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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 contract (Rey 2015, Miranda-Agrippino and Rey 2020). Although both academics and policymakers have signaled the first-order importance of this issue, there is limited consensus on how countries could protect themselves against this unexpected tightening of monetary policy.

Foreign exchange interventions (FXIs) are an increasingly popular policy protection tool among central banks to try to insulate themselves from those spillovers. A notable example is the recent Japanese FXI against the US dollar. Figure 1 plots the minute-by-minute US dollar to Japanese yen spot exchange rate on September 22, 2022. At 2 pm Eastern Daylight Time on September 21, the Federal Open Market Committee (FOMC) made an announcement to increase the Fed funds rate by 0.75 percentage points. The Japanese yen showed a clear depreciation trend until it reached nearly 1 USD = 146JPY, the weakest level after the early 1990s. However, when the Bank of Japan intervened in the FX market by selling the US dollar and buying Japanese yen at around 5 pm on the same date, the yen suddenly appreciated and became close to 1USD = 140JPY at around 6pm.[1][2] This example shows how "intervening against the Fed" can actually offset US monetary spillovers to exchange rates. However, despite widespread use, systematic evidence on how FX interventions function as a tool to insulate economies from US monetary policy spillovers is elusive. We aim to fill this gap in the literature.

First, we 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

[1]The timing of intervention is not publicly disclosed by the Bank of Japan. The Japanese yen was bought and started appreciating at around 5:03 pm JST. At 5:15 pm, The Ministry of Finance announced that the intervention was carried out and held a press conference at 6:30 pm. The volume of intervention in September 2022 was around 2.8 trillion yen or approximately 20 billion US dollars, which was a record high. The last time Japan intervened in the FX market by selling the US dollar was in 1998, making the intervention unexpected for markets (Duguid 2022). Another example is that Brazil sold 110 billion US dollars in two years following Fed's taper announcement in May 2013 (Chamon et al. 2017).

[2]FXIs are not necessarily conducted under the authority of central banks. For example, the Bank of Japan (BOJ) provides the Ministry of Finance (MOF) with background information on FX market. Based on this information, MOF gives BOJ the instruction for FXI and BOJ conducts FXI on behalf of MOF. In this paper, we use the term "central banks" to indicate the monetary authorities which conduct FXI in general.

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 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 interlinked and hard to isolate from other factors and 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.[3] 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.

To measure the direct effect of interventions, cleaned of confounding factors, we use daily FXI data from 13 countries to identify unexpected counter-interventions in the FX market. These unexpected counter-interventions can arguably be interpreted as direct effects of FXIs. We start by defining expected and unexpected counter-interventions as situations in which the central bank sells US dollars when the Fed unexpectedly tightens and buys US dollars when the Fed unexpectedly loosens policy.[4] Then, we estimate an FX counter-intervention policy rule to understand central banks' decision to intervene against the Fed depending on observable and unobservable macroeconomic and financial characteristics, as well as historical responses to Federal Reserve policy. The intervention implied by this rule can be interpreted as an expected intervention. Estimating an FXI rule allows us to decompose the variance of interventions into explained and unexplained parts. Deviations from the FXI policy rule can be interpreted as unexpected FXIs, similar to residuals from a monetary policy Taylor rule. Finally, we define "intervening against the Fed" if the central bank surprisingly counter-intervenes within five days after the FOMC meeting.

For US monetary policy, as standard in the literature, 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

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

[4]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.

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 interest parity (UIP) equation. According to an expenditure switching channel, the depreciation of the 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 payment, and lowering the cash flow, resulting in lower stock prices (Krugman 1999, Céspedes et al. 2004).

The 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.

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 those of the stock price for firms with US dollar debt. And, indeed, exchange rates depreciate strongly after the US monetary policy shock hits for countries that do not counter-intervene. Quantitatively, a 10 basis point increase in 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 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 rates (Gourinchas 2018).[5] In fact, when countries do not

[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.

intervene and the exchange rate depreciates, the stock price of exporters remains 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 FXI within a short window after the FOMC meeting, we likely capture the central banks' decision to "intervene against the Fed" to mitigate exchange rate fluctuations. If, instead, we studied the unconditional effect of FXIs on exchange rates, it becomes more difficult to disentangle the cause of the intervention. 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-intervention offsets 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 dollar 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 surprisingly changes. 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 through preventing a depreciation of the exchange rate and consequently higher debt repayments for firms with US dollar debt.

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.[6] If firms happen to have dollar debt that matures around unexpected Fed hikes, the

[6]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).

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 cost is small. We show that when the domestic central banks intervene against the Fed policy by buying local currency in response to a tightening shock, this disproportionately benefits the firms that have US dollar debt that matures around the FOMC announcement relative to a scenario in which the dollar debt does not mature around the FOMC announcement. Since the debt maturity structure is orthogonal to exchange rate movements, the effect of debt repayment on stock price can potentially be interpreted causally.

While an FXI may prevent a depreciation in response to a contractionary monetary policy shock, it does 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, FXI may harm exporters through a less depreciated exchange rate. Indeed, we find suggestive evidence that when countries do intervene, 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 there are other confounding factors that 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. 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. 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 FXI and those outcome variables. Moreover, the unobserved shock would likely not only affect the stock prices of firms with 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-intervenes, the true effect of FXI 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 FXI.

Literature. Our paper contributes to the FXI literature and to how US monetary spills over to other countries. Our 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 whether the accumulated reserves in the US dollar can potentially be used to insulate themselves against an unwarranted 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 FXI on exchange rates (Dominguez and Frankel 1993, Dominguez 2003, Dominguez et al. 2013, Adler et al. 2019, Fratzscher et al. 2019; 2020, 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 FXI on stock prices across the firm distribution, nor do they study the interaction between the interaction of FXI 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 a vast empirical evidence of spillover of US monetary policy to country-level equity markets (Zhang 2022, Wiriadinata 2021, Boehm and Kroner 2023), exchange rates (Gürkaynak et al. 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

[7]For example, the Swiss National Bank has sold franc to counter the over-valuation 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 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), and Itskhoki and Mukhin (2022) study FXI under partial segmentation of home and foreign currency bond markets. Since international financial intermediaries have limited risk-bearing capacity, FXI affects 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 shock, potentially representing the counterpart of the foreign central banks which sell the US dollar in response to contractionary monetary policy shocks.

[10]Akinci and Queralto (2019), Aoki et al. (2020), Gopinath and Stein (2021) study theoretically US monetary policy and corporate or bank balance sheet risk when firms issue debt denominated in dollars.

[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 FXI.

relevant country characteristics, such as their income level, dollar exchange rate flexibility, financial openness, trade openness vs. 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 that are 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 in stock prices on the 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 response 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 FXI into account when analyzing monetary policy spillovers. When we combine non-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 combines high-frequency US monetary shock with lower frequency data. Following Gertler and Gilchrist (2015) and Gorodnichenko and Weber (2016b), Miranda-Agrippino and Rey (2020) aggregate high-frequency US monetary shock in each month and Dedola et al. (2017) in each quarter, and study its implication on the exchange rate, capital flows, and/or real outcome. In contrast, we combine daily data on exchange rates, firm stock price, and FXI with US monetary surprise. There are several advantages of using daily data as dependent variables. FOMC meetings occur in irregular intervals within each year and aggregating monetary surprises over each month or quarter can induce serial correlation in aggregate shocks and inconsistent estimates of aggregate impulse response (Ramey 2016, Anderson and Cesa-Bianchi 2023). Moreover, the magnitude of high-frequency shock is small (see section 2). This complicates estimating the effect of variables in the distant future: for example, output several quarters away is influenced by many other confounding factors. In order to minimize this "power problem," we study the response of daily exchange rate and

[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 FXI 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 abstract from foreign firms (Gorodnichenko and Weber 2016a, 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).

stock price, which move contemporaneously with monetary shock (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), the reluctance of many central banks to let the exchange rate fluctuate. In fact, 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 harms firms with the US dollar. The IMF integrated policy framework (Basu et al. 2020) studies the interaction between monetary policy and FXI from a theoretical perspective. They show that after an adverse shock to the foreign appetite for domestic currency debt, FXI reduces the need for the policy rate to be increased, and in that sense can enhance monetary autonomy. 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]

2 Data

2.1 Sources

We combine data from several sources. Our sample period is between 2000 and 2019, during which the data on US monetary shock and corporate balance sheet are available.

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.[16] Some countries do not publicly disclose the data due to 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 high-frequency data as possible, we only use daily intervention data and exclude countries and time periods where only monthly or quarterly data is available. Second, since we study the interventions against US monetary shocks, our sample only comprises countries that intervened against the US dollar multiple times during the sample period. 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. One limitation is that the intraday data on FXI is difficult to obtain. However, even if we use daily data, our result shows that FXI has persistent effects on the exchange rate and stock market.[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] Due to the data limitation, we focus on central banks' direct purchases and sales of US dollar. In reality, central banks' communication with the market can also affect the exchange rate via signalling channel.

[17] Kuersteiner et al. (2018) study intraday intervention data in Colombia between 2001 and 2012. However, intraday data is

To address the endogeneity concern of monetary policy, we use the high-frequency change in 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 pm London time and FOMC announcement is made around 2 pm Washington time (7 pm 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, has 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.[18] Hence, the share of dollar bonds over total bonds is 39 percent. Capital IQ provides annual data on corporate balance sheets after 2001. The sample is restricted to publicly listed firms, as the data on stock prices is available.

We complement the data using a variety of sources. Firm-level data on exports and incorporation date is available on Worldscope. To measure the 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).[19] The SIC industry code in Capital IQ is matched with ISIC Revision 4 industry code using a conversion table in the United Nations Statistics Division. Appendix A 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 World Bank database and complemented by IMF World Economic Outlook.

not available for the other 12 countries in our sample. See also Dominguez (2003) and Dominguez et al. (2013) for analysis using intraday intervention data.

[18] Capital IQ converts the principal due of peso bond to US dollar using the end-of-year spot exchange rate.

[19] The limitation is that it is difficult to obtain firm-level data on invoicing currency of export and import for many countries. Hence, this paper focuses on the effect of FXI on firms with dollar debt.

2.2 Summary Statistics

Table 1 provides summary statistics for Fed funds rate shocks and changes in the exchange rate and stock price.[20] Our sample consists of 90 FOMC announcement dates between 2000 and 2019. Row (1) shows the summary statistics for 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.

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 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 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. The stock price is denominated in local currency. The standard deviation of exchange rate change is 0.72 percent and that of stock return is 3.47 percent.[21]

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 Fed funds rate shock and FXI accumulate over time, we consider a 5-day window after FOMC announcement dates.

We first define buying and selling intervention 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 intervention happened only outside the 5-day window around the meetings. To minimize the possibility that the intervention is affected by a myriad of other factors than US monetary shocks, our sample does not count interventions that happened outside the 5-day window around FOMC meetings.

Column (3) reports the frequency of counteracting intervention, which is the main focus of our analysis. We define counteracting intervention 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 $t+5$,

[20] Table 3 shows the sample of firms, which we will discuss later in this section.

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

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 intervention throughout the regression analyses in this paper.[22] We 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 15 times they intervened counteracting to Fed funds rate shocks. Focusing on this counter-intervention, we will study how the effects 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 45 million dollars and 14 million dollars, respectively.[23]

Column (6) reports the sample period when the FXI data are available. The availability of FXI data depends on the countries. Especially, our sample only includes countries and time periods in which daily FXI data is available. We excluded time 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.[24] 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%, conditioning 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).[25]

2.3 Identification of Unexpected FXI

To elaborate on our identification strategy of FXI, we estimate a central bank reaction function. The motivation is to extract the unexpected component of intervention which cannot be forecasted by Fed funds rate shocks, past exchange rate movement, and FXI before the FOMC events and other macroeconomic characteristics. This is a popular approach to minimize the endogeneity of intervention

[22] Subsection 5.4 defines the counteracting intervention differently: the central banks' average net sales of US dollar 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.

[23] 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 all FOMC announcement dates.

[24] We omitted the following countries from our sample firms. Turkey never conducted FXI in 5-day windows around FOMC announcement dates. In Switzerland, the daily FXI data is only available until 2001. In Costa Rica, Georgia, and Peru, there is very little data on corporate balance sheets.

[25] We define exporters as firms that report a positive amount of export at least once during the sample period since Worldscope has a missing value for export in some countries and time periods. Our sample contains 501 exporters (12% of all firms).

in the literature (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 Taylor rule residual.[26]

We consider the following FXI rule:

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

$\widetilde{FXI}_{c,t}$ is the indicator for counteracting intervention in country c on FOMC announcement date t, as discussed in column (3) of Table 2. $\widetilde{FXI}_{c,t}$ 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.[27]

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 FXI 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.[28] 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 intervention, 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 is no intervention.

The setup of FXI rule is based on previous empirical literature on FXI. 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

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

[27]In the benchmark analysis, we use $(0, 1, -1)$ indicator for daily FXI based on Ito and Yabu (2007). They use an FXI dummy instead of volume because the FXI volume is determined within the day depending on intraday exchange rate movement, but intraday intervention is not disclosed. By using the dummy variable, they mitigate this endogeneity concern caused by our inability to estimate the intraday reaction function. The limitation of the dummy variable is that it cannot capture how much central banks intervene. As a robustness check, in subsection 5.4, we replace $(0, 1, -1)$ dummy with a continuous measure of FXI volume and obtain a similar result to the benchmark.

[28]We use a monthly policy rate since the daily policy rate is not available for all sample countries. In subsection 5.6, we use daily policy rates in countries with available data and show our result is robust.

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 take the interaction between the Fed funds rate shock and macro variables, since countries with different macroeconomic characteristics can respond heterogeneously to Fed funds rate shock. We include the country fixed effect 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-intervention, in other words, the average response of FXI to Fed funds rate shock, past exchange rate, and intervention, and macroeconomic conditions. The residual, or the deviation from the FXI rule, can be interpreted as an unexpected component of FXI. We exploit this residual as the exogenous surprise component of FXI.

Figure 2 graphically illustrates the result for variance decomposition from estimating Equation (1). Our estimates show that 24% of 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 FXI cannot be predicted by the Fed funds rate shock or past exchange rate and intervention. 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 Fed funds rate shock and macro variables, 35% by past intervention, and 17% by country fixed effect. 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 rate has very limited explanatory power for FXI.

Having shown that the variation of intervention is difficult to predict, we will use the residual from estimating Equation (1) as an unexpected component of counter-intervention. 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.[29] We will use this definition of unexpected counter-intervention throughout our analysis.

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 expects that there is a 20% probability that

[29]Subsection 5.4 shows that our results are robust even if we use (a) 75th percentile criteria instead of median or (b) the value of residual without taking the dummy to define the unexpected counter-intervention.

the central bank will actually intervene against Fed's tightening shock by selling the US dollar, but an 80% probability that the central bank will not intervene. This large residual implies that the intervention is mostly unexpected. Similarly, panel (b) shows the example of unexpected US monetary easing: on March 22, 2005, the Fed delivered an accommodative 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 expects that the probability that the central bank will not intervene against the US monetary easing shock is more than 60% (the residual is 0.61 in absolute value). This suggests that the degree to which the intervention is unexpected can be measured using the absolute value of residual from estimating equation (1). To simplify the interpretation, in the baseline analysis, we define the intervention as unexpected if the residual is larger than its median in absolute value.

3 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:

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

where FFR_t is the Fed funds rate shocks by Nakamura and Steinsson (2018). The shock is defined as the change in 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 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 in 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' equal-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.

We consider two modifications to evaluate the effect of FXI. First, we introduce an interaction term between the Federal funds rate shock and a dummy of whether a firm holds US dollar debt in the previous year ($USD_{i(c),y-1(t)}$):

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

γ_h can be interpreted as 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 year before the FOMC meeting. $\alpha_{c,t}^h$ 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.

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

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

γ captures the effect of FXI mitigating the effect of US monetary spillover. $\gamma > 0$ for each $h \geq 0$ implies that the decline in stock price is smaller with FXI than the case without FXI. 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 are 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 still being 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 2. 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 spills over to firms' stock prices if a country intervenes against the Fed. In particular, in Equation 2 if we can reject the null hypothesis $\beta = 0$, 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 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 depreciations.

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 interventions and non-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, but 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:

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

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 firms with US dollar debt underperform those with US dollar debt. The triple interaction coefficient θ measures the marginal effect of FXI 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 FXI mutes the US monetary policy-induced balance sheet channel of exchange rate depreciations, while γ measures the extent of the balance sheet channel without intervention. 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 effect implies that the effect of FFR_t is not identified, as it is collinear with the fixed effects. Hence, when controlling for time-variant observed and unobserved characteristics at the country-level through country-time fixed effect, we can only make a relative statement about having US dollar debt. In an alternative specification, we remove the country-time fixed effect 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.

4 Results

4.1 Stock Market

We begin by estimating Equation 2 separately for firms with and without US dollar debt ($USD_{i(c),y-t(t)} = 1$ and 0). Table 4 shows the result, where panels (a) and (b) show the result without and with FXI, respectively. We first study the case without FXI ($FXI_{c,t} = 0$). Panel (a), columns (1) and (2) reports the estimated β_1 coefficient for a subsample of firms with and without dollar debt, respectively, based in countries without FXI. 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).[30] However, if firms do not have dollar debt, the decline in stock price is mitigated (0.9%). Next, to test if the difference in response between firms with and without dollar debt is significant, we estimate Equation 3 in countries without intervention. Column (3) reports the estimated β_1 and γ_1 coefficients for countries without intervention. The negative γ_1 coefficient shows that when the Fed funds rate increases, the decline in stock price for firms with dollar debt is significantly larger than 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 FFR_t standalone term. These results suggest the strong negative balance sheet channel driven by US monetary tightening without FXI.[31]

In contrast, panel (b) conducts a similar exercise with FXI ($FXI_{c,t} = 1$). Column (1) shows that, if central banks counter-intervene against the Fed's surprise hike, the decline of stock price is mitigated even if firms have dollar debt (2.2% in response to 10bp surprise hike, in contrast to 6.6% in panel (a)).[32] 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 FXI 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 FXI 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 intervention (6.4% in response to a 10bp hike), implying the negative balance sheet channel of US monetary policy. However, if central banks intervene, the decline in stock price is mitigated by 4.5bp, implying that FXI can mitigate this balance sheet channel. In column (2), we conduct a similar exercise for firms without dollar debt and find that the effects of US monetary shock and FXI are small. Finally, in columns (3) and (4), we estimate the triple interaction Equation 5 to study whether the effect of FXI

[30]As shown in Table 1, the standard deviation of 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 Fed funds rate shock is larger or equal to 10bp in absolute value. Hence, a 10bp monetary shock can be interpreted as a large shock.

[31]The limitation for 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 announcement, similar to those firms with no US dollar debt. This suggests that our results are lower-bound estimates of the effect of FXI 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.

[32]Even with FXI, the decline in stock price 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.

is greater for firms with dollar debt. The negative coefficient on $FFR_t \times USD_{i(c),y-1(t)}$ ($\gamma = -0.310$) implies the negative balance sheet channel of US monetary spillover. 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 implies that FXI entirely mutes the balance sheet channel. This result 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 $\text{FFR}_t \times FXI_{c,t}$.

To test whether the effect of FXI 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 result for countries without and with FXI, respectively. Without FXI, a 10 basis point surprise increase in the Fed funds rate leads to an immediate decline in stock price, and this accumulates up to nearly 1% after three days, suggesting that the balance sheet channel of US monetary shock 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 pre-trends of stock prices in countries without and with FXI, potentially suggesting that the post-FOMC differential response of stock price is driven causally by FXI. To test if the effect of FXI 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 FXI 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 FXI have little effect on the stock price of firms without dollar debt. Finally, to compare the effect of FXI on firms with and without dollar debt, we estimate 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 FXI is persistently greater for firms with dollar debt.

4.2 Mechanism: Exchange Rate

To further understand the balance sheet channel, we study the effect of FXI on the exchange rate. Our previous results suggest that US monetary tightening without FXI has a negative balance sheet effect on firms with dollar debt, but FXI can mute this spillover. For this result to be true, it must be the case that US monetary tightening depreciates local exchange rates when countries do not counter-intervene but does not depreciate it 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.

To check this hypothesis, we estimate Equation 2, where we now replace the dependent variable with the change in the log of the exchange rate in the country c between date $t - 1$ and $t + 1$. The exchange rate is defined as the value of one US dollar in terms of local currency so that higher value implies the appreciation of the US dollar or 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, FXI before the FOMC announcement date, and one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with Fed funds rate shock.

Table 6, columns (1) and (2) show the results for countries without and with intervention, respectively. If the local monetary authorities do not intervene, when the Fed unexpectedly hikes an interest rate, the domestic currency depreciates in a statistically significant manner (2.25% in response to a 10bp surprise hike). However, if they counter-intervene in the FX market by selling the US dollar, the exchange rate remains flat around the FOMC meetings. To check the effect of FXI is large enough, in column (3), we regress Equation 4 after replacing the dependent variable with a change in the exchange rate. Without intervention, a 10bp surprise hike in the Fed funds rate leads to 2.01% exchange rate depreciation. However, if central banks counter-intervene by selling the US dollar, the depreciation is smaller by 2.02% than in no counter-intervention case and this difference is statistically significant. Thus, intervention offsets the exchange rate depreciation caused by the Fed's surprise.

To study how the effect of FXI accumulates over time, we reestimate 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 FXI. However, when countries that do not counter-intervene by selling the US dollar experience persistent depreciation, while those that counter-intervene do not experience depreciation.[33] Moreover, to compare the trends of exchange rates around FOMC meetings in countries without and with FXI, panel (b) reestimates 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 no intervention case.[34] These results suggest that FXIs are successful in stabilizing the exchange rate in response to unexpected monetary shocks, giving further support to the balance sheet stabilization channel of FXI for firms with dollar debt.

4.3 Expenditure Switching Channel

In the previous sections, we have shown that FXI benefits firms with dollar debt by muting the negative balance sheet channel of US monetary tightening. However, US tightening may also have other spillover channels, most importantly via exporting firms. On one hand, depreciations induced by contractionary US monetary policy may increase foreigners' demand for exports due to lower prices (expenditure

[33]The depreciation slightly builds up over time, consistent with Roussanov and Wang (2023).

[34]The effect of FXI is statistically significant one day after the intervention. This is potentially due to the difference in time zone. 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 data on the exact timing of FXI in each country.

switching channel). On the other hand, US monetary tightening may reduce US demand for goods and thus the demand for exports (negative demand channel). If FXI mutes the depreciation-induced expenditure switching channel but does not mute the negative demand channel due to intertemporal substitution, we would expect FXI can be costly for exporters.

To check this possibility, we study the effect of FXI 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 without and with FXI, respectively. When the Fed tightens, the stock price response for exporters increases without FXI but decreases with FXI. 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 price for firms with dollar debt decreases significantly without FXI (9.0% at the trough), and FXI mitigates this decline. Next, panel (b) plots the interaction coefficient between FXI and the export indicator. We show that FXI decreases stock prices 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. However, Figure 4, panel (b) suggests that FXI has 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 FXI has a 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 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 large.

5 Robustness Checks

This section provides robustness checks to confirm the balance sheet channel of FXI. In Table 7, 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 the 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 FXI can mute the balance sheet channel. Similarly, in Table 8, we reestimate Equation 5 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 FXI mitigates this depreciation.

5.1 Debt Maturity

To further refine our identification strategy, we use the firms' debt maturity structure. 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 cost is negligible. Hence, FXI that counteracts 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 in a causal way.

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 within a one-year window around (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 $USD_{i(c),y-1(t)}$ so that it takes one if firms have maturing dollar debt in the previous year and zero if firms do not (including firms with non-maturing dollar debt but without maturing dollar debt, and firms with no dollar debt). Table Table 7, column (1) shows that US monetary tightening reduces stock price for firms with maturing dollar debt without intervention but does not decrease it with intervention.

We further compare this result with the benchmark case. Table 5, column (3) shows that, without FXI, a 10bp increase in Fed funds rate leads to a 3.1pp decline in stock price for firms with dollar debt (compared to those without dollar debt), while FXI mitigates this decline by 3.2pp. However, Table 7, column (1) shows that the same increase in the Fed funds rate leads to a 6.7pp decline in stock price without FXI and 6.2% mitigation with FXI. This suggests that the balance sheet channel of US monetary shock and FXI is particularly strong for firms with maturing dollar debt, thus FXI disproportionately benefits firms with maturing dollar debt, compared to firms with non-maturing dollar debt.

5.2 Intensive and Extensive Margins of dollar debt

The baseline result on the balance sheet channel focuses on whether firms issue borrow or not 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 a dummy 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 25th percentile and firms without dollar debt). Similarly, we define dummies for "high dollar debt" for firms with median dollar debt share, and "all dollar debt" for firms that only issue dollar debt but do not issue debt in other currencies.[35] This definition can capture the right tail of the distribution of dollar debt share across firms.

Table 7, columns (2)-(4) show the result. Comparing these columns, we find that both the balance sheet channel of US monetary policy shock (negative coefficient γ on $FFR_t \times USD_{i(c),y-1(t)}$) and FXI's mitigation of monetary spillover (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 ($\gamma = -0.303,\ \theta = 0.293$).

5.3 Controlling for International Sales and Asset Holdings

In the baseline results on stock prices, we control for export and import because they affect firms' foreign currency revenue and cost. There are other factors that potentially affect firms' foreign currency revenue, including international sales and international assets, as firms with international sales or assets may benefit from domestic currency depreciation. To take this into account, we control for one-year lagged international sales over total sales ratio and international assets over total asset ratio. The data is available in Worldscope. Table 7, column (5) shows the result, which is similar to the benchmark case in Table 5, column (3).

5.4 Alternative Definitions for Unexpected Counter-Intervention

We study different criteria for unexpected counteracting intervention. In the benchmark case, counteracting intervention is 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 defined unexpected counter-intervention 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 will also try four alternative definitions for unexpected counter-intervention. First, we define counter-intervention so that the central banks' average net sales of US dollars between dates t and $t+5$ is positive when the Fed funds rate increases on date t, and vice versa when the Fed funds rate decreases. Second, the counter-intervention is defined as unexpected if the residual from estimating Equation 1 is larger than 75 percentiles rather than the median in absolute value. Third, we use the residual of estimating Equation 1 without taking a dummy. To simplify the interpretation, we standardize the residual so that the interaction coefficient of FFR_t and $FXI_{c,t}$ implies the effect of Fed funds rate shock when the unexpected FXI is one standard deviation larger. Fourth, we use the volume of FXI in terms of US dollar in the first-stage regression (Equation 1), instead of using counter-intervention dummy.

[35]Conditioning on firms with positive dollar debt, around 29% of our firm-date observations are driven by firms only with dollar debt. Hence, 75th percentile of dollar debt share corresponds to "all dollar debt."

Table 7, columns (6)-(9) show that the balance sheet channel on stock price survives under these four alternative definitions. Moreover, Table 8, columns (1)-(4) show the result for the exchange rate under these alternative definitions. Comparing these results with Table 6, column (3), we find that our result on the exchange rate is also robust: US monetary tightening shock depreciates the exchange rate without FXI, but FXI mutes this depreciation.

5.5 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 FXI is heterogeneous across countries. We will test whether our main result holds even if we focus on relatively large FXI and exclude relatively small FXI. For each country and FOMC event date, we first calculate the average net purchase of the US dollar over 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 and smaller than 25 percentiles in absolute value, respectively. We then exclude small FXI from our sample. Table 7, column (10) and Table 6, column (5) show that our result is robust even after focusing on large FXI.

5.6 Sterilized Intervention

We further investigate the effect of sterilized interventions. Sterilization implies that central banks conduct an open market operation to offset the effect of FXI on the domestic financial market. We control for daily monetary policy rates in order to separate out the effect of monetary policy and focus on the FX purchases or sales by central banks.[36] In the benchmark result, we use monthly data on policy rates since the monthly data are available for all sample countries, but daily data is not. In this section, we instead use daily policy rate for a subsample of countries where the data is available.[37] We control for daily policy rates both in the first-step and second-step regressions. Table 7, column (11) and Table 6, column (6) show that our result is robust after controlling for the daily policy rate.

5.7 Foreign Exchange Reserves

Central banks' foreign exchange reserves have increased significantly in the last decades (see section 6) and investors might expect to use information on FX reserves to predict future intervention. To take this possibility into account, we control for lagged quarterly FX reserves in the first-stage regression. The

[36]As discussed in Fratzscher et al. (2020), we do not have information on whether the intervention is sterilized or unsterilized. Given that FXI is a distinct policy tool from the interest rate, it is reasonable to assume that interventions in our sample are generally sterilized.

[37]The data on daily policy rate is available in the following 10 countries out of the total 13 sample countries: Argentina, Australia, Brazil, Chile, Colombia, Hong Kong, Japan, Mexico, Turkey, and Peru. The data source is BIS statistics. We took the logarithm of daily policy rates since Argentina and Turkey have high policy rates.

data source is IMF International Financial Statistics.[38] Table 7, column (12) and Table 6, column (7) show that our result is robust even after controlling for FX reserves.

5.8 Currency Denomination of Stock Price

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 change in exchange rate affects the valuation of stock price. When the Fed funds rate increases, not only stock price decreases for firms with dollar debt, but also the exchange rate depreciates against the dollar. Hence, we expect that the stock price in terms of the US dollar decreases more than the local currency. This implies that firms with dollar debt are risky investment opportunities for US international investors compared to local investors. Table 7, column (13) shows that when the stock price is denominated in US dollar, a 10bp Fed tightening without FXI decreases the relative stock price for firms with dollar debt by 3.8bp, while FXI mitigates this decline by 3.8bp. These effects are greater than the benchmark case in Table 7, column (3), where the stock price is denominated in local currency.

6 Conclusion

US monetary policy has significant spillovers to other countries. Will the recent Fed tightening cause financial turmoil in other countries? In this paper, we have studied the spillover effects of US monetary policy using a high-frequency approach that allows us to more directly understand the effects and channels through which monetary policy affects foreign economies. When countries do not intervene and 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, mirroring the experience of earlier episodes, such as the 1990s or during the taper tantrum.

However, 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. Figure 8 shows the FX reserves in our sample countries. Reserves grew around 16 times, reaching 3.44 trillion USD in 2022, up roughly 0.21 trillion from 1990, likely explained by the hope that reserves can act as a self-insurance mechanism. Can the buildup of reserves over this period indeed mitigate the spillovers of US monetary contractions?

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, exchange rates, and stock prices for firms with and without

[38] A limitation of this analysis is that data on currency decomposition of FX reserves is available only at world level but not for each country, so we use the total FX reserves of each country.

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.

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

In this paper, we do not study the trade-offs that are associated with reserve accumulation, and instead, we only consider how reserves can be used against a monetary shock. We leave these questions for further 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 $t+1$. Higher $e_{c,t+1}$ implies the appreciation of US Dollar or depreciation of 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 times FOMC announcement dates (row 2), and firm times FOMC announcement dates (row 3).

Table 2: Interventions around 90 FOMC event dates in sample

Country	Frequency			Volume (Millions USD)		Periods
	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	0.11	0.15	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	45	14	2000-2019

Note: Columns (1) and (2) show the frequencies of buying and selling intervention. Buying intervention is defined so that central banks buy US Dollar at least once between date t and $t + 5$, where t is the FOMC announcement date, and selling intervention is defined similarly. Column (3) shows the frequency of counter-intervention, defined so that the central bank sells US Dollar at least once and never buys US Dollar between the dates t and $t + 5$ when the Fed funds rate increases at date t, and 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 dollar between date t and $t + 5$ over all FOMC announcement dates t, respectively. Column (6) shows the sample period when FXI data is available.

Table 3: Sample Firms

Country	Total	Dollar Debt
Argentina	34	25
Australia	1190	126
Brazil	68	21
Chile	3	1
Colombia	22	9
Hong Kong	480	42
Japan	2216	4
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$_t$ × 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 × 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$_t$ × 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 × Date FE				✓

Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock price 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 asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with 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$_t$ × Intervention$_{c,t}$	0.449***	-0.035	-0.042	
	(0.130)	(0.082)	(0.079)	
FFR Shock$_t$ × Dollar Debt$_{i(c),y-1(t)}$			-0.310***	-0.259***
			(0.083)	(0.070)
FFR Shock$_t$ × Intervention$_{c,t}$ × 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 × Date FE				✓

Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock price 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 asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with 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 log of 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 US dollar in terms of local currency, and higher value implies depreciation of 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 exchange rate before the FOMC announcement date, FXI before the FOMC announcement date, and one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with 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: Robustness Checks

Dependent variable:	ΔStock Price$_{i(c),t}$												
	Debt Maturity	Low \$ Debt	High \$ Debt	All \$ Debt	Int Asset Sales	Average FXI	p75 FXI	FXI Resid Value	FXI Volume	Large FXI	Daily Policy Rate	FX Reserves	Stock Denom.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
FFR Shock$_t$	-0.104**	-0.097**	-0.098**	-0.099**	-0.089**	-0.100**	-0.108**	-0.111**	-0.101**	-0.103**	-0.119**	-0.101**	-0.177**
	(0.047)	(0.045)	(0.046)	(0.046)	(0.043)	(0.046)	(0.046)	(0.046)	(0.048)	(0.047)	(0.045)	(0.045)	(0.075)
FFR Shock$_t$ × Intervention$_{c,t}$	-0.034	-0.039	-0.040	-0.041	-0.011	-0.110	0.066	-0.005	-0.007	0.029	0.016	-0.014	0.049
	(0.079)	(0.079)	(0.080)	(0.080)	(0.078)	(0.079)	(0.108)	(0.062)	(0.057)	(0.108)	(0.110)	(0.114)	(0.116)
FFR Shock$_t$ × Dollar Debt$_{i(c),y-1(t)}$	-0.666***	-0.303***	-0.311***	-0.345***	-0.323***	-0.247***	-0.206***	-0.153***	-0.278***	-0.308***	-0.264***	-0.273***	-0.382***
	(0.151)	(0.086)	(0.083)	(0.070)	(0.084)	(0.077)	(0.067)	(0.053)	(0.072)	(0.083)	(0.087)	(0.086)	(0.102)
FFR Shock$_t$ × Intervention$_{c,t}$ × Dollar Debt$_{i(c),y-1(t)}$	0.620**	0.293***	0.345***	0.468***	0.325***	0.309***	0.227**	0.158*	0.296***	0.339***	0.281***	0.307***	0.378***
	(0.302)	(0.082)	(0.073)	(0.145)	(0.092)	(0.100)	(0.099)	(0.090)	(0.082)	(0.098)	(0.103)	(0.101)	(0.110)
R^2	0.033	0.033	0.033	0.033	0.034	0.033	0.033	0.033	0.033	0.033	0.034	0.033	0.038
N	116,754	116,754	116,754	116,754	110,769	116,754	116,754	115,519	116,754	109,759	109,808	116,754	116,753
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

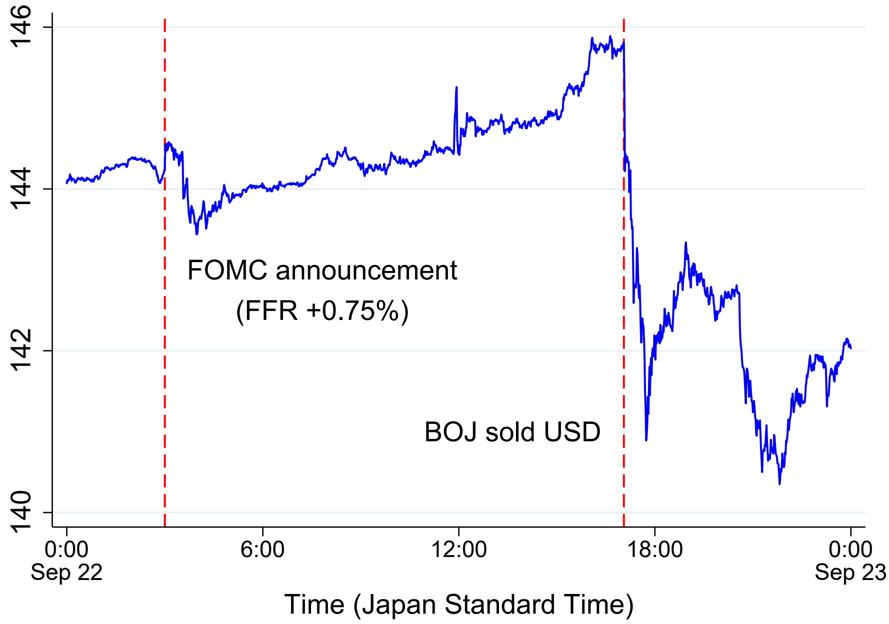
Note: ΔStock Price$_{i(c),t}$ is the change in the log of firm-level stock price from date $t-1$ to $t+1$, where t is the FOMC announcement date. FFR Shock$_t$ is the Fed funds rate shock in basis points. Dollar Debt$_{i(c),y-1(t)}$ is an indicator that takes one for firms with dollar debt in the previous year and zero otherwise. We control for one-year lagged export intensity, total asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with Fed funds rate shock. Column (1) estimates the specification for maturing dollar debt, defined as the dollar debt that matures within six months before and after FOMC announcement date. Columns (2) and (3) estimate the specification for firms with whose dollar debt over total debt ratio is above 25th and 50th percentiles, respectively. Column (4) estimates the specification for firms which only issue dollar debt. Column (5) controls for one-year lagged international asset over total asset ratio and international sales over total sales ratio. Column (6) defines counter-intervention so that the central banks' average net sales of US dollar between dates t and $t+5$ is positive when the Fed funds rate increases on date t, and vice versa when the Fed funds rate decreases. Column (7) defines unexpected counter-intervention if the residual from estimating Equation 1 is larger than 75th percentile. Column (8) uses the residual of estimating Equation 1 without taking dummy. Column (9) uses the volume of FXI when estimating Equation 1. Column (10) estimates the specification for large FXI, defined so that the average net purchase of US dollar is larger than 25th percentile in absolute value. Column (11) controls for daily monetary policy rate. Column (12) controls for FX reserves. Column (13) denominates the stock price in US dollar. 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: Exchange Rate: Robustness Checks

Dependent Variable:	ΔExchange Rate$_{c,t}$						
	Average FXI	p75 FXI	FXI Resid Value	FXI Volume	Large FXI	Daily Policy Rate	FX Reserves
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FFR Shock$_t$	0.146**	0.121**	0.115***	0.188**	0.197**	0.274**	0.229**
	(0.049)	(0.041)	(0.032)	(0.067)	(0.067)	(0.119)	(0.080)
Intervention$_{c,t}$	0.181	-0.047	0.041	0.030	0.212	0.303	0.246
	(0.168)	(0.162)	(0.054)	(0.276)	(0.161)	(0.205)	(0.139)
FFR Shock$_t$ $\times$ Intervention$_{c,t}$	-0.117**	-0.150*	-0.107**	-0.167**	-0.204**	-0.363**	-0.226**
	(0.044)	(0.076)	(0.040)	(0.060)	(0.079)	(0.155)	(0.084)
R^2	0.074	0.071	0.085	0.070	0.102	0.083	0.077
N	836	836	795	836	742	683	836
Country FE	✓	✓	✓	✓	✓	✓	✓

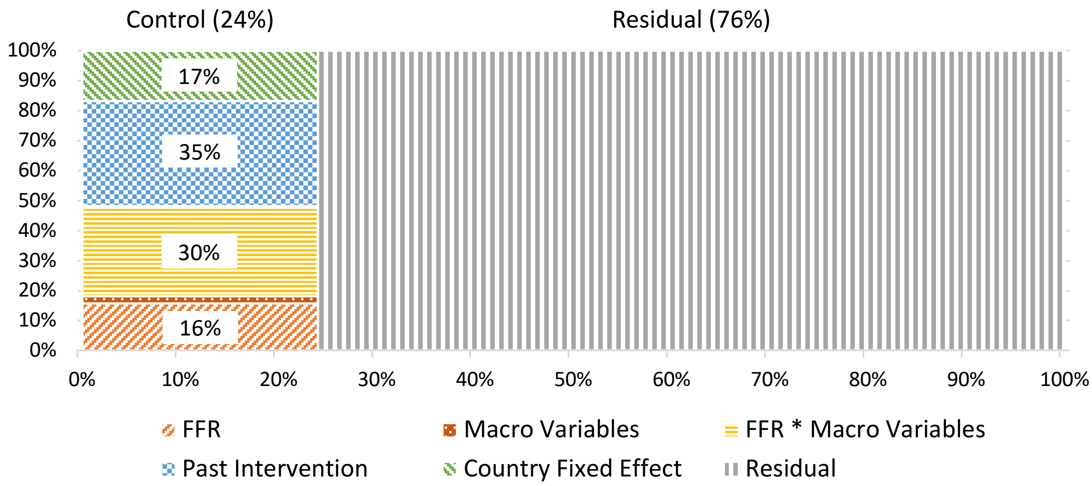
Note: ΔExchange Rate$_{c,t}$ is the change in log of exchange rate from date $t-1$ to $t+1$, where t is the FOMC announcement date. The exchange rate is defined as the value of US dollar in terms of local currency, and higher value implies depreciation of local currency. FFR Shock$_t$ is the Fed funds 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 exchange rate before the FOMC announcement date, FXI before the FOMC announcement date, and one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with Fed funds rate shock. Column (1) defines counter-intervention so that the central banks' average net sales of US dollar between dates t and $t+5$ is 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 75th percentile. Column (3) uses the residual of estimating Equation 1 without taking dummy. Column (4) uses the volume of FXI when estimating Equation 1. Column (5) estimates the specification for large FXI, defined so that the average net purchase of US dollar is larger than 25th percentile in absolute value. Column (6) controls for daily monetary policy rate. Column (7) controls for FX reserves. 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 1: Spot Exchange Rate: US Dollar to Japanese Yen



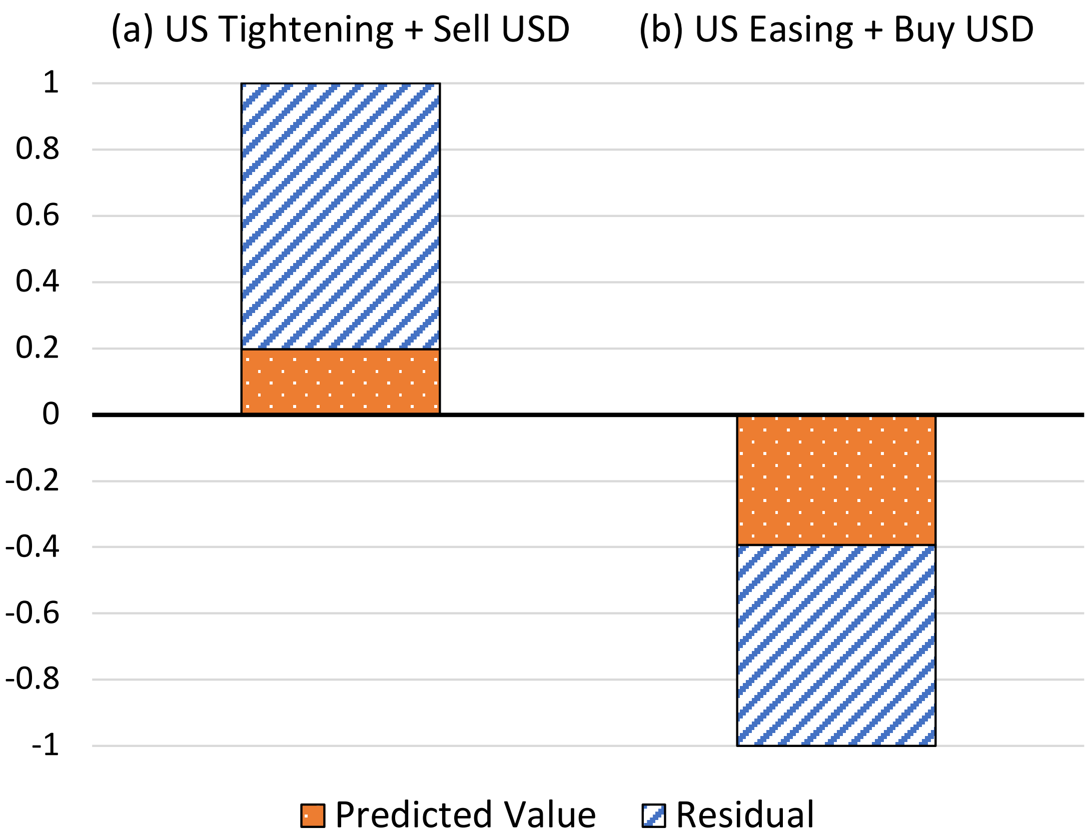
Note: The figure reports the minute-by-minute US Dollar to Japanese yen spot exchange rate on September 22, 2022. The exchange rate is defined as the value of one US Dollar in terms of yen and higher value implies the appreciation of Dollar or depreciation of Japanese yen. Source: Datastream.

Figure 2: Variance Decomposition for Counter-Intervention



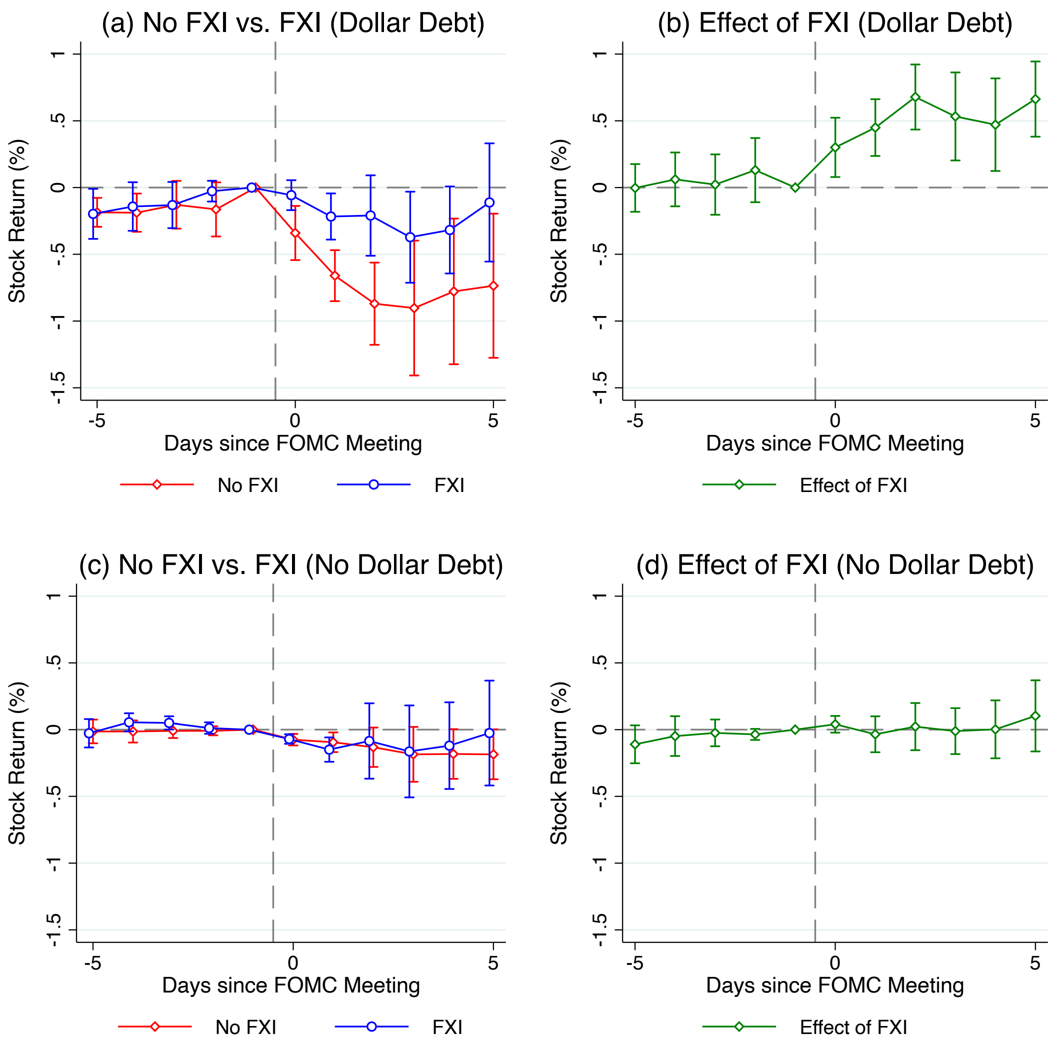
Note: The figure shows the results for variance decomposition for Equation (1). We control for the Fed funds rate shock, one-month lagged policy rate, one-year lagged GDP, CPI inflation rate, trade balance over GDP ratio, unemployment rate, and their interaction with Fed funds rate shock, FXI before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

Figure 3: Example for Estimating Policy Rule



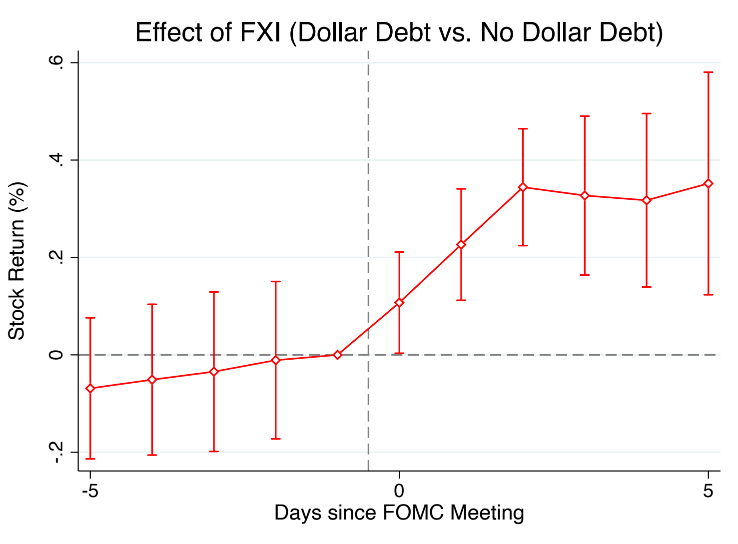
Note: The figure shows the result for variance decomposition for Equation (1). Column (a) shows the result for US monetary tightening and selling US Dollar intervention by the Reserve Bank of Australia on November 15, 2000. Column (b) shows the result for US monetary easing and buying US Dollar intervention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

Figure 4: Stock Price: Difference-in-Difference



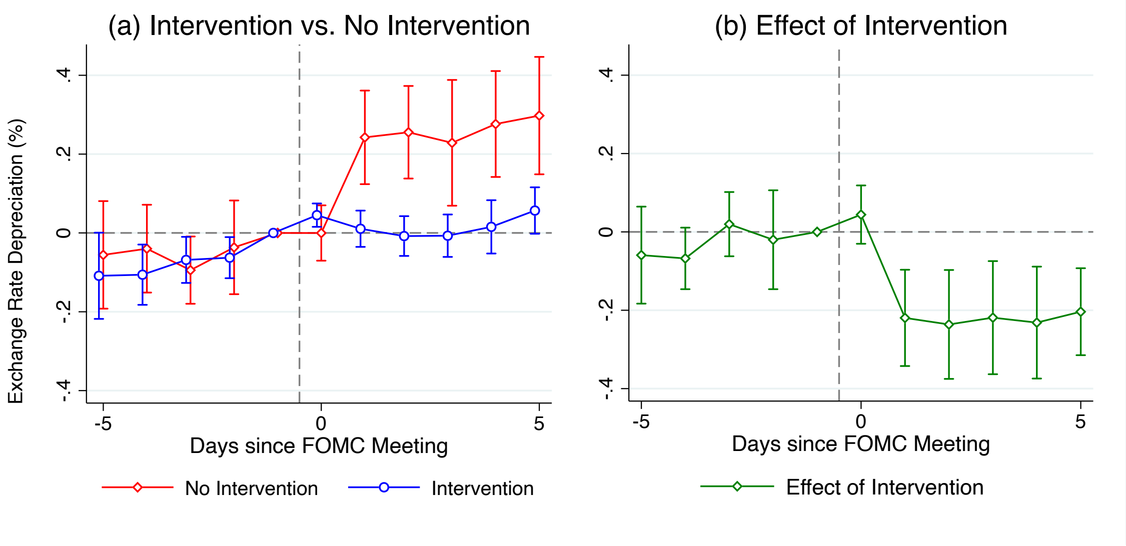
Note: The figure plots the estimates of the effect of Fed funds rate shock and FXI on stock price. See Equations 2 and 4 for specification. We control for one-year lagged export intensity, total asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with 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. The confidence interval is 90%.

Figure 5: Stock Price: Triple Interaction



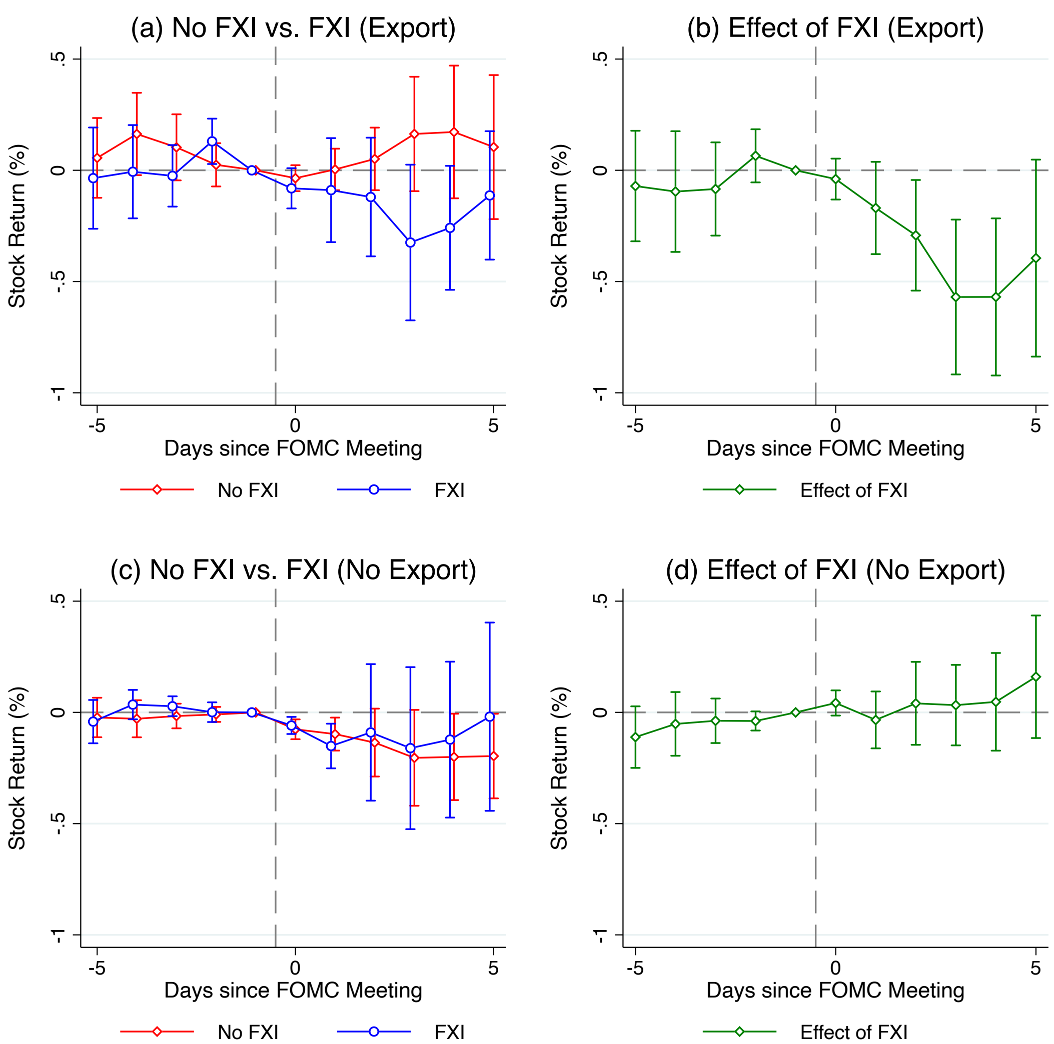
Note: The figure plots the estimates of the effect of Fed funds rate shock and FXI on stock price. See Equations 3 and 5 for specification. We control for one-year lagged export intensity, total asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with 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. The confidence interval is 90%.

Figure 6: Exchange Rate: Difference-in-Difference



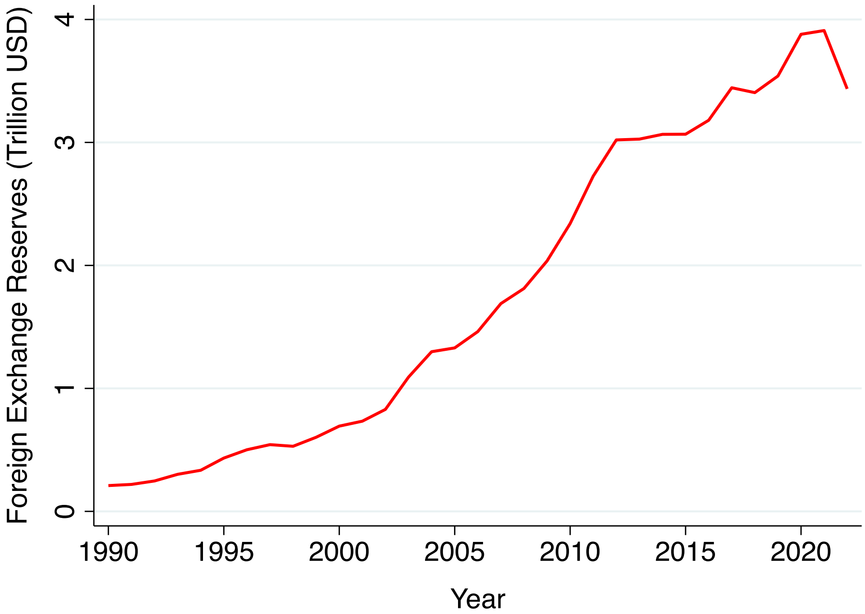
Note: The figure plots the estimates of the effect of Fed funds rate shock and FXI on exchange rate. See Equation 4 for specification. The exchange rate is defined as the value of US dollar in terms of local currency, and higher value implies depreciation of local currency. We control for the trend and standard deviation of exchange rate before the FOMC announcement date, FXI before the FOMC announcement date, and one-month lagged policy rate, one-year lagged GDP, inflation, trade balance over GDP ratio, unemployment rate, and their interaction with 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.

Figure 7: Stock Price: Expenditure Switching Channel



Note: The figure plots the estimates of the effect of Fed funds rate shock and FXI on stock price for exporters and non-exporters. See Equations 3 and 5 for specification. We control for one-year lagged dollar debt, total asset, liquidity-to-asset ratio, firm age (firm-level), one-year lagged import content of production (industry-level), and their interaction with 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. The confidence interval is 90%.

Figure 8: FX Reserve in Sample Countries



Note: The figure reports the sum of official foreign exchange reserve for our 13 sample countries. Source: IMF International Financial Statistics.

Appendix

A Data Construction

This section provides the data definition and cleaning procedure. the firm-level data on fundamentals and balance sheet, the data definition and cleaning procedure 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).

A.1 Data Definition

- *Leverage:* the ratio of total debt over total asset.
- *Share of Dollar debt:* the ratio of total due amount of dollar debt (the sum of due amounts of debt instruments whose repayment currency is U.S. Dollar) over the total due amount of debt denominated in all currencies.
- *Size:* the total asset which is denominated in local currency and deflated by consumer price index (CPI).
- *Liquidity:* the ratio of cash and short-term investments over total asset.
- *Age:* years after the incorporation date.
- *Export intensity:* the ratio of export over total sales.
- *Import content of production:* the imports content of exports, defined as the contribution of imports for the production of goods and services.

A.2 Data Cleaning Procedure

We only use data of publicly listed firms as the data on stock price 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 currency composition of debt is not reported.
- Each control, including total asset, principal due, tangible asset, liquidity, and long-term investment, belongs to top or bottom 1% in each country.
- Leverage belongs to 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 asset.
- Firm-year observations in which the difference between the total asset and the sum of total liability and equity is greater than 10,000 U.S. Dollar.
- 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. Dollar.
- Firm-year observations in which the sum of due amounts of Dollar debt in the detailed financial statement is greater than the total due amounts in the main financial statement.