective. They found that all three precious metals have low correlations with stock index returns which suggest that these metals may provide diversification within broad investment portfolios. They found that normally financial portfolios that

contain precious metals perform significantly better than standard equity portfolios. They also found that precious metals exhibit some hedging capability during periods of abnormal market volatility.

Spargoli and Zagaglia (2007) studied the linkages between prices of oil futures traded on the New York Mercantile Exchange and the Intercontinental Exchange of London. They estimated a structural BEKK-GARCH model on daily data from the 26th of April 1998 to the 26th of April 2007 data series on prices of futures. The main conclusion from their analysis is that in normal periods, NYMEX and ICE futures are used by investors for hedging purposes. However, in turbulent periods when there are peaks in the structural conditional variance of both innovations, the structural correlation between then is positive and hedging is no more feasible.

Most of the research that have been done until now have been mainly focused in the analysis of the gold market, a main area of interest have been the role of this precious metal as a hedger against inflation, some studies have also analysed variables that could be affecting the behaviour of gold prices, but little have been done with regard to the other precious metals (silver, platinum and palladium) as it is reflected in the literature review presented. It seems that the trend is changing and researchers are starting to pay more attention to the other precious metals markets and their behaviour as they are becoming aware of the importance of these markets in terms of portfolio risk management. There is a lack of study analysing the reaction of precious metals markets to the different financial crisis that had impacted the financial markets in the past, studies that are of key importance as they could provide important information to investors in order to help them to diversify their portfolio and to design their hedging strategies.

Our contribution to the existing literature in this area is that we provide new evidence on the volatility spillovers analysis. Our approach focuses on the analysis of volatility spillovers between the seven major stock markets (represented by the G-7) precious metals markets over the time period 1995 to 2006, an analysis that, to our knowledge, has not been done until today.

3. Data and Methodology

Our analysis focuses on the period 1 January 1995 to 31 December 2006. We will analyse the whole sample and also we decided to split it into three sub samples in order to provide greater details and a better understanding of volatility spillovers

between stock returns and precious metals returns. Thus our first sub sample spans over the year 1995-June 1997, the period prior to the Asian crisis. As we are interested in examining if the Asian crisis could generate volatility spillovers between these financial markets the second subsample will cover the July 1997-1998 period where the crisis hit the markets, and finally our last sample period covers the years 1999-2006, where we intend to analyse the behaviour of these markets after the major shock, and how they have behaved afterwards. The data set consists of daily closing values for the stock market indices in each country as follows: Canada (S&P/TSX Composite), France (CAC 40), Germany (DAX30), Italy (MIB 30), Japan (Nikkey 225), UK (FTSE 100) and US (Dow Jones Industrial). In the case of the precious metals data, we took the US$/Troy ounce for gold, the London Free Market Platinum price in US$/Troy ounce, and the Zurich silver price in US$/kilogram. All our data series are from DataStream International, giving a total of 3130 observations for each series. Following Kanas (2000) we use continuously compounded stock returns; we also applied the same procedure to work out the precious metals returns, calculated as the first difference of the natural log. That is, S= Stock Prices; $S_t = \ln\left(P_t^s\right) - \ln\left(P_{t-1}^s\right)$, and PM= Precious Metals Prices; $PM_t = \ln\left(P_t^{PM}\right) - \ln\left(P_{t-1}^{PM}\right)$.

As an initial step we provide descriptive statistics for stock returns and exchange rates, in order to summarise the statistical characteristics of our sample. We then proceed and perform a stationarity test on each of the relevant variables that are included in our analysis to ensure that the results from the analysis are not spurious. We apply the Dickey Fuller (DF) test, or Augmented Dickey-Fuller test (ADF) procedure if serial correlation is present. We also apply the Lagrange Multiplier (LMF) test, to ensure that a sufficient number of lags have been added in the ADF test to ensure that there is no serial correlation present, and that the results of the ADF test are valid. The LMF test is applied given that it is valid in the presence of lagged dependent variables as well as having the advantage of testing for first and higher orders of serial correlation. If our variables are non-stationary in levels, we then proceed and perform a cointegration test on our variables using the Johansen Cointegration test to investigate the long-run relationship between Stock Prices and Precious Metals Prices. As Enders (2004) notes given that the results of the test can be quite sensitive to the lag length, the most common procedure is to estimate a Vector Autoregression (VAR) model on the undifferenced data in order to determine the lag length for the Johansen test. We estimate the lag selection tests up 20 lags. In terms of choosing between the various lag length selection criteria we follow

Johansen *et al.*.(2000) who suggest that when different information criteria suggest different lag lengths, it is a common practice to select the Hannan-Quinn (HQ) criteria. Again, we ensure that the lag length selected for the VAR model is free from serial correlation after performing by applying the LMF test to test for serial correlation up to the number of lags in the VAR model. We then proceed with our volatility analysis and apply a bivariate extension of the EGARCH (*p,q*) model in order to examine whether the volatility of stock returns affects and is affected by the volatility of precious metals returns within each economy. The EGARCH specification (Nelson, 1991) is used in order to test whether the volatility spillover effects are asymmetric. For example, an asymmetric spillover from stock returns to exchange rate changes would suggest that the effect of "bad" stock market news on the exchange rate change is greater than the effect of "good" news. The model is specified as follows:

$$S_t = a_{s,0} + \sum_{i=1}^{r} a_{s,i} S_{t-i} + \sum_{i=1}^{r} a_{PM,i} PM_{t-i} + e_{S,t} \qquad \textbf{(1)}$$

$$PM_t = a_{PM,0} + \sum_{i=1}^{r} a_{PM,i} PM_{t-i} + \sum_{i=1}^{r} a_{S,i} S_{t-i} + e_{PM,t} \qquad \textbf{(2)}$$

$$e_{S,t} / \Omega_{t-1} \approx N(0, \sigma^2_{S,t})$$
$$e_{PM,t} / \Omega_{t-1} \approx N(0, \sigma^2_{PM,t})$$

The conditional variances of stock returns and exchange rates changes are specified as follows:

$$\sigma^2_{S,t} = \exp\left\{ c_{S,0} + \sum_{j=1}^{ps} b_{S,j} \log(\sigma^2_{S,t-j}) + \delta_{S,S}\left[\left(\left|z_{S,t-1}\right| - E\left|z_{S,t-1}\right| + \theta_{S,Sz_{s,T-1}}\right) + \delta_{S,PM}\left[\left(\left|z_{PM,t-1}\right| - E\left|z_{PM,t-1}\right| + \theta_{S,PMzPM,t-1}\right)\right]\right] \right. \qquad \textbf{(3)}$$

$$\sigma^2_{PM,t} = \exp\left\{ c_{PM,0} + \sum_{j=1}^{ps} b_{PM,j} \log(\sigma^2_{PM,t-j}) + \delta_{PM,PM}\left[\left(\left|z_{PM,t-1}\right| - E\left|z_{PM,t-1}\right| + \theta_{PM,PMz_{s,T-1}}\right) + \delta_{PM,S}\left[\left(\left|z_{S,t-1}\right| - E\left|z_{S,t-1}\right| + \theta_{PM,SzPM,t-1}\right)\right]\right] \right. \qquad \textbf{(4)}$$

$$\sigma_{S,PM,T} = \rho_{PM} \sigma_{S,t} \sigma_{PM,t}$$

Each of the relevant terms in equations (1-4) is explained in detail in Table A.

We specify the number of lags for the conditional mean equations (1) and (2) using the Hannan-Quinn (HQ) criterion; Griffin *et al.* (2005), Andersen *et al.* (2004), and Stulz *et al.* (2002) all note that the HQ criterion is preferable to the more commonly used Akaike's Information Criteria (AIC), as the latter tends to overparameterize the

models[1]. Next we apply the likelihood ratio (LR) test to determine the lag truncation length, *p*. We perform separate LR tests on the stock returns and exchange rate conditional variance equations (8) and (9) to determine the optimal lag length for the EGARCH specification of each equation. Hamilton (1994) defines the LR test as follows: $2\left[L(\hat{\theta}) - L(\tilde{\theta})\right] \approx \chi^2(m)$, where $L(\hat{\theta})$ denotes the value of the log likelihood function of the unrestricted estimate and $L(\tilde{\theta})$ denotes the value of the log likelihood functions of the restricted estimate. Bollerslev-Woolridge robust *t*-statistics are derived to take into account possible non-normality of the residuals.

4. Empirical Results

Our empirical results are presented through 4.1 to 4.5 sections. First we start presenting the basic descriptive statistics of our dataset which provide us with the details and characteristics of our series; second we will present the results of the unit roots analysis, the likelihood ratio tests performed and the basic tests that will provide the necessary information to identify which EGARCH(p,q) specification will be the most appropriate to model our two financial variables; and finally, we present the results of the EGARCH analysis, results that will provide information of volatility persistence, volatility spillovers and asymmetric spillovers effects from stock returns to precious metals returns and vice versa.

4.1 Descriptive Statistics

In relation to the descriptive statistics of stock returns (results are given in table 1 and table 2), we found a common trend. During the four periods of analysis, almost all markets present positive and small values, the exceptions being Nikkei 225 for the whole period, DAX 30 for 1995-June 1997 and Nikkei 225 for July 1997-1998 where the means are negative. The case of Japan reflects the extent o the Asian crisis. With regard to the precious metals markets the situation is rather different; our results show that for the whole sample the mean for platinum is negative while for gold and silver, they are positive. But when we analyse the sub samples, the situation change.

[1] For brevity here we do not report the number of lags selected for the conditional mean equations for stock prices and exchange rates for each period.

During the time previous to the crisis i.e. from 1995 to June 1997, gold and silver are showing negative means, results that are also negative for these two metals plus platinum during the crisis, the results for the last sub sample are showing positive means in all the cases . The analysis of the stock returns volatility for all our samples shows that overall the Nikkei 225, DAX30 and MIB30 are the most volatile stock returns series, with a daily standard deviation moving from 1.35% to 1.49% during 1995-2006, the most volatile period being during July 1997-1998 where the values where moving from 1.67% to 1.80% on a daily basis. In terms of the precious metals markets, silver is the most volatile returns series in all the periods under analysis, reaching the highest values for all three metals during the crisis period where the standard deviations are moving from 0.69% to 1.75%. The skewness and kurtosis coefficients indicate that stock returns and precious metals returns are leptokurtic relative to the normal distribution, which Caporale *et al.*. (2002) note is a common finding for stock returns. The Jarque-Bera test also rejects the hypothesis that stock returns and precious metals returns are normally distributed in all the cases.

4.2 Unit Roots and Likelihood Tests

The results from the ADF tests are given in table 3. The values of the test statistics indicate that we can reject the null hypothesis of the existence of a unit root in levels for all variables during all periods indicating that all series are *I(0)*.[2] Given that all variables are integrated of the same order, (i.e. *I(0),* we proceed directly to perform our volatility analysis using EGARCH (*p,q)* modelling.

In order to establish the correct lag length for the EGARCH model, we apply the Likelihood Ratio test. The results from this test for each of ours series are set out in tables 4 to 5.

We have marked with an asterisk the instances where we reject the null hypothesis; thus the estimates marked with an asterisk indicate where we have selected the EGARCH (2,1) model.. There was a mix of (1,1) and (2,1) models chosen for the different stock returns and precious metals returns, where the (2,1) model seems to be dominant.

[2] The LMF test results indicated that the ADF tests were free from serial correlation; for brevity we do not show the test results here.

The estimated parameters from the EGARCH estimation are set out in tables 6 to 8, for the four periods of analysis (1995-2006, 1995-June 1997, July 1997-1998 and 1999-06). The *p*-values are given in parentheses beneath each coefficient estimate. Those coefficient estimates which are significant at 1%, 5% and 10% levels are marked with the appropriate asterisk. And finally the diagnostic test on EGARCH models is set out in table 9 to 12.

4.3 Volatility Persistence

Analysing the results that we got from the coefficients on the volatility persistence term (results presented in table 6) the results vary depending on the country and the equation under analysis, but we find that in the majority of the cases the coefficients are insignificant in the case of volatility persistence running from stock returns to precious metals returns. In the opposite way this is not live for France, Germany, Japan and the US for all four periods. This result is surprising given that persistence is a feature of many financial markets data; therefore we expected to find evidence of significant coefficients in most of the cases. In relation to the remaining countries our results are quite mixed. If we analyse the case of Canada the results are showing insignificant coefficients during July 1997-1998 from stock returns to platinum and silver, and also insignificant coefficients in the latest period 1999-2006 in the case of silver. The analysis of Italy shows insignificant coefficients in our latest period of analysis from stock returns to all the three precious metals returns, and finally in the case of the UK the coefficients are insignificant from stock returns to precious metals returns during 1995-June1997 and in the case of platinum and silver during July1997-1998 (this results are presented in table 6). An interesting feature of our results is the insignificant coefficients obtained for the period where the Asian financial crisis happened; we expected to find significant coefficients during this particular time as the effect of the Asian crisis could be dragging all the markets into recession, expectations that are not supported by our results.

When we analyse the results in the case of volatility persistence from precious metals returns to stock returns our results are consistent in almost all the cases. The coefficients appear to be significant on the whole analysis, a few exceptions occur and they are located during the Asian crisis time period, where in most of the cases we found insignificant coefficients. For example in the case of Canada, France, Italy, the UK and the USA the coefficients are insignificant in the case of gold and platinum

during July1997-1998. With regard to the rest of the time periods we found insignificant coefficients for France in the case of gold and finally for Japan there is an insignificant coefficient during 1999-2006 with regard to gold.

Volatility persistence is a common finding is financial markets returns situation that is reflected by the findings of significant coefficients; If the following coefficients are significant and greater than zero ($\sum_{j=1}^{ps} b_{S,j}$ and $\sum_{j=1}^{pE} b_{PM,j}$ >0) implies that a deviation of the price from it is expected value will causes the variance of the price to be larger than otherwise, what will means that the amplitude of returns fluctuations represents the amount of variation of the returns during a short-time. In the presence of long memory process on volatility will means, that the fluctuations will remain in the markets for a while with the uncertainty that this situation will bring to the markets, what has important consequences in terms of risk management. Investors base their decisions in expectations, therefore, the diversity of expectations cause variability of stock returns. The insignificance of the volatility persistence coefficients found in this analysis in the precious metals returns could reflect that in general basis investors expect stability in the precious metals prices; therefore, their expectations tend to be constant and stable along time, situation that will be translated in the precious metals markets returns as a lower fluctuation in their prices. Characteristic that is supported by the appreciation of precious metals as store of value what directly implies the expectation of stability in prices.

Therefore, our volatility persistence analysis shows that overall there are no significant coefficients from stock returns to precious metals returns, this results indicates that stock markets returns fluctuations does not generate greater impacts on the precious metals while opposite results are obtained for the precious metals returns to stock returns, where almost all the coefficients appear indeed to be significant, indicating that when the precious metals markets face fluctuations, this movements will be transmitted to the stock markets, taking into account that precious metals markets are appreciated as more stable markets than the stock markets, fluctuations generated in these markets will be perceived as a sign of uncertainty in the rest of the markets where predictions and expectations will be affected and therefore these changes will be transmitted in the markets in terms of prices fluctuations and therefore volatility in returns.

Wu (2005) notes that a necessary condition for the volatility persistence terms to be stable is that the value of the estimated coefficients should be less than one; for our

results, this applies in all cases for the four periods in the case of the persistence terms for both stock returns and exchange rates where the magnitude of the coefficients are all less than one in all the cases and more importantly in the case where the coefficients are significant.

4.4 Volatility Spillovers

The analysis of the coefficients for the volatility spillovers are presented in table 7, the results are quite consistent across countries. Dealing first with spillovers from stock markets to precious metals returns, our main results are showing evidence of volatility spillovers from these markets to the precious metals markets at 1%, 5% and 10% significance levels. Some exceptions are found with regard to this evidence but most of them are affecting particular time periods. For example if we start to analyse the results per sample period we found that during the whole sample 1995-2006 all the coefficients are significant for all the countries and all the markets. In relation to the period prior to the Asian crisis (1995-June1997), the results show insignificant coefficients in the case of Canada and Italy. Regarding the Asian crisis period (July1997-1998) the coefficients are insignificant for all three periods just in the case of Italy. And finally during our last period of study (1999-2006) all our results appear to be significant.

In terms of volatility spillovers from precious metals returns to stock returns, the results are significant and consistent across countries and over time in most of the cases. As it happened when we analysed the relationship from stock returns to precious metals returns we found few exceptions. Analysing our whole sample we found that our coefficients are significant in all the cases through all the countries. Regarding the time periods prior to and during the Asian crisis we found that in all the countries and just in the case of gold the coefficients are insignificant. And finally during the last period of study the coefficients are insignificant in relation to silver in the cases of France, Germany and Italy (table 7).

Significant coefficients are indicative of integration between stock markets and precious metals markets as well as indicating that the volatility of stock returns was a determinant of the volatility of precious metals returns and vice versa, meaning that information contained in stock prices impacted on the behaviour of precious metals returns and the opposite way around in these markets. The consistency in our results is evidence of integration between these markets. These results are showing

that these markets are initially influenced, this means that at times of shocks or crises, these markets will generate reaction in each other.

4.5 Asymmetric Spillovers

For the asymmetric spillover effects from stock returns to precious metals returns we found that the coefficients are significant in almost all cases for all periods, with the following exceptions: during 1995-June1997 the coefficients are insignificant in the cases of all countries with regard to silver and during July1997-1998 for Japan in the case of silver and for the UK from stock returns to gold (results presented in table 8). The existence of insignificant coefficients indicates that the spillover effects in these instances are symmetric, that is that positive and negative shocks have the same impact on volatility.

The diagnostic tests on the standardised residuals are listed for each country in Tables 9-12. The Jarque-Bera test indicates that we reject the hypothesis that the residuals are normally distributed, hence justifying the use of the Bollerslev-Woolridge robust *t*-statistics. The Ljung-Box statistics for all three periods for all countries indicate that there are no residual linear or non linear dependencies. There are some exceptions where the coefficient was not significant but the problem was corrected after introducing more lags into the test. Finally to check the validity of the assumption of constant correlation adopted in the estimation of the bivariate models (Kanas, 2000), the LB statistics for the cross products of the standardised residuals from the stock returns equation and from the exchange rate equation are calculated and these statistics indicated that the assumption of constant correlation over time can be accepted.

5. Conclusions

The existing literature shows that little attention has been paid to the study of interlinkages between stock markets and precious metals markets and in particular to the analysis of volatility spillovers between them. The relationships between stock returns and precious metals returns demand more research, as these two markets are very important in terms of portfolio and risk management decisions. Hillier, Draper and Faff (2006) notice that gold, platinum and silver have the potential to play a diversifying role in investment portfolios, as precious metals exhibit some hedging

capability during periods of abnormal markets volatility. Wolfle (2006) analysed relationships between commodities and two stock markets and he concluded that information transmission between stock and commodity markets is rejected; consequently his findings support the use of commodities to diversify risk in stock portfolios. Therefore, our analysis is motivated but the results of previous studies, where precious metals markets appeared to be an interesting option for investors to diversify their portfolios and to implement their hedging techniques.

The main findings could be summarised as follows: in terms of volatility persistence, our analysis shows that overall there are no significant coefficients from stock returns to precious metals returns, while there is an opposite result in the opposite case, where almost all the coefficients appear to be significant. The analysis of the coefficients for the volatility spillovers shows that the results are quite consistent across countries, and markets over time in most of the cases, meaning that information from stock markets affects precious metals markets and vice versa. The results from the asymmetric spillovers analysis show that overall good news have less of an impact in the markets than bad news.

Our results are consistent with Wolfle (2006) with regard to insignificant evidence effects that were found running from the stock markets to the commodities markets, but our results differ in the opposite direction, where we found significant coefficients in some of the cases.

After getting the results from our EGARCH methodology and taking into account that even the results are showing that stock returns and precious markets returns are influenced by the information, reactions, shocks, events that take place in any of them, a question that will be necessary to address in a future research is which markets are being affected to a greater extent. If we found that stock returns are affected more negatively than precious metals it will mean that investors will be able to use precious metals to diversify their portfolio. As even the economy becomes in crisis of shock, probably metal markets will suffer a lower effect than stock markets. This is because they are characterized as a store of value and they will tend to keep their value for a longer period than in the case of the stock markets; then the use of precious metals markets could be important in order to prevent bigger loses.

Investors can use precious metals markets to diversify their portfolio in situations were the national currency is depreciating or where the stock markets returns decrease. Also it will be interesting to analyse if in some occasions it could be possible that the precious metals returns could be higher than the stock markets

returns. Tully and Lucey (2006) found that dollar depreciation and a growing risk of dollar devaluation are likely to strengthen investors demand for gold. Financial analysts have attributed to the rise in gold's price, the depreciation of the dollar value on international markets. Traditionally gold has played a significant role during times of political and economic crises and during equity market crashes. This is still the case in a post Bretton-Woods era.

Our results provide evidence of the need for further research in this area. Possible extensions could focus to implement this analysis in the case of the European markets, using multivariate techniques where key indicators such as economic growth, the interest rates and exchange rates should be included in the analysis in order to get information of the reaction of the markets when changes in interest rates or currency depreciation/appreciation occur.

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Table A: Description of Parameters Equations (1)-(4)

	Stock Returns	Precious Metals Returns
Error correction terms (lagged residuals from the cointegrating regression of S_t, PM_t)	$\lambda_{S,t-1}$	$\lambda_{PM,t-1}$
Stochastic error terms	$e_{S,t}$	$e_{PM,t}$
Information set at time *t-1*	Ω_{t-1}	Ω_{t-1}
Conditional (time varying) variances	$\sigma^2_{S,t}$	$\sigma^2_{PM,t}$
Standardised residuals assumed to be normally distributed with 0 mean and variances of $\sigma^2_{S,t}, \sigma^2_{PM,t}$	$z_{S,t} = e_{S,t} / \sigma_{S,t}$ $e_{S,t} / \Omega_{t-1} \sim N(0, \sigma^2_{S,t})$	$z_{PM,t} = e_{PM,t} / \sigma_{PM,t}$ $e_{PM,t} / \Omega_{t-1} \sim N(0, \sigma^2_{PM,t})$
Persistence of Volatility	$\sum_{j=1}^{ps} b_{S,j}$	$\sum_{j=1}^{pE} b_{PM,j}$
ARCH effect where the parameters $\theta_{S,S}, \theta_{PM,PM}$ allow this effect to be asymmetric	$\left[\lvert z_{S,t}\rvert - E\lvert z_{S,t}\rvert + \theta_{S,SPM_{S,t}}\right]$	$\left[\lvert z_{PM,t}\rvert - E\lvert z_{PM,t}\rvert + \theta_{PM,PM_{PM,t}}\right]$
Volatility Spillover	$\delta_{S,PM}\left[\lvert z_{PM,t-1}\rvert - E\lvert z_{PM,t-1}\rvert + \theta_{S,PMz_{PM,t-1}}\right]$	$\delta_{PM,S}\left[\lvert z_{S,t-1}\rvert - E\lvert z_{S,t-1}\rvert + \theta_{PM,Sz_{SSt-1}}\right]$
Measures of spillovers	$\delta_{S,PM}$	$\delta_{PM,S}$
Asymmetry of Spillovers	$\theta_{S,PM}$	$\theta_{PM,S}$
Correlation Coefficient for Standardised Residuals	$\rho_{S,PM}$	$\rho_{PM,S}$

TABLE 1: Descriptive Statistics Stock Returns

	Mean	SD	Skewness	Kurtosis	JB
1995-2006					
S&P/TSX Composite	0.000358	0.0094	-0.7059	9.4888	5749
CAC 40	0.000345	0.0135	-0.1080	5.9068	1108
DAX 30	0.000369	0.0149	-0.1689	6.2272	1373
MIB 30	0.000333	0.0135	-0.1097	6.0301	1203
NIKKEI 225	-4.33E-05	0.0139	-0.0259	5.1865	624
FTSE 100	0.000226	0.0106	-0.1976	6.2149	1368
Dow Jones	0.000377	0.0104	-0.2513	7.7645	2992
1995-June 1997					
S&P/TSX Composite	0.000652	0.0056	-0.6371	6.5221	380
CAC 40	0.000644	0.0100	-0.1630	3.9388	27
DAX 30	-0.00091	0.0084	0.2432	4.3997	59
MIB 30	0.000477	0.0122	0.2234	4.3261	53
NIKKEI 225	6.73E-05	0.0125	0.0937	5.3677	153
FTSE 100	0.000626	0.0061	-0.2018	3.3343	7
Dow Jones	0.001067	0.0073	-0.3743	4.8146	104
July 1997-1998					
S&P/TSX Composite	0.000173	0.0104	-1.1045	9.8534	1126
CAC 40	0.001021	0.0150	-0.2350	4.7557	72
DAX 30	0.001061	0.0167	-0.4105	5.0705	108
MIB 30	0.001547	0.0180	-0.2322	4.4308	49
NIKKEI 225	-0.000644	0.0168	0.1624	4.8557	77
FTSE 100	0.000684	0.0114	-0.0857	4.2899	37
Dow Jones	0.000678	0.0120	-0.6988	8.4702	692
1999-2006					
S&P/TSX Composite	0.00033	0.0100	-0.5478	8.3101	2554
CAC 40	0.000163	0.0140	-0.0798	5.9644	766
DAX 30	0.000132	0.0158	-0.0787	5.8040	685
MIB 30	8.04E-05	0.0126	-0.1566	6.6067	1139
NIKKEI 225	0.000105	0.0135	-0.1193	4.8653	307
FTSE 100	2.68E-05	0.0113	-0.2025	6.0828	840
Dow Jones	0.000147	0.0107	-0.0462	6.7601	1229

Table 2: Descriptive Statistics Precious Metals

	Mean	SD	Skewness	Kurtosis	JB
1995-2006					
Gold	0.000162	0.0086	0.1703	10.5384	7424
Platinum	-0.000315	0.0136	0.6427	19.1193	34091
Silver	0.000307	0.0174	-0.6741	12.9421	13124
1995-June 1997					
Gold	-0.000207	0.0044	0.3319	6.4210	329
Platinum	4.91E-05	0.0101	2.3290	33.2392	25353
Silver	-7.95E-05	0.0143	0.6299	10.4756	1557
July 1997-1998					
Gold	-0.000481	0.0069	0.0639	4.1675	30
Platinum	-4.20E-05	0.0155	0.6264	10.0941	1127
Silver	-2.13E-05	0.0175	0.2059	6.3548	248
1999-2006					
Gold	0.000379	0.0097	0.1240	9.2690	3420
Platinum	0.000541	0.0142	-1.0640	20.1818	26040
Silver	0.000453	0.0181	-1.0566	14.1642	11216

Table 3: Augmented Dickey-Fuller Test

	1995-2006	1995-June 1997	July 1997-1998	1999-2006
Stock Returns				
S&P/TSX Composite	-39.25*	-20.88*	-20.23*	-33.02*
CAC 40	-13.73*	-15.09*	-21.52*	-21.60*
DAX 30	-14.27*	-27.01*	-17.42*	-15.20*
MIB 30	-11.13*	-24.40*	-5.01*	-15.39*
NIKKEI 225	-41.68*	-26.91*	-18.79*	-46.81*
FTSE 100	-13.91*	-24.35*	-16.56*	-15.17*
Dow Jones	-41.02*	-15.83*	-22.83*	-33.62*
Precious Metals				
Gold	-22.48*	-25.69*	-21.17*	-18.09*
Platinum	-43.40*	-10.44*	-17.95*	-35.48*
Silver	-62.19*	-8.16*	-22.55*	-52.05*

*1% significance level

Table 4: Likelihood Ratio Test Stock Returns-Precious Metals

	1995-2006	1995-June 1997	July 1997-1998	1999-2006
S&P/TSX Composite-Gold	0.344	0.016	0.42	2.16
S&P/TSX Composite-Platinum	0.254	0.41	0.34	2.02
S&P/TSX Composite-Silver	0.504	0.54	0.1	2.29
CAC 40-Gold	6.81*	5.61	1.02	7.81*
CAC 40-Platinum	7.28*	3.54	0.962	8.5*
CAC 40-Silver	6.89*	3.672	1.094	8.31*
DAX 30-Gold	22.04*	8.12*	4.35	14.77*
DAX 30-Platinum	24.47*	7.81*	5.04	16.73*
DAX 30-Silver	24.56*	8.01*	4.68	16.81*
MIB 30-Gold	0.776	2.154	0.118	6.644*
MIB 30-Platinum	0.8	1.09	0.096	6.76*
MIB 30-Silver	0.824	0.75	0.124	6.66*
NIKKEI 225-Gold	8.07*	2.79	3.07	23.16*
NIKKEI 225-Platinum	8.72*	2.69	1.93	23.35*
NIKKEI 225-Silver	8.48*	3.21	5.05	23.23*
FTSE 100-Gold	1.6	0.236	0.824	2.274
FTSE 100-Platinum	1.66	0.284	0.038	2.312
FTSE 100-Silver	1.6	0.266	0.006	2.48
Dow Jones-Gold	6.4*	11.92*	2.49	1.78
Dow Jones-Platinum	6.52*	9.36*	2.65	1.62
Dow Jones-Silver	6.68*	9.26*	2.73	1.64

Note: H_0: EGARCH (1,1), H_1: EGARCH(2,1)* The 5% critical value for the LR test distributed as χ^2 with 2 degrees of freedom is 5.99.

Table 5: Likelihood Ratio Test Stock Returns-Precious Metals*

	1995-2006	1995-June 1997	July 1997-1998	1999-2006
Gold -S&P/TSX Composite	0.154	1.51	29.26*	27.63*
Platinum-S&P/TSX Composite	5.25	0.46	7.13*	4.19
Silver-S&P/TSX Composite	0.078	0.00	175.32*	119.71*
Gold- CAC 40	35.5*	0.718	0.326	32.05*
Platinum-CAC 40	9.242*	0.038	0.254	4.21
Silver-CAC 40	191.532*	14.43*	0.688	132.69*
Gold-DAX 30	36.98*	0.326	0.326	32.94*
Platinum-DAX 30	7.88*	0.044	0.24	3.48
Silver-DAX 30	191.02*	15.276*	0.72	129.12*
Gold-MIB 30	34.6*	0.724	0.364	25.93*
Platinum-MIB 30	9.14*	0.02	0.288	4.31
Silver-MIB 30	182.602*	14.562*	0.618	126.83*
Gold-NIKKEI 225	25.52*	0.418	0.372	24.89*
Platinum-NIKKEY 225	8.63*	0.03	0.27	3.67
Silver-NIKKEY 225	178.12*	16.286*	0.25	124.15*
Gold-FTSE 100	38.68*	0.89	0.388	34.92*
Platinum-FTSE 100	8.58*	0.008	0.294	4.02
Silver-FTSE 100	190.94*	13.77*	0.302	132.22*
Gold-Dow Jones	31.82*	0.48	0.676	32.51*
Platinum-Dow Jones	8.99*	0.002	0.08	4.22
Silver-Dow Jones	182.42**	16.35*	0.22	128.21*

*Note: H_0: EGARCH (1,1), H_1: EGARCH(2,1) The 5% critical value for the LR test distributed as χ^2 with 2 degrees of freedom is 5.99.

Table 6: EGARCH RESULTS VOLATILITY PERSISTENCE

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
Canada	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	0.1554	0.1557	0.1532	0.2500	0.2418	0.2320	0.1535	0.1742	0.1750	0.1141	0.1157	0.0442
	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.001)*	(0.009)*	(0.013)**	(0.013)**	(0.000)**	(0.000)*	(0.498)
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2396	0.2820	0.4082	0.1965	0.2330	0.5267	0.0976	0.2536	0.4913	0.2512	0.2293	0.4291
	(0.000)*	(0.000)*	(0.000)*	(0.002)*	(0.001)*	(0.000)*	(0.154)	(0.021)**	(0.000)*	(0.009)*	(0.000)*	(0.000)*
France	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	0.0228	0.0198	0.0228	0.0703	0.0739	0.0732	0.0842	0.0862	0.0697	0.0057	-0.0004	0.0014
	(0.696)	(0.732)	(0.696)	(0.022)**	(0.013)**	(0.011)**	(0.143)	(0.126)	(0.199)	(0.941)	(0.995)	(0.985)
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2587	0.2855	0.4328	0.2008	0.2286	0.4730	0.1113	0.2599	0.4753	0.2764	0.2308	0.4721
	(0.001)*	(0.000)*	(0.000)*	(0.012)**	(0.001)*	(0.000)*	(0.182)	(0.018)**	(0.000)*	(0.002)*	(0.000)*	(0.000)*
Germany	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	-0.0403	-0.0496	-0.0483	-0.1257	-0.1181	-0.1196	0.1231	0.1262	0.1197	-0.0313	-0.0432	-0.0424
	(0.493)	(0.392)	(0.403)	(0.070)***	(0.276)	(0.268)	(0.018)**	(0.018)**	(0.023)**	(0.696)	(0.582)	(0.590)
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2628	0.2808	0.4248	0.2305	0.2303	0.4643	0.1222	0.2546	0.4999	0.2747	0.2342	0.4581
	(0.001)*	(0.000)*	(0.000)*	(0.003)*	(0.002)*	(0.000)*	(0.152)	(0.021)**	(0.000)*	(0.004)*	(0.000)*	(0.000)*
Italy	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	0.1728	0.1732	0.1734	0.3079	0.3279	0.3327	0.2302	0.2314	0.2300	0.0534	0.0539	0.0546
	(0.000)*	(0.000)*	(0.000)*	(0.002)*	(0.001)*	(0.001)*	(0.000)*	(0.000)*	(0.000)*	(0.505)	(0.513)	(0.507)
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2533	0.2832	0.4177	0.2014	0.2284	0.4726	0.1127	0.2650	0.4829	0.2594	0.2330	0.4494
	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.172)	(0.014)**	(0.000)*	(0.006)*	(0.000)*	(0.000)*
Japan	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	0.0432	0.0374	0.0396	0.0737	0.0646	0.0678	0.0669	-0.0122	0.0125	-0.0675	-0.0667	-0.0661
	(0.493)	(0.562)	(0.535)	(0.142)	(0.146)	(0.111)	(0.042)**	(0.497)	(0.596)	(0.265)	(0.287)	(0.278)
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2337	0.2810	0.4127	0.2037	0.2280	0.4894	0.1199	0.2241	0.4693	0.2440	0.2287	0.4332
	(0.006)*	(0.000)*	(0.000)*	(0.005)*	(0.003)*	(0.000)*	(0.122)	(0.073)***	(0.000)*	(0.012)**	(0.000)*	(0.000)*
UK	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	0.0971	0.0980	0.0977	0.0026	0.0241	0.0012	0.0490	0.0709	0.0732	0.0858	0.0867	0.0837
	(0.000)*	(0.000)*	(0.000)*	(0.967)	(0.707)	(0.983)	(0.000)*	(0.011)**	(0.010)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2642	0.2827	0.4395	0.2099	0.2326	0.4956	0.1122	0.2585	0.4742	0.2767	0.2382	0.4773
	(0.002)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.182)	(0.020)**	(0.000)*	(0.004)*	(0.000)*	(0.000)*
US	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock Returns	0.0226	0.0224	0.0211	-0.1711	-0.1378	-0.1377	0.0646	0.0704	0.0748	0.0058	0.0650	0.0648
	(0.703)	(0.706)	(0.722)	(0.210)	(0.272)	(0.279)	(0.162)	(0.186)	(0.184)	(0.934)	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious Metals	0.2481	0.2842	0.4191	0.2179	0.2411	0.4861	0.1036	0.2584	0.4734	0.2610	0.2381	0.4551
	(0.004)*	(0.000)*	(0.000)*	(0.008)*	(0.001)*	(0.000)*	(0.161)	(0.020)**	(0.000)*	(0.008)*	(0.000)*	(0.000)*

*1% significance level, **5% significance level, *** 10% significance level

Table 7: EGARCH RESULTS VOLATILITY SPILLOVERS

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
Canada	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0636	-0.0641	-0.0597	-0.0562	-0.0580	-0.0592	-0.1263	-0.1313	-0.1266	-0.0511	-0.0497	-0.0492
Returns	(0.000)*	(0.000)*	(0.000)*	(0.171)	(0.149)	(0.135)	(0.006)*	(0.009)*	(0.013)**	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0554	-0.0653	0.0486	0.0407	0.1534	-0.2106	0.0694	0.1464	0.1492	0.0838	0.0669	0.0491
Metals	(0.013)**	(0.063)***	(0.002)*	(0.425)	(0.002)*	(0.003)*	(0.128)	(0.053)***	(0.079)***	(0.000)*	(0.027)**	(0.093)***
France	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0653	-0.0666	-0.0662	-0.0369	-0.0340	-0.0347	-0.1271	-0.1287	-0.1234	-0.0827	-0.0847	-0.0839
Returns	(0.000)*	(0.000)*	(0.000)*	(0.056)***	(0.082)***	(0.062)***	(0.000)*	(0.000)*	(0.001)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0561	0.0608	0.0442	0.0698	0.1623	-0.2050	0.0543	0.1495	0.1458	0.0793	0.0662	0.0418
Metals	(0.000)*	(0.002)*	(0.022)**	(0.227)	(0.001)*	(0.006)*	(0.269)	(0.044)**	(0.087)***	(0.000)*	(0.023)**	(0.205)
Germany	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0729	-0.0748	-0.0743	0.1578	0.1632	0.1616	-0.1402	-0.1371	-0.1402	-0.0810	-0.0831	-0.0830
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.007)*	(0.006)*	(0.006)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0512	0.0602	0.0445	0.0538	0.1597	-0.2174	0.0525	0.1474	0.1413	0.0775	0.0666	0.0432
Metals	(0.001)*	(0.002)*	(0.017)**	(0.341)	(0.000)*	(0.002)*	(0.285)	(0.047)**	(0.095)***	(0.000)*	(0.025)**	(0.172)
Italy	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0425	-0.0423	-0.0423	0.0284	0.0273	0.0220	-0.0419	-0.0393	-0.0416	-0.0896	-0.0904	-0.0902
Returns	(0.018)**	(0.020)**	(0.019)**	(0.614)	(0.631)	(0.696)	(0.284)	(0.317)	(0.290)	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0545	0.0610	0.0435	0.0520	0.1541	-0.2055	0.0589	0.1478	0.1465	0.0799	0.0667	0.0406
Metals	(0.000)*	(0.002)*	(0.031)**	(0.366)	(0.002)*	(0.004)*	(0.237)	(0.041)**	(0.087)***	(0.000)*	(0.025)**	(0.251)
Japan	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0919	-0.0927	-0.0914	-0.1258	-0.1205	-0.1199	-0.1201	-0.1365	-0.1267	-0.0711	-0.0720	-0.0715
Returns	(0.000)*	(0.000)*	(0.000)*	(0.051)***	(0.042)**	(0.035)**	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0570	0.0616	0.0474	0.0497	0.1522	-0.2200	0.0745	0.1617	0.1583	0.0842	0.0670	0.0498
Metals	(0.000)*	(0.001)*	(0.006)*	(0.363)	(0.003)*	(0.003)*	(0.142)	(0.031)**	(0.060)***	(0.000)*	(0.022)**	(0.098)***
UK	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0840	-0.0861	-0.0840	-0.0960	-0.1111	-0.1099	0.9512	-0.0967	-0.0922	-0.1047	-0.1055	-0.1029
Returns	(0.000)*	(0.000)*	(0.000)*	(0.038)**	(0.014)**	(0.010)**	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0523	0.0613	0.0448	0.0598	0.1516	-0.2127	0.0599	0.1461	0.1471	0.0796	0.0678	0.0435
Metals	(0.000)*	(0.002)*	(0.016)**	(0.280)	(0.003)*	(0.004)*	(0.231)	(0.049)**	(0.084)***	(0.000)*	(0.024)**	(0.000)*
US	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	-0.0942	-0.0947	-0.0950	-0.0440	-0.0492	-0.0464	-0.1600	-0.1643	-0.1705	-0.0927	-0.0940	-0.0939
Returns	(0.000)*	(0.000)*	(0.000)*	(0.076)***	(0.058)***	(0.073)***	(0.001)*	(0.002)*	(0.001)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.0526	0.0608	0.0455	0.0507	0.1514	-0.2178	0.0688	0.1422	0.1484	0.0795	0.0669	0.0443
Metals	(0.001)*	(0.002)*	(0.012)**	(0.378)	(0.003)*	(0.003)*	(0.151)	(0.054)**	(0.083)**	(0.000)*	(0.027)**	(0.000)*

*1% significance level, **5% significance level, *** 10% significance level

Table 8: EGARCH RESULTS ASYMMETRIC SPILLOVERS

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
Canada	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9836	0.9829	0.9844	0.9277	0.9274	0.9306	0.9562	0.9545	0.9558	0.9894	0.9890	0.9895
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9894	0.9800	0.9942	0.9596	0.9453	-0.2926	0.7840	0.8492	0.4162	0.9855	0.9602	0.9924
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.379)	(0.000)*	(0.000)*	(0.030)**	(0.000)*	(0.000)*	(0.000)*
France	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9875	0.9875	0.9875	0.9889	0.9882	0.9879	0.9452	0.9456	0.9489	0.9834	0.9834	0.9835
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9905	0.9825	0.9944	0.9459	0.9443	-0.2901	0.7429	0.8449	0.4360	0.9871	0.9614	0.9924
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.428)	(0.010)**	(0.000)*	(0.017)**	(0.000)*	(0.000)*	(0.000)*
Germany	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9812	0.9807	0.9809	0.8733	0.8657	0.8703	0.9556	0.9573	0.9563	0.9780	0.9774	0.9774
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9904	0.9820	0.9945	0.9452	0.9430	-0.3135	0.7428	0.8486	0.4623	0.9866	0.9601	0.9925
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.333)	(0.006)*	(0.000)*	(0.005)*	(0.000)*	(0.000)*	(0.000)*
Italy	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9832	0.9838	0.9837	0.6769	0.6921	0.6877	0.9490	0.9506	0.9491	0.9775	0.9778	0.9778
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9905	0.9822	0.9942	0.9504	0.9460	-0.3106	0.7398	0.8554	0.4442	0.9861	0.9592	0.9922
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.363)	(0.011)**	(0.000)*	(0.014)**	(0.000)*	(0.000)*	(0.000)*
Japan	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9642	0.9640	0.9645	0.9617	0.9651	0.9682	0.9777	0.9825	0.9803	0.9624	0.9628	0.9635
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9894	0.9825	0.9942	0.9502	0.9462	-0.2889	0.7381	0.8148	0.3453	0.9854	0.9634	0.9926
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.391)	(0.006)*	(0.000)*	(0.238)	(0.000)*	(0.000)*	(0.000)*
UK	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9890	0.9890	0.9892	0.7759	0.7607	0.7904	0.6980	0.9861	0.9851	0.9862	0.9862	0.9871
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.172)	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9906	0.9819	0.9943	0.9429	0.9463	-0.3043	0.7371	0.8425	0.4404	0.9868	0.9573	0.9925
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.392)	(0.012)**	(0.000)*	(0.017)**	(0.000)*	(0.000)*	(0.000)*
US	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
Stock	0.9823	0.9825	0.9823	0.9736	0.9688	0.9699	0.9464	0.9411	0.9364	0.9909	0.9917	0.9917
Returns	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*
	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
Precious	0.9901	0.9823	0.9942	0.9450	0.9442	-0.3052	0.7691	0.8461	0.4257	0.9866	0.9574	0.9925
Metals	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.355)	(0.001)*	(0.000)*	(0.025)**	(0.000)*	(0.000)*	(0.000)*

*1% significance level, **5% significance level, *** 10% significance level

Table 9 : Diagnostic Test on EGARCH models

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
Canada												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	1071	1169	1134	109	119	120	487	428	454	206	216	215
LB(20)	47.902	50.422	49.472	34.801	34.125	32.454	45.096	50.804	49.627	19.685	20.635	20.601
	(0.000)*	(0.000)*	(0.000)*	(0.021)	(0.025)	(0.039)	(0.001)*	(0.000)*	(0.000)*	(0.478)	(0.419)	(0.421)
$LB^2(20)$	8.2302	7.6437	9.1782	12.082	13.346	12.77	5.6233	7.6326	7.4712	12.883	13.056	13.307
	(0.990)	(0.994)	(0.981)	(0.913)	(0.862)	(0.887)	(0.999)	(0.994)	(0.995)	(0.882)	(0.875)	(0.864)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	2979	1500	6479	225	155	571	38	45	98	1408	1453	7172
LB(20)	27.605	16.152	37.707	11.639	15.858	36.046	20.321	19.178	24.181	25.33	11.99	28.61
	(0.119)	(0.707)	(0.01)	(0.928)	(0.725)	(0.015)	(0.438)	(0.510)	(0.235)	(0.189)	(0.916)	(0.096)
$LB^2(20)$	21.191	8.8491	4.3797	25.748	11.536	22.004	20.287	14.942	32.614	15.925	9.5636	4.3493
	(0.386)	(0.985)	(1.000)	(0.174)	(0.931)	(0.340)	(0.440)	(0.780)	(0.037)	(0.721)	(0.975)	(1.000)
Cross Products												
LB(20)	30.43	23.33	32.037	15.925	22.643	9.5188	17.604	12.062	17.382	31.01	20.376	36.462
	(0.063)	(0.273)	(0.043)	(0.721)	(0.307)	(0.976)	(0.613)	(0.914)	(0.628)	(0.055)	(0.435)	(0.014)
$LB^2(20)$	0.6422	9.9602	3.447	15.205	17.702	4.0504	4.3876	1.0662	16.711	0.997	114.96	2.3441
	(1.000)	(0.969)	(1.000)	(0.765)	(0.607)	(1.000)	(1.000)	(1.000)	(0.672)	(1.000)	(0.000)	(1.000)
France												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	76	69	71	24	16	16	13	11	14	52	47	48
LB(20)	32.927	32.66	31.902	24.577	24.61	23.27	31.987	33.762	30.394	18.458	18.23	17.949
	(0.034)	(0.037)	(0.044)	(0.218)	(0.217)	(0.276)	(0.043)	(0.026)	(0.064)	(0.557)	(0.572)	(0.591)
$LB^2(20)$	28.953	26.959	27.719	28.547	26.873	25.71	11.215	12.364	11.533	34.801	32.163	32.573
	(0.089)	(0.136)	(0.116)	(0.097)	(0.139)	(0.176)	(0.940)	(0.903)	(0.931)	(0.021)	(0.042)	(0.038)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	2253	1468	7403	194	157	593	42	47	102	1162	1249	7019
LB(20)	29.211	16.397	31.84	14.539	15.441	32.647	18.163	19.014	21.457	22.597	12.283	23.049
	(0.084)	(0.692)	(0.045)	(0.802)	(0.751)	(0.037)	(0.577)	(0.521)	(0.371)	(0.309)	(0.906)	(0.286)
$LB^2(20)$	20.168	8.0838	4.3957	27.18	11.636	20.331	17.674	14.855	33.083	13.125	10.071	4.2372
	(0.447)	(0.991)	(1.000)	(0.130)	(0.928)	(0.437)	(0.609)	(0.785)	(0.033)	(0.872)	(0.967)	(1.000)
Cross Products												
LB(20)	29.677	23.09	30.152	23.27	22.503	14.452	21.831	16.357	30.394	20.563	22.103	29.015
	(0.075)	(0.284)	(0.067)	(0.276)	(0.314)	(0.807)	(0.350)	(0.694)	(0.064)	(0.423)	(0.335)	(0.087)
$LB^2(20)$	0.6263	35.475	74.836	3.2541	10.141	8.0354	51.826	14.835	12.884	0.5136	64.118	48.73
	(1.000)	(0.018)	(0.000)*	(1.000)	(0.966)	(0.992)	(0.000)*	(0.786)	(0.882)	(1.000)	(0.000)*	(0.000)*

* LB(20) and $LB^2(20)$: In the cases where the coefficient is not significant is enough with increasing the number of lags and the coefficients become fine.

Table 10 : Diagnostic Test on EGARCH models

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
Germany												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	94	95	96	28	29	28	6	6	7	47	51	50
LB(20)	23.878	24.256	23.746	20.478	20.49	21.078	29.799	30.727	29.941	21.986	22.177	22.191
	(0.248)	(0.231)	(0.254)	(0.428)	(0.428)	(0.393)	(0.073)	(0.059)	(0.071)	(0.341)	(0.331)	(0.330)
$LB^2(20)$	34.217	33.404	33.858	31.847	32.538	32.218	22.352	22.125	22.026	35.537	35.142	35.067
	(0.025)	(0.030)	(0.027)	(0.061)	(0.038)	(0.041)	(0.322)	(0.334)	(0.339)	(0.017)	(0.019)	(0.020)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	2256	1493	7225	246	152	577	44	46	92	1177	1276	7092
LB(20)	27.848	16.525	32.765	11.649	15.291	33.348	17.743	18.202	21.753	22.849	12.435	24.197
	(0.113)	(0.684)	(0.036)	(0.928)	(0.759)	(0.031)	(0.604)	(0.574)	(0.354)	(0.296)	(0.900)	(0.234)
$LB^2(20)$	20.734	8.1311	4.3352	26.024	10.849	22.87	17.862	15.144	33.326	14.128	9.5252	4.2405
	(0.413)	(0.991)	(1.000)	(0.165)	(0.950)	(0.295)	(0.597)	(0.768)	(0.031)	(0.824)	(0.976)	(1.000)
Cross Products												
LB(20)	38.27	23.44	35.069	22.777	22.014	27.477	23.476	13.956	22.425	27.958	29.206	31.309
	(0.008)*	(0.268)	(0.020)	(0.300)	(0.340)	(0.122)	(0.266)	(0.833)	(0.318)	(0.110)	(0.084)	(0.051)
$LB^2(20)$	1.9285	11.687	17.88	24.216	0.9345	46.635	30.807	12.365	6.4189	1.9547	9.2439	26.16
	(1.000)	(0.926)	(0.595)	(0.233)	(1.000)	(0.001)*	(0.058)	(0.903)	(0.998)	(1.000)	(0.980)	(0.161)
Italy												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	240	254	240	25	21	22	3	2	3	103	106	107
LB(20)	26.026	26.828	26.026	17.322	19.644	18.632	28.145	27.429	28.031	16.092	16.756	16.803
	(0.165)	(0.140)	(0.165)	(0.632)	(0.480)	(0.546)	(0.106)	(0.124)	(0.109)	(0.711)	(0.669)	(0.666)
$LB^2(20)$	21.266	21.548	21.266	12.632	12.871	11.265	27.768	28.003	27.578	12.865	12.176	12.047
	(0.382)	(0.366)	(0.382)	(0.893)	(0.883)	(0.939)	(0.115)	(0.109)	(0.120)	(0.883)	(0.910)	(0.914)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	2324	1551	2324	213	161	22	41	46	103	1119	1316	7474
LB(20)	30.176	16.891	30.176	14.861	15.96	34.612	17.261	18.165	21.868	22.857	12.598	25.205
	(0.067)	(0.660)	(0.067)	(0.784)	(0.719)	(0.022)	(0.636)	(0.577)	(0.348)	(0.296)	(0.894)	(0.194)
$LB^2(20)$	20.715	7.7196	20.715	27.1	11.289	23.208	17.442	15.377	34.057	13.84	9.6315	4.0524
	(0.414)	(0.994)	(0.414)	(0.132)	(0.938)	(0.279)	(0.624)	(0.754)	(0.026)	(0.839)	(0.974)	(1.000)
Cross Products												
LB(20)	35.759	18.383	35.759	23.04	10.169	21.547	20.617	17.154	32.695	28.467	25.252	38.69
	(0.016)	(0.562)	(0.016)	(0.287)	(0.965)	(0.366)	(0.420)	(0.643)	(0.036)	(0.099)	(0.192)	(0.007)*
$LB^2(20)$	1.563	8.6148	1.563	20.079	1.9086	19.582	12.014	18.645	8.1558	1.0599	3.3146	17.162
	(1.000)	(0.987)	(1.000)	(0.453)	(1.000)	(0.484)	(0.916)	(0.545)	(0.991)	(1.000)	(1.000)	(0.642)

* LB(20) and $LB^2(20)$: In the cases where the coefficient is not significant there is only need of adding more lags and the coefficients become fine.

Table 11 : Diagnostic Test on EGARCH models

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
Japan												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	430	475	480	311	344	325	21	6	6	117	116	121
LB(20)	9.2276	8.6475	8.6268	16.402	17.076	15.978	16.731	17.378	17.03	8.9625	8.523	8.4713
	(0.980)	(0.987)	(0.987)	(0.691)	(0.648)	(0.718)	(0.670)	(0.628)	(0.651)	(0.983)	(0.988)	(0.988)
$LB^2(20)$	10.866	9.716	9.737	5.5449	5.6498	6.3459	23.146	24.205	22.168	18.93	17.736	19.115
	(0.950)	(0.973)	(0.973)	(0.999)	(0.999)	(0.998)	(0.282)	(0.234)	(0.331)	(0.526)	(0.605)	(0.514)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	2781	1534	6968	243	153	544	39	45	97	1376	1342	6657
LB(20)	27.825	16.405	35.218	12.619	15.622	33.721	20.218	18.318	22.283	25.213	12.025	28.849
	(0.114)	(0.691)	(0.019)	(0.893)	(0.740)	(0.028)	(0.444)	(0.566)	(0.325)	(0.193)	(0.915)	(0.091)
$LB^2(20)$	21.539	8.4573	4.4437	26.936	11.003	23.237	18.669	14.868	32.204	16.037	10.477	4.5077
	(0.366)	(0.988)	(1.000)	(0.137)	(0.946)	(0.277)	(0.543)	(0.784)	(0.041)	(0.714)	(0.959)	(1.000)
Cross Products												
LB(20)	33.738	10.768	20.294	11.086	12.636	18.492	27.736	31.413	17.383	31.802	7.2531	23.996
	(0.028)	(0.952)	(0.440)	(0.944)	(0.892)	(0.555)	(0.116)	(0.050)	(0.628)	(0.045)	(0.996)	(0.243)
$LB^2(20)$	10.352	9.5029	2.8882	10.332	7.7845	8.7577	1.8577	28.343	13.599	16.829	5.3342	5.0117
	(0.961)	(0.976)	(1.000)	(0.962)	(0.993)	(0.986)	(0.997)	(0.102)	(0.850)	(0.664)	(1.000)	(1.000)
UK												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	134	121	134	8	6	5	2	3	3	160	153	191
LB(20)	25.101	25.353	25.179	30.588	29.142	29.079	44.207	43.167	42.754	14.509	14.687	15.598
	(0.198)	(0.188)	(0.195)	(0.061)	(0.085)	(0.086)	(0.001)*	(0.002)*	(0.002)*	(0.804)	(0.794)	(0.741)
$LB^2(20)$	22.017	21.648	20.832	27.865	27.058	25.77	16	15.18	15.468	20.023	20.186	17.865
	(0.340)	(0.360)	(0.407)	(0.113)	(0.134)	(0.174)	(0.717)	(0.766)	(0.749)	(0.456)	(0.446)	(0.596)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	2346	1506	6851	205	162	576	40	47	100	1228	1341	6571
LB(20)	25.796	16.71	32.218	14.183	15.63	33.54	17.02	18.572	21.978	23.64	12.64	24.007
	(0.173)	(0.672)	(0.041)	(0.821)	(0.739)	(0.029)	(0.652)	(0.550)	(0.342)	(0.258)	(0.892)	(0.242)
$LB^2(20)$	23.247	7.8685	4.8847	27.823	11.166	22.618	17.839	15.402	32.746	16.328	9.577	4.5703
	(0.277)	(0.993)	(1.000)	(0.114)	(0.942)	(0.308)	(0.598)	(0.753)	(0.036)	(0696)	(0.975)	(1.000)
Cross Products												
LB(20)	28.836	18.418	28.298	26.126	32.113	18.233	30.384	17.564	33.568	19.261	10.146	17.756
	(0.091)	(0.560)	(0.103)	(0.162)	(0.042)	(0.572)	(0.064)	(0.616)	(0.029)	(0.505)	(0.965)	(0.603)
$LB^2(20)$	0.5646	4.6775	3.145	7.4426	9.3828	3.4381	13.913	10.767	35.088	0.4486	3.6424	1.0646
	(1.000)	(1.000)	(1.000)	(0.995)	(0.978)	(1.000)	(0.835)	(0.952)	(0.020)	(1.000)	(1.000)	(1.000)

* LB(20) and $LB^2(20)$: In the cases where the coefficient is not significant there is only need of adding more lags and the coefficients become fine.

Table 12 : Diagnostic Test on EGARCH models

	1995-2006			1995-June 1997			July 1997-1998			1999-2006		
US												
Stock Returns	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver	S-Gold	S-Platinum	S-Silver
JB	337	329	331	51	46	48	70	71	68	111	100	101
LB(20)	22.048	22.029	21.982	18.31	18.501	18.704	25.988	26.26	25.684	17.305	17.883	17.85
	(0.338)	(0.339)	(0.341)	(0.567)	(0.554)	(0.541)	(0.166)	(0.157)	(0.177)	(0.633)	(0.595)	(0.597)
$LB^2(20)$	8.9215	9.2453	9.0978	12.776	12.044	11.171	8.9561	8.7364	8.5482	12.368	13.148	13.267
	(0.984)	(0.980)	(0.982)	(0.887)	(0.915)	(0.942)	(0.983)	(0.986)	(0.986)	(0.903)	(0.871)	(0.866)
Precious Metals	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S	Gold-S	Platinum-S	Silver-S
JB	3001	1517	7235	251	152	609	37	45	103	1572	1401	7027
LB(20)	27.854	16.563	34.539	12.502	16.456	33.714	19.088	18.197	22.196	24.768	12.623	25.78
	(0.113)	(0.681)	(0.023)	(0.898)	(0.688)	(0.028)	(0.516)	(0.574)	(0.330)	(0.210)	(0.893)	(0.173)
$LB^2(20)$	22.127	8.0428	4.4506	27.581	11.041	22.563	17.664	15.109	32.826	15.463	9.6617	4.3131
	(0.334)	(0.992)	(1.000)	(0.120)	(0.945)	(0.311)	(0.610)	(0.770)	(0.035)	(0.749)	(0.974)	(1.000)
Cross Products												
LB(20)	29.197	31.565	25.183	25.592	15.089	27.501	15.928	18.306	18.816	20.021	41.159	29.886
	(0.084)	(0.048)	(0.195)	(0.180)	(0.771)	(0.122)	(0.705)	(0.567)	(0.534)	(0.457)	(0.004)*	(0.072)
$LB^2(20)$	6.2807	37.927	4.2465	16.484	7.6088	91.607	11.712	4.6055	9.3534	3.3659	109.65	2.5813
	(0.998)	(0.009)*	(1.000)	(0.686)	(0.994)	(0.000)*	(0.926)	(1.000)	(0.978)	(1.000)	(0.000)*	(1.000)

* LB(20) and $LB^2(20)$: In the cases where the coefficient is not significant there is only need of adding more lags and the coefficients become fine.