STOCKHOLM SCHOOL OF ECONOMICS

Safe Haven Assets

- the Role of Precious Metals in Preserving Wealth

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6/14/2011

Abstract

This study examines whether precious metals can be considered to be safe haven assets. The safe haven asset concept is part of the flight-to-quality theory. These assets possess certain qualities that make them attractive as investments in times of extreme stock market conditions. Previous research indicates that gold has this kind of qualities. This study is different to other studies in that it includes both gold and other precious metals as potential safe haven candidates. It is also different in that it considers time-varying skewness and co-skewness of metal and stock returns. We find gold, platinum and silver as good options for investors seeking diversification through safe haven assets.

Master Thesis in Finance
Supervisor: Roméo Tédongap
Discussants: Gustaf Jönsson and Nils Hübinette
Venue: June 7, 2011, at 10.15 in room 538

Acknowledgements: We would like to thank our supervisor Roméo Tédongap for inspiration and invaluable discussions.

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1 Introduction

As the growing interdependence across regions and assets has made the financial markets more receptive to downturns on a global basis, the recent financial crisis has revived the search for safe haven assets. At the time of writing this paper, there are numerous articles that deal with the recent surge in the price of gold. Between 2007 and 2011, the price of gold increased by more than 120 percent[1]. Explanations to the growth usually include the hedging attributes that investments in the precious metal entail; these include mean-variance hedges as well as inflation hedges.

Since the dawn of the financial crisis the flight-to-quality theories and literature have been revisited in the pursuit of assets with the necessary safe haven qualities that withstand financial turmoil but also sustain good price levels during subsequent high inflation periods. The first strand of the flight-to-quality literature observed investors' willingness to fly to bonds from stocks in times of financial uncertainties. Since then a case has been made for other assets such as gold, and there are several aspects that make the metal a good safe haven candidate. These include the historical importance that gold has had through the gold standard and the fact that it has intrinsic value.

The safe haven qualities of assets are separate from those of hedges and diversifiers, as safe haven assets are expected to be negatively correlated, uncorrelated or less positively correlated with other assets during extreme market conditions, but may be positively correlated during bullish times. The existence of these kinds of assets implies that they can assist in stabilizing tumultuous financial markets by restraining the market fall.

In the light of previous research on gold as well as the recent financial crisis, we find it interesting to study the safe haven qualities of gold and other precious metals. This paper attempts to verify that gold is a safe haven asset during a financial downturn but also to find other potential candidates. In order to find robust results we will approach this in different ways. The effort will lie in testing for time-varying CAPM relationships between precious metals returns and stock market returns and studying time-varying skewness and co-skewness.

[1] Between January 1, 2007 and January 1, 2011 the gold price increased by 123.4 percent.

1.1 Outline

In order to sort for relevant concepts we first provide a theoretical background to the flight-to-quality theory and the safe haven asset concept. We follow up with history on the potential safe haven metals and information on their use in practice. This section ends with the important role that higher-order moments play in portfolio theory and risk management; especially the roles of skewness and co-skewness are discussed. We then proceed by introducing prior findings in order to place our study in an academic context. The subsequent part presents the five hypotheses around which this empirical study revolves. We then clarify how we aim to test these hypotheses by giving a description over the data collected for this study and the empirical methods applied. The following part presents the results of the empirical analysis. A section with robustness checks is provided in order to give credibility to our findings. Finally, we conclude with discussions on potential drawbacks, findings as well as suggestions for further research.

2 Background and theoretical framework

2.1 Concepts

2.1.1 Flight-to-quality

Flight-to-quality refers to the action of investors moving from riskier assets into assets of safer nature. This move is normally triggered when financial markets become highly volatile or uncertain. In academic literature, flight-to-quality is generally used to describe the event of investors moving away from equities into government securities and money market funds. This becomes apparent as correlations between stocks and bonds strongly decrease in bearish markets. (Baur and Lucey, 2009)

2.1.2 Safe haven assets

A safe haven asset refers to an asset that possesses the quality of yielding returns that are uncorrelated or negatively correlated with more commonly held assets (such as equities) during extreme market conditions. The correlation can, however, be positive during periods of bullish markets. This quality is attractive as safe haven assets can be included in a portfolio across both bullish and bearish periods and thus in part compensate investors in times of market turmoils. An asset that is negatively correlated or uncorrelated with another asset (or portfolio) on average is called a hedge. (Baur and Lucey, 2010)

Among investors safe haven assets often refer to physical assets such as precious metals, land, oil and real estate.[2] The rationale is that these physical assets have intrinsic values that never fall to zero. Thus, they can preserve wealth in times of financial uncertainty as investors have confidence in such assets during extreme events. Furthermore, these assets are accumulated over time with the aspiration to safeguard portfolio wealth and are normally not used for speculation purposes. Another criteria that has to be fulfilled in order for an asset to be a suitable option as a safe haven asset is that it should be easy to store and transport. Since assets such as oil and natural gas do not fulfill the latter criteria they are left out of this study. Candidates for potential safe haven assets are instead gold, palladium, platinum and silver.

2.2 Background

2.2.1 Precious metals in history and today

Man has used gold as a means of exchange and store of value for many thousands of years.[3] Also silver has had a similar role as a precious metal. The 17th century economist Sir William Petty (1690) called gold and silver wealth “at all times and all places”. The perception of gold as an undisputable store of value has been reinforced by its historical importance and linkage to money. The gold standard system was a commitment to fix currencies to a specified amount of gold. Although this system is no longer in use, central banks continue to hold gold reserves in order to defend the value of their currencies. Palladium and platinum have not historically played the same role as gold and silver but are important metals today. Gold is used in industries such as high-tech, jewelry and dentistry. Silver is used in jewelry, electronics, X-rays and photography. Palladium and platinum are used in catalytic converters, jewelry, electronics and dentistry.

2.2.2 Investing in precious metals

There are several ways to invest in precious metals. Three of those are presented in this section. For investors with storing capabilities, the pure coin or bullion markets are to prefer

[2] The information in this passage is partly extracted from Seeking Alpha.
[3] The historical background is partly extracted from Baur and McDermott (2010).

as they best represent the intrinsic value that these assets possess. A second way of trading precious metals is through certificates that give the holder the ownership right of a certain quantity of the metal. These certificates are good to use if the investor lacks the necessary storing capacity. However, it is safe to assume that even though the certificates ensure the much important intrinsic value through the underlying asset, they are bought at a premium to e.g. bullions since somebody else has to store them. Both bullions and certificates can be accumulated over time and hence satisfy the purpose of safe haven assets. A third way of investing is through the use of precious metals futures. Futures are contracts to buy or sell the underlying asset at a particular price at a specific point in time. Contrary to the two previously mentioned ways of trading, futures are most often used as tools of speculation rather than accumulative investments.

In this paper, the prices of bullions are used as we believe that they best represent the global price of the precious metals at the same time that they secure the much necessary intrinsic value. As for certificates, the prices can vary as they include different premiums related to storing costs.

2.3 Skewness and co-skewness

The shape of data distributions is reflective of how the observations are distributed around the middle center. Skewness is the measure of asymmetry and known to be zero for a normal distribution, i.e. the observations are evenly distributed around the mean which also equals the median. On the contrary, a distribution is said to be skewed, or asymmetric, if the observations are not evenly spread around the middle center. A distribution that is positively skewed has a tail that is extended to the right and includes more positive values, whereas a negatively skewed distribution has a tail extended to the left. A positively skewed distribution has a mean larger than median, whereas the opposite holds for a negatively skewed distribution (Newbold et al., 2010). Relating this to periods of extreme conditions in financial markets, an asset with negative skewness in returns has a higher probability of producing extreme negative returns than an asset with positive skewness. Skewness is calculated according to the following formula, where r_i is the return, μ_i is the mean return and σ_i is the standard deviation of asset i.

$$Skew_i = E\left[\left(\frac{r_i - \mu_i}{\sigma_i}\right)^3\right]$$

Ever since Mandelbrot (1963) and Fama (1965) presented their findings that asset returns are not normally distributed, the search for explanatory factors has been extensive. Researchers such as Kraus and Litzenberger (1976) and Jondeau and Rockinger (2003) conclude that skewness is a crucial factor when pricing assets. The former also stress that investors have an aversion to variance and a preference for positive skewness.

Scott and Horvath (1980) support the findings of Kraus and Litzenberger by arguing for the importance of higher moments in portfolio theory using utility functions. The reasoning is that if the distribution of returns are asymmetric, then the investor's utility function will have a higher order than the quadratic. Thus, the third or higher moments (e. g. skewness) have to be considered as the mean and variance do not entirely explain the distribution.

Skewness could be described as the relationship between the return and the volatility of an asset. The measure in which the relationship between the return of one asset and the volatility of another is determined is called co-skewness. The co-skewness of asset i to asset j, i.e. the relationship between the return of asset i and the volatility of asset j, is calculated according to the following formula.

$$Coskew_{i,j} = E\left[\left(\frac{r_i - \mu_i}{\sigma_i}\right)\left(\frac{r_j - \mu_j}{\sigma_j}\right)^2\right]$$

3 Previous research

Gold has historically been argued to reduce risk in asset portfolios (see for example Lucey et al. (2006) and Ciner (2001)). Sherman (1982) shows that an equity based portfolio can increase returns and lower risk by including gold. Not only gold seems to have this effect on portfolios. By including gold, platinum and silver in a portfolio it performs better than a standard equity portfolio (Draper et al. (2006)). In the same study it is also shown that these three metals have some hedging capabilities, especially during periods of abnormal volatility in the stock market.

Another strand of research cope with the flight-to-quality theory during extreme market shocks. Flight-to-quality usually refers to the action in which investors move from equity markets into bond markets in times of high volatility or extreme negative shocks. One paper finds that simultaneous crashes in G-5 stock markets is twice as likely as in bond markets (Hartmann et al., 2004). However, investments in gold has also been considered to constitute a destination during extreme periods. Baur and Lucey (2010) find that "gold is a hedge against stocks on average and a safe haven in extreme stock market conditions". The authors observe German, UK and US stock and bond returns and their relationship with gold returns. They find that gold can be considered a safe haven for stocks during negative market shocks lasting up to 15 days. As for bonds, their empirical analysis cannot display any signs of gold being a safe haven. Another paper examines the role of gold in an international setting, and whether gold is a safe haven asset for stocks in developed and large emerging markets (Baur and McDermott, 2010). The authors find that gold is both a hedge and a safe haven for major European stock markets and the United States. However, this was not the case for Australia, Canada, Japan or the BRIC countries.

Gold has not only been claimed to be a hedge or safe haven to equity but also other variables. Chaudhry et al. (2000) find that the prices of gold and silver futures respond to news releases on economic variables such as unemployment rate, capacity utilization, CPI, GDP and PPI. Another paper assesses to which extent gold has acted as a hedge against the sterling-dollar and yen-dollar exchange rates (Capie et al., 2005). The authors find that gold serves as a hedge against these exchange rates only during unpredictable events or shocks.

Lucey et al. (2006) claim that gold, in contrast to equity markets that in most cases exhibit negative skewness, consistently has positively skewed returns. They examine the role of gold bullions in mean-variance-skewness portfolio optimization and find that gold at large has an important role in creating an optimal portfolio. They claim that gold is very attractive to investors that seek to select for positive skewness.

4 Hypotheses

As presented in the Previous research section, earlier studies indicate that gold is a safe haven asset. We want to perform similar tests as those carried out by Baur and Lucey (2010) and Baur and McDermott (2010) in order to study how the returns of gold and other precious metals correlate with stock market returns on average, but more importantly in times of poor performance by the latter. We choose a slightly less strict definition of a safe haven asset compared to Baur and Lucey (2010). It is sufficient that precious metals returns and stock market returns are less positively correlated than usual in times when the stock market performs poorly. This part of the thesis seeks to evaluate Hypothesis 1.

Hypothesis 1: In times of very poor performance on the stock market, returns on gold (and potentially other precious metals) are negatively correlated, uncorrelated, or less positively correlated than usual with stock market returns.

Investors are not only interested in getting high returns but also having as low risk as possible in their asset portfolios. Therefore it is relevant to study how correlations between returns on precious metals and stock market returns change with respect to changes in stock market volatility. More specifically, we want to investigate how these correlations are affected by high volatility in stock market returns. This part of the thesis seeks to evaluate Hypothesis 2.

Hypothesis 2: In times of high volatility in stock market returns, returns on gold (and potentially other precious metals) are negatively correlated, uncorrelated, or less positively correlated than usual with stock market returns.

As stated earlier, previous research has indicated that gold returns, in contrast to equities and most other assets, have positive skewness which is preferred by investors. We want to develop and expand this thought by studying the conditional skewness (time-varying) rather than the unconditional skewness which is used by Lucey et al. (2006). We want to find out whether the skewness of the metal returns is positive when it is needed the most, i.e. when the skewness in stock market returns is noticeably low. Through this we seek to investigate whether the characteristics of time-varying skewness in metal returns is an additional argument for including these metals into an investment portfolio in order to be protected against extreme negative shocks in the stock market. We will investigate this by evaluating Hypothesis 3.

Hypothesis 3: When skewness in stock market returns is low, skewness in gold returns (and potentially other precious metals) tends to be positive.

In order to further test how well the precious metals constitute as safe haven assets, we will investigate whether Hypothesis 1 holds when the safe haven characteristics are needed the most. More specifically, we want to determine whether it holds in times of high risk of extreme negative returns on the stock market, i.e. negative skewness in stock market returns.

Hypothesis 4: The safe-haven property of gold (and potentially other precious metals) is not absolute, but relative to the asymmetry in stock market returns.

To further develop the analysis based on skewness we will study co-skewness between precious metals returns and stock market returns, i.e. the relationship between metal returns and the volatility in stock market returns. By comparing the time-varying co-skewness with skewness in stock market returns, we want to determine how the expected performance of the precious metals compare to returns from the stock market when stock market volatility is high. We will investigate this by evaluating Hypothesis 5.

Hypothesis 5: When skewness in stock market returns is low, co-skewness between gold returns (and potentially other precious metals) and stock market returns tends to be higher than skewness in stock market returns.

5 Data

The input data in this paper include a world stock index as well as prices for four precious metals. These contain daily data that stretches over the period January 6, 1987 until January 28, 2011 in order to include as many observations and market turmoils as possible. All the variables are denominated in US$. The over the counter bullion metal prices are used as they best reflect the intrinsic value, and the global index is used as it best reflects the opportunity open to global investors. The input data was retrieved using Thomson Reuters Datastream.

MSCI WORLD U$ - PRICE INDEX

This world equity index includes a collection of 1500 world stocks from developed markets. Major markets included in the index are from countries such as United States, Japan, Germany and United Kingdom. This index is often used as a common benchmark for global stock funds.

Gold Bullion LBM U$/Troy Ounce and Silver Fix LBM Cash Cents/Troy ounce

The gold and silver prices are obtained from the London Bullion Market Association that quotes the wholesale price of over the counter market for gold and silver in London.

London Platinum Free Market U$/Troy Ounce and Palladium U$/Troy Ounce

The palladium and platinum prices are obtained from the London Platinum & Palladium Market that quotes the wholesale price of over the counter market for palladium and platinum in London.

6 Methodology

6.1 Return quantiles

In order to test Hypothesis 1 we run regressions similar to those run by Baur and Lucey (2010) and especially those by Baur and McDermott (2010). We run the regression on each of the four metals. This econometric model assumes that the price of the metal is dependent on changes in the stock market, and that the relationship is not constant but varies with market conditions. Specifically, it assumes that the relationship is influenced by extreme negative shocks to the stock market. Equations (1a) - (1d) present the regression model that is applied, and it can be viewed as a CAPM regression with time-varying beta.

$$r_{m,t} = \alpha^m + \beta_t^m r_{s,t} + \varepsilon_t^m \tag{1a}$$

$$\beta_t^m = \beta_0^m + \beta_1^m I\left(r_{s,t} < r_{(q)}\right) \tag{1b}$$

$$\varepsilon_t^m = \sqrt{h_t^m} u_t^m \tag{1c}$$

$$h_t^m = \pi_0^m + a^m (\varepsilon_{t-1}^m)^2 + b^m h_{t-1}^m \tag{1d}$$

The relationship between the return of the metal and the return of the stock market is modeled by equation (1a), where ε_t^m is the error term. The coefficient β_t^m is time-varying and given by equation (1b). $I\left(r_{s,t} < r_{(q)}\right)$ is a dummy variable that captures extreme negative returns in the stock market and is equal to one if the return is below a threshold ($r_{(q)}$) given by the q-quantile of the return distribution of stocks. For instance, if q is equal to 1% then the q-quantile is the lowest percentile in the return distribution. Equation (1d) is a GARCH(1/1) model that we use in order to make the results robust to heteroscedasticity in the data. The equations are jointly estimated by maximum likelihood. The regression we run in order to test this model is the following:

$$r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I\left(r_{s,t} < r_{(q)}\right) + \varepsilon_t^m \qquad \text{(Regression 1)}$$

β_0^m is the sensitivity between the return of the metal and the return of the stock market when the stock market return is above $r_{(q)}$. When the stock market return is below $r_{(q)}$ the sensitivity is $\beta_0^m + \beta_1^m$.

6.2 Stock market volatility as indicator

To test Hypothesis 2 we run a regression similar to Regression 1 with the difference that stock market volatility is the indicator instead of extreme negative returns.[4] We run the regression on each of the four metals. It assumes that the relationship between metal returns and stock market returns is influenced by volatility in the stock market. We measure the volatility in the stock market by creating a daily variable representing the standard deviation of the return distribution over the 250 latest days. Equations (2a) - (2d) present the regression model that is applied.

$$r_{m,t} = \alpha^m + \beta_t^m r_{s,t} + \varepsilon_t^m \qquad (2a)$$

$$\beta_t^m = \beta_0^m + \beta_1^m I\left(\sigma_{s,t} > \sigma_{threshold}\right) \qquad (2b)$$

$$\varepsilon_t^m = \sqrt{h_t^m} u_t^m \qquad (2c)$$

$$h_t^m = \pi_0^m + a^m (\varepsilon_{t-1}^m)^2 + b^m h_{t-1}^m \qquad (2d)$$

[4] Baur and McDermott (2010) also run a regression with volatility as the indicator. However, their method is different to the one in this paper, and it is thus expected that the results will not be comparable over the two papers.

The relationship between the return of the metal and the return of the stock market is modeled by equation (2a), where ε_t^m is the error term. As before, the coefficient β_t^m is time-varying and now given by equation (2b). $I(\sigma_{s,t} > \sigma_{threshold})$ is a dummy variable that captures volatility in the stock market and is equal to one if the stock market volatility is above a certain threshold. Equation (2d) is a GARCH(1/1) model that we use in order to make the results robust to heteroscedasticity in the data. The equations are jointly estimated by maximum likelihood. The regression we run in order to test this model is the following:

$$r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(\sigma_{s,t} > \sigma_{threshold}) + \varepsilon_t^m \qquad \text{(Regression 2)}$$

β_0^m is the sensitivity between the return of the metal and the return of the stock market when the stock market volatility is below the threshold. When the volatility of stock market returns is above the threshold the sensitivity is $\beta_0^m + \beta_1^m$.

6.3 Including skewness and co-skewness

In order to evaluate Hypotheses 3 and 4 we create a variable that shows the time-varying skewness of the return distributions. We do this by creating a daily variable representing the skewness of the return distribution over the 250 latest days. We create such a variable for all four precious metals and the stock market. We evaluate Hypothesis 3 by examining graphs and summary statistics over the time-varying skewness.

To evaluate Hypothesis 4 we create an econometric model that is similar to the first model but with the additional feature that β_1^m is a dynamic process (hence denoted $\beta_{1,t}^m$), and related to the skewness of the stock market returns. More specifically, whether the skewness of the stock market returns is negative or positive. Equations (3a) - (3e) present the regression model that is applied.

$$r_{m,t} = \alpha^m + \beta_t^m r_{s,t} + \varepsilon_t^m \qquad \text{(3a)}$$

$$\beta_t^m = \beta_0^m + \beta_{1,t}^m I(r_{s,t} < r_{(q)}) \qquad \text{(3b)}$$

$$\beta_{1,t}^m = \beta_1^m + \beta_2^m I(skew_{s,t} < 0) \qquad \text{(3c)}$$

$$\varepsilon_t^m = \sqrt{h_t^m} u_t^m \qquad \text{(3d)}$$

$$h_t^m = \pi_0^m + a^m(\varepsilon_{t-1}^m)^2 + b^m h_{t-1}^m \qquad \text{(3e)}$$

The relationship between the return of the metal and the return of the stock market is modeled by equation (3a), where ε_t^m is the error term. The coefficients β_t^m and $\beta_{1,t}^m$ are time-varying. These two processes are given by equations (3b) and (3c) respectively. The variables denoted as I(…) are dummy variables that take the value 1 if the expression in the parenthesis is satisfied, and 0 otherwise. Equation (3e) is a GARCH(1/1) model that we use in order to make the results robust to heteroscedasticity in the data. The equations are jointly estimated by maximum likelihood. The regression we run in order to test this model is the following:

$$r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I\left(r_{s,t} < r_{(q)}\right) + \beta_2^m r_{s,t} I\left(r_{s,t} < r_{(q)}\right) I\left(skew_{s,t} < 0\right) + \varepsilon_t^m$$

(Regression 3)

As in Regression 1, β_t^0 is the sensitivity between the return of the stock market and the return of the metal, when the stock return is above $r_{(q)}$. When the stock market return is below $r_{(q)}$ and positively skewed the sensitivity is β_0^m + β_1^m. The sensitivity is β_0^m + β_1^m + β_2^m when the stock market return is below $r_{(q)}$ and negatively skewed.

In order to evaluate Hypothesis 5 we create a variable that displays the time-varying co-skewness between precious metals returns and stock market returns. This variable is created in the same manner as the volatility and the skewness variables, i.e. through the creation of a daily variable based on the return distribution over the 250 latest days. We evaluate Hypothesis 5 by examining graphs and summary statistics over the time-varying co-skewness.

7 Empirical findings

7.1 Descriptive statistics

Table 1. Descriptive statistics of asset returns, annualized daily data.

Asset	mean	max	min	sd	skewness	kurtosis	N
Gold	0.0479	18.6026	-18.1894	0.1508	-0.1889	10.4306	6279
Palladium	0.0781	39.9168	-45.0047	0.3186	-0.1666	10.4040	6279
Platinum	0.0529	29.5546	-43.5380	0.2257	-0.7182	12.8447	6279
Silver	0.0655	46.0631	-40.5090	0.2897	-0.1735	10.8573	6279
Stocks	0.0504	22.9244	-26.1148	0.1499	-0.5559	15.0938	6279

Table 1 contains summary statistics for the returns of the four precious metals and the stock market. The table illustrates positive returns on average for all assets. During the sample period all of the assets show negative skewness in returns, although the skewness for gold, palladium and silver are less negative than those for platinum and stocks. Studying the kurtosis, we note that the distributions for all of the asset returns are leptokurtic, i. e. the data has higher peaks around the mean and thicker tails than a normal distribution. This means that the probability of extreme returns is higher than with normal distribution and this is not unusual in financial data.

7.2 Effect of negative shocks on the stock market

Table 2. Regression 1: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(1\%)}) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(r_{s,t} < r_{(1\%)})$. The dummy variable takes the value 1 if the stock market return is in the lowest percentile of the return distribution. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0511***	0.2609***	0.1952***	0.1196***
	(6.83)	(13.09)	(14.36)	(6.93)
Stock return*I($r_{s,t} < r_{(1\%)}$)	-0.0284**	0.2107***	-0.0805***	-0.3520***
	(-2.12)	(8.55)	(-3.80)	(-15.30)
Number of observations	6279	6279	6279	6279
R^2	0.0016	0.0166	0.0172	0.0013

Table 2 presents the results of Regression 1. From the regressions we note that all four precious metals returns are positively correlated with stock market returns when the stock market return is above the $r_{(1\%)}$[5], i.e. β_0^m is significantly positive. The coefficient (β_1^m) for the variable representing the difference in sensitivity when stock market returns are in the worst percentile of the return distribution is significantly negative for gold, platinum and silver. For palladium this coefficient is significantly positive. Hence, the outcome from these regressions is that we cannot reject Hypothesis 1 for gold, platinum and silver, but we can reject it for palladium. Silver is the metal with the strongest results for confirming Hypothesis 1. For silver the sensitivity (β_0^m + β_1^m) to stock market returns when stock market returns are in the lowest percentile is negative, but for gold and platinum it is only less positive than it is otherwise. The R^2 is very low for all four regressions. This is what should be expected and is not a problem for the credibility of the results since the purpose of these regressions is not to predict returns of precious metals.[6]

7.3 Effect of high volatility on the stock market

Table 3. Regression 2: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(\sigma_{s,t} > 0,010) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(\sigma_{s,t} > 0.010)$. The dummy variable takes the value 1 if the volatility of stock market return during the 250 last days is above 0.010. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.1057***	0.1803***	0.1702***	0.1110***
	(8.07)	(5.19)	(8.13)	(3.68)
Stock return*I($\sigma_{s,t} > 0{,}010$)	-0.1017***	0.2816***	0.0143	-0.0120
	(-6.76)	(7.77)	(0.59)	(-0.33)
Number of observations	6030	6030	6030	6030
R^2	0.0034	0.0207	0.0186	0.0040

Table 3 presents the results of Regression 2. The returns of all four metals are positively correlated with stock market returns when the stock market volatility is below 0.010[7]

[5] We have chosen q=1% since this will only capture days when the stock market is very bearish, but still give us enough observations where $I(r_{s,t} < r_{(q)}) = 1$ in order to get valid results. $r_{(1\%)} = -0.0269285$.
[6] R^2 is not reported in the earlier studies that have performed similar regressions and therefore it is difficult to know if the results differ from earlier results in the level of determination.
[7] We have chosen $\sigma_{threshold}$=0.010 since that will capture all large peaks in the time-varying volatility in stock market returns. A graph over the time-varying volatility that we use can be found in Appendix 1.

($\beta_0^m > 0$). The coefficient (β_1^m) representing the change in sensitivity to stock market returns in times of volatility higher than 0.010 in the stock market is significantly negative for gold and significantly positive for palladium. For platinum and silver this coefficient is not significant. Hence, we can reject Hypothesis 2 for palladium, platinum and silver but not for gold. When volatility in stock market returns is above 0.010, gold returns seem to be uncorrelated with stock market returns (β_0^m + β_1^m is not significantly different from zero[8]).

7.4 Time-varying skewness

Table 4. Descriptive statistics over time-varying skewness of asset returns.

Asset	mean	max	min	sd	skewness	kurtosis	N
Gold	-0.1402	3.3728	-3.2873	0.8374	0.0098	5.4625	6030
Palladium	-0.1676	1.9587	-2.6254	0.6703	-0.1008	3.2079	6030
Platinum	-0.3826	5.4406	-7.0727	0.8181	0.0532	8.1101	6030
Silver	-0.0611	1.9381	-2.2314	0.5355	-0.6789	3.2372	6030
Stocks	-0.2324	0.9570	-2.3724	0.4983	-2.3076	10.4562	6030

Table 5. Correlation matrix over time-varying skewness of asset returns.

	Gold	Palladium	Platinum	Silver	Stock
Gold	1.00				
Palladium	0.22	1.00			
Platinum	0.19	0.22	1.00		
Silver	0.40	0.27	0.45	1.00	
Stock	-0.05	0.08	0.10	-0.12	1.00

Table 4 shows the summary statistics over the time-varying skewness variables that we create in accordance to the Methodology section. Studying the summary statistics, we observe that the time-varying skewness of the returns are on average negative for all our variables. The mean values are, however, not the most important feature when studying these variables, but instead how they vary over time. Particularly how the time-varying skewness of the metal returns fluctuate relative to the one of the stock market returns is of importance. Table 5 is a correlation matrix over the time-varying skewness of the metal returns and the stock market returns. We conclude that the coefficients showing the correlations between the skewness of the metal returns and of the stock market returns are

[8] P-value = 0.5939

close to zero. For gold and silver the coefficients are slightly negative and for palladium and platinum they are instead slightly positive. For a deeper analysis of how the time-varying skewness of the asset returns co-move we need to study their relationships graphically.

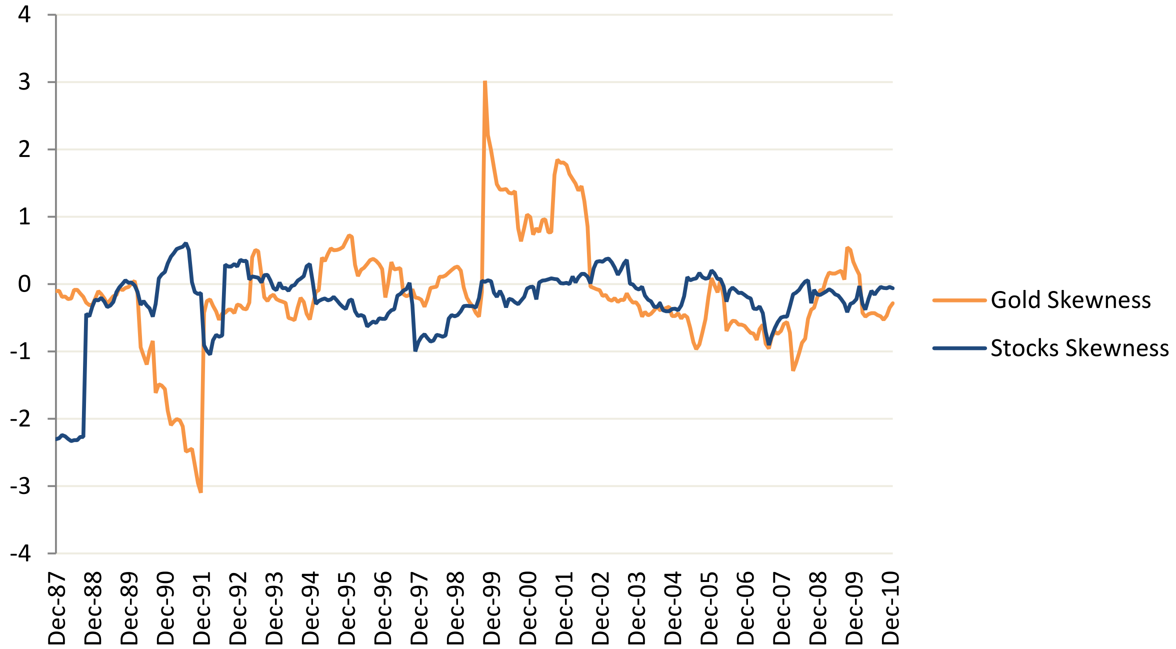

Figure 1. Smoothed time-varying skewness of gold and stock returns.

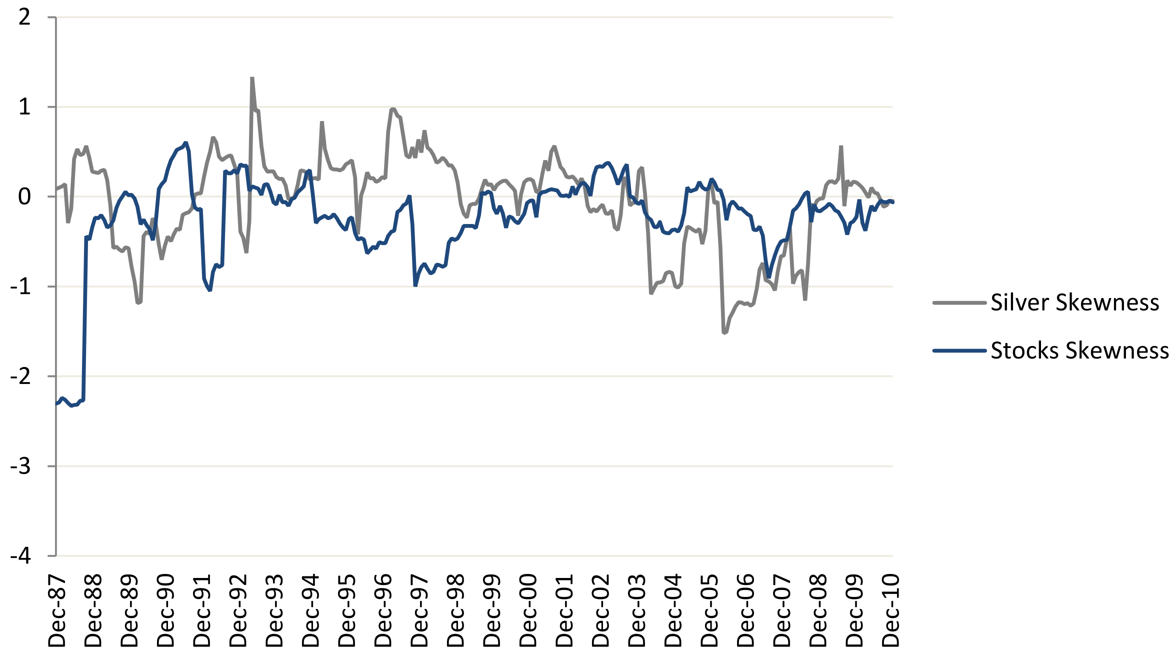

Figure 2. Smoothed time-varying skewness of silver and stock returns.

Figure 1 displays the time-varying skewness of gold returns and of stock market returns and Figure 2 displays the corresponding graph for silver returns and stock market returns.[9] Studying the first graph we cannot observe any clear relationship between the skewness of gold returns and stock market returns. During some periods, especially the 1990's, we observe a negative relationship while over the entire time period this relationship between the two variables is harder to identify. We can, however, not detect any clear pattern that the skewness in gold returns is positive when skewness in stock market returns is noticeably low. Studying the second graph, the relationship between skewness of silver returns and of stock market returns is a bit more apparent, but far from perfect. It appears as if there is a negative relationship between the two variables during the entire period except for sub-period 2004-2008. The most interesting feature that this relationship constitutes is that during the four periods (1988, 1992, 1995-2000 and 2004-2008) when the lowest values of the skewness in stock market returns are observed, the skewness of silver returns is, with the exception of the last period, predominantly positive. Studying the corresponding graph for platinum we can conclude that there is no clear pattern between the skewness of

[9] Similar graphs for palladium and platinum are illustrated in Appendix 2. We choose to include the graphs for gold and silver in the main text since gold demonstrates the best results for Hypothesis 2 and silver is the metal that demonstrates the strongest results for Hypothesis 1. The graphs shown in the main text and in Appendix 2 are smoothed out by plotting the mean for every month in order for the graphs to be more easily interpreted. The corresponding non-smoothed graphs are illustrated in Appendix 3.

platinum returns and of stock market returns. Regarding the sign that the skewness of the metal takes in times of noticeably low skewness in stock market returns it is possible to interpret skewness in palladium returns as having the tendency to be positive. The same is not observed for the skewness of platinum returns. Although difficult to interpret, the results from the graphical analysis implies that we can confirm Hypothesis 3 for palladium and silver, but neither confirm nor reject it for the other two metals.

7.5 Including skewness in regressions

Table 6. Regression 3: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(1\%)}) + \beta_2^m r_{s,t} I(r_{s,t} < r_{(1\%)}) I(skew_{s,t} < 0) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and two dummy variables. The first is $I(r_{s,t} < r_{(1\%)})$ and takes the value 1 if the stock market return is in the lowest percentile of the return distribution. The second is $I(skew_{s,t} < 0)$ and takes the value 1 if skewness in stock returns during the last 250 days is negative. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0520***	0.2577***	0.1938***	0.1146***
	(6.87)	(12.12)	(14.12)	(6.69)
Stock return*I($r_{s,t} < r_{(1\%)}$)	-0.1435	-0.3874***	-0.2826***	-0.3382
	(-1.43)	(-3.80)	(-2.95)	(-1.50)
Stock return*I($r_{s,t} < r_{(1\%)}$)*I($skew_{s,t} < 0$)	0.1678*	0.7791***	0.2229**	-0.0907
	(1.66)	(7.76)	(2.31)	(-0.40)
Number of observations	6030	6030	6030	6030
R^2	0.0011	0.0187	0.0184	0.0007

Table 5 presents the results of Regression 3. We conclude that the coefficient (β_2^m) of the variable added to Regression 1 is significantly positive for gold, palladium and platinum, and insignificant (negative) for silver. This implies that Hypothesis 4 cannot be rejected for gold, palladium or platinum, but we can reject it for silver. As earlier, the regressions have very low R^2 which means that they do not explain a large part of the variation in the returns of the precious metals.

7.6 Time-varying co-skewness

Table 7. Descriptive statistics over time-varying co-skewness between metal returns and stock market returns.

Asset	mean	max	min	sd	skewness	kurtosis	N
Gold	-0.0313	0.5690	-1.1429	0.2175	-1.1989	8.6755	6030
Palladium	0.0049	0.9201	-0.9349	0.1866	2.3472	11.0339	6030
Platinum	-0.0089	0.4214	-0.9290	0.1115	0.4765	5.7007	6030
Silver	-0.0082	0.5963	-0.7946	0.1499	0.7482	5.3080	6030

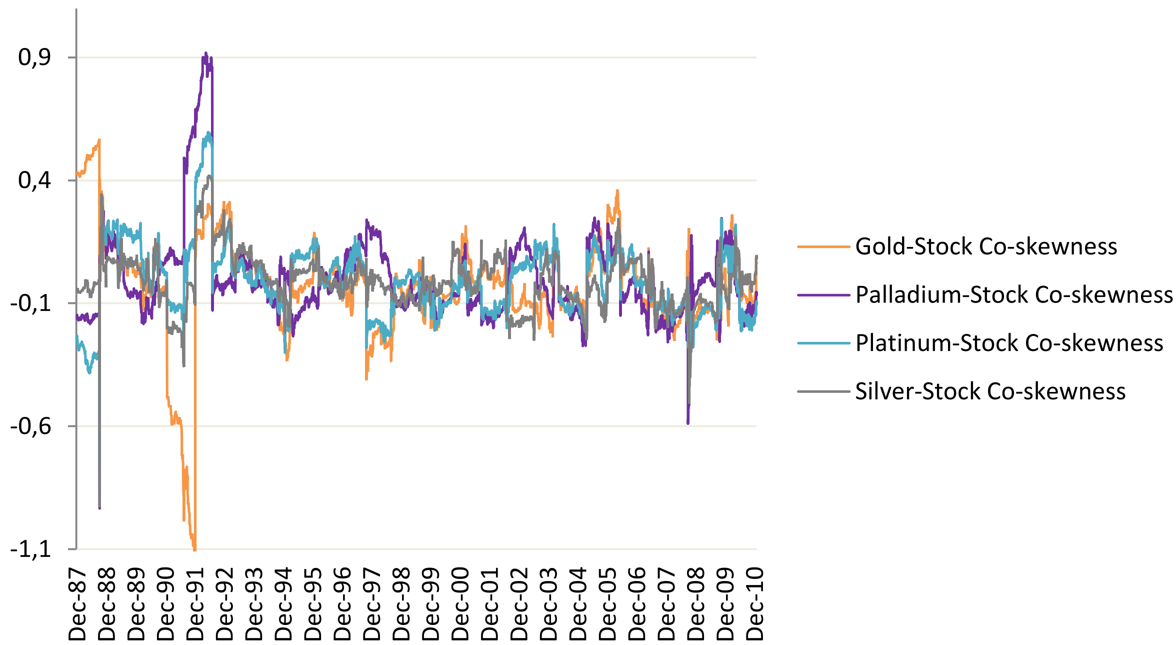

Figure 3. Time-varying co-skewness between metal returns and stock market returns.

Studying the summary statistics of the time-varying co-skewness between returns of precious metals and returns of the stock market, we are able to conclude that returns of all metals with the exception for that of palladium have a negative co-skewness with stock market returns. Studying Figure 3 that displays the co-skewness of the metal returns and of the stock market returns, it is apparent that they seem to follow the same pattern. Hence we would expect similar results for the different metals when evaluating Hypothesis 5.

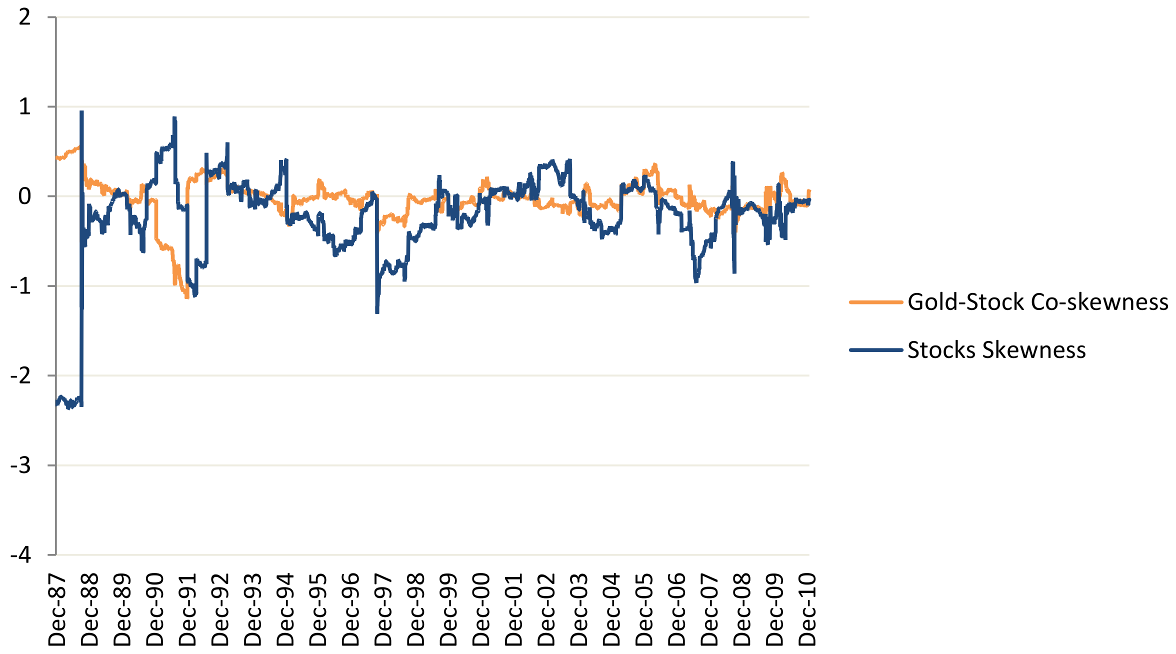

Figure 4. Time-varying co-skewness between gold returns and stock market returns and skewness in stock market returns.

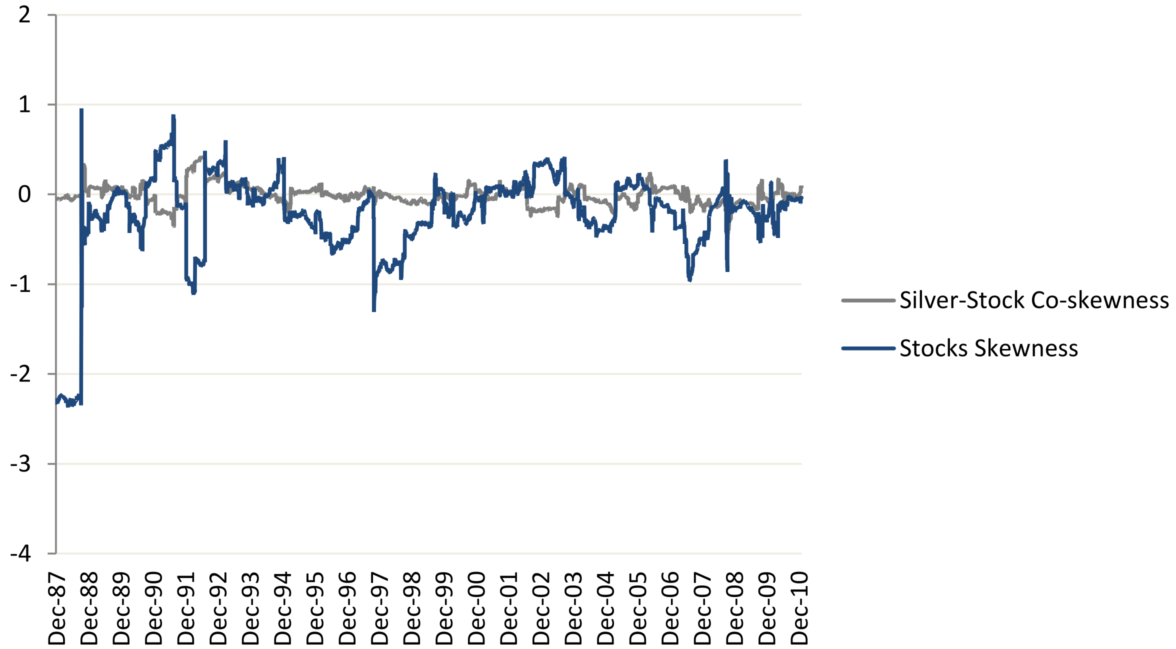

Figure 5. Time-varying co-skewness between silver returns and stock market returns and skewness in stock market returns.

By studying Figure 4 and Figure 5, displayed above, we conclude that Hypothesis 5 cannot be rejected for neither gold nor silver[10]. During periods of low skewness in stock market

[10] Only graphs for gold and silver are included in the main text. Corresponding graphs for palladium and platinum can be found in Appendix 4.

returns (e. g. 1988, 1992, 1996-1999 and 2007) the co-skewness between returns of gold and silver and that of stock market returns is higher than skewness in stock market returns. This also holds for palladium and platinum.

7.7 Robustness

To test the robustness of our results we run the same regressions as before but with different time periods and different thresholds for the indicators of low returns (Regression 1 and Regression 3) and of high volatility (Regression 2) on the stock market.[11] When running Regression 1 with 5%- and 10%-quantiles in the indicator variable, instead of 1% as before, we are still able to confirm Hypothesis 1 for platinum and silver, but not for gold. Yet again, Hypothesis 1 is rejected for palladium. When splitting the sample into two sub-samples (1987-1998 and 1999-2011) inconsistencies appear. The first period exhibits no significant correlation between stock market returns and returns for gold or silver when stock market returns are above $r_{(1\%)}$, but there is still a significant negative effect on these correlations in times of poor performance on the stock market (the lowest percentile of the return distribution). For platinum, we cannot confirm Hypothesis 1 by only studying the first time period. For palladium, however, the results of the first time period is in favor for Hypothesis 1 being true and thus contradicts the results of the regression over the entire sample. The regression results over the second time period cannot reject Hypothesis 1 for platinum and silver, but for gold. Hence, the results for Hypothesis 1 seem to some extent vary over time. From the robustness tests on Regression 1 we can conclude that the results are the strongest for platinum and silver.

In order to test how robust the results from Regression 2 are we run it with $\sigma_{threshold}$ equal to 0.008 and 0.012, instead of 0.010 as in the original regression.[12] When $\sigma_{threshold} = 0.008$ we obtain very similar results as before. With $\sigma_{threshold} = 0.012$, however, the results are different and Hypothesis 2 is rejected. One should bear in mind though, that setting the threshold to 0.012 one fails to capture several peaks in stock market volatility that was captured when $\sigma_{threshold} = 0.010$. Splitting the sample into two different time periods the results are very similar. The only difference that is of importance is that we are not able to

[11] Results are presented in Appendix 5.
[12] Results are presented in Appendix 6.

reject Hypothesis 2 for platinum by only studying 1987-1998. Overall, the results from Regression 2 are rather robust.

Performing the same robustness checks for Regression 3 as we do for Regression 1 the following is demonstrated.[13] When using a 5%-quantile in the indicator variable for bad performance on the stock market the rejections of Hypothesis 4 for gold, palladium and platinum seem to hold, while the confirmation of the hypothesis for silver is weakened. The results for the 10%-quantile regression are rather ambiguous and it is difficult to detect any clear patterns. When studying the two sub-samples (1987-1998 and 1999-2011), we can only reject Hypothesis 4 for palladium during the second time period. In the first time period there are too few observations in which the third variable takes other values than zero. This does not give proper results; hence the results are excluded from the appendix. To summarize, we conclude that the results from Regression 1 and Regression 2 are more robust than the results from Regression 3.

7.8 Data evaluation

In order to determine whether there are any econometrical issues that affect the validity of our results, we need to evaluate the data.[14] Such potential econometrical issues are heteroscedasticity, non-stationarity and non-normal data distribution. Heteroscedasticity is not an issue since we fit our regressions to a GARCH(1/1)-model that makes the results robust to heteroscadasticity . In order to determine if any of the variables is non-stationary we use the augmented Dickey-Fuller test (Dickey and Fuller, 1979). The null hypothesis in this test is that a variable contains a unit root. According to the results obtained we can reject the null hypothesis for all variables. Hence, the variables used in our regressions seem to be stationary. In order to test if the data is normally distributed we perform the Shapiro-Wilks test for normality (Shapiro and Wilk, 1965). According to these tests the data is non-normally distributed, i.e. significant skewness and kurtosis. However, since our data is stationary and we have more than 30 observations we rely on the central limit theorem. Due to this, our t-statistics are only approximations of their true values.

[13] Results are presented in Appendix 7.
[14] Results are presented in Appendix 8.

8 Discussion of results

We are not able to reject Hypothesis 1 for gold, platinum or silver. Our results demonstrate that in times of very bad performance on the stock market, returns from these three metals are negatively correlated, uncorrelated or less positively correlated than usual with returns from the stock market. For palladium, the results are the opposite, i. e. palladium returns are more correlated with the stock market in times of very bad performance. Earlier studies such as Baur and Lucey (2010) and Baur and McDermott (2010) have only observed the performance of gold. Our results are in line with earlier research regarding gold; it seems as gold is a safe haven asset to the stock market. What makes our results interesting is that when we study other precious metals, gold does not appear to be the best option when performing the type of tests carried out in Regression 1. Silver and platinum have stronger results and they are more robust to changes in the model and the sample time period.

As for Hypothesis 2 it seems to hold for gold, but not for the other three precious metals. Our results indicate that in times of high volatility in the stock market, the positive correlation between gold returns and stock market returns disappears. However, for palladium the correlation with the stock market increases in times of high volatility in the stock market. For platinum and silver there is no significant difference.

Earlier studies such as Lucey et al. (2006) has claimed that gold consistently has positively skewed returns. Using a longer time-sample we neither find positive unconditional skewness in gold returns nor in returns of any other precious metal. Presenting a new approach using time-varying skewness we are, however, able to show that there may be attractive characteristics of skewness in metal returns. Platinum and silver exhibit the strongest results in favor of Hypothesis 3. There are indications that the skewness of these metal returns vary favorably over time. It seems as it tends to be positive when needed, i.e. when skewness of stock market returns are very low.

By including skewness in stock market returns in the regression model that was used to evaluate Hypothesis 1, we were only able to reject Hypothesis 4 for silver. Thus, it seems as the safe haven qualities of gold and platinum are not absolute, but instead relative to the skewness in stock market returns. Our results indicate that the falling effect on correlations displayed between gold and platinum returns and stock market returns in times of bad performance on the stock market is weaker or non-existing when stock market returns are negatively skewed. Hence, the safe haven qualities of gold and platinum seem to be weaker or non-existing when the probability of extremely low stock market returns is higher. This is obviously a drawback for gold and platinum, as the safe haven qualities are needed the most in times of high probability of negative shocks on the stock market.

As for Hypothesis 5, all metals show similar characteristics. Our hypothesis seems to hold for all four metals; the co-skewness between metal returns and stock market returns is generally higher than the skewness in stock market returns when the latter is low. This implies that in times of high volatility in the stock market, precious metals are expected to perform better than the stock market.

9 Potential drawbacks

One obvious drawback of this study is that the use of graphical analysis often give ambiguous interpretations of the results. It is very difficult to find absolute patterns when evaluating Hypothesis 3 and Hypothesis 5 by only studying graphs. Another drawback is that some of our results from the regressions are not robust to changes in the specifications of the model. This is especially the case for the results of Regression 3 that evaluates Hypothesis 4. Hence, one should be careful when drawing conclusions on the above mentioned parts of the empirical analysis.

10 Conclusion

In this study we examine four precious metals in order to determine whether they can be considered to be safe haven assets against the stock market during extreme market conditions. These four assets were specifically chosen as they posses the necessary intrinsic value. A global stock index was used as proxy for the stock market.

To summarize the results of this study we would claim that there are strong reasons to believe that gold, platinum and silver are good to add to an asset portfolio if one wants protection against turbulent periods on the stock market. Palladium, however, does not seem to possess the right qualities for this purpose. In order to make our results as robust as possible we apply several different methods in order to find safe haven qualities in the returns of the metals. Although we are not able to rank which metal among gold, platinum and silver that is the best safe haven option, it is possible to distinguish some important differences in the features of their returns. In some instances silver was the candidate that showed the strongest qualities. Silver demonstrated the strongest (and together with platinum the most robust) results when confirming that its returns are negatively correlated, uncorrelated or less positively correlated with stock market returns in times of very low stock market returns. Silver (and palladium) return skewness displayed the most convincing negative relationship with stock market return skewness. Furthermore, silver was the only metal among the three with safe haven qualities where its qualities were not weakened or vanished when considering negative skewness in stock market returns. On the other hand, gold was the only metal where the positive correlation with the stock market disappeared in times of high volatility in the returns of the latter. Hence, gold, platinum and silver demonstrate safe haven qualities in different ways but none of them is completely better than the others. For an investor seeking diversification through safe haven assets, it would probably be best to include all of them in an asset portfolio.

11 Further research

A first suggestion to future research is to examine the relationship between gold and silver whilst holding the safe haven theory in mind. Historically there has existed an important price ratio between the two metals. In November 2009, this price ratio was 64 whilst over the last century it has been around 16. Another suggestion is to find other potential safe haven assets by for instance finding assets with safe haven qualities that lack the intrinsic value property. Studies to date have only promoted assets with intrinsic value and in some cases bonds as safe haven assets. Finally, we would like to promote the use of portfolio theory in order to confirm these safe haven assets. Our suggestion is to build a portfolio including stocks, gold, platinum and silver using a mean-variance-skewness optimization approach and compare its performance with that of a standard equity portfolio. We would also suggest the use of value-at-risk theory in order to investigate safe haven qualities.

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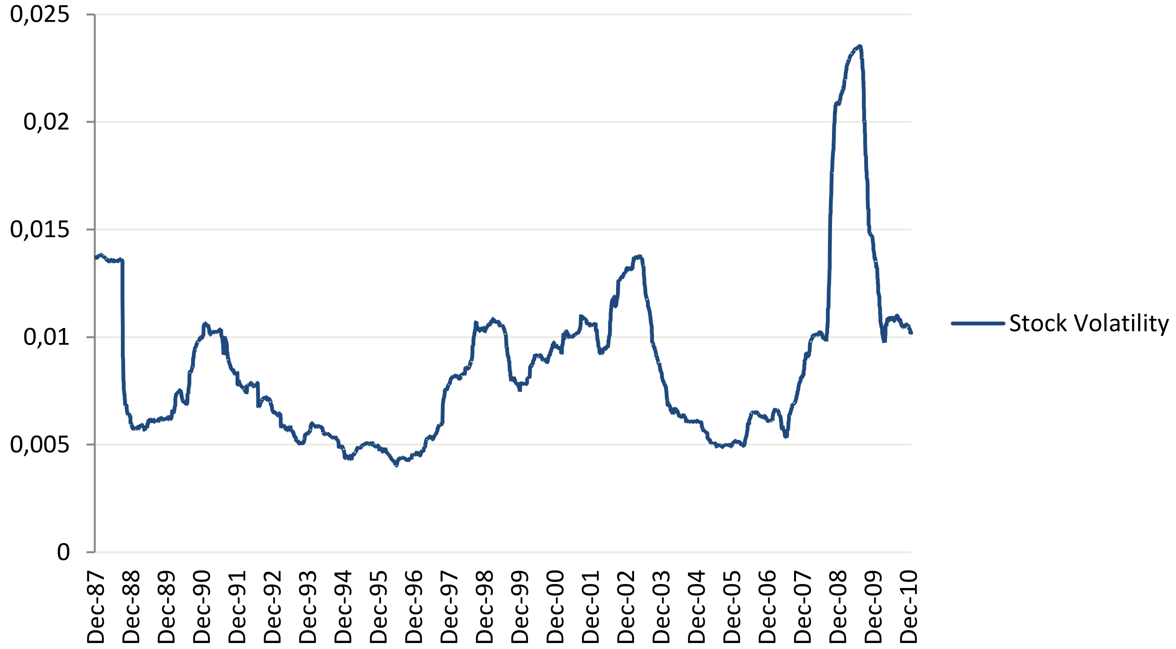
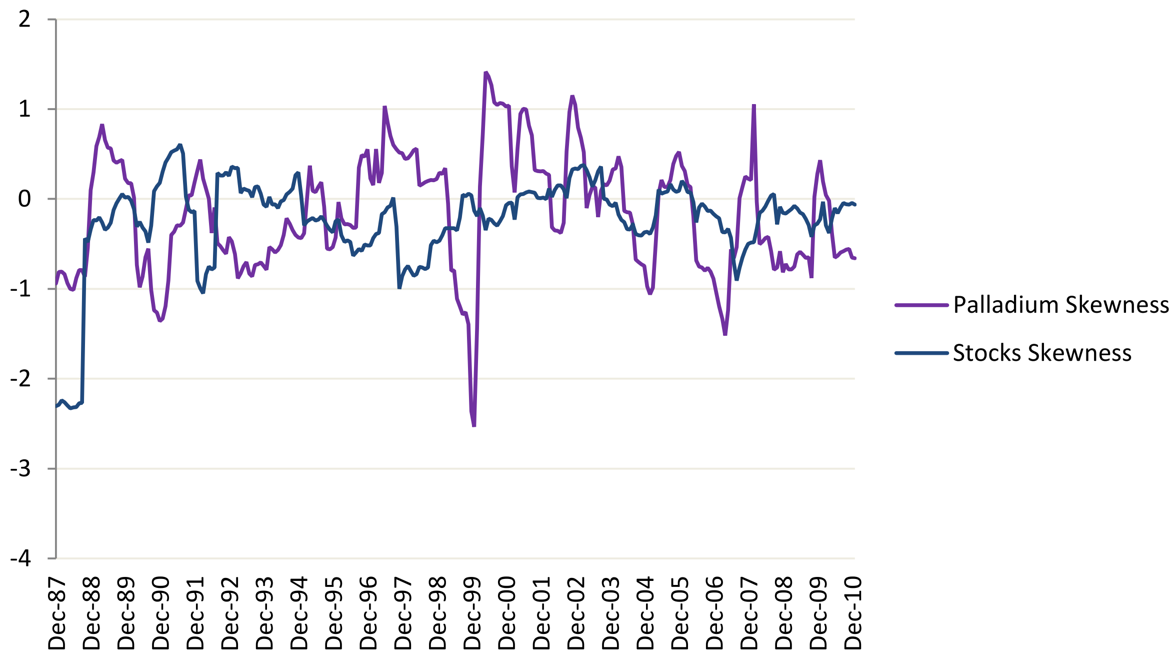
Appendix

Appendix 1

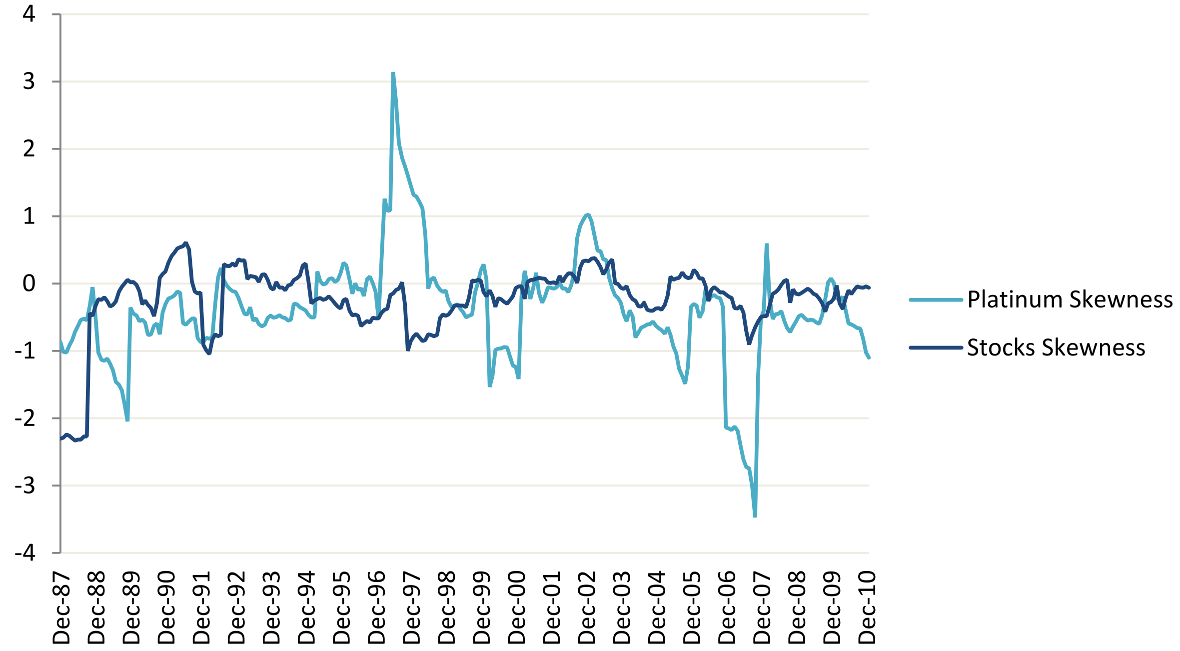


Appendix 1. 1 Time-varying volatility in stock market returns.

Appendix 2

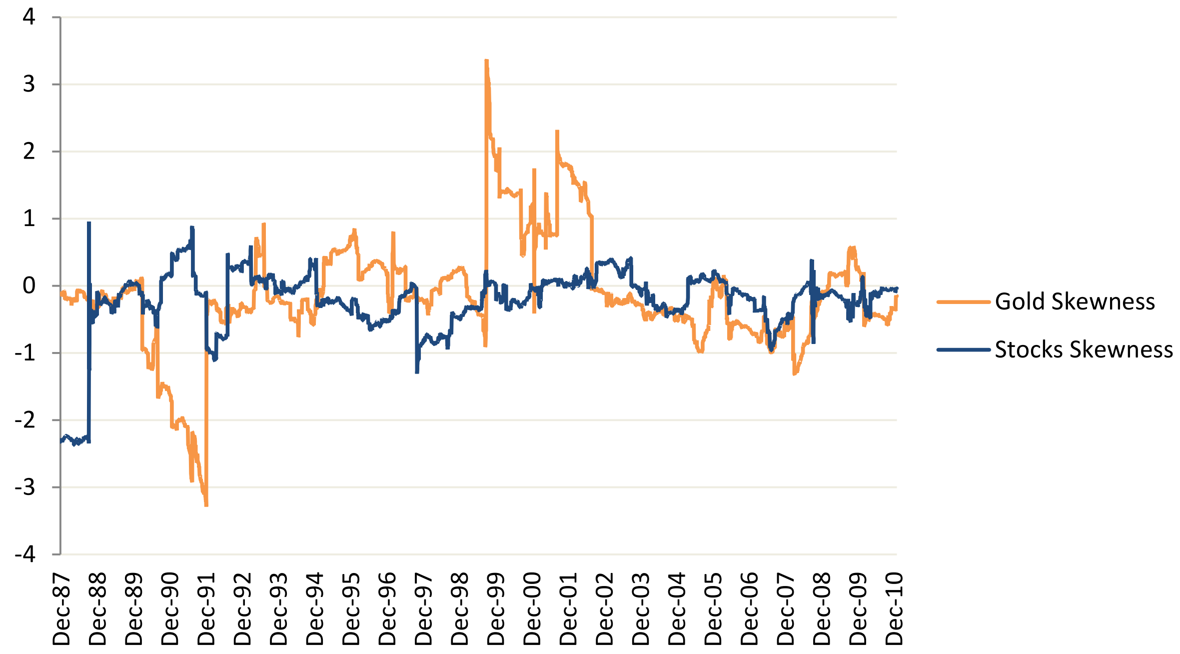


Appendix 2. 1 Smoothed time-varying skewness of palladium and stock market returns.

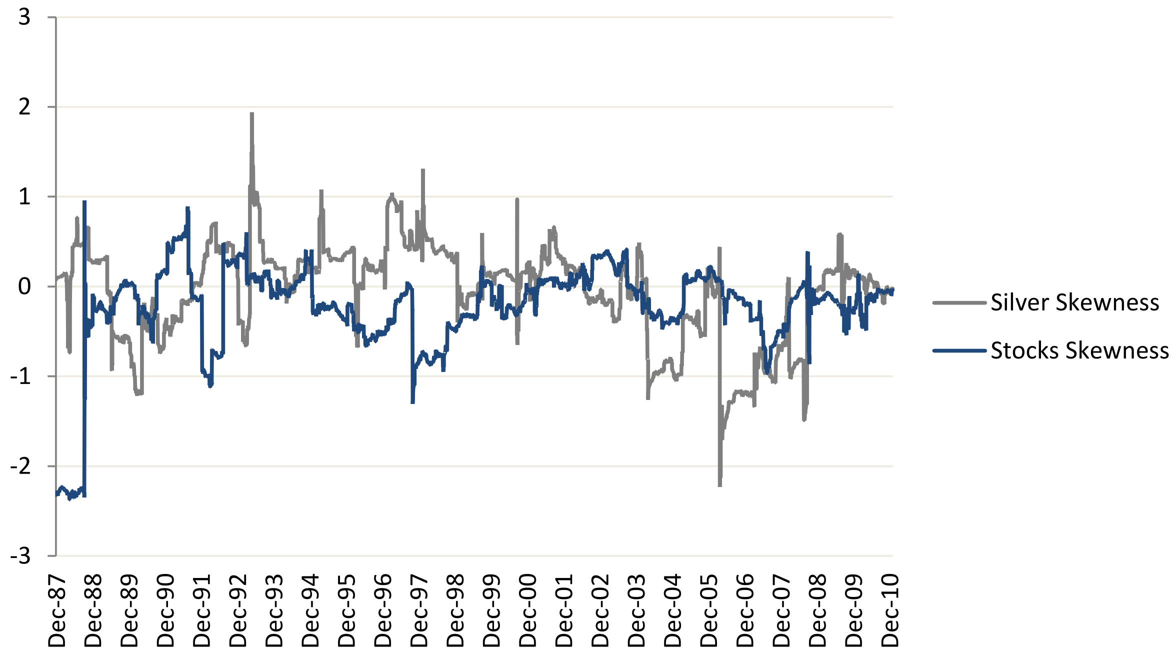


Appendix 2. 2 Smoothed time-varying skewness of platinum and stock market returns.

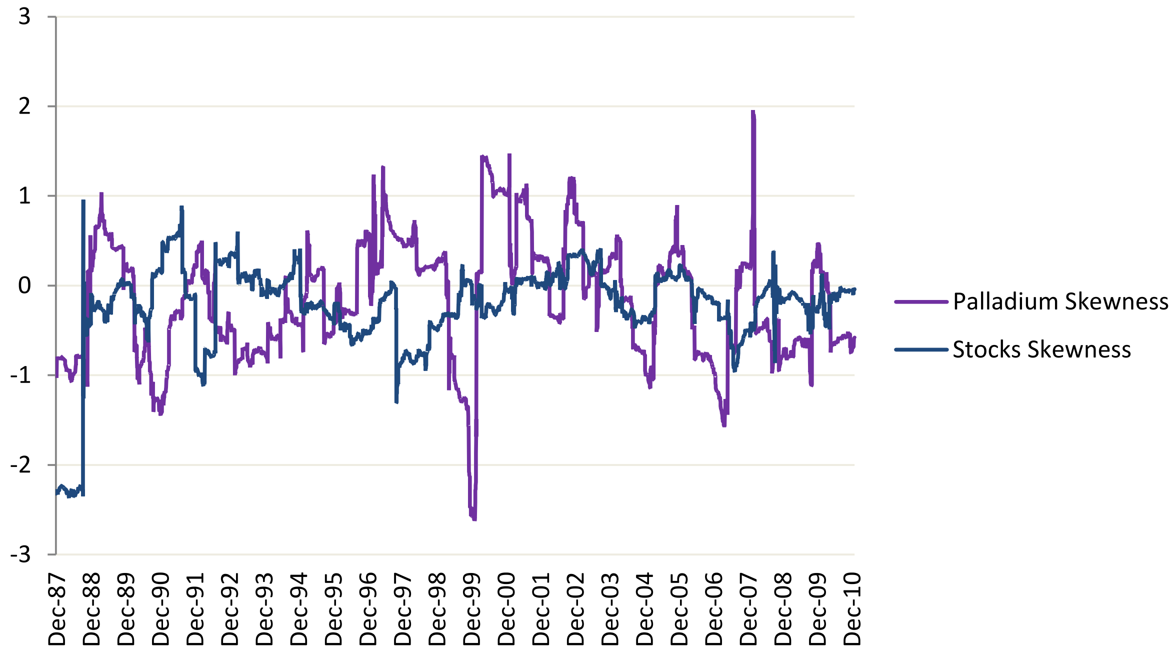
Appendix 3



Appendix 3. 1 Non-smoothed time-varying skewness of gold and stock market returns.



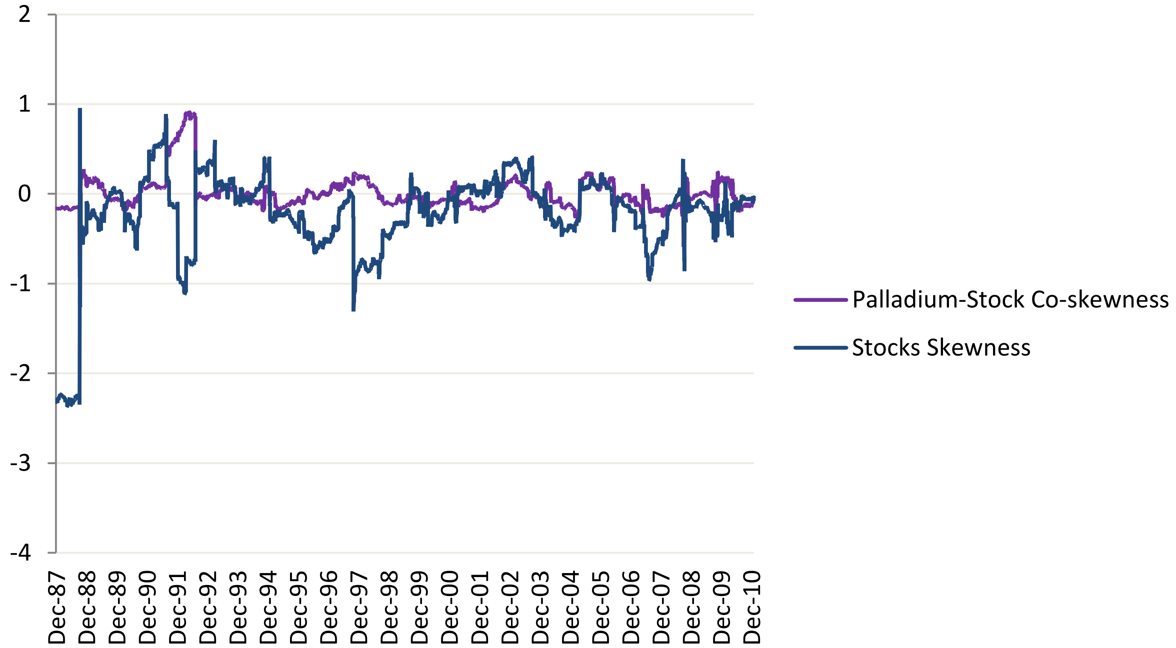
Appendix 3. 2 Non-smoothed time-varying skewness of silver and stock market returns.



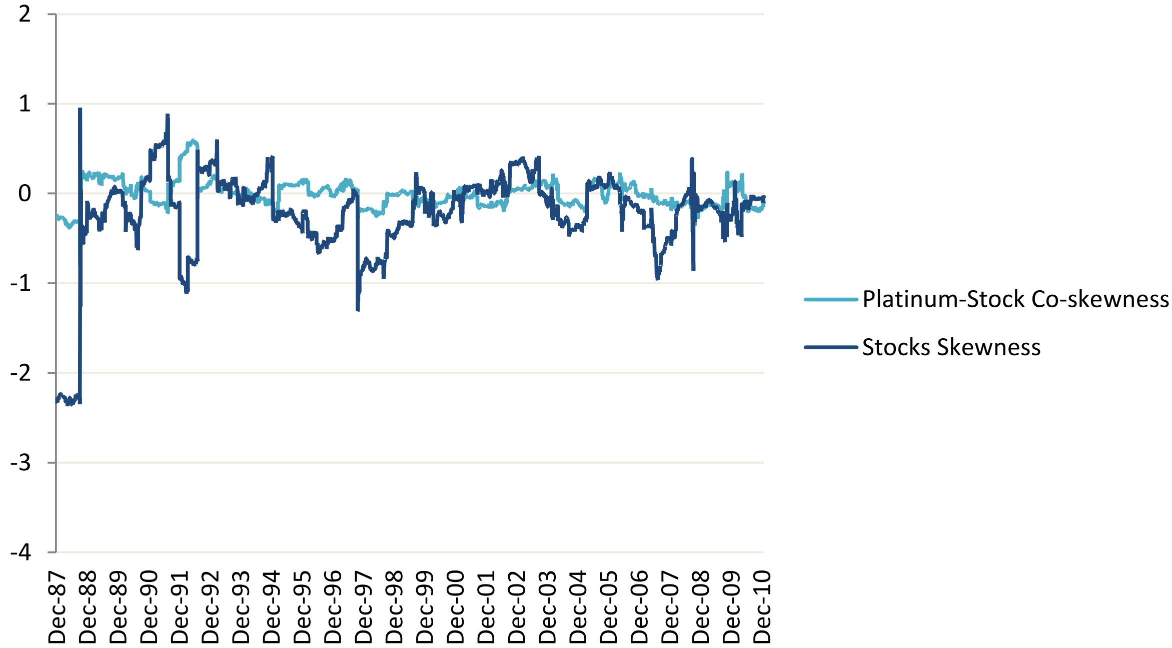
Appendix 3. 3 Non-smoothed time-varying skewness of palladium and stock market returns.

Appendix 3. 4 Non-smoothed time-varying skewness of platinum and stock market returns.

Appendix 4



Appendix 4. 1 Time-varying co-skewness between palladium returns and stock market returns and skewness in stock market returns.



Appendix 4. 2 Time-varying co-skewness between platinum returns and stock market returns and skewness in stock market returns.

Appendix 5

Appendix 5. 1 Regression 1: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(5\%)}) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(r_{s,t} < r_{(5\%)})$. The dummy variable takes the value 1 if the stock market stock market return is below $r_{(5\%)}$. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0513***	0.2356***	0.2111***	0.1202***
	(6.04)	(9.93)	(12.91)	(6.27)
Stock return*I($r_{s,t} < r_{(5\%)}$)	-0.0164	0.1693***	-0.0908***	-0.1258***
	(-1.18)	(6.29)	(-4.01)	(-3.89)
Number of observations	6279	6279	6279	6279
R^2	0.0014	0.0174	0.0172	0.0026

Appendix 5. 2 Regression 1: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(10\%)}) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(r_{s,t} < r_{(10\%)})$. The dummy variable takes the value 1 if the stock market stock market return is below $r_{(10\%)}$. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0513***	0.2293***	0.2135***	0.1293***
	(5.82)	(9.41)	(12.08)	(6.42)
Stock return*I($r_{s,t} < r_{(10\%)}$)	-0.0131	0.1488***	-0.0785***	-0.1068***
	(-0.92)	(5.26)	(-3.26)	(-3.17)
Number of observations	6279	6279	6279	6279
R^2	0.0013	0.0178	0.0177	0.0028

Appendix 5. 3 Regression 1: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(1\%)}) + \varepsilon_t^m$, sample period 1987-1998. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(r_{s,t} < r_{(1\%)})$. The dummy variable takes the value 1 if the stock market return is in the lowest percentile of the return distribution. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	-0.0144	0.0784**	0.1045***	0.0278
	(-0.96)	(2.35)	(4.38)	(0.88)
Stock return*I($r_{s,t} < r_{(1\%)}$)	-0.0448**	-0.1655***	-0.0178	-0.1584***
	(-2.25)	(-3.01)	(-0.53)	(-3.07)
Number of observations	3128	3128	3128	3128
R^2	0.0007	0.0029	0.0040	0.0003

Appendix 5. 4 Regression 1: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(1\%)}) + \varepsilon_t^m$, sample period 1999-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(r_{s,t} < r_{(1\%)})$. The dummy variable takes the value 1 if the stock market return is in the lowest percentile of the return distribution. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0860***	0.3786***	0.2569***	0.1786***
	(7.79)	(11.55)	(14.65)	(7.96)
Stock return*I($r_{s,t} < r_{(1\%)}$)	-0.0177	0.2092***	-0.1202***	-0.4301***
	(-0.82)	(5.09)	(-4.18)	(-12.62)
Number of observations	3151	3151	3151	3151
R^2	0.0046	0.0347	0.0288	0.0082

Appendix 6

Appendix 6. 1 Regression 2: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(\sigma_{s,t} > 0,008) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(\sigma_{s,t} > 0.008)$. The dummy variable takes the value 1 if the volatility of stock market return during the 250 last days is above 0.008. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.1412***	0.1667***	0.1861***	0.1225***
	(6.73)	(3.09)	(5.59)	(3.08)
Stock return*I($\sigma_{s,t} > 0,008$)	-0.1243***	0.2040***	-0.0122	-0.0247
	(-5.64)	(3.69)	(-0.35)	(-0.57)
Number of observations	6030	6030	6030	6030
R^2	0.0053	0.0178	0.0183	0.0042

Appendix 6. 2 Regression 2: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(\sigma_{s,t} > 0,012) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(\sigma_{s,t} > 0.012)$. The dummy variable takes the value 1 if the volatility of stock market return during the 250 last days is above 0.012. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0452***	0.2044***	0.1457***	0.0797***
	(4.10)	(8.29)	(9.14)	(3.17)
Stock return*I($\sigma_{s,t} > 0,012$)	0.0236*	0.3932***	0.1091***	0.0981***
	(1.74)	(14.59)	(5.31)	(2.96)
Number of observations	6030	6030	6030	6030
R^2	0.0016	0.0206	0.0210	0.0045

Appendix 6. 3 Regression 2: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(\sigma_{s,t} > 0{,}010) + \varepsilon_t^m$, sample period 1987-1998. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(\sigma_{s,t} > 0.010)$. The dummy variable takes the value 1 if the volatility of stock market return during the 250 last days is above 0.010. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0006	0.0556	0.1075***	0.0144
	(0.04)	(1.61)	(4.04)	(0.40)
Stock return*I($\sigma_{s,t} > 0{,}010$)	-0.0866**	-0.1002	-0.1762***	-0.0634
	(-2.40)	(-1.16)	(-3.38)	(-0.82)
Number of observations	2879	2879	2879	2879
R^2	0.0049	0.0005	0.0035	0.0002

Appendix 6. 4 Regression 2: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(\sigma_{s,t} > 0{,}010) + \varepsilon_t^m$, sample period 1999-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and the dummy variable $I(\sigma_{s,t} > 0.010)$. The dummy variable takes the value 1 if the volatility of stock market return during the 250 last days is above 0.010. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.2134***	0.3403***	0.2578***	0.2199***
	(9.56)	(5.20)	(9.15)	(4.99)
Stock return*I($\sigma_{s,t} > 0{,}010$)	-0.1947***	0.1337**	-0.0390	-0.0444
	(-7.95)	(1.98)	(-1.24)	(-0.91)
Number of observations	3151	3151	3151	3151
R^2	0.0106	0.0360	0.0315	0.0083

Appendix 7

Appendix 7. 1 Regression 3: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(5\%)}) + \beta_2^m r_{s,t} I(r_{s,t} < r_{(5\%)}) I(skew_{s,t} < 0) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and two dummy variables. The first is $I(r_{s,t} < r_{(5\%)})$ and takes the value 1 if the stock market return is below $r_{(5\%)}$. The second is $I(skew_{s,t} < 0)$ and takes the value 1 if skewness in stock returns during the last 250 days is negative. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0483***	0.2377***	0.2076***	0.1172***
	(5.61)	(9.29)	(12.67)	(6.19)
Stock return*I($r_{s,t} < r_{(5\%)}$)	-0.1714***	-0.2037***	-0.1514***	-0.1153
	(-4.02)	(-3.33)	(-3.27)	(-1.30)
Stock return*I($r_{s,t} < r_{(5\%)}$)*I($skew_{s,t} < 0$)	0.2243***	0.5086***	0.0749*	0.1772*
	(5.26)	(9.60)	(1.70)	(1.92)
Number of observations	6030	6030	6030	6030
R^2	0.0032	0.0202	0.0175	0.0041

Appendix 7. 2 Regression 3: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(10\%)}) + \beta_2^m r_{s,t} I(r_{s,t} < r_{(10\%)}) I(skew_{s,t} < 0) + \varepsilon_t^m$, sample period 1987-2011. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return ($r_{s,t}$) and two dummy variables. The first is $I(r_{s,t} < r_{(10\%)})$ and takes the value 1 if the stock market return is below $r_{(10\%)}$. The second is $I(skew_{s,t} < 0)$ and takes the value 1 if skewness in stock returns during the last 250 days is negative. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0441***	0.2308***	0.2062***	0.1187***
	(4.95)	(8.54)	(11.79)	(5.97)
Stock return*I($r_{s,t} < r_{(10\%)}$)	-0.1726***	-0.1930***	-0.1783***	-0.1957**
	(-4.94)	(-3.19)	(-4.16)	(-2.43)
Stock return*I($r_{s,t} < r_{(10\%)}$)*I($skew_{s,t} < 0$)	0.2440***	0.4881***	0.1452***	0.3308***
	(7.05)	(9.70)	(3.70)	(4.14)
Number of observations	6030	6030	6030	6030
R^2	0.0054	0.0215	0.0190	0.0052

Appendix 7. 3 Regression 3: $r_{m,t} = \alpha^m + \beta_0^m r_{s,t} + \beta_1^m r_{s,t} I(r_{s,t} < r_{(1\%)}) + \beta_2^m r_{s,t} I(r_{s,t} < r_{(1\%)}) I(skew_{s,t} < 0) + \varepsilon_t^m$, sample period 1999-2011.. The dependent variable $r_{m,t}$ is the return from one of the four metals. The independent variables consists of the stock market return $(r_{s,t})$ and two dummy variables. The first is $I(r_{s,t} < r_{(1\%)})$ and takes the value 1 if the stock market return is in the lowest percentile of the return distribution. The second is $I(skew_{s,t} < 0)$ and takes the value 1 if skewness in stock returns during the last 250 days is negative. The regressions are run on daily data and fitted to a GARCH(1/1)-model. * denotes significance at 1%, ** at 5% and * at 10%, t-statistics are reported in parenthesis.**

	Dependent variables			
	Gold	Palladium	Platinum	Silver
Independent variables				
Stock return	0.0859***	0.3779***	0.2571***	0.1776***
	(7.78)	(11.54)	(14.71)	(7.91)
Stock return*I($r_{s,t} < r_{(1\%)}$)	-0.1778	-0.3133	-0.2282	-0.3513
	(-1.33)	(-1.59)	(-1.15)	(-1.23)
Stock return*I($r_{s,t} < r_{(1\%)}$)*I($skew_{s,t} < 0$)	0.1843	0.6113***	0.1260	-0.0991
	(1.37)	(3.16)	(0.64)	(-0.35)
Number of observations	3151	3151	3151	3151
R^2	0.0048	0.0343	0.0021	0.0030

Appendix 8

Appendix 8. 1 Results of Shapiro-Wilks test for normality and Dickey-Fuller test for unit root on asset return distributions. The null hypothesis for Shapiro-Wilks is that the data is normally distributed. The null hypothesis for Dickey-Fuller is that the data contains a unit root and therefore is non-stationary. Both null hypotheses are rejected.

	Shapiro-Wilks				Dickey-Fuller	
Asset	W	V	z	Prob>z	Z(t)	Prob>Z(t)
Gold	0.9133	287.3720	14.9560	0	-73.4940	0
Palladium	0.9035	319.9760	15.2400	0	-67.4260	0
Platinum	0.9147	282.7980	14.9140	0	-71.8020	0
Silver	0.9197	266.2090	14.7540	0	-75.2770	0
Stocks	0.8984	336.9780	15.3770	0	-68.0940	0