Monetary Policy Transmission through Commodity Prices*

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Abstract

Monetary policy influences inflation dynamics by exerting impact on a diverse array of commodity prices. At high frequencies, we show that a 10 basis points increase in US monetary policy rate reduces commodity prices between 0.5% and 2.5%, after 18 to 24 business days. Beyond the dollar appreciation channel, the effects are larger for highly storable and industrial commodities, consistent with the cost of carry and the expected demand channel. We then study the quantitative importance of the *commodity-price channel* of monetary policy on domestic and international inflation at longer horizons (6-36 months). The results indicate that the six months' response of commodity prices—oil, base metals, and food prices—to monetary policy accounts for 41% of the total effect of US monetary policy on US headline inflation, and 66% of the effect of US monetary policy on other countries' headline inflation. The commodity price channel on core inflation is smaller and mainly driven by base metal prices. Finally, the commodity-price channel of ECB monetary policy is smaller and it mainly operates through its effect on energy prices.

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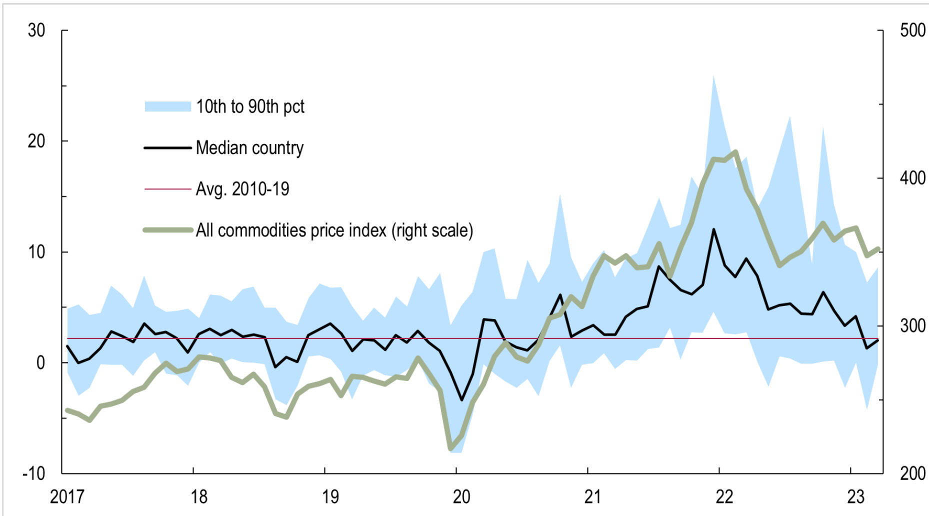
1 Introduction

Sharp fluctuations in commodity prices, in addition to pandemic-related dislocations and policy actions, have been blamed for the recent global surge in inflation (e.g., Gagliardone and Gertler, 2023; Bernanke and Blanchard, 2023; Ball et al., 2022) and for its subsequent fall (Figure 1). Commodity prices, however, are not exogenous with respect to the macroeconomy (e.g., Barsky and Kilian, 2004; Jacks and Stuermer, 2020). Indeed, part of the recent monetary policy reaction may have worked through a commodity-price channel as policy actions from major central banks affect global activity and financial conditions, which are typically major drivers of fluctuations in commodity prices. But, how quantitatively important is the commodity price channel of monetary policy—especially US monetary policy—in driving inflation in the US and worldwide?

Empirical analysis of this question has been limited (Breitenlechner et al., 2022; Ider et al., 2023). This paper contributes to filling this gap by estimating the effects of monetary policy shocks on a variety of commodity prices and, through this channel, their spillback to the domestic economy and spillovers to consumer prices in other countries.

The analysis focuses on the Federal Reserve and, to a less extent, the ECB—given the special role of the US dollar as a reserve currency and in the international payment system. Conceptually, US monetary policy can affect commodity prices through i) a cost of carry channel (by affecting the opportunity cost of commodity storage) ii) a real economy channel (by affecting current and future commodity consumption and uses) iii) a liquidity and portfolio channel (by affecting financial conditions and, thus, trading liquidity in physical and derivative markets), and iv) an exchange rate channel (as most commodities are traded in USD). Since monetary policy has typically long lags before affecting the real economy, an immediate

Figure 1. Headline inflation and commodity prices 2017-2023



Note: Year to year headline inflation distribution (shaded area) covers countries accounting for around 83.9% of WEO World GDP (in weighted purchasing power parity terms). Sources: Haver Analytics; IMF, Primary Commodity Price System; IMF staff calculations.

effect of a monetary policy shock through the real-economy channel could only work through expectations and, thus, only for easy-to-store commodities.[1]

We start by investigating the high-frequency, daily, response of 39 USD-denominated commodity prices to monetary policy shocks. Using local projection methods for the period 1990-2019, we find large and heterogeneous responses of commodity prices to US monetary policy shocks: base metals, crude oil, cotton and rubber, beverages, precious metals, and cereals decline by 2.5%, 2%, 1.9%, 1.3%, 1.1%, and 0.8%, respectively, to a positive 10 basis points shock to the US monetary policy rate. These responses are larger and more persistent than the ones implied by the 0.4% US dollar appreciation followed by the monetary policy tightening. Furthermore, for most metals and oil, inventories typically decline after a monetary policy tightening shock. Taken together, these results highlight the importance of the expected demand and the cost of carry channel. We repeat the previous analysis to study

[1]Recent evidence in Jacobson, Matthes, and Walker (2023) and Buda, Carvalho, Corsetti, Duarte, Hansen, Ortiz, Rodrigo, and Rodríguez Mora (2023) show that monetary policy can have high-frequency effects—days or weeks—on the economy.

the effects of ECB monetary policy shocks on commodity prices. Our results suggest that, unlike the case of US monetary policy, ECB monetary policy shocks affect oil prices only.

To investigate the importance of the commodity-price channel in the transmission of monetary policy to consumer prices, we extend our analysis to a monthly frequency proxy-SVAR which jointly considers the different transmission mechanisms of monetary policy, including the real demand effects, the financial channel, and the commodity-price channel. We study the domestic and international effects of the commodity-price channel of US and ECB monetary policy. In particular, in the spirit of Bernanke, Gertler, and Watson (1997), we reestimate the impulse response functions imposing that monetary policy has no effect on commodity prices (oil, food, and base metals) prices. Our results for the US show that the commodity-price channel—mainly through oil, food, and base metals—accounts for about 40% of the first 6-months effect of US monetary policy on US headline CPI. The main commodity affecting headline inflation is oil, while core inflation is mostly affected by base metals prices (e.g., copper and aluminum).

In our final section, we use a sample of 24 countries to analyze the inflation spillovers of US monetary policy through the commodity price channel. We document large and heterogeneous effects. For the average country, the commodity-price channel drives more than half of the 6-month total effect of US monetary policy on inflation. The channel manifests more strongly in advanced economies, in which a lower prevalence of price controls/subsidies could increase the pass-through of commodity prices to final consumer prices. Finally, for a subsample of countries, we explore the impact of the commodity price channel in foreign countries' core inflation (6-months horizon). Our results suggest an important role of oil and base metals in the total effect of US monetary policy on foreign countries core inflation.

Our paper makes contributions to three strands of literature. First, we contribute to the literature that studies the drivers of commodity price fluctuations as in Kilian (2009), Hamilton (2009), Alessio Anzuini and Pagano (2013), Frankel (2014), Kilian and Murphy (2014)) Hammoudeh, Nguyen, and Sousa (2015), Rosa (2014), Baumeister and Kilian (2016), Alam and Gilbert (2017), Alessio Anzuini and Pagano (2013), Jacks and Stuermer (2020), among others. We contribute to these studies by using local projections and documenting high-frequency responses to a broader set of commodity prices, using recent identified monetary policy price shocks as in Jarociński and Karadi (2020). We also provide monthly responses using proxy-SVAR approach.

We also contribute to the literature studying the spillovers of monetary policy decisions in major central banks (e.g., Dedola et al., 2017; Camara, 2021). Different from these papers, we disentangle a particular channel in which monetary policy can affect foreign in inflation: the commodity-price channel.

Finally, our results also shed lights into the literature investigating the transmission channels of monetary policy in Blanchard and Galı (2007), Gertler and Karadi (2015), Nakamura and Steinsson (2018), Jarociński and Karadi (2020), Gagliardone and Gertler (2023), and Bernanke and Blanchard (2023), among others. All these studies, consider how commodity price shocks affect monetary policy decisions, taking commodity prices as exogenous. Nevertheless, our results point to the importance of taking into account the effects of monetary policy on commodity prices. Complementing the results in Breitenlechner, Georgiadis, and Schumann (2022) and Ider, Kriwoluzky, Kurcz, and Schumann (2023), we document that US and ECB monetary policy transmission channels greatly hinge on how different commodities react and then affect domestic and international inflation.

2 Conceptual Framework

Among central banks, the US Federal Reserve plays a special role. This is because the bulk of crossborder capital flows are denominated in US dollar and US monetary policy is a key driver of the global financial cycle (Miranda-Agrippino and Rey, 2020; Dées and Galesi, 2021); changes in US interest rates have, thus, pronounced repercussions for the rest of the world (e.g., Rey, 2016). Kearns, Schrimpf, and Xia (2018) document that the importance of the ECB's spillovers have increased over time, especially after the European debt crises. The authors also show that spillovers from other major central banks, such as the Bank of Japan of the Bank of England, are only mild. Therefore, this analysis will focus on the effects of US and ECB monetary policy shocks.[2]

2.1 Transmission mechanisms

Conceptually, monetary policy can affect commodity prices through, at least, four channels. The first channel is the so-called cost of carry channel. Changes in interest rates affect the opportunity cost of commodity storage. Hence, a substantial increase in the Fed funds rate provides investors an incentive to reduce commodity storage and search for higher yields in the bond markets. Frankel (2014) also highlights another consequence of higher interest rates: they undermine the incentive for oil-producing countries to keep crude oil under the ground. By extracting oil instead of preserving it, OPEC countries could invest the proceeds at interest rates that were higher than the return to leaving it in the ground. Higher extraction rates increase supply; both lower demand and higher supply contribute to a fall in oil prices.[3] The

[2]In our Appendix, Table A3, we use Granger causality tests to show that US and ECB monetary policy shocks tend to drive other major central banks monetary policy shocks. Hence, our results for the US and ECB could represent a lower bound to total commodity-price channel of *global* monetary policy.

[3]In the Hotelling's resource model, higher interest rates raise the opportunity cost of holding the resource (above or under ground); the resource owner is, thus, incentives to accelerate the extraction rate to capitalize

same mechanisms apply to decisions about extracting minerals, logging forests, harvesting crops, etc.

A second channel is the real economy. Changes in interest rates affect investment and consumption, which then drives current and future commodity consumption. While the real effects of monetary policy take time to materialize, forward looking agents in commodity markets adjust their portfolios today in expectation of future changes. Moreover, as documented by Ottonello and Winberry (2020), monetary policy has important effects on investment, especially for financially healthy firms. Hence, as several commodities, for example base metals, have a large exposure to investment demand, commodity prices of more industrial commodities are also expected to react to monetary policy shocks.

A third channel is liquidity. Monetary policy of major central banks affects global financial conditions and, thus, it drives liquidity trading in physical and derivative markets. Finally, as we consider commodities that are internationally traded in USD, there is the exchange rate channel. An appreciation of the USD dollar, all else equal, increases the price of commodities in foreign local currency, which then decreases demand and stimulates supply, thus, putting downward pressure on prices.

In our first analysis of the effects of monetary policy on commodity prices, we consider daily high-frequency data. Since monetary policy has typically long lags affecting the real economy, an immediate effect of a monetary policy shock through the real-economy channel can only work through expectations and, thus, for easy-to-store commodities. In our next sections we study the longer-term effects of monetary policy for which we explicitly consider the current real demand channel.

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on the higher present value of the resource's revenue reducing today's price of the exhaustible resource.

3 High-frequency responses of commodity prices to monetary policy shocks

3.1 Data

We use disaggregated daily data on nominal commodity price futures (rolling front month contracts) from Bloomber L.P., denominated in USD, for 39 different commodities (see Table 1 in our Appendix). We also aggregate these commodities prices, only those with data for the whole sample period 1990-2019, using trade weights from the IMF Primary Commodity Price System (PCPS) database into 11 sub-indexes (e.g., agriculture, energy, metals, food). Table A2 in our Appendix shows the commodities we use along with their weights.

Our measure of monetary policy shocks, for the USA and Europe, follows Jarociński and Karadi (2020). In particular, we use the *pure* monetary policy shock identified within their proxy-SVAR. This is the exogenous interest rate shocks that correlate negatively with the stock market on the day of the announcement.

3.2 Empirical strategy

Following Jordà (2005) we run the following Local Projection (LP) regression

$$\ln y_{i,t+h} - \ln y_{i,t-1} = \alpha_{i,t} + \beta_{i,h} MPS_t + \sum_{l=1}^{L} \phi_{x,l} \mathbf{x}_{t-l} + \mu_{i,t} \tag{1}$$

in which $y_{i,t+h}$ is the price of commodity i at time $t+h$, for $h = 0, 1, \ldots, 24$. The variable MPS_t is the monetary policy shock, measured in basis points of futures' rates, around a 30-min window of the monetary policy announcement.[4] The vector x_{t-l} includes the l^{th} lag

[4]For the US, Jarociński and Karadi (2020) obtain the 1st principal component of the surprises in interest

of $\ln y_{i,t} - \ln y_{i,t-1}$ and the shock, MPS_t, with $L = 12$. Our sample for the US covers the business days for the period 1990M2-2019M5, while the ECB data covers the business days in the period 1999M1-2020M6.

3.3 United States: US monetary policy shocks

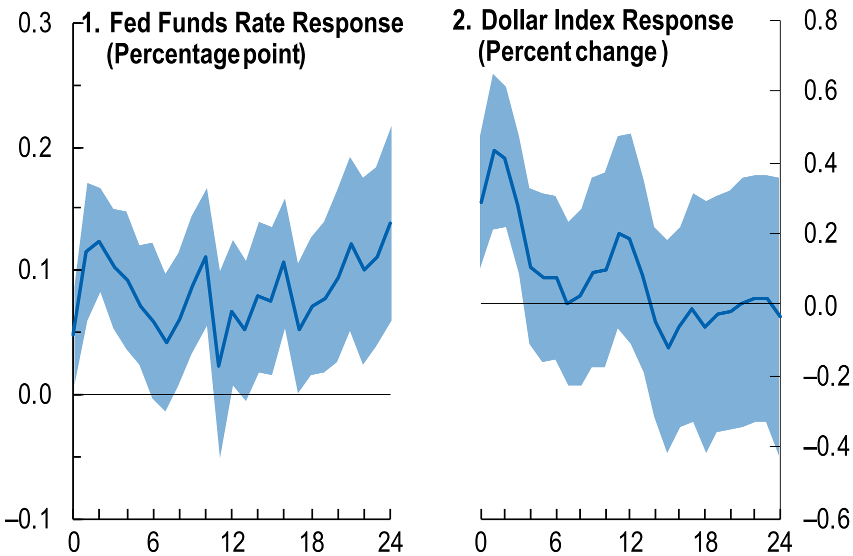
Before looking at commodity prices, we present the responses of the fed funds and the US dollar to a typical US monetary policy shock. Figure 2 depicts the impulse response function of a US monetary policy shock on the Fed Fund Rate (FFR) and the dollar exchange rate index (DXY). We can see that the shock has the expected effect on the Feds Fund Rate (left panel). On impact, a 10 basis points shock increases the Fed Fund Rate by 0.1 percentage points (10 basis points). The effect is persistent throughout the month. The dollar index also appreciates as expected with a peak response of 0.4% after 2 business days, however, the effect vanishes after a week (Figure 2, right panel).

We now report the peak response of commodity prices sub-indexes to a 10 basis points increase in US monetary policy. Figure 3 shows that base metals and energy commodities are the most responsive commodity prices. After a 10 basis points increase in the Fed Funds Rate, base metal prices decline 2.5% (after 18 business days), and energy commodities (WTI and Brent oil prices) decline by 2% (after 21 business days). Other commodities such as cotton and rubber, beverages, precious metals, and cereals also show significant declines. The correlation between the US dollar and commodity prices conditional to a monetary policy shock is, thus, in general, negative.[5]

rate derivatives with maturities from 1 month to 1 year (MP1, FF4, ED2, ED3, ED4, in their paper). The S&P500 is used to construct the shocks. For the ECB shocks, the authors obtain the 1st principal component of the Monetary Event-window changes in overnight index swaps (OIS) with maturities 1-, 3-, 6-months and 1-year (Identifiers: OIS1M, OIS3M, OIS6M, OIS1Y). The Euro Stoxx 50 is used to construct the shocks.

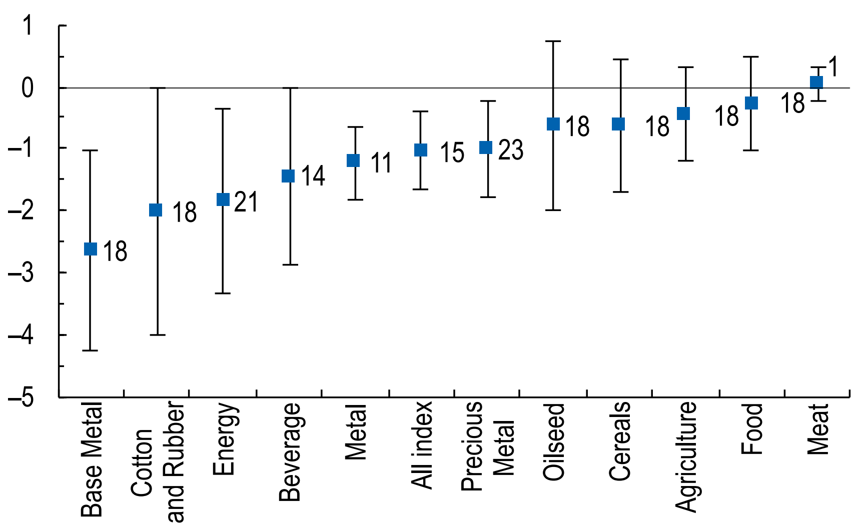
[5]The negative correlation between commodity prices and the US dollar is robust to choosing a more recent subsamples.

Figure 2. Impulse response of Fed Funds Rate and Dollar Index to a US monetary policy shock



Note: This figure reports the 24-day (x-axis) response of the Fed Funds rate (left panel) and dollar index (right) to a 10 basis points shock (increase) to the US monetary policy rate. The blue area represents 90% confidence bands, calculated using robust standard errors at each horizon.

Figure 3. Peak response of commodity price sub-indexes to a 10bp increase in Fed funds rate.



Note: 90% confidence bands reported. The numbers by the box indicate the day (h) of the peak response.

In Figure A1 of the Appendix we show the commodity-specific response to a broader set of commodity prices. We observe that a large fraction of commodity prices decline after a US monetary tightening. For example, the prices of coffee, sugar, wheat, and milk display a peak decline of 2.5%, 2.3%, 1.5%, 1.3%, respectively. All these responses are larger than the exchange rate responses, which implies that commodity prices overshoot, due to the channels emphasized above. In particular, as expected, more storable and industrial commodities are the most responsive. The response of gold prices sets a floor for storable metals, regarding the cost of carry channel. Therefore, the differential between base metals or oil and gold indicates the strength of the expected demand and investment channel.

In our Appendix Figure A5 we plot the response of daily commodity inventories for a sub sample of energy and base metal commodities for which we have daily information since 2016. While the responses are not precisely estimated we observe that, consistent with the price responses, base metals display a larger decline inventories after the monetary policy tightening. Hence, while real economic conditions do not respond immediately, the rise in the opportunity cost of storing commodities appears to operate in the direction and in the magnitude we expect.

3.3.1 The case of Natural Gas

The response of natural gas prices deserves special attention. The Henry Hub price in Figure A1 of our Appendix shows no response to US monetary policy shocks.[6] However, the natural gas market in the US went through important structural changes in the last decade as shale gas production increased dramatically and found its export markets as liquefied natural gas

[6]Henry Hub is a crucial benchmark and distribution point for natural gas in the United States. It is physically located in Erath, Louisiana, where several interstate and intrastate natural gas pipelines converge. The Henry Hub serves as a pricing reference point for natural gas futures and spot contracts traded on the New York Mercantile Exchange (NYMEX) and for LNG contracts.

(LNG). This has increased its storability and integration in the global LNG market increasing its co-movement with other gas prices.[7] Contrary to the whole sample, over the sample period 2016-2019 Henry Hub prices respond significantly to US monetary policy shocks. Indeed, Figure A2 in our Appendix shows that for the sample 2016-2019 Henry Hub prices are the most responsive commodity price to US monetary policy shocks.

3.4 Europe: ECB monetary policy shocks

Here we estimate the impact of ECB monetary policy shocks, estimated by Jarociński and Karadi (2020), on commodity prices. As additional control in the specification (1) we add 24 business days lags of the one-year US bond yield to control for US monetary policy stance. Figure 4 presents the results for the 9 subindexes. The effects on oil prices are like those documented for the US but less precisely estimated. However, we find no effect on base metals, raw materials, and cereals. The results for disaggregated commodity prices (Figure A4 in the Appendix) provide a similar conclusion. In general, ECB shocks have negative effects on commodity prices, but the responses are not refsely estimated.[8] [9]

4 The Commodity-Price Channel of US Monetary Policy

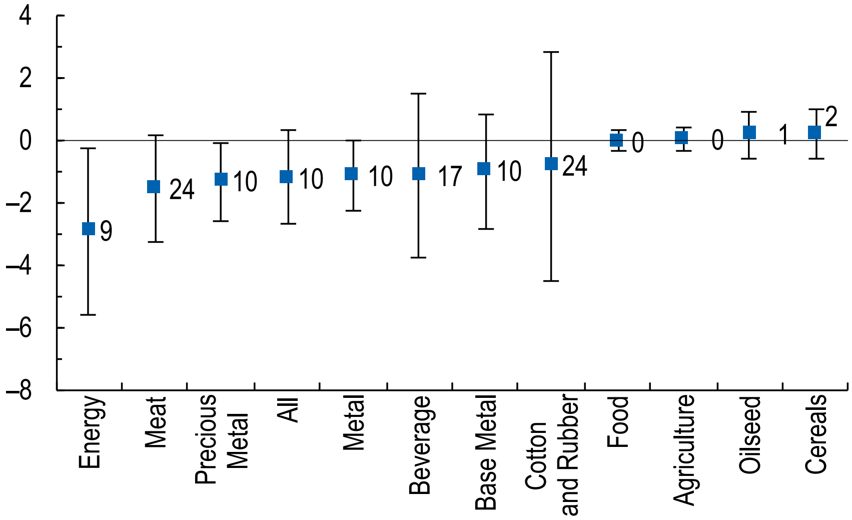
Having documented the importance of major central banks monetary policy in driving commodity prices, we now study the spillbacks and spillovers of US monetary policy on inflation.

[7]During the energy crisis in Europe in 2021-22, US LNG exports hit their capacity limit temporarily isolating US natural gas prices from international gas prices.

[8]In Figure A3 we show the responses of commodity prices to US monetary policy for a comparable sample, 1999-2019. There is a slight change in the ranking but the results stay the same. US monetary policy has larger and more precise effects on a wide range of commodity prices.

[9]In Figure A9 we show the effects of UK monetary policy shocks, estimated by Cesa-Bianchi et al. (2020), on commodity prices. Responses are small and not statistically significant.

Figure 4. Peak response of commodity price sub-indexes to a 10bp increase in ECB funds rate.



Note: 90% confidence bands reported. The numbers by the box indicate the day (h) of the peak response.

4.1 Proxy-SVAR

This section identifies the spillbacks effects of different commodity prices on the US (and other countries) prices after a monetary policy shock by employing a Proxy-SVAR. In particular, we consider the following structural SVAR:

$$A_0 Y_t = \sum_{j=1}^{p} A_j Y_{t-j} + B\varepsilon_t$$

Where Y_t is a vector containing n variables of interest, ε_t is a vector of unobservable zero mean white noise processes or structural shocks (with a diagonal variance and covariance matrix), A_j is the dynamic matrix, and B contains the coefficients with the impact effects of the structural shocks to the variables of interest. The structural SVAR above admits the following reduced form representation:

$$Y_t = \sum_{j=1}^{p} D_j Y_{t-j} + \mu_t$$

Where μ_t is a vector with the reduced-form residuals or innovations of the system $\mu_t = A_0^{-1} B \varepsilon_t$ and $D_j = A_0^{-1} A_j$. We focus on the identification of a monetary policy shock and, following a vast part of the literature, we use an instrument (a variable that is external to the VAR) to identify a particular structural shock. A key element for this strategy is that the instrument has to be correlated with the shock of interest and uncorrelated with other structural shocks, i.e.,

$$\begin{aligned} E[\epsilon_t^{MP}, z_t^{'}] &\neq 0 \\ E[\epsilon_t^{others}, z_t^{'}] &= 0 \end{aligned}$$

In addition to the monetary policy instrument, our baseline specification considers seven macroeconomic variables: one-year treasury bill yield, the US headline Consumer Price Index (CPI), US core CPI, US industrial production (IP), the excess bond premium (EBP), the WTI Oil price, the Food Price Index, or the Base Metals Price Index.[10] In our Appendix, we show that similar results hold for an augmented model that also includes a global IP index and the USD dollar index. The data span from 1990m1 to 2019m5. The pure monetary policy shock that we use as an instrument is by construction associated with monetary policy surprises and orthogonal to any other structural shocks. Then, we employ the two-stage

[10]We use the *pure* monetary policy shock identified by Jarociński and Karadi (2020), which cleans the monetary policy surprises associated with positive stock market comovement. Our monthly commodity prices are end-of-the-month futures prices.

traditional procedure to identify the impact effects of the monetary policy shock on all the macroeconomic variables. In the first stage, we regress the monetary policy surprise (our instrument) on the reduced-form VAR innovation for the one-year treasury bill. This step allows us to identify the impact effect of the monetary policy shock on the interest rate. The second stage regresses the predicted value from the first stage regression on the remaining VAR innovations. The coefficients from these regressions identify, up to a scaling factor, the impact coefficients of the matrix B, that shapes the effects of a structural monetary policy shock. Once we have identified the impact effects of the monetary policy shock, we compute the impulse response functions in a traditional way for the monetary policy shock (e.g., in position i), where:

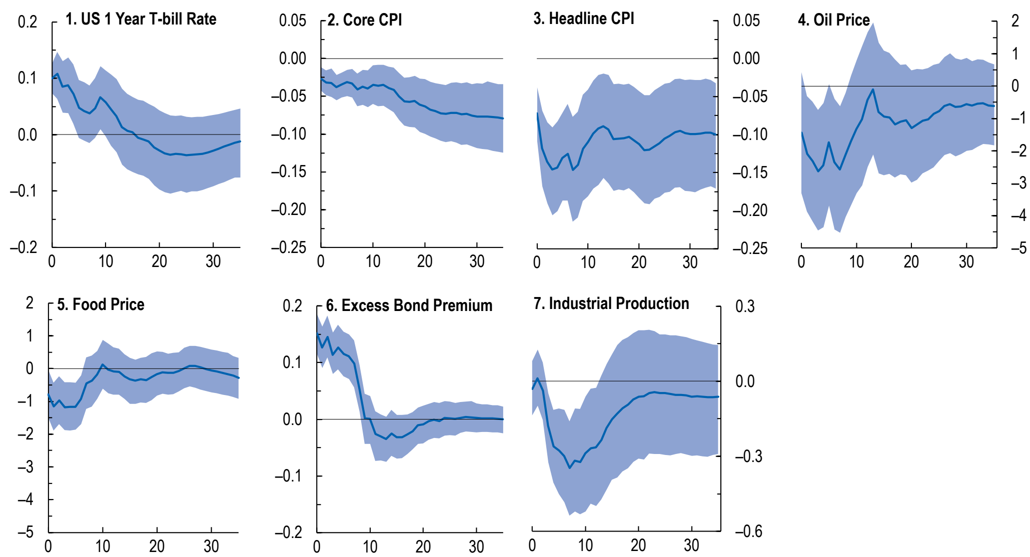
$$IR_t = (A_0^{-1}B)_i \quad \text{for} \quad t = 0$$

$$IR_t = \boldsymbol{D} \cdot \boldsymbol{IR}_{t-1} \quad \text{for} \quad t = 1, 2, \ldots, H$$

where (B_i is)the i-th column of the impact matrix B. Figure 5 reports the IRF of our proxy-SVAR. A 10 basis point increase in the US Federal Funds Rate induces a decline in oil prices of 2 percent on impact and the effect persists for 8 months. Food prices decline by 1 percent and the effect is less persistent. The observed decline in oil prices is similar to the one observed in the high-frequency local projection analysis (≈ 2% decline). Similarly, the effect on food prices—which include wheat, sugar, rice, and oranges, among others— is smaller in magnitude (around 1% decline). Later, we also study the response of copper price (see Figure 7). Consistent with the high-frequency estimation in which base metals are the most responsive group of commodities. A 10 bps increase in the fed funds rate reduces copper price by 6% after two months, with the effect vanishing after ten months.

The responses of headline CPI and IP are in line with the textbook implications of a monetary policy tightening. On impact, the one-year treasury bill increases, headline inflation declines, and industrial production and core inflation take about a year to display a more significant decline. We also observe significant impact effects on the excess bond premium. Similar results hold for an augmented proxy-SVAR that includes the USD dollar index and a global IP index (see Figure A6 in our Appendix).

Figure 5. Impulse response to US monetary policy using proxy-SVAR.



Note: The x-axis denotes months after the shock. The grey area denotes 68% confidence bands

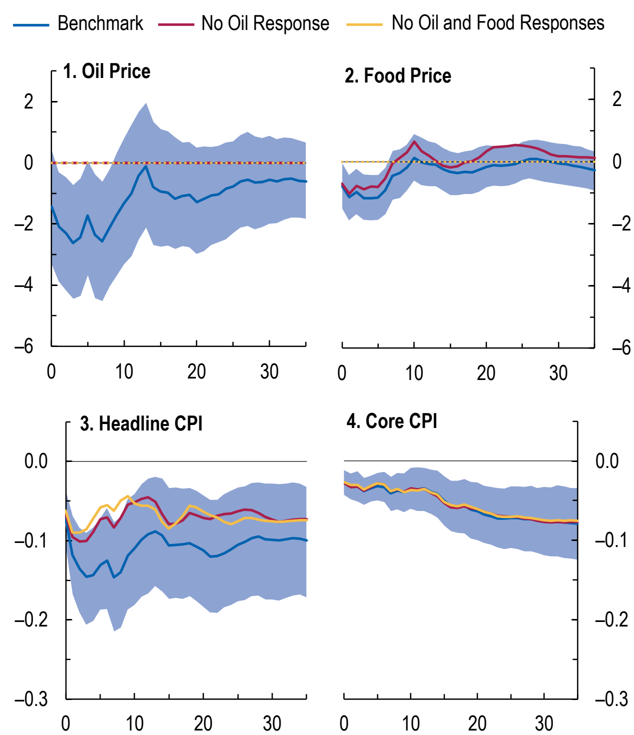
4.2 Commodity-price channel of US monetary policy

4.2.1 The case of oil and food prices

To quantify the contribution of the oil (and food) prices in the effect monetary policy shocks on inflation, we follow Bernanke, Gertler, and Watson (1997), and perform a decomposition exercise where we shut off the response of oil (and food) prices to the monetary policy shock at all times. We achieve this exercise by setting the coefficients of the oil price equation to zero.[11]

Figure 6 depicts the results from our decomposition. First, we shut down the commodity-price channel of oil and food. Clearly, US monetary policy has now smaller effects on the CPI. Absent oil and food prices responses, headline CPI would have declined by 0.07 percentage points rather than by 0.12 percentage points in the first semester.

Figure 6. The commodity-price channel: the role of oil and food



Note: The blue line represents the benchmark estimation. The red lines show the responses of inflation under the assumption that oil prices do not react to monetary policy shocks. The yellow line shows the response of inflation under the assumption that oil and food prices do not react to monetary policy.

[11]This strategy is equivalent to add an oil-specific shock that can affect the other variables in the SVAR (i.e., CPI, Core CPI, IP, the US exchange rate and the EBP) only through oil prices and use it to offset any effect on oil prices. Similarly, an additional shock would need to be added for food prices.

The contribution is similar for the first year but it declines over time, as core inflation becomes the main driver (see panel 4). Oil prices have a dominant role since oil prices affect food prices but not vice versa.

We observe no effect of oil and food commodity prices on core inflation. There are two potential reasons for this. First, the decline in their prices is mild and not highly persistent. There is a 1-2% reduction in oil and food prices that lasts 8-10 months, while the decline in core inflation is mainly observed after a year. Second, in terms of the exposure to final demand, oil and food are mainly non-durable commodities. Oil is burned and food is eaten within a year, which together with the relatively mild persistence in the commodity price decline yields to small effects on core inflation passed a year after the shock.

4.2.2 The importance of base metals

Here we focus on the role of base metals. First, as seen in the high frequency analysis, the most responsive commodity price index to US monetary policy shocks is the base metal index. Second, unlike oil and food, base metals have a crucial role in the production and investment network of the United States (Vom Lehn and Winberry, 2022). In particular, not only base metals are key suppliers of the investment hubs but the investment hubs are also the main clients demanding base metals. Thus, changes in investment, inevitably have a large impact on base metals' prices, which then feeds back to final demand via the cost of investment.

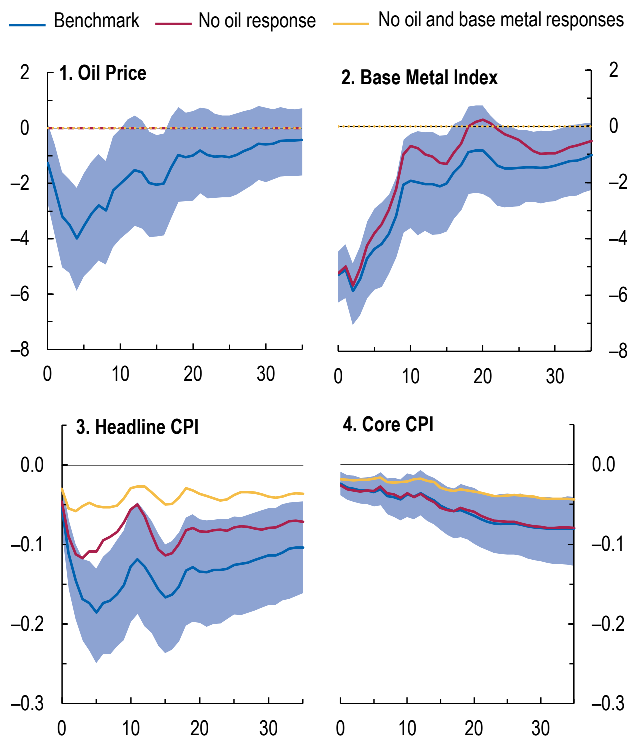
Indeed, as we observe in panel 2 of Figure 7 base metal prices decline substantially during the first six months and continue below their pre-shock level for more than a year (15 months). This reduction in base metal prices is larger and more persistent than that observed for oil and food. Panels 3 and 4 of Figure 7 show the importance of the base metal price channel on headline and core inflation. The relative importance of base metal prices on headline CPI is larger than that of food prices. Moreover, unlike the case of oil and food prices, base metal prices have significant effects on core inflation. One reason for this difference is the larger and more persistent decline in base metals prices. In addition, two additional factors could strengthen the impact of copper prices on core inflation. First, in non-reported results we observe that when base metal prices are assumed constant, the US dollar appreciates significantly less. Therefore, absent the depreciation in foreign currencies there is a smaller decline in commodity demand. Finally, as we can confirm in Figure IV of Vom Lehn and Winberry (2022), primary metals are key suppliers to downstream industries. In fact, once we take into account the fact that primary metals are crucial intermediate input suppliers of the key investment hubs in the US, we should observe that base metals have a stronger transmission to final prices compared to, for example, a price change in oil or food commodities.

5 Cross-country spillovers

Here we investigate the importance of the commodity price channel in accounting for the spillovers of monetary policy on foreign inflation. To this end, we augment the proxy-SVAR including countries' CPI and the bilateral exchange rate between the US and each country. Our main focus is on the effects on headline inflation of oil, base metals, and food prices. However, we also discuss the effects on core CPI for a subsample of countries.

In Figure 8 we report the effects of US monetary policy on countries' CPI (in blue) along with the effect of US monetary policy on countries' CPI absent the commodity-price channel (red) of oil and food prices. As expected, most countries' CPI decline after a US monetary policy tightening. From left to right, we organize the countries based on the size of the CPI decline. For example, over a period of 12 months, a 10 basis point increase in the US

Figure 7. The commodity-price channel: the role of oil and base metals

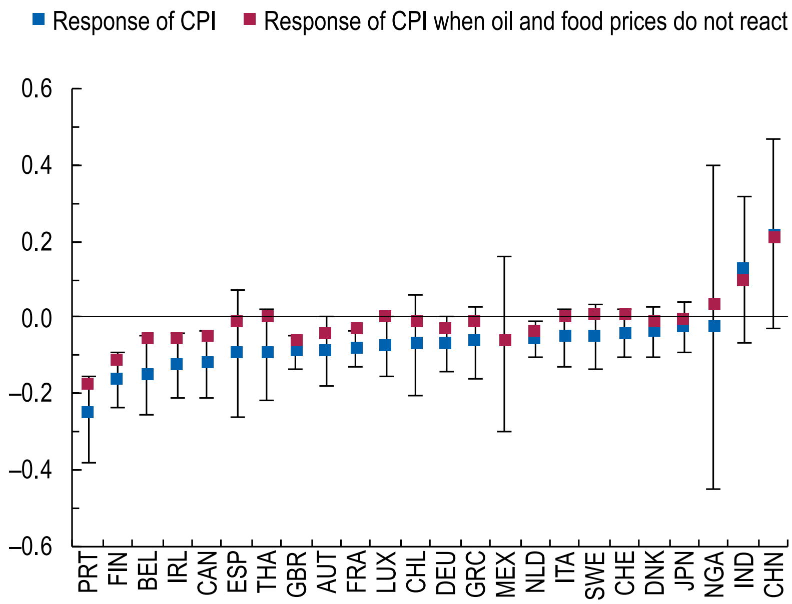


Note: The blue line represents the benchmark estimation. The red lines show the responses of inflation under the assumption that oil prices do not react to monetary policy shocks. The yellow line shows the response of inflation under the assumption that oil and copper prices do not react to monetary policy.

monetary policy rate induces a 0.1% decline in the headline CPI of Spain. Notably, all this effect is mediated by the response of oil and food prices.

In Figure A8 of our Appendix we also show the response of the bilateral exchange rate between the US and each of the countries. As expected, in most countries we observe an appreciation of the US dollar. While these responses are less precisely estimated, the exchange rate channel is an additional channel in which US monetary policy can affect foreign inflation. The exchange rate channel is not independent of the commodity price channel. For instance, take the case of Switzerland, a small open economy commodity exporter. A US monetary policy tightening depreciates the Swiss Franc, but this depreciation is mitigated

Figure 8. 12-month response of US monetary policy on countries inflation (proxy-SVAR): oil and food



Note: Blue square represents the peak response of headline CPI to US monetary policy. 68% confidence bands are displayed. The red square represents the response of CPI assuming commodity prices do not react to monetary policy.

once commodity prices are assumed not to decline in response to US monetary policy.

We also study the commodity price channel of oil and base metal prices. Consistent with the results for the US, Figure A7 in our Appendix shows that base metals prices significantly affect foreign inflation. For example, different from the results in Figure 8, in which oil and food prices reduced the headline CPI response of Portugal from -0.25% to -0.18%, in Figure A7 we observe that, absent the response of oil and base metal prices, Portugal headline CPI declines from -0.31% to -0.08%.

The role of the commodity-price channel is quantitatively important. Table 1 reports the relative importance of the spillbacks of oil and food prices on US inflation, along with the spillovers of oil and food prices on foreign prices.

For the average country, the commodity-price channel accounts for 66 percent of the

Table 1. Contribution of the commodity price channel to headline inflation

		0-6 Months	**0-12 Months**	**12-24 Months**
United States	Benchmark	-0.12%	-0.12%	-0.02%
	No oil	-0.09%	-0.07%	-0.02%
	Contribution	(32%)	(40%)	NA
	No oil, no food	-0.07%	-0.06%	-0.01%
	Contribution	(41%)	(47%)	NA
Other Countries	Benchmark	-0.07%	-0.07%	-0.00%
	No oil	-0.04%	-0.03%	-0.01%
	Contribution	(48%)	(57%)	NA
	No oil, no food	-0.02%	-0.02%	-0.00%
	Contribution	(66%)	(74%)	NA

Note: This table presents the relative importance of the commodity price channel to the total effect of US monetary policy on inflation.

total spillover of US monetary policy on inflation in the first semester. The oil price alone contributes 48 percent. These numbers are 41% and 32%, respectively, for the US (spillbacks). These contributions are even larger over a 12-month horizon but after a year they vanish as core inflation starts driving headline dynamics.

Finally, while we do not have core CPI data for all the countries in our sample, we estimate the commodity-price channel of oil and base metals on core inflation for a subsample of 20 countries. The results show a significant contribution of oil and base metal prices to core inflation. In particular, over a 6 months period and for the average country, the response of oil and food prices accounts for 1.56% of the response of core CPI to US monetary policy. On the other hand, the response of oil and base metal prices accounts for 69% of the response of core CPI to US monetary policy.

Conclusion

Monetary policy has a strong direct effect on commodity prices, especially for industrial and storable commodities such as oil and metals. Spillbacks and spillovers to other countries from US monetary policy shocks are fast. After a 10 bps monetary policy surprise, the decline in oil and food prices over the course of 6 months reduce both domestic and other countries' inflation by 0.05 percent on average. This result implies that the commodity price channel of US monetary policy has relatively larger spillovers to other countries than spillbacks to the US. While the commodity-price channel accounts for 41% of the total decline in US headline CPI (6-month), it accounts for 66% of the total decline in headline CPI for the average country in the sample. Spillovers from US monetary policy shocks tend to be more relevant for consumer prices in other AEs, while the reaction of consumer prices in EMs and also their commodity price channel are less precisely estimated, as EMs tend to have more regulated prices. The commodity channel for core inflation is mainly driven by base metals (i.e., copper). Major central banks should take into consideration their spillback and spillovers through a commodity price channel when setting their policy objectives. Finally, as the Federal Reserve tends to set the tone for the global monetary policy stance, and given that other major central banks such as the ECB can also affect commodity prices, the commodity price channel could be strengthened in periods of high monetary policy coordination.

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Appendix

5.1 The commodity-price channel decomposition

To isolate the contributions from commodity prices, we have adopted the following method in the spirit of Bernanke et al. (1997). Differently from their case, however, this is not a policy experiment. We are not after a structural change in the relation between commodity prices and the rest of the economy (which would be severely subject to the Lucas' critique), but a decomposition of the inflation response. The question is what would have been the response of inflation if oil (and food) prices had not moved?[12]

To illustrate the approach here we abstract from the identification of the monetary policy shock which we achieve using a proxy-SVAR. To make a more specific example, assume there are three variables, where x is the fed funds rate (ε_1 is the monetary policy shock), y is commodity price, and and z is a set of other variables, for example, IP and CPI.

$$\underbrace{\begin{bmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{bmatrix}}_{A_0} \begin{bmatrix} x_t \\ y_t \\ z_t \end{bmatrix} = \sum_{j=1}^{p} A_j \begin{bmatrix} x_{t-1} \\ y_{t-1} \\ z_{t-1} \end{bmatrix} + B_0 \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix}$$

We can rewrite the system as

[12] This question could also be answered by finding a series of oil-specific shocks (e.g., oil supply shocks) that can be used to stabilize oil prices and do not directly affect other variables in the SVAR, but only through commodity prices. This, however, would require additional identifying restrictions.

$$\begin{bmatrix} x_t \\ y_t \\ z_t \end{bmatrix} = \sum_{j=1}^{p} \underbrace{A_0^{-1} A_j}_{D_j} \begin{bmatrix} x_{t-1} \\ y_{t-1} \\ z_{t-1} \end{bmatrix} + \underbrace{A_0^{-1} B_0}_{B} \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix}.$$

Our decomposition below imposes that commodity price y does not react contemporaneously to $\epsilon_{1,t}$ and it does not respond to the dynamic effects from lags of x, y, z either. In particular, we have

$$\begin{bmatrix} x_t \\ y_t \\ z_t \end{bmatrix} = \sum_{j=1}^{p} \begin{bmatrix} d_{1,1} & d_{1,2} & d_{1,3} \\ 0 & 0 & 0 \\ d_{3,1} & d_{3,2} & d_{3,3} \end{bmatrix} \begin{bmatrix} x_{t-j} \\ y_{t-j} \\ z_{t-j} \end{bmatrix} + \begin{bmatrix} b_{1,1} & b_{2,1} & b_{1,3} \\ 0 & b_{2,2} & b_{2,3} \\ b_{3,1} & b_{3,2} & b_{3,3} \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix}$$

Tracing the effects of a shock to ε_1 would, thus, work only through its direct effect on x and z and the internal dynamics through lags in z and x.

5.2 Additional Tables

Commodity prices used in the whole sample high-frequency analysis are shown in Table A1 their weights in the construction of sub-indices in Table tab:weights.

Table A1. Commodities, units, and trading volumes

Commodity Name	Exchange	Unit	Trading Volume
Arabica coffee	ICE Futures US Softs	USD/lb.	4,096,534
Brent Crude Oil	ICE Futures Europe Commodities	USD/bbl.	64,355,775
Class III Milk	Chicago Mercantile Exchange	USD/cwt	46,951
Cocoa	ICE Futures US Softs	USD/MT	2,995,523
Copper	Commodity Exchange, Inc.	USD/lb.	10,342,374
Copper	London Metal Exchange	USD/MT	4,396,941
Corn	Chicago Board of Trade	USD/bu.	37,904,454
Cotton	ICE Futures US Softs	USD/lb.	2,574,415
Feeder Cattle	Chicago Mercantile Exchange	USD/lb.	765,089
Frozen Concentrate Orange Juice	ICE Futures US Softs	USD/lb.	206,598
Gasoline	New York Mercantile Exchange	USD/gal.	14,036,792
Gold	Commodity Exchange, Inc.	USD/t oz.	31,960,854
Hard Red Winter Wheat	Chicago Board of Trade	USD/bu.	5,829,377
Heating Oil	New York Mercantile Exchange	USD/gal.	11,822,198
Henry Hub Natural Gas	New York Mercantile Exchange	USD/MMBtu	35,657,120
Lead	London Metal Exchange	USD/MT	1,029,971
Lean Hogs	Chicago Mercantile Exchange	USD/lb.	3,294,821
Live Cattle	Chicago Mercantile Exchange	USD/lb.	3,518,903
Low Sulphur Gas Oil	ICE Futures Europe Commodities	USD/MT	14,113,332
Newcastle Coal	ICE Futures Europe Commodities	USD/MT	7,058
Nickel	London Metal Exchange	USD/MT	2,506,100
Oats	Chicago Board of Trade	USD/bu.	81,026
Palladium	New York Mercantile Exchange	USD/t oz.	747,480
Platinum	New York Mercantile Exchange	USD/t oz.	3,533,576
Richards Bay Coal	ICE Futures Europe Commodities	USD/MT	6,278
Robusta Coffee	ICE Futures Europe Commodities	USD/MT	1,119,074
Rotterdam Coal	ICE Futures Europe Commodities	USD/MT	11,553
Rough Rice	Chicago Board of Trade	USD/cwt	131,613
Primary Aluminum	London Metal Exchange	USD/MT	7,549,365
Silver	Commodity Exchange, Inc.	USD/t oz.	12,409,386
Soybean	Chicago Board of Trade	USD/bu.	18,607,309
Soybean Meal	Chicago Board of Trade	USD/T.	8,328,540
Soybean Oil	Chicago Board of Trade	USD/lb.	8,709,643
Sugar No.11	ICE Futures US Softs	USD/lb.	16,502,918
Sugar No.16	ICE Futures US Softs	USD/lb.	37,125
Tin	London Metal Exchange	USD/MT	144,824
Wheat	Chicago Board of Trade	USD/bu.	11,920,664
WTI Crude Oil	New York Mercantile Exchange	USD/bbl.	147,772,482
Zinc	London Metal Exchange	USD/MT	2,691,901

Note: Average daily trading value in 2019

Table A2. Commodities weights in indexes

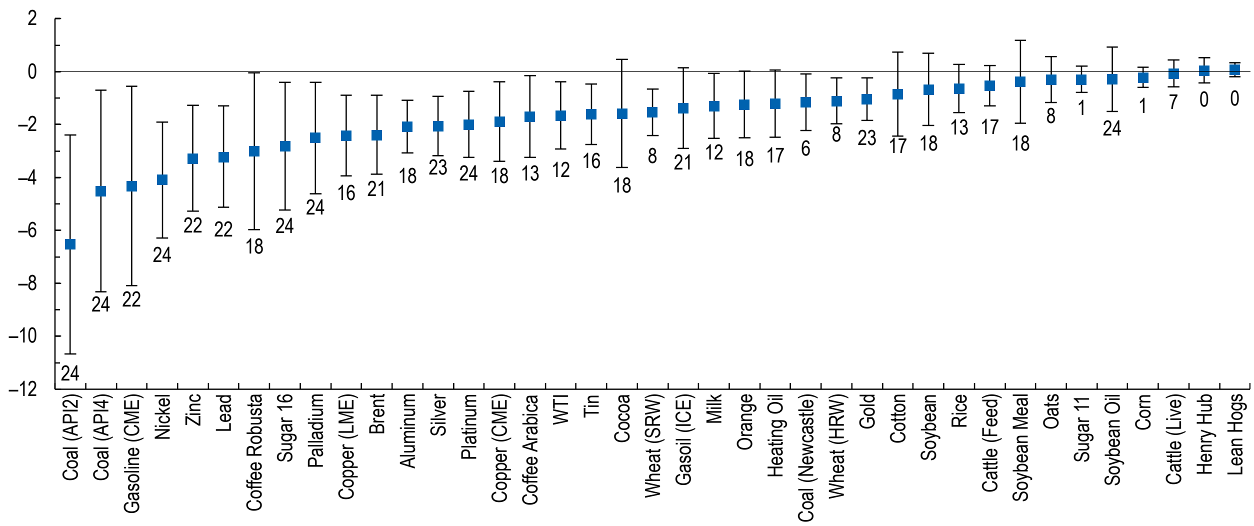
Commodity	All	Agriculture	Energy	Metal	Food	Base Metal	Beverage	Precious Metal	Soft	Cereal	Meat	Vegatable Oil
Aluminum	3.1%			8.9%		23.9%						
Beef	4.0%	14.4%			18.2%						57.6%	
Brent Crude	18.4%		50.0%									
Cocoa	1.2%	4.5%					46.1%					
Coffee Arabica	1.4%	5.2%					53.9%					
Copper	6.5%			18.4%		49.6%						
Corn	2.1%	7.6%			9.6%					34.8%		
Cotton	1.6%	5.7%							51.7%			
Gold	19.7%			55.4%				87.9%				
Lead	0.7%			2.0%		5.3%						
Nickel	1.3%			3.7%		10.1%						
Oats	0.1%	0.4%			0.5%					1.7%		
Orange	2.1%	7.5%			9.5%							
Palladium	0.6%			1.6%				2.6%				
Platinum	0.8%			2.4%				3.8%				
Rice	1.2%	4.2%			5.3%					19.1%		
Rubber	1.5%	5.4%							48.3%			
Silver	1.3%			3.6%				5.7%				
Soybeans	3.6%	13.0%			16.4%							85.8%
Soybeans Oil	0.6%	2.1%			2.7%							14.2%
Sugar No. 11	2.7%	9.7%			12.2%							
Swine	2.9%	10.6%			13.4%						42.4%	
Tin	0.3%			0.9%		2.4%						
Wheat	2.7%	9.7%			12.3%					44.4%		
WTI Crude	18.4%		50.0%									
Zinc	1.1%			3.2%		8.6%						

Note: this table presents the list of commodity prices that cover the whole sample period (1990-2019).

5.3 Testing independence across central banks

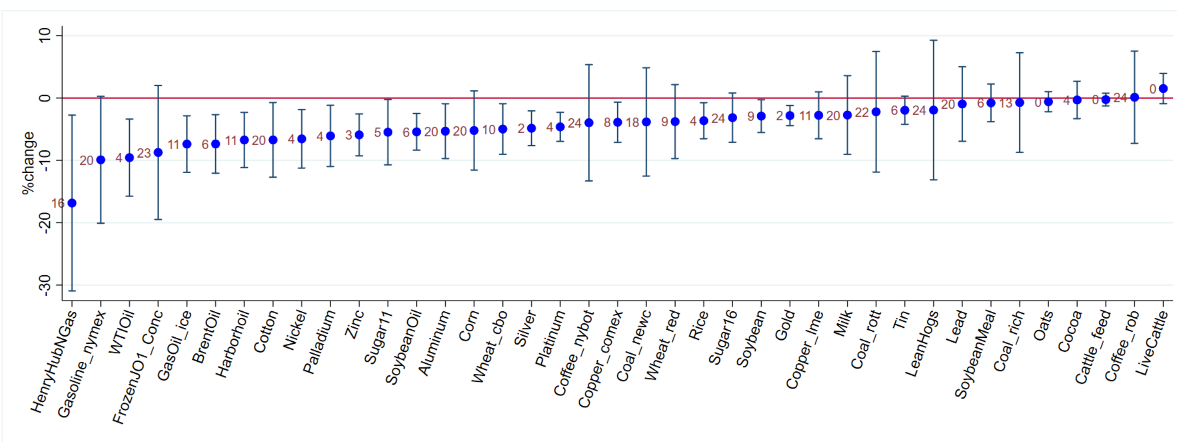
To test the hypothesis that monetary policy shocks in one country do not Granger-cause central bank decisions of another country, we run a series of pairwise Granger tests. We test for causality in both directions. In a regression of current values of a given shock (x) on its own lags and on the lags of another monetary policy shocks (y), rejecting the null hypothesis that coefficients on the lags of y are jointly zero provides evidence that y precedes - Granger causes - x. We focus on US, Canada, Japan and the ECB. Some of the pairwise tests do not reject the null of no Granger causality, although in three cases we find that monetary policy decisions of one central bank - ECB, US, US - have affected decisions of another monetary

Figure A1. Peak cumulative response of commodity prices to a 10bp increase in Fed funds rate.



Note: 90% confidence bands reported. The numbers next to the box represent the day of the peak response.

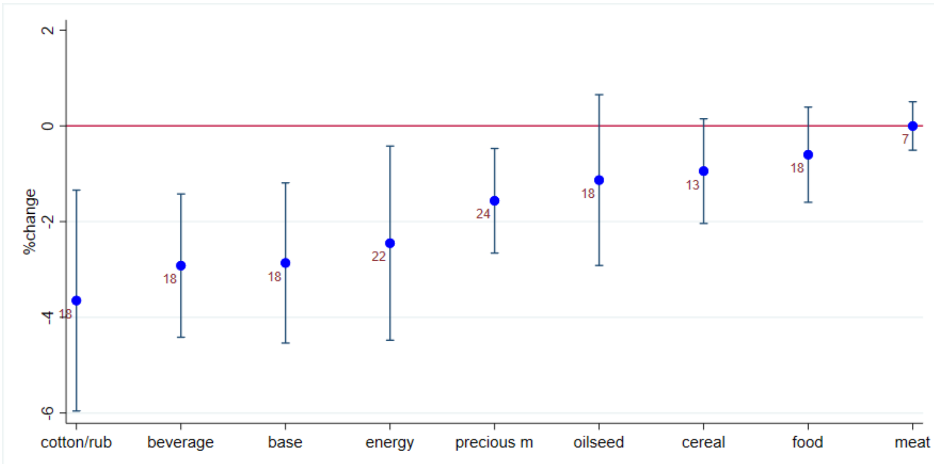
Figure A2. Peak cumulative response of commodity prices to a 10bp increase in Fed funds rate (2016-2019).



Note: 90% confidence bands reported. The numbers next to the box represent the day of the peak response.

authority - US, ECB, UK - respectively. In the case of US and European monetary authority decisions, the influence is mutual and Granger causality runs both ways.

Figure A3. Peak cumulative response of commodity prices to a 10bp increase in US rate: 1999-2019.



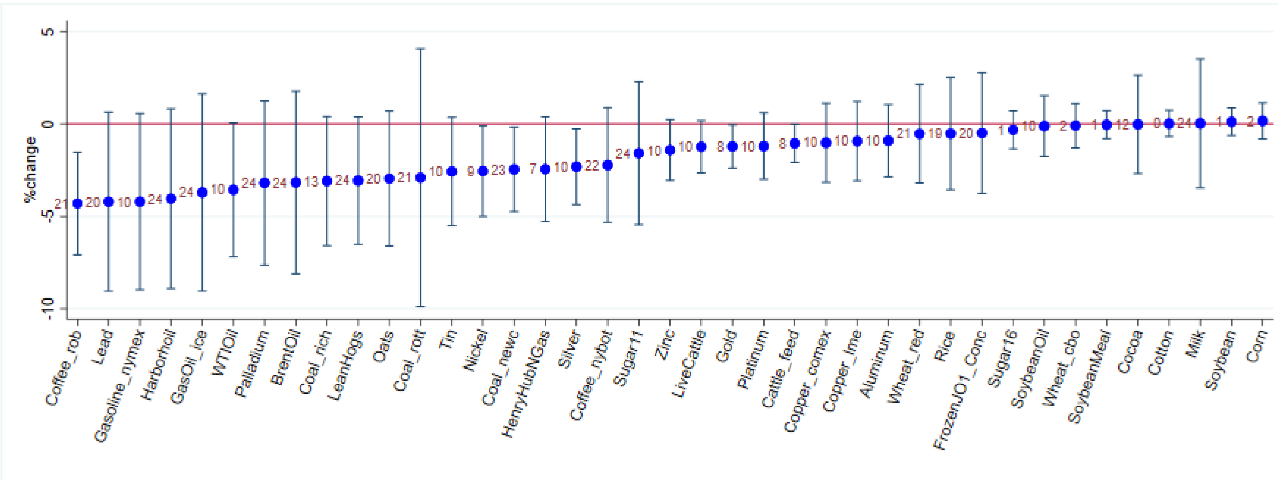
Note: 90% confidence bands reported. The numbers next to the box represent the day of the peak response.

Table A3. Granger test results

Equation	Controls	Prob >chi2
US	Canada	0.109
Canada	US	0.267
US	Japan	0.658
Japan	US	0.374
US	ECB	0.012
ECB	US	0.029
US	UK	0.093
UK	US	0.007

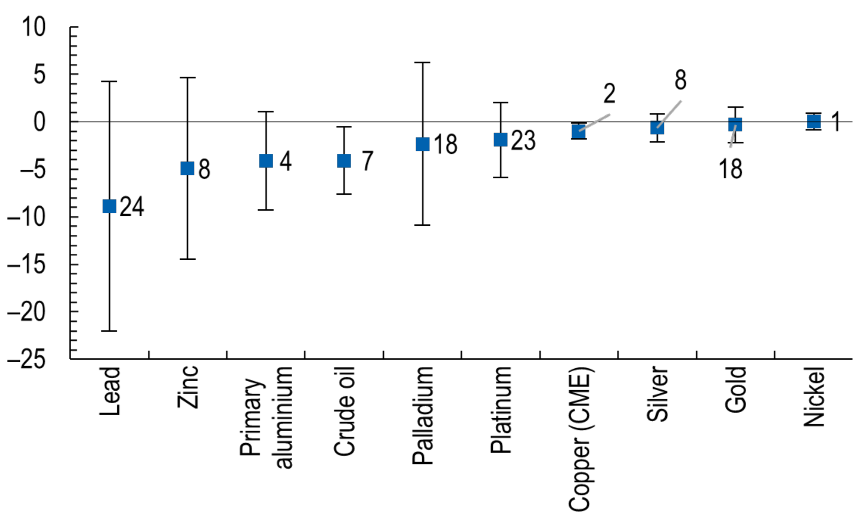
Note: The third column shows the p value of a Wald test of the null hypothesis that the coefficients of the lagged values of the controls are jointly zero.

Figure A4. Peak cumulative response of commodity prices to a 10bp increase in ECB rate.



Note: 90% confidence bands reported. The numbers next to the box represent the day of the peak response.

Figure A5. Peak response of commodity inventories to a 10bp increase in Fed funds rate.



Note: 90% confidence bands reported. The numbers by the box indicate the day (h) of the peak response.

Figure A6. IRF to a 10 bps shock to US monetary policy: extra controls

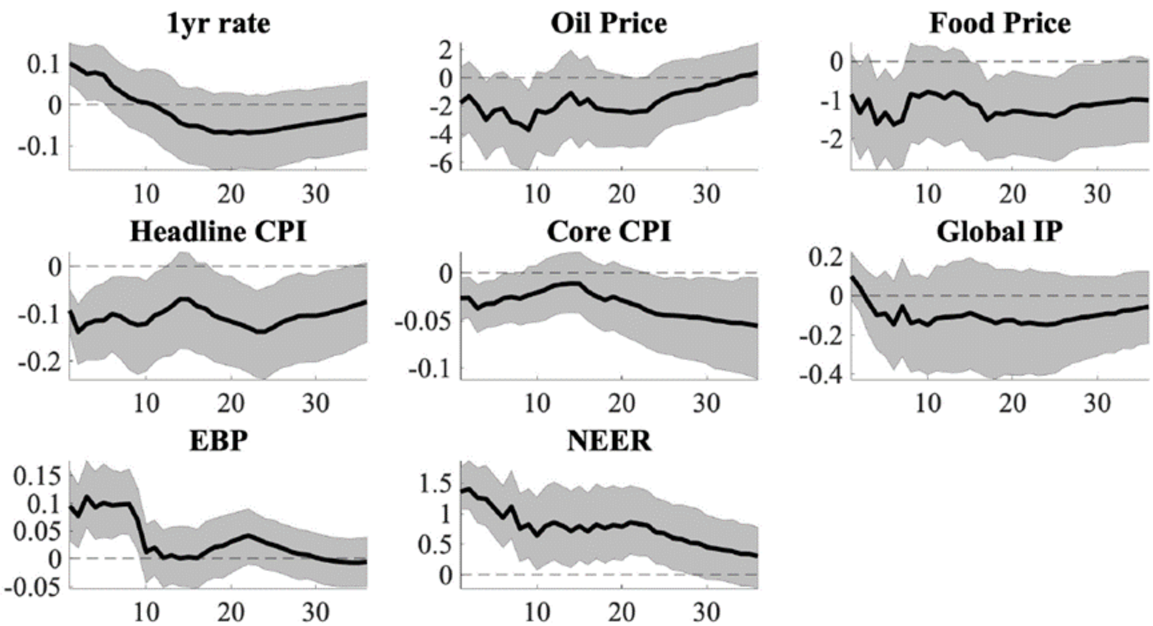
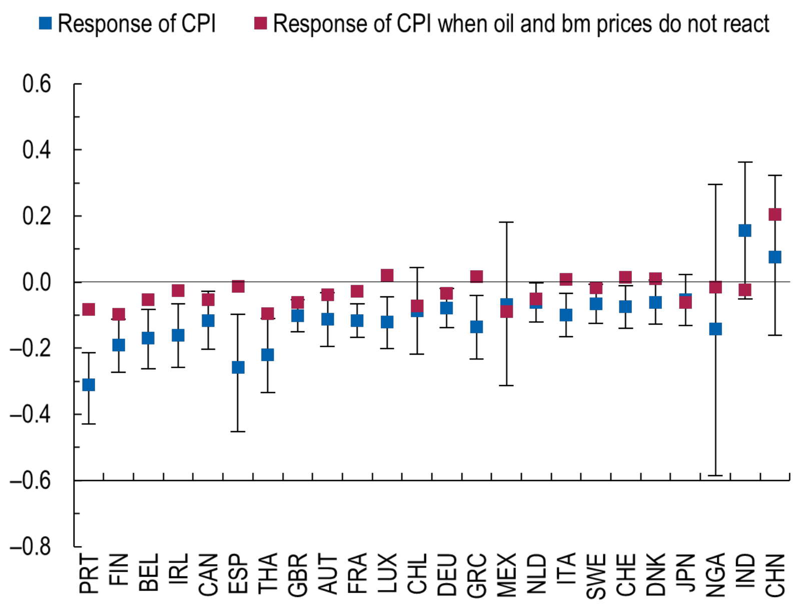
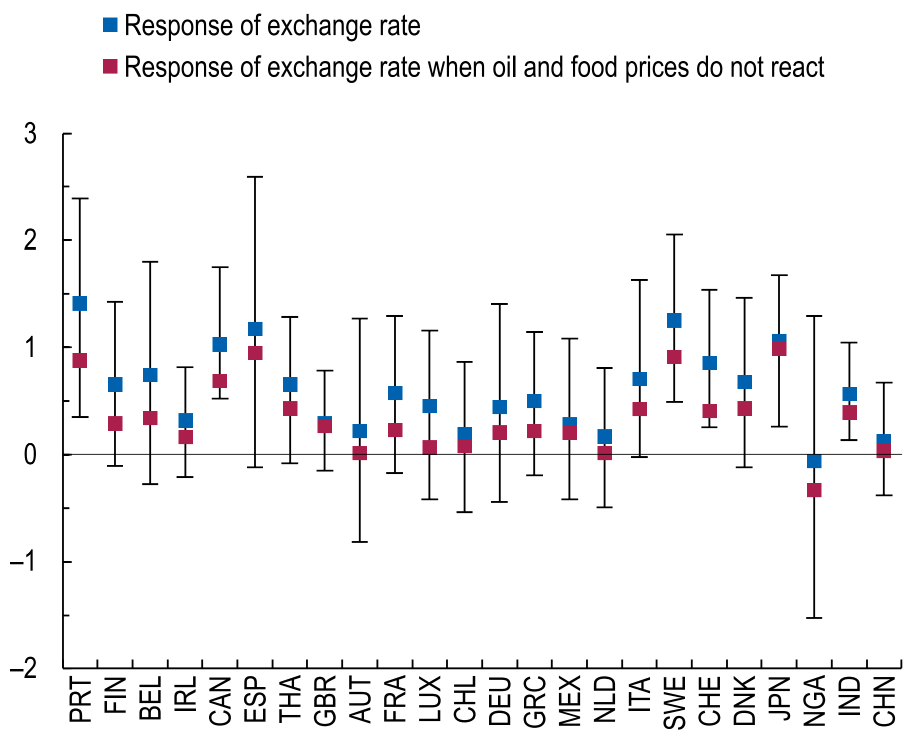


Figure A7. 12-month response of US monetary policy on countries inflation (proxy-SVAR): oil and base metals



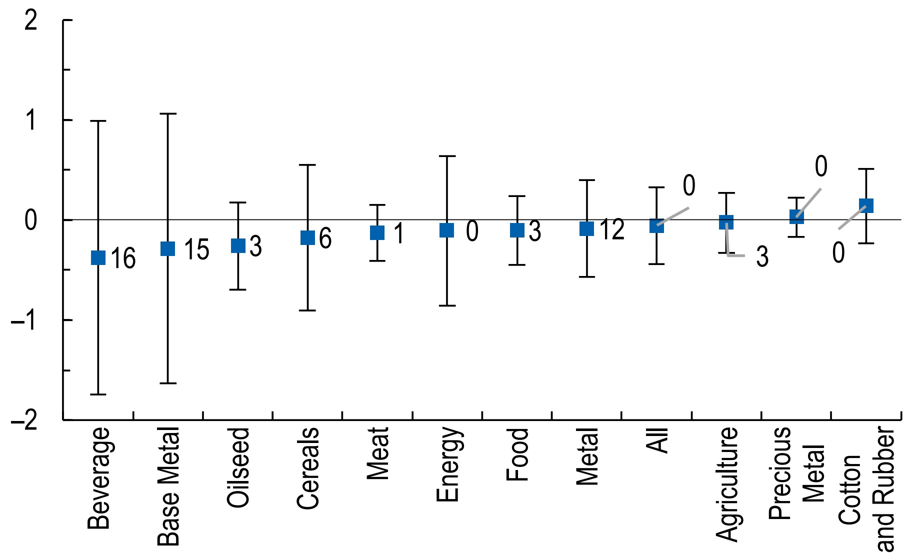
Note: Blue square represents the peak response of headline CPI to US monetary policy. 68% confidence bands are displayed. The red square represents the response of CPI assuming commodity prices (oil and base metals) do not react to monetary policy.

Figure A8. 12-month effect of US monetary policy on countries exchange rate (proxy-SVAR): oil and food



Note: Blue and red squares are the average one year response of exchange rate after an increase of 10 basis points in the US interest rate. 68 percent confidence intervals are displayed.

Figure A9. Peak response of commodity price sub-indexes to a 10bp increase in UK interest rate



Note: 90 % confidence bands are reported. The sample period is 1990 to 2014. The numbers by the box indicate the day (h) of the peak response.