



Revisiting the price of gold and exchange rates with quantile regression model

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Abstract

This paper provides a new perspective on the link between the price of gold and exchange rates, using weekly data from 1995 to 2016. Initially, we classify currencies as strong (RMB) or weak (RUB), by comparing them with a reference currency (USD or GBP). We find that there is no co-integration relationship between the price of gold in a certain currency and the currency's relation to any other exchange rate. Additionally, a negative relationship exists between the price of gold for currencies and the exchange rates of weak currencies. However, a positive relationship exists between gold and the exchange rate of a strong currency. Therefore, the negative relationship between the price of gold and exchange rate depends on the currency's strength. The results of this study are different from those obtained in previous studies in this area. Furthermore, robustness tests support the results above.

Keywords: Price of Gold; Exchange Rates; Correlation; Quantile Regression; Robust Test

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1. Introduction

Whether as a commodity or as a financial asset, the strengthened gold price in combination with the depreciation of some currencies, such as the US dollar (USD) and the UK pound (GBP), has attracted the attention of investors, risk managers, and the financial media.

Some studies have examined the role of gold as a hedge or safe haven asset against currency depreciation. For instance, Beckers and Soenen (1984) verify the gold and USD inverse relationship empirically, providing evidence on gold's hedging benefits for US and non-US investors. Sjasstad and Scacciavillani (1996) find that floating exchange rates among major currencies have been a major source of price instability in the global gold market since the dissolution of the Bretton Woods International monetary system. While Sjasstad (2008) confirms that, as the world gold market seemed to be dominated by the USD bloc, appreciations or depreciations of the USD would have strong effects on the price of gold in other currencies. Capie et al., (2005) confirm the positive relationship between USD depreciation and the price of gold, making gold an effective hedge against the USD. Additionally, many scholars find a positive dependence between gold and USD depreciation against a wide set of currencies (Joy, 2011; Rebores, 2013; Rebores and Rivera-Castro, 2014; Beckmann et al., 2015).

Different from existing literature, Pukthuanthong and Roll (2011) find that the price of gold can be associated with any currency depreciation, such as the USD price of gold can be related to USD depreciation and the euro (EUR) (GBP, JPY) price of gold can also be related to EUR (GBP, JPY) depreciation. However, Chen et al., (2014) explain gold price fluctuations from the perspective of the role of central banks worldwide.

Except for the hedge and safe haven roles of exchange rates, gold also has been widely acknowledged as a "safe haven" and "store of value" for central bankers and investors (Baur and Lucey, 2010; Baur and McDermott, 2010), especially in periods of financial and political turmoil. Additionally, gold also has been widely regarded as one of the most important precious metals (Blöse and Shieh, 1995; Bialkowski et al., 2015) and a standard underlying the international monetary and/or exchange rate system (Capie et al., 2005; Govett and Govett, 1982; Ming et al., 2016, among others).

In this paper, we study the structural correlation between gold price and exchange rates, given the fluctuation of gold prices in recent years, see Figure 1. There is a net increase in the price of gold over the last twenty years, which diverges across countries because of different exchange rate appreciations. Two aspects are obvious here. First, the Renminbi (RMB) appreciated the most over these twenty years relative to other currencies; thus, the RMB price of gold has the lowest overall increase. On the other hand, the Russian ruble (RUR) depreciated the most relative to the other currencies. Second, gold price changes are highly correlated across countries and display significant volatility.

Although the gold price in these four currencies increases during this period, except on rare occasions, all the exchange rates do not depreciate. Taking the RMB exchange rate as an example, it appreciates continuously over the twenty years, except for some short periods. For the purpose of understanding the RMB appreciation, we summarize the 2005 Chinese exchange rate reform. In short, China reformed the exchange rate regime by moving to a managed floating exchange rate based on market supply and demand,

with reference to a basket of currencies. As a consequence, the RMB began to appreciate after many years. Therefore, compared with the USD and the GBP, we regard RMB as a strong currency. However, the RMB gold price did increase 2.5 times compared with 1995. This is different from existing literature. Actually, the RMB is not the only currency that exhibits such an evolution. The Indian rupee (INR) has experienced an increase during these twenty years as well ¹. Conversely, the RUR has depreciated significantly over the past twenty years, especially during the RUR crisis in 1998. Accordingly, we view RUR as a weak currency in this paper. However, we may reasonably choose USD and GBP as a reference currency.

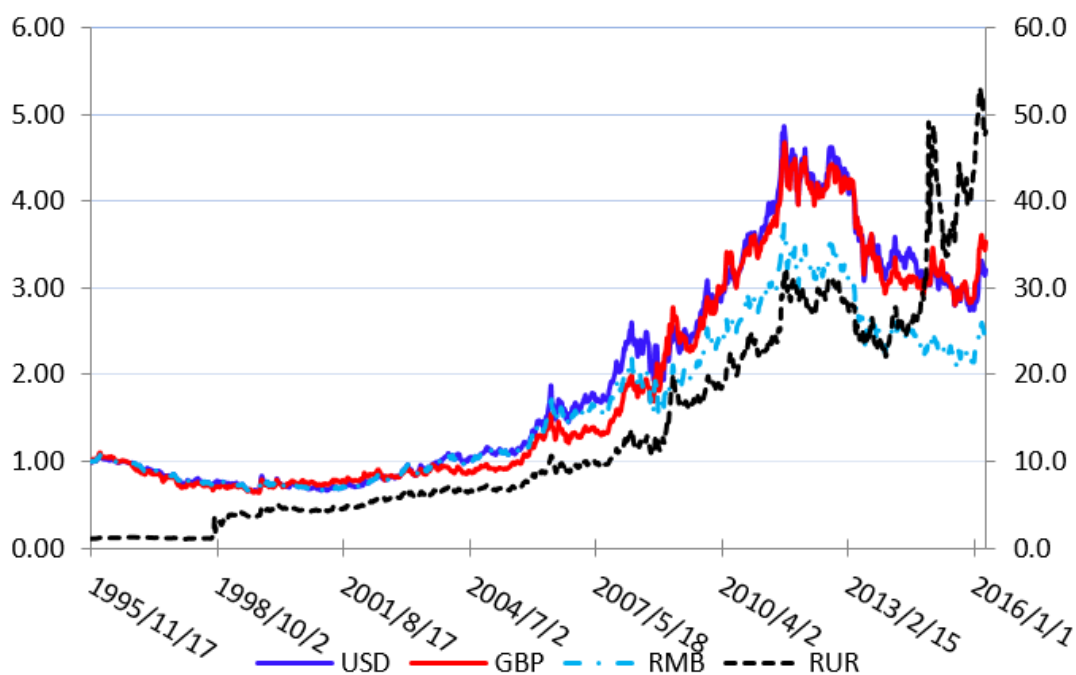


Figure 1. Gold price from 1995–2016. (Note: November 17, 1995 is the base period. The RUR price of gold is in accordance with the right axis, while the others with the left axis.)

Consequently, we study the relationship between gold price and the exchange rates of different currencies. Our research contributes to the literature on the dynamics between the gold price and exchange rates in two aspects. First, there is no long-run stable relationship among gold prices and bilateral exchange rates in the sample period. Second, on classifying the currencies into strong currency (RMB), weak currency (RUR), and reference currency (USD or GBP), a negative relationship exists between the price of gold in some currency and the exchange rate of a weak currency. However, a positive relationship exists between gold price and the exchange rate of a strong currency. Therefore, the negative relationship between the price of gold and exchange rate is decided by currency strength. This point is different from conventional wisdom.

The organization of this paper is as follows. Section 1 describes the study's purpose and previous research on the relationship between the price of gold and exchange rates. Section 2 briefly discusses the research methodology. Section 3 outlines the data and results. Section 4 presents the robust analysis. Finally, the last section provides a discussion and conclusion.

2. Methodology

We employ both the ordinary least squares (OLS) model and quantile regression (QR) model to explore the relationship between the price of gold and exchange rates in this paper. However, we only concentrate on correlation between the two variables and ignore other details. Moreover, the OLS model only identifies the average effects on exchange rates, that is, how gold prices impact average exchange rates. Fortunately, the QR model, introduced by Koenker and Basset (1978), provides a robust and distributional view of gold prices on exchange rates; for example, how would the USD price of gold affect the exchange rate of GBP to USD when USD prices of gold are at different quantile levels. Here, we set a simple univariate model

$$y_{ij} = \beta_0 + \beta_1 x_j + \varepsilon \quad (2.1)$$

where x_j is the gold price valued in currency j , while y_{ij} ² is the exchange rate of currency j per currency i . β_0 and β_1 are intercept and regression coefficient, respectively, ε is the residual term.

If β_1 is positive and significant, then the gold price valued in currency j increases, and currency j depreciates against currency i on average. However, if β_1 is negative and significant, then the gold price valued in currency j increases, and currency j appreciates against currency i on average.

In other words, we determine how would a one percent change of the gold price affect the exchange rates on average. This addresses our "average" concern, but we are also interested in the effects on the right tail of the exchange rate distribution. For example, it is important how would a one unit change of gold price affect the exchange rates when the exchange rate is already high. The QR model is a tool for addressing this. Corresponding to equation (2.1), the QR model could be written as:

$$\begin{aligned} y(\tau) &= x(\beta + \lambda f_{\varepsilon_i}^{-1}) \\ &= x\beta(\tau) \end{aligned} \quad (2.2)$$

where f_{ε_i} is the distribution function of ε_i , τ is the quantile of exchange rates conditional on gold price. Therefore, as long as $\lambda \neq 0$, $\lambda f_{\varepsilon_i}^{-1}$ captures the heterogeneous effects of gold price on exchange rates. By varying τ over the range of $(0,1)$, we obtain a distributional view of gold price effects on exchange rates. We use the expression $\beta(\tau)$ to indicate that β depends upon the choice of τ , which is the quantile of conditional distribution of gold prices. To obtain quantile estimates, we select a value for τ and then minimize the following expression

$$\hat{\beta}(\tau) = \arg \min_{\beta(\tau)} \left[\tau \sum_{y_i > \beta x_i} (y_i - \beta x_i) - (1 - \tau) \sum_{y_i \leq \beta x_i} (y_i - \beta x_i) \right] \quad (2.3)$$

In other words, $\beta(\tau)$ is derived as a line ($y = x\beta(\tau)$), such that τ percent of observations lie on or below the line (the first sum), while $1 - \tau$ percent of observations lie above the line (the second sum). Note that we can choose τ freely in the range $(0, 1)$.

3. Data and results

We empirically investigate the relationship between gold prices against exchange rates using weekly data from November 17, 1995 to April 8, 2016. Data for gold prices—measured in currency per ounce—are collected from the World Gold Council (WGC). All exchange rate data are downloaded from DataStream, a division of Thomson Financial.

Table 1 provides the preliminary statistics of the gold price for four currencies and the exchange rates between the four currencies. As shown in Panel A of Table 1, the average gold prices of the four currencies are 744.4, 458.5, 5191.6, and 23783.6 per troy ounce, respectively. The skewness and kurtosis indicate that these price series are not normally distributed, but right-skewed. Panel B reports the descriptive statistics of the exchange rates between the four currencies. Take the exchange rate USDGBP for example, the exchange rate of GBP to one USD, where a rise implies an appreciation of the USD or a devaluation of the GBP.

Table 1. Descriptive statistics

Panel A: The gold price in four currencies									
	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
USD	744.4	551.7	1875.3	253.8	474.3	0.6522	2.0118	118.8	0.0000
GBP	458.5	309.6	1164.5	157.2	304.4	0.7292	2.0119	137.7	0.0000
RMB	5191.6	4432.2	11969.0	2100.8	2751.3	0.5946	2.0423	103.5	0.0000
RUR	23783.6	15262.5	94159.6	1676.1	21109.1	1.0541	3.3010	201.2	0.0000
Panel B: The exchange rate between four currencies									
USDGBP	0.6133	0.6207	0.7322	0.4782	0.0546	-0.4957	2.6525	49.0	0.0000
USDRUR	28.1377	28.8160	83.5913	4.5370	12.9832	0.8406	6.1136	555.6	0.0000
USDRMB	7.5033	8.0616	8.3333	6.0488	0.8731	-0.4423	1.4209	145.4	0.0000
GBPUSD	1.6444	1.6112	2.0911	1.3658	0.1559	0.8687	3.0645	134.1	0.0000
GBPRUR	45.8555	48.3771	119.6024	7.0346	19.7177	0.3174	5.0848	210.7	0.0000

GBPRMB	12.3559	12.7438	16.0467	9.0691	1.9524	-0.0393	1.6888	76.6	0.0000
RMBUSD	0.1352	0.1240	0.1653	0.1200	0.0167	0.5320	1.5581	142.5	0.0000
RMBGBP	0.0831	0.0785	0.1103	0.0623	0.0135	0.3425	1.7022	95.6	0.0000
RMBRUR	3.9248	3.5386	12.5300	0.5457	2.1400	1.2282	5.9203	646.2	0.0000
RURUSD	0.0537	0.0347	0.2204	0.0120	0.0514	2.1078	5.7344	1120.4	0.0000
RURGBP	0.0330	0.0207	0.1422	0.0084	0.0324	2.1740	6.1062	1267.1	0.0000
RURRMB	0.4218	0.2830	1.8320	0.0800	0.4378	2.0832	5.6704	1086.7	0.0000

Table 2 displays the descriptive statistics for gold returns (i.e., first difference of the natural logarithm), and shows that normality is rejected for each series, since the kurtosis of each series is larger than 3, which means that the distribution is leptokurtic, or fat-tailed. Consequently, we select the QR model to study the structural correlation between gold price and exchange rates. As shown in Table 2, the average of gold return in RMB is the lowest, while that in RUR is the highest among the four currencies, which might be explained by the appreciation of the RMB against the other three currencies and the depreciation of RUR against all currencies.

Table2. Descriptive statistics of gold returns

	Mean	Median	Maximum	Minimum	Std. dev.	Skewness	Kurtosis	Jarque-Bera	p-Value
USD	0.0011	0.0013	0.1469	-0.1379	0.0244	-0.1189	6.9522	694.9730	0
GBP	0.0012	0.0008	0.1311	-0.1516	0.0236	0.1416	7.7995	1024.7650	0
RMB	0.0009	0.0011	0.1455	-0.1382	0.0243	-0.1208	6.9809	705.15840	0
RUR	0.0364	0.0019	0.6316	-0.6566	0.0436	0.6685	102.7692	441368.50	0

The strength of cross-country correlations in gold prices is verified for the entire sample in Table 3, which uses weekly logarithmic prices relative to gold. Every correlation exceeds 0.85 and two are above 0.99. The gold price in RUR has the lowest correlation with other currencies (below 0.90).

The correlations between the exchange rates are reported in Table 4. As shown in Table 4, the exchange rate USDRUR has a negative correlation with USDGBP and USDRMB, reflecting that, when the USD appreciates against the RUR, the USD depreciates against the GBP and RMB. The exchange rate GBPRUR has a negative correlation with GBPRMB, expressing that, when RUR depreciates against GBP, RMB appreciates against the GBP. RMBUSD, RMBGBP, and RMBRUR exhibit a positive correlation, indicating that RMB appreciates against all other three currencies. RURUSD, RURGBP, and RURRMB are positively related, reflecting that RUR depreciates against the other three currencies.

Table 3. Correlation matrix of gold prices

	USD	GBP	RMB	RUR
USD	1.0000	0.9921	0.9961	0.8723
GBP	0.9921	1.0000	0.9831	0.8902
RMB	0.9961	0.9831	1.0000	0.8533
RUR	0.8723	0.8902	0.8533	1.0000

Table 4. Correlation matrix of exchange rates

USD	GBP	RMB	RUR	GBP	USD	RUR	RMB	
	GBP	1.0000	0.2265	-0.1258	USD	1.0000	0.0071	0.7040
	RMB	0.2265	1.0000	-0.5571	RUR	0.0071	1.0000	-0.3737
	RUR	-0.1258	-0.5571	1.0000	RMB	0.7040	-0.3737	1.0000
RMB	USD	GBP	RUR	RUR	USD	GBP	RMB	
	USD	1.0000	0.8509	0.7073	USD	1.0000	0.9971	0.9985
	GBP	0.8509	1.0000	0.6884	GBP	0.9971	1.0000	0.9956
	RUR	0.7073	0.6884	1.0000	RMB	0.9985	0.9956	1.0000

Before testing for the presence of co-integration, we have to determine the time series properties of the variables. Dickey and Fuller (1979) (ADF), and Philips and Perron (1988) (PP) tests are the most commonly used methods to test for unit roots. However, it has been reported that both of these methods have weaknesses, so new techniques have been developed. Therefore, in addition to the ADF and PP, we also utilize Dickey-Fuller GLS (DF-GLS) and Kwiatkowski et al. (1992) (KPSS) unit root tests. The results are reported in Table 5. The common suggestion of all the tests is that all variables are integrated of order one (or I (1)).

The OLS results are shown in Table 6. β_0 is the constant term. In the panel of RMB, the coefficients β_1 are all below 0, which means that RMB appreciates against the other three currencies during the sample period. In the panel of RUR, β_1 are all above 0, suggesting that RUR depreciates against the other three currencies. Taking panel USD as an example, β_1 for GBP and RUR are -0.2800 and -0.4066, respectively, indicating that GBP and RUR depreciate against the USD. While β_1 of RMB is 0.3724, suggesting RMB appreciates against USD, the results of residual unit roots tests show that gold price denominated in local currency and the exchange rate of the local currency against one unit of the other are not co-integrated. Hence, our first result

is that (at least for the sample period under observation) there is no stable long-run relationship among gold prices and bilateral exchange rates.

Table 5. Unit root test of variables

Panel A: The unit root test of gold prices								
	Levels				First differences			
	ADF	DF-GLS	PP	KPSS	ADF	DF-GLS	PP	KPSS
USD	-0.6331	0.1368	-0.5054	3.5648***	-33.37***	-32.69***	-33.71***	0.2007
GBP	-0.2413	0.5627	-0.1913	3.4717***	-32.97***	-31.03***	-33.00***	0.2270
RMB	-0.7579	-0.0882	-0.6045	3.5417***	-33.55***	-32.58***	-33.98***	0.1692
RUR	1.1664	2.3677	0.7864	3.7044***	-22.80***	-22.57***	-37.81***	0.2557
Panel B" The unit root test of exchange rates								
USDGBP	-2.0584	-1.9153	-1.9473	0.4326	-33.68***	-3.60***	-33.72***	0.1170
USDRUR	-0.7463	0.9148	-0.1249	2.2956***	-10.03***	-10.01***	-33.75***	0.1841
USDRMB	0.2114	2.6639	-0.0102	3.7905***	-36.98***	-36.88***	-37.30***	0.4943**
GBPUSD	-1.9212	-1.7656	-1.8812	0.4632**	-33.02***	-3.97***	-33.02***	0.1210
GBPRUR	-1.3590	0.5477	-0.7353	2.4619***	-10.33***	-10.34***	-35.26***	0.1219
GBPRMB	-0.7071	-0.4994	-0.6895	2.1131***	-32.11***	-3.62***	-32.11***	0.1772
RMBUSD	0.1041	1.9448	-0.0821	3.7413***	-35.46***	-35.35***	-35.90***	0.4319*
RMBGBP	-0.5716	-0.2169	-0.4943	2.4616***	-25.32***	-3.71***	-33.02***	0.1698
RMBRUR	0.8016	2.2619	0.5399	2.8706***	-10.32***	-10.25***	-34.40***	0.2305
RURUSD	-3.2381**	0.4917	-3.7470***	1.9523***	-6.8093***	-3.8041***	-26.57***	0.7067**
RURGBP	-3.4342**	0.5371	-4.0442***	1.9716***	-7.0602***	-2.043	-26.64***	0.7914***
RURRMB	-3.2359**	0.5059	-3.8529***	2.1253***	-6.7066***	-3.8946***	-28.10***	0.7583***

Table 6. OLS results for 1995–2016

	β_0		β_1		Unit roots of residuals			
	Coefficient	Std. error	Coefficient	Std. error	ADF	DF-GLS	PP	KPSS
Panel A: Relationship between USD gold prices against exchange rates								
GBPUSD	16652.5***	88.659	-0.2800***	0.1005	-1.9894	-1.7648*	-1.9374	0.5030**
RMBUSD	1103.7***	3.000	0.3336***	0.0034	-2.4884	-2.0907**	-2.3585	0.4609*
RURUSD	839.9***	27.211	-0.4066***	0.0308	-3.3425**	0.4284	-3.5439***	0.9144***
Panel B: Relationship between GBP gold prices against exchange rates								
USDGBP	5977.6***	29.737	0.3382***	0.0540	-2.1846	-1.8867*	-2.0727	0.5833**
RMBGBP	659.8***	4.106	0.3724***	0.0075	-2.2148	-2.1877**	-2.0442	0.4594*
RURGBP	500.7***	16.853	-0.3721***	0.0306	-3.7259***	0.4265	-3.8500***	1.0112***
Panel C: Relationship between RMB gold prices against exchange rates								
USDRMB	90405.6***	205.636	-2.9610***	0.0350	-2.4474	-1.8773*	-2.2979	0.5588**
GBPRMB	148824.2***	930.613	-4.8666***	0.1584	-1.9067	-1.8971*	-1.7979	0.4966**
RURRMB	7667.9***	260.5111	-0.6645***	0.0443	-3.4226**	0.4316	-3.6787***	0.9071***
Panel D: Relationship between RUR gold prices against exchange rates								
USD RUR	166381.1***	3707.033	4.8351***	0.1166	-1.7440	0.0391	-1.5751	0.4894**
GBPRUR	291015.0***	5981.808	7.0444***	0.1881	-1.8038	-0.0548	-1.8985	0.5997**
RMBRUR	17762.3***	448.654	0.9034***	0.0141	-1.6850	-0.3478	-1.7739	0.4255*

Notes:***, **,and * denote significance at the 1%, 5%, and 10% levels, respectively.

We investigate the distributional effects for each individual factor. The estimation is obtained using weekly data from November 1995 to January 2016, with quantiles set at {0.05, 0.1, 0.25, 0.5, 0.75, 0.9, 0.95}. Table 7 shows that all factors are significant and the QR estimates are different from the OLS ones for most factors, indicating that distributional effects provide a more comprehensive picture than the “average” OLS effects.

Panel A of Table 7 shows that the gold price of USD has a significant effect on the exchange rates GBPUSD, RMBUSD, and RURUSD. The increase of gold price of USD leads to the depreciation of USD to RMB, while leading to the appreciation of USD to RUR. Interestingly, it results in the depreciation of USD to GBP at a low

quantile of the exchange rate, and to the appreciation of USD to GBP at a high quantile of the exchange rate. However, we may only conclude that the increasing gold price merely leads to appreciation of USD to GBP, on average, compared to OLS. Moreover, we can find that the impact between the USD gold price and the exchange rate RMBUSD is monotonously increasing due to the continuous appreciation of RMB over recent years. Additionally, the relation is stable for the USD gold price and the exchange rate RURUSD. However, the coefficients are steep when the quantile is above 0.75 because of the ruble crisis in 1998.

Table 7. Quantile regression results for 1995–2016

	0.05	0.1	0.25	0.5	0.75	0.9	0.95
Panel A: Relationship between USD gold prices against exchange rates							
GBPUSD	0.4424*** (0.1043)	0.6139*** (0.0661)	0.1661* (0.0900)	-0.2822*** (0.0562)	-1.2240*** (0.1489)	-1.7994** (0.7021)	0.9305 (1.2582)
RMBUSD	0.2787*** (0.0031)	0.2842*** (0.0032)	0.2965*** (0.0022)	0.3017*** (0.0054)	0.3992*** (0.0053)	0.4393*** (0.0045)	0.4477*** (0.0040)
RURUSD	-0.1895*** (0.0090)	-0.1653*** (0.0119)	-0.0475*** (0.0058)	-0.0340*** (0.0026)	-0.1008*** (0.0191)	-1.0353*** (0.0220)	-1.1505*** (0.0296)
Panel B: Relationship between GBP gold prices against exchange rates							
USDGBP	1.5320*** (0.0842)	1.2592*** (0.0761)	0.7962*** (0.0639)	0.2390*** (0.0348)	0.0626 (0.0586)	-0.3592*** (0.0551)	-0.1700* (0.0930)
RMBGBP	0.4142*** (0.0114)	0.4121*** (0.0100)	0.3861*** (0.0090)	0.3386*** (0.0084)	0.4148*** (0.0122)	0.3672*** (0.0096)	0.3738*** (0.0087)
RURGBP	-0.1668*** (0.0085)	-0.1450*** (0.0095)	-0.0519*** (0.0107)	-0.0290*** (0.0048)	-0.0662*** (0.0071)	-0.9904*** (0.0242)	-1.1921*** (0.0599)
Panel C: Relationship between RMB gold prices against exchange rates							
USDRMB	-4.0680*** (0.0449)	-3.9552*** (0.0494)	-3.5646*** (0.0565)	-2.6315*** (0.0336)	-2.6757*** (0.0251)	-2.5823*** (0.0328)	-2.4990*** (0.0514)
GBPRMB	-4.6286*** (0.1462)	-4.4462*** (0.1550)	-4.8030*** (0.3358)	-4.5756*** (0.1032)	-5.6705*** (0.3722)	-6.1263*** (0.8715)	-5.0086** (2.0796)
RURRMB	-0.3356***	-0.3122***	-0.1752***	-0.1339***	-0.2057***	-1.5534***	-1.7199***

	(0.0118)	(0.0152)	(0.0090)	(0.0046)	(0.0179)	(0.0352)	(0.0489)
Panel D: Relationship between RUR gold prices against exchange rates							
USDRUR	5.0456***	5.0929***	5.9783***	2.4729***	4.7497***	5.4501***	5.7024***
	(0.0556)	(0.0691)	(0.1694)	(0.2650)	(0.2327)	(0.1164)	(0.1078)
GBPRUR	8.0744***	7.9847***	9.2640***	4.3248***	6.9671***	7.6680***	7.9814***
	(0.0888)	(0.1104)	(0.2943)	(0.4805)	(0.2112)	(0.1806)	(0.1499)
RMBRUR	0.8370***	0.8506***	0.9702***	0.6942***	0.9439***	1.0110***	1.0587***
	(0.0078)	(0.0093)	(0.0341)	(0.0398)	(0.0169)	(0.0170)	(0.0168)

Notes: (1) ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. (2) The numbers in parentheses are standard errors.

As expected, the GBP price of gold has a totally different impact on the exchange rate USDGBP. It is not difficult to accept this point, since the reference currency is exactly opposite for USDGBP and GBPUSD, while the trends of USD gold price and GBP gold price are similar. The coefficients of GBP price of gold and exchange rate of RMBGBP fluctuate more than the coefficients of USD do. However, the exchange rate of RMB to GBP still appreciates under different quantiles. Moreover, the GBP price of gold has almost the same expected effect on the exchange rates of RURGBP as the USD price of gold has (see panel B of Table 7).

The RMB price of gold has a significant impact on the exchange rates USDRMB, GBPRMB, and RURRMB (see panel C of Table 7). The RMB price of gold has an almost positive linear impact on the exchange rate of USDRMB. A 1% increase in the RMB price of gold corresponds to a 2.5823 decrease at the high level ($\tau = 0.9$). The impact of the RMB price of gold on the exchange rate GBPRMB is almost horizontal and around -5 at different quantile levels. We also find that the RMB price of gold has the same expected effect on the exchange rates of RURRMB as the USD price of gold and the GBP one. As expected, the RMB price of gold also has a totally different impact on the exchange rate USDRMB, and the impact is monotonously increasing as well. Meanwhile, all the coefficients are negative, since the RMB mostly appreciates to the other three currencies during the last twenty years. That is to say, the RMB appreciates to the other three currencies although the gold price of RMB continues to increase. This empirical evidence is quite different from the conventional wisdom in existing literature. One of the reasons may be the double nature of the gold price (Ming et al., 2016), which is decided by its financial asset and commodity attributes. Although the exchange rate of RMB appreciates, the demand of gold in China is increasing, especially the gold demand for consumption.

The RUR price of gold has the largest impact on the exchange rates of USDRUR, GBPRUR, and RMBRUR, measured by both QR and OLS estimates. The OLS estimate indicates that a 1% increase in the RUR price of gold translates into a 4.8351 increase in the exchange rate USDRUR (the depreciation of RUR), on average. The QR approach indicates that the impact of RUR price of gold is dramatically different, depending upon the

exchange rates of USDRUR, GBPRUR, and RMBRUR. At median RUR price of gold levels, a 1% increase in the RUR price of gold causes the exchange rate of USDRUR to increase by 2.5%. However, at low or high gold price levels ($\tau = 0.2$ or $\tau = 0.9$), a 1% increase in the RUR price of gold will result in a 5.4% increase in the exchange rate USDRUR. The average effect delivered by OLS is indeed the “average” of quantile effects, and fails to capture this detail (see panel D of Table 7). Interestingly, compared with the positive coefficients in panel C, all figures are negative in panel D. In other words, the increase of gold price leads to the depreciation of RUR to other currencies.

4. Sub-Period Results

To gain further insight on the relationship between gold price and exchange rate, we split the original sample period into two equal time periods, November 17, 1995 to December 20, 2005 and January 6, 2006 to April 8, 2016.

On July 21, 2005, China began the RMB exchange rate formation mechanism reform. As a result, the RMB exchange rate is no longer pegged to the USD. The People's Bank of China (PBOC) announced that RMB would switch to a managed floating regime “with reference to a basket of currencies,” allowing a movement of up to $\pm 3\%$ in bilateral exchange rates within any given day (later widened to $\pm 5\%$). As such, we divide the sample period into two parts: before July 21, 2005 and afterwards. By making the same empirical analysis on the two time periods respectively, we find that: from 1995 to 2006, in the RMB panel of the OLS regression results, β_1 of USDRMB is below zero, β_1 of GBPRMB and RURRMB are above zero, which means the RMB appreciates against the USD, while it depreciates against the GBP and RUR during the sample period (see panel C, A1). From 2006–2016, in the panel of RMB, β_1 are all below zero, suggesting that RMB appreciates against the other three currencies during the sample period (see A2).

From the QR results, we can capture a more detailed relationship between the RMB price of gold and exchange rates before and after 2016. During 1995–2005, the effect of GBP gold prices on RURGBP is below zero at the low and median level, while it increased dramatically (above 0) at the high level (see panel B, A3). The RMB price of gold does not have a significant impact on the exchange rates of USDRMB. QR shows that the effect of RMB price of gold on USDRMB is below zero around the low and median level, while above zero at the high quantile (see panel C, A3). This suggests that the RMB appreciates against the USD when the RMB gold prices are low, while it depreciates against the USD when the RMB gold prices are at a high level. The RMB price of gold has a significant impact on the exchange rates of GBPRMB, and the GBPRMB exchange rates increase with the gold price of RMB. The gold price effect on RURRMB is close to zero around the low and median level, while it increases dramatically at the high level.

Generally, from 2006 to 2016, the QR results show that the relationship between the RMB price of gold and exchange rates is more significant. The regression results of the relationship between RMB gold prices against exchange rates are all below 0, which is consistent with the QR results in panel C of Table 7. The USDRMB exchange rates decrease with the gold price of RMB at all quantile levels, which suggests that RMB appreciates against the USD continuously during the sample period. The gold price effect on GBPRMB is close

to -1 at a low quantile level, while it decreases sharply at median and high quantile levels. The impact of the RMB gold price on RURRMB exchange rates is almost horizontal and around -0.1 at different quantile levels (see panel C, A4). From panel D, A4 we can see that the QR results are all above 0, which is consistent with the QR results of panel D, Table 7, suggesting that RUR depreciates against the other three currencies continuously during the sample period.

The empirical results can be explained by the real economic background. The 2005 RMB exchange rate reform is the result of internal and external appreciation pressures. As a result, the RMB exchange rate appreciated over the next 10 years. Therefore, the empirical results after 2006 are more significant due to the appreciation of the RMB exchange rate and the increase in volatility.

Due to space considerations, we do not provide a detailed description of the above process in this paper. However, the entire empirical analytical process can be found in the Appendix.

5. Conclusions

Numerous previous studies have noted that gold prices in USD are correlated with weaknesses in USD relative to other currencies. Pukthuanthong and Roll (2011) point out that the same phenomenon occurs for other currencies and, probably, for all freely convertible currencies. That is, a rise of the price of gold in a currency (Dollar, Euro, Pound, Yen) is associated with depreciation in the currency (Dollar, Euro, Pound, Yen)'s value, not just for USD, but also for other currencies (Euro, Pound, Yen).

However, our research results show that. (1) At least for the sample period under observation, there is no stable long-run relationship among gold prices and bilateral exchange rates. (2) By classifying the currencies into strong (RMB), weak (RUR), and anchor (USD or GBP) currencies, a negative relationship is indeed found between the price of gold in some currencies and the exchange rate of a weak currency such as RUR and INR. However, a positive relationship is found between gold price and the exchange rate of a strong currency.

1. We also test the relationship between INR gold price and its exchange rate with other currencies and the results are also significant.
2. Since the gold price is, typically, at least four orders of magnitude greater than the exchange rate, we amplify the exchange rate by multiplying it by 10,000 both in OLS and QR. Accordingly, the significance of regression is not changed by doing so.

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Appendix

—Tables A1–A4 here—

A1. OLS results for 1995–2005

	β_0		β_1		Unit roots of residuals			
	Coefficient	Std. error	Coefficient	Std. error	ADF	DF-GLS	PP	KPSS
Panel A: Relationship between USD gold prices against exchange rates								
GBPUSD	11238.94***	230.97	14.72***	0.67	-2.0740	-1.2415	-2.0498	0.3073
RMBUSD	1195.74***	1.44	0.04***	0.00	-0.4485	0.6281	-0.5953	0.5880**
RURUSD	390.20***	160.41	1.10***	0.47	-1.8948	0.7616	-2.0337	2.3746***
Panel B: Relationship between GBP gold prices against exchange rates								
USDGBP	7244.18***	149.56	-5.00***	0.71	-1.9973	-1.3570	-1.9242	0.5681**
RMBGBP	868.17***	17.87	-0.57***	0.09	-1.9658	-1.4506	-1.8903	0.5299**
RURGBP	-200.05***	129.17	3.24***	0.62	-1.4246	1.1339	-1.4610	2.5753***
Panel C: Relationship between RMB gold prices against exchange rates								
USDRMB	83529.25***	99.69	-0.28***	0.04	-0.3300	0.7170	-0.4765	0.6294**
GBPRMB	93941.60***	1939.07	14.38***	0.68	-1.9596	-1.2582	-1.9385	0.2846
RURRMB	2757.79***	1348.79	1.27***	0.48	-1.8636	0.8019	-1.9954	2.3990***
Panel D: Relationship between RUR gold prices against exchange rates								
USD RUR	37693.04***	3964.77	24.53***	0.47	-0.0579	-0.4740	-0.4871	0.7521***
GBP RUR	39405.02***	4163.46	42.74***	0.50	-0.2963	-0.6983	-0.9367	0.6857**
RMB RUR	4466.81***	473.09	2.98***	0.06	-0.2383	-0.5718	-0.4809	0.7526***

A2. The OLS results for 2006–2016

	β_0		β_1		Unit roots of residuals			
	Coefficient	Std. error	Coefficient	Std. error	ADF	DF-GLS	PP	KPSS
Panel A: Relationship between USD gold prices against exchange rates								
GBPUSD	20167.84***	210.39	-3.05***	0.18	-1.9915	-1.8486*	-1.9645	0.4759**
RMBUSD	1161.64***	10.39	0.29***	0.01	-1.8080	-0.9597	-1.7813	1.2098***
RURUSD	388.82***	10.43	-0.06***	0.01	0.4153	0.2606	-0.0911	1.4354***
Panel B: Relationship between GBP gold prices against exchange rates								
USDGBP	4849.87***	54.94	1.71***	0.07	-2.1853	-1.9591**	-2.0709	0.2861
RMBGBP	563.19***	10.21	0.49***	0.01	-1.9524	-1.9040*	-1.7852	0.7865***
RURGBP	197.03***	4.76	-0.01**	0.01	-0.2533	-0.2309	-0.2132	1.3713***
Panel C: Relationship between RMB gold prices against exchange rates								
USDRMB	85004.15***	707.59	-2.33***	0.09	-1.8310	-0.6257	-1.7990	1.4251***
GBPRMB	170906.80***	2678.08	-7.65***	0.34	-1.7488	-1.5777	-1.6151	1.1724***
RURRMB	3214.18***	99.93	-0.14***	0.01	-0.0053	0.3703	-0.0536	1.7700***
Panel D: Relationship between RUR gold prices against exchange rates								
USD RUR	119789.90***	6817.15	5.58***	0.15	-1.4215	-0.9457	-1.5149	0.6056**
GBPRUR	293522.80***	11157.75	6.67***	0.25	-1.2594	-0.8738	-1.4768	0.6624**
RMBRUR	11562.25***	946.81	1.01***	0.02	-1.6552	-1.2520	-1.7367	0.5598**

A3. QR results for 1995–2005

	0.05	0.1	0.25	0.5	0.75	0.9	0.95
Panel A: Relationship between USD gold prices against exchange rates							
GBPUSD	9.5745*** (0.8197)	10.6502*** (0.9410)	15.1879*** (1.2977)	17.1881*** (1.5674)	15.1960*** (0.8326)	17.1195*** (0.5545)	16.5757*** (0.4778)
RMBUSD	-0.0504*** (0.0030)	-0.0403*** (0.0029)	-0.0273*** (0.0041)	0.0013*** (0.0002)	0.0007*** (0.0001)	0.1260*** (0.0061)	0.1381*** (0.0039)
RURUSD	0.1388 (0.0880)	0.1398 (0.1125)	0.0254 (0.1687)	-0.0470 (0.2213)	11.5177*** (0.7888)	4.2279*** (0.8862)	4.2093*** (0.6912)
Panel B: Relationship between GBP gold prices against exchange rates							
USDGBP	-12.6825*** (0.8576)	-11.6852*** (0.9086)	-7.0838*** (1.0432)	-2.0246* (1.2069)	-2.8917** (1.3013)	-5.3604*** (0.7161)	-5.7296*** (0.6859)
RMBGBP	-1.5274*** (0.1034)	-1.4134*** (0.1101)	-0.7452*** (0.1495)	-0.2512** (0.1019)	-0.3977** (0.1577)	-0.6904*** (0.0888)	-0.7489*** (0.0850)
RURGBP	-0.6667*** (0.1686)	-0.6815*** (0.2160)	-0.8908*** (0.3259)	-0.6865* (0.4176)	10.7959*** (0.5606)	4.6321*** (0.4190)	4.5049*** (0.3263)
Panel C: Relationship between RMB gold prices against exchange rates							
USDRMB	-1.1768*** (0.0369)	-1.0622*** (0.0583)	-0.0057*** (0.0010)	-0.0106*** (0.0015)	0.2280*** (0.0320)	0.3303*** (0.0229)	0.4161*** (0.0238)
GBPRMB	10.0838*** (0.7385)	10.9593*** (0.6410)	14.0394*** (1.3571)	16.7860*** (1.7423)	15.2071*** (0.8570)	17.0975*** (0.5488)	16.5617*** (0.4704)
RURRMB	0.1061 (0.0907)	0.1087 (0.1159)	0.0067 (0.1739)	-0.0665 (0.2282)	11.4899*** (0.7428)	4.2893*** (0.8433)	4.2799*** (0.6582)
Panel D: Relationship between RUR gold prices against exchange rates							
USD RUR	20.8641*** (0.3331)	22.1259*** (0.2488)	23.2998*** (0.2871)	27.7195*** (0.9470)	34.4203*** (0.7943)	28.2416*** (10.8494)	29.2068*** (9.8861)

GBPRUR	37.6285*** (1.0467)	42.2444*** (0.4564)	43.2357*** (0.3030)	45.0294*** (0.5679)	42.0730*** (6.8062)	33.4880*** (3.3284)	31.3551*** (2.3107)
RMBRUR	2.5845*** (0.0299)	2.7084*** (0.0263)	2.8174*** (0.0334)	3.3495*** (0.1148)	4.1586*** (0.0960)	3.4145*** (1.3120)	3.5289*** (1.1953)

A4. QR results for 2006–2016

	0.05	0.1	0.25	0.5	0.75	0.9	0.95
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Panel A: Relationship between USD gold prices against exchange rates

GBPUSD	0.7821*** (0.2805)	0.6362** (0.2544)	-0.5410 (0.4590)	-2.1134*** (0.2686)	-3.6104*** (0.1679)	-4.2364*** (0.1363)	-4.2962*** (0.1302)
RMBUSD	0.2876*** (0.0034)	0.2923*** (0.0034)	0.2926*** (0.0047)	0.2521*** (0.0181)	0.3442*** (0.0393)	0.3484*** (0.0426)	0.3472*** (0.0454)
RURUSD	-0.0481 (0.2919)	-0.2630*** (0.0324)	-0.0844*** (0.0178)	-0.0591*** (0.0045)	-0.0558*** (0.0031)	-0.0749*** (0.0065)	-0.0877*** (0.0061)

Panel B: Relationship between GBP gold prices against exchange rates

USDGBP	1.8964*** (0.0387)	1.8767*** (0.0440)	1.7601*** (0.0562)	1.6500*** (0.1175)	1.5830*** (0.2316)	0.9960*** (1.1088)	0.5590*** (0.6260)
RMBGBP	0.4500*** (0.0062)	0.4666*** (0.0055)	0.4847*** (0.0074)	0.5290*** (0.0317)	0.6289*** (0.0435)	0.3705* (0.1011)	0.3438* (0.0865)
RURGBP	-0.2102*** (0.0119)	-0.1721*** (0.0124)	-0.0430*** (0.0148)	0.0076*** (0.0019)	0.0084*** (0.0031)	0.0024 (0.0041)	-0.0107 (0.0091)

Panel C: Relationship between RMB gold prices against exchange rates

USDRMB	-0.6239 (1.1679)	-0.8643 (1.3137)	-2.0275*** (0.4868)	-1.6667*** (0.1552)	-2.5479*** (0.0620)	-2.6662*** (0.0395)	-2.6385*** (0.0374)
GBPRMB	-1.1222** (0.4946)	-1.2615** (0.5485)	-0.9299** (0.4562)	-4.8117*** (0.8573)	-9.0679*** (0.2013)	-8.7897*** (0.1681)	-8.6290*** (0.1878)
RURRMB	0.0000	0.2344***	-0.0190	-0.1452***	-0.1554***	-0.1592***	-0.1536***

	(0.4452)	(0.0256)	(0.0332)	(0.0092)	(0.0052)	(0.0049)	(0.0050)
Panel D: Relationship between RUR gold prices against exchange rates							
USDRUR	2.1469***	2.1595***	2.1402***	3.4769***	6.1174***	6.7780***	6.9612***
	(0.1219)	(0.1416)	(0.1744)	(0.3700)	(0.1218)	(0.1270)	(0.1112)
GBPRUR	1.6028***	1.4193***	0.8882***	1.9106**	7.0730***	8.2954***	8.8597***
	(0.3943)	(0.4450)	(0.2766)	(0.7940)	(0.2202)	(0.1763)	(0.1584)
RMBRUR	0.4564***	0.4603***	0.5099***	0.8155***	1.1039***	1.1846***	1.2354***
	(0.0123)	(0.0150)	(0.0199)	(0.0506)	(0.0161)	(0.0175)	(0.0172)
