Intervening Against the Fed*

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Abstract

This paper studies the effectiveness and mechanism of foreign exchange interventions (FXIs) for mitigating US monetary policy spillovers. For identification, we combine deviations from a daily FXI policy rule with high-frequency US monetary policy shocks, daily exchange rates, firm-level stock prices, and firm-level balance sheet variables across multiple countries. We first present evidence that, without interventions, contractionary US monetary policy shocks spill over through a balance sheet channel: foreign exchange rates depreciate and stock prices fall, driven by those firms with US dollar debt. However, when countries counter-intervene, the spillover of a US monetary policy tightening is muted. FXIs entirely offset the depreciation of the domestic exchange rate and the reduction in stock prices for firms with US dollar debt, suggesting that "intervening against the Fed" protects economies from the adverse spillovers of US monetary policy tightening via the balance sheet channel of exchange rates.

Keywords: Foreign Exchange Interventions, Monetary Policy Spillovers, Balance Sheet Channel, Exchange Rates, Dollar Debt

JEL Classification Codes: E44, E52, F31, F32, F41

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1 Introduction

The Federal Reserve is an important driver of the "Global Financial Cycle" and changes in US monetary policy can have major spillovers to the global economy. When the Fed tightens monetary policy, the US dollar appreciates, and global stock prices as well as credit decline (Rey 2015, Miranda-Agrippino and Rey 2020, Gürkaynak et al. 2021). Although both academics and policymakers have signaled the first-order importance of how countries could protect themselves against this unexpected tightening of monetary policy, there is limited consensus on the effectiveness of different measures.

Foreign exchange interventions (FXIs) are one increasingly popular policy tool among central banks to try to insulate themselves from those spillovers. For instance, on September 21, 2022, the Federal Open Market Committee (FOMC) announced to increase the Fed funds rate by 0.75 percentage points after which the Japanese yen depreciated strongly (Figure 1). However, when the Bank of Japan intervened in the FX market by selling the US dollar and buying the Japanese yen, the depreciation immediately reversed. This example shows how "intervening against the Fed" can potentially offset US monetary spillovers to exchange rates. Despite their widespread use, systematic evidence of how FXIs function as a tool to insulate economies from US monetary policy spillovers is elusive. We aim to fill this gap in the literature.

We first provide evidence of a US monetary policy-induced balance sheet channel of exchange rate depreciation if countries do not counter-intervene. When US monetary policy unexpectedly tightens, domestic exchange rates depreciate against the US dollar and stock prices fall, and disproportionately so for firms that borrow in US dollars. The depreciation of the domestic exchange rate reduces firms' net worth and associated cash flows due to higher debt repayment, leading to lower stock prices. Then we show that intervening against the Fed, by unexpectedly selling the US dollar in response to a contractionary monetary policy shock, mitigates exchange rate depreciation and stock price declines for firms, but only for those with US dollar debt. When US monetary policy tightens and central banks counter-intervene, exchange rates, and stock prices for firms with and without US dollar debt remain statistically and economically unchanged. These results suggest that intervening against the Fed mutes the balance sheet channel of exchange rates triggered by US monetary policy and can protect countries from exposure to the Global Financial Cycle.

There are several challenges in identifying the channels through which US monetary policy spills over to other countries and whether FXIs are successful in mitigating them. Both US monetary policy and FXIs are endogenously conducted, taking current and future information into account. Moreover, changes in monetary or FX policy are inextricably linked and hard to isolate from other factors to identify the direct effect of monetary policy and FXIs. We overcome these issues in several ways.

We employ a multi-event study high-frequency approach by exploiting daily data on FXIs, firm-level stock returns, and exchange rates around US monetary policy decisions.[1] In particular, we use an event-study local projection difference-in-differences (LP-DID) approach in the spirit of Dube et al. (2023) around each FOMC meeting. The advantages of using exchange rates and stock prices around FOMC events are twofold. First, compared to outcomes only available at lower frequencies, such as investment, they can be measured at a daily frequency, which mitigates the aggregation bias introduced by aggregating monetary policy shocks or FXIs to lower frequencies. Second, market prices are forward-looking and therefore respond quicker as they incorporate expected future economic outcomes, such as slower-moving variables like firms' investments and profits, that would not appear in contemporaneous balance sheet measures. Third, our identification strategy helps to identify a counterfactual of what would have happened if countries had not intervened. Simply observing exchange rates and stock prices around an intervention without comparing it to a counterfactual can lead to misleading conclusions.

To measure the effect of interventions we use daily FXI data from 13 countries. We define expected and unexpected counter-interventions as situations in which the central bank sells (buys) US dollars when the Fed unexpectedly tightens (loosens) policy.[2] We then define intervening against the Fed if the central bank counter-intervenes within five days after the FOMC meeting. To address the potential concern that FXIs may be driven by economic fundamentals that could bias our estimates, we also estimate deviations from an FX counter-intervention policy rule incorporating observable and unobservable macroeconomic and financial characteristics, as well as historical responses to Federal Reserve policy. Deviations from the FXI policy rule can be interpreted as unexpected FXIs, helping to estimate the direct effects of interventions, cleaned of potential confounding factors.[3]

For US monetary policy we use cleanly identified high-frequency shocks by Nakamura and Steinsson (2018). The high-frequency monetary shocks are estimated by a change in Fed funds futures in sufficiently narrow time windows around the FOMC announcement so that monetary shocks are orthogonal to the limited amount of information revealed in this narrow window. Using this monetary surprise can be seen as an external driver of changes in the exchange rate and allows us to compare the responses of exchange rates and stock prices to FOMC announcements in countries that do and do not counter-intervene against the US dollar shortly after the announcement.

There are many channels through which US monetary policy can spill over to other countries. A tighter US monetary policy may lower demand and imports in the US, with adverse effects on foreign economies. Higher US monetary policy rates, ceteris paribus, also predict an appreciation of the US dollar on impact due to interest rate differentials in the uncovered

[1] We refer to daily as high-frequency. For the market microstructure literature, this definition may be inappropriate, but as the international finance literature predominantly focuses on monthly or quarterly changes, we consider our approach high-frequency within that tradition.

[2] Selling US dollars in exchange for domestic currency is intended to put appreciation pressure on the exchange rate by absorbing its supply and vice versa.

[3] While our baseline results are based on the surprise component of FXIs, we show that all results are robust using the raw FXI measure.

interest parity (UIP) equation. According to an expenditure switching channel, the depreciation of domestic exchange rates relative to the US dollar would then increase exports and raise the stock prices of firms. However, the depreciation of currency relative to the US dollar also reduces net worth for firms that borrow in US dollars, increasing their debt payments and lowering their cash flows, resulting in lower stock prices (Krugman 1999, Céspedes et al. 2004).

This balance sheet channel of exchange rates through US monetary policy predicts that stock prices of firms with US dollar debt decline by more than those that borrow in domestic currency. Our high-frequency approach, coupled with firm-level stock prices and information on the currency decomposition of corporate debt, allows us to compare the cross-sectional heterogeneity in firms' stock price responses within each country, at a given point in time, to a contractionary monetary policy shock, ruling out that other macroeconomic factors are driving the response. We find that, when countries do not counter-intervene against the Fed, stock prices of firms with US dollar debt decline immediately after US monetary policy unexpectedly tightens. Quantitatively, a 10-basis point surprise increase in the federal funds rate is associated with a 0.3% decline in stock prices for firms with US dollar debt on the day of the FOMC meeting, building up to almost 1% after three days. In contrast, firms without US dollar debt see a decline in the stock price of less than 0.1% on impact, and the effect does not build up. These results strongly suggest that US monetary policy affects stock prices abroad through a balance sheet channel.

We further corroborate whether the role of changes in debt repayments is due to the depreciation of the currency and not due to other factors that are correlated with having US dollar debt. We refine our identification strategy by exploiting the debt maturity structure of firms around the FOMC announcements.[4] If firms happen to have dollar debt that matures around unexpected Fed hikes, the depreciation of local currency increases the cost of rolling over debt in terms of local currency. On the other hand, if the debt does not mature around the monetary shocks, the increase in debt rollover costs is small. Since the debt maturity structure is orthogonal to exchange rate movements, the effect of debt repayment on stock prices can potentially be interpreted causally.

To shed more light on this channel, we move toward the effect of US monetary policy on exchange rates. If the balance sheet channel of US monetary policy is at work, one would expect the behavior of exchange rates to mirror that of the stock price for firms with US dollar debt. And, indeed, for countries that do not counter-intervene, exchange rates depreciate strongly after the US monetary policy shock. Quantitatively, a 10 basis point increase in the US monetary policy rate leads to a persistent 2-3% depreciation of foreign currency.

The depreciation of the exchange rate may also trigger an expenditure switching channel, increasing demand from foreigners due to lower prices, in which case exporting firms would

[4]The debt maturity identification approach follows the approach by Almeida et al. (2011) and Duval et al. (2020) that studies the effect of debt maturity during the global financial crisis on firms' outcomes. More recently, this approach has been applied in the context of the US dollar debt maturity structure around exchange rate movements by Casas et al. (2022).

benefit disproportionately (Mundell 1957, Fleming 1962). However, the contractionary US monetary policy shock reduces demand from the US via intertemporal substitution and therefore also demand for exports, potentially offsetting the positive effect from the exchange rate (Gourinchas 2018).[5] When countries do not intervene and the exchange rate depreciates, the stock prices of exporters remain stable while those of non-exporters fall, suggesting that the negative demand effects from the contractionary monetary policy shock and the positive effects from the expenditure switching channel offset each other.

Turning to the role of FXIs in US monetary policy spillover, we estimate the effect of intervening against the Fed on the exchange rate and stock prices across the firm distribution in response to monetary policy shocks. By tracking the effect of the FXIs within a short window after the FOMC meeting, we likely capture the central bank's decision to "intervene against the Fed" to mitigate exchange rate fluctuations. If, instead, we studied the unconditional effects of FXIs on exchange rates, it would be more difficult to understand the causal effect of the interventions. For instance, it may be possible that the central bank intervenes because it receives a signal about the economy that is unobservable, making it more difficult to understand the counterfactual response of the exchange rate if the central bank had not intervened. As we employ an event study in a short window around the FOMC announcement, the exchange rate change is likely driven by US monetary policy and, without the FOMC decision, would have remained stable, as the pre-trends indicate, allowing us to estimate a more precise counterfactual of not intervening. The marginal effect of counter-intervening in response to a contractionary US monetary policy shock appreciates the exchange rates and raises stock prices for firms with US dollar debt but does not affect the stock price of firms without US dollar debt, mitigating US monetary policy spillovers.

To evaluate the extent to which the counter-interventions offset the depreciation of the currency and the stock price decline for firms with US dollar debt, we only focus on situations in which the Fed surprisingly hikes rates and the country unexpectedly sells US dollars to counteract the surprise (and vice versa). Using these unexpected monetary shocks and FXIs, we present evidence that intervening against the Fed fully prevents exchange rate disturbances against the US dollar when US monetary policy changes suddenly. When the Fed hikes rates unexpectedly and the country sells the US dollar and buys domestic currency to counteract the surprise, the domestic currency does not depreciate against the US dollar, and stock prices for both firms with and without US dollar debt remain unchanged. These results suggest that the channel through which FXIs offset the spillover of US monetary policy is by preventing a depreciation of the exchange rate and consequently higher debt repayments for firms with US dollar debt.[6]

[5]Under dominant currency pricing, export quantities are not expected to increase in the short-run, but revenues in domestic currencies are, also with positive implications for the stock price of exporters.

[6]One potential concern could be that firms use derivatives to hedge their exchange rate risk. While we do not have derivative data available, recent studies suggest that only a small fraction of firms hedge their FX risk with derivatives; see, e.g., Casas et al. (2022). Moreover, we introduce a statistical approach that proxies whether

To credibly counter-intervene against the Fed to stabilize their exchange rate, countries need to have accumulated a sufficient level of reserves. In fact, since the Asian financial crisis in the 1990s, emerging market economies have built up reserves to hedge against rollover risk (Bianchi et al. 2018). When reserve levels are low, central banks' attempts to stabilize the exchange rate and consequently the economy may be unsuccessful as they lack the credibility to do so in the future (Fanelli and Straub 2021). Empirically, we find evidence that countries that have a large share of FX reserves are more effectively counter-intervening against the Fed relative to their counterparts. This result suggests that the buildup of reserves over the last decades could have dampened the role of US monetary policy spillovers if countries had counter-intervened.

While FXIs may prevent a depreciation in response to a contractionary monetary policy shock, they do not mitigate the negative demand effects on imports originating from the US. The benefits of the contractionary monetary policy shock through the expenditure-switching channel for exporters may therefore vanish. The costs, however, through reduced demand, remain the same. Consequently, FXIs may harm exporters through a less depreciated exchange rate. Indeed, we find suggestive evidence that when countries do intervene, the stock prices of exporters fall in the same manner as those of non-exporters, and hence, the effects of intervening against the Fed are negative for exporting firms.

One potential concern with our analysis could be that other confounding factors affect both our dependent variable (stock returns and the exchange rate) and our independent variable (FXI) concurrently and introduce an omitted variable bias to our estimates. We mitigate this concern already in our baseline specification, in which we estimate unexpected deviations from an FXI rule. Moreover, we perform a battery of robustness tests, such as controlling for domestic monetary policy expectations, market and currency risk factors, as well proxies for currency hedging. However, it is still possible that not all characteristics are controlled for, and our deviation from the FXI rule does not fully reflect an exogenous FXI. For instance, unwarranted market disturbances or negative news about the economy that are not captured in the FXI rule may affect stock prices and the exchange rate in response to US monetary policy, while at the same time inducing the central bank to intervene in the FX market.

While we acknowledge this limitation, it is unlikely that this omitted variable explains our results. The exchange rate tends to depreciate systematically in "bad times" against the US dollar (Hassan et al. 2023). When the negative shock hits the economy and stock prices fall, one would expect the central bank to sell the US dollar to prevent the depreciation of the exchange rate. However, we find that selling the US dollar against the domestic currency is rather associated with an appreciation of the domestic currency and an increase in stock prices relative to the no-intervention case. This renders it unlikely that unobservable confounders are driving the relationship between FXIs and those outcome variables.

Moreover, the unobserved shock would likely affect not only the stock prices of firms with

firms hedge their exchange rate risk and we do not find that those firms affect our results. See also discussion in Section 5.6.

US dollar debt but also the stock prices of other firms. In sum, if there were various unobservable confounders, such as a negative shock when the central bank counter-intervened, the true effect of FXIs would likely even be stronger than we find. Hence, our coefficients may, if anything, provide a "lower bound" estimate, and we would underestimate the true effect of FXIs.

2 Literature Review

Our paper contributes to the FXI literature and to how US monetary policy spills over to other countries. Our novel event study approach exploits daily firm-level stock prices across several countries, as well as exchange rates combined with FXI data and US monetary surprises purely identified by a high-frequency approach, see, e.g., Nakamura and Steinsson (2018).

Many central banks have accumulated FX reserves reaching record highs to keep their currencies depreciated.[7] However, often the benefits of a depreciated currency for boosting exports remain elusive (Gopinath et al. 2020). Instead, an increase in US dollar debt of companies in emerging markets has raised concerns that depreciations are contractionary rather than expansionary (Céspedes et al. 2004, Krugman 1999). This raises the question of whether the accumulated US dollar reserves can potentially be used to help insulate an economy against an undesired tightening of US monetary policy, and how FXIs can stabilize the exchange rate and the economy more broadly.

A large empirical literature studies the effect of FXIs on exchange rates (Dominguez and Frankel 1993, Dominguez 2003, Dominguez et al. 2013, Adler et al. 2019, Fratzscher et al. 2019; 2023, Hofmann et al. 2019, Blanchard et al. 2015, Kuersteiner et al. 2018, Fatum and Hutchison 2010).[8] However, none of these papers study the effect of FXIs on stock prices across the firm distribution, nor do they study the interaction between FXIs and US monetary policy.[9]

We also contribute to the literature on US monetary policy spillovers and the global financial cycle (Rey 2015, Miranda-Agrippino and Rey 2020, Kalemli-Özcan 2019).[10] There is vast empirical evidence of the spillover of US monetary policy to country-level equity markets (Zhang 2022, Wiriadinata 2021, Boehm and Kroner 2023), exchange rates (Gürkaynak et al.

[7]For example, the Swiss National Bank has sold the franc to counter the overvaluation due to its safe-haven status and boost the export industries (Jordan 2017). Chinese foreign reserves increased from 733 billion US dollars in July 2005 to 3.99 trillion US dollars in June 2014 (Das 2019).

[8]Recent theoretical advances show that interventions can affect the exchange rate and enhance welfare. Gabaix and Maggiori (2015), Cavallino (2019), Amador et al. (2020), Fanelli and Straub (2021), Maggiori (2022), Itskhoki and Mukhin (2023), and Yago (2024) study FXIs under partial segmentation of home and foreign currency bond markets. Since international financial intermediaries have limited risk-bearing capacity, FXIs affect the exchange rate by changing their balance sheet composition. Hassan et al. (2023) show that policies that appreciate domestic currency when the marginal utility of world investors is high increase the market value of firms and stabilize the country's wealth. Hence, small countries optimally choose to stabilize their currencies relative to the US dollar.

[9]Roussanov and Wang (2023) show that global FX dealers buy US dollars in response to contractionary monetary policy shocks, potentially representing the counterpart of the foreign central banks that sell the US dollar in response to contractionary monetary policy shocks.

[10]Akinci and Queralto (2024), Aoki et al. (2020), and Gopinath and Stein (2021) study US monetary policy theoretically and consider corporate or bank balance sheet risk when firms issue debt denominated in dollars.

2021, Roussanov and Wang 2023, Eichenbaum and Evans 1995, Faust et al. 2007, Anderson et al. 2003), and interest rates (Timmer 2018, Zhang 2022).[11] To identify the channels through which US monetary policy spills over, Wiriadinata (2021) uses foreign currency debt data, while Zhang (2022) uses currency invoicing shares. Dedola et al. (2017) show there is no clear-cut systematic relation emerges between country responses and likely relevant country characteristics, such as their income level, dollar exchange rate flexibility, financial openness, trade openness versus the US dollar exposure in foreign assets and liabilities, and incidence of commodity exports.

Using cross-country heterogeneity, however, is plagued by several issues in identifying the channels of monetary policy. For instance, it is impossible to rule out that other unobserved country-specific factors are driving the results correlated with the country's characteristics. Moreover, country-level data masks a large part of the heterogeneity within countries.[12]

We study the spillovers of US monetary policy on stock prices using a cross-section of firms' stock returns. Using daily stock-price data combined with high-frequency US monetary policy shocks allows us to understand the channel through which US monetary policy spills over to other countries. Surprisingly, at least to the best of our knowledge, we are the first to study the cross-section of stock price reactions to US monetary policy in an international context.[13] The advantage of using firm-level heterogeneity in stock price responses is that it allows us to identify the channels of US monetary policy more cleanly at a high frequency and only exploit differences across firms, controlling for time-variant country-specific observed and unobserved heterogeneity.[14] Our results highlight the importance of taking FXIs into account when analyzing monetary policy spillovers. When we combine no-intervention and intervention events, it is difficult to find evidence in favor of US monetary policy spillovers, as the interventions mask important heterogeneity in the effects of US monetary policy abroad.

The majority of literature on international US monetary spillover aggregates high-frequency US monetary shocks to lower frequency and study their implication on the exchange rate, capital flows, and/or real outcomes (Miranda-Agrippino and Rey 2020, Dedola et al. 2017). In contrast, we combine daily data on exchange rates, firm stock prices, and FXIs with US monetary surprises. There are several advantages to using daily data as dependent variables. FOMC meetings occur at irregular intervals within each year, and aggregating monetary surprises

[11]Di Giovanni and Hale (2022) study stock market spillovers of US monetary policy through the global production network. In contrast to exploiting firm-level heterogeneity, they aggregate stocks to the country-sector level and do not study foreign currency debt, or FXIs.

[12]An exception is Morais et al. (2019), who match loan-level bank lending data with firm-level balance sheet data and study the international risk-taking channel of US monetary policy. While they use monthly loan data, we use daily data on FXIs and firm-level stock prices, as discussed below.

[13]A vast literature studies US firm-level equity returns in response to US monetary policy but abstracts away from foreign firms (Gorodnichenko and Weber 2016, Ai et al. 2022, Ozdagli and Velikov 2020, Chava and Hsu 2020, Gürkaynak et al. 2022).

[14]The caveat of using stock price data is that we are only able to study public firms, and we cannot see whether a reduction in stock prices eventually materializes in changes in real outcomes, such as employment, domestic revenue, and profitability of those firms, see, e.g., Rodnyansky (2019).

over each month or quarter can induce serial correlation in aggregate shocks and inconsistent estimates of aggregate impulse responses (Ramey 2016, Anderson and Cesa-Bianchi 2023). Moreover, the magnitude of high-frequency shock is small. This complicates estimating the effect of variables in the distant future; for example, output several quarters away is influenced by many other confounding factors. To minimize this "power problem," we study the response of daily exchange rates and stock prices, which move contemporaneously with monetary shocks (Nakamura and Steinsson 2018).

We also relate to the literature that studies how central banks respond when US monetary policy tightens. In theory, the central bank should let the exchange rate depreciate (Gali and Monacelli 2005, Friedman 1953), but in practice, there is a fear of floating (Calvo and Reinhart 2002), and many central banks are reluctant to let the exchange rate fluctuate. Our results show that the monetary policy-induced depreciation does not benefit exporters as the positive expenditure switching effect is offset by negative demand effects, while at the same time harming firms that have US dollar borrowing.

The IMF integrated policy framework (Basu et al. 2020) studies the interaction between monetary policy and FXIs from a theoretical perspective. They show that after an adverse shock to the foreign appetite for domestic currency debt, FXIs reduce the need for the policy rate to be increased and, in that sense, can enhance monetary autonomy. Yago (2024) shows that by intervening against the Fed, central banks can offset the inflationary pressure driven by a US monetary policy-induced currency depreciation. This provides a rationale for why intervening against the Fed can be optimal.

Empirically, we show that by intervening against the Fed, central banks can offset the depreciation, helping firms with US dollar debt but harming exporters by muting the expansionary expenditure switching effect.[15]

3 Data

3.1 Sources

We combine data from several sources. Our sample period is between 2000 and 2019, during which the data on US monetary shocks and corporate balance sheets are available.[16]

First, we collect data on sterilized FXIs based on Fratzscher et al. (2019) and Adler et al. (2021). We use publicly available databases on central bank websites and the FRED database.[17]

[15] Kalemli-Özcan (2019) shows that monetary policy divergence vis-à-vis the United States has larger spillover effects in emerging markets than in advanced economies. Domestic monetary policy is ineffective in mitigating this effect, as the pass-through of policy rate changes into short-term interest rates is imperfect.

[16] Appendix A shows that the result is robust even after excluding special periods, including the global financial crisis and zero lower bound on the interest rate.

[17] We focus on central banks' direct purchases and sales of the US dollar. One may think the signaling channel of FXIs is driving the results, since dollar sales may signal the central bank's concern about the weakness of domestic currency which is correlated with future monetary tightening. To address this possibility, Appendix A controls for

Some countries do not publicly disclose the data due to the secret interventions, in which case we individually contacted the central banks to be granted access to the data. We then restricted the sample countries based on the following criteria: first, to use as much high-frequency data as possible, we only use daily intervention data and exclude countries and periods where only monthly or quarterly data is available. Second, since we study interventions against US monetary shocks, our sample only comprises countries that intervened against the US dollar multiple times during the sample period.[18] The following 13 countries have available data and satisfy the above criteria: Argentina, Australia, Brazil, Chile, Colombia, Costa Rica, Georgia, Hong Kong, Japan, Mexico, Peru, Switzerland, and Turkey.[19] One limitation is that the intraday data on FXIs is difficult to obtain. However, even if we use daily data, our result shows that FXIs have persistent effects on the exchange rate and stock market.[20]

To address the endogeneity concern of monetary policy, we use the high-frequency change in the Fed funds rate (FFR) identified by Nakamura and Steinsson (2018), which was subsequently updated by Acosta (2023). They estimate the changes in Fed funds futures in a 30-minute window around the FOMC announcement. We obtain daily data on the spot exchange rate and stock price from Thomson Reuters Datastream. Since Datastream reports the closing exchange rate at 4 p.m. London time and the FOMC announcements are made around 2 p.m. Washington time (7 p.m. London time), we moved the reported dates of exchange rates by one date forward so that the exchange rate on each date is reported after the FOMC announcement on the same date. Since the end-of-date stock price is released at different times in different time zones, we adjusted the reported dates for the stock price depending on whether the stock price is released before or after the FOMC announcement.

We use corporate balance sheet data on the Capital IQ platform provided by S&P Global Market Intelligence. The advantage of Capital IQ is that it provides information on the currency denomination of debt, which is not available in other databases such as Worldscope, Compustat, and Orbis. Its Capital Structure database provides detailed information on each debt instrument held by each firm, including the principal amount due, repayment currency, and maturity. For example, Agrometal S.A.I., a manufacturing firm in Argentina, had a total outstanding debt of 5.6 million dollars on December 31, 2015. Among them, 2.2 million dollars are repaid in US dollars, and the remaining 3.4 million dollars are repaid in Argentine pesos. Hence, the share of dollar bonds over total bonds is 39 percent. Capital IQ has provided annual data on corporate balance sheets since 2001. The sample is restricted to publicly listed firms, as the data on stock

government bond yield which reflects future monetary policy expectations and confirms our results on stock return and exchange rate remain robust. This confirms that the monetary policy expectation channel is not responsible for our results.

[18]We focus on US monetary shocks since a limited number of countries disclose daily FXI data against the euro and Japanese yen.

[19]To address the possibility that the result is driven by a particular country, in Appendix A, we exclude each country from the regression and show the results on stock prices and exchange rates are robust.

[20]Kuersteiner et al. (2018) study intraday intervention data in Colombia between 2001 and 2012. However, intraday data is unavailable for the other 12 countries in our sample. See also Dominguez (2003) and Dominguez et al. (2013) for analysis using intraday intervention data.

prices is available.

We complement the data using a variety of sources. Firm-level data on exports and the incorporation date is available on Worldscope. To measure firms' reliance on intermediate imports in their production, we use sector-level data on import content of exports in OECD input-output tables, following Rodnyansky (2019). The limitation is that it is difficult to obtain firm-level data on the invoicing currency of exports and imports for many countries. Hence, this paper focuses on the effect of FXIs on firms with dollar debt. Appendix B provides details on the data cleaning procedure and selection criteria for our sample of firms.

Finally, for country-level characteristics, we collect the data on monthly policy rates from the IMF Monetary and Financial Statistics. The data on GDP, inflation rate, trade balance, and unemployment rate are retrieved from the World Bank database and the IMF World Economic Outlook.

3.2 Summary Statistics

Table 1 provides summary statistics for Fed funds rate shocks and changes in the exchange rate and stock price. Our sample consists of 90 FOMC announcement dates between 2000 and 2019.[21] Row (1) shows the summary statistics for the Fed funds rate shock estimated by Nakamura and Steinsson (2018). The Fed funds rate shock is defined as the change in market expectations of the Fed funds rate over the remainder of the month in which FOMC meetings occur. The shock is in terms of basis points and a positive value implies a tightening surprise by the Federal Reserve. As Nakamura and Steinsson (2018) discuss, the magnitude of Fed funds rate shocks estimated by the high-frequency method is small: the standard deviation is 1.81 basis points. This "power problem" makes it difficult to estimate the effect on real economic outcomes, such as firm-level investment and economic growth, as the data is available only in quarterly or annual frequency and is affected by many unobservable confounding factors. Hence, we focus on the response of daily exchange rates and stock prices, which move contemporaneously with high-frequency monetary shocks.

Row (2) shows the summary statistics for the exchange rate depreciation, comparing before and after the FOMC announcement date. $e_{c,t}$ is the spot exchange rate at the end of date t in the country c. The exchange rate is defined as the value of the US dollar in terms of local currency so that a higher $e_{c,t}$ implies the appreciation of the US dollar or depreciation of local currency. We take the change in the logarithm of the exchange rate from date $t-1$ to $t+1$. Similarly, row (3) shows the summary statistics for the percentage change in the stock price, comparing before and after the FOMC announcement. $p_{i,t}$ is the stock price of firm i at the end of date t.

[21] Nakamura and Steinsson (2018) and Acosta (2023) report 151 FOMC sample dates between 2000 and 2019. We exclude 46 dates that are characterized by a zero change in the Fed funds rate. This is because our main focus is the unexpected change in the Fed funds rate and the central banks' counteracting intervention against Fed funds rate shocks. In Appendix A, we also include those dates in the sample and show the result is robust. We also excluded 15 FOMC event dates with large FFR shocks so that our result is not affected by outliers (see footnote 23).

The stock price is denominated in local currency.[22] The standard deviations of exchange rate change and stock return are 0.72 percent and 3.47 percent, respectively.[23]

Table 2 shows the frequency, amount, and sample period of interventions around the FOMC event dates in our sample countries. To consider the possibility that the effects of a Fed funds rate shock and FXIs accumulate over time, we consider a 5-day window after FOMC announcement dates.[24]

We first define buying and selling interventions so that central banks buy or sell the US dollar at least once between dates t and $t + 5$, where, t is the FOMC announcement date. Columns (1) and (2) report the frequency of buying and selling US dollar interventions. There is a large variation in the frequency of interventions across countries. For example, Argentina intervened 59 times by buying the US dollar and 45 times by selling it, out of a total of 90 FOMC event dates in our sample. In contrast, Switzerland never intervened and Turkey intervened only once around the FOMC meetings. However, the interventions happened only outside the 5-day window around the meetings. To minimize the possibility that the interventions are affected by a myriad of other factors besides US monetary shocks, our sample does not count interventions that happened outside the 5-day window around FOMC meetings.[25]

Column (3) reports the frequency of counteracting interventions, which is the main focus of our analysis. We define counteracting interventions as follows: if the Fed funds rate increases on date t, central banks sell the US dollar at least once and never buy the US dollar between dates t and $t+5$, and vice versa when the Fed funds rate decreases. Since a higher Fed funds rate depreciates the local currency, central banks offset the depreciation by selling the US dollar and buying the local currency. Unless otherwise stated, we will use this definition of counteracting interventions throughout the regression analyses in this paper. However, our result is robust even if we adopt different definitions of counter-intervention or if we include all intervention dates in our sample.[26] Columns (1)-(3) show that not all interventions are counteracting interventions against the Fed. For example, Argentina intervened by buying the US dollar 59 times and by selling the US dollar 45 times, but only on 15 occasions did they intervene by counteracting the Fed funds rate shock. Focusing on these counter-interventions, we will study how the effects

[22]Appendix A shows that, if the stock price is denominated in foreign currency, the stock price response to Fed tightening becomes larger since changes in exchange rates affect the valuation of stock prices. This implies that firms with dollar debt are riskier investment opportunities for foreign investors than those with local currency debt.

[23]We trimmed the top and bottom 5% of the Fed funds rate shocks and winsorized the top and bottom 5% of changes in the exchange rate and firms' stock prices in each country so that our result is not affected by outliers.

[24]For identification purposes, we focus on a 5-day window around FOMC announcements, since the estimates can be more affected by unobserved confounding factors in a longer time horizon. However, policymakers may be more interested in a longer-lasting effect, as the balance sheet and expenditure switching effects occur at a lower frequency. In Appendix C, we study this lower-frequency effect and find that the effects of US monetary shocks and FXIs on stock prices are persistent for six to eight weeks (1.5 to 2 months).

[25]To address the possibility that our result is affected by one particular country with either frequent or infrequent intervention, Appendix A excludes each country from the sample and shows that our result is robust.

[26]Appendix A defines the counteracting interventions differently: the central banks' average net sales of US dollars between dates t and $t + 5$ is positive when the Fed funds rate increases at date t, and vice versa when the Fed funds rate decreases. Our main results are robust to using this alternative definition.

of FOMC announcements on the exchange rate and stock price are different when the central banks do and do not counter-intervene against Fed funds rate shocks. Columns (4) and (5) report the FXI volume in terms of millions of US dollars around the FOMC announcement dates. The mean and median FXI volumes across all countries are 57 million dollars and 15 million dollars, respectively.[27][28]

Column (6) reports the sample period when the FXI data are available. The availability of the FXI data depends on the country. In particular, our sample only includes countries and periods in which daily FXI data is available. We excluded periods in which only monthly, quarterly, or annual data are available. For example, daily intervention data in Switzerland is available only until 2001.

Table 3 describes the sample of firms. The table shows the total number of firms and the number of firms that issued dollar debt at least once during the sample period in each country. Our sample consists of 4,060 firms in total, out of which 261 firms (6%) have dollar debt. The average share of dollar debt over total debt across all firms is 66%, conditional on firms issuing a positive amount of dollar debt. The share of firms with dollar debt is relatively large in emerging economies, while most of the Japanese firms do not issue dollar debt as they borrow in Japanese yen (if we exclude Japanese firms from the sample, 14% of firms have dollar debt).

3.3 Identification of Unexpected FXI

To elaborate on our identification strategy for FXIs, we estimate a central bank reaction function. The motivation is to extract the unexpected component of interventions that cannot be forecasted by Fed funds rate shocks, past exchange rate movements, FXIs before the FOMC events, and other macroeconomic characteristics. This is a popular approach to minimizing the endogeneity of interventions in the literature (Kearns and Rigobon 2005, Ito and Yabu 2007, Fatum and Hutchison 2010, Kuersteiner et al. 2018, Fratzscher et al. 2019) similar to residuals from a monetary policy Taylor rule. The advantage of the deviation from the FX policy rule relative to deviations from a monetary policy rule is that FX interventions vary on a daily level, while monetary policy decisions are usually only conducted every several weeks. The high-frequency FXI rule approach therefore more cleanly identifies surprises than that of the Taylor rule residual.[29]

All of our results are robust to various definitions or measurements of FXIs. If we do not use indicators but instead adopt continuous measures for raw volume (size) of FXIs, or if we do not take the surprise component by estimating the FXI rule and include all intervention dates in

[27]To calculate the mean and median FXI volumes around FOMC announcement dates, we first take the average of absolute values of FXI volumes between date t and $t+5$ for each FOMC announcement date t. Next, we take the mean and median of implied FXI volume over FOMC announcement dates, conditioning that there was at least one intervention between date t and $t+5$.

[28]Appendix A shows that our main results hold even after excluding the interventions with small sizes.

[29]For estimation of Taylor rule residual, see Taylor (2009), Maddaloni and Peydró (2011), and Dell'Ariccia et al. (2017).

our sample, our key economic implications on exchange rates and stock prices do not change. However, we use the below definition of FXIs as a benchmark to better identify the direct effects of FXIs that are less likely confounded by other factors.

To do so, we consider the following FXI rule:

$$\widetilde{FXI}_{c,t} = \sum_{c} \beta_c (FFR_t \times \gamma_c) + \delta Z_{c,t} + \gamma_c + \epsilon_{c,t}. \tag{1}$$

$\widetilde{FXI}_{c,t}$ is the indicator for counteracting intervention in country c on FOMC announcement date t, as discussed in column (3) of Table 2, as is standard in the literature.[30] $\widetilde{FXI}_{c,t}$ takes 1 if the Fed tightens unexpectedly on date t and the central banks intervene by selling the US dollar at least once but never intervenes by buying the US dollar between dates t and $t+5$. Similarly, $\widetilde{FXI}_{c,t}$ takes -1 if the Fed loosens unexpectedly on date t and the central banks intervene by buying the US dollar at least once but never intervenes by selling the US dollar between dates t and $t+5$. Otherwise, $\widetilde{FXI}_{c,t}$ takes zero. In Appendix A, we confirm that the result is robust even if we use a continuous measure of FXIs in estimating Equation (1).

FFR_t is the Fed funds rate shock in terms of basis points, and γ_c is the fixed effect for each country c. Their interaction $FFR_t \times \gamma_c$ captures the differential propensity to intervene against Fed funds rate shocks across countries. $Z_{c,t}$ is the set of controls, including the trend and standard deviation of the exchange rate and the dummy for FXIs before the FOMC event date, as well as the macroeconomic variables (one-month lagged policy rate, one-year lagged GDP, CPI inflation rate, trade balance over GDP ratio, and unemployment rate), and the interaction of macroeconomic variables with Fed funds rate shock.[31] For past exchange rate movement, we took the percentage change and standard deviation of the exchange rate between dates $t-1$ and $t-5$, where t is the FOMC event date. For past interventions, the dummy takes 1 if the average net purchase of US dollars between dates $t-1$ and $t-5$ is positive, -1 if the net purchase is negative, and zero if there are no interventions.

We follow the previous empirical literature on FXIs regarding the estimation of an FXI policy rule. Following Fratzscher et al. (2019), we control for the past exchange rate trend and volatility and past interventions, as they can affect the central bank's decision to intervene. Moreover, based on Fatum and Hutchison (2010), we also control for macroeconomic variables, such as GDP and trade balance, since countries with different macroeconomic conditions may adopt different interventions. We use lagged macroeconomic variables to remove the simultaneity bias. We also account for the interaction between the Fed funds rate shock and macro variables,

[30] We use an indicator variable for FXIs following the literature on FXI reaction function: Fatum and Hutchison (2010) and Fratzscher et al. (2019) (Appendix II) define a (0,1) indicator for intervention and no intervention, and Ito and Yabu (2007) define a (0,1,-1) indicator for buying and selling dollar interventions. Ito and Yabu (2007) use an FXI indicator instead of volume because the FXI volume is determined within the day depending on intraday exchange rate movement, but intraday interventions are not disclosed. By using the indicator variable, they mitigate this endogeneity concern caused by our inability to estimate the intraday reaction function.

[31] We use a monthly policy rate since the daily policy rate is not available for all sample countries. In Appendix A, we use daily policy rates in countries with available data and show that our result is robust.

since countries with different macroeconomic characteristics can respond heterogeneously to the Fed funds rate shock. We include the country fixed effects, γ_c, to control for the difference in average exchange rate trends in each country.

The predicted counter-intervention from estimating the reaction function (1) can be interpreted as the expected component of counter-interventions, in other words, the average response of FXIs to Fed funds rate shocks, past exchange rates, interventions, and macroeconomic conditions. The residual, or the deviation from the FXI rule, can be interpreted as the unexpected component of FXIs. We exploit this residual as the exogenous surprise component of FXIs.

Figure 2 graphically illustrates the result for a variance decomposition from estimating Equation (1). Our estimates show that 24% of the variation in counter-intervention can be explained by the set of controls ($R^2 = 0.24$), while the remaining 76% are unexplained. This low R-squared implies that a large part of FXIs cannot be predicted by the Fed funds rate shock, past exchange rates, or interventions. If we further decompose the controls, 16% can be explained by the Fed funds rate shocks, 2% by macroeconomic variables (policy rate, GDP, CPI inflation rate, trade balance over GDP ratio, unemployment rate), 30% by the interaction between the Fed funds rate shock and macro variables, 35% by past interventions, and 17% by country fixed effects. The contribution of past exchange rate trends and volatility is almost zero, so it is not displayed in the figure. This is consistent with Fratzscher et al. (2019), who show that past exchange rates have very limited explanatory power for FXIs.

Having shown that the variation of interventions is difficult to predict, we will use the residual from estimating Equation (1) as an unexpected component of counter-interventions. To simplify the interpretation of results in later sections, we define an unexpected counter-intervention dummy, $FXI_{c,t}$. If the residual from estimating Equation (1) is greater than its median in absolute value, $FXI_{c,t}$ takes one, and central banks counter-intervene unexpectedly against the Fed. Otherwise, $FXI_{c,t}$ takes zero and central banks do not counter-intervene unexpectedly. Although we use this indicator as the benchmark, we emphasize again that our results are robust even if we do not take dummies but instead the continuous measure for raw volume of FXIs.

Figure 3 shows a simple graphical example of this identification methodology. Panel (a) shows an example of unexpected US monetary tightening: on November 15, 2000, the Fed tightened unexpectedly, and the Reserve Bank of Australia intervened by selling the US dollar. The counter-intervention dummy $\widetilde{FXI}_{c,t}$ takes 1. The predicted value and residual from estimating the linear probability model (1) are around 0.2 and 0.8, respectively. This implies that the market expected that there was a 20% probability that the central bank would intervene against the Fed's tightening shock by selling the US dollar, but an 80% probability that the central bank would not intervene. This large residual implies that the interventions were mostly unexpected. Similarly, panel (b) shows the example of unexpected US monetary easing: on March 22, 2005, the Fed delivered an accommodating monetary policy shock, and the Central Bank of Argentina intervened by buying the US dollar. The counter-intervention dummy $\widetilde{FXI}_{c,t}$ takes -1. The predicted value and residual from estimating the linear probability model (1) are around -0.39 and -0.61, respectively. This implies that the market expected that the probability that the central bank would not intervene against the US monetary easing shock was more than 60% (the residual is 0.61 in absolute value). This suggests that the degree to which the interventions are unexpected can be measured using the absolute value of the residual from the estimating equation (1). In the baseline analysis, we define the interventions as unexpected if the residual is larger than its median in absolute value. Our result is robust even if we use different criteria for defining unexpected counter-intervention or use the continuous size of FXIs and include all intervention dates without taking the unexpected component.

4 Empirical Strategy

Our empirical strategy relies on a high-frequency event-study approach that examines the performance of equities and exchange rates around FOMC meetings. The event study approach has the advantage that the market reaction on FOMC dates is likely due to monetary policy itself, rather than other confounding factors that could influence equity prices or the exchange rate. For instance, in a simple time-series regression in which quarterly outcome variables are regressed on US monetary policy (shocks), it is more difficult to identify the causal effect of monetary policy as many confounding factors could be the reason for the market reaction that is not due to monetary policy itself. If the monetary policy shock is completely exogenous, the coefficient may not be biased, but aggregating high-frequency monetary policy shocks to the quarterly level may cause a "power issue", similar to a weak instrumental variable problem in two-stage least squares regressions.

We start with event-study local projections (Jordà 2005) by estimating the following sequence of regressions across FOMC dates:

$$y_{i(c),t+h} - y_{i(c),t-1} = \beta_h \mathrm{FFR}_t + \mathbf{X}\delta_x^h + \alpha_{i(c)}^h + \epsilon_{i(c),t}^h, \qquad \forall h =\in [-5,5] \tag{2}$$

where FFR_t is the Fed funds rate shocks developed by Nakamura and Steinsson (2018) and Acosta (2023). The shock is defined as the change in the Fed funds futures rate in a 30-minute window around the FOMC announcement. FFR_t is in terms of basis points, and positive FFR_t represents the unexpected increase in the Fed funds rate. $y_{i(c),t+h}$ is the logarithm of stock price of a firm i based in the country c, h days after the FOMC meeting. $\alpha_{i(c)}^h$ is a firm fixed effect. The standard errors are always double-clustered at the firm and event date level to account for correlation at the same firm and time. β_h is the effect of the Fed funds rate shock on the equal-weighted stock price h days after the FOMC meeting. Equation 2 is informative about the spillover effects of US monetary policy across all countries in our sample and across firms. $\beta < 0$ for each $h \geq 0$ implies that a surprise tightening of US monetary policy reduces stock prices abroad h days after the meeting. Then we can estimate Equation 2 for the country-FOMC date subsamples with and without unexpected counter-intervention ($FXI_{c,t} = 1$ and $FXI_{c,t} = 0$). For the subsample $FXI_{c,t} = 1$, $\beta = 0$ implies that monetary policy does not spill over negatively to countries' equally-weighted stock price index h days after the meeting if they counter-intervene against the Fed. $\mathbf{X}$ are a set of controls that include the one-year lagged export intensity, total asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interactions with Fed funds rate shock. The interaction of the Fed funds rate with the firm-level characteristics ensures that the differential responsiveness across firms to changes in interest rates is not responsible for the identified effect of the balance sheet channel. We consider two modifications to evaluate the effect of FXIs. First, we introduce an interaction term between the Federal funds rate shock and dollar debt:

$$y_{i(c),t+h} - y_{i(c),t-1} = \gamma_h \text{FFR}_t \times USD_{i(c),y-1(t)} + \mathbf{X}\delta_x^h + \alpha_{i(c)}^h + \alpha_{c,t}^h + \epsilon_{i(c),t}^h, \qquad \forall h =\in [-5,5] \quad (3)$$

γ_h can be interpreted as a state-dependent effect of the monetary policy shock, where the state is whether firms have US dollar debt or not (Cloyne et al. 2023). $USD_{i(c),y-1(t)}$ is a dummy if a firm has had US dollar debt in the previous year before the FOMC meeting. Appendix A shows that our results are robust even if we do not take a dummy but instead use a continuous measure for dollar debt. $\alpha_{c,t}^h$ is a country-time fixed effect and $\alpha_{i(c)}^h$ is a firm fixed effect. γ captures the balance sheet channel of US monetary spillover. $\gamma < 0$ for each $h \geq 0$ implies that a surprise tightening of US monetary policy reduces the stock price of firms with dollar debt relative to those without dollar debt. Note that the inclusion of the country-time fixed effects controls for all time-varying observed and unobserved characteristics, and only exploits the effects across firms within a country-time dimension. The inclusion of the fixed effects also implies that all other variables that are spanned by the fixed effects are collinear and cannot be estimated, e.g., FFR_t itself.

Next, we introduce an interaction term between the Federal funds rate shock and the intervention:

$$y_{i(c),t+h} - y_{i(c),t-1} = \beta_h \text{FFR}_t + \Omega_h FXI_{c,t} + \gamma_h \text{FFR}_t \times FXI_{c,t} + \mathbf{X}\delta_x^h + \alpha_{i(c)}^h + \epsilon_{i(c),t}^h, \quad \forall h =\in [-5,5] \quad (4)$$

γ captures the effect of FXIs mitigating the effect of US monetary spillover. $\gamma > 0$ for each $h \geq 0$ implies that the decline in stock price is smaller with FXIs than the case without FXIs. In contrast to standard local projections, we also consider $h < 0$ in the spirit of an LP-DID proposed by Dube et al. (2023). One difference between the LP-DID and the standard DID is that a sequence of regressions is estimated for each h. This has the advantage that β_h is unaffected by the choice of the number of lags and leads included. Moreover, the LP-DID avoids several other problems compared to estimating a difference-in-differences specification with two-way fixed effects, see, e.g., Callaway and Sant'Anna (2021), Goodman-Bacon (2021) among many others.

For the difference-in-differences estimator to be unbiased, we require the parallel trend assumption to be satisfied—that is, absent a shock, treated and control firms would have evolved the same way. While it is not possible to test this assumption, as the counterfactual post-FOMC behavior without the shock is unobservable, we can test whether there are differential pre-trends before the shock. Estimating β_h for $h < 0$ allows us to test whether there is a violation of the parallel trend assumption.

Recent literature has argued that DID designs are likely to be biased in the presence of a staggered DiD approach, as already treated units can act as effective comparison units (Baker et al. 2022). Note that this is not a concern in our setting as we set $h = \in [-5, 5]$, covering only a window of 10 days, which prevents overlapping observations and staggered treatment, as FOMC meetings only occur approximately every six weeks. The concern would be that firms with US dollar debt are treated for one FOMC meeting but not for the next, but would still be treated as comparison units for the next one.

We start by estimating Equations 2 and 3 separately for FOMC meetings when country c counter-intervenes in the FX market after the FOMC meeting, based on the definition in Section 3. Focusing on no-counter-intervention events allows us to test the degree and channels of US monetary policy spillovers if countries do not intervene against the Fed. Instead, focusing on counter-intervention events allows us to test whether US monetary policy spills over to firms' stock prices if a country intervenes against the Fed. In particular, if we can reject the null hypothesis that $\beta = 0$ in Equation 2, the data favors the alternative hypothesis that there exists a spillover effect of US monetary policy. If we cannot reject $\beta = 0$, there are likely no spillover effects. In Equation 3, the null hypothesis is that firms with US dollar debt are not differentially affected by a US monetary spillover, while the alternative hypothesis is that they are differentially affected. The alternative hypothesis, $\gamma < 0$, can be interpreted as a US monetary policy-driven balance sheet channel of depreciation.

The disadvantage of splitting the data into intervention and no-intervention events is that we cannot test whether β and γ are statistically different for intervention and no-intervention events. It is possible that when estimating the equations separately, we can reject the null hypothesis in one subsample but not in the other, yet due to large standard errors, the two situations are not different from each other in a statistically significant manner.

We therefore refine our regression equation by including the counter-intervention dummy specifically in the regression equation instead of splitting between situations when $FXI_{c,t}$ is either zero or one:

$$\begin{aligned} y_{i(c),t+h} - y_{i(c),t-1} = {} & \theta_h \mathrm{FFR}_t \times USD_{i(c),y-1(t)} \times FXI_{c,t} + \gamma_h \mathrm{FFR}_t \times USD_{i(c),y-1(t)} \\ & + \mathbf{X}\delta_x^h + \alpha_{i(c)}^h + \alpha_{c,t}^h + \epsilon_{i(c),t}^h, \qquad \forall h = \in [-5, 5] \end{aligned} \tag{5}$$

In Equation 5 the coefficient γ has the same interpretation as in the equation without the triple interaction (Equation 3) when estimating in the sample of no-intervention: the relative performance of firms with US dollar debt in response to a contractionary US monetary policy shock when the country does not counter-intervene. A negative coefficient implies that firms with US dollar debt underperform relative to those with US dollar debt. The triple interaction coefficient θ measures the marginal effect of FXIs for firms with US dollar debt in response to a contractionary monetary policy shock. A positive coefficient θ implies that FXIs lead to relatively higher stock prices for firms with US dollar debt in response to a contractionary monetary policy shock, compared to a counterfactual under which the central bank does not counter-intervene. θ can therefore be interpreted as the extent to which FXIs mute the US monetary policy-induced balance sheet channel of exchange rate depreciation, while γ measures the extent of the balance sheet channel without interventions. Summing θ and γ can be equivalently interpreted as Equation 3 for $FXI_{c,t} = 1$ as the balance sheet channel when countries intervene. $\theta + \gamma = 0$ implies FXIs entirely mute the balance sheet channel.

Note that estimating the relative stock market response of having US dollar debt in response to the monetary policy shock allows us to saturate the regression specification with country-time fixed effects ($\alpha_{c,t}$). Country-time fixed effects control for time-variant observed and unobserved characteristics at the country level, such as the movement of the exchange rates or the effect on the average stock price around the US FOMC meetings. The inclusion of country-time fixed effects implies that the effect of FFR_t is not identified, as it is collinear with the fixed effects (note that $\alpha^h_{c,t}$ absorbs the terms FFR_t, $FXI_{c,t}$, and $\text{FFR}_t \times FXI_{c,t}$). Hence, when controlling for time-variant observed and unobserved characteristics at the country level through country-time fixed effects, we can only make a relative statement about having US dollar debt. In an alternative specification, we remove the country-time fixed effects from the regression specification to evaluate the total effect of US monetary policy shocks for both firms with and without dollar debt, with the caveat of controlling for fewer potential confounding factors.

5 Results

5.1 Stock Market

We begin by estimating Equation 2 separately for firms with and without US dollar debt, i.e., meaning that ($USD_{i(c),y-t(t)} = 1$ and 0). Table 4 shows the result, where panels (a) and (b) show the result with and without FXIs, respectively. We first study the case without FXIs ($FXI_{c,t} = 0$). Panel (a), columns (1) and (2) report the estimated β_1 coefficient for a subsample of firms with and without dollar debt, respectively, based in countries without FXIs. Column (1) shows that, if central banks do not counter-intervene against the Fed, an unexpected increase in the Fed funds rate reduces the stock price for firms with dollar debt in a statistically significant manner (6.6% in response to a 10bp surprise hike).[32][33] However, if firms do not have dollar debt, the decline in stock price is mitigated (0.9%). Next, to test if the difference in the response between firms with and without dollar debt is significant, we estimate Equation 3 in countries without interventions. Column (3) reports the estimated β_1 and γ_1 coefficients for countries without interventions. The negative γ_1 coefficient shows that when the Fed funds rate increases, the decline in stock prices for firms with dollar debt is significantly larger than for those without dollar debt (3.1pp larger decline). Moreover, in column (4), we include the country-time fixed effect $\alpha^h_{c,t}$, which captures the time-varying observable and unobservable characteristics at the country level, and our result remains robust. Note that $\alpha^h_{c,t}$ absorbs the FFR_t standalone term. These results suggest a strong negative balance sheet channel driven by US monetary tightening without FXIs.

In contrast, panel (b) conducts a similar exercise with FXIs ($FXI_{c,t} = 1$). Column (1) shows that, if central banks counter-intervene against the Fed's surprise hike, the decline of stock prices is mitigated even if firms have dollar debt (2.2% in response to 10bp surprise hike, in contrast to 6.6% in panel (a)).[34] Columns (3) and (4) show the differential response of firms with and without dollar debt. The coefficient γ_1 is small and statistically insignificant, implying that if central banks counter-intervene against the Fed, the stock price response of firms with dollar debt is not different from those without dollar debt in a statistically significant manner. This suggests that FXIs can successfully mute the negative spillover of US monetary shocks via the balance sheet channel, disproportionately benefiting firms with dollar debt.

Next, to test whether the effect of FXIs is large in a statistically significant manner, we estimate Equation 4 separately for firms with and without dollar debt. Columns (1) and (2) of Table 5 report the estimated β_1 and γ_1 coefficients for firms with and without dollar debt, respectively. Column (1) shows that, if firms have dollar debt, a surprise hike in the Fed funds rate reduces the stock price without interventions (6.4% in response to a 10bp hike), implying a negative balance sheet channel of US monetary policy. However, if central banks intervene, the decline in the stock price is mitigated by 4.5bp, implying that FXIs can mitigate this balance

[32]As shown in Table 1, the standard deviation of the monetary shock in our sample is very small (1.81bp) since it is measured in a 30-minute window around the FOMC announcement. In fact, in the dataset of Nakamura and Steinsson (2018), there are only six FOMC announcement dates in our sample period (between 2000 and 2019) when the magnitude of the Fed funds rate shock is greater than or equal to 10bp in absolute value. Hence, a 10bp monetary shock can be interpreted as a large shock.

[33]One may think this decline in stock prices is driven by the portfolio rebalancing channel: a surprise US tightening lowers the US equity return and raises its expected returns, which induces US investors to shift funds to US assets. We would expect that this is not the main driver of our results. While the portfolio rebalancing channel can explain the overall decline in local stock returns, it is less likely to explain differential stock returns across firms, unless international investors disproportionately hold certain firms. One may potentially expect US investors to have a higher exposure toward larger firms, then the portfolio rebalancing channels are driven by large firms. To take this size effect into account, we control for firm size and its interaction with Fed funds rate shock. This disentangles the balance sheet and portfolio rebalancing channels. Finally, Section 5.4 exploits the debt maturity structure for identification. It is unlikely that international investors hold firms with differential maturity structure, even if they disproportionately hold firms with US dollar debt.

[34]Even with FXIs, the decline in stock prices is statistically significant. This can be due to other channels: for example, a higher US interest rate reduces the demand for domestic goods via intertemporal substitution.

sheet channel. In column (2), we conduct a similar exercise for firms without dollar debt and find that the effects of the US monetary shock and FXIs are small. Finally, in columns (3) and (4), we estimate the triple interaction (Equation 5) to study whether the effect of FXIs is greater for firms with dollar debt. The negative coefficient on $FFR_t \times USD_{i(c),y-1(t)}$ ($\gamma = -0.310$) implies a negative balance sheet channel due to US monetary policy spillovers. However, the coefficient on $FXI_{c,t} \times FFR_t \times USD_{i(c),y-1(t)}$ is positive ($\theta = 0.324$) and $\theta + \gamma = 0$ holds statistically. This result implies that FXIs entirely mute the balance sheet channel. The finding is robust even after including the country-time fixed effect (column 4). Note that $\alpha^h_{c,t}$ absorbs the terms FFR_t, $FXI_{c,t}$, and $\mathrm{FFR}_t \times FXI_{c,t}$. This key implication is robust even if we do not take a dummy but instead use a continuous measure of FXIs, and even if we do not take a surprise component of FXIs but include all intervention dates in our sample.

To test whether the effect of FXIs is persistent over time, we estimate Equation 2 over a 5-day window around the FOMC announcement. Figure 4, panel (a) plots the estimated coefficient β_h for all $h =\in [-5, 5]$. The red and blue lines show the results for countries with and without FXIs, respectively. Without FXIs, a 10 basis point surprise increase in the Fed funds rate leads to an immediate decline in stock prices, and this accumulates up to nearly 1% after three days, suggesting that the balance sheet channel of US monetary shocks is persistent. However, if countries intervene, the effect of the US monetary surprise is smaller, and it disappears five days after the shock. Importantly, the near-zero coefficients for $h < 0$ suggest that there is little difference in the pre-trends of stock prices in countries with and without FXIs, potentially suggesting that the post-FOMC differential response of stock prices is driven causally by FXIs. To test if the effect of FXIs is large in a statistically significant manner, in panel (b), we estimate Equation 4 and plot the coefficient γ_h for all $h =\in [-5, 5]$. $\gamma_h > 0$ for $h > 0$ implies that FXIs can successfully mute the persistently negative balance sheet effects of US monetary shocks. In panels (c) and (d), we repeat a similar exercise for firms without dollar debt. The graph shows that the US monetary shock and FXIs have little effect on the stock price of firms without dollar debt. Finally, to compare the effect of FXIs on firms with and without dollar debt, we estimate Equation 5 for all $h =\in [-5, 5]$. Figure 5 plots the estimated coefficient θ_h. $\theta_h > 0$ for $h > 0$ suggests that the effect of FXIs is persistently greater for firms with dollar debt.

5.2 Mechanism: Exchange Rate

To further understand the balance sheet channel, we study the effect of FXIs on the exchange rate. Our previous results suggest that US monetary tightening without FXIs has a negative balance sheet effect on firms with dollar debt, but FXIs can mute this spillover. For this result to be true, it must be the case that a US monetary tightening depreciates local exchange rates when countries do not counter-intervene but do not depreciate them when they counter-intervene. This is because the local depreciation increases the repayment of US dollar debt in terms of local currency and tightens the balance sheet of firms with US dollar debt.[35]

To check this hypothesis, we estimate Equation 2, where now the dependent variable is replaced with the change in the log of the exchange rate in the country c between dates $t-1$ and $t+1$. The exchange rate is defined as the value of one US dollar in terms of local currency so that higher values imply an appreciation of the US dollar or a depreciation of local currency. $\beta > 0$ implies that a surprise tightening of US monetary policy depreciates the local exchange rate h days after the meeting. We control for the trend and standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, the one-month lagged policy rate, one-year lagged GDP, inflation, the trade balance over GDP ratio, the unemployment rate, and their interaction with the Fed funds rate shock.

In Table 6, columns (1) and (2) show the results for countries with and without intervention, respectively. If the local monetary authorities do not intervene, when the Fed unexpectedly hikes interest rates, the domestic currency depreciates in a statistically significant manner (by 2.25% in response to a 10bp surprise hike). However, if local policymakers counter-intervene in the FX market by selling the US dollar, the exchange rate remains flat around the FOMC meetings. To check that the effect of FXIs is large enough, in column (3), we estimate Equation 4 after replacing the dependent variable with a change in the exchange rate. Without interventions, a 10bp surprise hike in the Fed funds rate leads to a 2.01% exchange rate depreciation. However, if central banks counter-intervene by selling the US dollar, the depreciation is reduced by 2.02% compared to a scenario without any counter-interventions, and this difference is statistically significant. Thus, interventions offset the exchange rate depreciation caused by the Fed's surprise.

To study how the effect of FXIs accumulates over time, we re-estimate Equation 2 for all $h = \in [-5, 5]$. Figure 6, panel (a) plots the estimates of β_h coefficient. Before the FOMC meeting, there is little difference in exchange rates between countries with and without FXIs. However, while countries that do not counter-intervene by selling the US dollar experience persistent depreciation, those that counter-intervene do not experience depreciation. The depreciation builds up slightly over time, consistent with Roussanov and Wang (2023). Moreover, to compare the trends of exchange rates around FOMC meetings in countries with and without FXIs, panel (b) re-estimates the γ_h coefficient in Equation 4 for the exchange rate. $\gamma_h < 0$ for $h > 0$ implies that the exchange rate depreciates less when the central banks counter-intervene against the Fed compared to a no-intervention case.[36] These results suggest that FXIs are successful in stabilizing the exchange rate in response to unexpected monetary shocks, giving further support

[35]To take into account the possibility that the effect on stock price is driven by currency risk premia rather as opposed to the exchange rate, in Section 5.8, we control for the currency risk factors in the spirit of Lustig et al. (2011) and Verdelhan (2018). In Appendix A, to take into account the equity risk premia, we control for the standard risk factor measured by market beta, and the result on the balance sheet channel remains robust.

[36]The effect of FXIs is statistically significant one day after the interventions. This is potentially due to the difference in time zones. Since the United States is one of the most western countries in the world, the FOMC announcement does not affect the exchange rate in eastern countries, such as Japan, on the same date. The limitation of our research is that we do not have intra-day data on the exact timing of FXIs in each country.

to the balance sheet stabilization channel of FXIs for firms with dollar debt.

5.3 Expenditure Switching Channel

In the previous sections, we have shown that FXIs benefit firms with dollar debt by muting the negative balance sheet channel of US monetary tightening. However, a US tightening may also have other spillover effects, most importantly via exporting firms. On the one hand, depreciation induced by contractionary US monetary policy may increase foreigners' demand for exports due to lower relative prices (expenditure switching channel). On the other hand, a US monetary tightening may reduce US demand for goods and thus the demand for exports (a negative demand channel). If FXIs mute the depreciation-induced expenditure switching channel but do not mute the negative demand channel due to intertemporal substitution, we would expect FXIs to be costly for exporters.

To check this possibility, we study the effect of FXIs on exporters and non-exporters. In Figure 7, we conduct a similar exercise to Figure 4 for exporters and non-exporters. Interestingly, although we do find some suggestive evidence for expenditure switching channels, the effect is quantitatively small. Figure 7, panel (a) studies the stock price response to Fed hikes for exporters in countries with and without FXIs, respectively. When the Fed tightens, the stock price response for exporters increases without FXIs but decreases with FXIs. However, the magnitude of the stock price decline is small (3.2% at the trough in response to the 10bp US hike) and the statistical significance is low. In contrast, Figure 4 suggests that stock prices for firms with dollar debt decrease significantly without FXIs (9.0% at the trough), and FXIs mitigate this decline. Next, panel (b) plots the interaction coefficient between FXIs and the export indicator. We show that FXIs decrease the stock price response for exporters compared to cases without FXIs. However, the effect is statistically significant only two days after the FOMC announcement, and the significance disappears five days after the event. In contrast, Figure 4, panel (b) suggests that FXIs have an immediate positive impact on firms with dollar debt on the FOMC announcement date and the effect is persistent over time. Our estimates suggest that, although FXIs have the cost of mitigating expenditure switching channels for firms that export, the benefits for firms with US dollar debt are larger. Ultimately, it may depend on the composition of firms whether FXIs increase or decrease stock prices in the aggregate. For countries in which a large share of firms borrow in US dollars, the positive effect may dominate, but for countries with a large exporting sector, the negative effects could be substantial.

5.4 Debt Maturity

To further refine our identification strategy, we use the firms' debt maturity structure, which is arguably exogenous to both FXIs and monetary policy shocks. If firms happen to have dollar debt whose maturity is around unexpected Fed hikes, the cost of rolling over debt increases. However, if the debt does not mature around the FOMC events, the effect on rollover costs is negligible. Hence, FXIs that counteract Fed hikes should disproportionately benefit firms with dollar debt that matures around the FOMC announcement dates. Since the maturity structure is exogenous to exchange rate movement, the stock price response can potentially be interpreted causally.

To test this hypothesis, we divide the dollar debt into maturing and non-maturing dollar debt. Maturing dollar debt is defined as the debt whose repayment currency is the US dollar and which matures two quarters (six months) before or after the FOMC announcement date. Non-maturing dollar debt is defined as dollar debt that does not mature within a one-year window around the announcement. We redefine the dummy for dollar debt so that it takes one if firms have maturing dollar debt and zero if firms do not.

Table 7 shows the result. Column (1) takes the dummy for dollar debt regardless of maturity, as in column (3) of Table 5, and column (2) takes the dummy for maturity dollar debt as defined above. Column (1) shows that, without FXIs, a 10bp increase in the Fed funds rate leads to a 3.1pp decline in stock prices for firms with dollar debt (compared to those without dollar debt), while FXIs mitigate this decline by 3.2pp. However, column (2) shows that, for firms with maturing dollar debt, the same increase in the Fed funds rate leads to a 5.5pp decline in stock prices without FXIs and a 5.4% mitigation with FXIs, both of which are greater than the benchmark case. This suggests that the balance sheet channel of US monetary policy and FXIs is driven by the increased cost of debt rollover around the maturity date. For robustness, columns (3) and (4) redefine maturity dollar debt as the dollar debt that matures three quarters or one year around FOMC announcements and obtain a similar result.

5.5 Foreign Exchange Reserves

Central banks' foreign exchange (FX) reserves have increased significantly over the last decades. Figure 8 shows the volume of FX reserves and the FX reserves over GDP ratio in our sample of countries. In the 1990s, FX reserves were low (roughly 0.21 trillion US dollars), and countries had limited instruments to insulate themselves from US monetary spillovers. However, reserves have increased by a magnitude of around 18 since the 1990s, reaching a peak of 3.91 trillion dollars in 2021. The FX reserve-to-GDP ratio also grew from 4.3% in 1990 to a peak of 32.5% in 2020. So far in 2022, the tightening of US monetary policy has not yet had severe negative consequences for emerging market economies, raising the question of whether FXIs are more effective when countries have relatively large FX reserves, as they can sell off those accumulated reserves to prevent sudden depreciations of exchange rates during times of crisis.

To test this hypothesis, we study the effects of FXIs on exchange rates and stock prices in countries with heterogeneous degrees of FX reserves. We use annual data on total FX reserves in IMF International Financial Statistics.[37] We define large and small FX reserves if the volume

[37] The dataset provides total FX reserves at a country level, but the currency composition of reserves is only

of FX reserves is larger or smaller than the median, respectively.

In Table 8, columns (1) and (2) estimate Equation 4 for exchange rates in countries with large and small reserves, respectively. We find that, in countries with large FX reserves, a 10bp Fed hike leads to a 2.5% depreciation in the exchange rate, but the depreciation is fully stable when the country intervenes. However, in countries with small FX reserves, the effect of FXIs is reduced to 1.6% and it is statistically less significant. Similarly, columns (3) and (4) estimate Equation 5 for stock prices of firms based in countries with large and small reserves, respectively. An increase in the Fed funds rate leads to a decline in stock prices for firms with dollar debt relative to those without dollar debt. FXIs mitigate this balance-sheet spillover in countries with large FX reserves (4.2pp), but the effect is weaker in countries with small FX reserves (1.3pp). Columns (5) and (6) show this result is robust even after including country-date fixed effects. These results suggest that FX reserve accumulation plays a crucial self-insurance role in mitigating US monetary spillovers.

5.6 Currency Risk Hedging

In this section, we address the possibility that firms hedge their exchange rate risk to limit their exchange rate exposure. Unfortunately, detailed firm-level data on derivatives is not available. Hence, we approximate whether firms hedge their currency risk through a statistical approach. If firms have unhedged US dollar debt, a depreciation of the domestic currency against the US dollar, should decrease firms' future profits in domestic currency due to higher debt repayments. In contrast, if firms are fully hedged, either naturally due to revenues in US dollars, or financially through derivative positions, a depreciation should not affect their future profits, as the derivative positions or revenues increase proportionately with the depreciation of the domestic currency. To measure the degree of risk hedging, we, therefore, take the correlation between firms' stock price, accounting for future discounted profits, and the exchange rate over the sample period. A higher value of the exchange rate implies a local currency depreciation, so a positive (negative) correlation implies that firms' profits increase (decrease) when the local currency depreciates. We define hedged and unhedged firms as those whose stock price has a positive and negative correlation with the exchange rate, respectively. Table 9 shows the number of hedged and unhedged firms. Among 261 firms with dollar debt (row a), 64 firms (25%) have a positive correlation and 195 firms (75%) have a negative correlation, indicating that the majority of firms with dollar debt are unhedged against exchange rate risks. Among firms without US dollar debt, one would not expect the firms to have a strong negative correlation with a depreciation of the exchange rate, as debt repayments are not mechanically increasing with the depreciation. In fact, without US dollar debt, a depreciation may even increase profits through an expenditure switching channel. Among 3799 firms without dollar debt (row b), 2409

available at the world level. Iancu et al. (2022) and Ito and McCauley (2020) provide data on the currency composition of FX reserves. Since the currency composition data is not available for all of our sample countries, we use the total FX reserves data.

firms (63%) have a positive correlation with the depreciation, while 1378 firms (36%) have a negative one.

One might also expect that if firms with dollar debt are exporters, they are naturally hedged in terms of cash flows since a depreciation increases export revenues in terms of local currency. This is, in fact, true in our data. Table 9, row c shows that, out of 501 exporters, 462 out of 501 exporters (92%) are hedged. Among the firms with dollar debt, only four are exporters. Hence, our sample firms are unlikely to be naturally hedged against exchange rate depreciations, and our result on the dollar debt channel is mainly driven by firms without corresponding export revenues. Our results on FXIs and the stock market are robust even after controlling for exports and imports, as well as their interaction with Fed funds rate shocks. As a robustness check, Appendix A also controls for international sales and asset holdings, which are important sources of foreign currency revenues, and our main results do not change.

To check that our result is not driven by hedged firms, Table 10, column (1) re-estimates Equation 5 after excluding the hedged firms defined above. Column (2) excludes exporters, and column (3) excludes both hedged firms and exporters. Comparing the result with the benchmark case in Table 4, column (3), we find that our result is robust after eliminating the effect of hedging.

The limitation of our analysis is that we do not have data on firms' derivative use. For firms that perfectly hedge their currency risk, we would expect the stock price to be unaffected around FOMC announcements, similar to those firms with no US dollar debt. However, our result suggests that, without FXIs, the stock price of firms with dollar debt rather decreases. This suggests that our results are lower-bound estimates of the effect of FXIs since controlling for hedging would further strengthen the negative stock price spillover of US monetary shocks. Moreover, the effects would likely be small, as only a very small share of firms use derivatives. For instance, Casas et al. (2022) show that only 2.9% of Colombian firms use FX derivatives. We expect that increased data availability on hedging would further improve our estimates, which is left for future research.

5.7 Monetary Policy Expectations

When the Fed raises interest rates, emerging market central banks may follow suit raising interest rates to protect themselves from a depreciation, which adversely affects borrowers with foreign currency debt (Timmer 2018). Our high-frequency approach reduces the probability that domestic central bank policy rates are responding to the Fed with their domestic policy rate within the timeframe we consider. And, indeed, once we control for the daily policy rate our results remain unaffected, as the rate remains mostly unchanged shortly after the FOMC meeting. However, there remains a possibility that investors are expecting the domestic policy rate to increase in response to a contractionary US monetary policy shock, leading to higher domestic bond yields, with consequences for both the stock market and the exchange rate.

To test for this expectation channel, we control for the 3-month London Interbank Offered Rate (LIBOR) across countries, which is frequently used to measure carry trade returns in finance literature (Lustig et al. 2011; 2014, Du et al. 2018, Verdelhan 2018). The interbank rate is a forward-looking variable since it is fixed at the beginning of the contract period and reflects the banks' expected borrowing costs. The advantage of using the interbank rate is that it reflects daily changes in banks' expectations, while the monetary policy rate does not change on a daily basis since monetary policy committee meetings are held infrequently.

First, we test this forward-looking nature by regressing the changes in interbank interest rates on the Fed funds rate shocks. Next, we control for the interbank rates in both the first- and second-stage regressions and check the robustness of our results. In Appendix A, we show that while the interbank interest rate increases in response to contractionary US monetary policy shocks, the effect is rather small, and hence, controlling for this domestic monetary policy channel, our results remain unchanged.

5.8 Currency Risk Factors

A growing literature shows currency risk factors can explain a large part of monthly exchange rate variations, especially carry and the dollar (Lustig et al. 2011; 2014, Verdelhan 2018). The factors are constructed from portfolios of multiple currencies. The carry (slope) factor is the difference in currency excess returns between high minus low interest rate currencies. The dollar (level) factor is defined as the average excess return between the dollar and all other currencies. In this section, we test if including the dollar and carry factors changes the measure of unexpected FXI and the transmission mechanisms of FXI on the exchange rate and stock prices.

We use data from 36 currencies, including 16 advanced and 20 emerging economies' currencies, to construct the carry and dollar factors. We choose the currencies based on the standard literature on international finance (Lustig et al. 2011, Du et al. 2018, Verdelhan 2018, Cerutti and Zhou 2024).[38] First, we calculate the UIP excess return relative to the US dollar for 36 currencies using the spot exchange rate and 3-month interbank interest rate available in Bloomberg. We then sort currencies into six portfolios at the beginning of each month. Portfolio 1 consists of low-interest-rate currencies and Portfolio 6 consists of high-interest-rate currencies. The slope factor is the excess return of Portfolio 6 minus Portfolio 1. The dollar factor is the average currency excess return across all currencies. Formally, the 3-month ex-post

[38]The sample countries include Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Costa Rica, Czech Republic, Denmark, Euro area, Hong Kong, Hungary, India, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Russia, Saudi Arabia, Singapore, South Africa, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Arab Emirates, and United Kingdom. Among the 13 countries in our main sample with daily FXI data, 12 (except for Georgia) have interbank rate data available.

UIP deviation is defined as:

$$UIP^c_{t,t+90} = i^c_t - i^\$_t - (s_{t+90} - s_t),$$

where i^c_t and $i^\$_t$ are the 3-month interbank rates in currency c and the US dollar, respectively, and s_t are the spot exchange rates on date t. The carry and dollar factors are defined as:

$$Carry_{t,t+90} = \frac{1}{N_6}\sum_{c\in P_6} UIP^c_{t,t+90} - \frac{1}{N_1}\sum_{c\in P_1} UIP^c_{t,t+90},$$
$$Dollar_{t,t+90} = \frac{1}{N}\sum_{c} UIP^c_{t,t+90},$$

where P_1 and P_6 are the set of currencies in portfolios 1 and 6, N_1 and N_6 are the numbers of currencies in portfolios 1 and 6, and N is the number of all currencies.

We first re-estimate Equation (1) and estimate the effect of FXIs controlling for the carry and dollar factors. Since investors use currently available information to predict the exchange rate, we control for $Carry_{t-90,t}$ and $Dollar_{t-90,t}$ so that the factors only depend on the current and past exchange rates and interest rates. The R^2 increases slightly from 24% (Figure 2) to 25%, which implies that FXI remains largely unpredictable even after controlling for currency risk factors. Next, Figure 9 and Figure 10 reproduce the local projection results in Figure 4 and Figure 6 using this newly identified FXI. The key results on the stock price and exchange rate remain unchanged.

5.9 Robustness Checks

Appendix A provides various robustness checks to confirm our result, including intensive and extensive margins of dollar debt, alternative specification for unexpected counter-interventions, size of the interventions, sterilized interventions, including periods with zero Fed funds rate shock, excluding global financial crisis and zero lower bound on the interest rate, controlling for risk factor, international sales and asset holdings, and currency denomination of stock price. Overall, the key economic implication on the balance sheet channel of FXIs under various settings.

6 Conclusion

US monetary policy has significant spillover effects on other countries. In this paper, we investigate those mechanisms of US monetary policy using a high-frequency approach that allows us to understand the effects and channels through which monetary policy affects foreign economies more directly. When countries do not intervene and US monetary policy unexpectedly tightens, domestic exchange rates depreciate against the US dollar and stock prices fall, disproportionately so for firms that borrow in US dollars, mirroring the experience of earlier episodes, such as the 1990s or during the taper tantrum.

In the 1990s, central bank holdings of foreign exchange reserves were low, and they had limited ability to protect themselves against the spillovers of US monetary policy. However, since the 1990s to today, FX reserves have grown by a magnitude of around 16, as shown in Figure 8, likely in anticipation that those reserves can act as a self-insurance mechanism.

In this paper, we have shown that intervening against the Fed mitigates exchange rate depreciation and stock price declines for firms, but only those with US dollar debt. When US monetary policy tightens and central banks counter-intervene, changes in exchange rates and stock prices for firms with and without US dollar debt remain statistically and economically insignificant. These results suggest that intervening against the Fed mutes the balance sheet channel of exchange rates triggered by US monetary policy and can protect countries from exposure to the Global Financial Cycle.

Overall, countries today should be less vulnerable to US monetary policy than in previous tightening cycles. However, some countries' reserves remain low, especially those of low-income countries, and their ability to protect themselves from the global financial cycle remains limited.

While we do not study the optimality of the policy interventions, in theory, intervening against the Fed can be optimal if US monetary policy triggers a risk appetite shock (Basu et al. 2020), pecuniary externalities (Fanelli and Straub 2021), or local inflationary pressures (Yago 2024). Further understanding general equilibrium implications and the optimality of policies is an important agenda for future research.

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Table 1: Summary Statistics: FFR shock, exchange rate, and stock price

	Mean	Med	S.D.	p5	p95	Obs
(1) FFR shock (basis point)	0.015	-0.48	1.81	-3.1	3.75	90
(2) Exchange rate (% change, $\log(e_{c,t+1}) - \log(e_{c,t-1})$)	0.04	0	0.72	-1.37	1.29	875
(3) Stock price (% change, $\log(p_{i,t+1}) - \log(p_{i,t-1})$)	0.02	0	3.48	-5.61	5.71	124,559

Note: t is the FOMC announcement date. $e_{c,t+1}$ is the exchange rate in country c at date $t+1$. A higher $e_{c,t+1}$ implies the appreciation of the US dollar or depreciation of the local currency. $p_{i,t+1}$ is the stock price of firm i at date $t+1$. The stock price is in terms of local currency. Observations (column 6) are the number of FOMC announcement dates (row 1), country × FOMC announcement dates (row 2), and firm × FOMC announcement dates (row 3).

Table 2: Interventions around 90 FOMC event dates in sample

	Frequency			Volume (Millions USD)		Periods
Country	Buy USD	Sell USD	Counter	Mean	Median	
	(1)	(2)	(3)	(4)	(5)	(6)
Argentina	59	45	15	86	52	2003-2019
Australia	0	2	2	19	19	2000-2019
Brazil	11	1	8	165	114	2009-2019
Chile	6	0	4	0.091	0.096	2008-2019
Colombia	34	2	18	19	17	2000-2019
Costa Rica	34	32	3	12	8.1	2006-2019
Georgia	9	12	15	3.9	3.1	2009-2019
Hong Kong	83	58	13	70	12	2000-2019
Japan	4	0	1	1115	1493	2000-2019
Mexico	0	24	7	27	22	2000-2011
Peru	72	51	26	23	4.3	2000-2019
Switzerland	0	0	0	0	0	2000-2001
Turkey	1	1	0	5.9	5.9	2002-2019
Total	312	229	111	57	17	2000-2019

Note: Columns (1) and (2) show the frequencies of buying and selling interventions. "Buying interventions" are defined as occurring when central banks buy the US dollar at least once between date t and $t+5$, where t is the FOMC announcement date; "selling interventions" are defined analogously. Column (3) shows the frequency of counter-interventions, defined as occurring when the central bank sells the US dollar at least once and never buys the currency again between the dates t and $t+5$ after the Fed funds rate increases at date t; vice versa when the Fed funds rate decreases. Columns (4) and (5) show the mean and median intervention volumes in terms of millions of US dollars between date t and $t+5$ over all FOMC announcement dates t, respectively, conditioning on intervening at least once between date t and $t+5$. Column (6) shows the sample period when FXI data is available.

Table 3: Sample Firms

Country	Total	Dollar Debt	Country	Total	Dollar Debt
Argentina	34	25	Colombia	22	9
Australia	1190	126	Hong Kong	480	42
Brazil	68	21	Japan	2216	4
Chile	3	1	Mexico	48	33
			Total	4060	261

Note: The table shows the number of all firms and firms with Dollar debt in each country. For firms with Dollar debt, the table shows the number of firms which issued Dollar debt at least once during the sample period.

Table 4: Stock Price: Baseline Regression

(a) Without Intervention

Dependent variable:	ΔStock Price$_{i(c),t}$			
	Dollar Debt	No Dollar Debt	Both	
	(1)	(2)	(3)	(4)
FFR Shock$_t$	-0.660***	-0.094**	-0.097**	
	(0.117)	(0.045)	(0.045)	
FFR Shock$_t$ $\times$ Dollar Debt$_{i(c),y-1(t)}$			-0.314***	-0.259***
			(0.087)	(0.071)
R^2	0.093	0.032	0.031	0.083
N	1,926	103,155	105,114	105,114
Firm FE	✓	✓	✓	✓
Country $\times$ Date FE				✓

(b) With Intervention

Dependent variable:	ΔStock Price$_{i(c),t}$			
	Dollar Debt	No Dollar Debt	Both	
	(1)	(2)	(3)	(4)
FFR Shock$_t$	-0.217**	-0.149***	-0.158**	
	(0.105)	(0.056)	(0.061)	
FFR Shock$_t$ $\times$ Dollar Debt$_{i(c),y-1(t)}$			-0.001	-0.033
			(0.042)	(0.035)
R^2	0.114	0.209	0.194	0.270
N	1,258	9,915	11,178	11,178
Firm FE	✓	✓	✓	✓
Country $\times$ Date FE				✓

Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 5: Stock Price: Effect of Intervention

Dependent variable:	ΔStock Price$_{i(c),t}$			
	Dollar Debt	No Dollar Debt	Both	
	(1)	(2)	(3)	(4)
FFR Shock$_t$	-0.647***	-0.093**	-0.096**	
	(0.116)	(0.045)	(0.045)	
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	0.449***	-0.035	-0.042	
	(0.130)	(0.082)	(0.079)	
FFR Shock$_t$ $\times$ Dollar Debt$_{i(c),y-1(t)}$			-0.310***	-0.259***
			(0.083)	(0.070)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$ $\times$ Dollar Debt$_{i(c),y-1(t)}$			0.324***	0.232***
			(0.093)	(0.067)
R^2	0.091	0.033	0.033	0.086
N	3,206	113,534	116,754	116,754
Firm FE	✓	✓	✓	✓
Country $\times$ Date FE				✓

Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Intervention$_{c,t}$ is an indicator that takes one if there is an unexpected counter-intervention and zero otherwise. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 6: Exchange Rate: Baseline Regression

Dependent Variable:	ΔExchange Rate$_{c,t}$		
	No Intervention	Intervention	Both
	(1)	(2)	(3)
FFR Shock$_t$	0.225***	0.004	0.201**
	(0.069)	(0.021)	(0.072)
Intervention$_{c,t}$			0.266
			(0.155)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$			-0.202**
			(0.072)
R^2	0.108	0.083	0.084
N	418	417	836
Country FE	✓	✓	✓

Note: ΔExchange Rate$_{c,t}$ is the change in the log of the exchange rate from date $t-1$ to $t+1$, where t is the FOMC announcement date. The exchange rate is defined as the value of the US dollar in terms of local currency, and a higher value implies a depreciation of the local currency. FFR Shock$_t$ is the Fed funds rate shock in basis points. Intervention$_{c,t}$ is an indicator that takes one if there is an unexpected counter-intervention and zero otherwise. We control for the trend and standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, the one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the country and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 7: Stock Price: Maturity of Dollar Debt

Dependent variable:	ΔStock Price$_{i(c),t}$			
	Benchmark	Matures 2Q	Matures 3Q	Matures 1Y
	(1)	(2)	(3)	(4)
FFR Shock$_t$	-0.103*	-0.111**	-0.109**	-0.109**
	(0.052)	(0.053)	(0.053)	(0.053)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	-0.035	-0.026	-0.028	-0.028
	(0.094)	(0.092)	(0.092)	(0.093)
FFR Shock$_t$ $\times$ Dollar Debt$_{i(c),y-1(t)}$	-0.310***	-0.552**	-0.660***	-0.585***
	(0.103)	(0.228)	(0.176)	(0.132)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$ $\times$ Dollar Debt$_{i(c),y-1(t)}$	0.326**	0.540*	0.564**	0.560***
	(0.127)	(0.318)	(0.279)	(0.174)
R^2	0.033	0.033	0.033	0.033
N	116,757	116,757	116,757	116,757
Firm FE	✓	✓	✓	✓

Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. In column (1), the dummy takes one for dollar debt regardless of maturity. In column (2), (3), and (4), the dummy takes one if firms have dollar debt and the dollar debt matures two quarters, three quarters, and one year around the FOMC announcement date, respectively. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 8: FX Reserves

Dependent variable:	ΔExchange Rate$_{c,t}$		ΔStock Price$_{i(c),t}$			
FX reserve:	Large	Small	Large	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
FFR Shock$_t$	0.252***	0.122	-0.075	-0.126		
	(0.065)	(0.071)	(0.067)	(0.094)		
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	-0.298***	-0.161*	-0.108	0.162		
	(0.089)	(0.080)	(0.079)	(0.143)		
FFR Shock$_t$ $\times$ Dollar Debt$_{i(c),y-1(t)}$			-0.387**	-0.261***	-0.352***	-0.230***
			(0.151)	(0.086)	(0.108)	(0.079)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$ $\times$ Dollar Debt$_{i(c),y-1(t)}$			0.418**	0.137	0.317***	0.201*
			(0.172)	(0.112)	(0.118)	(0.102)
R^2	0.121	0.149	0.053	0.051	0.109	0.098
N	422	413	90,860	25,880	90,860	25,880
Country FE	✓	✓				
Firm FE			✓	✓	✓	✓
Country $\times$ Date FE					✓	✓

Note: Columns (1) and (2) show the results for country-level exchange rates, and columns (3) to (6) show the results for firm-level stock prices. ΔExchange Rate$_{c,t}$ is the change in the log of the exchange rate from date $t-1$ to $t+1$, and ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Intervention$_{c,t}$ is an indicator that takes one if there is an unexpected counter-intervention and zero otherwise. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. Large and small FX reserves are defined so that the volume of FX reserves is larger and smaller than the median, respectively. In columns (1) and (2), we control for the trend and standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with the Fed funds rate shock. In columns (3)-(6), we control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 9: Stock Price: Numbers of Hedged and Unhedged Firms

	(1) Total firms	(2) Hedged firms Corr(exchange, stock) > 0	(3) Unhedged firms Corr(exchange, stock) < 0
(a) Dollar Debt	261	64	195
(b) No Dollar Debt	3709	2409	1378
(c) Export	501	462	38
(d) No Export	3559	2011	1535

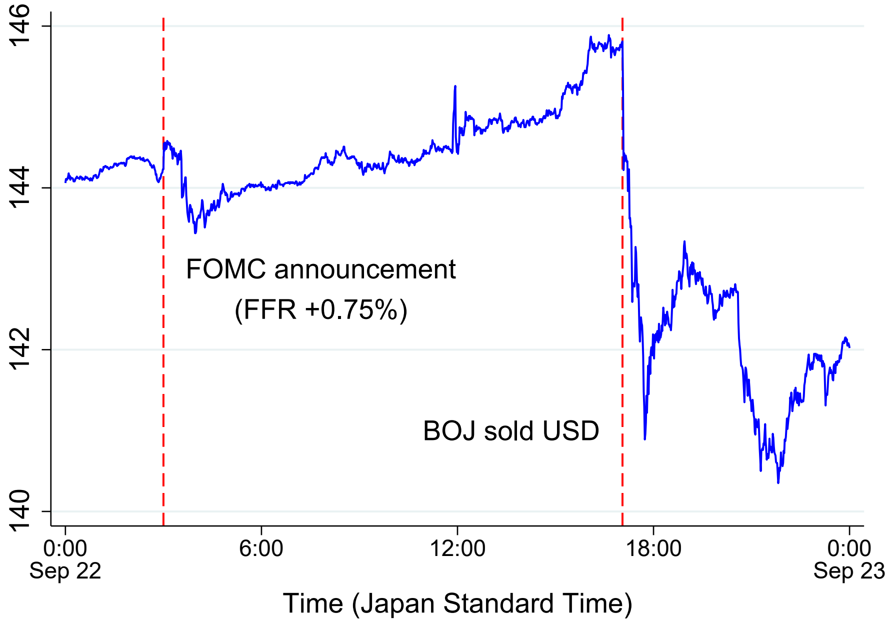
Note: the table shows the number of hedged and unhedged firms. Hedged and unhedged firms are defined as those whose stock price has positive and negative correlation with the exchange rate, respectively. The stock price is in terms of local currency. The exchange rate is defined as the value of dollar in terms of local currency so that higher value of exchange rate implies local depreciation. Rows (a) and (b) are firms with and without dollar debt and (c) and (d) are firms with and without exports. Column (1) is the total number of firms and (2) and (3) are hedged and unhedged firms, respectively.

Table 10: Stock Price: Exclude Hedged Firms

	(1)	(2)	(3)
FFR Shock$_t$	-0.111*	-0.104**	-0.111*
	(0.064)	(0.051)	(0.064)
FFR Shock$_t$ × Intervention$_{c,t}$	-0.054	-0.025	-0.040
	(0.115)	(0.093)	(0.116)
FFR Shock$_t$ × Dollar Debt$_{i(c),y-1(t)}$	-0.293***	-0.318***	-0.297***
	(0.101)	(0.107)	(0.104)
FFR Shock$_t$ × Intervention$_{c,t}$ × Dollar Debt$_{i(c),y-1(t)}$	0.288***	0.333**	0.281**
	(0.103)	(0.146)	(0.127)
R^2	0.032	0.033	0.032
N	49,665	101,768	48,912
Excluding Hedged Firms	✓		✓
Excluding Exporters		✓	✓

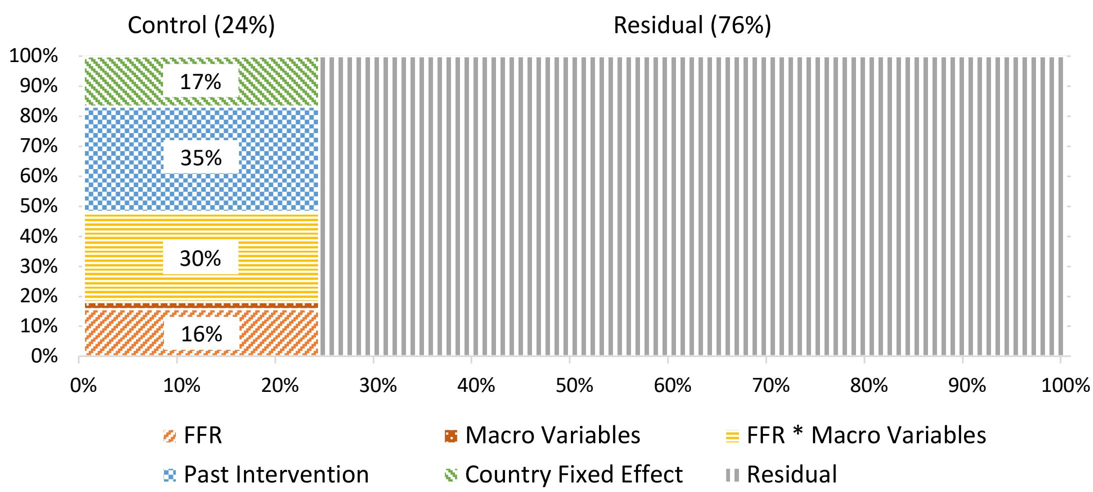
Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Column (1) excludes hedged firms, whose stock price has a positive correlation with the exchange rate. Column (2) excludes exporters. Column (3) excludes both hedged firms and exporters. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Figure 1: Spot Exchange Rate: US Dollar to Japanese Yen



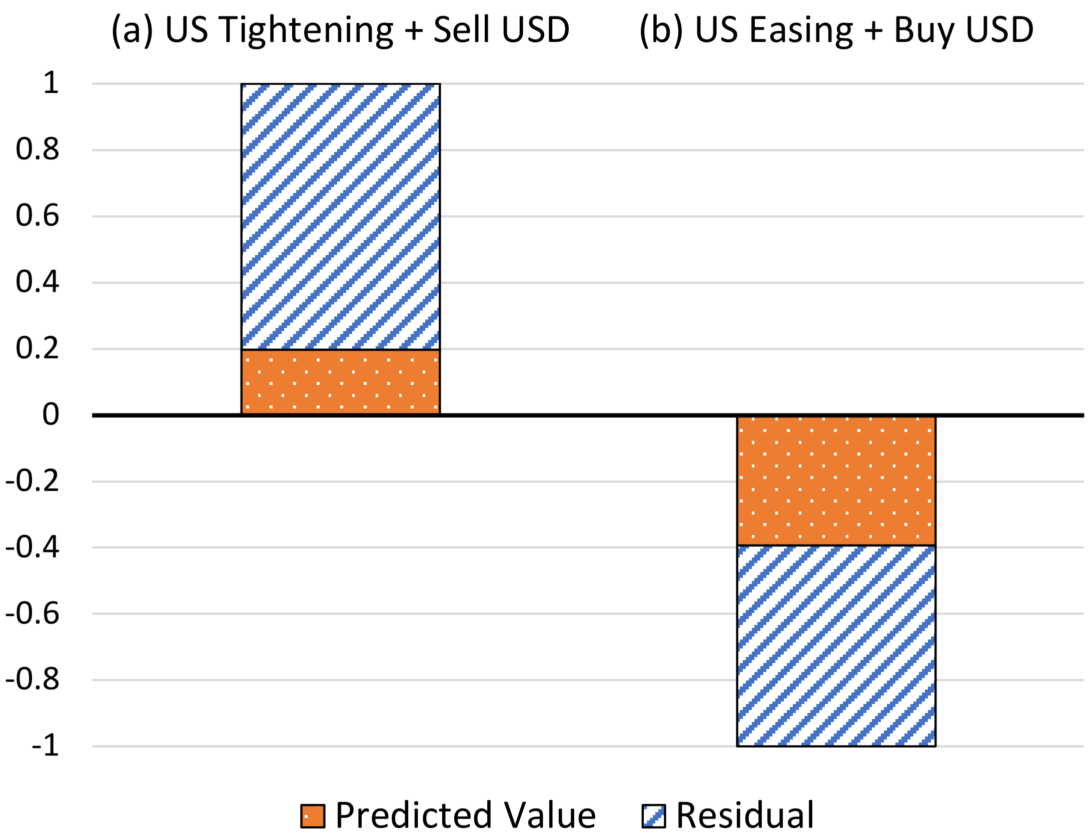
Note: The figure reports the minute-by-minute US dollar to Japanese yen spot exchange rate on September 22, 2022. The exchange rate is defined as the value of one US dollar in terms of yen, and a higher value implies the appreciation of the dollar or depreciation of the Japanese yen. Source: Datastream.

Figure 2: Variance Decomposition for Counter-Intervention



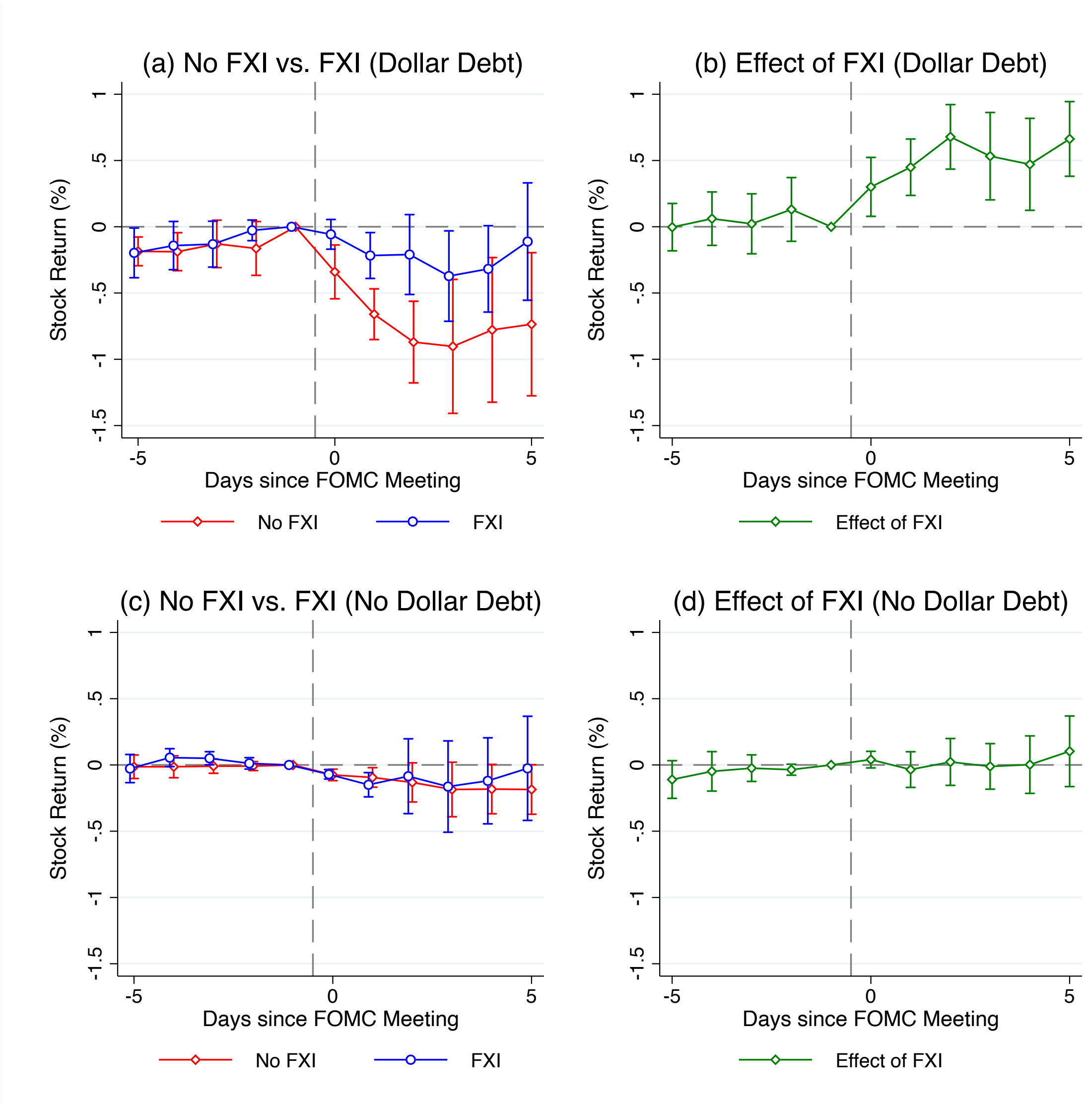
Note: The figure shows the results for variance decomposition for Equation (1). We control for the Fed funds rate shock, one-month lagged policy rate, one-year lagged GDP, CPI inflation rate, trade balance over GDP ratio, unemployment rate, their interaction with the Fed funds rate shock, and FXIs before the FOMC event dates. We include country fixed effect.

Figure 3: Example for Estimating Policy Rule



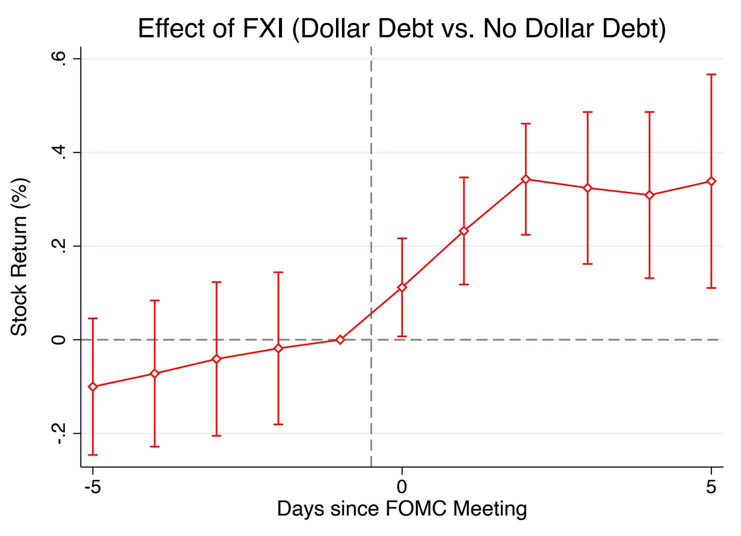
Note: The figure shows the result for the variance decomposition for Equation (1). Column (a) shows the result for a US monetary tightening and US dollar sales intervention by the Reserve Bank of Australia on November 15, 2000. Column (b) shows the result for a US monetary easing and US dollar purchase intervention by the Central Bank of Argentina on March 22, 2005.

Figure 4: Stock Price: Difference-in-Difference



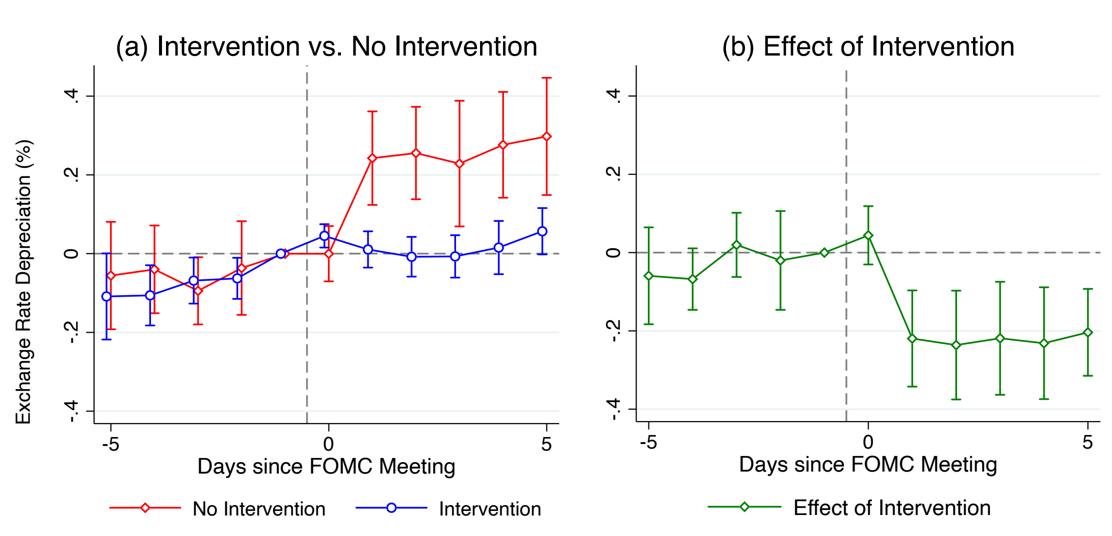
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices. See Equations 2 and 4 for the exact specifications. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are double clustered at the firm and date level. The confidence interval is 90%.

Figure 5: Stock Price: Triple Interaction



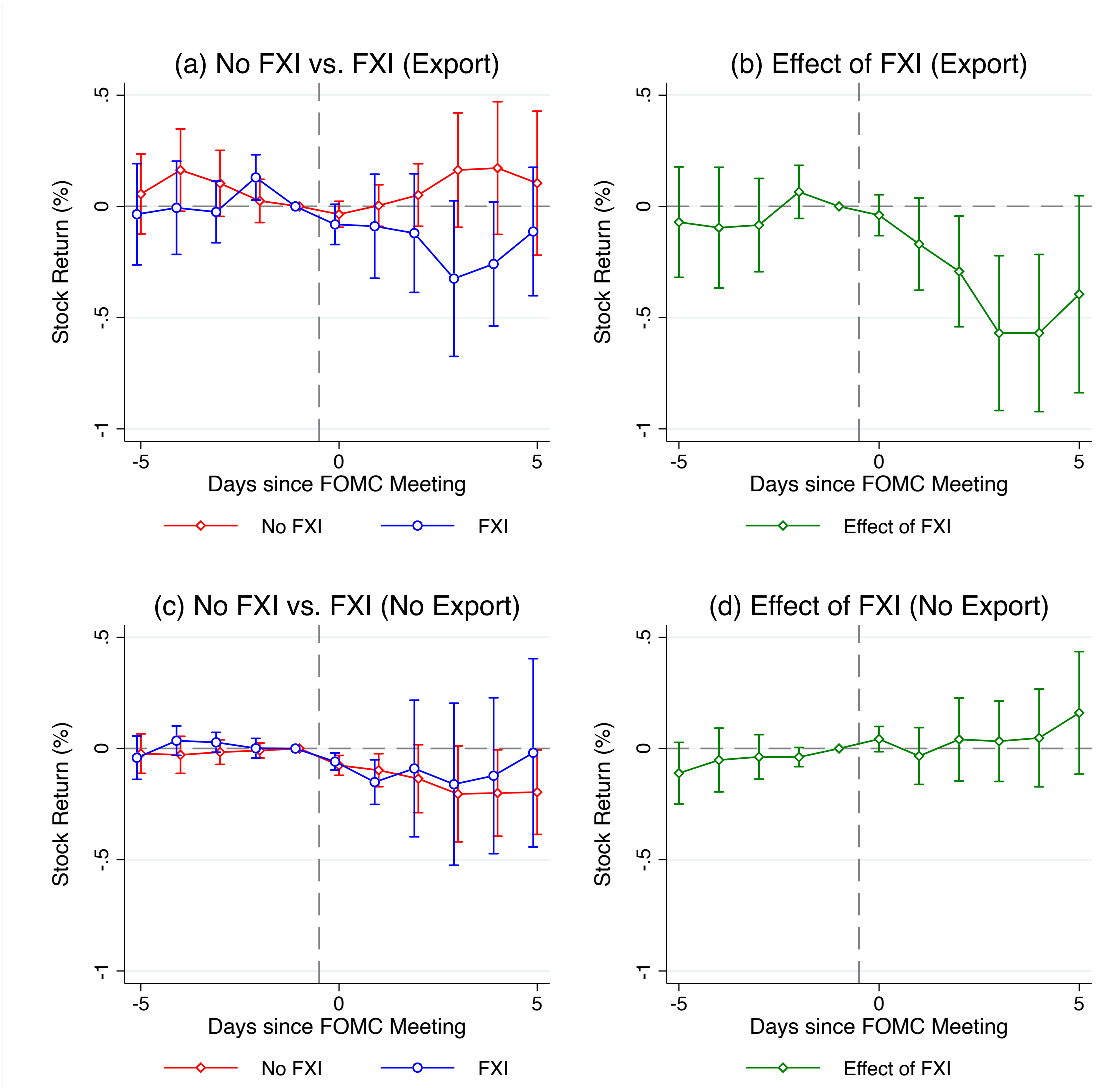
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices. See Equation 5 for the exact specifications. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The confidence interval is 90%.

Figure 6: Exchange Rate: Difference-in-Differences



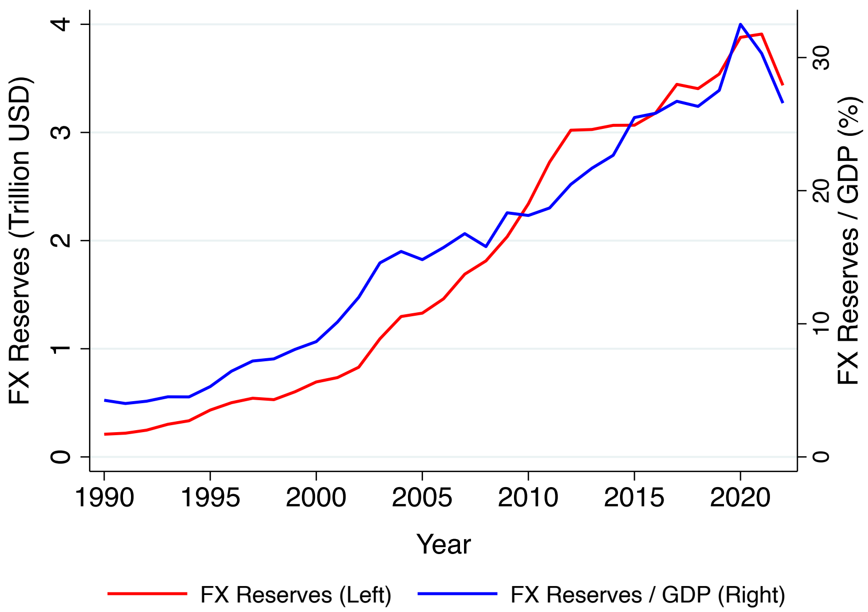
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on exchange rates. See Equation 4 for the exact specification. The exchange rate is defined as the value of the US dollar in terms of local currency, and a higher value implies a depreciation of the local currency. We control for the standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with the Fed funds rate shock. Standard errors are double clustered at the country and date level. The confidence interval is 90%.

Figure 7: Stock Price: Expenditure Switching Channel



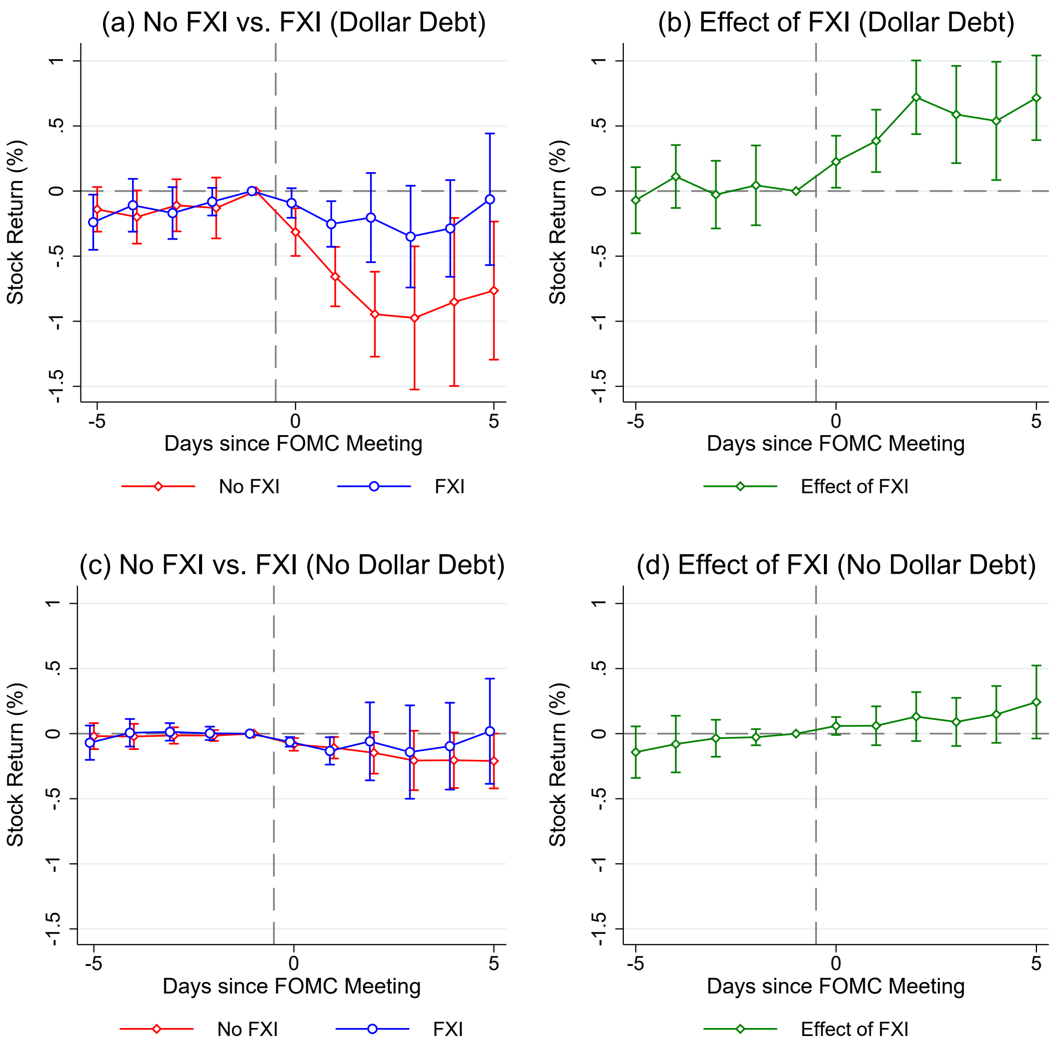
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices for exporters and non-exporters. See Equations 3 and 5 for the exact specifications. We control for one-year lagged dollar debt, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are double clustered at the firm and date level. The confidence interval is 90%.

Figure 8: Foreign Exchange Reserves in Sample Countries



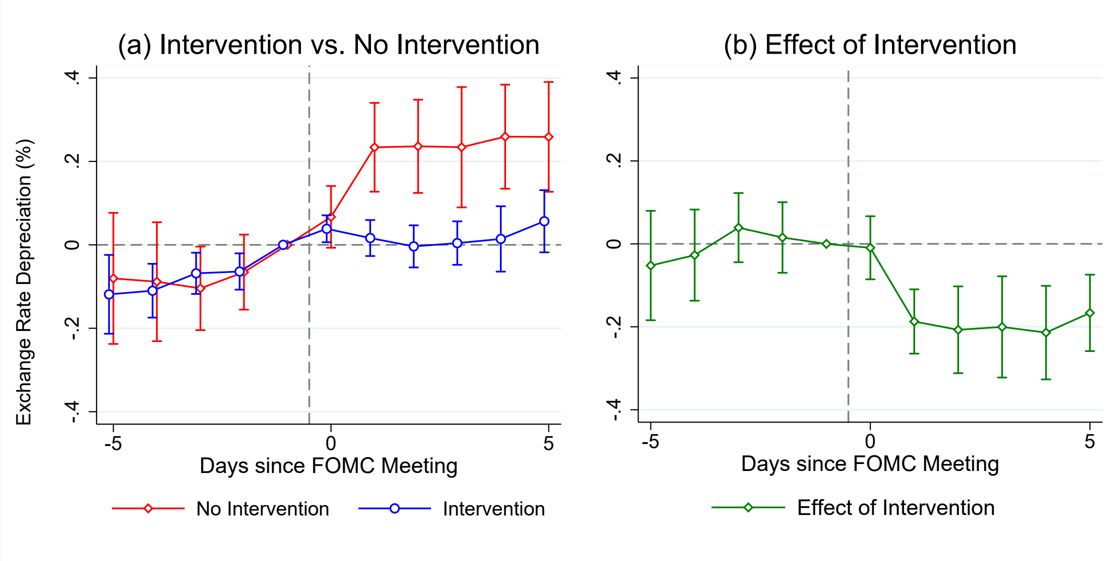
Note: The figure reports the volume of foreign exchange (FX) reserves (left) and the FX reserves over GDP ratio in our sample of 13 countries. For the FX reserves over GDP ratio, we took the ratio of total FX reserves over total GDP in our sample countries. Source: IMF International Financial Statistics.

Figure 9: Stock Price: Carry and Dollar Factors



Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices. See Equations 2 and 4 for the exact specifications. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. We control for carry and dollar factors in the first-stage regression. Standard errors are double clustered at the firm and date level. The confidence interval is 90%.

Figure 10: Exchange Rate: Carry and Dollar Factors



Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on exchange rates. See Equation 4 for the exact specification. The exchange rate is defined as the value of the US dollar in terms of local currency, and a higher value implies a depreciation of the local currency. We control for the standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with the Fed funds rate shock. We control for carry and dollar factors in the first-stage regression. Standard errors are double clustered at the country and date level. The confidence interval is 90%.

Internet Appendix

A Robustness Checks

This section provides robustness checks to test whether our results are robust and confirm the balance sheet channel of FXI. In Tables A1 and A2, we reestimate Equation 5 for stock prices under various alternative settings. The negative coefficient on $FFR_t \times USD_{i(c),y-1(t)}$ implies a balance sheet channel of US monetary policy shocks, while the positive coefficient on $FXI_{c,t} \times FFR_t \times USD_{i(c),y-1(t)}$ implies that FXIs can mute the balance sheet channel. Similarly, in Table A3, we reestimate Equation 4 after replacing the dependent variable with exchange rate depreciation. The positive coefficient on FFR_t implies that the US tightening depreciates the local exchange rate, while the negative coefficient on $FFR_t \times FXI_{c,t}$ implies that FXIs mitigate this depreciation. Overall, the results remain qualitatively the same in various settings.

A.1 Intensive and Extensive Margins of dollar debt

The baseline result on the balance sheet channel focuses on whether firms borrow in US dollars (extensive margin). However, in reality, the effect of interventions may also depend on how much they borrow in dollars (intensive margin). Firms with large amounts of dollar debt would be more exposed to currency risk than those with small amounts of dollar debt. To test this intensive margin, we define an indicator variable for "low dollar debt," which takes one if the firms' share of dollar debt over total debt is larger than the 25th percentile (conditional on having a positive amount of dollar debt) and zero otherwise (including firms with dollar debt lower than the 25th percentile and firms without dollar debt).[39] Similarly, we define dummies for "high dollar debt" for firms with a median dollar debt share, and "all dollar debt" for firms that only issue dollar debt. In our sample, around 29% of our firm-date observations are driven by firms only with dollar debt. This definition can capture the right tail of the distribution of the dollar debt share across firms.

Table A1 shows the result. Comparing columns (1)-(3), we find that both the balance sheet channel of US monetary policy shocks (negative coefficient γ on $FFR_t \times USD_{i(c),y-1(t)}$) and FXI's mitigation of monetary spillovers (positive coefficient θ on $FXI_{c,t} \times FFR_t \times USD_{i(c),y-1(t)}$) are the strongest for firms with high dollar debt ($\gamma = -0.345,\ \theta = 0.468$) and the weakest for those with low dollar debt ($\gamma = -0.303,\ \theta = 0.293$).

Moreover, instead of a dummy variable for large dollar debt, we take the continuous share of dollar debt over total debt. The dollar debt share is standardized so that one unit of dollar debt share corresponds to one standard deviation (around 12.2%). Column (4) shows that when the share of dollar debt is higher by one standard deviation, a 10bp increase in the Fed funds rate leads to a 0.43% decline in stock price without FXI. However, when the central bank intervenes,

[39] We also check that the result is robust with a continuous measure of dollar debt over total debt.

this decline is mitigated by 0.44%, entirely offsetting the effect of the US monetary shock. These results imply that US monetary shocks and FXIs have a large effect, especially on firms with large dollar debt.

A.2 Alternative Definitions for Unexpected Counter-Intervention

We study different criteria for defining unexpected counteracting interventions. In the benchmark case, counteracting interventions are defined so that, if the Fed funds rate increases on date t, central banks sell the US dollar at least once and never buy the US dollar between dates t and $t+5$, and vice versa when the Fed funds rate decreases. Then, we estimate Equation 1 and define unexpected counter-interventions if the residual is larger than its median in absolute value. While we use this definition in the benchmark results to simplify the interpretation, we also try alternative definitions for an unexpected counter-intervention.

First, we define counter-interventions as occurring when the central banks' average net sales of US dollars between dates t and $t+5$ are positive in case the Fed funds rate increases on date t, and vice versa when the Fed funds rate decreases. Second, counter-interventions are defined as unexpected if the residual from estimating Equation 1 is larger than the 75 percentile rather than the median in absolute value. Third, we use the volume of FXIs in terms of the FXI-over-GDP ratio in the first-stage regression (Equation 1), instead of using the counter-intervention dummy. We winsorized the top and bottom 5% of the FXI-over-GDP ratio. This removes the estimation bias when using a 0-1 dummy on the left-hand side of Equation 1. Columns (1)-(3) of Tables A2 and A3 show the results under these four alternative definitions. Comparing these findings with column (3) of Tables 4 and 6, we confirm our results on stock prices and exchange rates to be robust. Without FXI, a US monetary tightening shock depreciates the exchange rate and reduces the stock price for firms with dollar debt, but FXIs mitigate this effect.

A.3 Size of Intervention

Our baseline specification is whether central banks counter-intervene against unexpected Fed hikes or not. However, as shown in Table 2, the size of FXIs is heterogeneous across countries. We will test whether our main result holds even if we focus on relatively large FXIs and exclude relatively small FXIs. For each country and FOMC event date, we first calculate the average net purchase of the US dollar over the GDP ratio between t and $t+5$, where t is the FOMC event date. We then define large and small FXIs if the average net purchase is larger or smaller than the 25 percentile in absolute value, respectively. We then exclude small FXIs from our sample. Column (4) of Tables A2 and A3 shows that our result is robust even after focusing on large FXIs.

A.4 Sterilized Intervention

We further investigate the effect of sterilized intervention. Sterilization implies that central banks conduct an open market operation to offset the effect of FXIs on the domestic financial market. We control for daily monetary policy rates to separate the effect of monetary policy and focus on the FX purchases or sales by central banks.[40] In the benchmark result, we use monthly data on policy rates since the monthly data are available for all sample countries, but daily data are not. In this section, we instead use the daily policy rate in BIS statistics for a subsample of countries where the data is available. We control for daily policy rates in the first-step and second-step regressions. Column (5) of Tables A2 and A3 shows that our result is robust after controlling for daily policy rates.

A.5 FOMC Event Dates with Zero FFR Shocks

In the baseline analysis, we used 90 FOMC event dates with nonzero changes in the Fed funds rate, since our main focus is the counteracting interventions against unexpected changes in US monetary policy. Here, we also include 46 additional FOMC event dates with zero changes in the Fed funds rate. Column (6) of Tables A2 and A3 shows that our result is robust even after including these dates.

A.6 Excluding Special Periods

We check the possibility that our result is affected by a particular period. Column (7) of Tables A2 and A3 excludes the global financial crisis (between 2007 and 2009) and column (8) excludes the period with zero lower bound on the interest rate (policy rate is below or equal to zero) and our result is robust.

A.7 Monetary Policy Expectation

As discussed in Section 5.7, we use a 3-month interbank interest rate to take into account the expectation channel of domestic monetary policy. First, to test the forward-looking nature of the interbank rate, we estimate Equation 2 across all FOMC announcement dates, where we replace the left-hand side with the change in the interbank interest rate. The data source is Bloomberg. Figure A5 shows that in response to a 1bp Fed funds rate shock, the interbank rate increases by around 0.3pp in 2-5 days. This suggests that investors revise their expectations, predicting that the domestic monetary condition will also tighten. Next, in column (9) of Tables A2 and A3, we control for the interbank rates in both first- and second-stage regressions and

[40] We do not have information on whether the interventions are sterilized or unsterilized. As discussed in Fratzscher et al. (2023), given that FXIs are a distinct policy tool from the interest rate, it is reasonable to assume that interventions in our sample are generally sterilized.

confirm the results for stock price and exchange rate are robust. This suggests that the monetary policy expectation channel is not responsible for the results.

As an alternative measure for monetary policy expectation, we control for the change in domestic government bond yield, which reflects the expectation of the domestic monetary policy rate. The data source is Global Financial Data. We use daily data on 5-year government bond yield as a benchmark, which is available for many of our samples. If the data is not available, we complement the data by daily 10-year bond yield or weekly or monthly 5-year bond yield. In column (10) of Tables A2 and A3, we control for government bond yield as well as its interaction with Fed funds rate shock, local monetary policy rate, and FXI and the results remain robust.

A.8 Market Beta

We take into account the possibility that the effect of the FOMC announcement on stock prices is driven by risk premia as opposed to the exchange rate. To measure the standard risk factor, we define the market beta as $\beta_m = \text{cov}(R_{i(c)}, R_c)/\text{var}(R_c)$, where $R_{i(c)}$ is the stock return of firm i located in country c and R_c is the aggregate stock market index in country c. In Table A2, column (11), we control for the market beta and its interaction with Fed funds rate shock, and the result is robust.

A.9 Controlling for International Sales and Asset Holdings

In the baseline results on stock prices, we control for exports and imports because they affect firms' foreign currency revenue and cost. Other factors potentially affect firms' foreign currency revenue, including international sales and international assets, as firms with international sales or assets may benefit from a domestic currency depreciation. To take this into account, we control for the one-year lagged international sales over the total sales ratio and the international assets over the total asset ratio. The data is available in Worldscope. Table A2, column (12) shows the result is robust after including these additional controls.

A.10 Currency Denomination of Stock Prices

In the baseline analysis, the firm's stock price is denominated in local currency. In this section, we denominate the stock price in US dollars so that changes in exchange rates affect the valuation of stock prices. When the Fed funds rate increases, not only do stock prices decrease for firms with dollar debt, but the exchange rate depreciates against the dollar as well. Hence, we expect that the stock price in terms of the US dollar decreases more than the one denominated in local currency. This implies that firms with dollar debt are riskier investment opportunities for US international investors compared to local investors. Table A2, column (13) shows that when the stock price is denominated in the US dollar, a 10bp Fed tightening without FXIs decreases the relative stock price for firms with dollar debt by 3.8bp, while FXIs mitigate this decline by

3.8bp. Those effects are greater than the benchmark case in Table 4, column (3), where the stock price is denominated in local currency.

A.11 Other Robustness Tests

We conduct several other robustness tests. First, to take into account the difference in the number of firms with dollar debt across countries, we weight the regression by the number of firms with dollar debt in each country. In Figure A1, we reproduce Figure 4, panels (a) and (b) after weighting the regression by $1/n_{i(c)}$, where $n_{i(c)}$ is the number of firms with dollar debt in country c where firm i belongs. The result is qualitatively similar to the benchmark case.

Next, to address the concern that our result is driven by one particular country, we exclude each sample country from regression and show the result is robust. Each line in Figure A2, panels (a) and (b) show the estimates of Equations 2 after excluding each country from our sample. Without FXI, Fed funds hike leads to a decline in stock price for firms with dollar debt (panel a), while the stock price remains stable with FXIs (panel b). Next, Figure A2, panel (c) shows the estimates of Equations 4 after excluding each country from our sample. We learn that there is a positive difference in stock price response between the cases without and with FXI. These results are consistent with the benchmark case in Figure 4. Figure A3 conducts a similar exercise for exchange rate. Panels (a) and (b) show that the exchange rate depreciates after Fed funds hike without FXI, while it remains stable with FXI. Figure A3, panel (c) shows the difference in exchange rate responses without and without FXI. These results are consistent with the benchmark case in Figure 6.

B Data Construction

This section provides the data definition and cleaning procedure. The firm-level data on fundamentals and balance sheets, the variable definitions, and cleaning procedures follow the standard literature on monetary policy and corporate balance sheet risk, for example, Ottonello and Winberry (2020). The cleaning procedure of Capital IQ data follows Kim et al. (2020).

B.1 Data Definition

- *Leverage:* the ratio of total debt over total assets.
- *Share of dollar debt:* the ratio of the total due amount of dollar debt (the sum of due amounts of debt instruments whose repayment currency is the U.S. dollar) over the total due amount of debt denominated in all currencies.
- *Size:* total assets, which are denominated in local currency and deflated by the consumer price index (CPI).

- *Liquidity:* the ratio of cash and short-term investments over total assets.
- *Age:* years after the incorporation date.
- *Export intensity:* the ratio of exports over total sales.
- *Import content of production:* the import content of exports, defined as the contribution of imports to the production of goods and services.

B.2 Data Cleaning Procedure

We only use data from publicly listed firms, as the data on stock prices is available. The sample only includes ultimate corporate parents, which are headquartered in each country. Moreover, the sample excludes the following:

- Firm-year observations in which balance sheet information is not reported.
- Firm-year observations in which the currency composition of debt is not reported.
- Each control, including total assets, principal due, tangible assets, liquidity, and long-term investment, belongs to the top or bottom 1% in each country.
- Leverage belongs to the top 1% in each country.
- Financial firms (SIC industry code: 6000-6999).
- Government institution.
- Firm-year observations in which the sum of cash and cash equivalents and tangible assets is greater than the total assets.
- Firm-year observations in which the difference between the total assets and the sum of total liabilities and equity is greater than 10,000 U.S. dollars.
- Firm-year observations in which the difference between the sum of principal dues of all individual debt instruments, which is available in the detailed financial statement, and the total principal due of debt, which is available in the main financial statement, is greater than 100,000 U.S. dollars.
- Firm-year observations in which the sum of due amounts of U.S. dollar debt in the detailed financial statement is greater than the total due amounts in the main financial statement.

C Lower-frequency Effect of FXI

While we focus on a 5-day window around the FOMC announcement date to minimize the effect of unobservable confounders, it is also economically relevant whether the effects identified in the high-frequency are persistent and hold in the lower frequency. To test for such persistency, we regress Equation 5 over h weeks before and after the FOMC announcement, where $h = \in [-2, 10]$. Figure A4, panel (a) plots the coefficient γ_h on $\text{FFR}_t \times USD_{i(c),y-1(t)}$ and panel (b) the coefficient θ_h on $\text{FFR}_t \times USD_{i(c),y-1(t)} \times FXI_{c,t}$, respectively. Panel (a) shows that a 10 basis point increase in the Fed funds rate decreases the stock price of firms with dollar debt by around 5% relative to those without dollar debt and the effect is persistent over 6 weeks (around 1.5 months). Panel (b) shows that FXIs mitigate the stock price decline by around 0.5 to 1 percent. The effect accumulates over time and is persistent over 8 weeks (around 2 months). We also find that as we take a longer time horizon, the standard error increases since our estimate is affected by unobserved confounders. Hence, for identification purposes, we focus on a narrow time window around the FOMC announcement in our main analysis. Studying the macroeconomic implication of FXIs in a fully calibrated general equilibrium model is beyond the scope of this paper and is left for future research.

Table A1: Stock Price: Robustness Checks with Different Definitions with Dollar Debt

Dependent Variable	ΔStock Price$_{i(c),t}$			
	Low \$ Debt	High \$ Debt	All \$ Debt	Continuous \$ Debt
	(1)	(2)	(3)	(4)
FFR Shock$_t$	-0.097**	-0.098**	-0.099**	-0.102**
	(0.045)	(0.046)	(0.046)	(0.046)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	-0.039	-0.040	-0.041	-0.035
	(0.079)	(0.080)	(0.080)	(0.080)
FFR Shock$_t$ $\times$ Dollar Debt	-0.303***	-0.311***	-0.345***	-0.043***
	(0.086)	(0.083)	(0.070)	(0.011)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$ $\times$ Dollar Debt	0.293***	0.345***	0.468***	0.044***
	(0.082)	(0.073)	(0.145)	(0.010)
R^2	0.033	0.033	0.033	0.033
N	116,754	116,754	116,754	116,754
Firm FE	✓	✓	✓	✓

Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Intervention$_{c,t}$ is an indicator that takes one if there is an unexpected counter-intervention and zero otherwise. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Columns (1) and (2) estimate the specification for firms whose dollar debt over total debt ratio is above the 25th and 50th percentiles, respectively. Column (3) estimates the specification for firms that only issue dollar debt. Column (4) uses a standardized share of dollar debt over total debt. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table A2: Stock Price: Other Robustness Checks

Dependent Variable	ΔStock Price$_{i(c),t}$												
	Mean FXI	p75 FXI	FXI Volume	Large FXI	Daily Policy Rate	Zero FFR	Excl. GFC	Excl. ZLB	Interbank Rate	Bond Yield	Market Beta	Int Asset Sales	Stock Denom.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
FFR Shock$_t$	-0.108**	-0.116**	-0.113**	-0.103*	-0.128**	-0.115**	-0.111**	-0.125*	-0.110**	-0.347**	-0.117*	-0.095*	-0.185**
	(0.052)	(0.053)	(0.054)	(0.052)	(0.051)	(0.053)	(0.054)	(0.065)	(0.052)	(0.137)	(0.065)	(0.049)	(0.082)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	-0.106	0.110	-0.006	-0.008	0.018	-0.029	-0.018	-0.022	0.004	-0.070	0.080	0.003	0.056
	(0.096)	(0.113)	(0.108)	(0.132)	(0.126)	(0.098)	(0.100)	(0.097)	(0.121)	(0.201)	(0.096)	(0.089)	(0.130)
FFR Shock$_t$ $\times$ Dollar Debt$_{i(c),y-1(t)}$	-0.253***	-0.212***	-0.196**	-0.316***	-0.276***	-0.294***	-0.312***	-0.306***	-0.285***	-0.327***	-0.307***	-0.323***	-0.383***
	(0.088)	(0.079)	(0.081)	(0.103)	(0.101)	(0.102)	(0.106)	(0.111)	(0.099)	(0.101)	(0.105)	(0.104)	(0.121)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$ $\times$ Dollar Debt$_{i(c),y-1(t)}$	0.307**	0.212*	0.078	0.335***	0.293**	0.304**	0.337**	0.323**	0.307**	0.347***	0.275**	0.331**	0.382***
	(0.124)	(0.115)	(0.102)	(0.124)	(0.129)	(0.124)	(0.129)	(0.135)	(0.120)	(0.124)	(0.118)	(0.128)	(0.143)
R^2	0.033	0.033	0.033	0.034	0.034	0.022	0.037	0.036	0.033	0.035	0.033	0.034	0.038
N	116,757	116,757	115,226	112,560	109,809	188,394	99,258	85,267	116,757	116,717	116,507	110,770	116,757
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

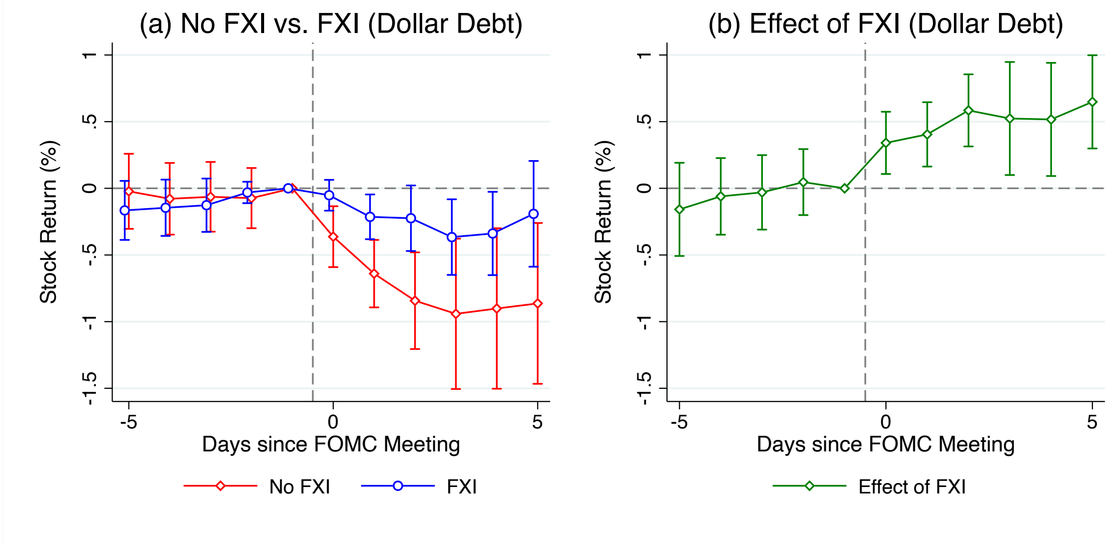
Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock prices from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Intervention$_{c,t}$ is an indicator that takes one if there is an unexpected counter-intervention and zero otherwise. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Column (1) defines counter-intervention so that the central banks' average net sales of US dollars between dates t and $t+5$ are positive when the Fed funds rate increases on date t, and vice versa when the Fed funds rate decreases. Column (2) defines unexpected counter-intervention if the residual from estimating Equation 1 is larger than the 75th percentile. Column (3) uses the FXI-over-GDP ratio when estimating Equation 1. Column (4) estimates the specification for large FXIs, defined so that the average net purchase of the US dollar is larger than the 25th percentile in absolute value. Column (5) controls for the daily monetary policy rate. Column (6) includes FOMC event dates with a zero Fed funds rate shock. Column (7) excludes the Global Financial Crisis. Column (8) excludes the period when the policy rate is below or equal to zero. Column (9) controls for the 3-month interbank interest rate. Column (10) controls for the government bond yield and its interaction with Fed funds shock, local monetary policy rate, and FXI. Column (11) controls for the market beta and its interaction with the Fed funds rate shock. Column (12) controls for one-year lagged international assets over total assets ratio and international sales over total sales ratio. Column (13) denominates the stock price in US dollars. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table A3: Exchange Rate: Robustness Checks

Dependent Variable:	ΔExchange Rate$_{c,t}$									
	Mean FXI	p75 FXI	FXI Volume	Large FXI	Daily Policy Rate	Zero FFR	Excl. GFC	Excl. ZLB	Interbank Rate	Bond Yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FFR Shock$_t$	0.146**	0.121**	0.143**	0.206**	0.274**	0.210**	0.243***	0.201**	0.279**	0.329***
	(0.049)	(0.041)	(0.064)	(0.071)	(0.119)	(0.084)	(0.067)	(0.067)	(0.097)	(0.088)
Intervention$_{c,t}$	0.181	-0.047	0.058	0.223	0.303	0.157**	0.217	0.247	0.099	0.181
	(0.168)	(0.162)	(0.183)	(0.163)	(0.205)	(0.061)	(0.158)	(0.152)	(0.135)	(0.240)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	-0.117**	-0.150*	-0.140**	-0.211**	-0.363**	-0.196**	-0.231***	-0.208**	-0.293**	-0.347***
	(0.044)	(0.076)	(0.051)	(0.083)	(0.155)	(0.081)	(0.068)	(0.070)	(0.113)	(0.083)
R^2	0.074	0.071	0.092	0.103	0.083	0.064	0.107	0.098	0.073	0.087
N	836	836	829	741	683	1,289	754	790	786	713
Country FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

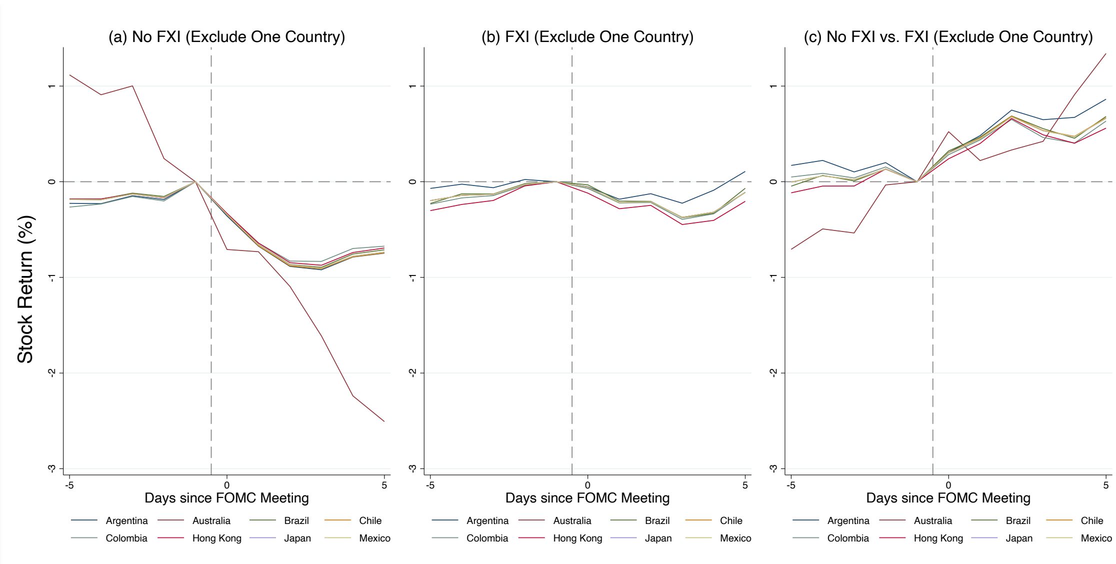
Note: ΔExchange Rate$_{c,t}$ is the change in the log of the exchange rate from date $t-1$ to $t+1$, where t is the FOMC announcement date. The exchange rate is defined as the value of the US dollar in terms of local currency, and a higher value implies a depreciation of the local currency. FFR Shock$_t$ is the Fed funds rate shock in basis points. Intervention$_{c,t}$ is an indicator that takes one if there is an unexpected counter-intervention and zero otherwise. We control for the trend and standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with the Fed funds rate shock. Column (1) defines counter-intervention so that the central banks' average net sales of US dollars between dates t and $t+5$ are positive when the Fed funds rate increases on date t, and vice versa when the Fed funds rate decreases. Column (2) defines unexpected counter-intervention if the residual from estimating Equation 1 is larger than the 75th percentile. Column (3) uses the FXI-over-GDP ratio when estimating Equation 1. Column (4) estimates the specification for large FXIs, defined so that the average net purchase of the US dollar is larger than the 25th percentile in absolute value. Column (5) controls for the daily monetary policy rate. Column (6) includes FOMC event dates with a zero Fed funds rate shock. Column (7) excludes the Global Financial Crisis. Column (8) excludes the period when the policy rate is below or equal to zero. Column (9) controls for the 3-month interbank interest rate. Column (10) controls for the government bond yield and its interaction with Fed funds shock, local monetary policy rate, and FXI. Standard errors are in parentheses. Standard errors are double clustered at the country and date level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Figure A1: Stock Price: Weight by the Number of Firms with Dollar Debt



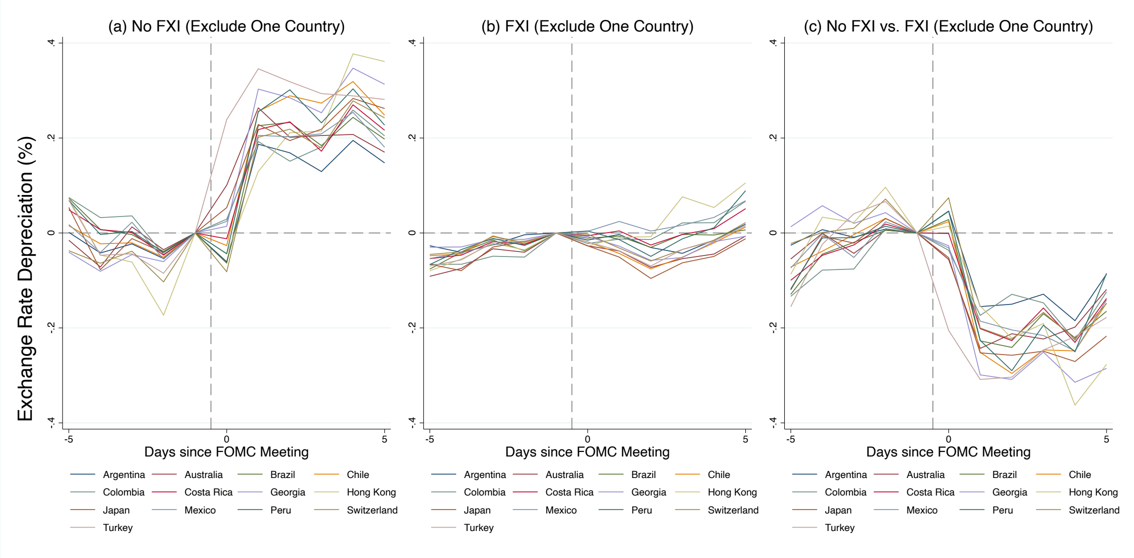
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices. See Equations 2 and 4 for the exact specifications. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. We weight the regression by $1/n_{i(c)}$, where $n_{i(c)}$ is the number of firms with dollar debt in country c where firm i belongs. The confidence interval is 90%.

Figure A2: Stock Price: Exclude Each Country from Sample



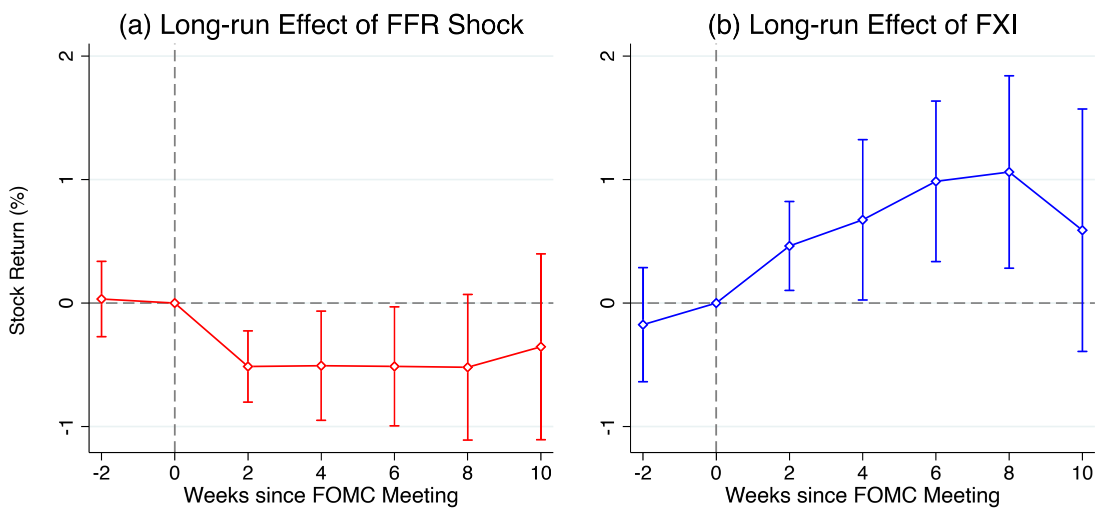
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices. Each line shows the point estimates after excluding each country when estimating Equations 2 and 4. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock.

Figure A3: Exchange Rate: Exclude Each Country from Sample



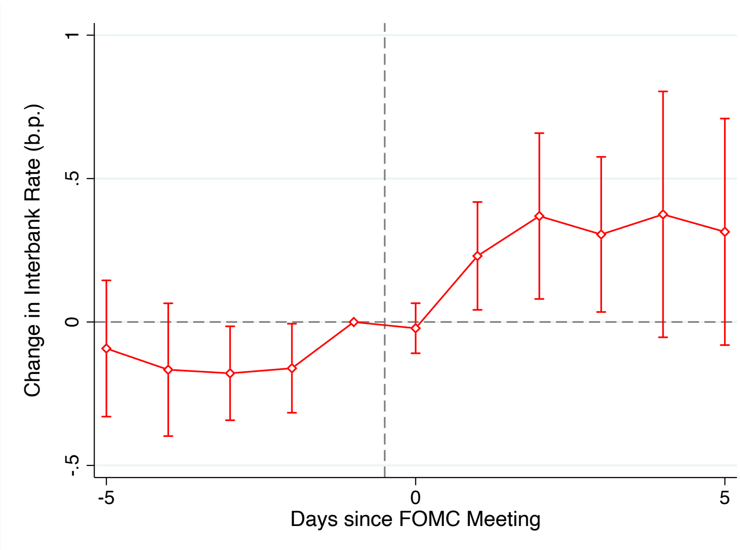
Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on the exchange rate. Each line shows the point estimates after excluding each country when estimating Equations 2 and 4. The exchange rate is defined as the value of the US dollar in terms of local currency, and a higher value implies a depreciation of the local currency. We control for the standard deviation of the exchange rate before the FOMC announcement date, FXIs before the FOMC announcement date, one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with the Fed funds rate shock.

Figure A4: Stock Price: Low-frequency Effect



Note: Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on stock prices. We regress Equation 5 over h weeks before and after the FOMC announcement, where $h = \in [-2, 10]$. Panels (a) and (b) plot the coefficients on $\text{FFR}_t \times USD_{i(c),y-1(t)}$ and $\text{FFR}_t \times USD_{i(c),y-1(t)} \times FXI_{c,t}$, respectively. We control for one-year lagged export intensity, total assets, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with the Fed funds rate shock. We include firm fixed effect and country times date fixed effect. Standard errors are in parentheses. Standard errors are double clustered at the firm and date level. The confidence interval is 90%.

Figure A5: Interbank Rate: Local Projection



Note: The figure plots the estimates of the effect of the Fed funds rate shock and FXIs on interbank rates. See Equation 4 for the exact specification. Standard errors are clustered at the country level. The confidence interval is 90%.