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Is gold still a safe haven?

This study was prepared under the authority of the Directorate General of the Treasury (DG Trésor) and does not necessarily reflect the position of the Ministry for the Economy, Finance and Industry.

- Since the inception of the financial crisis, the price of gold has evolved as a safe haven, i.e., an asset whose return is uncorrelated or negatively correlated with the return on another asset in periods of financial market tensions: the performance of gold, the price of which has risen from $650 per ounce ($650/oz) in June 2007 to close to $1650/oz in April 2012, thus contrasts with the performance of riskier assets (see chart below), such as the MSCI World Index of developed stock markets (MSCI World), which has fallen by 18% over the period.

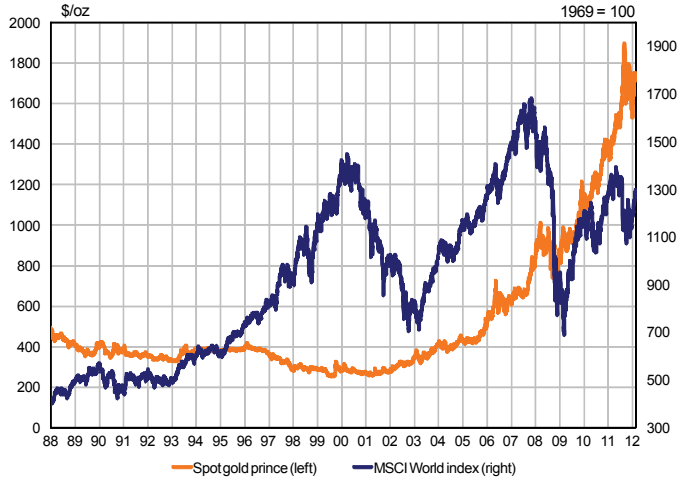
- The recent evolution of the gold price, however, does not appear to be consistent with the safe-haven assumption: after peaking at over $1950/oz in September 2011, the price of gold trended downward, in tandem with risky assets, in Q4 2011.

- This apparent shift can be explained by increased financial market tensions, which were very strong in autumn 2011, and the appreciation of the dollar, the currency in which gold is denominated.

- An econometric analysis suggests that the gold price behaves differently, depending on the degree of financial stress. In periods of moderate stress, gold is indeed a safe haven, as the return is negatively correlated with stock returns. On the other hand, in periods of extreme stress, stock and gold returns are generally positively correlated, probably because investors are then forced to reduce their positions on gold, a liquid asset, to cover their losses on other asset classes.

- The recent decline in the gold price may also be linked to the appreciation of the dollar: gold can act as a hedge against currency exposure for investors holding dollar-denominated assets. The negative correlation between the return on gold and the USD exchange rate is particularly pronounced in periods of very high volatility, when it is close to unity for some currency pairs (dollar-euro and dollar-Swiss franc).

Spot gold price and MSCI World Index



Source: Data Insight.

1. Since the inception of the crisis, global gold demand has risen by 17%, strongly driven by investors' demand

Gold is at once a metal with industrial applications, a monetary asset with properties as a store of value, and a liquid financial asset. Since the start of the crisis, gold demand has been fostered by demand from investors.

1.1 The supply of gold has reached a ten-year high, driven by new mine production and recycling rendered attractive by higher gold prices

The supply of gold increased by 17% between 2007 and 2011 (table 1), and came to 4067 tonnes ($206 billion) in 2011, the highest level since 2000. **Mine production and recycled gold have made positive contributions to the growth since 2007, while the contribution by central banks has been negative**.

Mine production accounted for 70% of supply in 2011, with China, Australia, the U.S., South Africa, and Russia providing roughly half of production (table 4). Recycled gold, the second source of supply in 2011, has accounted for a rising percentage since 2007, largely due to higher gold prices, which have stimulated recycling.

Central banks are no longer contributing to supply. Their gold sales, which accounted for 15% of supply between 2000 and 2007, have fallen sharply since 2007, and central banks actually became net buyers of gold in 2010 for the first time in twenty years. This development is attributable to (a) continued purchases by central banks in emerging-market economies (e.g., Russia and Mexico) that are diversifying reserves primarily held in foreign currencies, and (b) the drying of gold sales by central banks in Europe, which, after contributing 10% of the annual supply over the past decade, have virtually ceased sales since the start of the crisis.

Table 1: Global gold supply and demand, 2007 and 2010

	2007	2010	Growth between 2007 and 2010 (%)	Contribution to growth (percentage points)
Global gold supply (tonnes)				
Minde production	2 031	2 822	38.9	22.8
Institutional sales	484	−440	−190.8	−26.6
Recycled gold	956	1 612	68.6	18.9
Total sypply	**3 471**	**4 067**	**17.2**	
Global gold demand (tonnes)				
Jewellery	2 405	1 963	−18.4	−12.7
Technology	466	464	−0.3	0.0
Electronics	315	330	4.9	0.4
Other industrial	93	89	−4.2	−0.1
Dentistry	58	44	−24.1	−0.4
Investment	685	1 641	139.5	27.5
Bar and coin demand	432	1 487	244.2	30.4
ETFs and similar products	253	154	−39.1	−2.9
Other[a]	−85	−73	-	0.3
Total demand	**3 471**	**4 067**	**17.2**	

a. Includes institutional investment other than ETFs and similar, stock movements and other elements as well as any residual error.

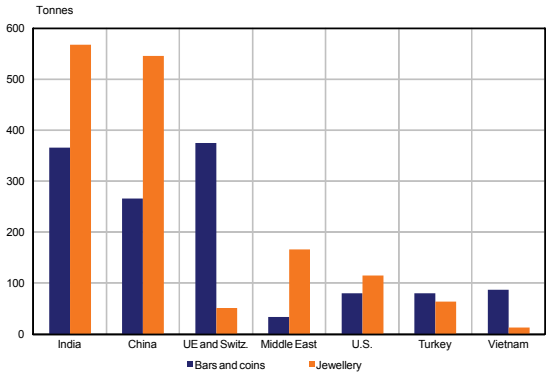
Source: World Gold Council, DG Trésor calculations.

1.2 Growth in demand since 2007 has been driven strongly by investment demand

Since 2007, gold demand has been boosted by investment demand, while demand from jewellery and technologies have been negative and nil, respectively (table 1).

Jewellery demand (54% of global demand) has fallen in recent years, as a result of the deterioration of the economic situation. Demand in the sector is dominated by India and China (chart 1), which accounted for 30% and 28% of jewellery demand, respectively, in 2011. While jewellery remains the leading source of demand, its decline since the start of the 2000s (chart 2) may be explained by changes in the Asian economies. According to the International Gold Council, jewellery demand is traditionally driven by rural populations seeking a store of value. Higher gold prices have recently driven those populations from the market, while urbanization and the emergence of a middle class could explain the growth in financial instruments for investing in gold, which are more accessible to urban populations.

Chart 1: Gold demand by country, 2011

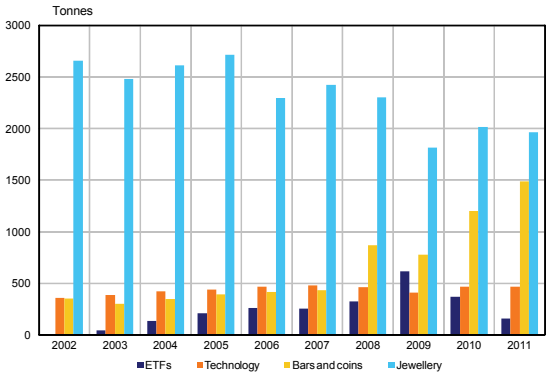


Source: World Gold Council.

Investment was the second source of demand (40% of total demand in 2011), and the key driver during the crisis. Demand for bars and coins accounted for 28% of total demand in 2010. India, China and the U.S. account for 50% of investment demand (chart 1); this includes gold for the inventories that are the underlying metal for gold-backed contracts on commodity exchanges. Investment in ETFs (exchange traded

funds),[1] which did not exist before the early 2000s, rose by 45% between 2007 and 2010, before declining in 2011, and accounted for 4% total of demand in 2011 (chart 1).

Chart 2: Changes in the components of global gold demand since 2001



Source: World Gold Council.

The industrial and medical sectors have contributed little to changes in demand, accounting for 11% and 1% of total demand, respectively. Industrial demand (electronics and connectors) has been relatively stable over the entire 2000s decade. Despite the crisis, demand for semiconductors has remained strong, driven mainly by consumer electronics (e.g., tablets and smartphones). Medical (dentistry) demand is declining, as gold is replaced by ceramic materials.

1.3 The bulk of the global stock of gold is held in the form of jewellery and, to a lesser extent, central bank reserves

All told, the global stock of gold is estimated by the World Gold Council at 160,000 tonnes, of which 60% is in the form of jewellery, and 20% for industrial and dental use. The institutional sector holds 18%, with the U.S. and European countries holding 60% of central bank gold reserves, which is considered a legacy of the gold standard.

2. The rise in the price of gold can be attributed mainly to its status as a safe haven in periods of crisis

Short-term fluctuations in the gold price can be attributed to four factors: appreciation or depreciation of the dollar, the return on other assets, inflation expectations, and macroeconomic surprises. But the relationship between the price of gold and the variables with which it is correlated is not stable over time.

2.1 Macroeconomic surprises can affect gold prices, but the impact appears to be short-term and dependent on the position in the cycle

The findings of studies of the impact of macroeconomic news on gold prices diverge, and are sensitive to the frequency of observations: some studies conclude that the price of gold is positively affected by macroeconomic announcements for, e.g., employment, GDP and consumer prices in the U.S.,[2] whereas other studies[3] suggest that the gold price does not respond to macroeconomic surprises, i.e., the release of numbers that do not meet expectations. Further, macroeconomic surprises seem to have a very short-term impact[4] and to depend on the position in the cycle.[5] Commodity prices could be positively affected by good macroeconomic surprises only during a recession, when positive indicators point ahead to increased demand for industrial commodities, while a rise in expected inflation stimulates demand for commodities seen as a hedge against inflation. On the other hand, during periods of expansion, the same developments augur monetary tightening and would have a negative impact on commodity prices.

2.2 Inflation expectations can affect the price of gold

While the price of gold tends to rise as the general price level rises, the relationship between the gold price and inflation is not stable over time. Some market analysts[6] consider that the price of gold and inflation are positively correlated in the short term, and that an upward revision of inflation expectations encourages investors to buy gold, a strategy that could be explained by expectations of a decline in the value of nominal cash on hand, or of a rise in the nominal price of gold owing to inflation pressures. However, the relationship between the price of gold and inflation does not appear to be stable over time:[7] while in the very long run (a century), gold is a hedge against inflation, the relationship does not hold over the most recent years. The relationship between the price of gold and inflation is therefore not examined in this paper, as no stable cointegration relationship could be found; the sharp rise in the price of gold since 2007 appears to be decorrelated from inflation.

2.3 Monetary conditions can affect the cost of investing in gold

The relationship between inflation and the price of gold can be transmitted via interest rates (Blose, 2010). A rise in inflation expectations affects the yield curve, as incorporating an inflation premium would tend to raise interest rates, whereas expectations of monetary tightening can affect the level of future expected interest

(1) ETFs allow investors to hold securities that track the performance of gold, without incurring the logistics costs (physical metal storage, delivery) associated with other instruments (options, futures). Essentially, fund managers acquire a quantity of physical gold, which is the basis for issuing exchange traded securities. The pricing of the securities is based on the gold spot price, multiplied by the quantity of metal underlying the security (after subtracting management fees).

(2) Christie-David, R., Cheung, Y-L., Wong, M.C.S, (2001), "What moves the gold market?", *Journal of Futures Markets 21*, pp. 257-278.

(3) Roache, S.K., Rossi M., (2010), "The Effects of Economic News On Commodity Prices: Is Gold Just Another Commodity?", *The Quarterly Review of Economics and Finance*, 50, pp. 377-385.

(4) Elder, J., Miao, H., Ramchander, S., (2011), "Impact of Macroeconomic News on Metal Futures", *Journal of Banking and Finance*, 36, pp. 51-65.

(5) Hess, D., Huang, H., Niessen, A., (2008), "How Do Commodity Futures Respond to Macroeconomic News?", *Financial Markets and Portfolio Management*, 22, pp. 127-146.

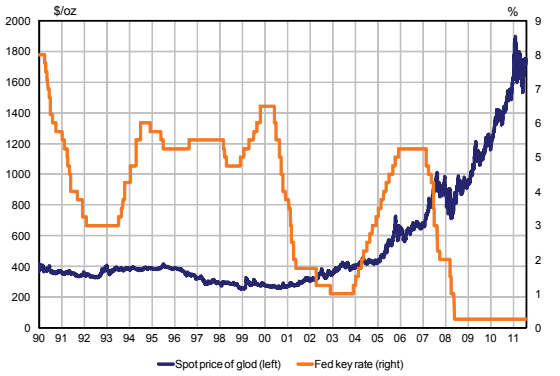
(6) Blose, L.E., (2010), "Gold prices, cost of carry and expected inflation", *Journal of Economics and Business*, 62, pp. 35-47.

(7) Ghosh D., E.J. Levin, P. Macmillan, R.E. Wright, (2004), "Gold as an inflation hedge?", *Studies in Economics and Finance*, 22, pp 1-25

rates, the series of which forms the yield curve, in keeping with the expectations theory of the term structure of interest rates. Investment in the gold market can prove beneficial when interest rates are expected to rise. Monetary tightening in period *t+1* makes investing in bonds unattractive in period t: an interest rate hike in the second period would lower the price of fixed-rate instruments acquired in the first period. This argument is consistent with the strong demand for gold since 2007 from the emerging-market economies (India, China), where inflation pressures led to monetary policy tightening.

The level of interest rates also affects the real cost (if financed by credit) **or the opportunity cost** (if financed by own funds) **of investing on the gold market**. On the spot market, a drop in interest rates reduces the acquisition cost of gold, and is capable of stimulating demand. Accommodative monetary policy in the advanced countries since 2008 may also have favored demand growth.

Chart 3: Gold spot price and the U.S. key interest rate



Source: Data Insight, Fed.

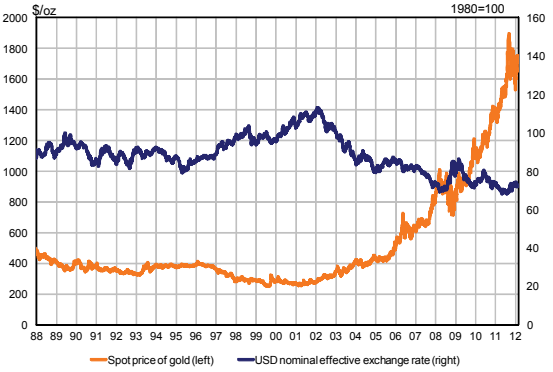
Monetary policy does not however appear to be the only explanatory factor. While the interest rate cutting cycles in the U.S. that began in 2000, and then in 2007, indeed went in tandem with a rise in gold prices, the hike in Fed funds rate between 2004 and 2006 did not prevent the rise in gold prices over the period (chart 3). The current run-up in the price of gold is thus probably due to the combination of accommodative monetary conditions in the advanced countries and the low return on other low-risk assets.

2.4 The price of gold also depends on the price of other assets

The price of gold can be affected by the price of other assets, notably in periods of financial market tensions: investors may then seek to diversify their portfolios to reduce exposure, and seek low-risk, liquid assets like gold to counterbalance underperformance by risky assets. Thus the price of gold appears negatively correlated to the return on the MSCI World Index[8] in periods of financial market tensions (see chart on front page), e.g., in the 2000-2003 period characterized by a fall in equity indices after the bursting of the internet bubble and the 2001 U.S. recession. That negative correlation is not observed outside of periods of financial stress; from 2003 to 2007, gold and the MSCI Index rose in tandem.

Gold price fluctuations can also be affected by fluctuations in the exchange rate of the dollar, the currency in which gold is denominated. The nominal price of gold thus tends to rise when the dollar depreciates, thus preserving the real value of gold: the nominal depreciation of the dollar since 2009, for example, coincided with the rise in the price of gold (chart 4). As the price of gold is denominated en dollars, gold can act as a hedge against currency exposure for investors holding dollar-denominated assets.[9]

Chart 4: Gold spot price and USD nominal effective exchange rate



Source: Data Insight, Fed.

The relationship between the price of gold and the dollar is not stable over time: a preliminary statistical analysis suggests that the negative correlation between the price of gold and the dollar has increased since 2007: a break in the trend is identified in September 2007, prompting a more detailed examination of the relationship between the price of gold and the price of other assets since the start of the financial crisis.

(8) The MSCI World Index reflects the stock market performance of 24 developed markets (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the UK, and the U.S.).

(9) Capie, F., Mills, T.C., Wood, G., (2005), Gold as a hedge against the dollar. *Journal of International Financial Markets, Institutions and Money* 15, 343-352.

3. Gold turns out to be a safe haven stocks in periods of high volatility, but not in periods of extreme volatility

The financial properties of gold are tested econometrically against two asset classes, with a distinction between periods of different intensities of financial market tensions.

3.1 Distinguishing between periods of greater or lesser volatility suggests the existence of nonlinearities in the relationship between the return on gold and the return on risky assets

Many analysts attribute the rise in the price of gold since 2007 to its status as a safe haven. More specifically, three types of assets can be distinguished: safe havens, hedging instruments, and diversifiers.[10]

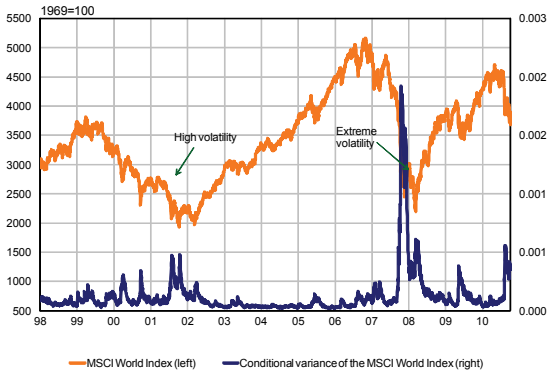
- A **safe haven** is an asset the price of which is negatively correlated or uncorrelated with the price of another asset (or asset portfolio) during specific periods of time (and not on average), notably in periods of financial market tensions.
- An asset is considered a **strong-form hedge** (a **weak-form hedge**) when its return is negatively correlated (uncorrelated) with the return on another asset on average, without distinction between periods of high and low volatility.
- A **diversifier** is an asset whose return is positively but imperfectly correlated with the return on other assets on average. The recent trend in gold prices, however, does not appear to be consistent with the safe-haven assumption: after peaking at over $1950/oz in September 2011, gold and risky assets both moved lower in Q4 2011.

To determine under what conditions gold is a safe haven, its properties (as a safe haven, diversifier, or hedge) are tested econometrically against two asset classes: stocks and exchange rates.

The analysis examines the years 2001-2011, when gold was in a rising trend (chart on front page), after the price had fallen through 2000.

Periods of tensions (chart 5) on stock markets (on currency markets) are identified using the conditional variance (box 1) of the MSCI World Index (of the USD effective exchange rate): periods associated with a high variance (very high variance) are called periods of high volatility[11] (extreme volatility). The analysis of the financial properties of gold is based on the econometric model described in box 1.

Chart 5: Return and conditional variance of the return on the MSCI World Index



Source: Date Insight, DG Trésor calculations.

3.2 On average over the 2001-2011 period, gold is a hedge against the dollar and des advanced countries' stock returns, and a diversifier relative to emerging-market indices

Gold is a hedge against advanced economy stock indices: on average over the 2001-2011 period, the return on gold is negatively correlated with returns on European and North American regional indices (table 2, column 3), and with the return on German, U.S., French, Italian, UK and Swiss national indices. The conclusions are the same, whether the indices are denominated in dollars (reflecting the viewpoint of a U.S. investor) or in domestic currencies (reflecting the viewpoint of national investors), so the findings are not influenced by any "currency" effect.

Gold is a diversifier relative to the stock returns in emerging-market economies (table 2): there is a positive correlation between the return on gold and returns on the regional indices (for the BRICs as a region, and the Emerging Asia index). The return on gold is positively correlated with stock returns in Australia, in China, and in Russia - three gold-producing countries. This positive correlation may be explained by the share of the mining sector in the national indices, whose returns move in tandem with commodity prices.

(10) Baur, D., Lucey, B., (2006), "Is Gold a Hedge or a Safe Haven? An Analysis of Stocks, Bonds and Gold", Institute for International Integration Studies, *Discussion Paper* No. 198.

(11) The high-volatility periods correspond to points in July, August and October 2002; in September, October, November and December 2008; in January, February, March and April 2009; and in August, September, October, November and December 2011, or a total of 180 points, in the 90th quantile of the distribution of the conditional variance of the MSCI Index. The extreme-volatility periods correspond to October and December 2008; March and April 2009; and August 2011, or a total of 90 points, in the 97th quantile of the distribution of the conditional variance of the MSCI Index.

Table 2: Correlations between gold returns and MSCI stock index returns

Stock returns	Volatility > 90 %		Volatility > 97 %		Mean coefficient	
	Coefficient β5	Z-statistic	Coefficient β4	Z-statistic	Coefficient β6	Z-statistic
Regional indices ($)						
MSCI World	**−0.07**	**−2.46**	**0.33**	**3.10**	**0.04**	**2.96**
North America	**−0.09**	**−3.84**	**0.22**	**2.10**	**−0.03**	**−2.63**
Asia	0.00	−0.13	−0.05	−0.84	**0.03**	**2.87**
Europe (EMU)	**−0.09**	**−3.63**	**0.21**	**2.76**	**−0.04**	**−4.26**
Latin America	**−0.06**	**−2.25**	0.06	0.96	0.01	0.73
G7	**−0.08**	**−2.72**	**0.34**	**3.07**	0.00	−0.09
BRIC	0.00	0.04	−0.11	−1.60	**0.20**	**13.04**
National indices (national currencies)						
Germany	**−0.08**	**−3.65**	0.02	1.02	**−0.03**	**−3.66**
Australia	0.00	0.04	0.09	1.74	**0.07**	**4.18**
Brazil	**−0.04**	**−1.93**	0.07	1.39	0.00	0.47
Canada	**−0.06**	**−1.99**	**0.21**	**4.01**	**0.03**	**2.03**
China	−0.02	−0.93	−0.04	−0.36	**0.04**	**5.09**
European Union	**−0.10**	**−4.08**	0.01	0.18	**−0.04**	**−3.09**
France	**−0.08**	**−3.56**	0.02	0.43	**−0.06**	**−5.83**
India	0.00	0.08	**−0.09**	**−2.31**	**0.03**	**3.77**
Italy	**−0.07**	**−2.99**	0.01	0.25	**−0.06**	**−5.56**
Japan	0.02	0.70	0.05	0.91	**0.04**	**3.02**
UK	**−0.11**	**−3.81**	−0.01	−0.20	**−0.03**	**−2.51**
Russia	0.01	0.37	**0.14**	**3.10**	**0.04**	**5.73**
Switzerland	**−0.10**	**−3.65**	**0.02**	**0.32**	**−0.07**	**−5.71**

Reading the table: This table sets out the results of the estimations described in box 1. In periods of high volatility, a 1-percent rise (fall) in the return on the World MSCI index is associated with a fall (rise) of 0.07% in the return on gold[12]. Coefficients that are significant at the 5-percent level are in bold; coefficients that are significantly negative are in red, and those that are significantly positive are in green.

Gold is a hedge against the dollar: its return is negatively correlated or uncorrelated with variations in the principal bilateral exchange rates on average (table 3).

Tableau 3 : correlations between the return on gold and les variations des USD bilateral exchange rates

Exchange rates	Volatility > 90 %		Volatility > 97 %		Mean coefficient	
	Coefficient β5	Z-statistique	Coefficient β4	Z-statistique	Coefficient β6	Z-statistique
Australian dollar	**−0.14**	**−3.59**	**−0.38**	**−2.28**	**−0.29**	**−18.02**
Canadian dollar	**−0.32**	**−5.69**	**−0.06**	**−2.95**	**−0.28**	**−11.62**
Euro	**−0.37**	**−6.08**	**−0.83**	**−4.11**	**−0.33**	**−17.99**
Swiss franc	**−0.47**	**−7.43**	**−0.87**	**−3.57**	**−0.33**	**−18.76**
Brazilian real	−0.04	−1.01	−0.14	1.31	−0.02	−1.70
Indian rupee	**−0.48**	**−6.26**	−0.04	0.11	**−0.44**	**−10.39**
Russian ruble	**−0.36**	**−6.20**	**−0.87**	**−2.37**	**−0.16**	**−6.33**
Sterling	**−0.29**	**−4.85**	**−0.55**	**−2.32**	**−0.35**	**−15.22**
Yen	**−0.25**	**−4.20**	**−0.56**	**−1.98**	**−0.15**	**−7.99**

Reading the table: This table sets out the results of the estimations described in box 1, with the return on gold as the dependent variable and variations in bilateral exchange rates as the explanatory variable. Exchange rates are quoted in foreign-currency units per U.S. dollar ($1= x units of foreign currency): a rise in the exchange rate corresponds to appreciation of the dollar. In periods of high volatility, appreciation of 1% of the dollar against the euro is associated with a 0.37% fall in the return on gold. Coefficients that are significant at the 5-percent level are in bold; coefficients that are significantly negative are in red; and those that are significantly positive are in green.

3.3 In periods of high volatility, gold is a safe haven relative to advanced economy and emerging market stock indices

In periods of high volatility, gold is a strong safe haven relative to advanced economy stock indices, as suggested by the significantly negative coefficients (table 2, column 1) associated with the stock index returns, whether denominated in dollars (the North American and European regional indices, and the world index) or in national currencies (Germany, Canada, U.S., France, Italy, Switzerland and the UK).

Gold is also a safe haven, but in a weak form, relative to emerging market stock indices. This finding holds for regional indices (for the BRIC countries as a whole, i.e., Brazil, Russia, India and China, and for the Emerging Asia index) and for national indices (in India, Russia, and China), as suggested by coefficients not significantly different from zero (table 2, column 1).

(12) Gold pays no dividends, so the return on gold is the difference in the gold price between two periods. Data are indicated as the daily change in the natural logarithms of the prices.

3.4 In periods of extreme volatility, gold is positively correlated with stock returns, and does not appear to serve as a safe haven

In periods of extreme volatility, stock and gold returns are positively correlated: gold no longer appears to be a safe haven (table 2, column 2). These results are reported in the literature (Baur and Lucey, 2006) and are consistent with the trends observed in Q4 2011, when gold and stocks both moved lower against a backdrop of strong uncertainties regarding economic activity and public finances. This positive correlation in periods of high volatility could be explained by the need for investors to liquidate some of their holdings in gold-a liquid asset-to cover losses on other asset classes and meet margin calls.[13]

The correlation between the return on gold and the U.S. dollar exchange rate remains negative in periods of very high volatility, unlike the correlation between gold and stock returns. This correlation is more pronounced in periods of above-average volatility (table 3, column 2). Other studies have reached the same conclusion.[14] The correlation is actually close to one for some currency pairs (dollareuro, and dollarSwiss franc). The magnitudes are also greater than those observed for the relationship between gold and stock returns.

In periods of moderate tension on financial markets, gold is indeed a safe haven. On the other hand, in periods of extreme stress, stock and gold returns are positively correlated, probably due to investors' need to liquidate part of their gold positions to cover losses on other asset classes.

Easing tension on financial markets since early 2012 could foreshadow a pickup in the rise of the price of gold, which would recover its status as a safe haven in periods of moderate stress.

Box 1: **GARCH estimation of gold's safe haven properties**

The analysis of the financial properties of gold is based on GARCH estimations on daily data, to identify the volatility of the variance over time (heteroskedasticity) and the alternating low-volatility and high-volatility periods characteristic of the financial series. High-volatility periods are identified using the conditional variance of the MSCI World Index, estimated by a GARCH(1.1) model. The indicators d_90, d_95 and d_97 are equal to one when the conditional variance of the MSCI Index is bounded by the 90th, 95th and 97th quantile thresholds of the distribution of the conditional variance.

A first estimation examines the correlation of gold and stocks over four subperiods characterized by higher levels of volatility.

$$r_{or,t} = c + \beta_1 s_t \times d{<}90 + \beta_2 s_t \times d{-}90 + \beta_4 s_t \times d{-}95 + \beta_4 s_t \times d{-}97 + \varepsilon_t \quad (1)$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon^2 t - 1 + \theta_1 \sigma_{t-1}^2 \quad (2)$$

The GARCH model is based on estimation of expected return (1) and the variance (2) of the return on gold, in which the variance is conditional on past information, with r_t the return on gold and s_t the return on the MSCI Index as differences of logarithms, and the residual, ε_t. The conditional variance (2) is a function of a constant α_0, corresponding to the long-term mean of the variance, new information available in period *t*, captured by the square of the residual ε_t^2 and the forecast of the conditional variance.

A second estimation underscores the correlation between gold and stock returns in periods of volatility, when the conditional variance of the stock market index exceeds the 90th quantile threshold.

Data are indicated as the daily change in the natural logarithms of the prices on consecutive trading dates.

$$r_{or,t} = c + \beta_1 s_t \times d{<}90 + \beta_5 s_t \times d{>}90 + \varepsilon_t \quad (3)$$

A significantly negative (zero) coefficient implies that gold is a strong-form (weak-form) hedge.

To analyze the properties of gold as a hedge, the conditional expectation is estimated without distinction between periods of high and low volatility.

$$r_{or,t} = c + \beta_6 s_t + \varepsilon_t \quad (4)$$

A negative (zero) coefficient over the entire period suggests that gold is a hedge.

The examination of the financial properties of gold relative to the dollar is performed in the same way, substituting variations in bilateral exchange rates for stock returns.

Because the data are non-normal, the expected return and variance equations are estimated simultaneously by maximum pseudo-likelihood in order to compute standard deviations that are robust to non-normality. The skewed, leptokurtic distribution (peak at zero and fat tails) is taken into account by using a generalized error distribution (GED) for the estimations.

Violaine FAUBERT,

(13) A clearing house centralizes counterparty risk on organized futures markets. To manage counterparty risk, participants pay an initial margin deposit, the amount of which is determined with reference to market volatility, as a percentage of the nominal value of the contract. There are also daily margin calls, which are intended to restore the margin if it was affected by market fluctuations. Margin calls require participants to immediately deposit additional funds (in cash or collateral) to cover losses on an open position. If a participant buys 100 futures contracts at $100 in the morning, and they are worth only $90 at the close, then the clearing house withdraws $(100-90)*100 = $1000 from the margin account or, if the margin account does not have sufficient funds, demands payment before the market opens the following day. When a participant is unable to meet a margin call, the position is liquidated.

(14) See Joy M. (2011), "Gold and the US dollar: hedge or haven?", *Finance Research Letters*. The magnitudes estimated in this paper are generally higher than those estimated par Joy (2011), notably in periods of high volatility; this may be attributable to the difference in sampling periods (1986-2008 for Joy, and 2001-2011 here). These results are consistent with Joy's observation that the negative correlations between gold and exchange rates increased over the 2000s.

Appendix

Table 4: Mine production and estimated gold reserves in 2011

	Production (tonnes)	% of global production	Reserves (tonnes)	% of global reserves
China	355	13.1	1 900	3.7
Australia	270	10.0	7 400	14.5
European Union	237	8.8	3 000	5.9
Russia	200	7.4	5 000	9.8
South Africa	190	7.0	6 000	11.8
Peru	150	5.6	2 000	3.9
Canada	110	4.1	920	1.8
Indonesia	100	3.7	3 000	5.9
Uzbekistan	90	3.3	1 700	3.3
World total	2 700	100.0	51 000	100.0

Source: US Geological Survey 2011, DG Trésor calculation.

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