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Causality and volatility patterns between gold prices and exchange rates*

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Abstract

This paper provides a new perspective on the link between gold prices and exchange rates. Based on gold prices denominated in five different currencies and the related bilateral exchange rates, we put causalities and short-run volatility transmission under closer scrutiny. We provide evidence that the identification of a strong hedge function of gold requires an explicit modeling of the volatility component. For all currencies, exchange rate depreciations initially have a negative impact on the gold price after one day which turns out to be positive after two days in most of the cases. Contrary to previous studies, our results point to a specific role of the dollar in the context of gold-exchange rate relationships: Volatility of dollar exchange rates more frequently results in strong hedging functions of gold prices. Furthermore, the gold price denominated in the US dollar tends to increase after a depreciation of the dollar.

Keywords: exchange rates, gold, hedge, volatility

JEL classification: F31, G15

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1 Introduction

A long-established relationship between gold prices and dollar depreciations is based on the law of one price: If gold is denominated in US dollar, dollar depreciations coincide with increasing gold prices in order to eliminate arbitrage opportunities. This identity has been established by Beckers and Soenen [1984] and Sjaastad and Scacciallani [1996] among others.[1] Studies by Capie, Mills and Wood [2005] and Sjaastad [2008] confirm this finding for different dollar exchange rates with the latter study also identifying a causality from dollar movements to the price of gold denominated in different currencies.

In this vein, the present paper contributes to the literature in three different ways: Firstly, we focus on volatility transmission between the gold prices denominated in different currencies and bilateral exchange rates as a novel issue. This is important since both gold and exchange rates are (1) traded at a high frequency and (2) linked to each other through hedge or safe haven features which are related to periods of volatility [Ciner, Gurdgiev and Lucey, 2013]. Secondly, we pay specific attention to the issue of causality, allowing for spillover effects in both directions. The literature is notably silent when it comes to a clarification of the causality issue between gold prices and exchange rates. Considering that exchange rates and gold prices are asset prices, it is reasonable to assume that causalities can go into both directions.[2] Finally, we investigate whether a special pattern for the US dollar can be identified if several gold prices and exchange rates are considered. Pukthuanthong and Roll [2011] have recently shown that the price of gold can be associated with currency depreciation not only for the US dollar but also for other currencies. While they focus on a correlation analysis and Granger causality tests, we investigate whether volatility spillover effects offer a specific role for the United States. To analyze these questions, we estimate a GARCH-in-mean SVAR model in the tradition of Elder [2003] which allows us to estimate the parameters of interest in an internally consistent fashion.

The remainder of this paper is organized as follows: We briefly turn to a review of the most relevant literature in Section 2 before proceeding with a description of our data in Section 3 and of our methodology in Section 4. Section 5 presents our results and Section 6 concludes.

[1] In addition, there is a large body of literature on the general role of gold in financial markets. For instance, Gallais-Hamonno, Hoang and Oosterlinck [2015] examine the informational efficiency of the gold market in Paris.

[2] Turning to a related topic in terms of causality, evidence for different causalities between dollar exchange rates and oil prices have been provided. This is true for both in-sample causalities as well as out-of sample predictability [Chen, Rogoff and Rossi, 2008; Beckmann and Czudaj, 2013].

2 Review of the literature

Taking into account the large body of literature on gold prices and exchange rates, we only elaborate on a few selected studies in the following review. Early studies by Capie *et al.* [2005] and Sjaastad [2008] have examined the hedge property of gold with respect to changes of the US dollar and have shown that dollar exchange rates and gold prices are inversely related with the latter study also identifying a causality from dollar movements to the price of gold denominated in different currencies. More recently, Joy [2011] focused on a sample period covering 1986-2008 for 16 currencies (G7 and emerging markets) on a weekly basis. Applying DCC-GARCH models he confirms the finding that gold acts as a hedge against the dollar. Relying on weekly data from 2000-2012, Reboredo [2013] also finds that gold acts as a hedge and a safe haven against the dollar while examining seven major currencies against the dollar (Australian dollar, Canadian dollar, euro, British pound sterling, Japanese yen, Norwegian krona, and Swiss franc) based on standard copula techniques. These insights have been deepened in two follow-up studies in which Reboredo and Rivera-Castro [2014a,b] also examine the safe haven properties of gold for the same seven currencies and the same sample period relying on a likelihood ratio test and a wavelet correlation analysis, respectively. Apergis [2014] also shows that gold is an useful predictor for the Australian dollar. Based on simple cointegration and Granger causality tests Jain and Ghosh [2013] confirm a relationship between gold prices and the Indian rupee-US dollar exchange rate using daily data spanning from January 2009 to December 2011.[3] Studying the relationship between commodities and currencies from a more general perspective, Antonakakis and Kizys [2015] find that gold is the dominant transmitter of volatility spillovers to other commodities and currencies. Recent literature also highlights the role of gold during the crisis period [Bampinas and Panagiotidis, 2015].

While previous studies have focused on either VAR models applying cointegration and Granger causality tests or GARCH models to analyze causalities and volatility spillovers between gold prices and exchange rates, respectively, we combine both methodologies to achieve further insights. Therefore, we rely on GARCH-in-mean SVAR models in the tradition of Elder [2003] which has the additional advantage that the parameters of interest are estimated internally consistent. To the best of our knowledge, this framework has not been considered to examine causalities and volatility spillovers between gold prices and exchange rates in previous studies. The second empirical contribution of our paper to the existing literature is the fact that we do not restrict our study to bilateral exchange

[3] See also O'Connor, Lucey, Batten and Baur [2015] for an excellent overview of the whole strand of literature.

against the US dollar but also consider several other bilateral exchange rates. We see both aspects as fruitful developments of the present literature.

3 Data

Our sample period covers data from January 1979 to June 2013 on a daily basis. Data on gold prices and bilateral exchange rates is taken from the World Gold Council and Thomson Reuters Datastream, respectively. Gold prices are denominated in the US dollar, British pound sterling, euro, Japanese yen, and Indian rupee[4] and the evolution of these is shown in Figure I for the entire sample period. Bilateral exchange rates against the other economies are used for each gold price series. In each case, a rise of the exchange rate corresponds to a depreciation of the domestic currency. Table I reports the descriptive statistics for the returns (i.e. first difference of the natural logarithm) of all series included in our study and clearly shows that normality is rejected for each series due to skewness and kurtosis.

Figure I about here

Table I about here

Table II reports the results for testing the null of a unit root by means of the augmented Dickey-Fuller (ADF) test for both the level and the first difference of each series in logarithmic terms. These show that each series is integrated of order one, i.e. $I(1)$, since in the predominant amount of the cases the unit root null cannot be rejected for the level but for the first difference of a series. In addition, we have also checked each pair (i.e. gold price denominated in local currency and the exchange rate of the local currency against one unit of the other) for cointegration and found that these are not cointegrated[5] due to a bunch of tests [Engle and Granger, 1987; Johansen, 1988; Enders and Siklos, 2001].[6] Hence, our first result is that (at least for the sample period under observation) there is no stable long-run relationship between gold prices and bilateral exchange rates. This is the reason why our study focuses on short-run effects between these variables and examines causality and volatility spillovers between them. As already mentioned in the previous section, in doing so, we estimate

[4]Gold prices are from the London Gold Exchange as one of the main international gold markets. See also Hoang, Wong and Zhu [2015] for a recent study on the relatively new and relatively isolated Shanghai Gold Exchange.

[5]Alagidede, Panagiotidis and Zhang [2011] have found a similar result between stock prices and exchange rates for several economies.

[6]Unsurprisingly, gold prices denominated in different currencies as well as nominal exchange rates are cointegrated. However, this result, which mirrors the elimination of arbitrage opportunities, is not important considering that we are interested in linkages between gold prices and exchange rates.

bivariate GARCH-in-mean SVAR models in first differences, which is described in the next section. To account for GARCH effects is sensible since we started by estimating linear VAR models and testing for the presence of ARCH effects in the residuals. In each case the null of no ARCH effects has been rejected highly significant with a p-value of 0.00.

Table II about here

4 Empirical framework

One focus of our study is to analyze the volatility spillover effect between gold prices and exchange rates, therefore we apply a framework in the tradition of Elder [2003] which allows us to estimate the parameters of interest in an internally consistent fashion. This approach is based on a structural vector autoregression (SVAR) that is modified to accommodate GARCH-in-mean errors. We use the conditional standard deviation of the one-step-ahead forecast error as our measure of volatility [Elder and Serletis, 2010]. Thus, for each gold price and exchange rate pair we consider the following bivariate structural system, which is a linear function of lagged endogenous variables augmented by the conditional standard deviation:

$$AY_t = c + \Gamma_1 Y_{t-1} + \Gamma_2 Y_{t-2} + \ldots + \Gamma_p Y_{t-p} + \Lambda(L) H_t^{1/2} + \varepsilon_t, \quad t = 1, \ldots, T, \tag{1}$$

where Y_t is a bivariate vector that contains returns of the bilateral exchange rate and the gold price in the corresponding currency, A and Γ_i are 2×2 coefficient matrices, and $\varepsilon_t | \psi_{t-1} \sim$ iid $N(0, H_t)$. $H_t^{1/2}$ is diagonal, $\Lambda(L)$ is a matrix lag polynomial, and ψ_{t-1} denotes the time $t-1$ information set.[7] This framework allows the conditional standard deviation $H_t^{1/2}$ to affect the conditional mean of the system. Therefore, to test whether there is an operating volatility transmission between gold prices and exchange rates implies the testing of restrictions on the elements of $\Lambda(L)$ that, for instance, relate the conditional standard deviation of gold returns (or exchange rate returns) to the conditional mean of Y_t.

We model the conditional variance H_t by a bivariate GARCH approach in the spirit of Engle and

[7] We assume the structural errors ε_t to be uncorrelated and additionally impose exclusion restrictions on A to ensure identification of the system given in Equation (1) [Elder, 2003; Elder and Serletis, 2010].

Kroner [1995]:

$$h_t = c_v + \sum_{j=1}^{J} F_j vec(\varepsilon_{t-j}\varepsilon'_{t-j}) + \sum_{i=1}^{I} G_i h_{t-i}, \quad \varepsilon_t = H_t^{1/2} z_t, \quad z_t \sim \text{iid } N(0, I), \tag{2}$$

where $h_t = vec(H_t)$, c_v denotes a 4-dimensional vector of intercept terms, and F and G are 4×4 coefficient matrices. Given that the structural disturbances are not contemporaneously correlated, the conditional variance matrix H_t is diagonal and so Equation (2) can be expressed as:

$$diag(H_t) = c_v + \sum_{j=1}^{J} F_j diag(\varepsilon_{t-j}\varepsilon'_{t-j}) + \sum_{i=1}^{I} G_i diag(H_{t-i}). \tag{3}$$

We estimate this bivariate GARCH-in-mean SVAR model, given by Eq. (1) and (3), by means of full information maximum likelihood (FIML), since this procedure avoids generated regressor problems pointed out by Pagan [1984] which would arise if one estimates the variance function parameters separately from the conditional mean parameters [Beckmann and Czudaj, 2014].

5 Empirical results

Our empirical findings can be classified into four categories: The impact of gold price volatility and gold price changes on exchange rate changes and the reversed causalities from exchange rates to gold prices. The latter causality has been frequently analyzed in the context of hedge or safe haven functions of gold without incorporating an explicit modeling of volatility shocks. Gold is said to be a weak or strong hedge if it is uncorrelated or negatively correlated with exchange rates on average, respectively [Baur and McDermott, 2010; Beckmann, Berger and Czudaj, 2015].

Table III reports the findings for all estimated GARCH-in-mean SVAR models providing possible causalities between gold prices and exchange rates in terms of statistical significance of lagged exchange rate returns. The empirical pattern for an impact of gold prices on exchange rates is in line with the short-run phenomenon of the hedging property: Exchange rates changes always either have a negative or no significant impact on gold price changes for the first lag, suggesting that either the hedge or safe haven function is at work. However, a positive impact of exchange rate changes is frequently observed over the second lag for the UK and Japan in two out of four cases, for India in all cases and for the US in one case. These results suggest that the short-run property of gold acting as a hedge and a safe haven is not observed for all gold prices and that shocks stemming from dollar exchange rates do not exhibit a specific pattern.

Another important finding corresponds to the impact of exchange rate volatility on gold returns. There are 7 cases where increasing exchange rate volatility results in negative gold price changes, mirroring a strong hedge function of gold. In none of these cases does the first lag impact of exchange rate changes on gold returns turn out to be significant. Hence, the identification of a strong hedge function of gold requires an explicit modeling of the volatility component. The results also hint at a specific role of the dollar since 4 out of 7 cases mentioned above that imply a strong hedge function stem from dollar exchange rates. In the reverse causation there is no case where a significant impact of dollar exchange rate changes on gold returns is observed.

The results presented in the second column of Table III show that the findings for gold prices on exchange rate changes provide a different pattern. Firstly, the impact of gold price volatility on the exchange rate is ambiguous since both positive and negative coefficients are observed. More importantly, first or second lag gold price changes result in negative exchange rate responses in 13 cases, while a positive impact is only observed in 3 cases. Hence, an increase of the gold price results in an appreciation of the domestic currency in many cases. Once again, the pattern for the dollar is different. A rise of the gold price results in a depreciation of the dollar against the euro and the Japanese yen for the first lag but turn to be negative for the second lag. These findings show that the US dollar is the only currency for which a gold price increase results in a depreciation while an appreciation of the local currency is observed in most other cases. This result is of course based on a daily frequency and does not necessarily contradict the law of one price since we take lagged gold price changes as a starting point.

Table III about here

6 Conclusions

Previous research has established a link between gold prices and currency depreciations based on the law of one price without accounting for volatility transmission. Using daily data and explicitly allowing for volatility spillovers, we do not find clear evidence for such a relationship over the very short-run. Exchange rate depreciations have a negative impact on the gold price measured in different currencies after one day which partly turns out to be positive after two days.

Contrary to previous studies, our results point to a specific role of the US dollar in the context of the gold price-exchange rate nexus: Increasing volatility of dollar exchange rates more frequently results in a strong hedging function of gold. Furthermore, the gold price denominated in the US dollar exclusively increases after a depreciation of the dollar. In particular the first aspect might be of relevance from a practical perspective. Volatility of dollar exchange rates can result in substantial losses for investors and the fact that gold is partly able to offset these losses therefore deserves attention in further research. Focusing on investor's utility in a multivariate portfolio framework might for example be an interesting way to proceed.

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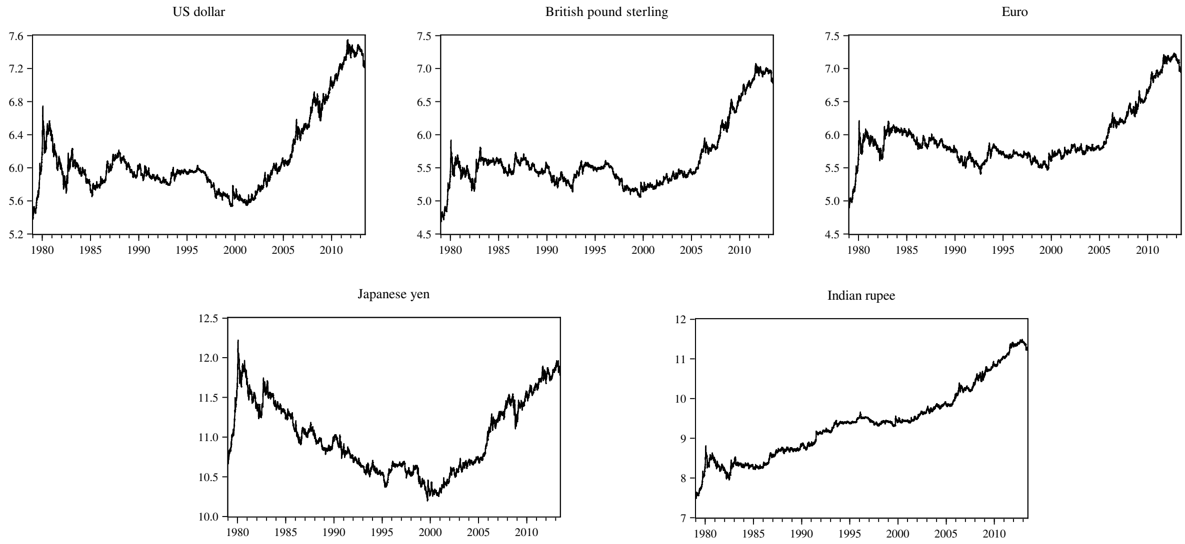
Figures

Figure I **Gold price in five currencies**

This figure presents the natural logarithm of daily gold prices in five different currencies from January 1979 to June 2013.



Tables

Table I **Descriptive statistics of the returns**

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	p-value	T
G_USD	0.0002	0.0000	0.1250	-0.1420	0.0124	0.0250	15.5627	59117.80	0.0000	8990
EX_USD_EUR	-0.0000	0.0000	0.0462	-0.0384	0.0063	0.1147	5.8178	2993.92	0.0000	8990
EX_USD_INR	-0.0002	0.0000	0.0505	-0.0909	0.0044	-3.4550	77.9132	1688722.0	0.0000	7161
EX_USD_JPY	0.0001	0.0000	0.0768	-0.0583	0.0071	0.4381	9.9005	14436.65	0.0000	7161
EX_USD_GBP	-0.0000	0.0000	0.0502	-0.0392	0.0062	-0.0157	6.9285	5781.48	0.0000	8990
G_GBP	0.0002	0.0000	0.1259	-0.1382	0.0123	0.0446	14.5133	49656.15	0.0000	8990
EX_GBP_EUR	0.0000	0.0000	0.0377	-0.0270	0.0046	0.3177	6.6597	5104.31	0.0000	8879
EX_GBP_INR	-0.0002	0.0000	0.0656	-0.1280	0.0071	-0.9122	23.2348	154618.3	0.0000	8990
EX_GBP_JPY	0.0001	0.0000	0.0694	-0.0634	0.0075	0.5001	9.1718	14642.81	0.0000	8990
EX_GBP_USD	0.0000	0.0000	0.0392	-0.0502	0.0062	0.0157	6.9285	5781.48	0.0000	8990
G_EUR	0.0002	0.0000	0.1251	-0.1395	0.0122	0.0673	15.0321	54235.27	0.0000	8990
EX_EUR_INR	-0.0001	0.0000	0.1119	-0.0925	0.0071	0.4926	28.5255	100107.4	0.0000	3682
EX_EUR_JPY	0.0000	0.0000	0.0525	-0.0735	0.0085	-0.0440	8.4041	4587.50	0.0000	3769
EX_EUR_GBP	-0.0000	0.0000	0.0270	-0.0377	0.0046	-0.3177	6.6597	5104.31	0.0000	8879
EX_EUR_USD	0.0000	0.0000	0.0384	-0.0462	0.0063	-0.1147	5.8178	2993.92	0.0000	8990
G_JPY	0.0001	0.0000	0.1235	-0.1710	0.0135	-0.1358	15.2148	55903.17	0.0000	8988
EX_JPY_EUR	-0.0000	0.0000	0.0735	-0.0525	0.0085	0.0440	8.4041	4.587.5	0.0000	3769
EX_JPY_INR	-0.0003	0.0000	0.0773	-0.1122	0.0085	-1.3353	22.1388	91131.65	0.0000	5857
EX_JPY_GBP	-0.0001	0.0000	0.0634	-0.0694	0.0075	-0.5001	9.1718	14642.81	0.0000	8990
EX_JPY_USD	-0.0001	0.0000	0.0583	-0.0768	0.0071	-0.4381	9.9005	14436.65	0.0000	7161
G_INR	0.0004	0.0002	0.1320	-0.1618	0.0135	0.0633	15.3658	57272.3	0.0000	8988
EX_INR_EUR	0.0001	0.0000	0.0925	-0.1119	0.0071	-0.4926	28.5255	100107.4	0.0000	3682
EX_INR_JPY	0.0002	0.0000	0.1122	-0.0773	0.0085	1.3353	22.1388	91131.65	0.0000	5857
EX_INR_GBP	0.0002	0.0000	0.1280	-0.0656	0.0071	0.9122	23.2348	154618.3	0.0000	8990
EX_INR_USD	0.0002	0.0000	0.0909	-0.0505	0.0044	3.4550	77.9132	1688722.0	0.0000	7161

Note: This table reports the mean, the median, the maximum, the minimum, the standard deviation (Std. Dev.), the skewness, the kurtosis, the Jarque-Bera normality test statistic with the corresponding p-value, and the number of observations T for the returns of the gold price in five different currencies and all bilateral exchange rates for the US dollar (USD), the British pound sterling (GBP), the euro (EUR), the Japanese yen (JPY), and the Indian rupee (INR). The maximum number of observations (8990) refers to the full sample period running from January 1979 to June 2013 on a daily basis. For some series the sample period starts later due to data availability like, for instance, for the USD/INR exchange rate starting in January 1986 (7161 observations).

TABLE II **Unit root tests**

	Level	Lag	First difference	Lag	Max Lag
G_USD	0.8903	1	0.0001	0	36
EX_USD_EUR	0.2225	0	0.0001	0	36
EX_USD_INR	0.0589	1	0.0001	0	34
EX_USD_JPY	0.0417	0	0.0001	0	34
EX_USD_GBP	0.0929	1	0.0001	0	36
G_GBP	0.8541	1	0.0001	0	36
EX_GBP_EUR	0.6060	0	0.0001	0	36
EX_GBP_INR	0.7602	5	0.0000	4	36
EX_GBP_JPY	0.5882	1	0.0001	0	36
EX_GBP_USD	0.0929	1	0.0001	0	36
G_EUR	0.6156	1	0.0001	0	36
EX_EUR_INR	0.8038	0	0.0001	0	29
EX_EUR_JPY	0.4318	1	0.0001	0	29
EX_EUR_GBP	0.6060	0	0.0001	0	36
EX_EUR_USD	0.2225	0	0.0001	0	36
G_JPY	0.7937	1	0.0001	0	36
EX_JPY_EUR	0.4318	1	0.0001	0	29
EX_JPY_INR	0.0197	0	0.0001	0	33
EX_JPY_GBP	0.5882	1	0.0001	0	36
EX_JPY_USD	0.0417	0	0.0001	0	34
G_INR	0.8684	1	0.0001	0	36
EX_INR_EUR	0.8038	0	0.0001	0	29
EX_INR_JPY	0.0197	0	0.0001	0	33
EX_INR_GBP	0.7602	5	0.0000	4	36
EX_INR_USD	0.0589	1	0.0001	0	34

Note: This table reports the ADF-test p-values for the levels and first differences of the gold price in five different currencies and all bilateral exchange rates for the US dollar (USD), the British pound sterling (GBP), the euro (EUR), the Japanese yen (JPY), and the Indian rupee (INR). The test regression includes a constant for testing the levels and no deterministic terms for testing the first difference. (For gold prices we have also checked the same null including a constant plus trend into the test regression without changing the overall finding.) The lag length provided in the table as been determined by minimizing the Schwarz information criterion based on the maximum number of lags also reported in the table.

Table III **GARCH-in-mean SVAR models**

		Exchange rate → Gold price			Gold price → Exchange rate		
		1. and 2. lag		Volatility	1. and 2. lag		Volatility
US dollar	Euro	0.00 (0.40)	0.09*** (5.03)	−0.23*** (−3.14)	0.01** (2.22)	−0.00 (−0.11)	0.00 (0.55)
	Ind. rupee	−0.00 (−1.08)	0.00 (0.02)	0.00 (0.25)	−0.00 (−0.53)	0.00* (1.77)	−0.07*** (−3.78)
	Jap. yen	−0.00 (−0.60)	−0.00 (−0.37)	−0.11* (−1.88)	−0.00 (−1.22)	0.00 (1.20)	0.07* (1.73)
	Brit. pound stir.	0.00 (0.83)	0.01 (0.70)	−0.02 (−0.23)	0.02*** (3.93)	0.00 (0.35)	−0.00 (−0.75)
Ind. rupee	Euro	−0.00 (−0.56)	0.40*** (17.37)	−0.11 (−1.42)	0.02* (1.67)	0.00 (0.75)	−0.05 (−1.20)
	Jap. yen	−0.03** (−2.01)	0.05*** (3.49)	−0.06 (−1.14)	0.02** (1.89)	0.01 (1.36)	−0.02 (−0.47)
	Brit. pound stir.	−0.00 (−1.45)	0.65*** (41.24)	−0.06 (−1.41)	0.00 (0.79)	0.00** (2.11)	−0.00 (−1.12)
	US dollar	−0.03*** (−2.69)	0.06** (2.55)	0.05 (1.10)	0.00 (1.34)	0.00 (0.63)	0.03* (1.88)
Euro	Brit. pound stir.	−0.01 (−1.20)	0.02 (0.75)	−0.08 (−1.06)	0.01*** (3.21)	−0.00 (−0.77)	−0.02*** (−2.77)
	Jap. yen	−0.02 (−1.30)	−0.01 (−0.71)	0.00 (0.10)	0.08*** (7.22)	0.01 (1.17)	0.10** (2.15)
	Ind. rupee	−0.03** (−1.97)	−0.02 (−0.73)	−0.06 (−0.85)	0.00 (0.55)	−0.03*** (−3.19)	−0.07 (−1.44)
	US dollar	−0.02 (−1.41)	0.02 (0.98)	−0.15* (−1.74)	−0.00 (−1.52)	−0.00 (−0.22)	−0.01 (−0.67)
Jap. yen	Brit. pound stir.	0.00 (0.23)	0.65*** (46.39)	0.04 (0.89)	−0.00 (−0.20)	0.00 (1.02)	−0.03** (−2.04)
	Euro	−0.00 (−0.56)	0.03 (1.13)	−0.10 (−1.53)	0.02* (1.92)	−0.01 (−1.22)	−0.00 (−0.05)
	Ind. rupee	−0.02 (−1.41)	0.00 (0.46)	−0.10* (−1.85)	0.02** (2.35)	−0.02*** (−2.59)	−0.00 (−0.04)
	US dollar	−0.01 (−1.18)	0.11*** (6.07)	−0.22** (−2.53)	0.00 (0.27)	−0.00 (−1.28)	−0.03 (−0.84)
Brit. pound stir.	Euro	−0.02** (−2.16)	−0.00 (−0.11)	−0.09 (−1.13)	0.01*** (3.77)	0.00 (0.17)	0.00 (0.94)
	Jap. yen	−0.00 (−0.73)	0.05*** (3.96)	0.12*** (5.97)	−0.00 (−0.04)	−0.00 (−0.54)	0.02 (1.27)
	Ind. rupee	−0.01 (−1.38)	0.02 (0.87)	−0.09*** (−3.12)	−0.00 (−0.38)	−0.00 (−0.45)	0.00 (0.52)
	US dollar	−0.00 (−0.74)	0.08*** (5.29)	0.00 (0.14)	−0.00* (−1.87)	0.00 (0.42)	0.00 (0.46)

Note: This table reports the estimates (with t-statistics in parentheses) of each bivariate GARCH-in-mean SVAR model given in Eq. (1), which includes the returns of the bilateral exchange rate and the gold price in the corresponding currency. The first column shows the estimates of the first and second lag of the exchange rate returns as well as their volatility in the gold equation and the second column reports the estimates of the first and second lag of the gold returns and their volatility in the exchange rate equation. All other estimated coefficients such as the reaction to own lagged values and own volatility are not shown to save space, but are available upon request.