Does gold offer a better protection against sovereign debt crisis than other metals?

SAM AGYEI-AMPOMAH[a], DIMITRIOS GOUNOPOULOS[b], KHELIFA MAZOUZ [c1]

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ABSTRACT

It is a commonly held view that gold protects investors' wealth in the event of negative economic conditions. In this study, we test whether other metals offer similar or better investment opportunities in periods of market turmoil. Using a sample of 13 sovereign bonds, we show that other precious metals, palladium in particular, offer investors greater compensation for their bond market losses than gold. We also find that industrial metals, especially copper, tend to outperform gold and other precious metals as hedging vehicles and safe haven assets against losses in sovereign bonds. However, the outcome of the hedge and safe haven properties is not always consistent across the different bonds. Finally, our analysis suggests that copper is the best performing metal in the period immediately after negative bond price shocks.

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[1] Sam Agyei-Ampomah is from Cranfield School of Management, Cranfield University, Cranfield, MK43 0AL, UK., Dimitrios Gounopoulos is from School of Business Management and Economics, University of Sussex, Falmer, Brighton, BN1 9SL, UK. Khelifa Mazouz is from Management School, University of Bradford, Bradford, BD9 4JL, UK. We are grateful to the Co-Editors Carol Alexander and Ike Mathur, an Associate Editor and two anonymous referee for their detailed and insightful comments. We would like to thank Dirk Baur, Taufiq Choudhry, Theoharry Grammatikos, Alexander Kupfer, Shawkat Hammoudeh, M. Thenmozhi, Dalu Zhang, seminar participants at the Southampton International Conference on the Global Financial Crises, the European Financial Management Conference (EFM2013), the Multinational Finance Conference (MFS2013), Cardiff Business School at University of Cardiff and School of Business, Management and Economics at University of Sussex for useful comments and suggestions.

1. Introduction

The financial media normally regard gold as a safe haven asset. Its characteristics as a financial asset have also been widely explored in the academic literature. Gold has been a traditional investment vehicle since it serves as a hedge against inflation and a safe haven in periods of market crises (see e.g., Baur and McDermott, 2010; Daskalaki and Skiadopoulos, 2011; Batten et al., 2013). It has also been widely documented that gold protects investors' wealth against fluctuations in the foreign exchange value of the US dollar (Capie et al., 2005; Pukthuanthong and Roll, 2011; Reboredo, 2013 and Ciner et al., 2013). The observed increase in the value of gold during the recent financial crisis has motivated other researchers to test explicitly its viability as a safe haven from losses in other financial markets. Baur and McDermott (2010) show that gold protects investors against stock market shocks in major European countries and the US, but does not serve as a safe haven for Australia, Canada, Japan and emerging stock markets. Similarly, Baur and Lucey (2010) find that gold is a safe haven for stocks, but not for bonds, in the US, the UK and Germany.

The main objective of this study is to investigate whether gold is a special investment vehicle or if it has become relegated in status to the same standing as other metals, which are primarily for industrial purposes and traded as commodities. There is no sound theoretical model to explain why gold may act as a safe haven, but a major explanation often put forward is that gold was among the first forms of money and has traditionally acted as an inflation hedge (Baur and Lucey, 2010). However, since the collapse of Bretton Woods system and the move to floating exchange rate regimes, the market for gold and silver have changed dramatically (Hillier et al., 2006). The monetary element of these precious metals has gradually been replaced and their industrial use has been extended. Furthermore, the extensive use of gold as a hedging vehicle has also sparked the utilization of other precious metals as risk management tools and diversifying commodity portfolios (see, e.g., Marshall et al., 2008; Belousova and Dorfleitner, 2012). Since gold has more characteristics in common with other metals, particularly precious ones, than it does with any other commodities, investors may treat metals as a separate asset class (Belousova and Dorfleitner, 2012). This, in turn, would cause gold prices to comove more with metals than other commodities (see Pindyck and Rotember, 1990; Pierdzioch et al., 2013 among others)[2, 3]

Consistent with the comovement evidence, Daskalaki and Skiadopoulos (2011) show that the returns on major precious metals, including gold, silver, platinum and palladium, exhibit low correlations with stock returns. Morales and Andreosso-O'Callaghan (2011) find that the precious metals markets are less affected by the recent global financial crisis than other major financial markets around the world. Erb and Harvey (2006) and Roache and Rossi (2010) also find that gold and silver prices are counter-cyclical, implying that precious metals other than gold may also protect investors' wealth in the events of negative stock market conditions. Furthermore, observed marked data (see Figure 1 and Panel B of Table 2 below) suggests that industrial metals also comove with precious metals. Thus, industrial metals may also serve as a place of safety in the events of negative economic conditions and this leads to the following important questions: (i) to what extent does gold protect investors' wealth against sovereign-debt crisis? (ii) does gold offer a better protection against sovereign-debt crisis than other metals? and (iii) is the protection, if any, offered by gold and other metals against sovereign credit deteriorations short- or long-lived?

While the hedge and safe haven properties of gold have explicitly been examined in the context of both stock and bond markets (Baur and McDermott, 2010; and Baur and

[2] Gold and precious metals can be reused or recycled for new fabrication, which provide an additional source of supply. This is in stark contrast to energy, agricultural and livestock commodities which are spent, consumed, or transformed but are rarely recoverable. Metals also tend to have longer shelf lives and are less susceptible to adverse storage conditions than agricultural commodities. They can also be transported without the need for specialised infrastructure such as in the case of oil or natural resources.

[3] Indeed, our correlation analysis (see Table 2 below) indicates that metals tend to co-move and the comovement is, in some cases, stronger during periods of crisis.

Lucey, 2010), the role of other precious and industrial metals as hedging vehicles and safe haven assets has not yet been explicitly explored. This study investigates the relative abilities of industrial and precious metals to protect investors' losses in the sovereign debt markets. Existing studies tend to focus on assets that provide protection against investors' losses in stock and foreign exchange markets, with government bonds typically seen as relatively safe assets. However, recent evidence suggests that sovereign debt markets, particularly in the Eurozone (except for Germany), have recently become more volatile due to the "flight to safety" syndrome that has gripped financial markets (Schwarz, 2008). Furthermore, the (unreported) finding that the correlation between the conditional volatility of government bonds and that of the world index increases significantly during crisis periods suggests that the extreme movements in sovereign bond markets may be representative of the crisis episodes[4]. Thus, since government bond markets are affected by the economic downturns and since sovereign debt crisis (e.g. the recent European sovereign debt crisis) and government defaults (e.g. Russia in 1998 and Argentina in 2001) are not uncommon, it would be useful for investors to identify asset classes that can protect their wealth against the sudden deterioration in the government bonds.

While metals may not be the only place of safety[5], we choose to focus on safe haven properties of these assets for, at least, two reasons. First, metals are the closest related assets to gold (a traditional "investment of last resort"). Second, metal prices are driven by the global demand as opposed to domestic demand in the case of many domestic bonds and stocks. In some cases, such as the recent European sovereign debt crisis, investors face losses on both (domestic) stocks and bonds and may, therefore, seek refuge from other asset classes.

[4] Further details on these tests are available upon request.

[5] In unreported tests, we show that other commodities, including S&P GSCI agricultural index and S&P GSCI Crude Oil Index and stocks, namely MSCI BRIC Equity Index and MSCI World Equity Index, can also be used as a hedge and safe haven against losses in the sovereign bond market. Further details on these results can be obtained from the authors.

By investigating the role of metals in protecting investors against sovereign debt losses this study makes three important contributions to the literature. First, it provides a detailed analysis on the hedge and safe haven properties of gold and other selected metals against the deteriorations in the credit quality of sovereign bonds. Second, it tests whether the outcome of the hedge and safe haven properties of the metals against sovereign bonds is consistent across different sovereign bonds. Finally, it examines the performance of metals in periods following large negative bond price changes to evaluate the speed at which investors recover losses from extreme negative bond price movements and the profit (or loss) associated with holding different metals in periods of high bond market turmoil.

Our empirical analysis focuses on sovereign bonds in the US, the UK, the EMU and ten Eurozone countries (Austria, Belgium, France, Greece, Germany, Ireland, Italy, Netherlands, Portugal and Spain) and yields the following interesting findings. First, we find that gold serves as a strong hedge only for bonds in Belgium, Greece, Italy, the Netherlands and Portugal and a strong safe haven for bonds in Finland, Spain and the EMU. Second, other precious metals, palladium in particular, outperform gold both as a hedge and safe haven asset and bond investors are even better off holding industrial rather than precious metals in periods of extreme negative shocks. The superiority of industrial metals in protecting investors against losses in the US and European bonds may be attributed to increased demand for these metals from major emerging countries, such as the BRIC, which have not been strongly affected by the recent crisis. Third, we show that gold commoves strongly with both UK and German bonds in periods of high bond market volatility. This evidence is consistent with the "flight to safety" argument, and that investors may view high quality bonds, such as the UK and German bonds, and gold as substitutes in protecting themselves against the downturns in the government bond markets. Finally, we find that copper (palladium) is the best performing industrial (precious) metal in the period immediately after extreme negative bond price changes.

The remainder of the paper is structured as follows. Section 2 provides a brief review of the literature on the role of metals in the financial systems. Section 3 presents a description and summary statistics of our data. Section 4 describes the methodology. Section 5 contains the results of our analysis and Section 6 offers our concluding remarks.

2. A brief review of the related literature

The markets did not expect at the time when Greece had the highest credit rating by top agents that its deep debt problems could trigger the European sovereign-debt crisis. The deterioration of government finance after 2008 led to a sudden loss of confidence in both sovereign debt and equity markets and drove the prices of alternative investments, such as gold and the precious metals to record highs. The impressive performance of metals (especially gold) during the economic downturns, in general, and recent European sovereign-debt, in particular, presents a strong motivation to examine the characteristics of these assets and their role in the global financial system.

A number of other studies, including Jaffe (1989), Chua et al. (1990) and Draper et al. (2006), focus on the role of metals in portfolio diversification. Their general findings suggest that investments in metals and other commodities help to improve the overall performance of stock and bond portfolios. Draper et al. (2006) show that gold, silver and platinum have low correlations with stock index returns. Their evidence implies that these metals may provide diversification within broad investment portfolios. Conover et al. (2009) examines the benefits of adding precious metals (gold, silver and platinum) to U.S. equity portfolios. They evaluate different weights (from 5% to 25%) of these metals in a typical portfolio and find that adding a 25% allocation of precious metals to a portfolio consisting of equities substantially improves the portfolio performance.

The role of precious metals in protecting investors' wealth against negative economic conditions has also been widely investigated. Chow et al. (1999) suggest that commodities, including metals, are more attractive when the general financial climate is negative. Edwards and Caglayan (2001) support this position by demonstrating that commodity funds provide higher returns when stocks perform poorly. This evidence suggests that the inclusion of key commodity contracts should provide a positive contribution to more broad-based financial trading and investments. Erb and Harvey (2006) and Gorton and Rouwenhorst (2006) show that gold and other major precious metals are useful for hedging against inflation. Draper et al. (2006) also show that precious metals have hedging capability and a potential for playing the role of safe havens, particularly during periods of abnormal stock market volatility. Baur (2013) analyzes monthly gold returns over the period 1980-2010 and finds that September and November are the only months with significantly positive gold price changes. He argues that investors seemed to have learned that some of the most extreme periods of financial turmoil occur in September and October (e.g. the stock market crash in October 1987, the Asian financial crisis in October 1997 and the Global Financial Crisis in September and October 2008). This leads to increased purchases of gold during these months to hedge against the potential financial turmoil (see also Bouman and Jacobsen, 2002; Jacobsen and Zhang, 2012)[6].

Erb and Harvey (2006) show that the prices of precious metals and industrial metals react differently to economic shocks. This is because a surprise improvement in economic growth may cause gold and silver prices to drop because of portfolio rebalancing effects, but result in higher industrial metal prices due to greater industrial demand. Roache and Rossi

[6] It is also possible that investors buy gold as an insurance against stock market losses before they are heavily invested in stocks, that is, between November and May establishing the "Halloween effect" or the "sell in May and go away effect".

(2010) suggest that announcements which reflect an unexpected improvement in the economy[7] tend to have a negative impact on gold and silver prices, but a positive effect on copper. This is attributed to the fact that copper and other industrial metals are important input goods in manufacturing and production related industries (about 70% of the demand for copper comes from electrical and construction industries), and a more sanguine economic climate would be indicative of greater demand for this industrial metal. Elder et al. (2012) use intra-day data to examine the intensity, direction and speed of the impact of U.S. macroeconomic news announcement on the return, volatility and trading volume of metal futures. They report that announcements which reflect an unexpected improvement in the economy tend to have a negative impact on gold and silver prices and a positive effect on copper prices. However, observed market data (see Figure 1 below) suggests that both industrial and precious metals enjoy some price appreciation during crisis periods.

While many studies highlight the potential ability of precious metals (gold in particular) to serve as safe haven against losses in financial markets, this claim has rarely been explicitly tested in the literature. In fact, Baur and McDermott (2010) and Baur and Lucey (2010) appear to be the only studies that directly examine the role of gold as a hedge and safe haven against losses in stock and bond markets. Baur and McDermott (2010) find that gold may act as a stabilizing force for the financial system by reducing losses in the face of extreme negative market shocks. They also show that gold is both a hedge and a safe haven for major European markets and the US but not for Australia, Canada, Japan and large emerging markets, such as the BRIC countries. Baur and Lucey (2010) examine the safe haven property in the context of German, UK and US stock and bond markets. They show that gold is a safe haven for stocks, but not bonds. Thus, the ability of gold to serve as a

[7] As conveyed by improvements in real activity (e.g., advance retail sales), consumption (e.g., new home sales) and investment (e.g., durable goods orders).

hedging and/or a safe haven asset may vary significantly across different markets and asset classes.

3. Data and descriptive statistics

The data sample covers the period from July 1993 to June 2012. Our analysis focuses on this period due to lack of data for some industrial metals before July 1993. Daily data on the closing US dollar prices are collected for each industrial and precious metal. The precious metals used in this study are Gold, Silver, Platinum and Palladium. The industrial metals group consists of Aluminium, Copper, Lead, Nickel, Tin and Zinc. We also collect daily data for the US dollar to pound exchange rate and US dollar to euro exchange rate. We then calculate the closing prices of the metals in pounds and euros using the dollar prices of the metals and the foreign exchange rates. This is done to ensure that the return on metals and the return on bonds in the subsequent analysis are denominated in the same currency.[8]

Figure 1 reports the daily movements of metal prices over the entire sample period. It shows that gold price has exhibited a phenomenal increase during the financial crisis. Its price increased from $634.5 per oz in January 2007 to $942.9 in July 2008. The largest drop in gold price was observed in the period between August and December 2008. Gold price reached its peak of almost $1,800 per oz in 2011. Similar price patterns are also observed in the case of other precious metals. Silver price, for example, increased from $11.24 per oz in the beginning of 2007 to $15.37 per oz in January 2008. Similar to the case of gold, silver value declined sharply between September and December 2008. The behaviour of industrial metals during the crisis is not very much different from that of the precious ones. For instance, the price of Copper rose from $6380 in January 2007 to $6641 in January 2008 and its value began to decline in the second half of 2008. Copper price started to rise again in

[8] For example, when examining the hedge properties of metals against bonds denominated in euros, we use the euro prices to calculate the return on the metals.

beginning of 2009 and reached its peak of around $10000 in 2011. Overall, Figure 1 suggests that metal prices tend to move together over time. Specifically, it shows that metal prices were generally stable prior to June 2005. It also shows that all metal prices increased dramatically during the period 2005-2007; declined sharply in 2007; pick up again in July 2008 and started to decline in February 2011. This finding implies that bond market investors may find metals other than gold as useful hedging instruments in periods of high financial and economic uncertainty.

Please Insert Figure 1 About Here

Closing return index values for 5-year, 10-year and 30-year benchmark bonds for the US, the UK, the EMU benchmark and ten euro-zone countries with the relevant data are collected. The euro-zone countries in our sample are Austria, Belgium, Finland, France, Germany, Greece, Italy, Netherlands, Portugal and Spain. The return index on the benchmark bonds are denominated in the local currency. All the data (dollar closing prices of metals, foreign exchange rate and the return index on benchmark bonds) are obtained from the DataStream database. Benchmark bond data for Greece is only available for 10-year maturities and Finland and Portugal did not have data for the 30-year bond. As a result, we present results mainly for the 10-year bonds but we obtain similar results for the other maturities[9]. The EMU benchmark data starts from January 1999.

Table 1 reports the descriptive statistics of the return distributions of bonds, metals and the world index. Whilst bonds and metals exhibit similar average returns, the returns on bonds is relatively more stable than those on metals. Gold is the most stable metal with returns ranging from a minimum of -0.0714 to a maximum of 0.0003 and a standard deviation of 0.0104. With the exception of Greece, bonds exhibit lower risk (standard deviation) and less extreme values than gold and other metals. The data also illustrates that

[9] More details on the results of the 5- and 30-year bonds are available upon request.

the return on the world index is more stable than the returns on metals, but more volatile than the returns on bonds.

Table 2 also presents the correlations between various metals in different states of the economy. Specifically, it reports both the average correlations and the correlations during crisis periods, which are defined as the three calendar months following each of the Asian crisis (October 22, 1997) and the global finance crisis (September 10, 2008)[10]. Several interesting observations can be made from the correlation results. First, consistent with the comovement view, metal prices are all positively correlated. Second, precious metals tend to co-move more amongst themselves than with industrial metals, and vice versa. Third, the comovement between metals is stronger during episodes of crisis. Specifically, we find that, except for Zinc, the correlations between individual metals and the Industrial Metals Index (IMD) increase during the crisis periods. With the exception of Zinc and Lead, the correlations between industrial metals and the Precious Metal Index (PMD) also increase during the times of crisis. Finally, we find that individual precious metals co-move more with PMDX (the portfolio of all precious metals excluding the individual precious metal in the correlation, but less with IMD (except for palladium), during the crisis periods. The increased commovement between metals during episodes of crisis indicates that gold may not be the only place of safety and other metals may protect investors' wealth in the economic downturn.

Please Insert Tables 1 and 2 About Here

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[10] These dates are also used by Baur and McDermott (2010) in their definition of the pick of the Asian and the global financial crisis.

4. Methodology

There is already strong evidence that gold protects investors' wealth during times of uncertainty and instability (Wallace and Choudhry, 1995; Davidson et al., 2003; Bordo and MacDonald, 2003; Baur and Lucey, 2010 and Baur, 2013). However, this study addresses a different question, namely do other precious and industrial metals offer similar, or even better, investment opportunities in periods of crisis? To assess the hedge and safe haven properties of industrial and precious metals against sovereign debt, we use a methodology similar to that of Baur and McDermott (2010). Eqs(1a), (1b) and (1c) present the principal regression model used to analyse the role of precious and industrial metals as hedge and/or safe haven investment assets for sovereign bonds. We assume that changes in the precious or industrial metals prices are dependent on changes in the bond market. Further, we speculate that extreme market conditions affect the balance of the relationship.

Let $R_{M,t}$ denote the local currency return on the respective metal and $R_{Bond,t}$ be the local currency return on the benchmark bond index. Then, as in Baur and McDermott (2010), we model the return generating process of the metals as:

$$R_{M,t} = \alpha + \beta_t R_{Bond,t} + e_t \tag{1a}$$

$$\beta_t = \delta_0 + \delta_1 D1 + \delta_2 D5 + \delta_3 D10 \tag{1b}$$

$$\sigma_t^2 = \omega + \theta e_{t-1}^2 + \vartheta \sigma_{t-1}^2 \tag{1c}$$

where $D1$, *D5* and *D10* are dummy variables, which are used to capture extreme bond market movements, with values of one if the bond return on day *t* falls in the lower 1^{st}, 5^{th} and 10^{th} percentile, respectively, and zero otherwise. The error term, e_t, assumed to follow a GARCH (1, 1) process with a time varying variance, σ_t^2. The GARCH (1, 1) process is used to control for heteroscedasticity in the data, which is common in daily financial data[11]. The coefficients δ_i (for i = 0, 1, 2, 3) measure the hedge and safe haven properties of the metal under consideration. Specifically, a significantly negative estimate for δ_0 would suggest that the metal is a strong hedge against the sovereign bond. If δ_0 is not statistically different from zero, then the metal is considered as weak hedge. However, a metal is not a hedge if δ_0 is positive and statistically significant. Nonlinearities in the hedge property are captured through the parameters δ_1, δ_2 or δ_3. If one of the parameters δ_1, δ_2 or δ_3 is significantly different from zero, this will indicate a non-linear relationship between the metal and the sovereign bond. For a metal to be considered a safe haven, it must offer protection against extreme adverse market conditions in the sovereign bond market. In other words, a metal would only be viewed as a safe haven in given threshold of extreme shocks when the sum of the relevant exposure coefficients δi ($SH_1 = \sum_{i=0}^{1} \delta i$ in the case of negative returns in the lower 1st percentile, $SH_2 = \sum_{i=0}^{2} \delta i$ for the negative returns in the lower 5th percentile and $SH_3 = \sum_{i=0}^{3} \delta i$ for the negative returns in lower 10th percentile) is significantly negative (strong safe haven) or not statistically different from zero (weak safe haven). A metal is not a safe haven if the sum of the exposure coefficients is positive and statistically significant. Thus, we focus on the statistical significance of the sum of the estimates, rather than simply the sum of the estimates, as in Baur and McDermott (2010). We take this approach to control for disparities in estimation precision due to differences in the residual variances across the various types of bonds. It should be noted that the coefficient estimates from models with high residual variances suffer from a lack of precision. Such coefficient estimates could be spurious or simply due to chance, regardless of the size and/or direction of the estimates. For these reasons, we focus on the relationships that are statistically significant.

[11] Note that Eqs(1a), (1b) and (1c) are estimated using weekly and monthly data. Despite some quantitative differences, our final conclusions do not seem to depend on the return frequencies used in the analysis. More details on these results are available upon request.

5. Empirical results

In this section, we present the empirical results on the hedge and/or safe haven properties of precious and industrial metals against the sovereign debt price movements using both individual and portfolio approach. We also use sub-period analysis to test whether the role of metals varies across market conditions. Finally, we assess the speed at which investors recover losses from the sharp decline in bond prices and the profit (or loss) associated with holding metals jointly with sovereign bonds in the periods of crisis.

5.1. Individual precious metals

Table 3 presents the estimation results for the models in Eqs(1a), (1b) and (1c) with individual precious metals as the dependent variables in Eq(1a). The results indicate that the values and the statistical significance of the hedging coefficients δ_0 vary considerably across bonds and precious metals. The hedging parameters δ_0 indicate that gold is a strong hedge for bonds in Belgium, Greece, Italy, the Netherlands and Portugal and a weak hedge for the rest of sovereign bonds. The statistical significance of the estimates δ_1, δ_2 and δ_3 in Eq(1b) implies the presence of non-linear relationship between gold and bond returns in many cases, particularly for extreme negative shocks in the lower 10th and 5th percentiles[12].

The results in Table 3 indicate that the safe haven property of gold, which implies that investors that hold gold receive compensation for losses caused by extreme negative bond returns through positive gold returns, seems to depend largely on the magnitude of the negative shock in the bond prices. For this, we use Wald test to investigate the statistical significance of the parameters SH_1, SH_2 and SH_3. For extreme negative bond returns in the lower 1st percentile, gold is not a safe haven for Germany and the EMU benchmark bonds as SH_1 is significantly positive in these two cases, but gold appears to be a weak safe haven for

[12] The parameters δ_1, δ_2 and δ_3 in Eq(1b) are not report in the Table to save space. More detailed on the non-linear relationship between bonds and metals are available from the authors.

the remaining sovereign bonds. The parameters $SH_2$and SH_3 suggest that gold is mainly a weak safe haven against negative shocks in the lower 5th and 10th percentiles. It only serves as a strong safe haven for bonds in Austria, Belgium, France, Germany and the Netherlands for extreme negative returns in the lower 5th percentile and for the bond in Portugal for negative shocks in the lower 10th percentile.

The sign of the coefficients δ_0 in Table 3 suggests that bond returns are negatively related with silver returns on average, and silver is, therefore, a hedge for all sovereign bonds. However, the statistical significance of these coefficients implies that the hedging ability of silver is strong only for bonds in Austria, Belgium, Germany, Italy, the Netherlands and Portugal. Our findings also suggest that the non-linear relationship is less (more) pronounced in the case of silver rather than of the gold for extreme shocks in the 10th and 5th (1st) percentile. The sums of the relevant exposure coefficients δ_i (SH_1, SH_2 and SH_3) imply that silver is, at best, a weak safe haven for the sovereign bonds except those of France and the Netherlands.

Similar evidence is also reported in the case of platinum and palladium. Specifically, the parameters δ_0 in Table 3 indicate that platinum serves as a hedge for all the sovereign bonds except Greece. The hedging ability of platinum is strong in the cases of bonds in Austria, Belgium, Finland, France, Germany and the UK and weak for the remaining bonds. Our findings also suggest that the relationship between platinum and sovereign bonds is mainly linear and non-linearity is only detected in Portuguese bonds for extreme shocks in the lower 1st percentile. Palladium also hedges against all bonds except Greece, with hedging performance being strong for Austria, Germany, the EMU benchmark and UK bonds. The non-linear relationship between palladium and bond returns is detected in many markets and is more pronounced for extreme shocks in the lower 10th percentile. Platinum is at least a weak safe haven asset for all sovereign bonds, except Greece. The relevant coefficient estimates (SH_1, SH_2 and SH_3) suggest that the safe haven hypothesis in the case of palladium is supported in all markets, except Finland and Portugal in the case of extreme negative returns in the lower 5th percentile.

Our evidence so far suggests that gold can be used as a hedging vehicle or a safe haven varies in certain sovereign bond markets. More specifically, we find that gold provides a stronger hedge against weaker bonds, such as Greece, Italy and Portugal, than stronger ones, including Germany, UK and the US. For extreme negative bond returns in the lower 1st percentile, gold exhibits a significant positive association with German bonds, implying that investors view stronger bonds and gold as substitutes in their flight to safety. The finding aligns with Beber et al.'s (2009) argument, which suggests that investors tend to rebalance their portfolios towards less risky and more liquid securities in times of economic distress. It is also consistent with Schwarz (2008), who explains the increases in the spreads of sovereign debt within the Eurozone (excluding German government bonds) by the sudden decline in the government bond market liquidity due to the flight to safety syndrome that has gripped the financial markets in recent crisis. Unreported analysis however suggests that while some high quality sovereign bonds, UK and US bonds in particular, exhibit some negative comovement with Greek bonds, gold and other metals provide far much better protection against losses in the sovereign bond markets[13]. Our analysis also implies that gold is not the only place for safety or refuge and in many cases other precious metals could offer similar, if not better, protection in the events of negative economic conditions. The strong correlation between gold and other precious metals in times of economic distress is consistent with the widely held view that investors treat gold and other precious metals as a similar investment class (see, e.g. Erb and Harvey, 2006; Daskalaki and Skiadopoulos, 2011; Elder et al., 2012; among others).

[13] The details of the results are available upon request.

Please Insert Table 3 About Here

5.2. Individual industrial metals

Table 4 reports the estimation results for Eqs(1a), (1b) and (1c) for individual metals as the dependent variable in Eq(1a). We find that industrial metals offer a much stronger hedge against adverse movements in sovereign debt prices than gold or any other precious metal. The coefficient δ_0 is negative for all sovereign bonds and industrial metals used in the analysis. The magnitude of δ_0 is much larger and more significant for the industrial metals than the precious metals, indicating that investors receive better compensation for adverse bond price movements when holding the former than the latter. With the exception of the UK bonds in the case of aluminium and Greek bonds in cases of lead, nickel and zinc, the parameter δ_0 is negative and statistically significant, implying that industrial metals offer a strong hedge against the adverse movements in the sovereign bond prices.

Please Insert Table 4 About Here

In unreported tests, we find that the coefficients δ_i (for i = 1, 2, 3) are significant in many cases, indicating the presence of non-linear relationship between industrial metals and bond returns. The results of the Wald test on SH_1, SH_2 and SH_3 in Table 4 suggest that the safe haven property of industrial metal tends to be stronger than that of precious metals. Apart from Greece and Portugal in the case of Aluminium and Copper, and Finland, Portugal and Spain in the case of Nickel, industrial metals offer at least a weak safe haven to the sovereign bonds.

Overall, industrial metals seem to outperform precious metals as hedging vehicles and safe haven assets against losses in the sovereign debt markets. The ability of industrial metals in protecting investors against losses in the US and European bonds may be attributed to increased demand for these metals from major emerging countries, including the BRIC, which have not been less strongly affected by the recent crisis.

5.3. The portfolio approach

Table 5 shows the estimates of Eqs(1a), (1b) and (1c) using equally weighted portfolios of precious metals, industrial metals and all metals as the dependent variable in Eq(1a), respectively. The purpose of this analysis is to investigate whether investors gain better protection against the adverse movements in the sovereign bonds by holding portfolios rather than individual metals. The coefficient δ_0 in Table 5 implies that the hedging power of the metal portfolio varies considerably across bonds. Specifically, the portfolio of precious metals serves as a strong hedge for bonds in Austria, Belgium, France, Italy, Portugal, the EMU and the UK and a weak hedge for the remaining bonds. However, the values of δ_0 associated with industrial metals and all metals portfolios are negative and statistically significant, with the portfolio of industrial metals containing the largest (negative) and highest significant hedging coefficients, δ_0. This result implies that the portfolio of industrial metals outperforms both the portfolio of precious metals and that of all metals in its hedging ability against adverse movements in sovereign bonds. However, some individual industrial metals, such as copper, seem to provide a stronger hedge against all bonds than any of the three portfolios.

Please Insert Table 5 About Here

The parameters SH_1, SH_2 and SH_3 in Table 5 suggests that the portfolio of precious metals serves a strong safe haven only for Italian bonds for shocks in the lower 1th and 10th percentiles. The portfolio of industrial metals serves as strong safe haven for bonds in Germany, the Netherland and the EMU in the case of negative shocks in the lower 1st percentile and for bonds in the Netherlands, the UK and the US for negative bond returns in the lower 10th percentile. The safe haven property of the portfolio of all metals is shown to be strong only for bonds in the Netherlands and the US for negative bond returns in the lower 5th and 10th percentiles, respectively. These findings, therefore, suggest that industrial metals offer a better protection against the deterioration of the sovereign debt quality than the precious metals.

6.4. Sub-period analysis

To gain a further insight on whether metals protect investors' wealth against the stormy weather, we divide our sample period into three sub-periods, July 1993 to December 2000, January 2001 to December 2006 and January 2007 to June 2012. The last sub-period includes the global financial crisis, which originated as the subprime crisis in 2007 and peaked in September 2008, and the on-going European debt crisis.

Table 6 presents the estimates of Eqs.(1a), (1b) and (1c) for individual precious metals for the three sub-periods. To save space, Table 6 only reports the hedge parameter δ_0 and one safe haven measure, SH_1.[14] The exposure estimates δ_0 suggest that the hedging power of precious metals is tend to vary considerably over time. The results in Panel A of Table 6 suggest that gold and silver serve as a strong hedge in more markets in the period 1993-2000 than the other two sub-periods. In the period 2001-2006 (see Panel B), the statistical significance of the hedging coefficients disappears almost completely in the cases of gold, silver and platinum, suggesting that these instruments offer only a weak hedge against the adverse movements in the sovereign bond prices. During the same period, palladium serves as a weak hedge for only the US sovereign bond, but does not compensate investors for the adverse bond price movements in other markets. In the period 2007-2012 (see Panel C), gold offers a strong hedge for bonds in Greece, Italy, Portugal and Spain, a

[14] Detailed results on Eqs(1a), (1b) and (1c) estimates for individual and portfolio of metals are available upon request.

weak hedge for bonds in Austria, Belgium, France, the UK and the US and a no hedge for bonds in Finland, Germany and the EMU. The significantly positive comovement between gold and the German bond could also suggest that investors viewed the two assets as substitutes in their flight to safety following the euro debt crises. This evidence is consistent with Beber et al. (2009) finding that, in times of economic distress, investors rebalance their portfolios towards less risky and more liquid securities.

Silver's hedging coefficients are mainly negative, but not statistically different from zero, indicating that this metal serves as a weak hedge against losses in the sovereign bond markets. Platinum exhibits significantly positive comovements with bonds in Greece and Spain, but hedges against losses in the rest of the markets (the hedge is strong in Finland, Germany, Netherland, the EMU and the UK, but weak in Austria, Belgium, Italy and the US). Palladium serves as a hedge in all markets, with the hedge being strong in 8 out of the 13 bonds included in the analysis. Thus, palladium outperforms other precious metals as a hedge against the deterioration in the credit quality of sovereign bonds in the period 2007-2012.

Please Insert Table 6 About Here

The results in Table 6 also suggest that the safe haven properties of the precious metals vary over time. In the period 1993-2001 (see Panel A), the safe haven test indicates that gold is largely a weak safe haven in all markets except Greece. In the period 2001-2006 (see Panel B), gold is a strong safe haven for bonds in Finland, France, Germany, Greece, Netherlands, Portugal and the EMU benchmark bond for negative shocks in the lower 5^{th} percentile. Besides gold, palladium also offered some safe haven protection for some bonds during the period. These include Germany, Greece, the UK and the US. Silver and platinum are at best weak safe havens during this period as the safe haven tests are largely not significantly different from zero. In the period 2007-2012 (see Panel C), gold offers a safe haven against Italian and Portuguese bonds. However, we also find a strong comovement between gold and UK, German and the EMU benchmark bonds, suggesting that gold is not a safe haven for these bonds. The a strong comovement between gold and the UK and German bonds is also consistent with the "flight to safety" argument, which would indicate that investors may view high quality bonds, such as the UK and German bonds, and gold as substitutes in protecting themselves against lower quality bonds. Palladium also serves as a strong safe haven against extreme negative shocks in six out of the 13 bonds. For shocks in the lower 1st percentile, palladium offers a safe haven for the bonds in Finland, Germany, Italy, Netherlands, Portugal and the EMU benchmark bond and a weak safe haven for the rest of the sovereign bonds. Thus, in this particular period palladium offers greater protection in more markets than the other precious metals.

Table 7 reports the results of the sub-period analysis for the industrial metals. Again for the sake of brevity, only δ_0 and SH_1 are reported and the rest of the results are available upon request. The results in Table 7 suggest that the time variation in the hedging power is less pronounced for industrial than precious metals. The hedging parameters δ_0 suggest that industrial metals serve at least as a weak hedge. Our results also suggest that copper is the strongest hedging assets and investors are more likely to be protected from losses in the bond markets by holding industrial rather than precious metals. In the period 1993-2000 (see Panel A), industrial metals mainly serve as a weak safe haven against different categories of extreme negative bond returns. However, as shown in panel B, the sums of the relevant exposure coefficients are significantly negative almost across all the bonds for shocks in the lower 10th percentile, during the period 2001-2006. This finding suggests that industrial metals serve as a strong safe haven against extreme bond price fluctuations during this period. In the period 2007-2012 (see panel C), the statistical significance of the safe haven parameters associated with the industrial metals disappears in most cases. However, some industrial metals, particularly copper and lead, still serve as a strong safe haven in more cases than gold. Overall, the safe haven properties of some lesser known metals, such as palladium, copper and lead are much better than those of the popular metals such as gold, silver and aluminium.

Please Insert Table 7 About Here

We also conduct sub-period analysis for the various portfolios of metals. While the details are not reported to save space, the results suggest that as portfolios, industrial metals serve as a stronger hedge for more markets than precious metals. The portfolio of industrial metals is a strong safe haven in all the markets except the US in the period 2001-06 but largely a weak safe haven in the later period 2007-12. On the other hand, we find that safe haven property of precious metals is weak in both periods. Thus, in general, the portfolio of industrial metals provides a better protection for investors' losses in the sovereign bond market, particularly in periods of high bond market turmoil, than the portfolio of precious metals.

Insert Table 7 about here

6.5. The post-shock performance

The dummy coefficients in Eq(1b) focus on the correlation between bonds and metals on the day of the shock and does not tell us anything about the post-shock performance of these assets. This section analyses the average cumulative returns of portfolios comprising of individual sovereign bonds and the individual metals over a period of 20 trading days (approximately one calendar month) following extreme negative bond returns. The analysis sheds some light on the speed at which investors recover losses from declining bond prices and the profit (or loss) associated with holding metals along with sovereign bonds in the crisis periods.

To save space, we only report the average cumulative returns of the equally weighted portfolios of the bonds with the various metals following extreme negative bond returns in the lower 5th percentile, and for the cases of the EMU benchmark, the UK and the US bonds[15]. Figure 2 shows the average cumulative returns of portfolios consisting of individual sovereign bonds and metals. It shows that palladium consistently outperforms gold and other precious metals in its ability to compensate investors for losses in the sovereign bond markets. Investors who hold gold, silver, platinum and palladium, respectively, with the EMU sovereign bonds enjoy their first positive returns of 0.09%, 0.1%, 0.05% and 0.03% in about 15, 13, 13 and 9 days following extreme negative shocks in the lower 5th percentile. Similar findings are evident when individual precious metals are held with the UK or the US sovereign bonds. Specifically, while the returns associated with a portfolio of palladium and UK sovereign bond begin to turn positive 8 days after extreme shocks, the portfolio that includes silver turns positive after 19 days. The other two portfolios comprising the UK sovereign bond and gold or silver remain negative throughout the post-shock period covered in the analysis. Figure 2 also shows that investors in the US sovereign bonds recover their losses from extreme negative price movements more quickly by holding palladium than any other precious metals. In short, our results palladium (gold) offers investors the highest (lowest) compensation for their losses in the sovereign bond market.

Please Insert Figures 2, 3 and 4 About Here

Figure 3 presents the average cumulative returns of portfolios consisting of individual bonds and industrial metals over a period of 20 trading days subsequent to extreme negative bond returns in the lower 5th percentile. The figure shows that copper generates higher post-shock returns than any other industrial metals. It also shows investors recover their bond

[15] Despite some quantitative differences, our conclusions remain largely valid for other sovereign bonds and negative shocks in the lower 10th and 1st percentiles. The details of this further analysis are available upon request.

market losses more quickly by holding copper with their sovereign bonds. The result in Figures 2 and 3 also implies that copper is the best metal to be held in conjunction with the US sovereign bond, as it copper generates higher post-shock returns than palladium, the best performing precious metal. Figure 4 implies that metals seem to offer better protection against the adverse movements in the bond prices when held individually than as a portfolio. It also shows that the portfolio of precious metals outperform (underperform) that of industrial metals after extreme negative shocks in the EMU and the UK (the US) sovereign bonds.

Overall, this analysis suggests that i) metals offer a better protection against the negative movements in the sovereign bond market when held individually than as portfolios; ii) all precious metals and many industrial metals outperform gold in protecting investors against losses in the sovereign debt market; and iii) copper is the best performing metal in the period immediately after negative bond price shocks.

6. Conclusion

This study provides new evidence on the role of precious and industrial metals as hedging vehicles and safe haven assets. Consistent existing evidence, we also find evidence that metal prices tend to co-move (see, e.g. Pindyck and Rotember, (1990) and Pierdzioch et al. (2013)). In particular we document that gold is a strong hedge for sovereign bonds of countries with serious debt issues (i.e. Greece, Italy and Portugal). The safe haven property of gold depends on the magnitude of the extreme negative bond price movement. More importantly, we show gold is not the useful metal for seeking safety in turbulent times. It is therefore worthwhile for individual and financial institutions to consider investing in other precious and industrial metals in the event of negative economic conditions. This translates that industrial metals offer a stronger hedge against the adverse movements in sovereign debt prices than gold or any other precious metal. The outperformance of industrial metals as risk management vehicles in the government bond markets is attributed to their increasing global demand as they are seen as key indicators of the health of the global economy.

Furthermore, this study shows that a portfolio of industrial metals outperforms a portfolio of precious metals and that of all other metals in as a hedging instrument against the adverse movement in sovereign bonds. In terms of sub-period analysis, there is strong evidence that industrial metals provide a better compensation for investor losses particularly in periods of high bond market turmoil. Palladium, copper and lead serve as a strong safe haven as they are able to hedge against the deterioration in the credit quality during the recent financial crises.

In response to the issues raised in the introduction, the findings of this paper imply four major findings. Firstly, gold is a good investment opportunity during financial crises periods, but other precious and even industrial metals constitute better investment alternatives. Secondly, investors are better off holding industrial rather than precious metals in the periods of stormy weather. Thirdly, all metals have the ability to protect investors' wealth against sovereign crises. Finally, as the hedge and safe haven properties of gold and other metals vary across bonds, a tactical allocation strategy that manages the bond-metal composition may be necessary to protect investors' wealth against extreme losses in the government bond markets.

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Table 1: Description of the sample

This table presents descriptive statistics of the returns on the bond indices, precious metals, industrial metals and the FTSE World Stock Index. The returns on the metals and the FTSE World Index are in US dollars but the returns on the bonds are in local currency.

	Minimum	Median	Mean	Maximum	Standard Deviation	No. of Observations
Austria	-0.0234	0.0002	0.0003	0.0177	0.0033	4788
Belgium	-0.0261	0.0003	0.0003	0.0333	0.0036	4788
Finland	-0.0429	0.0003	0.0003	0.0285	0.0036	4788
France	-0.0200	0.0003	0.0003	0.0231	0.0037	4788
Germany	-0.0248	0.0004	0.0003	0.0224	0.0035	4788
Greece	-0.1727	0.0002	-0.0003	0.2885	0.0118	3342
Italy	-0.0360	0.0003	0.0003	0.0581	0.0045	4788
Netherlands	-0.0174	0.0003	0.0003	0.0186	0.0033	4788
Portugal	-0.1139	0.0003	0.0002	0.1125	0.0062	4769
Spain	-0.0257	0.0003	0.0003	0.0642	0.0041	4788
EMU	-0.0149	0.0003	0.0002	0.0224	0.0035	3404
UK	-0.0227	0.0003	0.0003	0.0243	0.0041	4788
US	-0.0283	0.0002	0.0003	0.0405	0.0048	4788
Gold$	-0.0714	0.0002	0.0003	0.0738	0.0104	4788
Silver$	-0.1869	0.0000	0.0004	0.1828	0.0206	4788
Platinum$	-0.1554	0.0000	0.0003	0.1393	0.0144	4788
Palladium$	-0.1786	0.0000	0.0003	0.1584	0.0220	4788
Aluminium$	-0.1268	0.0000	0.0001	0.1171	0.0122	4788
Copper$	-0.1048	0.0003	0.0003	0.1173	0.0174	4788
Lead$	-0.1320	0.0005	0.0003	0.1301	0.0206	4788
Nickel$	-0.1836	-0.0003	0.0003	0.1331	0.0231	4777
Zinc$	-0.1262	0.0002	0.0001	0.0961	0.0184	4783
Tin$	-0.1145	0.0000	0.0003	0.1539	0.0165	4778
FTSE World $	-0.0732	0.0008	0.0002	0.0904	0.0101	4664

Table 2: Correlations between metals

This table reports the correlation between metals over the sample period and during crisis periods only. Crisis period is defined as three months following the Asian financial crisis in October 1997 and the Global Financial Crisis in September 2008. PMD (IMD) represents portfolio of all precious (industrial) metals, PMDX (IMDX) represents portfolio of all precious (industrial) metals excluding the metal in that column.

Panel A: Precious Metals – Full sample period

	Gold	*Silver*	*Platinum*	*Palladium*	*PMD*	*IMD*
Gold	1.000					
Silver	0.437	1.000				
Platinum	0.287	0.451	1.000			
Palladium	0.300	0.383	0.428	1.000		
PMDX	0.441	0.541	0.528	0.480	NA	
IMD	0.286	0.199	0.115	0.232	0.277	1.000

Panel B: Precious Metals – Crisis period only

	Gold	*Silver*	*Platinum*	*Palladium*	*PMD*	*IMD*
Gold	1.000					
Silver	0.477	1.000				
Platinum	0.274	0.537	1.000			
Palladium	0.316	0.330	0.507	1.000		
PMDX	0.451	0.562	0.608	0.485	NA	
IMD	0.227	0.068	0.091	0.431	0.276	1.000

Panel C: Industrial Metals – Full sample period

	Alum	*Copper*	*Lead*	*Nickel*	*Zinc*	*Tin*	*PMD*	*IMD*
Alum	1.000							
Copper	0.527	1.000						
Lead	0.407	0.569	1.000					
Nickel	0.389	0.564	0.477	1.000				
Zinc	0.471	0.661	0.622	0.531	1.000			
Tin	0.352	0.475	0.431	0.433	0.443	1.000		
IMDX	0.543	0.741	0.656	0.622	0.725	0.546		
PMD	0.199	0.232	0.224	0.175	0.219	0.226	1.000	
IMD	0.643	0.829	0.786	0.778	0.822	0.678	0.277	1.000

Panel D: Industrial Metals – Crisis period only

	Alum	*Copper*	*Lead*	*Nickel*	*Zinc*	*Tin*	*PMD*	*IMD*
Alum	1.000							
Copper	0.642	1.000						
Lead	0.609	0.712	1.000					
Nickel	0.488	0.731	0.654	1.000				
Zinc	0.426	0.672	0.573	0.596	1.000			
Tin	0.470	0.589	0.475	0.579	0.421	1.000		
IMDX	0.640	0.846	0.745	0.768	0.664	0.610		
PMD	0.225	0.245	0.211	0.205	0.141	0.320	1.000	
IMD	0.709	0.902	0.840	0.859	0.771	0.733	0.276	1.000

Table 3: Hedge and safe haven characteristics of precious metals – Full sample period

This table reports estimation results for the models in Eqs(1a), (1b) and (1c) for the full sample period, with individual precious metals as the dependent variables in Eq(1a). SH1 tests the hypothesis $\delta_0 + \delta_1 = 0$, SH2 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 = 0$, SH3 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 + \delta_3 = 0$. The asterisks ***, **, * represent significance of the estimates at the 1%, 5% and 10% level, respectively.

	Gold				Silver			
Bond	δ_0	**SH1**	**SH2**	**SH3**	δ_0	**SH1**	**SH2**	**SH3**
Austria	0.008	0.201	-1.860***	0.057	-0.207**	0.389	0.342	0.061
Belgium	-0.107***	-0.026	-1.929***	-0.052	-0.194**	0.182	0.346	0.077
Finland	0.013	0.252	0.223	0.062	-0.070	0.386	0.336	-0.072
France	-0.055	-0.148	-1.909***	-0.126	-0.117	0.175	0.579**	0.058
Germany	0.019	0.203*	-1.630***	0.062	-0.239***	-0.124	-0.072	-0.167
Greece	-0.068***	-0.005	-0.135	-0.011	0.001	0.006	0.087	0.005
Italy	-0.141***	-0.143	-0.190	-0.093	-0.233***	-0.360**	-0.279	-0.263**
Netherlands	-0.118***	0.043	-1.987***	0.077	-0.110	0.546*	0.228	0.110
Portugal	-0.073***	-0.149*	0.025	-0.095***	-0.130***	-0.106	0.175	-0.058
Spain	-0.045	0.100	-0.011	-0.059	-0.058	-0.050	0.333	-0.059
EMU	0.110	0.446**	0.143	0.133	-0.122	0.446	0.186	0.075
UK	-0.025	0.105	-0.013	0.070	-0.131*	0.359	0.258	0.154
US	-0.026	0.061	0.090	0.054	-0.008	0.163	0.045	0.014

	Platinum				Palladium			
Bond	δ_0	**SH1**	**SH2**	**SH3**	δ_0	**SH1**	**SH2**	**SH3**
Austria	-0.116*	0.086	0.343	0.089	-0.155*	0.092	0.140	-0.365**
Belgium	-0.098*	0.133	-0.115	0.110	-0.049	-0.173	0.029	-0.367**
Finland	-0.106**	0.128	-0.115	-0.001	-0.123	-0.094	0.736**	-0.211
France	-0.116**	0.028	-0.059	0.061	-0.055	-0.356	0.035	-0.496***
Germany	-0.173***	-0.005	-0.159	-0.023	-0.279***	-0.215	0.089	-0.398**
Greece	0.063*	0.030	0.011	0.076**	0.094*	-0.045	0.120	0.032
Italy	-0.073*	-0.135	-0.131	-0.119	-0.006	-0.048	0.183	-0.194
Netherlands	-0.079	0.089	-0.138	-0.038	-0.137	-0.453*	-0.660**	-0.817***
Portugal	-0.043	-0.238***	-0.107	-0.084*	0.028	0.087	0.516**	-0.003
Spain	0.027	-0.011	0.100	-0.061	-0.006	-0.446**	0.269	-0.178
EMU	-0.104	0.261	0.023	0.122	-0.323***	0.330	0.426	0.016
UK	-0.113**	-0.056	-0.112	-0.034	-0.173**	-0.031	-0.391	-0.29
US	-0.017	-0.090	-0.146	-0.081	-0.079	0.268	-0.365	-0.178

Table 4: Hedge and safe haven characteristics of industrial metals – Full sample period

This table reports estimation results for the models in Eqs(1a), (1b) and (1c) for the full sample period, with individual industrial metals as the dependent variables in Eq(1a). SH1 tests the hypothesis $\delta_0 + \delta_1 = 0$, SH2 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 = 0$, SH3 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 + \delta_3 = 0$. The asterisks ***, **, * represent significance of the estimates at the 1%, 5% and 10% level, respectively.

	Aluminium				**Copper**			
Bond	δ_0	**SH1**	**SH2**	**SH3**	δ_0	**SH1**	**SH2**	**SH3**
Austria	-0.460***	-0.246	-0.110	-0.124	-0.771***	-0.286	0.283	-0.028
Belgium	-0.387***	-0.180	0.028	-0.037	-0.602***	-0.268	-0.022	-0.088
Finland	-0.357***	-0.022	0.079	0.070	-0.680***	-0.091	0.297	0.187
France	-0.263***	0.030	0.039	-0.127	-0.586***	-0.370	-0.189	-0.178
Germany	-0.435***	-0.219	-0.088	-0.094	-0.872***	-0.772***	-0.074	-0.204
Greece	-0.072***	-0.035	0.387***	0.027	-0.069***	-0.138*	0.383**	0.047
Italy	-0.207***	-0.039	-0.173	0.059	-0.396***	-0.109	0.081	0.207*
Netherlands	-0.367***	-0.216	-0.392*	-0.269**	-0.828***	-0.574**	-0.548*	-0.327
Portugal	-0.129***	0.075	0.365**	0.007	-0.168***	0.032	0.324*	0.014
Spain	-0.237***	0.148	0.244	0.056	-0.405***	-0.021	0.393	0.051
EMU	-0.474***	-0.085	0.238	-0.085	-1.092***	-1.036***	-0.336	-0.574***
UK	-0.080	-0.139	0.131	-0.173*	-0.421***	-0.115	0.307	0.019
US	-0.169***	-0.120	-0.121	-0.172**	-0.392***	-0.139	-0.290	-0.267**

	Lead				**Nickel**			
Bond	δ_0	**SH1**	**SH2**	**SH3**	δ_0	**SH1**	**SH2**	**SH3**
Austria	-0.680***	-0.108	0.161	0.131	-0.821***	-0.049	0.148	0.225
Belgium	-0.522***	-0.104	0.293	0.215	-0.502***	0.050	0.248	0.188
Finland	-0.701***	-0.198	-0.105	0.204	-0.597***	0.344	0.300	0.374**
France	-0.492***	-0.187	0.183	0.041	-0.538***	-0.239	-0.481	-0.155
Germany	-0.763***	-0.467	0.074	0.008	-0.820***	-0.415	0.140	0.101
Greece	-0.056	-0.028	0.182	0.040	-0.028	0.124	0.296	0.076
Italy	-0.348***	0.017	-0.204	0.157	-0.298***	-0.047	0.019	0.160
Netherlands	-0.824***	-0.494*	-0.343	-0.082	-0.738***	-0.357	-0.747*	-0.305
Portugal	-0.199***	-0.033	0.278	0.019	-0.138**	0.129	0.517**	0.090
Spain	-0.433***	0.034	0.298	0.211	-0.295***	0.127	1.107***	0.245
EMU	-0.979***	-0.739**	-0.214	-0.259	-0.988***	-0.723	-0.474	-0.597
UK	-0.335***	-0.439*	0.026	-0.226	-0.246**	-0.236	0.004	-0.245
US	-0.372***	-0.451**	-0.436**	-0.327**	-0.347***	-0.350*	-0.569**	-0.591***

Table 4: Hedge and safe haven characteristics of industrial metals – Full sample period (cont'd)

This table reports estimation results for the models in Eqs(1a), (1b) and (1c) for the full sample period, with individual industrial metals as the dependent variables in Eq(1a). SH1 tests the hypothesis $\delta_0 + \delta_1 = 0$, SH2 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 = 0$, SH3 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 + \delta_3 = 0$. The asterisks ***, **, * represent significance of the estimates at the 1%, 5% and 10% level, respectively.

	Tin				Zinc			
Bond	δ_0	**SH1**	**SH2**	**SH3**	δ_0	**SH1**	**SH2**	**SH3**
Austria	-0.607***	-0.206	0.190	0.244	-0.599***	0.245	0.217	0.259*
Belgium	-0.483***	-0.537**	-0.067	-0.054	-0.419***	-0.234	0.096	0.065
Finland	-0.501***	-0.159	0.027	0.205	-0.494***	0.083	0.463*	0.323**
France	-0.366***	-0.007	-0.283	0.042	-0.391***	-0.002	-0.082	0.076
Germany	-0.626***	-0.398*	-0.057	0.085	-0.664***	-0.143	0.096	0.164
Greece	-0.067*	-0.045	0.198	0.014	-0.043	0.028	0.280	0.016
Italy	-0.294***	-0.149	-0.175	0.162	-0.261***	-0.110	0.188	0.227**
Netherlands	-0.458***	-0.408*	-0.224	-0.259	-0.571***	-0.058	-0.125	0.005
Portugal	-0.168***	-0.247*	-0.068	-0.047	-0.159***	-0.188	0.378**	0.046
Spain	-0.349***	-0.010	0.338	0.175	-0.294***	0.153	0.544**	0.217
EMU	-0.849***	-0.821**	-0.444	-0.310	-0.943***	-0.587*	-0.413	-0.382*
UK	-0.111*	-0.253	0.044	-0.218	-0.250***	-0.220	0.370*	-0.110
US	-0.133***	-0.075	0.079	-0.216**	-0.320***	-0.234	-0.360**	-0.270***

Table 5: Hedge and safe haven characteristics of portfolio of metals

This table reports results for the models in Eqs(1a), (1b) and (1c) for the full sample period, with portfolios of metals as the dependent variables in Eq(1a). SH1 tests the hypothesis $\delta_0 + \delta_1 = 0$, SH2 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 = 0$, SH3 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 + \delta_3 = 0$. The asterisks ***, **, * represent significance of the estimates at the 1%, 5% and 10% level, respectively.

	Portfolio of Industrial Metals				Portfolio of Precious Metals			
Bond	δ_0	**SH1**	**SH2**	**SH3**	δ_0	**SH1**	**SH2**	**SH3**
Austria	-0.660***	-0.086	0.174	0.125	-0.127**	0.235	0.273	0.021
Belgium	-0.477***	-0.197	0.150	0.030	-0.112**	0.026	0.040	-0.034
Finland	-0.575***	-0.007	0.179	0.213**	-0.050	0.216	0.243	-0.054
France	-0.428***	-0.129	-0.046	-0.073	-0.083*	-0.090	0.057	-0.130
Germany	-0.709***	-0.413**	0.055	0.020	-0.160***	-0.032	-0.010	-0.113
Greece	-0.054*	-0.029	0.262*	0.039	0.020	0.008	0.041	0.023
Italy	-0.291***	-0.043	-0.020	0.164	-0.110***	-0.201*	-0.209	-0.177**
Netherlands	-0.639***	-0.397**	-0.380	-0.244*	-0.077	0.137	-0.141	-0.096
Portugal	-0.151***	-0.016	0.321**	0.027	-0.070**	-0.103	0.078	-0.040
Spain	-0.328***	0.135	0.537***	0.182	-0.018	-0.114	0.166	-0.083
EMU	-0.879***	-0.678***	-0.259	-0.355*	-0.106*	0.356	0.189	0.118
UK	-0.244***	-0.235	0.131	-0.159	-0.092*	0.080	-0.051	-0.024
US	-0.266***	-0.159	-0.179	-0.264***	0.021	0.061	-0.078	-0.077

	Portfolio of Industrial and Precious Metals			
Bond	δ_0	**SH1**	**SH2**	**SH3**
Austria	-0.463***	0.045	0.195	0.115
Belgium	-0.360***	-0.099	0.071	0.038
Finland	-0.363***	0.085	0.254	0.129
France	-0.291***	-0.086	0.017	-0.052
Germany	-0.491***	-0.162	0.090	0.049
Greece	-0.038*	-0.037	0.196*	0.024
Italy	-0.218***	-0.090	-0.033	0.053
Netherlands	-0.429***	-0.216	-0.322*	-0.162
Portugal	-0.140***	-0.078	0.231**	0.008
Spain	-0.224***	0.070	0.406***	0.131
EMU	-0.581***	-0.247	-0.061	-0.167
UK	-0.184***	-0.089	0.048	-0.082
US	-0.159***	-0.095	-0.094	-0.182***

Table 6: Hedge and safe haven characteristics of precious metals – sub period analysis

This table reports estimation results for the models in Eqs(1a), (1b) and (1c) for the three sub-periods, with individual precious metals as the dependent variables in Eq(1a). SH1 tests the hypothesis $\delta_0 + \delta_1 = 0$, SH2 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 = 0$, SH3 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 + \delta_3 = 0$. Panel A presents results for the period July 1993 to December 2000, Panel B presents results for the period January 2001 to December 2006 and Panel C presents results for the period January 2007 to June 2012. The asterisks ***, **, * represent significance of the estimates at the 1%, 5% and 10% level, respectively.

Panel A: July 1993 to December 2000

	Gold		Silver		Platinum		Palladium	
Bond	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**
Austria	-0.096*	-0.053	-0.542***	-0.377	-0.197**	-0.084	-0.198	0.027
Belgium	-0.122**	0.015	-0.476***	0.204	-0.198**	0.14	-0.148	0.085
Finland	-0.090**	0.007	-0.134	-0.056	-0.058	0.173	-0.073	-0.198
France	-0.111**	-0.102	-0.203*	0.305	-0.112*	-0.078	-0.038	-0.015
Germany	-0.109**	0.1	-0.604***	-0.486	-0.206**	0.195	-0.185	-0.154
Greece	-0.439	0.838	-0.799***	-0.911	0.099	1.361	0.306	1.893**
Italy	-0.093**	-0.071	-0.395***	-0.357	-0.145***	-0.065	-0.117	-0.106
Netherlands	-0.165***	-0.003	-0.257*	0.533	-0.017	0.127	-0.057	-0.11
Portugal	-0.082*	-0.181	-0.375***	-0.397	-0.106	-0.308	-0.148	-0.174
Spain	0.055	0.075	-0.151	-0.547*	0.01	-0.122	-0.203*	-0.701***
EMU	-0.988***	-0.193	-0.998***	-0.332	-0.258	0.863	-0.127	0.838
UK	-0.045	-0.172	-0.236**	0.018	-0.087	-0.029	-0.056	-0.039
US	-0.083**	0.038	-0.049	-0.106	0.005	-0.015	-0.004	0.092

Panel B: January 2001 to December 2006

	Gold		Silver		Platinum		Palladium	
Bond	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**
Austria	-0.134	0.004	0.015	0.691	0.067	0.084	0.641***	0.792
Belgium	-0.004	0.309	0.032	0.53	0.023	-0.04	0.637***	0.953
Finland	-0.15	0.168	0.025	0.829*	0.049	0.003	0.734***	0.69
France	-0.026	0.145	0.04	0.718	0.021	-0.171	0.674***	0.424
Germany	-0.17	0.58	0.006	0.496	0.006	-0.167	0.586***	0.102
Greece	-0.067	0.194	0.019	0.887*	0.036	0.085	0.698***	1.05
Italy	0.211	0.606	-0.124	0.187	0.119	-0.202	0.742***	0.905
Netherlands	-0.005	0.326	0.016	0.676	0.008	-0.093	0.631***	1.264*
Portugal	0.047	0.179	-0.023	0.612	0.038	-0.092	0.774***	1.876**
Spain	-0.017	0.204	-0.009	0.541	0.04	-0.235	0.607***	0.505
EMU	-0.019	0.134	0.02	0.528	0.007	-0.114	0.595***	0.188
UK	0.004	0.067	0.077	0.04	-0.02	-0.845*	0.358*	0.289
US	0.148**	0.136	0.076	0.375	-0.04	0.045	0.208	-0.257

Table 6 cont'd

Panel C: January 2007 to June 2012

	Gold		Silver		Platinum		Palladium	
Bond	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**
Austria	0.099	0.192	-0.064	1.431**	-0.179	0.524	-0.711***	0.562
Belgium	-0.106	-0.32	-0.136	-0.367	0.066	0.409	-0.164	0.484
Finland	0.255**	-0.162	-0.173	-0.881	-0.327***	-0.136	-1.021***	-1.991**
France	0.072	0.14	-0.194	0.374	-0.222*	0.124	-0.661***	-0.853
Germany	0.294***	0.820**	-0.18	0.55	-0.358***	-0.713	-1.088***	-1.899***
Greece	-0.030**	0.126**	0.014	0.137	0.072**	0.114	0.056	-0.067
Italy	-0.129**	-0.602***	-0.054	-0.68	0.096	-0.36	-0.052	-0.838*
Netherlands	0.252**	0.169	-0.061	0.275	-0.272**	0.269	-0.908***	-1.698***
Portugal	-0.073**	-0.276***	-0.071	-0.207	-0.027	-0.307**	-0.02	-0.396*
Spain	-0.106*	0.175	-0.005	-0.012	0.158*	0.258	-0.071	-0.371
EMU	0.294***	0.819**	-0.178	0.551	-0.357***	-0.712	-1.086***	-1.899***
UK	0.108	1.207***	-0.119	1.799**	-0.209**	-0.296	-0.838***	-0.496
US	-0.018	0.094	-0.155	-0.744	-0.064	-0.403	-0.445***	-0.041

Table 7: Hedge and safe haven characteristics of industrial metals – sub-period analysis

This table reports estimation results for the models in Eqs(1a), (1b) and (1c) for the three sub-periods, with individual industrial metals as the dependent variables in Eq(1a). SH1 tests the hypothesis $\delta_0 + \delta_1 = 0$, SH2 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 = 0$, SH3 tests the hypothesis $\delta_0 + \delta_1 + \delta_2 + \delta_3 = 0$. Panel A presents results for the period July 1993 to December 2000, Panel B presents results for the period January 2001 to December 2006 and Panel C presents results for the period January 2007 to June 2012. The asterisks ***, **, * represent significance of the estimates at the 1%, 5% and 10% level, respectively.

Panel A: July 1993 to December 2000

	Aluminium		Copper		Lead		Nickel		Tin		Zinc	
Bond	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**
Austria	-0.48***	-0.88***	-0.55***	-0.35	-0.45***	-0.09	-0.59***	-0.24	-0.36***	-0.61**	-0.45***	0.11
Belgium	-0.31***	-0.46*	-0.41***	-0.19	-0.27*	0.14	-0.24	0.08	-0.25**	-0.59**	-0.24*	-0.02
Finland	-0.18**	-0.53***	-0.28***	-0.13	-0.27**	-0.23	-0.26*	-0.00	-0.19**	-0.35	-0.18*	-0.40
France	-0.14*	-0.29	-0.32***	-0.51	-0.28**	-0.43	-0.17	-0.72*	-0.04	-0.21	-0.16	-0.04
Germany	-0.43***	-0.49**	-0.56***	-0.30	-0.36***	0.32	-0.43***	-0.03	-0.39***	-0.15	-0.38***	0.16
Greece	-0.35	0.01	-0.45**	-0.63	-0.39	-0.40	-0.34	-0.30	-0.19	0.40	-0.46	0.28
Italy	-0.11	-0.26	-0.18*	-0.07	-0.17	-0.17	-0.09	-0.15	-0.01	-0.06	-0.03	-0.09
Netherlands	-0.18*	-0.48*	-0.43***	-0.48	-0.52***	-0.37	-0.35**	-0.41	-0.05	-0.47	-0.26*	-0.10
Portugal	-0.04	-0.11	-0.11	0.03	-0.27***	-0.29	0.03	0.12	-0.13	-0.52**	-0.09	-0.30
Spain	-0.20**	0.07	-0.23**	0.26	-0.28**	0.30	-0.08	0.32	-0.15*	0.09	-0.08	0.37
EMU	-0.73***	-0.09	-0.82***	-1.25	-0.40*	0.55	-0.68**	-0.28	-0.49***	0.21	-0.61***	-0.20
UK	-0.03	-0.14	-0.13	-0.19	-0.06	-0.31	0.05	-0.26	0.13*	-0.50**	-0.07	-0.28
US	-0.15**	0.06	-0.17*	-0.22	-0.15	-0.04	-0.17	-0.14	-0.01	-0.14	-0.14*	-0.16

Table 7 cont'd.

Panel B: January 2001 to December 2006

	Aluminium		Copper		Lead		Nickel		Tin		Zinc	
Bond	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**
Austria	-0.70***	-0.45	-1.04***	-0.76	-0.80***	-0.55	-0.74***	-0.33	-1.01***	-0.72	-0.94***	-0.61
Belgium	-0.71***	-0.34	-1.06***	-0.88*	-0.88***	-0.74	-0.79***	-0.85	-0.99***	-0.90*	-0.96***	-0.78*
Finland	-0.72***	-0.24	-1.08***	-0.46	-0.86***	-0.66	-0.73***	-0.14	-1.00***	-0.41	-0.94***	-0.39
France	-0.68***	-0.24	-1.01***	-0.37	-0.86***	-0.40	-0.70***	0.10	-0.85***	-0.13	-0.89***	-0.30
Germany	-0.71***	-0.15	-0.99***	-0.58	-0.83***	-0.38	-0.78***	-0.11	-0.91***	-0.42	-0.91***	-0.33
Greece	-0.76***	-0.40	-1.08***	-0.41	-0.86***	-0.64	-0.80***	-0.11	-0.93***	-0.33	-0.96***	-0.39
Italy	-0.73***	-0.59*	-1.19***	-0.70	-0.87***	-0.60	-0.85***	-0.57	-1.04***	-0.87	-1.06***	-0.57
Netherlands	-0.68***	0.10	-0.99***	-0.36	-0.76***	-0.31	-0.70***	0.01	-0.90***	-0.28	-0.87***	-0.27
Portugal	-0.74***	0.05	-1.02***	-0.71	-0.88***	-0.39	-0.67**	-0.50	-0.93***	-0.39	-0.91***	-0.61
Spain	-0.72***	-0.17	-1.13***	-0.62	-0.95***	-0.46	-0.81***	0.12	-0.96***	-0.16	-0.95***	-0.42
EMU	-0.70***	-0.21	-0.99***	-0.57	-0.83***	-0.34	-0.77***	-0.14	-0.90***	-0.48	-0.90***	-0.30
UK	-0.29***	-0.16	-0.62***	-0.70	-0.59***	-0.61	-0.28	-0.59	-0.39***	-0.61	-0.45***	-0.12
US	-0.03	0.19	-0.30***	0.23	-0.22*	-0.20	-0.09	-0.39	-0.01	0.30	-0.29***	-0.14

Panel C: January 2007 to June 2012

	Aluminium		Copper		Lead		Nickel		Tin		Zinc	
Bond	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**	δ_0	**SH1**
Austria	-0.18*	0.28	-0.88***	-0.62	-1.10***	-0.35	-1.15***	-0.65	-0.77***	0.30	-0.66***	0.47
Belgium	-0.17*	0.01	-0.46***	-0.58	-0.60***	-0.42	-0.70***	-0.78	-0.50***	-1.46***	-0.21	-0.11
Finland	-0.25**	0.60	-1.15***	-1.13*	-1.48***	-1.71*	-1.25***	-0.68	-0.94***	-1.47*	-1.02***	-0.44
France	-0.11	0.59	-0.70***	-0.03	-0.82***	0.67	-1.02***	-0.51	-0.74***	0.14	-0.55***	0.63
Germany	-0.20**	0.01	-1.19***	-1.89***	-1.59***	-2.98***	-1.25***	-2.46**	-0.95***	-1.65**	-1.11***	-1.69**
Greece	-0.02	0.01	-0.01	-0.04	-0.01	-0.05	0.03	0.05	-0.01	-0.06	0.03	0.02
Italy	-0.07	-0.08	-0.25***	-0.72*	-0.24***	-0.39	-0.35***	-0.47	-0.39***	-0.65	-0.26***	-0.67
Netherlands	-0.18*	1.41***	-1.15***	-0.85	-1.55***	-1.34	-1.24***	-1.46	-0.84***	-1.12	-0.95***	-0.02
Portugal	-0.05	-0.01	-0.06	-0.06	-0.09	0.00	-0.13*	-0.08	-0.05	-0.04	-0.08	-0.02
Spain	-0.06	-0.01	-0.29***	-0.37	-0.38***	0.28	-0.38***	-0.16	-0.41***	-0.69	-0.29***	0.14
EMU	-0.20**	0.01	-1.19***	-1.89***	-1.59***	-2.97***	-1.26***	-2.46**	-0.94***	-1.65**	-1.11***	-1.68**
UK	-0.04	-0.23	-0.80***	-0.68	-0.99***	-0.15	-0.89***	-0.21	-0.54***	0.18	-0.71***	0.27
US	-0.45***	-0.30	-1.00.***	-0.74**	-1.17***	-1.02**	-1.02***	-0.54	-0.84***	-0.00	-1.07***	-0.34

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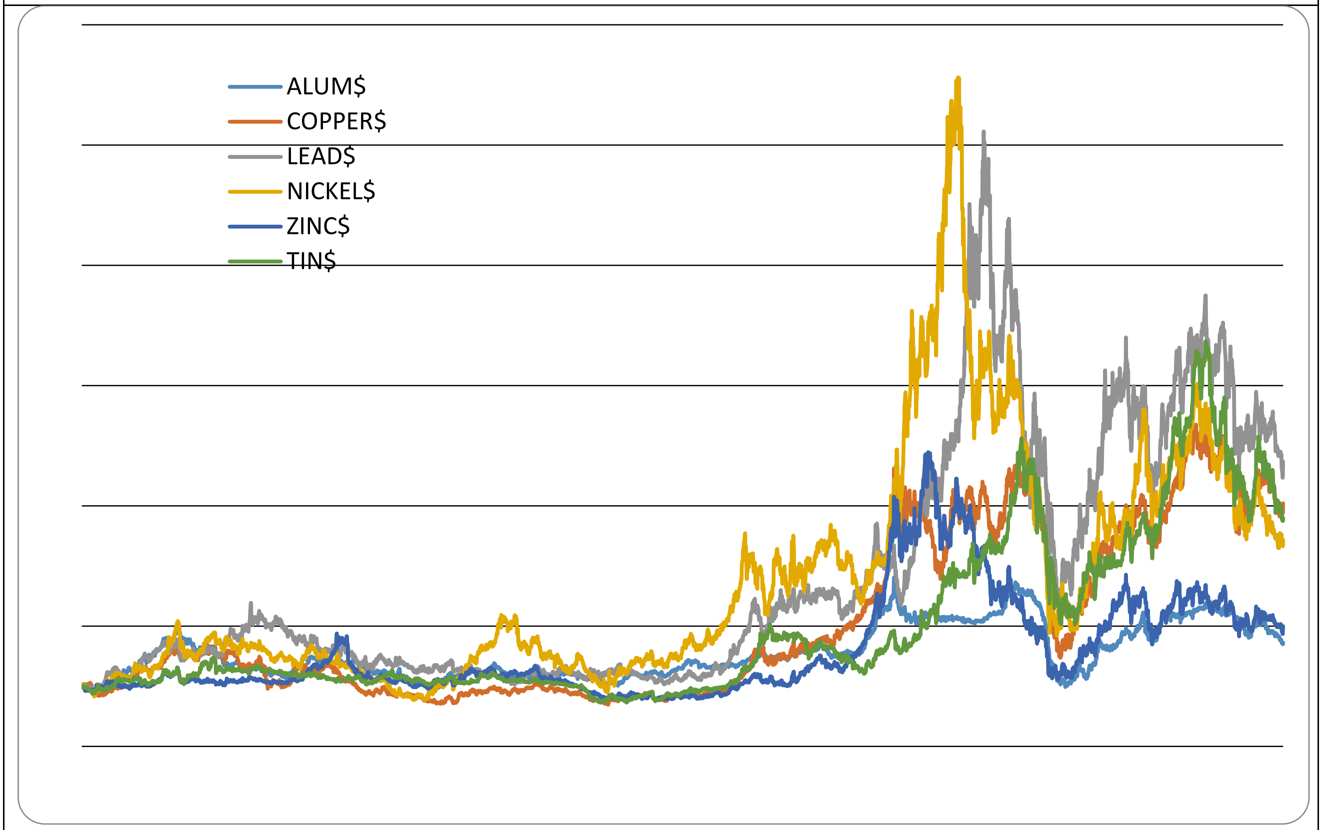
Figure 1: Dollar price indices of industrial and precious metals - July 1993 t0 June 2012 (July 1993 = 100).

Panel A: Dollar Price Indices of the Six Industrial Metals – July 1993 to June 2012



Panel B: Dollar Price Indices of the Four Precious Metals – July 1993 to June 2012

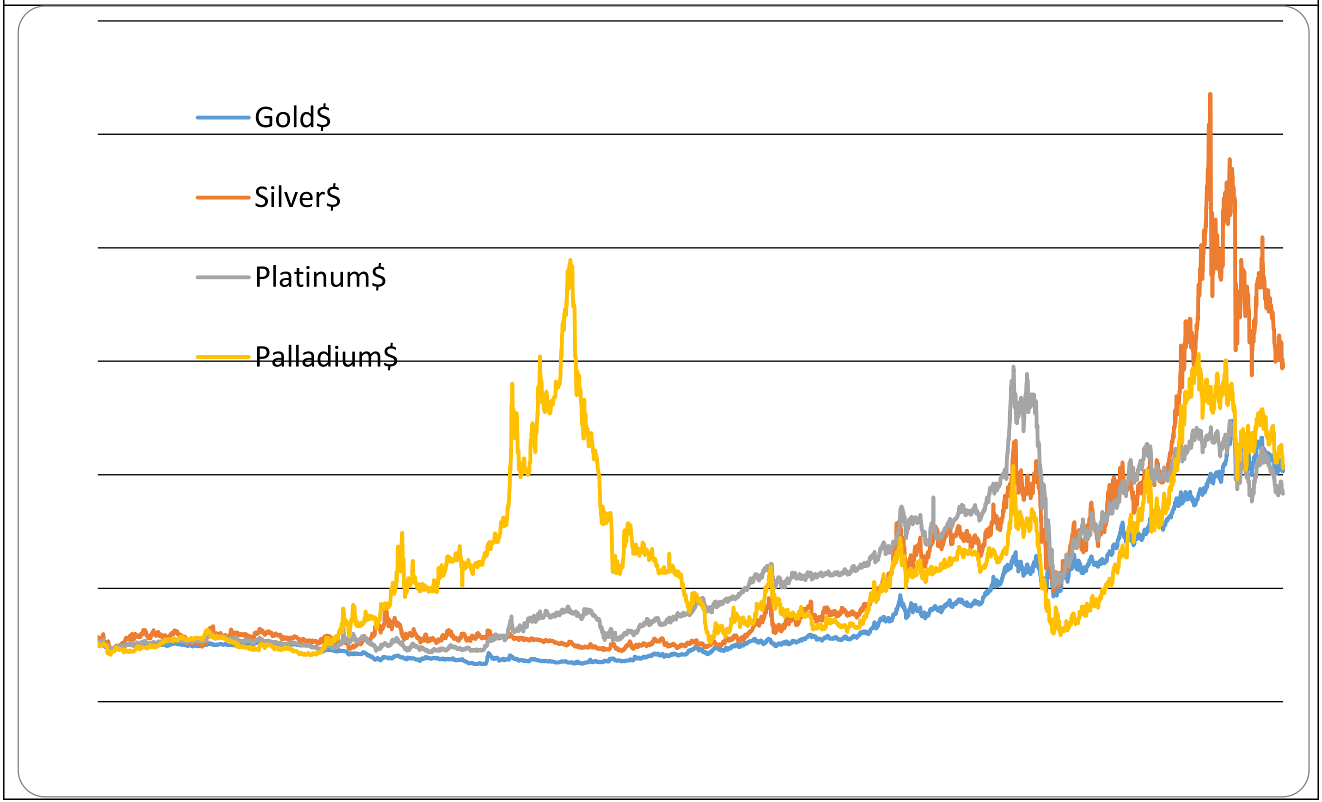
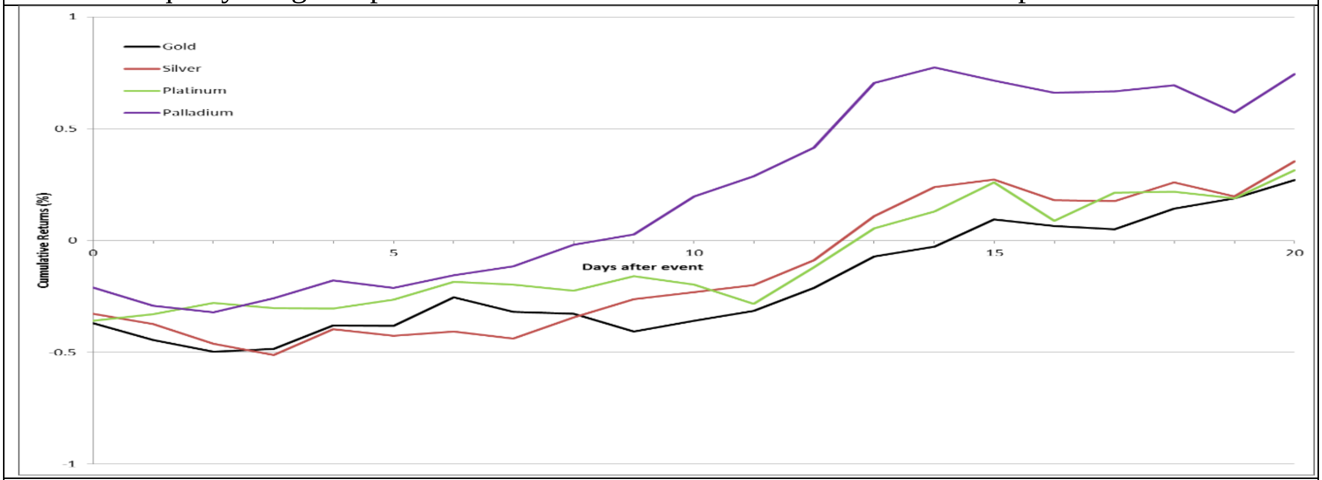
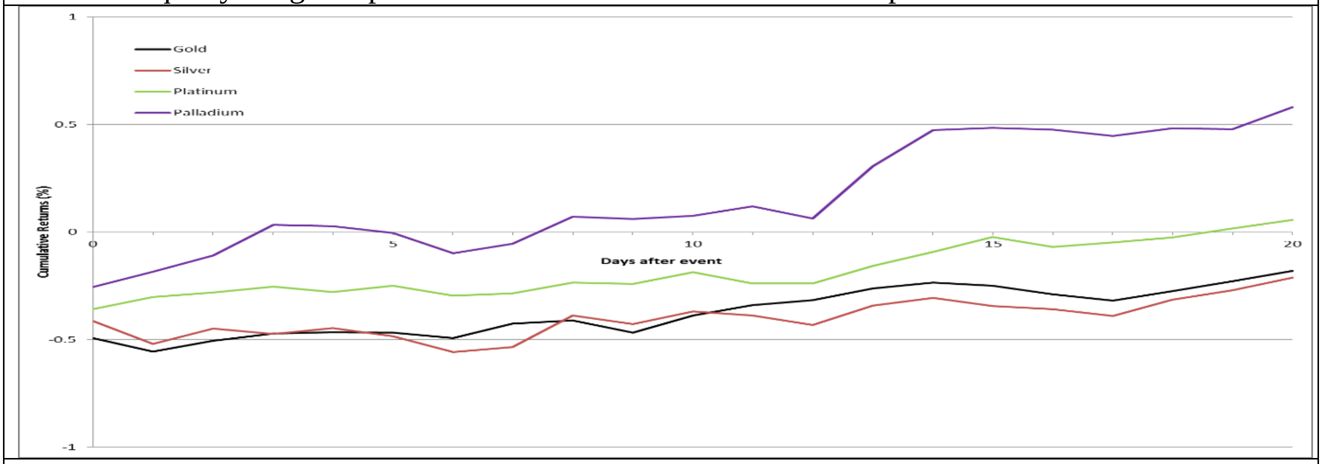


Figure 2: Post-shock performance of equally weighted portfolios consisting of the bond and dedicated precious metals

Panel A: Equally weighted portfolio of EMU benchmark bond and individual precious metals



Panel B: Equally weighted portfolio of the UK bond and individual precious metals



Panel C: Equally weighted portfolio of the US bond and individual precious metals

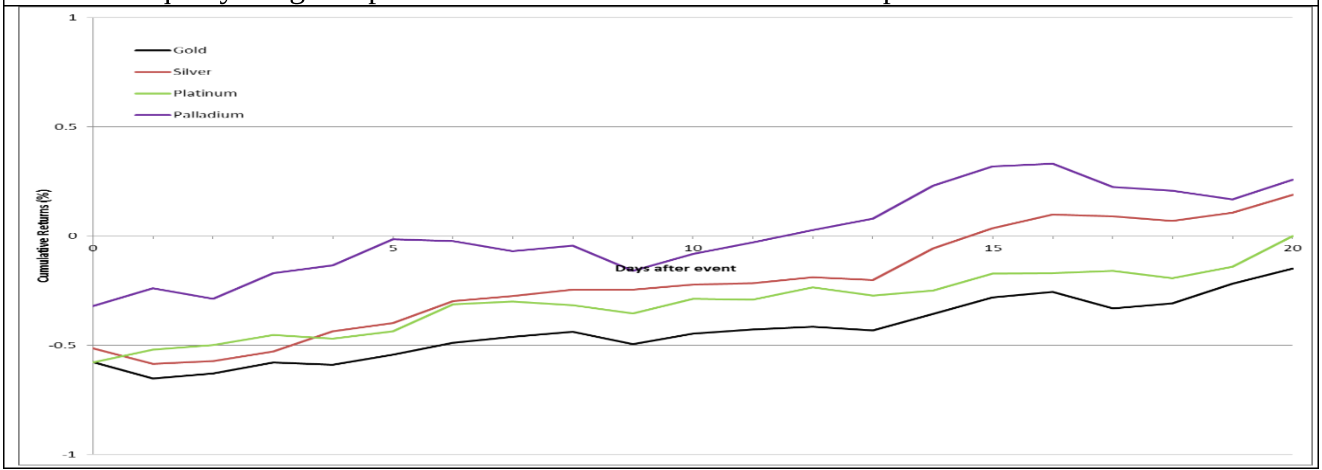
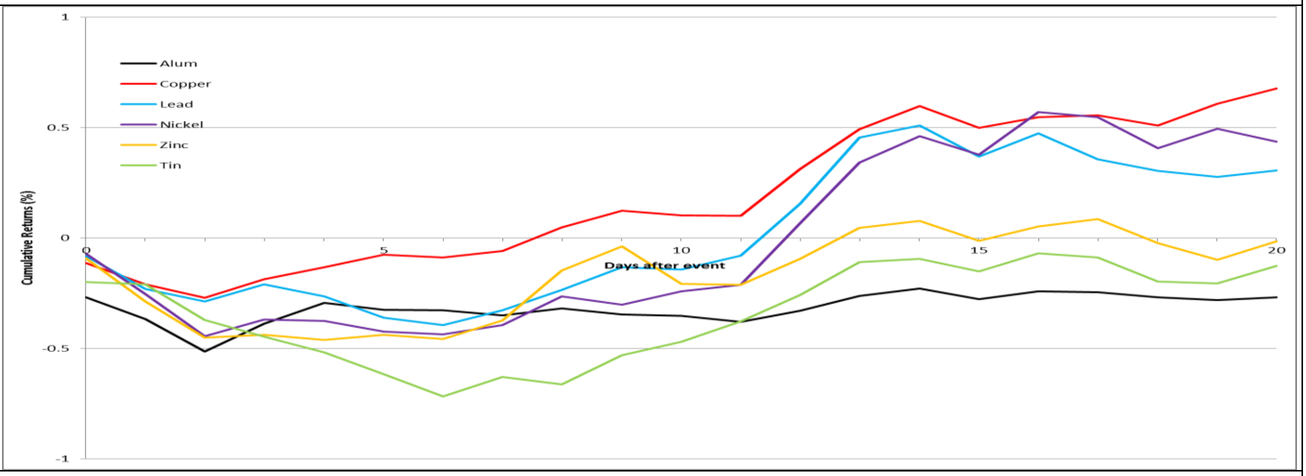
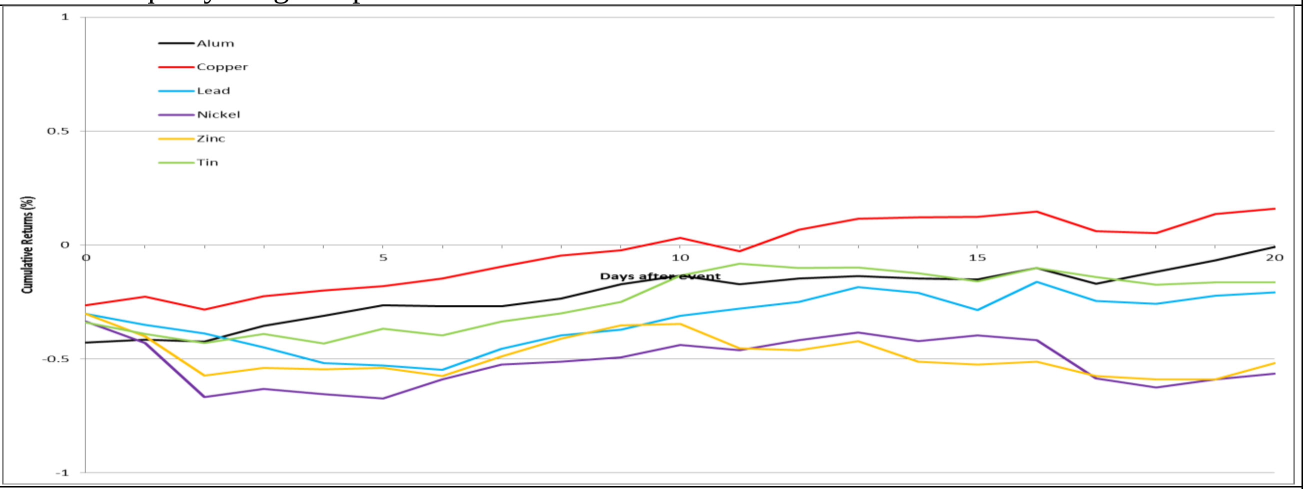


Figure 3: Post-shock performance of equally weighted portfolios consisting of the bond and dedicated industrial metals

Panel A: Equally weighted portfolio of the EMU benchmark bond and individual industrial metals



Panel B: Equally weighted portfolio of the UK bond and individual industrial metals



Panel C: Equally weighted portfolio of the US bond and individual industrial metals

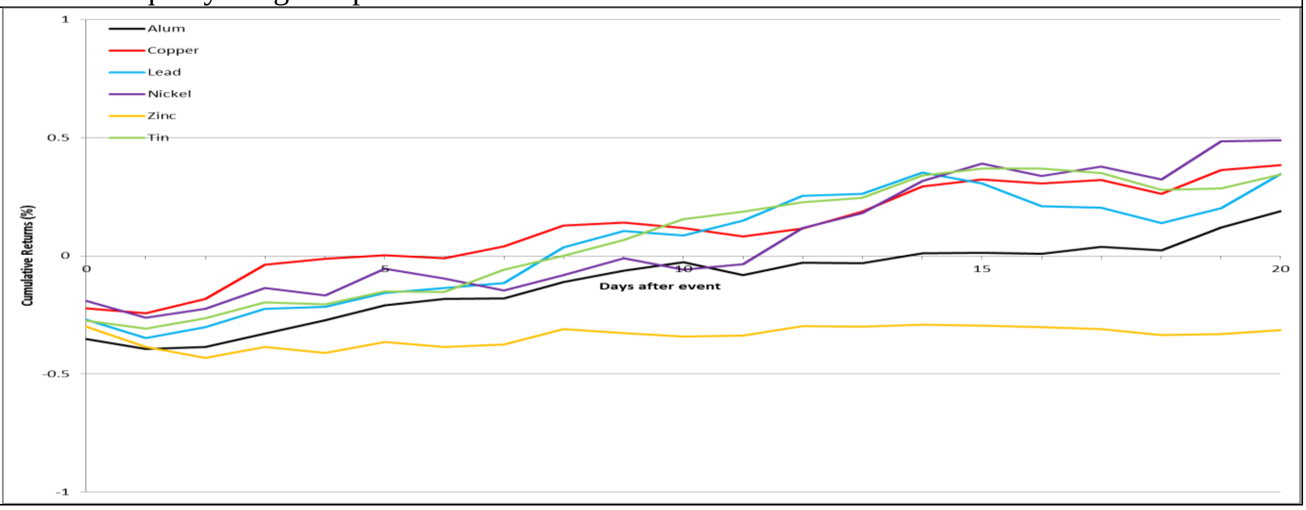
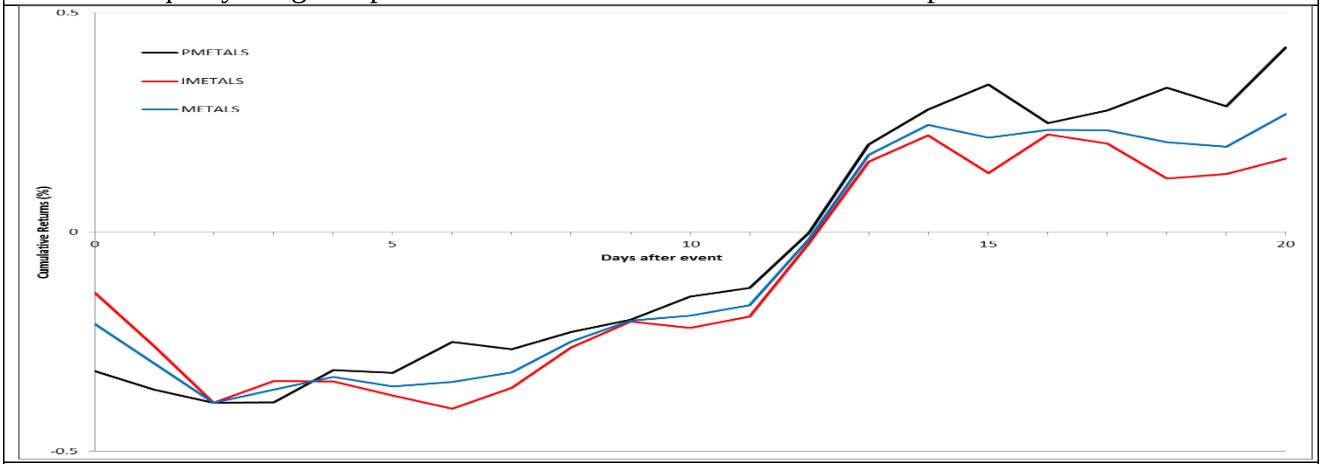
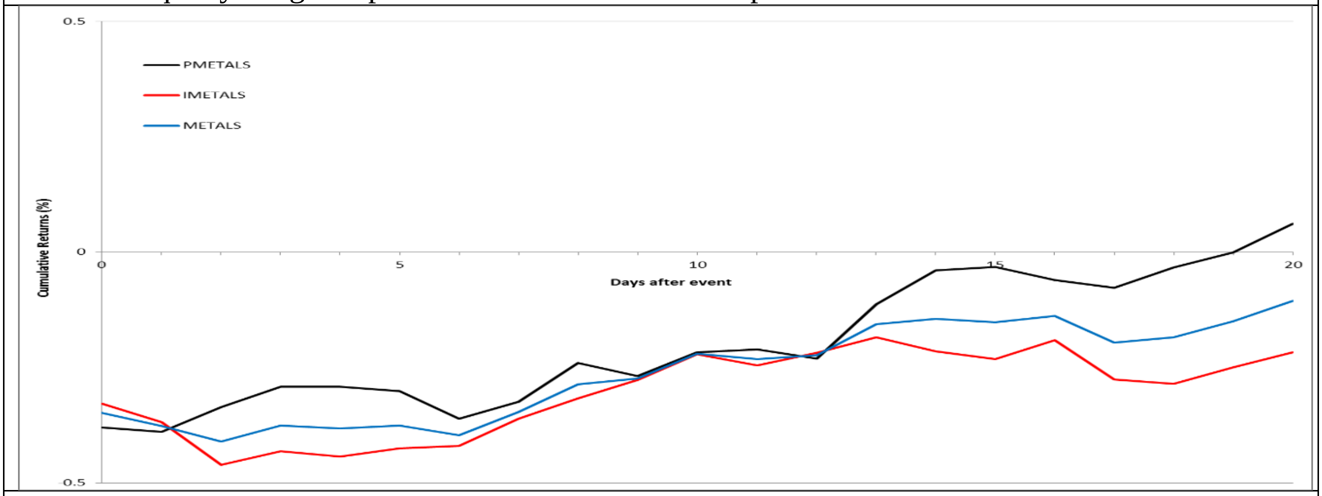


Figure 4: Post-shock performance of equally weighted portfolios consisting of the bond and portfolio of metals

Panel A: Equally weighted portfolio of the EMU benchmark bond and portfolio of metals



Panel B: Equally weighted portfolio of the UK bond and portfolio of metals



Panel C: Equally weighted portfolio of the US bond and portfolio of metals