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THE PRICE OF GOLD AS A HEDGE AGAINST THE US DOLLAR

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Abstract: We address the issue of whether the dollar (US dollar) price of gold can be used to hedge the external purchasing power of the dollar. We decompose the dollar price of gold into two parts: a global price of gold and a global price of the dollar. We find that there is no correlation between fluctuations in the global price of gold and fluctuations in the global price of the dollar, or fluctuations in the global price of any individual currency. We show that the observed negative correlation reported in the literature between fluctuations in the dollar price of gold and fluctuations in the dollar is caused by the appearance of the dollar in both variables. The dollar appears in the dollar price of gold with a negative sign that tilts the correlation with fluctuations in the dollar towards negative one.

Keywords: Gold; Exchange rates; Hedge

1. Introduction

The link between the dollar price of gold and the dollar was broken by the collapse of the Bretton Woods international monetary system in the early 1970s. Thereafter, empirical research has found that fluctuations in the dollar price of gold are negatively correlated with fluctuations in the dollar (Beckers and Soenen, 1984). Pukthuanthong and Roll (2011) addressed the question of why the dollar should behave differently from other currencies, and found that the price of gold expressed in a chosen currency tended to rise simultaneously with depreciation of that currency. In general, there appears to be an observed negative correlation between fluctuations in the price of gold expressed in a currency and fluctuations in that currency.

The observed negative correlation between fluctuations in the dollar price of gold and fluctuations in the dollar has encouraged researchers to propose the use of the dollar price of gold to hedge against fluctuations in the dollar: a hedge for the external purchasing power of the dollar. Capie et.al (2005) concluded that the dollar price of gold has been a hedge against the dollar. Similarly, Joy (2011) argued that the dollar price of gold has behaved as a hedge against the dollar. Furthermore, Reboredo (2013) found evidence of average dependence between the dollar price of gold and dollar depreciations and concluded that the dollar price of gold is a hedge. Subsequently, Reboredo and Rivera-Castro (2014) extended this research to show that the dependence between the dollar price of gold and dollar depreciations was robust across different time scales. Moreover, Erb and Harvey (2013) found a significant

negative relationship between fluctuations in the dollar price of gold and fluctuations in dollar exchange rates; although the authors questioned whether this negative relationship was strong enough for hedging purposes.

In this paper we address whether gold can be used to hedge the external purchasing power of individual currencies: a hedge for individual currency risk. Specifically, we look at whether dollar risk can be hedged with the dollar price of gold.

We contribute to the literature by decomposing the price of gold expressed in a chosen currency into two parts: a global price of gold and a global price of that currency. We find that there is no correlation between fluctuations in the global price of gold and fluctuations in the global price of any currency. The observed negative correlation reported in the literature is driven by the appearance of the chosen currency in both variables. The chosen currency appears with a negative sign in the price of gold expressed in that currency, which tilts its correlation with fluctuations in that currency towards negative one.

An implication of this result is that gold is not a hedge against the external purchasing power for individual currencies and thus should not be used to hedge individual currency risk.

2. Material and methods

2.1 Currency universe

To keep the examples simple throughout, we use a small currency universe that consists of the following four currencies: the US dollar (USD), the Eurozone euro (EUR), the Japanese yen (JPY), and the British pound sterling (GBP).

2.2 The dollar price of gold

The price of gold is usually expressed in dollars. For example, if the price of one ounce (oz) of gold expressed in dollars is USD 1000 = 1oz gold, an investor buys one ounce of gold with dollars by selling 1000 dollars. Thus the dollar price of gold represents the price a quantity of dollars can be exchanged for a quantity of gold. In log terms[1], we can write the dollar price of gold as:

$$p_{GOLD/USD,t} = q_{GOLD,t} - q_{USD,t}\,, \tag{1}$$

where $t = 1,...,T$; $p_{GOLD/USD,t}$ is the dollar price of gold; $q_{GOLD,t}$ is the quantity of gold; and $q_{USD,t}$ is the quantity of dollars.

[1] In nominal terms, we can write the dollar price of gold as $P_{GOLD/USD,t} = Q_{GOLD,t} / Q_{USD,t}$.

Table 1: Nominal quantities for buying the dollar price of gold

	Gold	USD	EUR	JPY	GBP
$Q_{GOLD,t}$	1000				
$Q_{USD,t}$		1000			
$P_{GOLD/USD,t} = Q_{GOLD,t} / Q_{USD,t}$	1000	-1000			

In Table 1 we report the nominal quantities in dollars[2] for buying USD 1000 worth of gold at the dollar price of gold. To buy at the dollar price of gold, an investor buys a quantity of gold with dollars by selling a quantity of dollars.

2.3 Global prices for currencies

A bilateral exchange rate for the *ith* currency in terms of the *jth* currency is the price at which a quantity of the *jth* currency can be exchanged for a quantity of the *ith* currency. In log terms[3], we can write the exchange rate as:

$$p_{i/j,t} = q_{i,t} - q_{j,t}, \tag{2}$$

where $t = 1,...,T$; $p_{i/j,t}$ is the exchange rate for the *ith* currency in terms of the *jth* currency: with $p_{i/i,t} = 0$; $q_{i,t}$ is the quantity of the *ith* currency; and $q_{j,t}$ is the quantity of the *jth* currency.

Kunkler and MacDonald (2015) show that, in log terms, a system of N_S bilateral exchange rates with respect to a numeraire (0th) currency can be decomposed into a unique set of $N_S + 1$ global prices for each currency:

$$p_{i/0,t} = p_{i,t} - p_{0,t}, \qquad i = 1,...,N_S \tag{3}$$

where $t = 1,...,T$; $p_{i/0,t}$ is the exchange rate for the *ith* currency in the numeraire currency; $p_{i,t}$ is the global price of the *ith* currency and $p_{0,t}$ is the global price of the numeraire currency. In this paper, we use the dollar as the numeraire currency such that $p_{0,t} = p_{USD,t}$.

The global price of the *ith* currency, in log terms, is simply a multilateral exchange rate and is calculated by:

[2] It should be noted that, in all tables, the nominal quantities are displayed in dollars to make interpretation easier.

[3] In nominal terms, we can write the exchange rate as $P_{i/j,t} = Q_{i,t} / Q_{j,t}$.

$$p_{i,t} = \frac{1}{N_S + 1} \sum_{j=0}^{N_S} p_{i/j,t}\ ,\ i = 0,...,N_S \qquad (4)$$

where $t = 1,...,T$; $p_{i/j,t}$ is the exchange rate in (2). In terms of quantities, in log terms[4], the global price of the *ith* currency can be calculated by substituting equation (2) into equation (4):

$$p_{i,t} = \frac{1}{N_S + 1} \sum_{j=0}^{N_S} (q_{i,t} - q_{j,t}) = q_{i,t} - q_{CU,t}\ , \qquad i = 0,...,N_S \qquad (5)$$

where $q_{CU,t} = \sum_{j=0}^{N_S} q_{j,t} / (N_S + 1)$ is the quantity of the currency universe: a basket of currency quantities.

The global price of the *ith* currency is the price of the *ith* currency relative to all the currencies in the currency universe. In Table 2 we report the nominal quantities in dollars for buying USD 1000 worth of the global price of the dollar relative to the currency universe: USD, EUR, JPY, and GBP.

Table 2: Nominal quantities for the global price of the dollar

	Gold	USD	EUR	JPY	GBP
$Q_{USD,t}$		1000			
$Q_{CU,t}$		250	250	250	250
$P_{USD,t} = Q_{USD,t} / Q_{CU,t}$		750	-250	-250	-250

2.4 Decomposing the dollar price of gold

The dollar price of gold can be decomposed into two parts by adding, and subtracting, the currency universe quantity $q_{CU,t}$ to, and from, equation (1):

$$p_{GOLD/USD,t} = q_{GOLD,t} - q_{USD,t} + q_{CU,t} - q_{CU,t} = p_{GOLD,t} - p_{USD,t}\ , \qquad (6)$$

where $t = 1,...,T$; $p_{GOLD,t} = q_{GOLD,t} - q_{CU,t}$ is the global price of gold; and $p_{USD,t} = q_{USD,t} - q_{CU,t}$ is the global price of the dollar.

The dollar price of gold can therefore be decomposed into two parts: the global price of gold; and the global price of the dollar. The first part, the global price of gold $p_{GOLD,t}$, is the price of gold relative to all currencies in the currency universe: a multilateral price

[4] In nominal terms, we can write the global price of the *i*th currency as $P_{i,t} = Q_{i,t} / Q_{CU,t}$

of gold. The second part, the global price of the dollar $p_{USD,t}$, is a multilateral price of the dollar.

In practice, an investor would buy the global price of gold by buying the dollar price of gold and buying the global price of the dollar. This can be seen, in log terms[5], by rearranging equation (6) to be in terms of the global price of gold:

$$p_{GOLD,t} = p_{GOLD/USD,t} + p_{USD,t} \,. \tag{7}$$

In Table 3 we report the nominal quantities in dollars for buying USD 1000 worth of the global price of gold that consists of buying USD 1000 worth of the dollar price of gold and buying USD 1000 worth of the global price of the dollar.

Table 3: Nominal quantities for the global price of gold

	Gold	USD	EUR	JPY	GBP
$P_{GOLD/USD,t}$	1000	-1000			
$P_{USD,t}$		750	-250	-250	-250
$P_{GOLD,t} = P_{GOLD/USD,t} \times P_{USD,t}$	1000	-250	-250	-250	-250

2.5 The law of one price

We assume that the law of one price in an open economy holds for gold, where gold sells for the same price when expressed in a common currency. In this situation, the price of gold expressed in dollars can be converted into the price of gold expressed in the *ith* currency by using the *ith* /USD exchange rate $p_{i/USD,t}$:

$$p_{GOLD/i,t} = p_{GOLD/USD,t} - p_{i/USD,t} = p_{GOLD,t} - p_{i,t} \tag{8}$$

where $p_{GOLD/USD,t} = p_{GOLD,t} - p_{USD,t}$ is the decomposition of the dollar price of gold from equation (6) and $p_{i/USD,t} = p_{i,t} - p_{USD,t}$ is the decomposition of the *ith* /USD exchange rate from equation (3) with $p_{0,t} = p_{USD,t}$.

In general, the price of gold expressed in the *ith* currency can therefore be decomposed into two parts: the global price of gold; and the global price of the *ith* currency.

The decomposition of the price of gold expressed in the *ith* currency allows us to investigate which part is the source of the observed negative correlation reported in the literature between fluctuations in the price of gold expressed in the *ith* currency and fluctuations in the *ith* currency.

[5] In nominal terms, we can write the global price of gold as $P_{GOLD,t} = P_{GOLD/USD,t} \times P_{USD,t}$

We begin the investigation by looking at the covariance between the log returns of the price of gold expressed in the *ith* currency and the log returns of the global price of the *ith* currency:

$$\text{cov}(\Delta p_{GOLD/i,t}, \Delta p_{i,t}) = \text{cov}(\Delta p_{GOLD,t}, \Delta p_{i,t}) - \text{var}(\Delta p_{i,t}), \quad (9)$$

where $\Delta p_{GOLD/i,t} = \Delta p_{GOLD,t} - \Delta p_{i,t}$ from equation (8) and Δ is the first difference operator. The covariance $\text{cov}(\Delta p_{GOLD/i,t}, \Delta p_{i,t})$ and the correlation $cor(\Delta p_{GOLD/i,t}, \Delta p_{i,t})$ are both negative[6] when: $\text{cov}(\Delta p_{GOLD,t}, \Delta p_{i,t}) < \text{var}(\Delta p_{i,t})$, which will always be true when the variance of the fluctuations in the global price of gold is less than the variance of the fluctuations in the global price of the *ith* currency, i.e. when $\text{var}(\Delta p_{GOLD,t}) < \text{var}(\Delta p_{i,t})$. However, in practice, the variance of the log returns of the global price of gold is usually larger than the variance of the log returns of the global price of each currency, i.e. $\text{var}(\Delta p_{GOLD,t}) >> \text{var}(\Delta p_{i,t})$.

2.6 Data

The data consists of the dollar price of gold and a system of 3 bilateral exchange rates (4 currencies) against the dollar (numeraire currency) for over 35 years of end of monthly values from Bloomberg, using New York closing prices from 4th January 1980 to 31st December 2014. The currency universe consists of the four currencies: USD, EUR[7], JPY, and GBP.

3. Results and discussion

In this section we first report the volatilities of the fluctuations for all data variables, which will provide a guide on the sign of the observed correlation between fluctuations in the price of gold expressed in the *ith* currency and fluctuations in the *ith* currency. We then look at a subset of the correlation matrix to investigate the observed correlation values of interest. Finally, we test the significance of the relationship between fluctuations in the global price of gold and fluctuations in the global prices of each currency.

In Table 4 we report the annualised volatilities for the log returns of: the global price of gold, the price of gold expressed in each currency and the global price of each currency. The annualised volatility of 16.7% for fluctuations in the global price of gold is less than of the annualised volatilities of the fluctuations in the price of gold expressed in different currencies, which range from a low of 17.6% to a high of 18.7%. The global price for gold is a multilateral price of gold that diversifies currency risk. Furthermore, converting the global price of gold into any single currency therefore tends to add risk. Thus the global price for gold is a purer, less volatile, price of gold.

[6] The sign of the correlation between two variables is the same as the sign of the covariance between the same variables.

[7] The euro started trading at the beginning of 1999, and the German deutsche mark is used prior to this.

The annualised volatility of 16.7% for the fluctuations in the global price of gold is more than twice the average annualised volatility of approximately 6.7% for the fluctuations in the global price of the four currencies. This clearly shows that $\text{var}(\Delta p_{GOLD,t}) > \text{var}(\Delta p_{i,t})$ for all currencies.

Table 4: Annualised volatilities of log returns

The global price of gold $(\Delta p_{GOLD,t})$ The dollar price of gold in $(\Delta p_{GOLD/USD,t})$; the euro price of gold $(\Delta p_{GOLD/EUR,t})$; the yen price of gold $(\Delta p_{GOLD/JPY,t})$; the pound sterling price of gold $(\Delta p_{GOLD/GBP,t})$; and the global price of the four currencies: dollar $(\Delta p_{USD,t})$, euro $(\Delta p_{EUR,t})$, yen $(\Delta p_{JPY,t})$, and pound sterling $(\Delta p_{GBP,t})$

	Volatility
$\Delta p_{GOLD,t}$	16.7%
$\Delta p_{GOLD/USD,t}$	17.8%
$\Delta p_{GOLD/EUR,t}$	17.6%
$\Delta p_{GOLD/JPY,t}$	18.7%
$\Delta p_{GOLD/GBP,t}$	17.8%
$\Delta p_{USD,t}$	6.6%
$\Delta p_{EUR,t}$	6.3%
$\Delta p_{JPY,t}$	7.7%
$\Delta p_{GBP,t}$	6.1%

Table 5 contains a selected subset of values from the correlation matrix of the variables in Table 4. In the first row of Table 5, we find that there is a highly significant positive correlation between fluctuations in the global price of gold and fluctuations in the price of gold expressed in each currency. This reinforces the result in Pukthuanthong and Roll (2011), where it was found that there is a strong and positive correlation between the fluctuations in gold prices expressed in different currencies.

In the first column of Table 5, we find that fluctuations in the global price of gold $\Delta p_{GOLD,t}$ are not correlated with fluctuations in any of the four currencies, with the observed correlation values varying from a low of -0.04 to a high of +0.04.

In the diagonal terms of Table 5, we find that fluctuations in the price of gold expressed in the *ith* currency are negatively correlated with fluctuations in the global price of the *ith* currency: for all currencies. The observed negatively correlation for each currency is caused by the global price of that currency appearing in both variables. The largest observed negative correlation of -0.45 is between fluctuations in the global price of the yen $\Delta p_{JPY,t}$ and fluctuations in the price of gold expressed in yen $\Delta p_{GOLD/JPY,t}$; this is due to the volatility of $\Delta p_{JPY,t}$ being the largest of the four currencies in Table 4.

Table 5: Correlations

A subset of the sample correlation matrix of the log returns for the global price of gold, the price of gold expressed in each currency and the global price of each currency

	$\Delta p_{GOLD,t}$	$\Delta p_{GOLD/USD,t}$	$\Delta p_{GOLD/EUR,t}$	$\Delta p_{GOLD/JPY,t}$	$\Delta p_{GOLD/GBP,t}$
$\Delta p_{GOLD,t}$	**1.00**	**0.93**	**0.93**	**0.91**	**0.94**
$\Delta p_{USD,t}$	**0.02**	**-0.35**	0.18	0.12	0.12
$\Delta p_{EUR,t}$	**0.04**	0.20	**-0.32**	0.21	0.04
$\Delta p_{JPY,t}$	**-0.04**	0.06	0.12	**-0.45**	0.15
$\Delta p_{GBP,t}$	**-0.01**	0.10	-0.01	0.22	**-0.35**

Specifically to the dollar, we find that fluctuations in the global price of the dollar $\Delta p_{USD,t}$ has an observed negative correlation of -0.35 with fluctuations in the dollar price of gold $\Delta p_{GOLD/USD,t}$. However, we find that fluctuations in the global price of the dollar $\Delta p_{USD,t}$ has an insignificant correlation of 0.02 with fluctuations in the global price of gold $\Delta p_{GOLD,t}$. Thus the observed negative correlation reported in the literature between fluctuations in the dollar price of gold and fluctuations in the dollar is caused by the dollar appearing in both variables.

Finally, we test the significance of the relationship between the log returns of the global price of gold $\Delta p_{GOLD,t}$ and the log returns of the global price of the *ith* currency $\Delta p_{i,t}$ with the following regression:

$$\Delta p_{GOLD,t} = \alpha_i + \beta_i \Delta p_{i,t} + u_t \ , \quad i = 0,\ldots, N_S \tag{10}$$

where α_i is an intercept term, β_i is the sensitivity of $\Delta p_{GOLD,t}$ to $\Delta p_{i,t}$, and u_t is a disturbance term.

Table 6 contains the individual regression results from equation (10) for fluctuations in the global price of gold $\Delta p_{GOLD,t}$ against fluctuations in the global price of each currency: $\Delta p_{USD,t}$, $\Delta p_{EUR,t}$, $\Delta p_{JPY,t}$, and $\Delta p_{GBP,t}$. The t-statistics for all currencies are not significant, which provides further evidence that fluctuations in the global price of gold are not correlated with any of the four individual currencies.

Table 6: Regression Results

Individual regression results for the log returns of the global price of gold $\Delta p_{GOLD,t}$ against the log returns of the global price of each currency: $t(\beta_i)$ represents the *t*-statistic for testing the hypothesis that $\beta_i = 0$

	β_i	$t(\beta_i)$
$\Delta p_{USD,t}$	0.04	0.35
$\Delta p_{EUR,t}$	0.10	0.81
$\Delta p_{JPY,t}$	-0.08	-0.77
$\Delta p_{GBP,t}$	-0.03	-0.23

4. Conclusion

We have shown that the dollar price of gold can be decomposed into two parts: a global price of gold and a global price of the dollar. The global prices for both gold and the dollar are multilateral prices: relative to a group of currencies. It was found that fluctuations in the global price of gold are not correlated with fluctuations in the dollar, or fluctuations in any other currency.

The global price of the dollar is the part of the dollar price of gold that is responsible for the observed negative correlation reported in the literature between fluctuations in the dollar price of gold and fluctuations in the dollar.

If investors chose to hedge fluctuations in the dollar with the dollar price of gold, they should be aware that they are hedging the dollar fluctuations with the global price of the dollar and not with the global price of gold.

In general, we found that fluctuations in the global price of gold are not correlated with fluctuations in any individual currency. It therefore appears that gold is not a hedge against the external purchasing power for any individual currency. An implication of this finding is that the global price of gold should not be used for hedging individual currency risk.

However, we do not conclude that the global price of gold cannot be used to hedge global currency risk, such as competitive devaluations. The exchange rate market is a relative market, where currencies move relative to other currencies. In this situation, all currencies cannot depreciate at the same time. Unfortunately, this restricts the ability to create a global "market" index for the exchange rate market. We leave this issue open for future research.

Most commodities are expressed in dollars. As long as the law of one price in an open economy holds, then the general decomposition methodology used to create global prices can be applied to these commodities, as well as commodities expressed in other currencies. Global prices are multilateral prices that diversify currency risk.

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