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A Smooth Transition Approach

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Joscha Beckmann, Theo Berger, and Robert Czudaj[1]

Does Gold Act as a Hedge or a Safe Haven for Stocks?

A Smooth Transition Approach

Abstract

This study deals with the issue whether gold actually exhibits the function of a hedge or a safe haven as often referred to in the media and academia. In order to test the Baur and Lucey [2010] hypotheses, we contribute to the existing literature by the augmentation of their model to a smooth transition regression (STR) using an exponential transition function which splits the regression model into two extreme regimes. One accounts for periods in which stock returns are on average and therefore allows to test whether gold acts as a hedge for stocks, the other one accounts for periods characterized by extreme market conditions where the volatility of the stock returns is high. The latter state enables us to test whether gold can be regarded as a safe haven for stocks. The study includes a broad set of 18 individual markets as well as five regional indices and covers a sample period running from January 1970 to March 2012 on a monthly frequency. Overall, our findings show that gold serves as a hedge and a safe haven. However, this ability seems to be market-specific. In addition, by applying a portfolio analysis we also show that our findings are useful for investors.

JEL Classification: G11, G14, G15

Keywords: Gold; hedge; safe haven; smooth transition; stock prices

August 2014

1 Joscha Beckmann, UDE and Kiel Institute for the World Economy; Theo Berger, University of Bremen; Robert Czudaj, UDE. *– Thanks for valuable comments are due to the participants of the 11th INFINITI Conference on International Finance, SciencesPo Aix, Aix-en-Provence/France, the 88th WEAI Annual Conference, Seattle/Washington, the 12th Annual EEFS Conference, Berlin/Germany, the 10th BMRC-DEMS Conference on Macro and Financial Economics/Econometrics, London/UK, and the 18th International Conference on Macroeconomic Analysis and International Finance, Crete/Greece.* *– All correspondence to: Joscha Beckmann, University of Duisburg-Essen, Department of Economics, Chair for Macroeconomics, 45117 Essen, Germany, e-mail: joscha.beckmann@uni-due.de*

1 Introduction

Since the breakdown of Bretton Woods gold is no longer a central cornerstone of the international monetary system, but nevertheless it still attracts considerable attention from investors, researchers, and the media. Owing to the increasing uncertainty of financial markets, diversifying a portfolio through hedging becomes more and more important. Especially, during the global financial and economic crisis that started in 2007 the gold price experienced an intense increase while other assets (in particular stock prices) exhibited losses (see Figure I). Given the surge in the price of gold following the global financial crisis and the most recent decline in the price of gold as stock markets have started to hit new highs (for example in April 2013), understanding the relationship between gold and stock markets is an interesting task.

In the era of globalization correlations among most types of assets increased dramatically, however gold is still known to be frequently uncorrelated with other assets [Baur and Lucey, 2010] and is said to be a zero-beta asset [McCown and Zimmerman, 2006]. In this vein, gold seems to be appropriate to be considered as a hedge or safe haven for financial assets or portfolios. The reason is that, in contrast to many other commodities, gold is well-known to be durable, easily recognizable, storable, portable, divisible, and easily standardized [Baur, 2013]. Particularly, the financial media often refers to gold as a safe haven asset for portfolio investors.[1] However, Baur and Lucey [2010] are the first to formulate empirically testable definitions for a hedge and a safe haven with regard to financial assets such as bonds or stocks. Following their definitions, a hedge (safe haven) is an asset that is uncorrelated (negatively correlated) with another asset or portfolio on average (only in times of market stress or turmoil). Baur and McDermott [2010] also distinguish between a strong and a weak form of the hedge and the safe haven property.[2] With regard to this distinction, the question is whether a negative correlation of the returns on gold and on stocks occurs on average or in extreme market conditions. The former (latter) would indicate a strong hedge (safe haven) function of gold. This implies that the gold price increases after a fall of stock prices in such conditions and therefore compensates investors for losses incurred with stock investments.

Figure I about here

This study builds on the work of Baur and Lucey [2010] as well as Baur and McDermott [2010] by augmenting their empirical testing procedure. Our econometric framework is based on a regression of gold returns on stock returns as suggested by Baur and Lucey [2010]. To test the safe haven hypothesis they apply the lower 5%, 2.5%, and 1% quantiles of the stock and bond returns as regressors which take a value of zero if the particular return is larger than the quantile in a given period. Instead of adopting this ad hoc procedure, we contribute to the existing literature by the augmentation of the model to a smooth transition regression (STR) inspired by the work of Teräsvirta [1994] using an exponential transition function which splits the regression model into two extreme regimes. One

[1] For instance, see the article 'Gold: Haven turns riskier but retains its appeal' (Financial Times, December 20, 2011) by Jack Farchy.

[2] Aizenman and Inoue [2012] also point out that central bank's gold position signals economic might, and that gold retains the stature of a safe haven asset at times of global turbulence.

accounts for periods where stock returns are on average and allows to test whether gold acts as a hedge for stocks, the other one accounts for periods of 'extreme times', where the magnitude of the difference between stock returns and their averages is large. The latter state enables us to test whether gold can be regarded as a safe haven for stocks. Hence, the question is whether different regimes can be identified without relying on a priori thresholds. In addition, STR models allow not solely for a discrete switching from one scenario to the other, but account for a smooth transition between them. A discrete switching pattern seems inadequate in cases where investors with different expectations and risk assessments are involved, since market participants may not all act promptly and uniformly as they are confronted with heterogeneous information and opportunity costs which implies different bands of inaction. Moreover, their reaction to new information might also exhibit different delays. Therefore, our framework allows to test the Baur and Lucey [2010] hypotheses in a more fexible and thus realistic fashion. In doing so, we include a broad set of 18 individual markets as well as five regional indices that comprise the largest developed countries, the largest emerging markets as well as the major gold consumers and producers. We cover a sample period running from January 1970 to March 2012 on a monthly frequency. As will be shown, our findings indicate that the ability of gold to serve as a hedge or a safe haven depends on the economic environment. We also confirm that our approach fits the data well, since two extreme regimes with different characteristics can be distinguished.

The reminder of this paper is organized as follows. The following section provides a brief summary of previous empirical studies. Section 3 describes our dataset as well as our econometric framework and presents our findings. Section 4 concludes.

2 Review of the literature

The gold price literature is both vast as well as manifold and the most important strands should be introduced briefly before turning to the specific studies closely related to ours. Firstly, Sherman [1982, 1983], Ariovich [1983], Fortune [1987], Dooley, Isard and Taylor [1995], Sjaastad and Scacciallani [1996], Faff and Hillier [2004], Lucey, Tully and Poti [2006], and Wang and Lee [2011] provide studies which are concerned with impacts of macroeconomic variables such as output, exchange rates, or interest rates on the price for gold. Secondly, Koutsoyiannis [1983], Diba and Grossman [1984], Baker and van Tassel [1985], Pindyck [1993], and Aggarwal, Lucey and O'Connor [2014] give attention to prediction of the gold price. In general, evidence for different relationships and causalities has been provided, however a detailed description of the corresponding outcomes is beyond the scope of this paper. Thirdly, Tschoegl [1980], Solt and Swanson [1981], Ho [1985], Basu and Clouse [1993], and Smith [2002] performed tests of the market efficiency hypothesis for the gold market. More recently, motivated by the lately gold price boom Bialkowski, Bohl, Stephan and Wisniewski [2012] test whether the gold price is subject to a speculative bubble by conducting a Markov regime-switching augmented Dickey-Fuller test and conclude that the high value of the gold price seems to be fundamentally justified. In contrast, Baur and Glover [2012] identify that the price of gold followed an explosive price process between 2002 and 2012 using a test developed by Phillips, Wu and Yu [2011]. Lucey and O'Connor [2013] and Baur and Glover [2014] come to a similar conclusion.

Fourthly, studies which examine the inflation hedge effectiveness of gold have been carried out by Kolluri [1981], Moore [1990], Laurent [1994], Chappell and Dowd [1997], Mahdavi and Zhou [1997], Harmston [1998], Ghosh, Levin, Macmillan and Wrigh [2004], Levin and Wright [2006], Worthington and Pahlavani [2007], and Beckmann and Czudaj [2013b]. These surveys are often based on the analysis of a long-run relationship between the price for gold and the general price level by means of cointegration techniques. The results are not clear-cut and vary depending on the sample period and the country under investigation. Early studies are based on the estimation of a conventional vector error correction model (VECM). However, Beckmann and Czudaj [2013b] recently demonstrate that conducting a Markov-switching VECM is more appropriate in this context. They indicate that gold is partially able to hedge future inflation in the long-run and this ability tends to be stronger for the USA and the UK compared to Japan and the Euro Area.

Finally, we now turn to studies related to the key question of our investigation: Does gold act as a hedge or a safe haven with regard to financial assets such as stocks (or bonds)?[3] The issue of correlation between gold and other major assets has previously been tackled in earlier studies by Sherman [1986], Jaffe [1989], Chua, Stick and Woodward [1990], Upper [2000], Ciner [2001], Michaud, Michaud and Pulvermacher [2006], Hillier, Draper and Faff [2006], McCown and Zimmerman [2006], and Kaul and Sapp [2006] and the overall results suggest that correlation is low or even negative.[4] Recently, Baur and Lucey [2010] provide definitions for a hedge, a diversifier or a safe haven property as follows: an asset acts as a hedge if it is uncorrelated or negatively correlated with another asset or portfolio on average. An asset is regarded as a diversifier if it is positively (but not perfectly correlated) with another asset or portfolio on average as well. A hedge and a diversifier cannot shield a portfolio of exhibiting losses in times of extreme adverse market conditions, since both properties only work on average. Finally, an asset is seen as a safe haven if it is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil. Baur and McDermott [2010] state more precisely that a strong (weak) hedge and safe haven is an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average and only in times of market stress or turmoil, respectively.

Baur and Lucey [2010] test whether gold acts as a hedge, a diversifier or a safe haven for US, UK, and German stocks or bonds using a sample period that ranges from November 30, 1995 to November 30, 2005 and therefore they regress gold returns on stock and bond returns as well as dummy variables for their lower 5%, 2.5%, and 1% quantiles which take a value of zero if the particular return is larger

[3] It should be pointed out that our analysis solely focuses on stocks. Testing the hedging and safe haven hypotheses with regard to bonds is also promising, however we abstain from that, since the available data basis for bonds is not that profound than the one for stocks.

[4] Moreover, Capie, Mills and Wood [2005], Wang and Lee [2011], and Reboredo [2013] show that gold has the potential to hedge against fluctuations of the exchange rate. Faugère and Van Erlach [2005] illustrate that gold can be viewed as a global real store of wealth and construct a valuation theory for gold.

than the quantile in a given period. Their findings indicate that gold acts as a hedge for stocks in the US and in the UK but not in Germany, however, gold does not act as a hedge for bonds in the US and in the UK but in Germany. Furthermore, gold seems to be a safe haven for stocks in all markets with stronger evidence in the UK and in Germany, however gold does not provide a safe haven function for bonds in any of the three markets. A portfolio analysis also indicates that the safe haven property is short-lived. Baur and McDermott [2010] apply a related approach to check whether gold is a strong (weak) hedge or a safe haven against stocks of major emerging and developing countries using daily, weekly, and monthly data for a sample spanning a period from 1979 to 2009.[5] Taken as a whole, the outcomes show that gold acts as a hedge and a strong safe haven for European countries as well as the US, but gold does not act as a hedge or a safe haven for emerging economies as well as for Australia, Canada, and Japan. Using the Baur and McDermott [2010] framework Pasutasarayut and Chintrakarn [2012] show that gold displays neither a hedge nor a safe haven ability in the Thai market for the daily dataset from July 2001 to February 2011. While adopting the same approach and using a daily sample period for the US and the UK running from January 1990 to June 2010 Ciner, Gurdgiev and Lucey [2013] investigate how and under what circumstances each of the five major financial assets (stocks, bonds, oil, gold, and the US dollar) provide a hedge or a safe haven function to each other. They detect that gold acts as a safe haven for most assets, except of oil. More generally, Li and Lucey [2015] analyze the safe haven property for precious metals.

3 Empirical analysis

3.1 The data

Our sample period ranges from January 1970 to March 2012 on a monthly basis and therefore also includes periods of major oil price shocks as well as several other crises.[6] Having also run the whole subsequent analysis for daily and weekly data, we solely rely on monthly data in the following due to the fact that both daily and weekly data appears to be too noisy to capture the regimes we are interested in, and also due to the conjecture that there may be non-synchronicity issues, which are easier to neglect at a monthly frequency. The gold price data has been provided by the World Gold Council (WGC) and is denominated in Australian dollar, British pound sterling, Canadian dollar, Chinese renmimbi, Egyptian pound, euro, Indian rupee, Indonesian rupiah, Japanese yen, Korean won, Russian ruble, South African rand, Swiss franc, Thai baht, Turkish lira, and US dollar. Stock indices for the corresponding countries denominated in their local currencies and for several regions such as Emerging Markets, the Economic and Monetary Union (EMU), the European Union (EU), North America, and the World denominated in US dollar are taken from Morgan Stanley Capital International (MSCI). Therefore our panel includes each economy and region that is part of the study

[5] They include the seven largest developed countries (G7), the largest emerging markets (BRIC countries) as well as Australia and Switzerland in their study.

[6] Since the price of gold already showed significant volatility before the breakdown of Bretton Woods, we feel legitimized to start our investigation prior to 1973 when the data is available. However, in most cases the start of the estimation period is not prior to 1979 (See Table I).

carried out by Baur and McDermott [2010] and extends the latter by both a longer sample period as well as the incorporation of economies that are also regarded by the WGC as major gold consumers (Indonesia, Turkey, Thailand, Egypt, and Korea) and major gold producers (South Africa). This helps to get a deeper insight into the functioning of gold as hedge or safe haven. We calculate gold and stock returns by taking the first difference of the natural logarithm of each series. To avoid a spurious regression, we have ascertained that all returns are stationary by the application of several unit root tests.

For some markets the sample period is shorter than mentioned above, therefore all sample periods and descriptive statistics for annualized returns are given in Table I. Overall, the latter supports the typical finding that asset returns are non-Gaussian. The descriptive statistics can be seen as prima facie evidence for gold as a hedge unconditionally, since for most of the markets we observe the following two important properties: first, stock returns exhibit negative and gold returns positive skewness. Second, stock returns have larger medians than gold returns as the former are riskier. In addition, we have also plotted the quantiles of gold and stock returns against each other (reported by Figure II) and it becomes evident that especially the lowest and highest quantiles differ. This indicates that the distributions of gold and stock returns differ for extreme market conditions.

Table I and Figure II about here

3.2 Econometric methodology

Following Baur and Lucey [2010] our econometric framework is based on a regression of gold returns on stock returns, however we account for asymmetries of positive and negative extreme shocks in a quite different manner. Thus we simultaneously estimate the following two equations by means of the BFGS numerical optimization method [Broyden, 1970; Fletcher, 1970; Goldfarb, 1970; Shanno, 1970]:

$$r_{G,t} = \xi_1 + \psi_1 r_{S,t} + (\xi_2 + \psi_2 r_{S,t})\, G(z_t, \gamma, \kappa) + \varepsilon_t, \tag{1}$$

$$h_t = \pi + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}, \tag{2}$$

where $r_{G,t}$ and $r_{S,t}$ denote gold and stock returns, respectively, and ε_t stands for a random error term. Equation (1) gives the nonlinear relation between gold and stock returns and Equation (2) represents a GARCH(1,1) model of the errors which accounts for the existing heteroscedasticity in the data. $G(z_t, \gamma, \kappa)$ is a transition function which ascertains the speed of transition between two extreme regimes, in our case a state that can be regarded as 'normal times' which allows to test the hedging hypothesis of gold and a state that can be referred to as 'extreme times' (market stress or turmoil) and therefore allows to check for the safe haven hypothesis of gold. Thus we apply a bounded continuous exponential transition function which takes values between 0 and 1 as follows:

$$G(z_t, \gamma, \kappa) = 1 - \exp(-\gamma (z_t - \kappa)^2 / \sigma_{z_t}) \quad \text{with} \quad \gamma > 0, \tag{3}$$

where z_t indicates the transition variable, σ_{z_t} represents its standard deviation, γ denotes a slope parameter, and κ is a location parameter. In order to create a scale-free smoothness parameter, γ is normalized by the standard deviation of the transitional variable z_t, as suggested by Teräsvirta [1998]. A natural choice for the transition variable is the lagged stock return $r_{S,t-j}$, since the asymmetry of Equation (1) depends on the state of the stock returns. If stocks exhibit extreme volatile returns, investors urge to purchase gold and this pressure boosts the gold price. In normal market conditions investors neither sell nor buy gold to a great extent. The location parameter κ can be interpreted as a threshold value and an exponential transition function is symmetrically inverse-bell-shaped ($G(z_t, \gamma, \kappa) \to 1$ for $z_t \to \pm\infty$ and $G(z_t, \gamma, \kappa) \to 0$ for $z_t \to 0$), so that an adjustment for large deviations of the stock returns above and below the threshold κ is symmetric. This allows for a distinction between low and high deviations from the threshold in Equation (1) and therefore for a discrimination between a state of 'normal times' which allows to test the hedging hypothesis of gold and a state of 'extreme times' which allows to check for the safe haven hypothesis of gold. The terms ξ_1 and ψ_1 correspond to the lower regime where the function $G(z_t, \gamma, \kappa)$ takes a value of zero, while $(\xi_1 + \xi_2)$ and $(\psi_1 + \psi_2)$ belong to the upper regime where $G(z_t, \gamma, \kappa)$ equals unity. Thus ψ_1 and $(\psi_1 + \psi_2)$ can be used to test for the hedging and safe haven hypothesis of gold, respectively. If ψ_1 turns out to be significantly negative (not to be significantly different from zero), it would imply that gold acts as a strong (weak) hedge for stocks, since the assets are negatively correlated (uncorrelated) with each other on average. Related to this, if $(\psi_1 + \psi_2)$ shows up to be significantly negative (not to be significantly different from zero), it would imply that gold acts as a strong (weak) safe haven for stocks, since the assets are negatively correlated (uncorrelated) with each other in times of extreme market conditions. Our smooth transition framework can be derived from a modeling approach where several market participants with different thresholds exist. In contrast, discrete switching models assume that one threshold holds for all participants which is a fairly restrictive assumption. However, our smooth transition approach includes the discrete switching model as a special case if $\gamma \to \infty$.

3.3 Testing for linearity against nonlinearity

As a first step, it is necessary to formally test for nonlinearity, though it is also important to choose an adequate transition variable, which in the present study means the choice of a lag order for the stock return. Both issues can be tackled by applying a Lagrange multiplier (LM) test introduced by Luukkonen, Saikkonen and Teräsvirta [1988] which is based on the following third order Taylor approximation of the transition function:[7]

$$r_{G,t} = \varphi_0 + \varphi_1 r_{S,t} + \varphi_2 r_{S,t} z_t + \varphi_3 r_{S,t} z_t^2 + \varphi_4 r_{S,t} z_t^3 + \varepsilon_t. \quad (4)$$

The linear model is nested in Equation (1) for $G(z_t, \gamma, \kappa) = 0$ and the null hypothesis which refers to the linear model being adequate is tested as H_0: $\varphi_i = 0$ with $i = 2, 3, 4$ against the alternative

[7] In the case of small samples in combination with a large number of explanatory variables, F versions of the LM test statistics are preferable, as they have better size properties [Granger and Teräsvirta, 1993; Teräsvirta, 1998; Van Dijk, Teräsvirta and Franses, 2002].

H_1 that at least one $\varphi_i \neq 0$, implying that the higher order terms are significant [Teräsvirta, 1998]. The test statistic has a χ^2 distribution with three degrees of freedom.[8] In the case of the hypothesis of linearity being rejected, a method for choosing the transition variable lies in computing the test statistic for several transition functions, i.e. different values of the lag order j, and selecting the configuration for which its value is maximized [Taylor, Peel and Sarno, 2001; Van Dijk *et al.*, 2002; Beckmann and Czudaj, 2013a].

In the present study, delays from one to twelve are considered. The p-values of the LM tests presented in Table II indicate that the hypothesis of linearity is rejected for almost each market at least for one lag.[9]

Table II about here

Hence, the overall conclusion is that a nonlinear framework seems to be adequate. An inspection of the tests statistics shows that the optimal transition variable differs with different lag orders for the stock return considered to be the most adequate choice. We therefore estimate each model with the lagged stock return as transition variable associated with the highest test statistic denoted by an asterisk in Table II.

3.4 Estimation results

The coefficient estimates of Equations (1) and (2) are presented in Table III.[10]

Table III about here

Table III indicates that in the EMU, Indonesia, Russia, and Turkey gold provides a strong hedging function while there appears to be no hedge in the case of China, Germany, and the whole world index, since the estimates of the ψ_1-coefficient show up to be significantly negative and positive, respectively. For all other economies gold seems to perform a weak hedging function in monthly frequency. In India, as one of the major gold consumers, the UK, and the whole world gold exhibits a strong safe haven function, since in that case the ψ_2-coefficient estimates turn out to be significantly negative. The opposite holds for the EMU, Indonesia, and Russia; therefore gold does not show a safe haven function in these economies. In each other economy gold appears to be a weak safe haven asset in turbulent times. The fact that the estimated value of γ differs across countries shows the usefulness of our approach.

Overall, our findings show that gold can provide both a hedging as well as a safe haven function. At least a weak form of both properties has been observed in the overwhelming number of all cases (independent from the chosen data frequency). More specifically, the results depend on the market under observation. Compared to Baur and McDermott [2010] we do not get a clear pattern that gold

[8] The number of degrees of freedom $3p$ refers to the number of regressors p which in our case is one.

[9] A further finding is that the evidence for nonlinearity in the relationship between gold and stock returns is so much the better, the higher the frequency is chosen. For monthly data evidence appears to be weak, while daily data clearly shows the nonlinear pattern.

[10] In order to save space residual diagnostic tests are not shown in the tables, but these are available upon request. Overall, the findings do not indicate any serious violation of the classical assumptions related to the error terms.

just acts as a hedge and a safe haven for European countries as well as the United States. However, our outcomes confirm that the use of a regime-dependent approach is appropriate, since we get quite different behavior in both extreme regimes for most of the cases. The fact that the speed of transition between the two extreme cases (of normal times and times of turmoil) indicated by γ turns out to be very fast in some cases, suggests that the switching between the two states is almost instantaneous and points in favor of a nearly discrete transition between the regimes, which is also nested in our framework. However, our approach is not restricted to that case and therefore enables the data to speak freely. While in particular industrial economies are characterized by near-discrete threshold dynamics, other countries display a pattern of gradual transition between the regimes. The estimated threshold values for κ also differ owing to the fact that different stock prices exhibit different degrees of volatility. Moreover, the significance of the coefficient estimates for π, α, and β confirms that the heteroscedasticity structure of the data is appropriately accounted for by the use of a GARCH(1,1) term.

In the following we point out some drawbacks of our study. When focusing on stock prices, we use the major market indices with prices quoted in local currency. This gives a true, unitless return on the local market and the price of gold used in the analysis is the price in the local market as well. Therefore, the price of gold in the analysis could also depend on the exchange rate – the US dollar price converted into local currency. Consequently, there is a potential confounding role being played by the exchange rate in the results. This means that part of the relationship between the price of gold and the stock market could also be related to the exchange rate, however it is important to keep in mind that the gold price is much more influenced by exchange rate changes. The price of gold is mostly denominated in US dollar, but gold is also traded in the different currencies. Through arbitrage conditions, changes in the dollar price of gold also change the gold price in other currencies. On the opposite, domestic stocks are mostly traded in the domestic currency and are not directly affected by changes of the US dollar (or other foreign currencies). Correlations mostly occur if common shocks, for example through interest rates, affect both the domestic exchange rate and stock markets. The question of the linkage between gold prices and exchange rates and a potential exchange rate pass-through into the gold market is an issue that is currently under investigation by the authors in a separate study.

Another point related to the use of stock indices is that the different compositions of the indices across countries could have a potential impact on the results. For instance, Canada and Australia have many more natural resource firms in their indices than many other countries. Consequently, we would expect to see a different relationship between gold and the indices in these countries and gold and the indices from countries with less exposure to resources. Although the impact on the results is not clear, it is worth mentioning. One way to address this issue in further research could be to use industry specific indices from each country to more clearly identify the role of gold. However, this is beyond the scope of this study.

3.5 Portfolio analysis

As a final step of our analysis, we assess the importance of our results from an economic perspective by indicating the usefulness of our findings in the context of applied asset management. We make use of the information provided by the transition function in order to find the optimal hedge ratio for stocks and gold. To show that our results are valid for different market characteristics, we take account for different hedge and safe haven compositions and focus on three different economies which refer to different scenarios. The first economy, the US, is characterized by both a weak hedge and a weak safe haven function. Secondly, we investigate the UK characterized by no hedge but a strong safe haven property. As well, we consider Russia as a sensible choice since a strong hedge but no safe haven function is observed. Those three cases are chosen since they mirror extreme changes between the hedge and safe haven function (Russia and the UK) as well as no changes (US) and are therefore useful representatives.

Further, we consider an investor who holds a portfolio of stocks and gold and analyze two strategies: the first trading strategy is described by monthly changes of the portfolio composition depending on the two scenarios, hedge and safe haven, and the value of the transition function. For the US, we assume that the investor holds 20% gold as a hedge and 30% as a safe haven with the transition function separating two market regimes based on the realized volatility. For the UK, the investor holds 0% gold during the first regime since gold does not provide a hedge function and 50% during the second regime where gold strongly acts as a safe haven. For Russia, we consider the opposite case where the investor holds 50% gold as a hedge during the first regime and 0% gold during the second regime since gold does not act as a safe haven. As an indicator for both regimes, we choose a threshold value of 0.5 for the transition function to distinguish between both regimes (below 0.5 = hedge, above 0.5 = safe haven).

Additionally, we investigate a second strategy by replacing the threshold value with a stock-gold-ratio which linearly depends on the transition function to allow for a smooth calibration of the bivariate portfolios.[11] As a benchmark, we consider a naive portfolio diversification, which is fixed with the average weights of the defined strategies. Namely 25% of the portfolio is invested in gold and 75% in stocks. Additionally, we present an investor who exclusively invests in stocks. To investigate the risk adjusted performance of the analyzed trading strategies, we evaluate the results via the Sharpe ratio. Considering that an addition of gold to stocks categorically improves risk adjusted performance measures like the Sharpe ratio (owing to the lower volatility of gold), the naive portfolio diversification represents a sensible benchmark.

Table IV gives the results for the investigated strategies. By comparing the two scenarios according to their Sharpe ratios, we are able to assess whether our results provide an improvement compared to the case where an investor relies on a preselected portfolio structure. Our findings underline the importance of the information provided by the transition function. Especially for the UK and

[11] We are aware that our exercise is not strictly out-of-sample, however, the setting is sufficient to illustrate the importance of our findings from an investors perspective.

Russia, which are both characterized by changing gold scenarios within the investigated sample (no hedge/strong safe haven and strong hedge/no safe haven, respectively), the trading strategies based on the information of the transition function outperform the applied benchmark. As the US (weak hedge and weak safe haven) are not characterized by changing scenarios, the superiority of the applied strategies is weaker.

Table IV about here

4 Conclusion

In this study we extend the existing literature by the adoption of a novel regime-dependent framework to answer the question whether gold can be considered as a hedge and/or safe haven with regard to stocks. To examine the latter, we perform a broad study that includes data from 18 individual economies and five regional indices on a monthly frequency. Finally, we have shown that gold generally serves as a hedge and a safe haven, however this ability depends on the specific economic environment under observation. Interestingly, our results also do not exhibit a unique pattern for gold exporters or importers. We also confirm that our approach fits the data well, since two extreme regimes with different characteristics can be distinguished. Altogether, our findings show that previous studies have been based on a too simplistic discrete framework when analyzing nonlinearities in the relationship between stock markets and gold prices, although the transition between the two extreme regimes appears to be very fast in some cases. From an economic point of view, our results do not provide a direct explanation for the recent increase in the price of gold. However, a reasonable conclusion is that hedging or safe haven functions have played an important role for the recent pattern. This line of reasoning can also be justified according to the results of our portfolio analysis where we have shown that our findings are useful for an investor. The latter holds stocks and gold in proportions which are subject to change according to the transition function and the observed hedge and safe haven property. Overall, our findings show that the gold market is of special importance for policymakers and investors, providing a useful ingredient for portfolio diversification and being closely related to expectations of market participants.

A further issue which could be addressed in future research is the aggregation of the models for each individual economy to a panel smooth transition regression that accounts for the existing cross-sectional dependence between the countries.

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A Tables

Table I: Descriptive statistics

Market	Series	Spl. period	Mean	Median	Max	Min	Std.dev.	Skew.	Kurt.	JB (p-val.)	Obs.
Emerg. markets	r_S	1988-2012	.10	.14	2.41	-3.83	.87	-.79	5.12	84.01 (.00)	290
EMU	r_S	1988-2012	.05	.12	1.97	-3.13	.73	-.69	4.76	60.41 (.00)	290
EU	r_S	1970-2012	.06	.12	2.49	-2.79	.63	-.61	5.12	125.98 (.00)	506
North America	r_S	1970-2012	.06	.11	1.79	-2.94	.55	-.71	5.90	219.87 (.00)	506
World	r_S	1970-2012	.06	.11	1.63	-2.50	.54	-.66	5.04	124.28 (.00)	506
Australia	r_G	1979-2012	.06	.02	2.90	-2.72	.66	.63	6.23	199.02 (.00)	397
	r_S	1970-2012	.05	.10	2.65	-5.61	.69	-1.17	12.31	1942.14 (.00)	506
Canada	r_G	1979-2012	.06	.00	2.82	-2.41	.63	.56	6.49	221.91 (.00)	397
	r_S	1970-2012	.07	.09	1.97	-2.73	.60	-.69	5.61	183.56 (.00)	506
China	r_G	1985-2012	.10	.07	4.47	-2.31	.62	1.19	11.28	1005.36 (.00)	325
	r_S	1993-2012	-.03	-.03	4.17	-3.60	1.22	-.03	3.74	5.22 (.07)	230
Egypt	r_G	1989-2012	.10	.09	2.39	-2.05	.56	.07	4.62	30.67 (.00)	278
	r_S	1995-2012	.14	.14	4.13	-3.52	1.17	.20	4.18	13.30 (.00)	206
France	r_G	1970-2012	.10	.04	3.03	-2.51	.66	.63	5.66	182.65 (.00)	505
	r_S	1970-2012	.06	.11	2.45	-3.15	.72	-.41	4.50	61.28 (.00)	506
Germany	r_G	1970-2012	.10	.04	3.03	-2.51	.66	.63	5.66	182.65 (.00)	505
	r_S	1970-2012	.04	.09	2.04	-3.45	.70	-.75	5.13	143.15 (.00)	506
India	r_G	1979-2012	.12	.07	2.89	-2.55	.65	.64	6.36	214.16 (.00)	397
	r_S	1993-2012	.10	.08	3.25	-2.98	1.01	-.13	3.15	.87 (.65)	230
Indonesia	r_G	1979-2012	.14	.07	8.36	-4.17	1.00	2.10	18.63	4334.87 (.00)	397
	r_S	1988-2012	.16	.15	8.02	-5.88	1.38	.66	10.38	678.57 (.00)	290
Italy	r_G	1970-2012	.10	.04	3.03	-2.51	.66	.63	5.66	182.65 (.00)	505
	r_S	1970-2012	.04	.06	3.16	-2.45	.81	.18	3.97	22.49 (.00)	506
Japan	r_G	1970-2012	.06	.06	3.01	-3.21	.71	.10	6.34	236.05 (.00)	505
	r_S	1970-2012	.04	.06	2.06	-3.01	.66	-.39	4.73	75.93 (.00)	506
Korea	r_G	1979-2012	.09	.03	5.09	-2.85	.77	1.30	10.83	1125.80 (.00)	397
	r_S	1988-2012	.07	.10	4.70	-3.08	1.07	.38	4.72	42.81 (.00)	290
Russia	r_G	1993-2012	.30	.21	6.58	-1.64	.90	2.57	16.09	1887.36 (.00)	229
	r_S	1995-2012	.12	.29	7.35	-10.24	2.01	-.98	8.52	294.28 (.00)	206
South Africa	r_G	1979-2012	.13	.11	2.76	-2.85	.70	.30	5.46	106.51 (.00)	397
	r_S	1993-2012	.11	.17	2.19	-3.70	.71	-.66	6.06	106.59 (.00)	230
Switzerland	r_G	1979-2012	.04	.04	3.24	-1.91	.65	.65	5.82	159.56 (.00)	397
	r_S	1970-2012	.05	.11	2.41	-3.25	.59	-.75	6.24	267.90 (.00)	506
Thailand	r_G	1979-2012	.07	.04	3.08	-2.81	.69	.53	7.27	320.36 (.00)	397
	r_S	1988-2012	.06	.05	6.38	-4.04	1.27	.15	5.95	105.98 (.00)	290
Turkey	r_G	1983-2012	.36	.38	4.35	-2.06	.70	.70	7.26	293.60 (.00)	350
	r_S	1988-2012	.37	.23	7.49	-6.60	1.79	.40	5.06	59.03 (.00)	290
UK	r_G	1970-2012	.10	.05	3.05	-2.45	.68	.63	5.62	177.05 (.00)	505
	r_S	1970-2012	.07	.14	5.15	-3.86	.68	.15	11.53	1535.21 (.00)	506
US	r_G	1970-2012	.09	.05	3.04	-3.04	.70	.37	6.72	303.05 (.00)	505
	r_S	1970-2012	.06	.12	1.91	-2.92	.55	-.70	5.74	199.75 (.00)	506

Note: JB denotes the Jarque-Bera test statistic.

Table II: Linearity test

j	1	2	3	4	5	6	7	8	9	10	11	12
Emerg. markets	.08	.65	.64	.11	.46	.03	.89	.43	.21	.55	.20	.03*
EMU	.24	.78	.05	.21	.86	.26	.04*	.86	.98	.50	.46	.65
EU	.59	.24	.60	.37	.98	.54	.29	.91	.85	.83	.04*	.87
North America	.84	.87	.79	.65	.78	.52	.11*	.57	.60	.39	.38	.49
World	.62	.87	1.00	.48	.96	.73	.12	.80	.61	.67	.11*	.89
Australia	.04	.11	.17	.03	.87	.69	.85	.64	.47	.68	.00*	.46
Canada	.19	.94	.72	.17	.57	.23	.41	.62	.12	.09*	.56	.16
China	.36	.30	.89	.33	.03	.06	.18	.24	.17	.15	.02*	.23
Egypt	.67	.52	.86	.23	.67	.67	.75	.86	.95	.12*	.92	.60
France	.46	.40	.81	.85	.18	.97	.76	.71	.27	.42	.11*	.89
Germany	.33*	.55	.37	.65	.60	.84	.95	.91	.77	.58	.62	.60
India	.22	.48	.92	.06*	.28	.09	.57	.07	.23	.95	.77	.24
Indonesia	.00*	.72	.01	.01	.11	.13	.63	.00	.13	.61	.24	.65
Italy	.71	.56	.16	.80	.50	.06	.53	.99	.34	.04*	.44	.50
Japan	.71	.85	.05*	.43	1.00	.08	.67	.59	.70	.99	.66	.33
Korea	.00*	.21	.07	.70	.20	.02	.75	.01	.53	.89	.05	.67
Russia	.03	.02	.00*	.58	.08	.04	.00	.00	.00	.02	.03	.26
South Africa	.75	.62	.93	.53	.81	.51	.07	.74	.76	.00*	.99	.41
Switzerland	.59	.83	.07*	.95	1.00	.25	.49	.94	.69	.53	.64	.94
Thailand	.52	.73	.00*	.04	.00	.00	.99	.02	.70	.14	.01	.99
Turkey	.29	.00*	.89	.45	.75	.20	.10	.03	.25	.43	.29	.21
UK	.43	.77	.58	.95	.58	.91	.32	.99	.89	.37	.23*	.55
US	.91	.90	.77	.91	.62	.31	.13*	.57	.44	.34	.39	.36

Note: The table displays the p-values for the linearity test proposed by Luukkonen *et al.* [1988] for different lag orders j. The asterisk denotes the lag length which corresponds to the highest test statistic.

Table III: Estimation results

Market	Lag	ξ_1	ψ_1	ξ_2	ψ_2	γ	κ	π	α	β
Emerg. markets	12	-.01*	-.08	.02**	.11	523.33	.03***	.00**	.15***	.79***
		(.01)	(.08)	(.01)	(.10)	(402.47)	(.00)	(.00)	(.05)	(.06)
EMU	7	.01	-.21**	-.00	.43***	39.34**	.03***	.00	.10***	.88***
		(.00)	(.09)	(.01)	(.11)	(20.15)	(.01)	(.00)	(.04)	(.04)
EU	11	.01	-.59	-.00	.63	2.87	-.82	.00***	.14***	.84***
		(.03)	(1.80)	(.03)	(1.80)	(2.87)	(1.61)	(.00)	(.02)	(.03)
North America	7	-.02**	.09	.02***	-.09	538.50*	.02***	.00***	.13***	.85***
		(.01)	(.16)	(.01)	(.18)	(323.39)	(.00)	(.00)	(.03)	(.03)
World	11	-.11***	1.23**	.11***	-1.20**	27662.73**	.00***	.00***	.13***	.85***
		(.03)	(.58)	(.03)	(.58)	(13944.11)	(.00)	(.00)	(.03)	(.03)
Australia	11	-.00	.43	1.75	-200.38	.00*	.21	.00***	.22***	.61***
		(.01)	(.64)	(1.80)	(133.47)	(.00)	(.29)	(.00)	(.06)	(.07)
Canada	10	.01**	.03	-.01*	-.10	56.08*	.01	.00**	.16***	.79***
		(.00)	(.08)	(.01)	(.12)	(33.04)	(.01)	(.00)	(.04)	(.05)
China	11	-.00	.11***	.14	-1.20	.34	.05**	.00*	.11*	.89***
		(.00)	(.04)	(.37)	(2.91)	(.97)	(.02)	(.00)	(.06)	(.06)
Egypt	10	.00	-.03	.01	.27	3.67	-.04	.00***	.26**	-.22**
		(.01)	(.05)	(.01)	(.22)	(3.76)	(.04)	(.00)	(.10)	(.11)
France	11	.00	.07	.00	.13	7.84	-.03	.00***	.15***	.77***
		(.01)	(.05)	(.01)	(.22)	(19.79)	(.05)	(.00)	(.04)	(.05)
Germany	1	.01**	.08*	-.08	.20	.61	-.02	.00**	.13***	.83***
		(.00)	(.04)	(.34)	(.67)	(3.22)	(.04)	(.00)	(.04)	(.04)
India	4	.01**	.05	-4.04	-143.14***	.00***	.03	.00***	.23**	-.11
		(.00)	(.04)	(7.50)	(33.19)	(.00)	(.03)	(.00)	(.10)	(.17)
Indonesia	1	-.01	-1.29***	.02	1.27***	9.44**	-.34***	.00**	.35***	.65***
		(.04)	(.46)	(.04)	(.46)	(4.01)	(.02)	(.00)	(.07)	(.06)
Italy	10	.01	.09	-102.34	-1720.72	.00	-.13	.00***	.14***	.78***
		(.00)	(.08)	(2154.15)	(36062.37)	(.00)	(.26)	(.00)	(.04)	(.05)
Japan	3	.01	-.10	-.01	.21	103.27	.02	.00**	.13***	.83***
		(.01)	(.13)	(.01)	(.14)	(181.79)	(.01)	(.00)	(.04)	(.05)
Korea	1	-.01*	.08	.02***	-.14	58.04	-.02***	.00**	.34***	.63***
		(.01)	(.08)	(.01)	(.09)	(59.77)	(.01)	(.00)	(.10)	(.09)
Russia	3	.04***	-.18***	-.04***	.19**	115.11	-.00	.00***	.62***	.06
		(.01)	(.07)	(.01)	(.08)	(78.58)	(.01)	(.00)	(.16)	(.06)
South Africa	10	.00	.06	574.94	-7163.84	0.00	.00	.00	.48**	.56***
		(.00)	(.04)	(663.11)	(8029.30)	(.00)	(.02)	(.00)	(.20)	(.10)
Switzerland	3	-.01	-.05	.01	.19	25.36	.06***	.00***	.21***	.56***
		(.01)	(.16)	(.01)	(.20)	(27.49)	(.01)	(.00)	(.06)	(.09)
Thailand	3	.01***	.06*	-.05	-.43	1.56	.01	.00*	.14***	.75***
		(.00)	(.04)	(.06)	(.44)	(2.72)	(.02)	(.00)	(.06)	(.09)
Turkey	2	.03***	-.06**	-109.68	22027.97	.00	.10***	.00	.15*	.59**
		(.00)	(.03)	(704.10)	(141344.48)	(.00)	(.03)	(.00)	(.08)	(.26)
UK	11	.01	.47**	-.01	-.50**	722.79	.03***	.00***	.14***	.80***
		(.01)	(.20)	(.01)	(.21)	(694.65)	(.00)	(.00)	(.03)	(.04)
US	7	-.02***	.25	.03***	-.26	1144.19	.02***	.00***	.14***	.85***
		(.01)	(.18)	(.01)	(.20)	(734.22)	(.00)	(.00)	(.03)	(.03)

Note: * Statistical significance at the 10% level, ** at the 5% level, *** at the 1% level. The coefficients are estimated by nonlinear least squares. Newey-West standard errors are given in parentheses. The table provides estimates for the following equations: (1) $r_{G,t} = \xi_1 + \psi_1 r_{S,t} + \left(\xi_2 + \psi_2 r_{S,t}\right) G(z_t, \gamma, \kappa) + \varepsilon_t$, (2) $h_t = \pi + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$, (3) $G(z_t, \gamma, \kappa) = 1 - \exp(-\gamma(z_t - \kappa)^2/\sigma_{z_t})$.

Table IV: Hedging strategies

Market		Stocks	Benchmark	Threshold	Linear
UK	μ	0.006	0.007	0.008	0.007
	σ^2	0.003	0.002	0.002	0.002
	SR	10.80%	15.22%	19.39%	18.23%
US	μ	0.007	0.007	0.007	0.007
	σ^2	0.002	0.002	0.002	0.002
	SR	11.48%	16.72%	17.48%	16.94%
Russia	μ	0.006	0.004	0.006	0.006
	σ^2	0.002	0.001	0.002	0.002
	SR	12.65%	10.94%	12.70%	12.72%

Note: Stocks represents an investor who exclusively invests in stocks. Benchmark represents an investor who invests 75% in stocks and 25% in gold. Thresholds means, that the threshold of 0.5 for the transition function distinguishes between both regimes (below 0.5 = hedge, above 0.5 = safe haven). Linear represents an investment in gold which is linearly related to the transition function. SR denotes the Sharpe ratio: $SR = \mu/\sigma$.

B Figures

Figure I **Gold prices (black line) and US stock prices (blue line) both in US dollar**

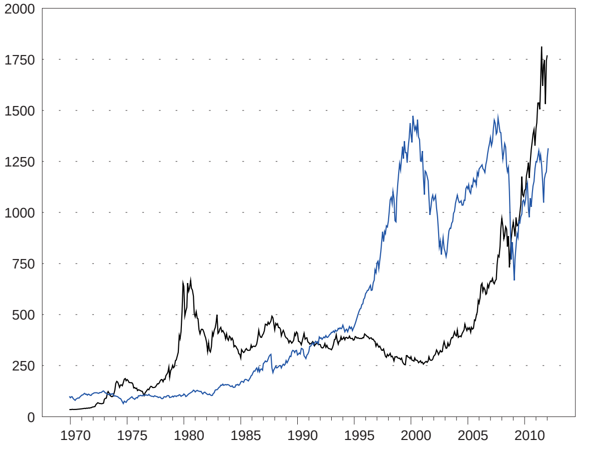

FIGURE II **QQ-plot for each market**