# Currency and commodity return relationship under extreme geopolitical risks: Evidence from the invasion of Ukraine

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## ABSTRACT

We examine the relationship between currency and commodity returns around the invasion of Ukraine in February 2022. We find that the expected positive contemporaneous relationship between currency and commodity returns reverses and becomes negative during this period of extreme geopolitical risks. In addition to commodity returns, currency returns around the invasion of Ukraine are significantly affected by geopolitical factors, particularly geographic distance to the war. Our results indicate that a war between two major commodity-exporting countries significantly affects global currency pricing.

**Keywords:** Foreign exchange rates, currency return, commodity returns, Ukraine-Russia war, geographic distance

**JEL classifications**: F31; F51; G13; G14

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## 1. Introduction

The Russian invasion of Ukraine on 24 February 2022 was the most extensive military operation in Europe since World War II (Sullivan, 2022). Although there were signs, at least from January 2022, that an invasion could occur, it largely came as a shock to global financial markets. The heightened geopolitical and economic risks associated with the invasion of Ukraine triggered a sharp increase in commodity prices, already impacted by COVID-19-related supply chain disruptions, and an appreciation of the US dollar due to a flight-to-safety (or hedge) motive. In this paper, we examine whether a war between two major commodity-exporting countries impacts the relationship between currencies and commodity markets.

The financialization of commodity markets has increased co-movements among commodities (Tang and Xiong, 2012) and across asset classes (Natoli, 2021). Indeed, existing literature documents a positive contemporaneous relationship between the currency (relative to the US dollar) and commodity returns, particularly in commodity-exporting economies (Chen *et al.*, 2010; Chan *et al.*, 2011; Liu *et al.*, 2020), and accordingly, a negative relationship between commodity and the US dollar returns (Erb and Harvey, 2006). Moreover, economic theory predicts that spillovers caused by financialization should be particularly relevant in episodes of great uncertainty and high volatility (Basak and Pavlova, 2016).

Using a sample of daily returns of 31 currencies (in terms of the US dollar) from 1 January 2012 to 11 March 2022, we document the expected positive relationship between commodity and currency returns. On average, an increase in commodity prices is associated with an increase in the value of the currency relative to the US dollar. However, this positive relationship reverses and becomes negative during the period when the invasion of Ukraine was highly probable (from 20 January 2022) and remains negative during the outset of the war (24 February – 11 March 2022). Our results suggest that the war's anticipation and subsequent start changed the sign of the relationship between commodity and currency prices. In other

words, during this period of heightened geopolitical risks, the observed increase in commodity prices was associated with a decrease in the value of currencies. We also examine whether the exposure to the geopolitical risk around the invasion of Ukraine affects currency returns. We document that geographic distance to the war significantly affects currency returns during the period of the anticipation and the outset of the war; that is, the further away the country is from the war, the higher the country's currency return.

Our paper is related to research on the relationship between currencies and commodity prices (e.g., Beckmann *et al.*, 2020). These variables are linked through a variety of channels. The terms of trade channel focuses on real commodity prices and exchange rates (Ayres *et al.*, 2020). The portfolio and wealth channels propose the nominal exchange rate to the nominal commodity price effect (Krugman, 1983). Finally, the expectations channel allows for nominal causalities in both directions (Chen *et al.*, 2010). The causal link between these variables has been documented (e.g., Zhang *et al.*, 2016; Belasen and Demirer, 2019). Moreover, Fan *et al.* (2020) document the information content of speculative pressure across futures commodity and currency markets.

Our paper also contributes to the literature on the impact of uncertainty on foreign currency (Bartsch, 2019; Chen *et al.,* 2020) and commodity prices (Joëts *et al.*, 2017; Bakas and Triantafyllou, 2018). Furthermore, geopolitical risk is attracting much attention recently. Qin *et al.* (2020) show that geopolitical concerns have asymmetric effects on energy returns and volatility under various market conditions. Filippou *et al.* (2018) demonstrate that political risk is priced in the cross-section of currency momentum, which provides information not contained in other risk indicators.

Our paper aims to shed further light on the scarcely explored and still open question in the literature about the impact of geopolitical risks on pricing in currency markets. We contribute

to the literature by analyzing the relationship between currency and commodity returns around the Russian invasion of Ukraine.

## 2. Data

We examine currencies classified as free-floating or floating (IMF, 2021), excluding the currencies of the countries directly affected by the war (Ukraine, Russia, and Belarus). Our sample includes 31 currencies (Table 1) and spans from 1 January 2012 to 11 March 2022.[1] We have a special interest in two subperiods: (1) before the war from 20 January to 23 February 2022 (the anticipation period), and (2) from the outset of the war from 24 February to 11 March 2022 (the war period). The "before" or the anticipation period comprises the time of a heightened possibility of war, when many observers reportedly predicted that Russia would invade Ukraine.[2]

To measure the performance of currencies and commodities, we calculate daily currency and commodity log-returns using WM/Refinitiv foreign exchange rates (expressed as the US dollar price) and the S&P GSCI commodity futures index and energy, precious metals, agriculture, and industrial metals subindices (total return) data from Refinitiv Datastream.

We capture the degree of geopolitical risk using measures of political exposure, geographical distance, and economic proximity to the war (Federle *et al.*, 2022). We use three dummy variables to capture the political exposure to the war: (1) the heritage of being a member of the

[1] We do not include currencies of Albania, Georgia, Moldova, Madagascar, Mozambique, Seychelles, Slovak Republic, Somalia, Uganda, Uruguay, and Zambia because there is no available data for control variables for these countries.

[2] On 20 January 2022, the Atlantic Council issued a report confirming that Russia had deployed critical combat capabilities to the border with Ukraine (https://www.atlanticcouncil.org/blogs/new-atlanticist/will-russia-make-a-military-move-against-ukraine-follow-these-clues/) and the US President reportedly predicted that Russia would move into Ukraine ("Biden Predicts Putin Will Order Ukraine Invasion, but 'Will Regret Having Done It'". The New York Times. 20 January 2022. Washington D.C. ISSN 0362-4331)

Eastern bloc, (2) NATO membership,[3] and (3) being included in the list of Russia's 'unfriendly' countries.[4] We measure the geographic distance to the war using the distance in km between Kyiv, the capital of Ukraine, and the country's capital (for the euro, we use the distance to Frankfurt, Germany) obtained from cepiigeodist dataset.[5] We determine the economic proximity to the war using a country's bilateral trade with Russia, measured by the share of the Russian exports and imports in the country's total exports and imports (using data from the Direction of Trade statistics DOTS from IMF[6]).

As other potential determinants of currency returns, we include the News Sentiment Index, which captures the US economic uncertainty,[7] local stock market returns (in local currency) calculated using MSCI stock market indices' prices obtained from Refinitiv Datastream, and local interest rates measured with overnight interbank interest rates from Refinitiv Datastream.[8,9]

Table 1 reports summary statistics. The average currency return across countries is -4.24% per year, meaning the sample currencies have lost value relative to the US dollar in the sample period. On average, local stock market returns have increased 4.25% per year, and the average local interest rate is 3.29%. Noticeably, there is considerable heterogeneity across the sample currencies (Table 1).

[3] Data source: https://www.nato.int/cps/en/natohq/nato_countries.htm
[4] Data source: https://tass.com/politics/1418197
[5] Available from https://cran.r-project.org/web/packages/cepiigeodist/cepiigeodist.pdf
[6] https://data.imf.org/?sk=9d6028d4-f14a-464c-a2f2-59b2cd424b85&sId=1409151240976
[7] The News Sentiment Index of the Federal Reserve Bank of San Francisco is available at https://www.frbsf.org/economic-research/indicators-data/daily-news-sentiment-index/
[8] Overnight interbank interest rate is the most common interest rate with the shortest maturity across our sample countries. When overnight interbank interest rates are not available, we use the available interest rate with the shortest maturity.
[9] Other potential determinants of exchange rates are changes in inflation rates, current account deficits, public debt, and terms of trade (Chen et al., 2010). Given we are studying the short-term effect of the Russian invasion of Ukraine on the exchange rates and the above variables are available at a monthly frequency, at best, we do not include those controls. However, in the regression analysis, we control for time-invariant heterogeneity across currencies (by including currency fixed effects) and common exchange rate trends (by including month-year fixed effects), which could alleviate this issue.

| Currency name | Currency code | Country of the currency | Currency return (%) | | Stock market return (%) | | Interest rates (%) | | Former Eastern bloc (Yes=1) | NATO (Yes=1) | Russia's unfriendly country (Yes=1) | Distance to Kyiv (km) | Economic proximity to Russia |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Mean* | *STD* | *Mean* | *STD* | *Mean* | *STD* | | | | | |
| Australian dollar | AUD | Australia | -3.394 | 9.768 | 5.261 | 15.565 | 1.727 | 1.090 | 0 | 0 | 1 | 14,913 | 0.17% |
| Brazilian real | BRL | Brazil | -9.884 | 15.527 | 4.706 | 24.094 | 8.500 | 3.667 | 0 | 0 | 0 | 10,569 | 1.02% |
| Canadian dollar | CAD | Canada | -2.198 | 7.432 | 5.756 | 14.976 | 0.868 | 0.478 | 0 | 1 | 1 | 7,224 | 0.14% |
| Chilian peso | CLP | Chile | -4.260 | 10.406 | -2.328 | 18.843 | 3.016 | 1.436 | 0 | 0 | 0 | 13,566 | 0.69% |
| Colombian peso | COP | Colombia | -6.677 | 12.313 | 0.173 | 20.764 | 4.342 | 1.528 | 0 | 0 | 0 | 10,708 | 0.29% |
| Czech koruna | CZK | Czech Republic | -1.304 | 9.849 | -0.416 | 16.742 | 0.119 | 0.125 | 1 | 1 | 1 | 1,142 | 1.79% |
| Euro | EUR | Eurozone (Germany) | -1.630 | 7.825 | 5.758 | 19.160 | -0.258 | 0.268 | 0 | 1 | 1 | 1,204 | 1.81% |
| Ghanaian cedi | GHS | Ghana | -14.644 | 11.285 | 8.754 | 12.744 | 18.426 | 4.660 | 0 | 0 | 0 | 5,756 | 0.60% |
| Hungarian forint | HUF | Hungary | -3.225 | 11.647 | 7.252 | 22.982 | 1.663 | 1.981 | 1 | 1 | 1 | 896 | 2.03% |
| Icelandic króna | ISK | Iceland | -0.568 | 9.344 | -0.178 | 17.594 | 3.294 | 1.721 | 0 | 1 | 1 | 3,379 | 0.72% |
| Indian rupee | INR | India | -3.550 | 6.389 | 11.706 | 16.691 | 6.270 | 1.771 | 0 | 0 | 0 | 4,583 | 1.49% |
| Indonesian rupiah | IDR | Indonesia | -4.475 | 6.321 | 4.257 | 21.063 | 4.072 | 1.234 | 0 | 0 | 0 | 9,581 | 0.72% |
| Israeli Shekel | ILS | Israel | 1.552 | 6.983 | 0.480 | 17.928 | 0.518 | 0.731 | 0 | 0 | 0 | 2,071 | 1.83% |
| Jamaican dollar | JMD | Jamaica | -5.627 | 4.341 | 10.568 | 25.239 | 1.490 | 1.117 | 0 | 0 | 0 | 9,650 | 1.42% |
| Japanese yen | JPY | Japan | -4.234 | 8.676 | 9.142 | 19.179 | 0.005 | 0.060 | 0 | 0 | 1 | 8,216 | 1.32% |
| Kazakhstani tenge | KZT | Kazakhstan | -12.092 | 13.210 | -0.137 | 31.725 | 7.291 | 3.853 | 1 | 0 | 0 | 2,846 | 23.30% |
| South Korean won | KRW | Korea | -0.686 | 7.575 | 4.423 | 16.552 | 1.659 | 0.767 | 0 | 0 | 1 | 7,309 | 1.92% |
| Malaysian ringgit | MYR | Malaysia | -2.753 | 6.175 | -1.157 | 10.605 | 2.810 | 0.555 | 0 | 0 | 0 | 8,424 | 0.51% |
| Mauritian rupee | MUR | Mauritius | -3.948 | 6.958 | 1.192 | 16.172 | 1.577 | 0.911 | 0 | 0 | 0 | 8,292 | 0.15% |
| Mexican peso | MXN | Mexico | -3.881 | 12.393 | 3.469 | 15.407 | 5.158 | 1.777 | 0 | 0 | 0 | 10,832 | 0.28% |
| New Zealand dollar | NZD | New Zealand | -1.336 | 10.578 | 5.829 | 14.955 | 1.893 | 1.086 | 0 | 0 | 1 | 17,284 | 0.74% |
| Norwegian krone | NOK | Norway | -3.945 | 11.388 | 4.869 | 17.382 | 1.872 | 0.554 | 0 | 1 | 1 | 1,630 | 0.95% |
| Sol | PEN | Peru | -3.164 | 5.864 | -0.111 | 20.037 | 2.995 | 1.476 | 0 | 0 | 0 | 12,293 | 0.50% |
| Philippine peso | PHP | Philippines | -1.730 | 4.330 | 5.208 | 19.856 | 2.886 | 0.980 | 0 | 0 | 0 | 8,801 | 0.43% |
| Polish złoty | PLN | Poland | -2.103 | 11.030 | -0.845 | 20.100 | 1.753 | 1.217 | 1 | 1 | 1 | 691 | 2.67% |
| South African rand | ZAR | South Africa | -6.082 | 15.502 | 6.414 | 19.249 | 4.115 | 1.194 | 0 | 0 | 0 | 8,478 | 0.50% |
| Swedish krona | SEK | Sweden | -3.162 | 9.785 | 8.350 | 18.185 | 0.098 | 0.688 | 0 | 0 | 1 | 1,267 | 0.98% |
| Swiss franc | CHF | Switzerland | -0.067 | 8.833 | 6.970 | 14.807 | -0.556 | 0.376 | 0 | 0 | 1 | 1,731 | 0.93% |
| Thai baht | THB | Thailand | -0.554 | 4.829 | 2.531 | 17.544 | 1.655 | 0.736 | 0 | 0 | 0 | 7,430 | 0.39% |
| Turkish lira | TRY | Turkey | -20.087 | 19.510 | 11.624 | 23.507 | 12.405 | 5.098 | 0 | 1 | 0 | 1,181 | 5.57% |
| British pound | GBP | United Kingdom | -1.678 | 8.982 | 2.282 | 15.804 | 0.389 | 0.204 | 0 | 1 | 1 | 2,138 | 2.59% |
| Whole sample | All | All countries | -4.238 | 9.518 | 4.252 | 18.563 | 3.292 | 1.398 | 0.1290 | 0.2903 | 0.4516 | 6,583 | 1.89% |

*Table 1.* Summary statistics by currency

This table reports the annualized mean and standard deviation (STD) of currency returns, stock market returns, and interest rates by currency. This table also reports country-level variables that capture the exposure to the war: former Eastern bloc and NATO memberships, Russia's 'unfriendly' country status, geographic distance to Kyiv (in km), and economic proximity to Russia.

## 3. Empirical Results

The uncertainty and extreme geopolitical risks associated with the anticipation and the start of the war sent commodity (natural gas, oil, industrial metals, and agricultural products) prices rising, and many currencies, especially European currencies, depreciating against the US dollar. Figure 1 plots the S&P GSCI commodity index and the equally weighted index of the sample currencies from 1 December 2021 to 11 March 2022. Figure 1 depicts the changes in the trends in both commodity prices and exchange rates around the invasion date on 24 February 2022.[10]

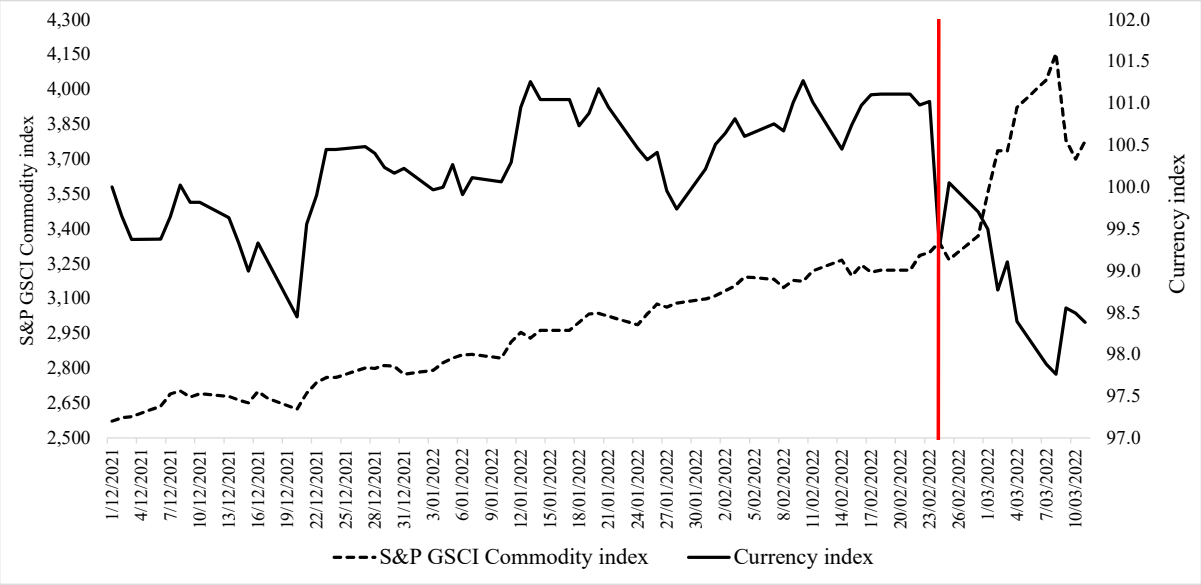


*Figure 1*. Commodity price index and Currency index since 1 December 2021

The figure plots the S&P GSCI commodity price index and the equally weighted index of the sample currencies (expressed as the US dollar price of foreign currency) obtained from Refinitiv Datastream from 1 December 2021 to 11 March 2022. We highlight the invasion date of 24 February 2022 with a vertical line.

Figure 2 plots individual currency returns from 20 January to 23 February 2022 (Before War) and from 24 February to 11 March 2022 (War). Before the war, when there was already a possibility of a war, 61% of the sample currencies suffered losses. From the war's outset, this

[10] Although Figure 1 shows a negative co-movement between commodity prices and exchange rates around the invasion, we cannot draw conclusions because co-movement between two nonstationary series, such as the S&P GSCI and the Currency indices, does not indicate causality.

number increased to 71%, with currencies of Kazakhstan, Hungary, and Poland having the lowest returns and currencies of Colombia, Jamaica, and Peru having the highest returns. Notably, there is significant heterogeneity in responses to the war across currencies.

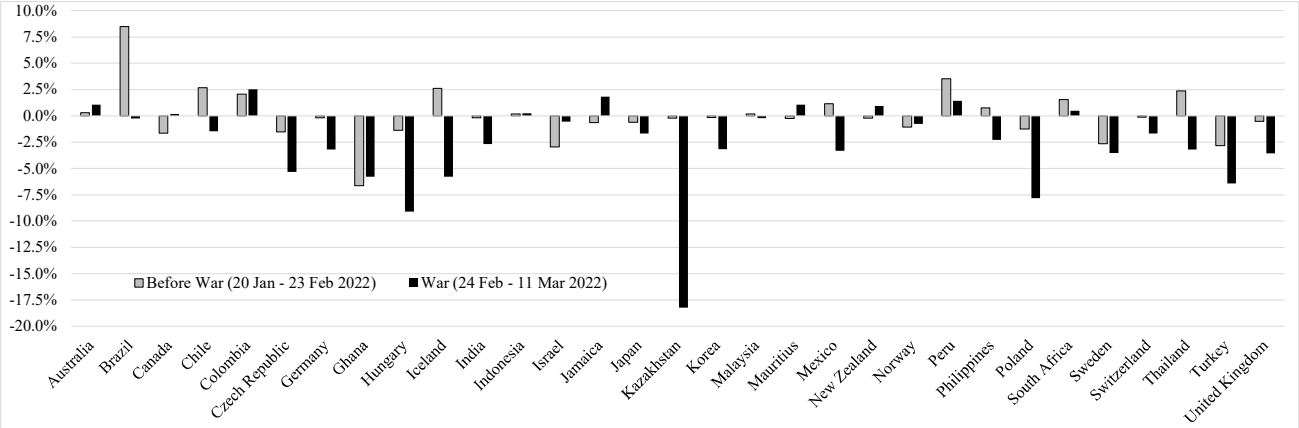


*Figure 2*. Currency returns around the start of the war

The figure plots cumulative currency returns calculated using foreign exchange rates for two periods: before the war from 20 January to 23 February 2022 and the beginning of the war from 24 February to 11 March 2022.

We employ panel fixed effects regressions to evaluate the relationship between currency and commodity returns. To isolate the impact of the determinants before and at the start of the war, we include interaction terms of the explanatory variables with the dummy variables that capture these two subperiods. First, we estimate the relationship between currency and commodity returns without evaluating the role of country-level variables:

$$\begin{aligned} r\_ft_{i,t} = \alpha &+ \left(\beta_1 + \beta_1^{bef} \times 1\_bef_t + \beta_1^{war} \times 1\_war_t\right) \times r\_commo_t + \\ &+ \left(\beta_2 + \beta_2^{bef} \times 1\_bef_t + \beta_2^{war} \times 1\_war_t\right) \times news\_s_t + \\ &+ \left(\beta_3 + \beta_3^{bef} \times 1\_bef_t + \beta_3^{war} \times 1\_war_t\right) \times r\_mkt_{i.t} + \\ &+ \left(\beta_4 + \beta_4^{bef} \times 1\_bef_t + \beta_4^{war} \times 1\_war_t\right) \times r\_f_{i,t} \; + \; \varepsilon_{i,t} \end{aligned} \quad (1)$$

where $r\_fx_{i,t}$ is the return of currency *i* at day *t*, $1\_bef_t$ and $1\_war_t$ are dummy variables equal to one from 20 January to 23 February 2022 and from 24 February to 11 March 2022, respectively, and zero otherwise; $r\_commo_t$ is the commodity index return; $news\_s_t$ is the news sentiment index; $r\_mkt_{i,t}$ is the local stock market return; $r\_f_{i,t}$ is the local overnight

interest rate; and $\varepsilon_{i,t}$ is the residual. We estimate the OLS regression with currency and month-year fixed effects. The inferences are based on White t-statistics with double-clustered standards errors by currency and day-year. We have an unbalanced panel with a total number of observations of 74,581 ($T = \sum_{i=1}^{31} T_i = 74{,}581$ where $T_i$ is the number of observations for the currency $i$ with $i$=1, …, 31).

Panel A of Table 2 reports the estimation results of Equation (1). Model 1 confirms a significant depreciation of the sample currencies against the US dollar over the sample period, especially from the war's outset. Models 2-6 estimate the impact of global commodity, energy, precious metals, agricultural, and industrial metals commodity indices' returns. The coefficient estimates for all commodity indices are positive and significant at the 1% level, confirming the positive relationship in regular times (Chan *et al.*, 2011). The coefficient estimates on the interaction term of the commodity return and the war dummy variable are negative and significant at the 1% level for all indices, indicating that the relationship between currency and commodity returns reverses during the war. Before the war (from 20 January 2022), the relationship between currency and commodity returns is negative and significant for the global commodity index and energy and agricultural commodities subindices. These findings align with other studies highlighting the asymmetric risk-return relationship in financial markets (Bekiros *et al.*, 2018) and the reversal of causal linkages in main commodity markets (Lahmiri, 2017).

| | Panel A. Currency and various commodity returns | | | | | | Panel B. Country-level exposure to the war | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dep.: r_fx (%) | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Constant | -0.016*** | 0.178* | 0.178* | 0.085 | 0.161 | 0.138 | 0.185* | 0.187* | 0.184* | 0.174* | 0.186* | 0.192* |
| | (-6.76) | (1.82) | (1.78) | (0.94) | (1.63) | (1.63) | (1.89) | (1.90) | (1.88) | (1.69) | (1.90) | (1.87) |
| 1_bef | 0.017 | -0.051 | -0.084 | -0.074 | -0.073 | -0.088 | -0.048 | -0.039 | -0.016 | -0.335 | -0.051 | -0.518** |
| | (0.72) | (-0.24) | (-0.39) | (-0.37) | (-0.34) | (-0.53) | (-0.22) | (-0.18) | (-0.07) | (-1.10) | (-0.24) | (-2.00) |
| 1_war | -0.200*** | -0.482 | -0.509 | -0.805 | -0.737 | -0.314 | -0.446 | -0.416 | -0.335 | -1.808 | -0.473 | -1.090 |
| | (-5.94) | (-0.65) | (-0.68) | (-1.14) | (-1.18) | (-0.38) | (-0.59) | (-0.58) | (-0.48) | (-1.49) | (-0.62) | (-1.58) |
| r_commo | | 0.065*** | | | | | 0.065*** | 0.065*** | 0.065*** | 0.065*** | 0.065*** | 0.065*** |
| | | (5.72) | | | | | (5.71) | (5.71) | (5.71) | (5.70) | (5.71) | (5.71) |
| r_commo × 1_bef | | -0.087* | | | | | -0.086* | -0.086* | -0.086* | -0.086* | -0.086* | -0.085* |
| | | (-1.86) | | | | | (-1.85) | (-1.85) | (-1.81) | (-1.84) | (-1.84) | (-1.78) |
| r_commo × 1_war | | -0.139*** | | | | | -0.141*** | -0.139*** | -0.140*** | -0.140*** | -0.141*** | -0.141*** |
| | | (-4.71) | | | | | (-4.77) | (-4.61) | (-4.52) | (-4.44) | (-4.68) | (-4.47) |
| r_energy | | | 0.029*** | | | | | | | | | |
| | | | (4.56) | | | | | | | | | |
| r_energy × 1_bef | | | -0.056* | | | | | | | | | |
| | | | (-1.75) | | | | | | | | | |
| r_energy × 1_war | | | -0.080*** | | | | | | | | | |
| | | | (-4.19) | | | | | | | | | |
| r_prec_metals | | | | 0.115*** | | | | | | | | |
| | | | | (6.94) | | | | | | | | |
| r_prec_metals × 1_bef | | | | -0.060 | | | | | | | | |
| | | | | (-0.70) | | | | | | | | |
| r_prec_metals × 1_war | | | | -0.252*** | | | | | | | | |
| | | | | (-3.61) | | | | | | | | |
| r_agr | | | | | 0.054*** | | | | | | | |
| | | | | | (6.09) | | | | | | | |
| r_agr × 1_bef | | | | | -0.080** | | | | | | | |
| | | | | | (-2.12) | | | | | | | |
| r_agr × 1_war | | | | | -0.150*** | | | | | | | |
| | | | | | (-3.17) | | | | | | | |
| r_ind_metals | | | | | | 0.110*** | | | | | | |
| | | | | | | (7.74) | | | | | | |
| r_ind_metals × 1_bef | | | | | | -0.020 | | | | | | |
| | | | | | | (-0.81) | | | | | | |
| r_ind_metals × 1_war | | | | | | -0.221*** | | | | | | |
| | | | | | | (-3.00) | | | | | | |
| Eastern Bloc | | | | | | | -0.001 | | | | | 0.011* |
| | | | | | | | (-0.21) | | | | | (1.78) |
| Eastern × 1_bef | | | | | | | -0.008 | | | | | 0.028 |
| | | | | | | | (-0.14) | | | | | (0.43) |
| Eastern × 1_war | | | | | | | -0.488** | | | | | -0.209 |
| | | | | | | | (-2.04) | | | | | (-0.63) |
| NATO | | | | | | | | -0.004 | | | | -0.011 |
| | | | | | | | | (-0.72) | | | | (-1.64) |
| NATO × 1_bef | | | | | | | | -0.035 | | | | 0.060 |
| | | | | | | | | (-0.64) | | | | (1.11) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NATO × 1_war | | | | | | | | -0.217 | | | | 0.010 |
| | | | | | | | | (-1.31) | | | | (0.17) |
| Unfriendly | | | | | | | | | 0.001 | | | 0.004 |
| | | | | | | | | | (0.24) | | | (0.61) |
| Unfriendly × 1_bef | | | | | | | | | -0.055 | | | -0.042 |
| | | | | | | | | | (-0.90) | | | (-0.69) |
| Unfriendly × 1_war | | | | | | | | | -0.235 | | | -0.077 |
| | | | | | | | | | (-1.30) | | | (-0.40) |
| Distance to Kyiv | | | | | | | | | | 0.001 | | -0.001 |
| | | | | | | | | | | (0.43) | | (-0.23) |
| Distance × 1_bef | | | | | | | | | | 0.034 | | 0.056** |
| | | | | | | | | | | (1.20) | | (2.18) |
| Distance × 1_war | | | | | | | | | | 0.156** | | 0.079*** |
| | | | | | | | | | | (1.97) | | (2.63) |
| Econ. prox to Russia | | | | | | | | | | | -0.091** | -0.141*** |
| | | | | | | | | | | | (-2.42) | (-3.19) |
| Econ. prox × 1_bef | | | | | | | | | | | 0.303 | 0.570 |
| | | | | | | | | | | | (0.44) | (0.66) |
| Econ. prox × 1_war | | | | | | | | | | | -3.866*** | -2.247 |
| | | | | | | | | | | | (-2.94) | (-0.70) |
| news_s | | 0.211 | 0.188 | 0.040 | 0.100 | 0.236 | 0.211 | 0.211 | 0.211 | 0.211 | 0.211 | 0.211 |
| | | (1.13) | (0.99) | (0.22) | (0.52) | (1.27) | (1.13) | (1.13) | (1.13) | (1.13) | (1.13) | (1.13) |
| news_s × 1_bef | | -0.407 | -0.764 | -0.275 | -0.046 | -1.216 | -0.394 | -0.396 | -0.389 | -0.417 | -0.380 | -0.390 |
| | | (-0.12) | (-0.24) | (-0.09) | (-0.01) | (-0.45) | (-0.12) | (-0.12) | (-0.12) | (-0.13) | (-0.12) | (-0.12) |
| news_s × 1_war | | -2.013 | -2.222 | -4.236 | -3.621 | -0.905 | -2.123 | -2.028 | -2.045 | -2.079 | -2.137 | -2.174 |
| | | (-0.57) | (-0.64) | (-0.92) | (-0.93) | (-0.20) | (-0.57) | (-0.56) | (-0.57) | (-0.57) | (-0.57) | (-0.57) |
| r_mkt | | 0.079*** | 0.085*** | 0.092*** | 0.091*** | 0.077*** | 0.079*** | 0.079*** | 0.079*** | 0.079*** | 0.079*** | 0.079*** |
| | | (4.15) | (4.32) | (4.57) | (4.52) | (3.98) | (4.15) | (4.15) | (4.15) | (4.15) | (4.15) | (4.15) |
| r_mkt × 1_bef | | 0.042 | 0.035 | 0.031 | 0.028 | 0.027 | 0.041 | 0.041 | 0.040 | 0.039 | 0.042 | 0.039 |
| | | (1.38) | (1.18) | (1.00) | (0.92) | (0.89) | (1.35) | (1.35) | (1.30) | (1.29) | (1.38) | (1.27) |
| r_mkt × 1_war | | 0.090* | 0.087* | 0.080* | 0.080* | 0.103** | 0.082* | 0.089* | 0.088* | 0.085* | 0.081 | 0.079 |
| | | (1.83) | (1.74) | (1.92) | (1.83) | (2.09) | (1.65) | (1.87) | (1.82) | (1.77) | (1.57) | (1.45) |
| r_f | | -0.001 | -0.001 | -0.002* | -0.001 | -0.001 | -0.003*** | -0.003*** | -0.003*** | -0.003*** | -0.003*** | -0.003*** |
| | | (-0.79) | (-0.93) | (-1.75) | (-1.19) | (-1.04) | (-4.66) | (-4.88) | (-4.56) | (-4.75) | (-4.98) | (-6.00) |
| r_f × 1_bef | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.001 | -0.001 | -0.004 | -0.001 | -0.002 | -0.005 |
| | | (0.01) | (0.03) | (-0.00) | (0.04) | (-0.03) | (-0.05) | (-0.08) | (-0.40) | (-0.06) | (-0.14) | (-0.41) |
| r_f × 1_war | | -0.031*** | -0.031*** | -0.031*** | -0.031*** | -0.031*** | -0.027*** | -0.033*** | -0.047*** | -0.032*** | -0.015* | -0.025 |
| | | (-3.20) | (-3.24) | (-2.81) | (-3.12) | (-3.34) | (-3.37) | (-3.05) | (-3.66) | (-2.96) | (-1.87) | (-1.24) |
| Month-year fixed effects | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Currency fixed effects | No | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No | No |
| R-squared (%) | 0.05 | 6.87 | 6.20 | 8.59 | 6.08 | 8.21 | 6.87 | 6.85 | 6.85 | 6.87 | 6.87 | 6.89 |
| N. observations | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 | 74,581 |

*Table 2.* The relationship between currency and commodity returns

This table reports the estimation results of Equation (1). The dependent variable is daily currency returns. Panel A reports estimations between currency and commodity returns. Panel B reports estimations with country-level variables to capture country-level heterogeneity. Distance to Kyiv (km) is in logs. Month-year and currency fixed effects are included in all the models unless otherwise stated. The sample period is from 1 January 2012 to 11 March 2022. White t-statistics with standard errors clustered by currency and day-year (except for Model 1 where standard t-statistics are used) are reported in parenthesis. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively.

Regarding the control variables, the News sentiment index is an insignificant determinant of currency returns. Local stock market returns are positively related to currency returns with an additional positive and significant effect during the war. The interest rates are an insignificant determinant of currency returns over the sample period and before the war but are negative and significant during the war period.[11]

Next, we estimate Equation (1) with country-level variables that capture a country's exposure to the war (instead of currency fixed effects). We evaluate the relationship between currency and commodity returns and whether a country-level exposure to the war can explain currency returns before and during the war. Panel B of Table 2 reports the estimation results that confirm the reversal in the relationship between currency and commodity returns around the war in Ukraine documented in Panel A of Table 2. Regarding the country-level variables, we find that the currencies of former Eastern bloc members depreciate more from the war's outset. Currencies of countries that are more geographically distant from the war have higher returns during the war. Countries with significant economic ties to Russia have currencies that underperform during the sample period and even more so from the war's outset. When we include all country-level variables in one regression (Model 12), we find that currencies of 'former Eastern bloc countries marginally outperform and currencies of countries with

[11] The online Appendix S1 shows that the main findings are not affected when we exclude Kazakhstan as a potential outlier (as shown in Figure 2), when we include the USD index returns as a control variable, when we control for the daily geopolitical risk index of Caldara and Iacoviello (2022) or control for local stock market return in US dollars.

economic ties to Russia strongly underperform over the sample period. However, before and during the war, the only significant country-level determinant of currency returns is the geographic distance to the war, that is the further away from the war, the higher the currency return. This result is in line with the 'proximity penalty' documented by Federle *et al.* (2022) when examining stock market reactions to the invasion of Ukraine and the evidence of spillover effects via information transmission from the directly affected markets to the rest (Ehrmann *et al*. 2011). Our results highlight the importance of geopolitical factors in explaining currency returns when geopolitical risks are heightened.[12]

## 4. Conclusions

We analyze the relationship between the currency (in terms of the US dollar) and commodity returns during a period of high geopolitical risk in February-March 2022 when Russia invaded Ukraine. While there is a positive association between currency and commodity returns in regular times, this relationship reverses around the conflict. Furthermore, we document that geopolitical factors, notably the distance to the war, have a considerable impact on currency returns. Our findings show that heightened geopolitical risks associated with a war between two large commodity-exporting countries significantly impact the currency and commodity price relationship. Further research is called to investigate potential explanations of the observed change in the currency-commodity return relationship under extreme uncertainty and geopolitical risks.

[12] In an additional analysis, we distinguish between commodity currencies (Chen and Rogoff, 2003; Norland, 2020) and non-commodity currencies (discussed in Section S2 of the online Appendix). The main result is observed in both subsamples, but the effect is stronger for commodity currencies.

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**Supplementary Appendix to**

**Currency and commodity return relationship under extreme geopolitical risks: Evidence from the invasion of Ukraine**

This supplementary appendix is divided into two sections. In Section S1, we show the robustness of our results reported in Table 2. In Section S2, we report the results for commodity currencies and non-commodity currencies.

## S1. Robustness tests

We performed several robustness checks to assess the sensitive of our findings to different model specifications. Table S1 presents the results obtained when excluding Kazakhstan as a potential outlier (Panel A), when we include the USD index returns as a control variable (Panel B), when controlling for the daily geopolitical risk index of Caldara and Iacoviello (2022) (Panel C), and when controlling for local stock market return in US dollars (Panel D).

| | Panel A: No Kazakhstan | | Panel B: USD index | | Panel C: GPR index | | Panel D: Stock returns USD | |
|---|---|---|---|---|---|---|---|---|
| Dep.: r_fx (%) | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Constant | 0.185* | 0.186* | 0.121 | 0.119 | 0.179* | 0.176* | 0.140** | 0.131* |
| | (1.85) | (1.75) | (1.51) | (1.38) | (1.81) | (1.67) | (2.25) | (1.92) |
| 1_bef | -0.056 | -0.350 | 0.153 | -0.139 | 0.018 | -0.267 | 0.046 | -0.054 |
| | (-0.25) | (-1.15) | (0.76) | (-0.41) | (0.08) | (-0.85) | (0.31) | (-0.22) |
| 1_war | -0.551 | -1.720 | -0.322 | -1.694 | -3.390*** | -4.835*** | -0.261 | -1.176 |
| | (-0.86) | (-1.56) | (-0.58) | (-1.49) | (-5.03) | (-4.01) | (-0.59) | (-1.50) |
| r_commo | 0.065*** | 0.065*** | 0.047*** | 0.047*** | 0.065*** | 0.065*** | 0.009 | 0.009 |
| | (5.64) | (5.63) | (4.83) | (4.82) | (5.71) | (5.69) | (1.08) | (1.07) |
| r_commo × 1_bef | -0.082* | -0.081 | -0.051 | -0.050 | -0.085* | -0.085* | -0.022 | -0.021 |
| | (-1.67) | (-1.64) | (-1.62) | (-1.59) | (-1.75) | (-1.73) | (-0.67) | (-0.65) |
| r_commo × 1_war | -0.137*** | -0.138*** | -0.067* | -0.067* | -0.168*** | -0.169*** | -0.052*** | -0.053** |
| | (-4.93) | (-4.60) | (-1.83) | (-1.69) | (-5.22) | (-5.00) | (-2.36) | (-2.29) |
| Distance to Kyiv | | 0.001 | | 0.001 | | 0.001 | | 0.002 |
| | | (0.33) | | (0.39) | | (0.43) | | (0.69) |
| Distance × 1_bef | | 0.035 | | 0.035 | | 0.034 | | 0.012 |
| | | (1.23) | | (1.17) | | (1.20) | | (0.47) |
| Distance × 1_war | | 0.138* | | 0.162* | | 0.165* | | 0.108* |
| | | (1.67) | | (1.89) | | (1.84) | | (1.87) |
| news_s | 0.234 | 0.234 | 0.050 | 0.051 | 0.212 | 0.212 | 0.430*** | 0.430*** |
| | (1.23) | (1.23) | (0.38) | (0.39) | (1.13) | (1.13) | (2.86) | (2.86) |
| news_s × 1_bef | -0.411 | -0.417 | 2.222 | 2.219 | -0.386 | -0.396 | 0.784 | 0.788 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (-0.12) | (-0.12) | (0.90) | (0.89) | (-0.12) | (-0.12) | (0.34) | (0.35) |
| news_s × 1_war | -3.053 | -3.106 | -1.584 | -1.649 | -8.672*** | -8.847*** | -0.714 | -0.786 |
| | (-0.92) | (-0.91) | (-0.46) | (-0.47) | (-3.62) | (-3.48) | (-0.32) | (-0.34) |
| r_mkt | 0.086*** | 0.086*** | 0.081*** | 0.081*** | 0.079*** | 0.079*** | | |
| | (4.31) | (4.31) | (4.46) | (4.46) | (4.15) | (4.15) | | |
| r_mkt × 1_bef | 0.041 | 0.038 | 0.032 | 0.029 | 0.040 | 0.038 | | |
| | (1.06) | (0.98) | (1.30) | (1.17) | (1.34) | (1.24) | | |
| r_mkt × 1_war | 0.120*** | 0.115** | 0.067 | 0.062 | 0.057 | 0.051 | | |
| | (2.67) | (2.28) | (1.54) | (1.45) | (1.33) | (1.20) | | |
| r_f | | | | | | | | - |
| | 0.000 | -0.003*** | 0.000 | -0.003*** | -0.001 | -0.003*** | -0.001 | 0.003*** |
| | (-0.28) | (-4.44) | (-0.28) | (-4.67) | (-0.79) | (-4.66) | (-0.96) | (-4.58) |
| r_f × 1_bef | 0.000 | -0.001 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 | -0.001 |
| | (-0.00) | (-0.11) | (-0.04) | (-0.12) | (0.03) | (-0.05) | (-0.06) | (-0.12) |
| r_f × 1_war | | | | | | | | - |
| | -0.021*** | -0.023*** | -0.032*** | -0.033*** | -0.032*** | -0.033*** | -0.031*** | 0.031*** |
| | (-3.14) | (-3.90) | (-2.74) | (-2.77) | (-2.69) | (-2.68) | (-3.35) | (-2.78) |
| USD index | | | -0.432*** | -0.432*** | | | | |
| | | | (-6.62) | (-6.62) | | | | |
| USD index x 1_bef | | | -0.104 | -0.105 | | | | |
| | | | (-0.83) | (-0.84) | | | | |
| USD index x 1_war | | | -0.122 | -0.132 | | | | |
| | | | (-0.53) | (-0.56) | | | | |
| GPR | | | | | 0.000 | 0.000 | | |
| | | | | | (-0.09) | (-0.08) | | |
| GPR × 1_bef | | | | | 0.000 | 0.000 | | |
| | | | | | (-0.55) | (-0.55) | | |
| GPR × 1_war | | | | | 0.005*** | 0.005*** | | |
| | | | | | (4.32) | (4.33) | | |
| r_mkt_USD | | | | | | | 0.254*** | 0.254*** |
| | | | | | | | (8.81) | (8.81) |
| r_mkt_USD × 1_bef | | | | | | | -0.040 | -0.041 |
| | | | | | | | (-1.34) | (-1.36) |
| r_mkt_USD × 1_war | | | | | | | -0.041 | -0.044 |
| | | | | | | | (-1.16) | (-1.24) |
| Month-year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Currency fixed effects | Yes | No | Yes | No | Yes | No | Yes | No |
| R-squared | 7.27 | 7.27 | 13.73 | 13.73 | 6.96 | 6.97 | 33.18 | 33.17 |
| Observations | 72,014 | 72,014 | 74,581 | 74,581 | 74,581 | 74,581 | 74,252 | 74,252 |

*Table S1.* Robustness results

This table reports the estimation results of the robustness tests of Equation (1) of the manuscript. The dependent variable is daily currency returns in percentages. Panel A excludes Kazakhstan from the sample; Panel B controls for the effect of the US dollar index return; Panel C controls for the daily geopolitical risk index of Caldara and Iacoviello (2022); and Panel D employs the local stock market return in US dollars. Distance from Kyiv (km) is in logs. Month-year and currency fixed effects are included in all the models unless otherwise stated. The sample period is from 1 January 2012 to 11 March 2022. White t-statistics with standard errors clustered by currency and day-year are reported in parenthesis. ***, ** and * denotes significant at the 1%. 5% and 10% level, respectively.

**S2. Commodity vs. non-commodity currencies**

Existing literature documents a strong relationship between currency and commodity returns for major commodity-exporting countries, or 'commodity currencies' (Chen and Rogoff, 2003). We examine whether our findings documented in Table 2 of the manuscript hold only for commodity currencies (Norland, 2020). Table S2 reports the estimation results for commodity and non-commodity currencies. Non-commodity currencies experience negative returns during the war (Model 4). In contrast, the returns of commodity currencies during the war are not significantly different from the rest of the sample period (Model 1). We find that the positive relationship between currency and commodity returns and the reversal of this relationship around the war, documented in Table 2 of the manuscript, hold for both commodity and non-commodity currencies. Notably, the coefficient estimates on *Commodity* and *Commodity×War* are substantially higher for commodity currencies (Models 2, 3, 5, and 6). Furthermore, we find that the geographic distance to the war is a significant positive determinant of currency returns before the war only for commodity currencies (Models 3).

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dep.: r_fx (%) | Panel A. Commodity currencies | | | Panel B. Non-commodity currencies | | |
| Constant | -0.020*** | 0.245* | 0.239** | -0.015*** | 0.165* | 0.139 |
| | (-3.72) | (1.94) | (1.97) | (-5.67) | (1.78) | (1.37) |
| 1_bef | 0.083 | 0.100 | -0.226 | -0.006 | -0.111 | -0.262 |
| | (1.52) | (0.25) | (-0.80) | (-0.22) | (-0.63) | (-0.73) |
| 1_war | 0.048 | -0.561 | -1.003 | -0.286*** | -0.431 | -1.583 |
| | (0.62) | (-0.37) | (-0.77) | (-7.86) | (-0.85) | (-1.16) |
| r_commo | | 0.128*** | 0.128*** | | 0.040*** | 0.040*** |
| | | (10.28) | (10.27) | | (4.28) | (4.28) |
| r_commo × 1_bef | | -0.123 | -0.122 | | -0.076* | -0.076* |
| | | (-1.45) | (-1.42) | | (-1.73) | (-1.71) |
| r_commo × 1_war | | -0.225*** | -0.224*** | | -0.107*** | -0.107*** |
| | | (-4.79) | (-4.65) | | (-3.28) | (-3.34) |
| Distance to Kyiv | | | 0.002 | | | 0.003 |
| | | | (1.22) | | | (0.70) |
| Distance × 1_bef | | | 0.036** | | | 0.018 |
| | | | (2.46) | | | (0.49) |
| Distance × War | | | 0.049 | | | 0.139 |
| | | | (1.40) | | | (1.19) |
| news_s | | 0.269 | 0.270 | | 0.195 | 0.195 |
| | | (1.00) | (1.00) | | (1.09) | (1.09) |
| news_s × 1_bef | | 3.636 | 3.654 | | -1.824 | -1.825 |
| | | (0.56) | (0.55) | | (-0.72) | (-0.72) |
| news_s × 1_war | | -3.244 | -3.246 | | -1.463 | -1.522 |
| | | (-0.38) | (-0.37) | | (-0.63) | (-0.62) |
| r_mkt | | 0.128*** | 0.128*** | | 0.059*** | 0.059*** |
| | | (5.08) | (5.08) | | (2.72) | (2.72) |
| r_mkt × 1_bef | | 0.066 | 0.066 | | 0.040 | 0.038 |
| | | (0.93) | (0.93) | | (1.23) | (1.18) |
| r_mkt × 1_war | | -0.013 | -0.013 | | 0.114** | 0.111** |
| | | (-0.10) | (-0.10) | | (2.21) | (2.21) |
| r_f | | -0.000 | -0.003*** | | -0.001 | -0.003*** |
| | | (-0.06) | (-5.01) | | (-0.78) | (-4.51) |
| r_f × 1_bef | | 0.038*** | 0.038*** | | -0.009 | -0.009 |
| | | (7.22) | (7.90) | | (-1.23) | (-1.26) |
| r_f × 1_war | | -0.006 | -0.007 | | -0.037*** | -0.037** |
| | | (-0.33) | (-0.38) | | (-3.33) | (-2.39) |
| Month-year fixed effects | No | Yes | Yes | No | Yes | Yes |
| Currency fixed effects | No | Yes | No | No | Yes | No |
| R-squared | 0.01 | 14.26 | 14.26 | 0.11 | 4.81 | 4.80 |
| Observations | 20,536 | 20,536 | 20,536 | 54,045 | 54,045 | 54,045 |

*Table S2.* Commodity vs. non-commodity currencies

This table reports the estimation results of Equation (1) for two sub-sample: (1) commodity currencies (AUD, BRL, CAD, CLP, COP, NZD, NOK, and ZAR) in Panel A, and (2) non-commodity currencies (the rest of the currencies) in Panel B. The dependent variable is daily currency returns. Distance to Kyiv (km) is in logs. Month-year and currency fixed effects are included unless otherwise stated. The sample period is from 1 January 2012 to 11 March 2022. White t-statistics with standard errors clustered by currency and day-year (except for Models 1 and 4 where standard t-statistics are used) are reported in parenthesis. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.