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Commodity Currencies and Causality: Some High-Frequency Evidence

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Abstract

I investigate the link between economic fundamentals and exchange rate adjustment to commodity price fluctuations. I overcome the traditional issue of simultaneity by exploiting the September 14, 2019 drone attack on two Saudi Arabian refineries as a natural experiment. This unanticipated event caused the largest 1-day global crude oil price spike in over a decade. Using high-frequency exchange rate data for 30 countries, I measure each currency's return around the event window, and link currency return heterogeneity to country-level economic and monetary fundamentals. Crude export and import intensities were associated with appreciation (depreciation). In addition, countries with current account surpluses, as opposed to deficits, and greater international reserves saw more currency appreciation, thereby buffering the depreciating effects on crude oil importers. Countries with higher policy interest rates, consisting of mostly Emerging Market economies, experienced greater depreciation conditional on crude oil export/import exposure.

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1 Introduction

The complex relationship between commodity prices and exchange rates is of great interest to international economists and policymakers, especially for those focusing on resource-dependent open economies [See Edwards (1986)[6], Chen and Rogoff (2003)[4], Cashin et al. (2004)[3], Aizenman et al. (2012)[2].]. Despite the rich literature on exchange rate adjustment to commodity shocks, establishing causality under this context remains challenging because of simultaneity: it's possible that exchange rates fluctuations cause commodity prices to adjust [Chen et al. (2010)[5]] or for commodity fluctuations to impact exchange rates under the assumption that open economies are price takers in the world commodity market[1]. Several studies report evidence of predictability or cointegration [Chen et al. (2010)[5], Lee and Chen (2014)[10], Kohlscheen et al. (2017)[9], among others.], oft considered the second-best approach when causal identification can't be achieved.

This paper takes an alternative approach to identify the causal effect of commodity prices on exchange rates. I exploit the September 14, 2019 surprise attack on two Saudi Arabian oil refineries as a natural experiment, where this completely unanticipated shock to global crude oil supplies sent world crude prices sharply higher, leading to the largest 1-day spike in over a decade. Using high-frequency data on exchange rates across 30 countries, I measure exchange rate adjustment around the window of the unanticipated oil shock and link the heterogeneity in exchange rate adjustment back to various country-specific fundamentals. Consistent with the literature, I find that both a country's trade-related oil exposure and financial/monetary conditions jointly explain exchange rate adjustment to the oil shock. Heavier crude exporters (importers) saw greater appreciation (depreciation). Current account surpluses (as opposed to deficits) and greater international reserves are associated with appreciation, thereby buffering depreciation effects on crude oil importers. Countries with higher policy interest rates, usually observed among Emerging Market economies, saw greater depreciation for any given level of crude oil exposure. At least in the very short-run, this evidence of exchange rate adjustment goes against the conventional view that exchange rates are un-responsive to commodity supply shocks [Basher et al. (2015)[12] and Habib et al. (2016)[8]].

[1] As done in several of the mentioned papers. A reasonable assumption though with exceptions: Russia as an oil exporter, OPEC countries as a coordinating organization, China as an importer of copper, Chile as an exporter of copper, United States corn production.

Figure 1: September 14, 2019 Drone Attacks

Source: VOAnews.com

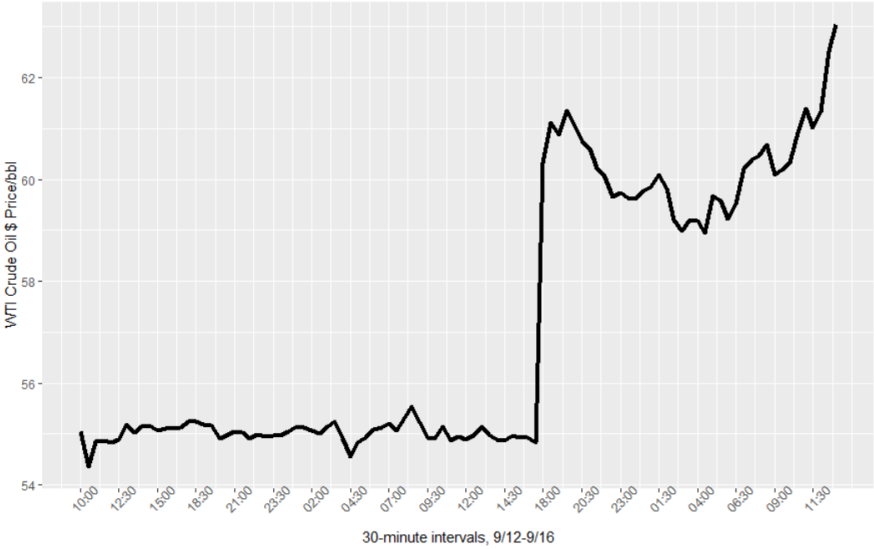
2 September 14, 2019 Oil Supply Shock

2.1 Crude Oil Prices

In Saudi Arabia on September 14, 2019, drones were used in a surprise attack on two of the largest Saudi Aramco oil refineries - state-owned facilities: Abqaiq and Khurais in Eastern Saudi Arabia (Figure 1). According to the Saudi Arabian interior ministry, the flames induced by the attack were put out relatively quickly, but both facilities were shut down for repairs, temporarily cutting the country's oil production (about 5 percent of global production) by about half. Despite the country communicating that it will tap into its oil reserves to buffer the supply shock, the news led the the sharpest one-day rise in global crude oil prices in over a decade.

Figure 2 shows that as the futures market opened on the subsequent Sunday evening, crude oil futures prices jumped over 10 percent from roughly $55 per barrel to $61, and then continued to rise through Monday to a peak of over $63. While the attack happened while markets were closed, the opening gap largely represents the market response to the news, as no other news over the weekend was release that would have such a profoundly distinct impact on crude oil prices.

Figure 2: Intra-day WTI Crude Oil Futures Response to 9/14 Drone Attack

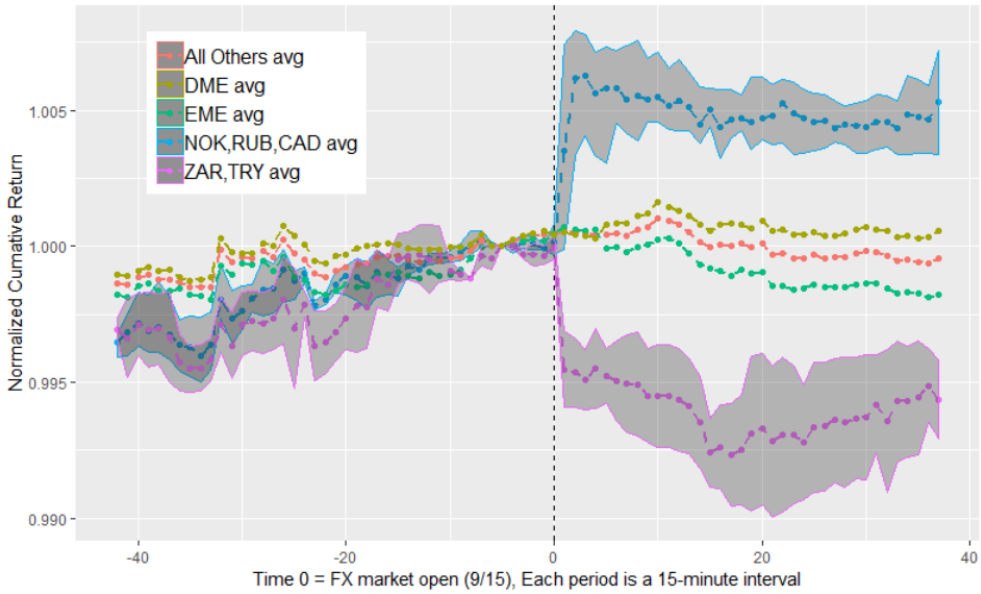


2.2 Exchange Rate Adjustment

Meanwhile, as foreign exchange markets around the world opened, currency responses varied. Naturally, those countries which do not have oil-intensive dependencies continued to operate as 'business as usual'. In contrast, exchange rates of Russia, Norway, and Canada - major oil exporters - saw sudden appreciation. Other countries observed marked depreciation, including Turkey and South Africa. These countries tend to be oil importers, and also financially fragile. Figure 3 reports visually the heterogeneity observed in exchange rate responses before and after news of the oil supply shock. Figure 5 breaks down the exchange rate responses by country upon market open.

What determined the varying exchange rate responses to the oil shock? Visually, it appears that crude oil dependency is a relevant factor determining whether the exchange rate experienced meaningful adjustment. But as the theoretical literature suggests, there are other interactions which could amplify otherwise limited commodity exposure, such as a country's net financial position, credit worthiness, monetary regime, etc.

Figure 3: Intra-day Exchange Rate Response to 9/14 Drone Attack



15-minute frequency data. All currencies vis-a-vis the USD. Positive change is appreciation against the USD.

3 Empirical Strategy

3.1 Data

For a sample of 30 countries, I collect intra-day exchange rate data at the 30-minute frequency around the weekend of the Saudi refinery strike from Bloomberg. The sample contains 12 developed market currencies (including the G10 less United States), and 18 emerging market currencies. All exchange rates are vis-a-vis the USD, and a positive change implies appreciation against the U.S. Dollar.

I also compile a cross-sectional data set on country-specific trade and financial fundamentals from various public sources: UN COMTRADE, IMF, World Bank, and the CIA World Factbook. The most recent data is taken, mostly from 2018/2019, but on some occasions the statics are dated from 2017. Tables 2 and 3 report sample mean and standard deviations respectively, across all countries and for Developed Market Economies (DMEs) and Emerging Market Economies (EMEs) subgroups. China is by far, the largest country in the sample by GDP (over $12 trillion), which pulls up the average GDP of EMEs to be comparable to DMEs, though EME GDP is nearly twice as volatile. While most crude oil / refined petrol trade variables are balanced across countries, DMEs import considerably more refined petroleum than EMEs. EMEs also tend to have lower current count surpluses than DMEs, on average, along with larger external debt/GDP and lower public debt/GDP and international reserves/GDP. Policy interest rates are much higher and more varied among EMEs than DMEs. Many DMEs have rates pinned near the effective lower bound, explaining both their lower average level and standard deviation.

3.2 High-Frequency Identification

Truly exogenous macroeconomic shocks are rare. Therefore, the unanticipated attack on Saudi oil refinery's makes for a valuable case study because the direction of causality between commodity prices and exchange rates is unambiguous. Moreover, an isolated shock to a specific commodity - crude oil - provides valuable cross-sectional heterogeneity in exchange rates, which I aim to link back to the variation in fundamentals across countries. High-frequency event studies are ubiquitous in the macro-finance literature (See Gurkaynak and Wright (2013)[7] for a survey. Aizenman et al. (2016)[1] and Neely (2015)[11] specifically look at exchange rate responses to monetary pol-

icy in an event study framework). The key identification assumption is that within the window of the event, no other news or fundamental changes occur which would impact the exchange rate. Because we are analyzing a narrow window of exchange rate responses, the assumption is reasonably satisfied. Moreover, the fact that many non-exposed currencies saw no discernible effect is supportive of little to no other market-moving macroeconomic news announcements over the event period.

Cross-country fundamentals are taken as fixed over the event window. Because country fundamentals tend to evolve slowly, and almost certainly do not rapidly vary from day-to-day, the assumption of fundamentals being exogenous over the event window is very likely to hold. Moreover, since the data on fundamentals updates with a lag, using data from 2017-2019 up until the event also ensures against any potential endogeneity.

3.3 Regression Analysis

Let the percent change in the exchange rate vis-a-vis the USD (where positive change implies local appreciation against the USD) be denoted as:

$$\Delta e_{i,ab} = \frac{E_{i,a} - E_{i,b}}{E_{i,b}}, \tag{1}$$

where $\Delta e_{i,ab}$ is the exchange rate percent return of country i from period b (before event) to period a (after event). $E_{i,a}$ and $E_{i,b}$ are the corresponding nominal exchange rate levels, before and after the event. For each country, the before-period corresponds to the exchange rate recorded at the close of 9/13. Most recorded closing values are from 16:30:00 EST, though closing times vary across FX markets[2]. Post-event exchange rates are mostly recorded on 9/15 20:00:00[3]. The constructed returns capture the percent change in exchange rates over the period of the oil shock.

The following regression specification tests the effect of fundamentals on exchange rate adjustment to the oil price shock:

$$\Delta e_{i,ab} = \alpha + \beta' X_i + e_i, \tag{2}$$

where $[OX_i, OI_i, RX_i, RI_i, CA_i, ED_i, PD_i, IR_i, r_i] \in X_i$ and OX_i and OI_i are crude oil exports/GDP and crude oil imports/GDP, respectively.

[2]For Peru and Malaysia values are taken from 14:30:00 and 11:30:00 EST, respectively.

[3]With the exception of: India (9/15 20:30:00), Malaysia, Sweden, Hungary, and Colombia (all of which have new prints by 9/16 05:00:00).

RX_i and RI_i are refined petroleum exports and imports (normalized by GDP). CA_i is the current account surplus/GDP. ED_i and PD_i are external debt/GDP and public debt/GDP, respectively. IR_i are international reserves/GDP, and r_i is the nominal policy interest rate of the country. The intercept term, α, captures the average change vis-a-vis the USD across all exchange rates, or $\Delta\bar{e}_{ab}$. Because the average exchange rate return is statistically indifferent from zero, I restrict the regression intercept to equal zero to preserve degrees of freedom[4].

Table 1: Cross-section correlation, FX returns over event window and economic fundamentals

	OX_i	OI_i	RX_i	RI_i	CA_i	ED_i	PD_i	IR_i	r_i
$\Delta e_{i,ab}$	0.58	-0.37	-0.05	-0.14	0.15	0.12	0.18	0.15	-0.34

Table 1 reports sample cross-section correlations between exchange rate returns over the event period and different economic variables. Unsurprisingly, heavier exporters and importers of crude oil appreciated and depreciated on average following the supply shock. More intriguingly, exposure to refined petroleum trade is considerably weaker, and countries with higher interest rates also experienced depreciation, suggesting a role for financial fragility.

4 Results

The regression results are reported in Table 4. Interesting interactions between a country's crude oil exposure and financial condition emerge. Refined petroleum exports and imports are not significant upon including crude oil imports and exports. Crude oil exporters and importers react to the oil shocks as expected, by appreciating and depreciating, respectively. Though the cumulative exchange rate change may have been economically small (Figure 3), this evidence of reacting to a *supply* shock goes against the conventional view that exchange rates do *not* react to supply shocks - at least in the very short run[5]. The first few columns of the results highlight a potential asymmetry, where importers' exchange rates were doubly sensitive to the oil shock compared to exporters. The asymmetry disappears in column 5 upon including policy interest rates which itself has significant explanatory power

[4] $\Delta\bar{e}_{ab}$ is equal to -0.0007, t-stat of -1.13.

[5] Habib et al. (2016)[8], Basher et al. (2015)[12].

over exchange rate responses. Column 5 implies that a country with exports (imports)/GDP of 0.05, or 5%, would have appreciated (depreciated) by an expected +0.48% (-0.64%) in response to the oil shock[6]. Conditional on exposure to crude oil, countries with higher policy rates, composed mostly of EMEs, saw their exchange rates depreciate more. Similarly, countries with current account deficits saw their exchange rates depreciate relative to those with surpluses, but this effect becomes insignificant after jointly including IR and policy rates. Crude importers will higher IR and lower policy rates saw their currencies buffered, depreciating less. Conversely, crude exporters with higher IR and lower rates saw their exchange rates appreciate more. Debt variables are insignificant, and the full specification can explain 62 percent of the cross-sectional variation in exchange rate responses around the oil shock, half of which (about 30%) is attributed to the country's crude oil exposure. Overall the results are consistent with the view that exchange rates adjust to oil shocks via both the trade channel and financial channels[7].

A limitation of this study is that it is considering a single, specific event. Moreover, high-frequency identification comes at the cost of only obtaining short-run effect estimates. We cannot extend these short-run claims to the long-run. Despite this limitation, most studies on commodity currencies focus on the longer run, thus this approach provides a novel view of the phenomena.

5 Conclusion

Exchange rate adjustment to commodity price fluctuations is an important topic to understand for economists and policymakers, yet causal inference remains challenging. To overcome the issue of simultaneity, I exploit the September 14, 2019 drone attack on two Saudi Arabian refineries as a natural experiment. This unanticipated event caused the largest 1-day crude oil price spike in over a decade. Using high-frequency exchange rate data for 30 countries, I measure currency returns around the oil shock, and link cross-country heterogeneity to country-specific trade and monetary fundamentals. Trade exposure through exports and imports of crude oil, international reserves holdings, policy interest rates, and current account position together explain over half of the cross-country variation in exchange rate adjustment to the oil price shock.

[6] Russia and Norway have greater than 6% exports/GDP. Singapore and Taiwan have greater than 6% imports/GDP.

[7] Aizenman et al (2012)[2] and Lee and Chen (2014)[10].

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6 Appendix

Table 2: Economic Fundamentals, Sample Mean

Sample Mean	All	DMEs	EMEs
GDP	1454.1000	1433.0000	1468.1667
Exports	342.5167	363.6083	328.4556
Imports	289.2667	336.2917	257.9167
Oil Exported	9.0135	8.8872	9.0977
Refined Exported	10.2014	10.4762	10.0182
Oil Imported	17.4621	16.2467	18.2724
Refined Imported	9.1934	12.4512	7.0215
Crude/GDP	-0.0042	-0.0069	-0.0024
Crude/Trade	0.0002	-0.0033	0.0025
Trade Openness	0.6326	0.6440	0.6250
Current Account/GDP	0.0194	0.0481	0.0002
External Debt/GDP	1.0050	1.7775	0.4900
Public Debt/GDP	0.5814	0.7501	0.4689
Int'l Reserves/GDP	0.2755	0.3234	0.2435
Policy Rate	0.0306	0.0069	0.0464
N	30	12	18

Values (first 7 rows) in USD ($ Billions). Data taken from various public sources: UN COMTRADE, IMF IFS, CIA World Factbook and World Bank. All Statistics are from 2018/2019 or latest available date.

Figure 4: Regression Results

	Dependent Variable: FX returns				
Covariates	(1)	(2)	(3)	(4)	(5)
Refined Exports/GDP	0.052				
	(0.053)				
Refined Imports/GDP	-0.032				
	(0.053)				
Crude Exports/GDP	0.065***	0.078***	0.072***	0.071***	0.096***
	(0.021)	(0.020)	(0.021)	(0.021)	(0.025)
Crude Imports/GDP	-0.105*	-0.1489***	-0.167***	-0.173***	-0.128***
	(0.053)	(0.031)	(0.041)	(0.039)	(0.035)
Current Account/GDP		0.0339***	0.0371***	0.035***	0.013
		(0.010)	(0.010)	(0.012)	(0.009)
External Debt/GDP			-0.0003	-0.0003	-0.0005
			(0.0004)	(0.0004)	(0.0004)
Public Debt/GDP			0.0012	0.0015	0.0014
			(0.0011)	(0.0011)	(0.0008)
Int'l Reserves/GDP				0.0011	0.003***
				(0.0011)	(0.0010)
Policy Rate					-0.037***
					(0.010)
Adj. R-2	0.30	0.52	0.52	0.50	0.62
N	30	30	30	30	30

Robust standard errors in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level, respectively.

Table 3: Economic Fundamentals, Sample Standard Deviation

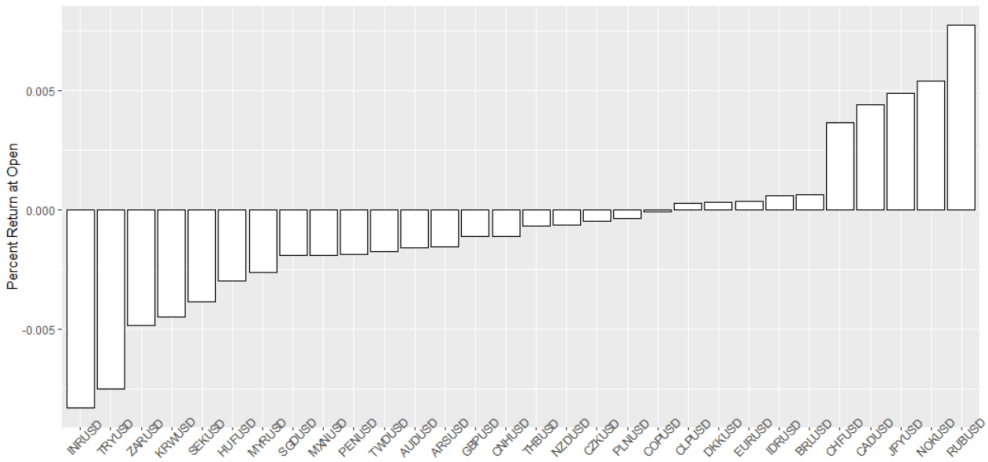
Sample Standard Deviation	All	DMEs	EMEs
GDP	2318.0396	1521.1746	2769.1932
Exports	466.3483	352.5479	538.5630
Imports	324.2887	302.0441	343.1659
Oil Exported	20.2255	16.7850	22.7048
Refined Exported	14.2736	12.0371	15.9282
Oil Imported	30.7564	17.4262	37.6225
Refined Imported	9.4871	12.0207	6.8958
Crude GDP	0.0310	0.0347	0.0292
Crude Trade	0.0701	0.0583	0.0785
Trade Openness	0.4371	0.4526	0.4395
Current Account/GDP	0.0590	0.0718	0.0404
External Debt/GDP	0.9814	1.1615	0.2608
Public Debt/GDP	0.4074	0.5774	0.1839
Int'l Reserves/GDP	0.2664	0.3922	0.1373
Policy Rate	0.0346	0.0083	0.0366
N	30	12	18

Values (first 7 rows) in USD ($ Billions). Data taken from various public sources: UN COMTRADE, IMF IFS, CIA World Factbook and World Bank. All Statistics are from 2018/2019 or latest available date.

Table 4: Country List

	Country	EME/DME	FX
1	Argentina	EME	ARSUSD
2	Australia	DME	AUDUSD
3	Brazil	EME	BRLUSD
4	Canada	DME	CADUSD
5	Chile	EME	CLPUSD
6	China	EME	CNHUSD
7	Colombia	EME	COPUSD
8	Czech	EME	CZKUSD
9	Denmark	DME	DKKUSD
10	Euro	DME	EURUSD
11	Hungary	EME	HUFUSD
12	India	EME	INRUSD
13	Indonesia	EME	IDRUSD
14	Japan	DME	JPYUSD
15	Malaysia	EME	MYRUSD
16	Mexico	EME	MXNUSD
17	New Zealand	DME	NZDUSD
18	Norway	DME	NOKUSD
19	Peru	EME	PENUSD
20	Poland	EME	PLNUSD
21	Russia	EME	RUBUSD
22	S. Korea	EME	KRWUSD
23	Singapore	DME	SGDUSD
24	South Africa	EME	ZARUSD
25	Sweden	DME	SEKUSD
26	Switzerland	DME	CHFUSD
27	Taiwan	DME	TWDUSD
28	Thailand	EME	THBUSD
29	Turkey	EME	TRYUSD
30	United Kingdom	DME	GBPUSD

Figure 5: Intra-day Exchange Rate Response to 9/14 Drone Attack



Percent change in exchange rate from 9/13 close to 9/15 open. All currencies vis-a-vis the USD. Positive change is appreciation against the USD.