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Gold and financial assets: are there any safe havens in bear markets?

Virginie Coudert & Hélène Raymond

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GOLD AND FINANCIAL ASSETS: ARE THERE ANY SAFE HAVENS IN BEAR MARKETS?

NON-TECHNICAL SUMMARY

The current crisis has clearly renewed the interest in gold as a possibly good investment in times of financial turmoil. Indeed, the surge in the price of gold while stocks prices plummeted in 2008 hints at a safe haven role. A safe haven can be broadly defined as an asset allowing the preservation of wealth during periods of financial turmoil. After having reviewed several possible definitions, we go for characterizing safe havens by their negative correlations with risky assets specifically during crises.

We then argue that gold can qualify for being a safe haven for several reasons. To start with, its image to the public, as well as to investors, makes it an ultimate resort in very troubled times, as it still owes to its historical role as a standard of exchange in the international monetary system along the centuries. Furthermore, gold is a liquid asset, continuously quoted on spot and futures markets and easy to trade. It is also an international asset, the value of which is independent of the decision of a particular State. Last but not least, gold does not co-move with stocks in case of extremely negative returns on stocks, according to recent papers by Baur and Lucey (2010) and Baur and McDermott (2010).

We take stock of these former papers and try to extend their results mainly in three ways. First, we identify crisis periods by exogenous methods, considering successively recessions and bear stock markets. As regards to recessions, we use the NBER dating procedure. Commodity futures have been shown to outperform stocks during recessions (Gorton and Rouwenhorst, 2006). We find that this result is also true for gold on average. As regards to bear markets, we split bear and bull periods on the US stock market by applying the algorithm proposed by Pagan and Sossounov (2003). Second, we choose a model allowing for time varying conditional covariances between gold and stocks returns. We estimate it on monthly data for gold and several stock market indices (France, Germany, UK, US, G7) over the period 1978:2-2009:1. Third, we test for long run relationships between gold and stocks, and check if these relationships can be used to construct a hedged portfolio able to weather crises.

In the short run we find that the correlation between gold and stocks is close to zero during recessions. This qualifies gold for being a "weak safe haven". This null correlation means an absence of co-movement with stocks, which is an interesting property during crises. Indeed, a more interesting property would be to have significantly negative correlations, which would qualify the asset for being a "strong safe haven". We do find this property for gold during bear markets, if we consider the US stocks and the G7 stocks as a whole. A closer look at the data shows that these results only hold on average, but not for every crisis period in every country. In the longer run, we find a negative relationship between gold and three stock

markets (France, UK, US) and the speed of reversal towards this long run relationship increases during crises. Therefore gold appears as a hedge for stocks in the long run and the reversal towards this long run equilibrium not only holds, but increases during crises. However, using this long run relationship to construct a hedged portfolio - mixing gold and stocks - does not allow to over-perform constantly an undiversified portfolio of stocks only during all crises. Overall, gold appears as an interesting asset to diversify away from stocks, but remains a risky investment.

ABSTRACT

This paper looks into the role of gold as a safe haven against stocks during recessions and bear markets. Following Baur and McDermott (2010) and Baur and Lucey (2010), we characterize safe havens by their negative correlations with stocks during crises. We extend their results in three ways. First, we identify crisis periods by exogeneous means using, successively, recession periods provided by the NBER and periods of bear US stock markets. Second, we estimate a model allowing for time varying conditional covariances between gold and stocks returns. Third, we test if long run relationships exist between gold and stocks and explore whether they can be used to construct portfolios immune to crises. The regressions are run on monthly data for gold and several stock market indices (France, Germany, UK, US, G7) over the period 1978:2-2009:1. In the short run, we find that the correlation between gold and stocks is close to zero during recessions, which qualifies gold for being a "weak safe haven". This is also the case during bear markets against the stock indices of most considered countries, although gold appears as a strong hedge versus the US stock index. A closer look at the data shows that these results only hold on average and not for every crisis episode or every country. In the longer run a negative relationships exists between gold and some stock markets (France, UK, US). However, it does not allow the construction of a hedged portfolio immune to all crises. Overall, despite its interest for the diversification of portfolios, gold stays a risky investment, even during crises.

JEL Classification: G01; G15; F30; F36
Key Words: gold; stock; safe haven; hedge; nonlinearity

L'OR ET LES ACTIFS FINANCIERS : PEUT-ON TROUVER DES VALEURS REFUGES DANS LES MARCHÉS BAISSIERS ?

RÉSUMÉ NON TECHNIQUE

La crise actuelle a renouvelé l'intérêt porté à l'or comme investissement porteur durant les périodes de crises. L'envolée du prix de l'or alors que les prix des actions s'effondraient en 2008 suggère un rôle de valeur refuge. Une valeur refuge peut être définie de façon générale comme un placement qui permet de préserver la richesse pendant les périodes de turbulences économiques et financières.

L'or semble constituer une valeur refuge pour plusieurs raisons. Tout d'abord, l'or fait figure d'un placement en dernier ressort en cas de tensions économiques, financières ou politiques. Cela peut s'expliquer par son rôle monétaire historique dans le cadre du système monétaire international. Ensuite, l'or est un actif liquide, coté en continu sur les marchés comptant et à terme et facile à échanger. C'est aussi un actif international, dont la valeur n'est pas tributaire de la conjoncture économique et politique d'un État particulier. Enfin, selon des articles récents de Baur et Lucey (2010) et Baur et McDermott (2010) l'or ne co-varie pas avec les actions lorsque les cours de celles-ci s'effondrent.

L'objet de notre travail est de préciser le rôle de l'or comme valeur refuge contre les moins values sur actions durant les récessions et les krachs boursiers. À la suite de Baur Lucey (2010) et Baur et McDermott (2010), nous caractérisons les valeurs refuge par leurs corrélations négatives avec les actions durant les crises. Nous étendons leurs résultats dans trois directions.

Premièrement, nous identifions les périodes de crises par des méthodes exogènes. En ce qui concerne les récessions, nous reprenons les dates définies par les experts du NBER. Gorton et Rouwenhorst (2006) trouvent, en effet, que les contrats à terme sur matières premières surperforment les placements en actions pendant les récessions. Nous montrons que ce résultat est valable aussi en moyenne sur l'or. Pour ce qui concerne les périodes de baisse boursière, nous les datons en prolongeant sur la période récente les résultats de l'algorithme proposé par Pagan et Sossounov (2003). Deuxièmement, nous choisissons de modéliser la dynamique des rendements de l'or et des actions en tenant compte de la variabilité temporelle de leur covariance conditionnelle. Nous estimons ce modèle pour des données mensuelles sur l'or et divers rendements boursiers (France, Allemagne, RU, EU, G7) sur la période 1978:2-2009:1. Troisièmement, nous testons l'existence de relations de long terme entre l'or et les actions et vérifions si elles peuvent être utilisées pour construire un portefeuille « couvert », qui résiste bien pendant les crises.

À court terme, nous trouvons que la corrélation entre l'or et les actions est proche de zéro durant les récessions ainsi que, globalement, durant les périodes de baisse boursière. Cela qualifie l'or comme valeur refuge au sens faible. Cette corrélation nulle implique une absence de co-mouvements avec les actions qui est une propriété intéressante pendant les crises. Mais une propriété plus intéressante serait d'avoir des corrélations significativement négatives, qui permettraient de qualifier l'or comme valeur refuge au sens fort. Cette propriété est vérifiée, durant les périodes de baisse boursière, vis-à-vis des actions américaines et des actions des marchés du G7 dans leur ensemble. Un examen plus approfondi révèle toutefois que ces résultats sont valables seulement en moyenne, sans tenir systématiquement durant toutes les périodes de crises, ni pour chaque pays. À long terme, nous détectons bien une relation inverse entre l'or et trois marchés d'actions (France, RU, EU) et la convergence vers cette relation s'accélère pendant les crises. Mais cette relation de long terme ne permet pas de construire, à partir d'or et d'actions, un portefeuille qui résiste durant toutes les crises. Au total, l'or apparaît comme un actif intéressant pour diversifier les portefeuilles initialement investis en actions ; il reste toutefois un investissement risqué, y compris en période de crise.

RÉSUMÉ COURT

L'objet de cet article est l'étude du rôle de l'or comme valeur refuge contre les moins values sur actions durant les récessions et les krachs boursiers. À la suite de Baur and McDermott (2010) et Baur et Lucey (2010), nous caractérisons les valeurs refuge par leurs corrélations négatives avec les actions durant les crises. Nous étendons leurs résultats dans trois directions. Premièrement, nous identifions les périodes de crises de façon exogène en utilisant successivement les périodes de récession définies par le NBER et les périodes boursières baissières aux États-Unis. Deuxièmement, nous modélisons les interactions entre les rendements des actions et ceux de l'or en tenant compte de la variabilité temporelle de leur covariance conditionnelle. Troisièmement, nous testons l'existence de relations de long terme entre l'or et les actions et tentons de les exploiter pour construire des portefeuilles « couverts » robustes aux crises. Les régressions portent sur des données mensuelles sur les contrats à terme d'or et divers indices boursiers (France, Allemagne, RU, EU, G7), sur la période 1978:2-2009:1. À court terme, nous trouvons que la corrélation entre l'or et les actions est proche de zéro durant les récessions, ce qui qualifie l'or comme valeur refuge au sens faible. Le même résultat se retrouve globalement durant les périodes de baisse boursière, même si l'or ressort comme une valeur refuge forte (corrélation négative) contre l'indice boursier américain. Un examen plus approfondi révèle que ces résultats tiennent en moyenne et non pas durant chaque période de crise et chaque pays. À long terme, nous détectons une relation négative entre l'or et trois marchés d'actions (EU, France, RU). Mais elle ne permet pas de construire un portefeuille couvert qui résiste durant toutes les crises. En dépit de son intérêt pour la diversification des portefeuilles, l'or reste donc un investissement risqué, y compris pendant les crises.

Classification JEL : G01; G15; F30; F36
Mots-clefs : or; action; valeur refuge; portefeuille "couvert"; non-linéarité

GOLD AND FINANCIAL ASSETS: ARE THERE ANY SAFE HAVENS IN BEAR MARKETS?

Virginie Coudert* & Hélène Raymond**

1. INTRODUCTION

Safe haven assets are particularly sought after during episodes of economic and financial turmoil. In these periods, the prices of risky financial assets tend to plummet simultaneously, through different channels of contagion. Several mechanisms contribute to spreading over the price falls across the board: realized losses on one market forcing investors to withdraw their positions from others, increasing margin calls and the consequent drying-up of liquidity, tighter risk management rules, all these factors are able to promptly trigger sell-offs of risky assets. Conversely, it results in a rush to buy assets perceived as safe, such as T-bills and government bonds, and sometimes also strong currencies, gold or various commodities. As this "flight to quality" takes place (Caballero and Krishnamurthy, 2008), the prices of these safer assets surge. The subprime crisis was no exception: as the prices of risky assets fell dramatically, investors looked for more promising investments opportunities. From 2 July 2007 to 9 March 2009, the S&P500 stock index lost 55%, while gold rallied by 40%.

This ability to offer positive returns during a crisis of such a magnitude has renewed the interest in gold. It has also reactivated the old common knowledge of gold being a safe haven, inherited from its monetary role throughout history. Nevertheless, apart from the studies by Baur and Lucey (2010) and Baur and McDermott (2010), there have been few papers analysing the role of gold during economic and financial crises. Besides, the expression "safe haven" itself is not always clearly defined, for it is commonly used to label very different assets, ranging from money and Treasury Bills, to various risky investments in commodities. In this framework, the objective of this paper is threefold: first, it aims at clarifying the definition of a safe haven asset; second, it tests whether gold functions in the short run as a hedge for stocks and/or a safe haven during crises; third, it explores whether the long run relationship between gold and stocks can help to devise portfolios that weather crises.

* Bank of France, CEPII, and EconomiX-CNRS, University of Paris Ouest-Nanterre, e-mail address: virginie.coudert@banque-france.fr.
** EconomiX-CNRS, University of Paris Ouest-Nanterre, e-mail address: helene-raymond-feingold@u-paris10.fr.
Corresponding authors: SEGMI, 200 av. de la République, 92001 cedex, France. Tel.: +33 40 97 77 80; fax: +33 40 97 77 84.
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A safe haven can be broadly defined as an asset that protects investors' wealth against financial turmoil. Therefore an asset with a stable real value or, at least a stable nominal value, is an uncontroversial safe haven, as it allows its holder to resell it without loss at any time. In this way, money can be seen as a safe haven when financial markets collapse; this was illustrated during the year 2008, when a number of major investment fund managers tilted their portfolios towards cash. Treasury bills and even government bonds issued by low-yield countries also meet this criterion to some extent, as long as they can be held until maturity and their default risk is negligible.

At first sight, gold does not fit this definition of a safe haven, as it is a risky investment with highly volatile returns. However, combining two assets with perfect inverse correlation yields a portfolio with a zero variance around the mean return. Consequently, if a risky asset has a perfect inverse correlation with stocks, adding it to a portfolio of stocks provides a good hedge[1]. In this framework, some risky assets could be considered safe havens, if they have negative correlations with the other assets in the investor's portfolio. One difficulty is that correlations are seldom perfect, are unstable and tend to rise during crises, so that a negative correlation can turn positive during crises. For safe havens, correlations during crises matter much more than overall correlations. That is why Baur and McDermott (2010) and Baur and Lucey (2010) state that risky assets such as gold can qualify as safe havens for an initial portfolio of stocks if they have negative (or at least zero) correlations with stocks during crises.

Market liquidity is also a key property of safe havens, as investors should be able to trade large amounts at any time, without triggering big changes in prices or in the bid-ask spread. Indeed, liquidity is highly sought after during crises, and "flight to liquidity" is likely to be as widely-spread as "flight to quality" (Vayanos, 2004). Another related property is that a safe haven asset should ideally stay marketable even during extreme events, including political turmoil and natural disasters, as well as financial turmoil.

There are several candidates for safe havens. US Treasury bills are generally considered as such; indeed, they match both afore mentioned properties: the stability of their nominal value – as long as held to maturity – and the high liquidity of the market. German bonds play this role as well (Upper, 2000). Some currencies can also be seen as safe havens, since they tend to appreciate during financial turmoil. This is the case for the yen and the Swiss Franc (Ranaldo and Söderlind, 2010), which also matches the results found in the literature on carry-trades (Lustig and Verdelhan, 2008; Burnside *et al.*, 2008). The US dollar does not usually play this role, as noted by Froot and Thaler (1990), but it does happen in very specific times, like the passage to the new millennium (Kaul and Sapp, 2007) or in the immediate aftermath of the bankruptcy of Lehman Brothers in late 2008, when uncertainty about the whole financial system was at its peak (McCauley and McGuire, 2009).

[1] Obviously, the mean return of the portfolio must also be positive: a zero variance portfolio around a negative mean return does not preserve wealth.

Gold appears as a good candidate for being a safe haven for several reasons. (i) Although its nominal value is not stable over time, its historical role as a standard of exchange in the international monetary system may still hint at it as the ultimate resort in very troubled times[2]. Besides, gold could be seen as a hedge against inflation (Jaffee, 1989) – though this point is debatable – which means investing in gold preserves the real value of wealth on average. (ii) It does not co-move with stocks in case of extremely negative returns on stocks, according to Baur and Lucey (2010). (iii) Gold can be considered as a liquid asset, as it is continuously quoted on spot and futures markets and easy to trade[3], (iv) it is also an international asset, the value of which is independent of the decision of a particular State.

In this paper, we take stock of the work by Gorton and Rouwenhorst (2006), who showed that the returns on commodity futures were positive, contrary to those on stocks, during the periods of recessions defined by the NBER[4]. We replicate their calculations on gold futures and confirm that contrary to stocks, gold yields positive returns on average during crises. Gold therefore appears as a good safe haven against stocks. However this result hinges on the precise definition of the period of crisis. The definition of the period of crises is a well known point of dispute of the literature on contagion, as different definitions of crisis periods can heavily impact the results. Baur and Lucey (2010) define periods of crises as days of extreme negative stock returns, whereas Baur and McDermott (2010) also consider three crises episodes arbitrarily dated. We extend their results in three ways. First, we identify crisis periods by exogeneous means using, successively, recession periods provided by the NBER and periods of bear US stock market derived from the implementation of the algorithm by Pagan and Sossounov (2003). Second, we allow for time varying conditional covariances between gold and stocks returns through a bivariate ARMA-GARCH-X modelling. Then, we test the hypothesis of a rupture in the covariance between gold and stock prices across crises and non crises periods. Third, we explore whether a long run negative relationships exists between gold and stocks, that could help to construct a portfolio immune to losses during crises. We use real returns rather than nominal returns to control for the role of inflation and to test for the "real" safe haven property of gold, that is, its ability to preserve real wealth during crises. The regressions are run on monthly data for gold and several stock market indices (France, Germany, UK, US, G7) over the period 1976:2-2009:4. We find that the correlation between gold and stocks is close to zero during recessions, which qualifies gold for being a "weak safe haven". This is also the case during bear markets against the stock indices of most considered countries, although its correlation is significantly negative versus the US stock index. A closer look at the data shows that gold is (weak/strong) safe haven on average and not for every crisis episode or every country. In the long run a negative relationship exists between gold and three stock markets (France, UK, US), however the use of the long run hedge ratio derived from this relationship does not allow to construct a portfolio immune to crises. Overall, our results confirm the very interesting properties of gold

[2] When credit risks rise, holding gold allows escaping the risk of default, as gold is independent from a specific issuer.

[3] This is true not only in normal conditions, but also in times of extreme economic and political stress: gold stays marketable during catastrophic events such as wars, etc.

[4] This is especially true during the first half of recessions.

to diversify away from stocks: the correlation between gold and stock stays low at all times. However, gold despite its interesting properties is not a bulletproof save haven: it stays a risky investment, even during crises.

The rest of the paper is organized as follows. Section 2 summarizes the main findings in the literature on gold and specifies the contribution of this study relatively to the previous ones. Section 3 gives descriptive statistics of gold and stock returns along the business cycle, and according to bear and bull markets. Section 4 describes the methodology used to test for safe havens and hedges. Section 5 displays the econometric results and comments on them. Section 6 concludes.

2. Brief literature survey on gold and open issues

2.1. Summary of main findings

There is an extensive literature on the links between gold price and financial assets. Most of it is focused on the role of gold as a hedge or as a tool of diversification, while few studies are devoted to its role as a safe haven. Jaffe (1989) finds that gold is a hedge against both stocks and inflation: including gold in financial portfolios can reduce their variance, while slightly improving returns. However, these results were somewhat contested, or at least qualified by following studies. According to Johnson and Soenen (1997), gold is an attractive investment in terms of diversification only in specific periods, for example in 1978-1983, whereas it yielded negative returns in 1984-1995. Its role as a hedge against inflation is also found episodic by Taylor (1998), as it occurred only before 1939 and in the late seventies. These latter results are obtained by improving on the econometric method, through decomposing the short and long run relationships. More recently, McCown *et al.* (2007) confirm these mixed results, since they argue that gold is a hedge against stocks and expected inflation in the long-run, but only intermittently and mostly during the seventies. As inflation was especially high in the seventies, McCown *et al.* (2007) consider the hypothesis that gold be a hedge for inflation, instead of stocks. However, Blose (2010) does not find any impact of the unexpected change in inflation on gold prices or returns, contrary to bond yields.

Intermittences in the relationships are further explored by studies linking the price of gold to the behaviour of other variables. For example, Capie *et al.* (2005) emphasize the role of the US dollar exchange rate that they find negatively related to the gold price on weekly data over the period 1971-2004. Besides, Jensen *et al.* (2002) highlight the role of the monetary stance. They show that commodities, and especially precious metals, yield higher returns during phases of restrictive monetary policy in the US. They link this to the fact that commodity prices tend to rise with inflation, while interest rates are hiked up precisely in times of inflation. According to them, including commodities in a portfolio does not necessarily improve its performance, but an active management of these assets can do it, when taking into account the monetary stance.

Baur and Lucey (2010) and Baur and McDermott (2010) take stock of the idea of a discontinuous relation between gold and financial assets. Interestingly, they distinguish between the two functions of gold as a hedge or a safe haven. They run a regression, explaining the returns of gold by those of stocks[5], in which they add interactive variables. These variables are equal to stock returns in the periods when the return is in the *qth* lower quintile[6] of its distribution and to zero elsewhere. These interactive variables are meant to capture the specific co-movements between the assets under "times of stress in financial markets". The authors then define a hedge or a safe haven depending on the sign of the coefficients estimated in this regression. If the coefficient on stock returns is negative, then gold is said to be a *hedge* for stocks. If the sum of the coefficients on the stock returns and the stock interactive variables is negative (or zero), then gold is a *safe haven*. Baur and Lucey (2010) run this regression on daily data, successively for three countries: the US, the UK and Germany. They find gold is a *hedge* for stocks. It is also a safe haven, but only in the very short run. On average, investors earn a positive return on gold on the day of the extreme negative stock return, but the day after, gold return becomes negative. Moreover, two weeks after the shock, the cumulated returns on gold are negative on average.

Baur and McDermott (2010) extend the analysis of Baur and Lucey (2010) in a number of ways. They use different frequencies of data: daily, weekly and monthly and introduce simultaneously a range of lower quintiles of stock returns. They extend the number of stock markets studied from three to thirteen, including emerging markets. Baur and McDermott (2010) also explore the role of currency movements in the safe haven property of gold. According to their results gold is a hedge and a safe haven for all European markets and the US but not for the BRICs, Australia, Canada and Japan. As one single day of bad stock returns does not necessarily indicate a crisis, Baur and McDermott (2010) also use two alternative definitions of crises. In the first one, crises are defined as the upper 90% (95% and 99%) quintiles of stock volatility; in the second one, three crises episodes are arbitrarily dated[7]. They obtain different results depending on the crisis periods and the countries considered. Gold is shown to be a safe haven during periods of high volatility on the stock market, but not during extreme returns uncertainty. Gold is also evidenced to have been a strong safe haven against losses on European and US stocks during the crisis of October 2008.

On the whole, although the literature has documented the relationship between gold and stocks (or gold and inflation), the results are mixed and there are very few studies on the specific role of a gold as a safe haven against stocks. The relation is generally found negative on large samples. However, it fades away on some periods. Interestingly, periods when gold and stocks are negatively correlated can be featured as times of high inflation, financial or

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[5] Baur and Lucey (2010) add bonds returns as explanatory variables of gold returns.

[6] q = 5%, 2.5% or 1%.

[7] These three episodes are: the stock market crash in October 1987, the Asian crisis in October 1997 and the crisis which originated as a sub-prime crisis in 2007. Baur and McDermott (2010) define October 16, 1987, October 22, 1997 and September 10, 2008, respectively, as the start dates for each crisis period. The length of each period is set equal to 21 trading days.

political turmoil. This is in line with gold being a *safe haven*, because it stays marketable at all times and still has a convenience value in case of catastrophe.

2.2. This paper's contribution

These mixed results incite us to revisit the issue. Especially, we take stock of the two recent papers by Baur and Lucey (2010) and Baur and McDermott (2010) and try to extend their methodology in several ways.

First, we extend the definition of crises in two successive ways, by considering recessions, as defined by the NBER and by referring to bear markets, as defined by Pagan and Sossounov (2003). The advantage is to rely on an exogenous method to date crises, which is completely independent of the gold price itself. Another side benefit is to be able to compare our results with those found for commodities by Gorton and Rouwenhorst (2006). Second, following again Gorton and Rouwenhorst (2006), we use forward prices on gold instead of spot prices, as the forward market is more actively used by traders than the spot one. Third, we test for long-term relationships between stocks and gold prices, instead on focusing only on short term returns. More precisely, we test whether gold is a hedge against stocks in the long run and whether the convergence towards the long run equilibrium changes during crises. Fourth, we remove the assumption of a constant conditional covariance between gold returns and stock returns: as autoregressive conditional heteroskedasticity is well documented for stock returns and gold returns it seems sensible to assume the same pattern for their conditional covariance. We then test the safe haven property of gold in the framework of a bivariate ARMA-GARCH-X. Fifth, we run our estimations with real returns, in order to control for the effects of inflation.

3. GOLD AND STOCKS OVER THE BUSINESS AND FINANCIAL CYCLES

There are two main ways of investing in gold, buying or selling physical bullions of gold, which implies to have secured storage facilities, or trading on derivatives market. Futures and options trading of gold on exchanges have considerably increased in recent years, reaching $5.1 trillion at the end of 2008 (IFSL, 2009).

3.1. Forward and spot prices of gold

Spot and futures prices are closely linked through arbitrage strategies. For financial assets, if all arbitrage is possible, the forward price $F_t^{\,t+1}$ in t for $t+1$, is equal to the spot price S_t in t plus the interest cost foregone during the period ($r_t S_t$).

$$F_t^{\,t+1} = S_t + r_t S_t \qquad (1)$$

For commodities, things are a little more complicated, as arbitrages are not complete. In particular, short-selling includes some uncertainty linked to the future production. Moreover, the storage costs must be taken into account (Fama and French, 1988). Therefore, we must add a cost of physical storage w_t and deduct a *convenience yield* c_t. to the forward price defined in Equation (1),

$$F_t^{t+1} = S_t + r_t S_t + w_t - c_t \qquad (2)$$

The *convenience yield* is defined as the gain that may be obtained from storing the commodity. Considering the buyer's point of view, the *convenience yield* stems from the uncertainty of the future production. In this prospect, the forward price has to be discounted because the contract may not be honored. The discount is greater when inventories are low, as the risk is greater. Hence, the *convenience yield* negatively depends on the level of inventories. For most commodities, as inventories are low, the convenience yield is high to such an extent that the forward price is usually cheaper than the spot: $F_t^{t+1} < S_t$. In this situation, the market is said to be in *backwardation*. This is the normal situation, when you pay less for a good delivered later, than for the same good to-day. When commodities are considered as rare, spot prices are bid up relatively to forward, as buyers fare the dearth of the commodity.

For gold, the situation is exactly the opposite. Inventories are huge, especially because it is not destroyed by consumption; all the gold mined in the past is part of the above-the-ground-stock, which is always increasing. So there is no threat of dearth. This results in a very low convenience yield. Hence, the forward price is regularly higher than the spot, $F_t^{t+1} > S_t$. The market is said to be in *contango*.

The *contango* on the gold market can also be imputed to the widespread practice among central banks to lease gold, in order to boost their incomes, although the lent amounts are constrained. In this situation, gold producers are able to borrow gold and sell it on the spot market, which depresses spot prices, and contributes to the *contango* (Zigler, 2009). If gold was not lent, producers would sell their gold on the futures market, as they do for other commodities, which would depress the forward market and contribute to the backwardation.

Generally speaking, the total return on commodity futures can be split into three terms (Mongars and Marchal-Dombrat, 2006): (i) the return on the spot price $[S_{t+1} - S_t]$; (ii) the « roll » yield, equal to the difference between the spot and the forward price $[S_t - F_t]$; (iii) the Treasury bill rate, r_t, considering that investment in futures is collaterized by Treasury bills:

$$tr_t = [S_{t+1} - S_t] + [S_t - F_t^{t+1}] + r_t \qquad (4)$$

tr = return on the spot + roll yield + Treasury bill rate

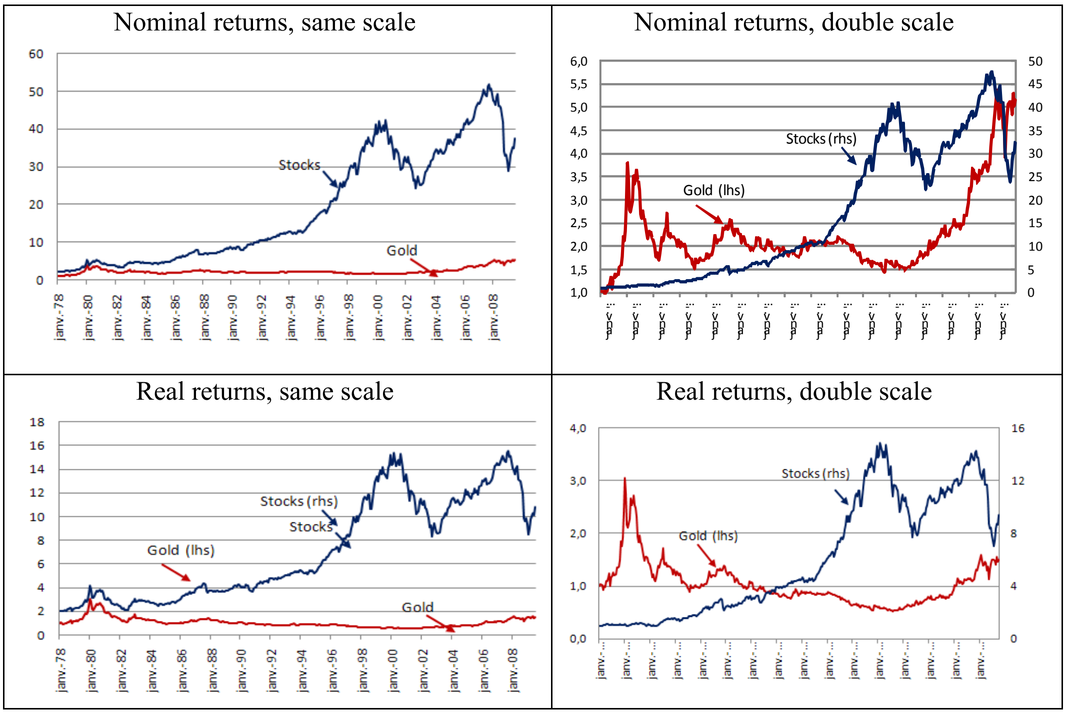
The second term, the roll yield, can be interpreted as the gain on the future if the spot was constant over the whole duration of the contract. As the price of a future converges towards the spot when the maturity expires, the roll is equal to the difference between the spot and the forward prices. For most commodities, the roll is usually positive, as the market is often in *backwardation*. In this case, it is clear from Equation (4) that the total return on commodities futures is greater than that on the spot.

In the case of gold, the roll yield is negative, as the gold market is in *contango*. This negative term in Equation (4) is significant enough to wipe out the effect of the interest rate most of the time. Consequently, contrary to other commodities, investing in gold futures is generally not more rewarding than investing in physical gold.

3.2. Comparison over a long period

We compare these total returns on gold futures to those of stocks on the period 1978/01-2009/07. The data for gold total returns come from Standard and Poors' and Goldman Sachs Commodity Index database (S&P GSCI), and are extracted from Bloomberg. For the stocks, we also consider total returns, including changes in prices and dividends, based on a US stock index extracted from Datastream. Figure 1 compares the cumulated returns on gold futures and US stocks, for investing one dollar in January 1978, both in nominal and real terms. Differences are striking: gold appears much less profitable on the long run. At the end of the period, in July 2009, the initial 1$ investment is worth 32.3$ if invested in stocks and only 5.2$ if invested in gold futures. In real terms, all over the period, the purchasing power of the investment is multiplied by 9.4 if invested in stocks, and only by 1.5 for gold. However, the graphs in double scale suggest an interesting property of gold, as returns do not seem to co-move with those of stocks.

Figure 1: Cumulated returns on gold futures and US stocks
(base 1 in January 1978)



Source: Bloomberg data, authors' calculations.

Table 1 displays some descriptive statistics on the returns of the two assets. On average, over the whole period, the returns on gold (7.1% per year) are far smaller than those on stocks (11.8%), though both assets succeed in preserving the purchasing power of the investment (3.2 and 8.3% respectively for real returns in gold and stocks). Surprisingly, the smaller returns on gold do not compensate for a lesser volatility. On the contrary, standard-errors are greater for gold (19.7%) than for equities (15.3%). Extreme returns on gold are also more frequent than in a normal distribution and more than for stocks, as shown by their respective kurtosis 4.44 versus 2.22. However, one advantage of gold is that its extreme returns tend to occur more often upwards than downwards, contrary to stocks. Hence the asymmetry coefficient is positive for gold while negative for stocks.

In fact, when considering only negative returns, the annualized volatility is 16.5% for gold, versus 25.8% stocks, which turns to the advantage of a gold investment. Table 1 also confirms another interesting characteristic of gold, *ie* its returns do not co-move with those of stocks, as their correlation coefficient is quasi null (0.001).

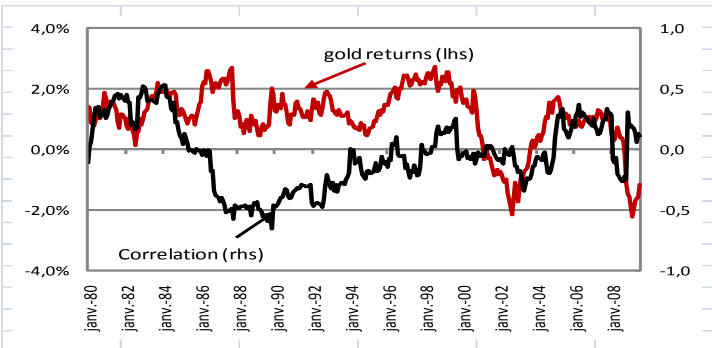
Table 1: Returns on gold and US stocks
(February 1978-July 2009, annualized)

	Nominal returns		Real returns	
	Gold futures	stocks	Gold futures	stocks
Mean	7.1%	12.3%	3.2 %	8.3%
Standard error	19.7 %	15.3%	19.6%	15.4%
Asymmetry coefficient	0.72	-0.69	0.61	-0.64
Kurtosis	4.44	2.22	4.02	1.94
Correlation	0.001		0.001	

Source: Bloomberg data, authors' calculations.

To check for the stability of correlations between both assets, we calculated them over a 2 year-window (Figure 2). As expected, the correlation coefficients are unstable and fluctuate over time. However, an interesting point is that they do not seem to increase when stock returns are negative.

Figure 2: 2 year-window correlations between gold and stocks



Source: Bloomberg data, authors' calculations.

3.3. Comparison over the business cycle

Gorton and Rouwenhorst (2006) argue that commodity futures are able to generate positive returns at times when price of stocks decline. To carry their point, they compute the returns of both assets over the different phases of the business cycle. According to their results, commodity futures yield positive returns whereas equity prices fall during the first halves of recession periods, called "early recessions". We replicate these calculations taking gold futures instead of commodities. We take into account the periods of recession defined by the NBER. The results are reported in Table 2.

Table 2: Average returns on gold and US stocks over the business cycle
(February 1978-July 2009, annualized in %)

	Nominal returns		Real returns	
	Gold	Stocks	Gold	Stocks
Expansion	6.3	15.2	2.5	11.4
Early Expansion	4.0	16.7	1.1	13.7
Late Expansion	8.2	13.9	3.7	9.4
Recession	11.9	-4.2	7.1	-9.0
Early Recession	-0.5	-16.5	-7.6	-23.5
Late Recession	23.8	7.7	21.3	5.0
All periods	7.1	12.3	3.2	8.3

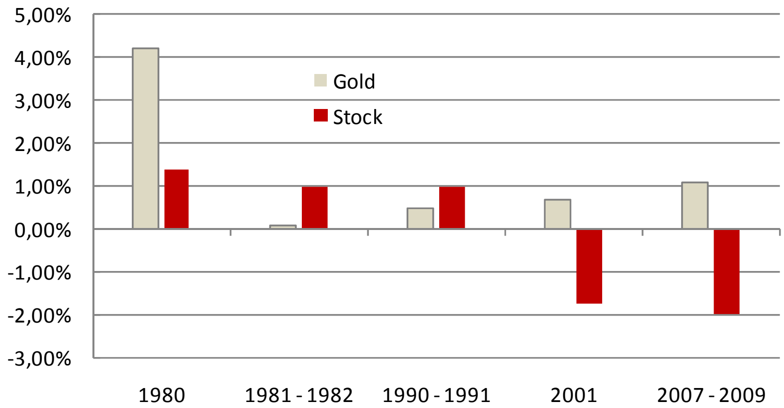
Source: Bloomberg data, authors' calculations. The periods are those defined by the NBER. Early expansion (recession) is the first half of expansion (recession). Late expansion (recession) is the second half of the period. We assume that the latter recession ends in July 2009.

Results show that gold clearly outperforms stocks during recessions as it yields an average return of 11.9% while stocks have negative returns (-4.2%). Its real return also stays positive if held throughout the recession (7.1%, versus -9% for stocks). Conversely, it deeply underperforms stocks during expansions periods (6.3% against 15.2%). The interesting point is the cyclicality of the relative returns between the two assets, as for commodities. Nevertheless, periods of early or late recessions do not seem to matter for the arbitrage between gold and stocks, contrary to the findings on commodities by Gorton and Rouwenhorst (2006). Returns on gold are higher in both halves of recession periods. This result hints at a safe haven role for gold. Indeed, a long position in gold futures protects against the fall in stock prices that generally occurs during slowdowns.

We check that these results are stable over time and not only due to the last recession, when stock prices plunged and the price of gold soared. Leaving out the last recession, we recalculate the average returns of both assets over the business cycle for the period February 1978-November 2007. We still find a higher return for gold (11.5%) than for stocks (5.7%) during recessions, though the difference is lesser than on the whole period.

Figure 3 takes a closer look at the individual results for each recession since 1980. It shows that gold returns are indeed positive on average for each recession. This is not the case for stocks, as their returns are sometimes positive, sometimes negative, depending on recessions.

Figure 3: Average returns on gold and US stocks during recessions



Source: Bloomberg data, authors' calculations

3.4. Comparison over the stock market cycle

A more straightforward way to look into this safe haven role of gold is to consider its returns during the periods of bear markets. If gold is able to yield positive returns when equity prices tumble, it could qualify for being a safe haven.

To check that, we first have to identify the periods of bear and bull markets. According to Pagan and Sossounov (2003), a bear market occurs every time the stock prices have declined for a "substantial period since their previous (local) peak", which is also the definition given by Chauvet and Potter (2000). Pagan and Sossounov (2003) use the algorithm developed by Bry and Boshan (1971) for detecting turning points in the business cycle, after having adapted it to financial series (for example on the length of the phase and of the whole cycle). The bear phases span from peak to trough. Gonzalez *et al.* (2005) also identify bull and bear markets, by applying the Bry and Boshan's algorithm on long-run series of the US stock market. The dates that are obtained in the two papers are identical on our period of interest[8]. We have updated the dates by using Pagan and Sossounov's algorithm on the US S&P500 stock price index. Table 3 gives the dates found.

[8] They are identical except for one crisis in 1967:09-1968:02 which is detected only by Gonzalez et al. (2005), but is out of our period of interest.

Table 3: Dates identified by Pagan and Sossounov (2003) as bull and bear markets for the S&P500 and Dow Jones updated with the same method up to July 2009 (*)

Peak	Trough
1961 :12	1962 :06
1966 :01	1966 :09
1968 :11	1970 :06
1971 :04	1971 :11
1972 :12	1974 :09
1976 :12	1978 :02
1980 :11	1982 :07
1983 :06	1984 :05
1987 :08	1987 :11
1990 :05	1990 :10
1994 :01	1994 :06
2000 :08	2002 :09
2007 :10	2009 :02

** Bear markets span from peaks to troughs; bull markets from troughs to peaks.*
Source: Pagan and Sossounov (2003), updated by the authors.

Then we calculate average returns on both stocks and gold futures over these different two types of periods, bulls and bears (Table 4). On average, gold increased by 9.8% during bull markets, whereas stocks surged by 22.8%. In bear markets, like in recessions, these performances are inverted. Returns on gold are only slightly negative (-1.2%) while equity prices tumble by 20.1% a year. On the whole, the inclusion of gold futures in a portfolio seems able to limit the losses on stocks during bear markets.

Table 4: Average returns on gold and US stocks over the stock market cycle
(February 1978-July 2009, annualized in %)

	Nominal returns		Real returns	
	Gold	Stocks	Gold	Stocks
Bull markets	9.8	22.8	5.9	18.9
Bear markets	-1.2	-20.1	-5.2	-24.2
All periods	7.1	12.3	3.2	8.3

Source: Bloomberg data, authors' calculations. Bull and bear markets are defined by Pagan and Sossounov's algorithm.

4. METHODOLOGY

Following Baur and Lucey (2010) and Baur and McDermott (2010), we consider gold as a hedge against stocks if the correlation between stock and gold returns is negative. We conclude in favour of gold being a safe haven against stocks when the correlation is negative during crises.

4.1. Usual methodology

The bulk of the empirical literature on gold as a hedge or a safe haven is based on univariate regressions between gold returns and the returns of the asset to hedge. The purpose is to assess the response of gold to exchange rate changes (Capie *et alii*, 2005) or to stock returns (Baur and Lucey, 2010; Baur and McDermott, 2010; McCown and Zimmermann, 2007). Therefore the return of the hedge (gold) is regressed on the return of the initial investment (foreign currency, stock index, ...). If we neglect lags, the simplest specification of this model can be sketched by:

$$r_t^G = \alpha + \beta r_t^S + \varepsilon_t^G \qquad (3)$$

where r_t^G is the return on gold and r_t^S, the return on stocks.

In most papers, the estimated equations are close to Equation (3) except that they include lags on both returns. Sometimes excess returns are used (McCown and Zimmermann, 2007), computed as the difference between the return and a risk free rate (yield on 30 days US Treasury bills).

If β is strictly negative, then both assets are inversely correlated and gold is considered as a hedge. This characterisation of a hedge is extended by Baur and McDermott (2010) to include the case when β=0 under the denomination of a "weak hedge".

A straightforward extension of the above model is to test whether the value of β changes during crises (Baur and Lucey, 2010; Baur and McDermott, 2010). If during crises β is strictly negative, then gold is a safe haven: it can be used to hedge stocks (temporarily at least) during crises. If during crises β is zero, then, according to the terminology of Baur and McDermott (2010), gold is a weak safe haven. If, indeed, β is zero during crises, then negative stock returns will not be compensated by positive returns on gold; but gold still appears as an attractive asset for diversification, as it is preserved from the turbulence on stock markets.

4.2. Limitations and underlying assumptions

Actually, the univariate framework of Equation (3) is questionable for it relies on very restrictive implicit assumptions. In this framework, stocks returns are exogenous from gold, but the gold returns do depend on the returns on stocks. In other words – assuming a negative beta - when the returns on stocks decrease, investors buy gold (and the returns on gold rise), whereas when they increase, there is less interest for gold (and the returns on gold decrease).

Another restrictive assumption generally made in estimating Equation (3) is that the covariance between stocks and gold is constant over tranquil periods. As stock returns are assumed exogenous, the conditional covariance between the error term ε_t^G and r_t^s is constantly zero. However, this is really dubious. Since the autoregressive heteroskedasticity of stock and gold returns has long been well documented, there is no reason to assume that the conditional covariance between ε_t^G and r_t^s does not follow the same pattern[9].

This caveat clearly appears when we relate the usual tests for safe havens to the literature aiming at calculating an optimal hedge ratio (Choudhry, 2003). The latter is defined as the optimal amount of futures, expressed in percentage of the existing investment to hedge. Conceptually, the two approaches are close. However, the optimal hedge ratio is calculated as the ratio of the conditional covariance to the conditional variance of the returns of the hedge (Choudhry, 2003), whereas most estimations of β in equation (3) are made using unconditional statistics.

These limitations incite us to adapt the methodology, by running tests in the framework of bivariate GARCH models. In addition, we test for gold being a hedge against stocks in the long run by means of cointegration tests.

4.3. Tests for gold being a hedge and/or a safe haven in a bivariate ARMA-GARCH (1,1)-X model

To test if gold is a hedge for stocks and a safe haven in the short run, we fit a bivariate ARMA-GARCH(1,1)-X process on the returns of gold and stocks, for each of the six stock indices under study.

In the *ARMA(p,q)* part of the model, formed by the two equations below, *p* and *q* are set for each series, with $(p,q)=(p_1,q_1)$ for gold and $(p,q)=(p_2,q_2)$ for stocks, so as to ensure white residuals:

$$r_t^G = c^G + \sum_{i=1}^{p1} a_i^G r_{t-i}^G + \sum_{i=1}^{q1} b_i^G \varepsilon_{G,t-i} \quad (4)$$

$$r_t^S = c^S + \sum_{i=1}^{p2} a_i^S r_{t-i}^S + \sum_{i=1}^{q2} b_i^S \varepsilon_{S,t-i} \quad (5)$$

We select p_1=7 and q_1=0 for gold and different *ARMA*(p_2,q_2) for each stock return series.

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[9] When r_t^s is not a white noise, the conditional covariance is rather computed between ε_t^G and ε_t^S, ε_t^S being the error term of the equation describing the process followed by r_t^s in a bivariate system allowing to model jointly the dynamics of gold and stocks returns.

Then we use a diagonal VECH GARCH[10], with an asymmetric effect and a dummy for crises as an additional explanatory variable. It can be written as the following set of three equations:

$$\begin{cases} h_t^{GG} = c^{GG} + \alpha^G \varepsilon_{G,t-1}^2 + \beta^G h_{t-1}^{GG} + d^G dum_{\varepsilon_G<0}\, \varepsilon_{G,t-1}^2 + \delta^G dum_{crisis} \\ h_t^{GS} = c^{GS} + \alpha^{GS} \varepsilon_{G,t-1} \varepsilon_{S,t-1} + \beta^{GS} h_{t-1}^{GS} + d^{GS} dum_{\varepsilon_S<0,\varepsilon_G<0}\, \varepsilon_{G,t-1} \varepsilon_{S,t-1} + \delta^{GS} dum_{crisis} \\ h_t^{SS} = c^{SS} + \alpha^S \varepsilon_{S,t-1}^2 + \beta^S h_{t-1}^{SS} + d^S dum_{\varepsilon_S<0}\, \varepsilon_{S,t-1}^2 + \delta^S dum_{crisis} \end{cases} \quad (6)$$

where h_t^G is the conditional variance for gold, h_t^{GS} is the conditional covariance between gold and stocks and h_t^S is the conditional variance for stocks[11], dum_{crises} standing for the indicator dummy for crises, equal to 1 during crises and 0 elsewhere[12].

The asymmetric effect is formulated according to Glosten et al. (1993), through the product of the squared lagged error terms (or the cross product of the error terms in case of the covariance) and an indicator function $dum_{\varepsilon<0}$ equal to 1 when $\varepsilon < 0$ ($\varepsilon_G < 0$ and $\varepsilon_S < 0$ for the covariance), and 0 elsewhere. When the coefficient *d* is positive, negative shocks increase volatility more than positive shocks. This is usually the case for stocks, therefore d^S>0 is expected. For gold, we expect $d^G \leq 0$, as the descriptive statistics in Section 3 showed it was skewed positively, positive shocks should then increase its volatility more than negative shocks.

The dummy for crises allows us to test if the covariance between gold and stocks changes during crises. If $\delta^{GS} > 0$, then covariance increases and there may be some contagion effect. If $\delta^{GS} < 0$, then gold may rather be a safe haven during crises. However, $\delta^{GS} \leq 0$ is not a sufficient or even a necessary condition for gold to be a safe haven. What is important is the overall sign of the covariance between gold and stocks during crises, not its marginal variation. The conditional covariance being time-varying, it is not straightforward to check its sign: it can change from positive to negative, and the reverse, even during the short spans of crises. A first solution is to check if $h_t^{GS} < 0$ has been systematically true - or at least true on average - during the crises included in the sample. A second way of gauging the overall sign of the covariance between gold and stocks is simply to have a look at the unconditional covariance.

10 We prefer it to other specifications, such as the BEKK model or restricted correlations models (CC, DCC), because the interpretation of the parameters is straightforward and it does not restrict the dynamics of the correlation. It also keeps the total number of parameters to estimate at a manageable level in the bivariate case, which is a good compromise between flexibility and feasibility.

11 $h_t^{ij} = E_{t-1}(\varepsilon_t^i \varepsilon_t^j) - E_{t-1}(\varepsilon_t^i) E_{t-1}(\varepsilon_t^j)$, for *i* = *G*, *S* and *j* = *G*, *S*, where $E_{t-1}(.)$ is the conditional expectation.

12 Crises periods are defined either as recessions (NBER definitions) or stock bear markets.

When $\left|\alpha^{GS} + \beta^{GS} + d^{GS} dum_{\varepsilon_S<0,\varepsilon_G<0}\right| < 1$, the unconditional covariance between gold and stocks can be written as:

$$\sigma^{GS} = \frac{c^{GS} + \delta^{GS} dum_{crisis}}{\left(1 - \alpha^{GS} - \beta^{GS} - d^{GS} dum_{\varepsilon_S<0,\varepsilon_G<0}\right)} \qquad (7)$$

and its sign is given by the sign of its numerator. Then, we can put forward the following definitions.

- *Gold is safe haven if and only if* $c^{GS} + \delta^{GS}$ *<0,*
- *Gold is a hedge in "normal times" if and only if:* c^{GS} *< 0.*

"Normal times" here refer to non crises periods: either bull markets or expansion phases, according to the definition that we retain for crises. An alternative would be to check the sign of the average numerator of the "unconditional" covariance over all periods (tranquil times and crises). But this average is dependent on the number and length of the recessions included in the sample.

The crisis dummy is also allowed to impact the conditional variances: as recessions (and of course bear stock markets) often begin by stock markets busts, raising volatility, $\delta^S > 0$ is expected, while $\delta^G = 0$ might be expected if gold is preserved from economic and financial turbulence accompanying crises. The expected sign of δ is less clear cut for gold than for stocks: if the flight to gold during crises entails some extreme positive results for gold, then the crises might also increase the volatility of gold.

Overall, our estimates of the time varying covariances between gold and stocks real returns (reported later on in Section 5) will confirm that gold can in most cases be considered as weak hedge and a weak safe haven against stocks. The correlation between stocks and gold is low on average and remains so even during crises. This very interesting feature points at gold providing an efficient way to diversify away from stocks. However, as the correlation is low on average, fluctuates and is seldom significantly negative, these results cannot be used to compute short run hedge ratios[13]. For such ratios to have an economic interpretation, the covariance between stocks and gold returns has to be significantly below zero. Besides, for the rare cases in which the correlation between gold and stocks is negative, the resulting short term hedge ratios would be too time varying and close to zero on average for the hedge to be financially attractive. The transactions costs incurred to adjust continuously the proportion of

[13] Recall that according to Section 4.2, the hedge ratio is computed as the conditional covariance divided by conditional variance of gold. When the covariance is negative the absolute value of the ratio gives the optimal proportion of gold to be held in addition to stocks to hedge their losses.

gold in the portfolio would be too expensive, for a poor performance of gold as a short run hedge against stocks.

4.4. Cointegration for testing gold as a hedge in the long-run

So far our tests are based on the stationary monthly real returns of gold and stocks, calculated as the first difference of their logged indices. The short run correlations computed from the bivariate EGARCH model, reported in the next section, appear as low on average, fluctuating close to zero. However, this does not preclude a long run negative relationship between the levels of gold and stocks indices of cumulated returns. Such a relationship would mean that gold is a hedge for stocks in the long run. It also yields a long run hedge ratio giving the proportion of gold to be held jointly with stocks to hedge their losses. Then we can check whether such hedged portfolios out-perform undiversified portfolios of stocks only during crises.

To test whether gold is hedge for stocks in the long run, we use a variant of the Engle-Granger cointegration test (Engle and Granger, 1987). The popular Engle-Granger cointegration test between two unit root processes involves two steps. In the first stage the following cointegrating model is estimated:

$$y_t = \alpha + \beta x_t + \varepsilon_t \tag{8}$$

In the second stage, cointegration between y_t and x_t is examined through the test of the stationarity of the residuals, using a Dickey Fuller test of the form:

$$\Delta\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \eta_t \tag{9}$$

A limitation of the Engle-Granger cointegration test is that only one speed of reversion to equilibrium is permitted, whether the variable is above or below its long-run equilibrium. To overcome this limitation, Enders and Siklos (2001) allow for two different speeds of reversions to equilibrium. The second stage of the modified Engle-Granger cointegration test then becomes:

$$\Delta\hat{\varepsilon}_t = I_t \rho_1 \hat{\varepsilon}_{t-1} + (1 - I_t)\rho_2 \hat{\varepsilon}_{t-1} + \eta_t \tag{10}$$

where I_t is the Heaviside indicator function. Enders and Siklos (2001) use different specifications of the indicator function depending on the sign of the gap to the equilibrium. The TAR threshold cointegration test employs the following specification *It = 1* if $\hat{\varepsilon}_{t-1} \geq 0$; *It = 0* if $\hat{\varepsilon}_{t-1} < 0$. The MTAR threshold cointegration test employs the following specification: $I_t = 1$ *if* $\Delta\hat{\varepsilon}_{t-1} \geq 0$; $I_t = 0$ if $\Delta\hat{\varepsilon}_{t-1} < 0$.

Here we want to allow for asymmetric adjustment during business cycle expansions and contractions. Therefore we define the indicator function simply as:

$I_t = 1$ if there is a recession according to the NBER (11)

$I_t = 0$ otherwise.

Perron and Rodriguez (2000) and Cook (2007) employ local-to-unity detrending *via* generalised least squares as means of increasing the powers of the Engle-Granger cointegration test and the MTAR threshold cointegration test of Enders and Siklos (2001), respectively.

We use the methodology Perron and Rodriguez (2000) and Cook (2007) to generate GLS detrended series for all the I(1) series of logged indices. If gold is a strong hedge for gold in the long run, then the gold and stocks real indices should be cointegrated and the coefficient β in the cointegrating relationship (8) should be negative. Besides, in the regression of the stock index on the gold index, β can be interpreted as the long run hedge ratio.

5. Econometric Results

5.1. The sample

We use monthly data over the period 1978:2-2009:1 for regressions including gold returns and over the period 1976:2 to 2009:4 when using precious metals index instead. All series are expressed in USD and deflated using the US CPI. The gold SP&GSCI total return index is extracted from Bloomberg, as in Section 3; the total return index on Precious Metals futures is the precious metal SP&GSCI total return index. The real stock returns are calculated from Datastream total return stock indices, expressed in USD and defined over the following areas: France, Germany, the UK, the US, Europe. These series are computed in the same way and available on relatively long periods. For the G7, as there is no Datastream stock index available, we use the G7 MSCI index. All series are integrated of order one[14].

5.2. The impact of recessions on the conditional covariance between gold and stocks

In this section we use the recessions of the NBER to define the crisis periods. Although they are defined for the US, we also use them in the regressions of the other countries for homogeneity. We consider that given the large share of the US economy in the world GDP, a recession in the US generally spreads over to the rest of the world. Even if there are some delays in the transmission of US shocks to the GDP of the rest of the world, the reaction of financial variables such as stocks and gold is much quicker. It is therefore realistic to assume that the prices and returns of both gold and (foreign and US) stocks react within a month to a US recession.

[14] The results of the unit root tests are available upon request.

The results of the estimation of the bivariate ARMA-GARCH(1,1)-X models on gold and stocks real returns are listed in Tables 5a and 5b.

In the equation of the conditional covariance (table 5b), the constant c^{GS} is positive in four cases out of six (Germany, UK, Europe, G7) and in half of these cases (UK, Europe) it is significantly different from zero at a 1% significance level. The parameter c^{GS} is negative only for France and the US. It is significantly different from zero at a 10% significance level only for the US. Gold does not appear to be a strong hedge for stocks, except for the US. It is however a weak hedge in all but two cases (UK, Europe). The estimates of the coefficient of the dummy for recessions (δ^{GS}) are always negative – except for the US - but never significantly different from zero. Therefore gold is not a strong safe haven: holding gold during recessions does not offset the losses on a portfolio of stocks. Gold can however be considered as a weak hedge in all cases except two (UK, Europe).

Table 5a: Estimation results for the ARMA part of the bivariate models of gold and stock returns, with a dummy for recessions

This table gives the results of the estimations of an ARMA model of the form:

$$r_t^J = c^J + \sum_{i=1}^{p1} a_i^J r_{t-i}^J + \sum_{i=1}^{q1} b_i^J \varepsilon_{J,t-i} \ ,$$

for both the Gold (*J=G*) and the stock returns (*J=S*). The two ARMA equations for gold and the stock returns of each country are jointly estimated with a bivariate GARCH, by the maximum of likelihood. The results for the bivariate GARCH part are given in table 5b. The estimation period is 1978:9-2009:1. Standard errors are given between brackets. The Ljung-Box statistics (stat. *Q30*, with p-value below) is computed for 30 lags, using standardized residuals.

	France	Germany	UK	US	Europe	G7
ARMA equation for gold						
c^G	0.0001 (0.0020)	0.0003 (0.0021)	0.0004 (0.0018)	0.0008 (0.0021)	-0.0001 (0.0021)	-0.0002 (0.0021)
a_1^G	-0.0645 (0.0515)	-0.0552 (0.0515)	-0.0320 (0.0446)	-0.0512 (0.0494)	-0.0473 (0.0521)	-0.0598 (0.0542)
a_2^G	-0.0965* (0.0508)	-0.1029* (0.0531)	-0.1091** (0.0522)	-0.1020** (0.0517)	-0.1276** (0.0517)	-0.1048** (0.0526)
a_3^G	0.0669 (0.0511)	0.0652 (0.0507)	0.0778 (0.0511)	0.0510 (0.0502)	0.0745 (0.0504)	0.0688 (0.0515)
a_4^G	-0.0550 (0.0486)	-0.0463 (0.0535)	-0.0240 (0.0513)	-0.0324 (0.0494)	-0.0376 (0.0485)	-0.0577 (0.0504)
a_5^G	0.0713 (0.0571)	0.0875 (0.0573)	0.1113** (0.0556)	0.0829 (0.0557)	0.1318** (0.0544)	0.0857 (0.0550)
a_6^G	-0.1383*** (0.0531)	-0.1020* (0.0538)	-0.0855* (0.0502)	-0.1161** (0.0540)	-0.1028** (0.0505)	-0.1137** (0.0536)
a_7^G	0.1450*** (0.0498)	0.1465*** (0.0518)	0.1421*** (0.0435)	0.1426*** (0.0508)	0.1619*** (0.0515)	0.1343** (0.0527)
R²	0.028	0.033	0.041	0.038	0.037	0.031
Q30	22.799 (pv: 0.47)	22.743 (pv: 0.48)	22.465 (pv: 0.49)	21.872 (pv: 0.53)	24.141 (pv: 0.40)	22.901 (pv: 0.47)
ARMA equation for stocks						
c^S	0.0101*** (0.0029)	0.0065** (0.0026)	0.0071*** (0.0021)	0.0069*** (0.0017)	0.0078*** (0.0024)	0.0060*** (0.0019)
b_1^S	-0.0850* (0.0480)	-	-	-0.0309 (0.0368)	-0.0065 (0.0423)	-
b_2^S	-	-	-	-0.0256 (0.0389)	-0.0199 (0.0415)	-
b_3^S	-	-	-	0.0720 (0.0459)	0.0856* (0.0451)	-
b_4^S	-	-	-	-0.1173*** (0.0361)	-0.0326 (0.0441)	-
b_5^S	-	-	-	0.0289 (0.0454)	0.0472 (0.0489)	-
R2	0.002	0.000	0.000	0.014	0.017	0.000
Q30	35.296 (pv: 0.19)	24.297 (pv: 0.76)	18.923 (pv: 0.94)	21.616 (pv: 0.66)	29.985 (pv: 0.22)	37.935 (pv: 0.15)

**** 1% sign. level; ** 5% sign. level; * 10% sign. level.*

Table 5b: Estimation results for the GARCH part of the bivariate models of gold and stock returns, with a dummy for recessions

This table gives, for each country, the results of the estimations by maximum of likelihood of the bivariate GARCH:

$$\begin{cases} h_t^{GG} = c^{GG} + \alpha^G \varepsilon_{G,t-1}^2 + \beta^G h_{t-1}^{GG} + d^G dum_{\varepsilon_G<0}\, \varepsilon_{G,t-1}^2 + \delta^G dum_{crisis} \\ h_t^{GS} = c^{GS} + \alpha^{GS} \varepsilon_{G,t-1}\varepsilon_{S,t-1} + \beta^{GS} h_{t-1}^{GS} + d^{GS} dum_{\varepsilon_S<0,\varepsilon_G<0}\, \varepsilon_{G,t-1}\varepsilon_{S,t-1} + \delta^{GS} dum_{crisis} \\ h_t^{SS} = c^{SS} + \alpha^S \varepsilon_{S,t-1}^2 + \beta^S h_{t-1}^{SS} + d^S dum_{\varepsilon_S<0}\, \varepsilon_{S,t-1}^2 + \delta^S dum_{crisis} \end{cases},$$

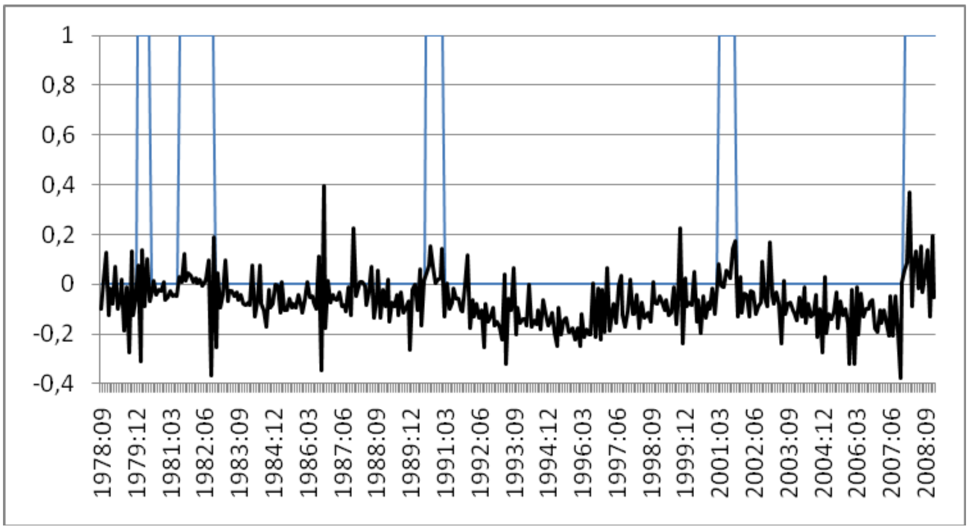
Where the first and third equations model the autoregressive dynamics of the conditional variance of, respectively, gold and stocks, and the second equation models the conditional covariance between gold and stocks returns. The estimation period is 1978:9-2009:1. Standard errors are given between brackets.

	France	Germany	UK	US	Europe	G7
The conditional variance of gold						
c^{GG}	<0.0001**	0.0001*	0.0001*	0.0001*	0.0001***	0.0001*
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
α^G	0.1166***	0.1305***	0.1015***	0.1164***	0.1098***	0.1260***
	(0.0325)	(0.0491)	(0.0387)	(0.0362)	(0.0231)	(0.0472)
β^G	0.8838***	0.8527***	0.8800***	0.8772***	0.8725***	0.8594***
	(0.0315)	(0.0567)	(0.0496)	(0.0438)	(0.0215)	(0.0542)
d^G	-0.0313	-0.0510	-0.0602**	-0.0507	-0.0613*	-0.0315
	(0.0385)	(0.0424)	(0.0282)	(0.0327)	(0.0363)	(0.0431)
δ^G	<0.0001	0.0002	0.0002	0.0001	0.0002	0.0001
	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
The conditional covariance between gold and stocks						
c^{GS}	-0.0001	0.0001	0.0005***	-0.0002*	0.0004***	0.0001
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(2.94)	(0.0001)
α^{GS}	-0.0369	-0.0338	-0.1746***	-0.1113*	-0.1678***	-0.0997**
	(0.1388)	(0.0492)	(0.0369)	(0.0607)	(0.0403)	(0.0413)
β^{GS}	0.2057	0.5934	-0.6175***	-0.4052	-0.6062***	-0.0763
	(0.7772)	(0.4315)	(0.1062)	(0.2565)	(0.1225)	(0.3102)
d^{GS}	-0.0590	0.0263	0.2182***	0.1284	0.1439**	0.1552
	(0.1049)	(0.0629)	(0.0547)	(0.1096)	(0.0664)	(0.0989)
δ^{GS}	-0.0006	-0.0003	-0.0005	0.0003	-0.0006	-0.0006
	(0.0009)	(0.0004)	(0.0005)	(0.0005)	(0.0007)	(0.0005)
The conditional variance of stocks						
c^{SS}	0.0014***	0.0001*	<0.0001*	<0.0001*	0.0015***	0.0010***
	(0.0004)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0001)	(0.0002)
α^S	0.1100	0.1136***	0.0780***	0.1381***	0.0096	-0.0814***
	(0.0802)	(0.0389)	(0.0071)	(0.0167)	(0.0466)	(0.0117)
β^S	0.2661*	0.8599***	0.9144***	0.8671***	0.1988	0.3609***
	(0.1494)	(0.0400)	(0.0122)	(0.0257)	(0.2048)	(0.1349)
d^S	0.3172**	-0.0642	-0.0338	-0.0662*	0.0799	0.1717***
	(0.1514)	(0.0417)	(0.0249)	(0.0398)	(0.0682)	(0.0615)
δ^S	0.0015*	0.0008***	0.0004***	0.0003**	0.0025**	0.0016***
	(0.0008)	(0.0003)	(0.0001)	(0.0001)	(0.0010)	(0.0006)
Nb. of obs.:	365	365	365	365	365	365
Log likelihood	1138.38	1133.68	1170.49	1242.54	1198.28	1248.86

*** 1% sign. level; ** 5% sign. level; * 10% sign. level.

Figure 4 illustrates the dynamics of the correlation between gold and stocks, computed from the conditional covariance and variances for the US. The correlation slightly increases during the crises because $\delta^{GS} > 0$ for the US, though the estimate is not significantly different from zero. What is apparent from this figure is that the correlation fluctuates around zero and switches signs very frequently, even during periods over which it stays mostly below zero.

Figure 4: Time varying correlation between US stocks and gold, and recessions



The correlation between gold and stocks stays close to zero during recessions as well as during booms: therefore even if gold is not a strong hedge, nor a strong safe haven, it may still be an attractive investment. It is far more efficient to diversify a portfolio of US stocks by buying gold, than by adding, for instance, French stocks. The correlation between French and US stocks returns rises on average from 66% to 80% during recessions, whereas the correlation between gold and US stocks returns rises only from -6.7% to 4%. Besides, according to the previous estimates, the long run covariance between gold and US stocks is not significantly different from zero (c^{GS}=0) and its rise during recessions is not significant ($\delta^{GS} = 0$).

According to Table 5b, δ^{S} is systematically positive and generally significant at the 5% level: the volatility of stock returns rises during recessions. On the contrary, the volatility of gold returns does not seem affected by recessions, which is consistent with the low correlation between gold and stocks during recessions.

When d^{S} is significantly different from zero at the 5% level, it is positive: therefore, negative shocks on stock returns increase more volatility than positive shocks, which was expected. For gold it is the reverse, positive shocks on returns increase volatility more than negative shocks: d^{G} is systematically negative, though significantly different from zero only in the bivariate GARCH estimated for UK (5% significance level) and for Europe (10% significance level).

To check the robustness of the results, the same estimations have been conducted, using this time the precious metal SP&GSCI total return index instead of the gold SP&GSCI total return index. This precious metal index includes gold along with other precious metals (platinum, silver, …) that can also play the part of safe havens. We start estimations in 1976:2, as this series is available earlier[15]. The results of the estimation of bivariate ARMA-GARCH-X models for the returns of precious metals and each stock returns are reported in the appendix A. They are quite similar to those found before in the case of gold. The constant in the covariance equation (c^{MPS}) is always positive (and significantly different from zero for Europe): precious metals are not a strong hedge for stocks. The parameter δ^{MPS} is negative in 4 cases out of 6, but not significant: statistically precious metals do not provide a strong safe haven against stocks during recessions. The recession increases the volatility of stocks returns $(\delta^{S} > 0)$, but does not increase significantly the volatility of precious metals returns $(\delta^{MP} = 0)$. There is a negative asymmetry for stocks ($d^{S}>0$) and a positive asymmetry for precious metals $(d^{MP} < 0)$.

5.3. Testing for the impact of bear stock markets on the conditional covariance between gold and stocks

In this section, we use the bear markets periods defined through the algorithm by Pagan and Sossounov (2003) as crises periods. Here again, the periods concern the US index, but we use the same dating for other countries, for homogeneity. Given the share of the US in the world market capitalization, when there is a bear market in the US, stock prices generally decline in other countries as well. Moreover, the US stock market has often been evidenced to lead other countries' stock markets, amongst others, by Eun and Shim (1989), Becker et al. (1995), Masih and Masih (2001), Bessler and Yang (2003), Beine *et al.* (2008).

The results of the estimation of bivariate ARMA-GARCH(1,1)-X models on gold and stocks real returns are listed in Tables 6a and 6b. According to these results, the constant in the covariance equation c^{GS} is significantly different from zero in three cases: for the UK ($c^{GS}>0$ at 1%), for the US ($c^{GS}<0$ at 10%), and for Europe ($c^{GS}>0$ at 1%). Therefore gold appears as a strong hedge ($c^{GS}<0$) for US stocks and a weak hedge ($c^{GS}=0$) for French stocks and G7 Stocks. However, it is not a hedge ($c^{GS}>0$) for UK and European stocks.

The estimate of parameter δ^{GS} is always negative, but significantly different from zero (at 10%) only for the UK and the G7. Overall, the conditional covariance between gold and stock

[15] We begin estimation in 1976 :2, just after the Jamaïca agreement (January 1976), when the Bretton Wood system is officially ended.

returns decreases slightly (and often not significantly) during bear stock markets. This seems to confirm that gold is a safe haven against losses on stocks during bear markets. However, the sum $\delta^{GS} + c^{GS}$ is clearly negative only for the US and the G7. Gold appears as strong safe haven in these two cases, whereas it is a weak safe haven in the four other cases $(\delta^{GS} + c^{GS} = 0)$. The fact that the safe haven hypothesis is supported in the US case, but not for European countries might be attributed to the indicator of crises, which is based on the US stock market.

According to the estimates of δ in the variance equations, the volatility of stocks increases strongly during bear markets ($\delta^{S} > 0)$, whereas the volatility of gold seems unaffected ($\delta^{G} = 0)$. The asymmetric effect disappears here for stocks ($d^{S} = 0$, except for the G7), as it is probably already captured through the dummy of bear markets.

Table 6a: Estimation results for the ARMA part of the bivariate models of gold and stock returns, with a dummy for bear stock markets

This table gives the results of the estimations of an ARMA model of the form:

$$r_t^J = c^J + \sum_{i=1}^{p1} a_i^J r_{t-i}^J + \sum_{i=1}^{q1} b_i^J \varepsilon_{J,t-i} \quad ,$$

for both the Gold ($J=G$) and the stock returns ($J=S$). The two ARMA equations for gold and the stock returns of each country are jointly estimated with a bivariate GARCH, by the maximum of likelihood. The results for the bivariate GARCH part are given in table 6b. The estimation period is 1978:9-2009:1. Standard errors are given between brackets. The Ljung-Box statistics (stat. *Q30*, with p-value below) is computed for 30 lags, using standardized residuals.

	France	Germany	UK	US	Europe	G7
			ARMA equation for gold			
c^G	-0.0005	-0.0003	0.0002	-0.0001	-0.0002	-0.0009
	(0.0020)	(0.0023)	(0.0004)	(0.0020)	(0.0020)	(0.0020)
a_1^G	-0.0704	-0.0511	-0.0360	-0.0688	-0.0540	-0.0661
	(0.0507)	(0.0575)	(0.0435)	(0.0502)	(0.0459)	(0.0532)
a_2^G	-0.0958*	-0.0977*	0.1068**	-0.0938**	-0.1273***	-0.1041**
	(0.0493)	(0.0570)	(0.0468)	(0.0486)	(0.0492)	(0.0508)
a_3^G	0.0642	0.0665	0.0597**	0.0425	0.0658	0.0670
	(0.0508)	(0.0552)	(0.0262)	(0.0512)	(0.0494)	(0.0509)
a_4^G	-0.0555	-0.0574	-0.0246	-0.0343	-0.0464	-0.0701
	(0.0488)	(0.0534)	(0.0471)	(0.0495)	(0.0452)	(0.0515)
a_5^G	0.0601	0.0700	0.0980**	0.0752	0.1192**	0.0779
	(0.0541)	(0.0508)	(0.0488)	(0.0548)	(0.0564)	(0.0561)
a_6^G	-0.1420***	-0.1105**	-0.0873*	-0.1174**	-0.1106**	-0.1157**
	(0.0514)	(0.0492)	(0.0513)	(0.0496)	(0.0488)	(0.0517)
a_7^G	0.1470***	0.1452***	0.1424***	0.1451***	0.1596***	0.1310***
	(0.0496)	(0.0503)	(0.0529)	(0.0492)	(0.0484)	(0.0502)
R^2	0.024	0.029	0.041	0.033	0.035	0.025
Q30	23.099	22.371	21.546	21.693	23.523	23.301
	(pv= 0.45)	(pv= 0.50)	(pv= 0.54)	(pv= 0.53)	(pv= 0.43)	(pv= 0.44)
			ARMA equation for stocks			
c^S	0.0127***	0.0073***	0.0091***	0.0097***	0.0106***	0.0076***
	(0.0026)	(0.0030)	(0.0024)	(0.0020)	(0.0024)	(0.0020)
b_1^S	-0.0885*	-	-	-0.0164	-0.0187	-
	(0.0477)			(0.0350)	(0.0408)	
b_2^S	-	-	-	-0.0386	-0.0867*	-
				(0.0410)	(0.0473)	
b_3^S	-	-	-	0.0859**	0.0738*	-
				(0.0442)	(0.0453)	
b_4^S	-	-	-	-0.1096***	-0.0616	-
				(0.0351)	(0.0442)	
b_5^S	-	-	-	0.0307	0.0584	-
				(0.0418)	(0.0453)	
R2	<0.001	0.000	0.000	0.005	0.005	0.000
Q30	25.609	22.589	19.967	24.365	28.119	38.239
	(pv= 0.65)	(pv= 0.83)	(pv= 0.92)	(pv= 0.49)	(pv= 0.30)	(pv= 0.14)

**** 1% sign. level; ** 5% sign. level; * 10% sign. level.*

Table 6b: Estimation results for the GARCH part of the bivariate models of gold and stock returns, with a dummy for bear stock markets

This table gives, for each country, the results of the estimations by maximum of likelihood of a bivariate GARCH of the form:

$$\begin{cases} h_t^{GG} = c^{GG} + \alpha^G \varepsilon_{G,t-1}^2 + \beta^G h_{t-1}^{GG} + d^G dum_{\varepsilon_G<0}\, \varepsilon_{G,t-1}^2 + \delta^G dum_{crisis} \\ h_t^{GS} = c^{GS} + \alpha^{GS} \varepsilon_{G,t-1} \varepsilon_{S,t-1} + \beta^{GS} h_{t-1}^{GS} + d^{GS} dum_{\varepsilon_S<0,\varepsilon_G<0}\, \varepsilon_{G,t-1} \varepsilon_{S,t-1} + \delta^{GS} dum_{crisis} \\ h_t^{SS} = c^{SS} + \alpha^S \varepsilon_{S,t-1}^2 + \beta^S h_{t-1}^{SS} + d^S dum_{\varepsilon_S<0}\, \varepsilon_{S,t-1}^2 + \delta^S dum_{crisis} \end{cases},$$

Where the first and third equations model the autoregressive dynamics of the conditional variance of, respectively, gold and stocks, while the second equation models the conditional covariance between gold and stocks returns.

The estimation period is 1978:9-2009:1. Standard errors are given between brackets.

	France	Germany	UK	US	Europe	G7
The conditional variance of gold						
c^{GG}	<0.0001*	0.0001*	0.0001**	0.0001**	0.0001**	0.0001*
	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
α^G	0.1248***	0.1181***	0.0912***	0.1202***	0.0967***	0.1294***
	(0.0373)	(0.0434)	(0.0338)	(0.0356)	(0.0307)	(0.0445)
β^G	0.8802***	0.8787***	0.9061***	0.8810***	0.8952***	0.8618***
	(0.0347)	(0.0458)	(0.0361)	(0.0364)	(0.0346)	(0.0509)
d^G	-0.0312	-0.0318	-0.0482	-0.0407	-0.0399	-0.0201
	(0.0384)	(0.0436)	(0.0327)	(0.0375)	(0.0332)	(0.0423)
δ^G	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	(<0.0001)	(0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0001)
The conditional covariance between gold and stocks						
c^{GS}	-0.0001	0.0001	0.0004***	-0.0002*	0.0004***	0.0002
	(0.0001)	(<0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)
α^{GS}	-0.0664	-0.0613	-0.1933***	-0.1226**	-0.1557***	-0.1158***
	(0.0703)	(0.0446)	(0.0394)	(0.0527)	(0.0431)	(0.0451)
β^{GS}	-0.0403	0.7484***	-0.5733***	-0.3742*	-0.5401***	-0.1243
	(0.4657)	(0.1846)	(0.1236)	(0.2103)	(0.1776)	(0.3303)
d^{GS}	-0.0590	0.0263	0.2182***	0.1284	0.1439**	0.1552
	(0.1049)	(0.0629)	(0.0547)	(0.1096)	(0.0664)	(0.0989)
δ^{GS}	-0.0007	-0.0002	-0.0005*	-0.0004	-0.0006	-0.0008*
	(0.0005)	(0.0002)	(<0.0001)	(0.0004)	(0.0005)	(0.0004)
The conditional variance of stocks						
c^{SS}	0.0006***	0.0003**	0.0001*	0.0004**	0.0004	0.0006***
	(0.0002)	(0.0001)	(<0.0001)	(0.0002)	(0.0003)	(0.0001)
α^S	0.1425**	0.1146**	0.1088***	0.0517	0.0762	-0.0640***
	(0.0681)	(0.0487)	(0.0371)	(0.0895)	(0.0588)	(0.0160)
β^S	0.6036***	0.8056***	0.8852***	0.5726***	0.6988***	0.5265***
	(0.1016)	(0.0666)	(0.0243)	(0.1108)	(0.1582)	(0.0979)
d^S	-0.0551	-0.0758	-0.0748	0.1086	-0.0568	0.1470***
	(0.0825)	(0.0489)	(0.0524)	(0.1416)	(0.0628)	(0.0549)
δ^S	0.0017***	0.0007**	0.0004***	0.0010***	0.0010**	0.0010***
	(0.0005)	(0.0003)	(0.0001)	(0.0003)	(0.0005)	(0.0004)
Nb. of obs.	365	365	365	365	365	365
Log likelihood	1148.16	1135.10	1173.63	1250.79	1202.00	1250.38

**** 1% sign. level; ** 5% sign. level; * 10% sign. level.*

5.4. Cointegration tests: is gold a hedge against stocks in the long run?

Following the two stages methodology described in Section 4, we regress the real index of precious metals on stocks real index and then test for the stationarity of the series of residuals according to two variants. The first variant is the traditional Engle and Granger test in which the speed of adjustment (ρ) is constrained to be identical across recessions and expansions. In the second variant, we allow for different speeds of adjustment during recessions (ρ1) and expansions (ρ2). According to the results reported in the Table 7 the nul of no cointegration against non linear cointegration can be rejected at 5% for France, the UK, the US and Europe[16]. The tests of no cointegration against linear cointegration (column 3) also reject the hypothesis of no cointegration at the 5% or 10% significance level. The cointegrating coefficient (β) is always negative and comprised between -0.55 (UK) and -0.46 (Europe): gold and stocks are inversely related in the long-run, which is consistent with gold being a hedge. When the speed of adjustment is allowed to change between recessions and expansions, it is systematically higher during recessions (ρ1>ρ2), even though the difference is not significant at 5%. During recessions, the half life of deviations from equilibrium is only 8 to 17 months, whereas during expansions it can last as much as 23 months. The reversal to this long run relationship not only holds during recessions, but its speed of adjustment even accelerates.

Table 7: Regression of the gold price level on the stock price level, cointegration coefficients and speeds of adjustment during recessions and expansions

	Period	β	ρ ♦	ρ_1 ♦	ρ_2 ♦	p	$F_{\rho1=0=\rho2}$ [17]	$F_{\rho1=\rho2}$ ♦♦
France	1978:4-2009:1	-0.54	-0.05**	-0.08	-0.05	11	7.72**	1.17
			(-3.77)	(-2.94)	(-2.97)			(28%)
Germany	1978:4-2009:1	-0.38	-0.03	-0.04	-0.03	11	4.13	0.22
			(-2.84)	(-2.01)	(-2.23)			(64%)
UK	1978:4-2009:1	-0.55	-0.05***	-0.07	-0.05	11	8.00**	0.44
			(-3.95)	(-2.77)	(-3.19)			(51%)
US	1978:4-2009:1	-0.50	-0.06**	-0.08	-0.05	11	7.45**	0.97
			(-3.73)	(-3.02)	(-2.78)			(32.5%)
EUR	1978:4-2009:1	-0.43	-0.04*	-0.05	-0.03	11	5.74*	0.64
			(-3.29)	(-2.54)	(-2.50)			(42.5%)
G7	1978:4-2009:1	-0.54	-0.03◊	-0.05	-0.03	11	4.79◊	0.39
			(-3.03)	(-2.06)	(-2.47)			(53.3%)

**** Significant at 1%, ** significant at 5%, * significant at 10%, ◊ significant at 13%. ♦ T-stat between brackets.*
♦♦ P-values between brackets.

[16] Except for Europe in the regression of Gold on stocks, where the significance level of the residuals test is only 10%.
[17] Tabulated critical values are available in appendix B.

To check the robustness of these results, we again run the same tests, using the precious metal SP&GSCI total return index instead of the the gold SP&GSCI total return index. The results, reported in the appendix B, are quite similar to those found with gold. The absence of cointegration is rejected for France, UK, US and Europe, but no cointegrating relationship is detected between precious metals and the German stock index or the G7 stock index. The cointegration coefficients are always negative, comprised between -0.79 and -0.75, confirming that precious metals can hedge stocks in the long run. The adjustment speed towards equilibrium is systematically higher during recessions than during expansions, even though the difference is seldom significant at 5%. During recessions, the half live of deviations from equilibrium is only 5 to 10 months, whereas during expansions it can last as much as 23 months.

The inverse regressions (of stock index of real return on gold index real return) have also been conducted. The results - reported in the Table 8 - confirm the cointegration relationship for France and Germany at the 5% level and for the US and Europe at the 10% level. For these 4 areas, the speed of adjustment towards equilibrium increases notably during recessions - compared with tranquil periods - though again the difference is not statistically significant. The cointegration coefficients (β) are systematically negative, comprised between -0.97 (US) and -0.48 (Europe). It is worth noticing that these coefficients can here be interpreted as long run hedge ratios: to hedge its investment in stocks in the long run, an investor should buy gold for a value comprised between 48% and 97% of its initial investment. Therefore, the higher speed of adjustment during recessions can be interpreted as faster return to the long run hedging relationship linking gold to stocks. Using the long run hedge ratio to construct a hedged portfolio is therefore legitimate and could work even during crises.

Table 8: Regression of stock price level on gold price level, cointegration coefficients and speeds of adjustment during recessions and expansions

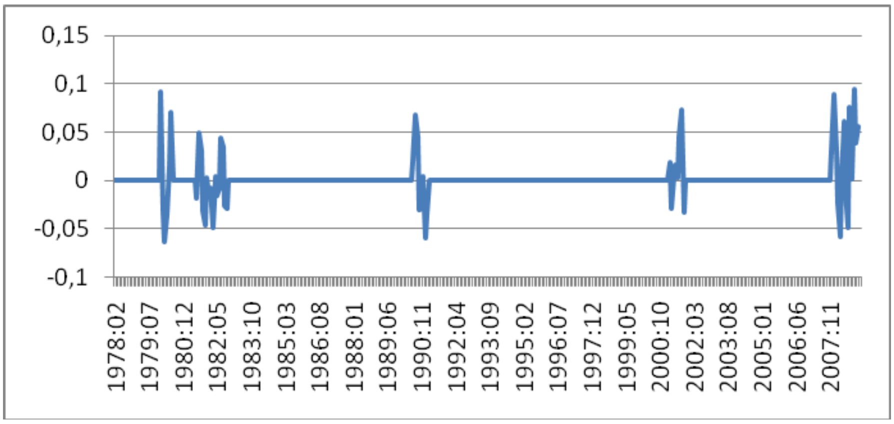
	Period	β	ρ ♦	ρ_1 ♦	ρ_2 ♦	p	$F_{\rho1=0=\rho2}$ [18]	$F_{\rho1=\rho2}$ ♦♦
France	1978:4-2009:1	-0.69	-0.05** (-3.79)	-0.07 (-2.78)	-0.05 (-3.01)	11	7.60**	0.81 (37%)
Germany	1978:4-2009:1	-0.41	-0.04◊ (-3.04)	-0.04 (-1.96)	-0.03 (-2.55)	11	4.67	0.14 (71%)
UK	1978:4-2009:1	-0.55	-0.05** (-3.67)	-0.09 (-2.94)	-0.04 (-2.94)	11	7.85**	2.15 (14.3%)
US	1978:4-2009:1	-0.97	-0.04* (-3.32)	-0.07 (-3.04)	-0.03 (-2.20)	11	6.63**	2.17 (14.2%)
EUR	1978:4-2009:1	-0.48	-0.04* (-3.28)	-0.06 (-2.95)	-0.03 (-2.34)	11	6.46**	2.11 (14.8%)
G7	1978:4-2009:1	-0.37	-0.02 (-1.75)	-0.01 (-0.47)	-0.02 (-1.7)	1	1.54	0.02 (88.7%)

**** Significant at 1%, ** significant at 5%, * significant at 10%, ◊ significant at 13%.*
♦ T-stat between brackets, ♦♦ p-values between brackets.

[18] Tabulated critical values are available in appendix A.

On the whole, the cointegration tests between gold and stocks indices point at precious metals playing the part of a hedge for stocks in the long run. Besides, the speed of adjustment towards this inverse relationship increases during recessions, when stocks perform relatively badly. This can be consistent with gold being a safe haven. However, some caution is required in exploiting this inverse relationship, as it holds only in the long run and does not ensure that gold will always yield positive returns during hard times. To illustrate this point, we have computed the performance during recessions of a portfolio of US stocks and gold based on the estimated long run hedge ratio (Figure 5).

Figure 5: The spread during recessions between the return of an optimally hedged portfolio (with gold) and the return of a portfolio of US stocks only



The long run hedge ratio being 97% of the initial investment in US stocks, the resulting portfolio is approximately balanced between stocks and gold. Figure 5 shows the spread during recessions between the monthly return on this "balanced" portfolio and the monthly return on a portfolio of US stocks only. The hedged portfolio underperforms the undiversified portfolio during the recessions of 1980 and of 1990/1991. It clearly outperforms the undiversified portfolio only during the two last recessions. But even during these latter recessions, there are still a few months during which the hedged portfolio underperforms. The negative long-run relation between gold and stocks means that gold is a "strong hedge" for stocks in the long run. But it does not mean that gold is a "strong hedge" at shorter horizons or during all recessions.

6. CONCLUSION

In this paper, we have investigated if gold is a safe haven and/or a hedge against stocks, by estimating a time varying conditional covariance between gold and stocks returns and testing the safe haven property of gold in the framework of a bivariate ARMA-GARCH-X. Following the definitions of Baur and McDermott (2010), we find that gold is generally a weak hedge in the short run. During recessions, it is a weak safe haven. During bear stock markets, gold appears to be a strong safe haven for the US and the G7 and a weak safe haven for France, Germany, the UK and Europe.

We have also tested for long-run relationships between the two assets. Gold and stocks real prices appear cointegrated for France, the UK, the US and Europe. The cointegration coefficients are systematically negative, which is consistent with gold being a hedge against stocks in the long run. The speed of adjustment is higher during recessions. However, during recessions a portfolio mixing US stocks and gold in "optimal" long term proportions does not systematically outperform a portfolio of US stocks only.

Overall gold appears as an interesting asset to diversify a portfolio away from stocks, but remains a risky investment. Using different definitions of crises and alternative methodologies we therefore confirm the results of Baur and Lucey (2010) and Baur and McDermott (2010). They found also that the strong safe haven property of gold against stocks is rather short-lived and does not systematically hold for every country and crisis episode.

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