US MONETARY POLICY SHOCK SPILLOVERS: EVIDENCE FROM FIRM-LEVEL DATA

Elif Arbatli-Saxegaard Melih Firat Davide Furceri Jeanne Verrier

ABSTRACT

We examine three main channels through which U.S. monetary policy shocks affect firm investment in foreign countries: (i) the balance sheet channel, (ii) the financial channel of the exchange rate, and (iii) the trade channel. For this purpose, we use quarterly firm-level data for 63 advanced and emerging market economies over 1996-2016. Our results suggest an important and independent role for all three key channels. U.S. monetary policy shocks have larger effects on investment for firms that are more leveraged (balance sheet channel), have a higher share of debt in foreign currency (financial channel of the exchange rate) and operate in sectors with higher export dependence (trade channel). In addition, we find that the role of leverage is more significant for smaller firms with lower liquidity, while the exchange rate channel is more important for leveraged firms.

JEL-codes: F4, E5, C3
Keywords: U.S. monetary policy shock, foreign spillovers, firm-level data

1. INTRODUCTION

Over the last three decades, international trade and financial integration have reached unprecedented levels. One consequence of a highly interconnected world economy is the spillover of shocks between countries, mainly from center to periphery. Monetary policy in advanced economies, and in particular in the U.S., has been identified as a key source of such international spillovers ((Rey (2013), Rey (2016), Kalemli-Ozcan (2019), Miranda-Agrippino and Rey (2020)). With the beginning of a new monetary policy tightening cycle in the US, amidst a highly uncertain inflation outlook, potential spillovers from U.S. monetary policy pose a pertinent risk for the global economic recovery (IMF (2021)). While spillovers will likely depend on many factors, including the domestic policy response, a country's exposure to different spillover channels is likely to play an important role.

Against this backdrop, we focus on how U.S. monetary policy shocks affect firm investment in foreign countries, using a rich, quarterly, firm-level dataset, covering 63 advanced and emerging market economies. Leveraging the extensive heterogeneity across firms, we examine the role of three key channels: (i) the non-financial firm balance sheet channel (sensitivity to a change in the cost of external finance); (ii) the non-financial firm financial channel of the exchange rate (financial vulnerability to exchange rate fluctuations); and (iii) the trade channel (ratio of exports to the output). The roles of these channels have been discussed in Gourinchas (2018) and Kalemli-Özcan (2019) in a Mundell-Fleming framework.

We proxy each channel with different firm- and industry-level characteristics. In particular, we use firm leverage (debt-to-assets ratio) as a proxy for balance sheet vulnerabilities. For the financial channel of the exchange rate, we take advantage of a unique feature of our dataset—detailed firm-level data on the currency composition of liabilities—and use firms' FX liability ratio as a proxy for the financial channel. For the trade channel, we construct a country-industry level measure of export dependence and analyze whether export dependence acts as a shock absorber (expenditure switching) or amplifier (expenditure reducing). Following Cloyne et al. (2020) and Duval et al. (2021), we use a difference-in-difference framework, assigning firms into different groups (for example, low, medium, high) based on their exposure to the different spillover channels discussed above. We then use a semi-parametric approach and estimate differential impulse responses for each group using local projections. We follow Duval et al. (2021) to identify

exogenous U.S. monetary policy shocks using a proxy-SVAR, where high-frequency movements in U.S. interest rate futures around FOMC meetings are used as instruments for the 1-year bond yield.

Our paper contributes to the literature in two key aspects. First, by leveraging a rich, firm-level dataset, it provides new evidence on different spillover channels, their relative significance, and how they interact with each other for a large sample of advanced and emerging market economies. Second, our quarterly, firm-level dataset allows us to significantly improve the identification of different transmission channels. The vast majority of studies on US monetary policy spillovers use aggregate data which offers limited cross-country heterogeneity and is prone to endogeneity problems. Our dataset offers significant firm-level and sectoral heterogeneity in exposure to different spillover channels, improving identification. The panel feature of our firm-level data also allows us to control for sector and country-specific time effects, and limit potential endogeneity problems stemming from, for example, the domestic policy response to the U.S. monetary policy shock. Finally, the quarterly frequency of our dataset is particularly well-suited to study the impact of US monetary policy shocks, improving identification relative to previous studies that use annual data.

Our results suggest an important and independent role for all three key channels. In particular, U.S. monetary policy shocks have larger effects on investment for firms that are more leveraged (balance sheet channel), with a higher share of debt in foreign currency (exchange rate channel) and operating in sectors with higher trade linkages (trade channel). The cumulative difference in the one-year-ahead response of firm investment rate—ratio of capital expenditures to net property, plant, and equipment—to a 25 basis points monetary policy shock in the U.S. between the top and bottom quartile of firm distribution in leverage is about 1.5 percentage points. A similarly large differential impact is estimated for firms that have a foreign currency debt share of more than 15 percent, and firms that operate in sectors that are in the upper quartile of dependence on exports. Furthermore, the role of leverage is larger for smaller firms with lower liquidity, which is consistent with the idea that leverage is likely to pose a larger constraint on the borrowing capacity of smaller and less liquid firms. We also find important interactions between different channels. For example, balance sheet and exchange rate channels tend to amplify each other, with firms that are classified as having both high leverage and high foreign currency liability share experiencing the largest impact on investment.

We conduct a host of different robustness checks. While our proxy variables for different transmission channels are well established in the empirical and theoretical literature, our results are robust to the use of alternative proxy variables and alternative approaches for classifying firms into different exposure groups. Our results are also robust to focusing on alternative measures of firm investment and different estimates of US monetary policy shocks.

The remainder of the paper proceeds as follows. Section 2 provides a brief literature review. Section 3 describes our data, identification of monetary policy shocks and our empirical strategy. Section 4 presents results, and section 5 concludes.

2. RELATED LITERATURE

This paper relates to three strands of literature. The first strand analyzes the international spillovers of U.S. monetary policy. This voluminous literature has developed around the use of country-level data and typically employs VAR models or event study approaches. Several papers examine the differential response across advanced and emerging market economies and the role of country characteristics such as macroeconomic fundamentals, financial and trade integration or the exchange rate regime (e.g. Mishra et al., 2014; Georgiadis, 2016; Bräuning and Sheremirov, 2019; Iacoviello and Navarro, 2019). Other studies find that the magnitude of spillovers depends on the state of the business cycle, the source of the interest rate shock (Carceres et al, 2016; Hoek, Kamin and Yoldas, 2020; Arbatli-Saxegaard et al., 2021) or whether the Fed conducts conventional or unconventional monetary policy (Chen, Mancini-Griffoli and Sahay, 2014; Gilchrist, Yue and Zakrajšek, 2019). Although some macro-level studies analyze the different channels of monetary policy transmission (e.g. Ammer et al. 2016; Albagli et al., 2019; Kalemli-Ozcan 2019), macro data is typically ill-suited to analyze transmission mechanisms. The key contribution of our paper to this strand of the literature is to use a very rich firm-level dataset and exploit heterogeneity across firms and country-sectors observations to shed light on the main channels of monetary policy transmission. Moreover, while this literature has largely focused on financial spillovers (examining bond yields in particular), studies looking at real outcomes such as real output and investment are still rare (Bräuning and Sheremirov, 2019; Arbatli-Saxegaard et al., 2021). This paper is one of the very first to provide insight into international spillovers to non-financial corporates.

The second related strand of literature examines the heterogeneous effects of monetary policy across firm characteristics. While a few seminal papers in the 1990s introduced the concept of the financial accelerator, providing evidence from large and small manufacturing firms (e.g. Gertler and Gilchrist, 1994; Bernanke, Gertler and Gilchrist, 1996), this literature has grown rapidly in the past few years. The paper most closely related to ours is Li et al. (2020), which examines U.S. monetary policy spillovers to emerging countries using firm-level data. It finds a role for leverage suggesting, like in our study, the existence of a bank lending channel of monetary policy. Other contributions focus on spillovers to firms in specific countries (e.g. Banerjee and Mohanty, 2021, in the case of India). A larger body of the literature exploits firm-level heterogeneity in a domestic context. Three recent studies find that firm characteristics such as leverage, liquidity, distance to default or age play a role in monetary policy transmission, although with conflicting results despite similar data and empirical frameworks (Jeenas, 2019; Cloyne et al., 2020; Ottonello and Winberry, 2020). In addition, Duval et al. (2021) finds a role for firm markups, suggesting that market power interacts with the transmission of monetary policy. We build on the semi-parametric approach in Cloyne et al. (2020) and Duval et al. (2021) but study monetary policy transmission in an international setting, offering a broader scope and taking advantage of larger heterogeneity across firms. The quarterly frequency of our dataset, instead of the annual frequency used in most of these studies, also allows for cleaner identification.

Finally, our paper adds to the literature on the exchange rate channel. The latter has two main conduits which operate in opposite directions: the well-studied trade (or competitiveness) channel and the lesser-known financial channel of the exchange rate, which operates through a firm's foreign currency exposure. To our knowledge, all studies so far have analyzed how investment responds to exchange rate shocks rather than monetary policy shocks. The empirical papers most closely related to ours examine the firms' heterogeneous responses against exchange rate fluctuations (Agarwal, 2021; Aguiar, 2005; Avdiev et al., 2019; Banerjee et al., 2020; Bleakley and Cowan, 2008; Dao et al., 2021; Kalemli-Ozan, Liu and Shim, 2021; Kim, Tesar and Zhang, 2015; Serena and Sousa, 2017).[1] We contribute to this literature by analyzing the exchange rate channel simultaneously with the firm balance sheet channel of monetary policy. Moreover, we put together a unique dataset which contains information on foreign-currency liabilities at the firm level and a measure of export dependence at the country-sector level (and at the firm level for a subset of firms) in a large panel.

[1] Seminal theoretical studies include Krugman (1999), Céspedes et al. (2004), and Feldstein (1999).

3. EMPIRICAL FRAMEWORK

This section describes our main firm-level data source—S&P Capital IQ database—as well as other datasets that are used in the analysis. We also introduce the variables used throughout the paper and how we identify US monetary policy shocks. Finally, we present our empirical approach for estimating the impact of US monetary policy shocks on firm investment and the role of different channels.

3.1. Data

Our main source of data is S&P Capital IQ (CIQ), which provides extensive balance sheet and income statement information at the firm-level. It has two key advantages compared to other leading corporate data providers such as Orbis or Worldscope. First, the data is available at the quarterly frequency, which allows for a clean identification of firm-level responses to monetary policy shocks. Second, it contains information on foreign currency liabilities. Previous studies in the spillover literature have focused on the standard balance sheet variables such as leverage, size, and liquidity. By using the S&P Capital IQ dataset, we are therefore able to provide a detailed examination of the role of foreign currency liabilities, considering the importance of exchange rate fluctuations, especially for EMEs.

Our dataset covers a long time span and a broad set of countries. We collect data for 20 years, from 1996Q3 to 2016Q3, and for 29 advanced and 34 emerging market economies in all regions. Emerging market economy firms are dominated by firms from India and China, while for advanced economies by firms from Japan and Canada. Firms also belong to a wide range of industries (20 CIQ-defined industries in total), after filtering out firms in the financial, insurance and utilities sectors. Details on the distribution of firms across countries and sectors are shown in Appendix A, Figures A1-4.

To maximize the consistency and reliability of the data, we focus on listed firms. Both active and inactive firms are included in our sample. Data is collected by Capital IQ on a consolidated basis only. To avoid double counting, we keep only companies that are ultimate corporate parents. We also exclude state-owned firms, by dropping them from the sample if the type of corporate parent is identified as a government body. After filtering, the sample consists of close to 29,000 firms.

The panel, however, is highly unbalanced. The size of the economy and different filing requirements across countries also introduces large disparities in firm coverage.

Our main variable of interest, the investment rate, is defined as the ratio of capital expenditures (CAPEX) to net property, plant, and equipment (NPPE). To identify the role of the exchange rate channel, we define the foreign-currency liability ratio as foreign currency liabilities to total liabilities. Foreign currency liabilities are computed using data from Capital IQ's Capital Structure module and unlike other datasets, cover both bank debt and bond issuance. Furthermore, Kim et al. (2020) finds that the foreign currency liability ratio obtained using firm-level data from Capital IQ is similar to the aggregate level data compiled by the BIS.

To explore the role of the trade channel, data limitation prevents us from exploiting firm-level heterogeneity. Although Capital IQ provides export revenue data for firms, the coverage is very limited. To obviate to this data limitation, we use the World Input Output Database which provides cross-country trade data for 56 sectors in 43 countries. We calculate the export dependence for each sector-country pair from 2000 to 2014 as:

$$ExportDependence_{cst} = \frac{Exports_{cst}}{Output_{cst}}$$

where *c* and *s* denote country and sector, respectively. $ExportDependence_{cst}$ denotes the share of exports ($Exports_{cst}^{US}$) in sector *s* and the country *c* in the value of total output ($Output_{cst}$). After calculating the export dependence of each sector-country pair for each year, we calculate the average export dependence across time. We then assign each firm to a group - low, medium, or high export dependence - depending on their primary industry of operation and the country-specific distribution of sectoral export dependence.[2]

The regressions also include several additional firm-level characteristics such as collateral, liquidity, size, bank-debt ratio, short-term debt ratio and net interest expenses. The definitions of all variables and their summary statistics are provided in Table 1.

To clean the data, we mainly follow Kim (2019) and Kim et al. (2020). Firms with negative assets in a given year are entirely dropped from the sample, while firm-observations with unexpected

2 The sectoral classification of Capital IQ database is in Standard Industry Classification (SIC), but WIOD defines sectors in NACE REV. 2 classification. We apply the many to one matching between two classifications by hand.

signs for capital expenditure, net property plant and equipment, revenue are excluded. In addition, an observation is filtered out if the difference between assets and liabilities is greater than USD 10,000, or if the amount of cash and cash equivalents and that of tangible assets are greater than total assets. All variables are winsorized at 5 percent to control for outliers.

3.2. Monetary Policy Shock Identification

We follow Duval et al. (2021) to identify exogenous U.S. monetary policy shocks. In particular, we first generate monetary policy surprises as the changes in Federal fund futures around FOMC announcements with a tight window of 30 minutes following Gürkaynak et al. (2005). Here, the identification assumption is that the response of agents in financial markets reflects exclusively monetary policy news during this time interval. Following Gertler and Karadi (2015) we then use these surprises in a proxy-SVAR framework to instrument one-year government bond yield together with industrial production, consumer price index and Gilchrist and Zakrajsek (2012) credit spread. We estimate this 4-variable VAR over the period 1973m1-2016m8 at a monthly frequency.[3] Since our data sample also includes the period after the global financial crisis, we allow for a structural break in the coefficient of impact during this period to account for the unconventional monetary policy period. By using the 1-year government bond yield, we are able to capture the impact of forward guidance to a larger extent than the Fed funds rate, which had remained constant and close to zero during the post-global financial crisis period of our sample.

3.3. Empirical Strategy

In this section, we outline our empirical strategy. As a first step, we estimate the average (unconditional) effect of U.S. monetary policy shocks on firm investment using Jorda's (2005) local projections:

$$logY_{ft+h} - logY_{ft-1} = \beta_h \times i_t^{US} + \gamma_f + \gamma_{csq} + \epsilon_{fct+h} \qquad (1)$$

where dependent variable, Y_{ft}, is the investment ratio and i_t^{US} denotes the exogenous U.S. monetary policy shock. We control for heterogeneity in firm characteristics using firm fixed effects (γ_f) and seasonality in the data using country-sector-quarter fixed effects (γ_{csq}).

[3] In our baseline specification, we use one-year government bond yield as the policy rate and the three-month ahead Fed fund futures as instrument, but our results are robust to using different sets of Fed fund futures and government bond yield combinations.

To estimate how the effect of US monetary policy shocks varies across firms, we follow the semi-parametric approach of Cloyne et al. (2018) and Duval et al. (2021). Specifically, we modify equation (1) as follows:

$$logY_{ft+h} - logY_{ft-1} = \sum_{gc=1}^{G} \beta_{gch} \times I\left[X_f \in gc\right] \times i_t^{US} + \rho_h Z_{ft-1} + \gamma_f + \gamma_{cst+h} + \epsilon_{fct+h} \qquad (2)$$

where *I* is an indicator function which equals one if the firm characteristic X_f is in a specific group gc. For example, if the average leverage of a firm is above (below) 75th (25th) percentile of average leverage across all firms within a country, then the firm is classified as in the "High-Leverage" ("Low-Leverage") group. γ_{cst+h} are country-sector-time fixed effects; Z_{ft-1} are firm-specific characteristics, lagged by one period to reduce reverse causality concerns; and the other terms are as described in equation (1). We estimate equation (2) first separately for each transmission channel, but also for all three channels together, to control for potential multicollinearities between exposure factors. Using country-sector-time fixed effects allows us to control for potential endogeneity problems. Furthermore, our semi-parametric approach allows us to estimate the impact of U.S. monetary policy shocks in a more flexible way and without making assumptions about the functional form of the relationship.

We finally examine the firm-level differential impulse responses using multiple classifications to explore potential interactions between different transmission channels—for example, between leverage and foreign currency liabilities—and between transmission channels and other firm characteristics—for example, between leverage and firm size. In particular, we estimate the following specification:

$$logY_{ft+h} - logY_{ft-1} = \sum_{gc^1=1}^{G^1} \sum_{gc^2=1}^{G^2} \beta_{gc^1 gc^2 h} \times I\left[X_{f^1} \in gc^1\right] \times I\left[X_{f^2} \in gc^2\right] \times i_t^{US} + \rho_h Z_{ft-1} + \gamma_f + \gamma_{cst+h} + \epsilon_{fct+h} \quad (3)$$

where the indicator function, *I*, uses two criteria that are interacted with each other, for example, low/medium/high leverage and small/medium/large firms.

4. Results

4.1. Average Effects

As discussed in section 3.3, we first estimate the average impact of U.S. monetary policy shocks on foreign firms in our sample. Figure (1) displays the average investment response following a

25 basis points exogenous US monetary policy shock. As expected, U.S. monetary policy tightening is followed by an economically and statistically significant decline in investment, with a peak impact of 1.3 percent decline after two quarters. The sign and magnitude of the investment response that we estimate are consistent with the impulse response functions generated using aggregate data. Estimating the same equation for U.S. firms, we find a relatively larger and a more persistent decline in investment, which is broadly consistent with the estimated impact of U.S. monetary policy shocks on investment in other studies using firm-level data for the U.S. (Jeenas (2019), Cloyne et al. (2020)). Considering emerging market economies (excluding China) and advanced economies separately, we find larger spillovers for firms in emerging market economies.[4] Our benchmark result is robust to alternative specifications—including lags of the dependent variable, monetary policy shocks, and different firm characteristics.

4.2. Spillover Channels

Next, we examine the role of three main spillover channels. We discuss the classification of firms into different exposure groups, and present differential impulse responses estimated using equation (2).

4.2.1. Role of the Balance Sheet Channel

We begin our analysis by focusing on the role of the balance sheet channel. Recall that we use firm leverage to proxy the role of balance sheet channel, but our results are similar if we use alternative proxies for sensitivity to external finance premium such as firm size, bank debt to total debt ratio, dividend payment status and firm age. To assign firms into low/medium/high leverage groups, we first calculate average leverage for each firm during our sample period. Then, we calculate the 25th and 75th percentiles of average leverage for each country. We use the country-specific distribution of leverage to assign firms with average leverage below (above) 25th (75th) percentile into low (high) leverage groups.

Figure (2) displays the difference between investment responses for firms in high leverage group versus low leverage group ($\beta_{HighLeverage,h} - \beta_{LowLeverage,h}$) against a 25 basis points U.S. monetary policy tightening shock, estimated using equation (2). Consistent with the presence of a significant balance sheet channel, the negative differential impulse response (blue line) implies that highly leveraged firms are more responsive to US monetary policy shocks than low leverage

[4] Including Chinese firms reduces the estimated impact of U.S. monetary policy shocks.

firms. The differential impulse responses are significant over most of the projection period, suggesting a persistent negative impact in the short- and medium-term.

4.2.2. Role of Exchange Rate Channel

To look at the role of the financial channel of the exchange rate, we focus on firms' foreign currency debt to total debt ratio (FX liability ratio). Similar to leverage, we calculate each firm's average FX liability ratio over time. We assign firms into low (high) FX liability ratio groups if the average FX liability ratio of the firm is below (above) the cross-country sample mean of 15%. Unlike leverage, using the country-specific distributions is not a useful benchmark, given the large number of firms with no FX debt in many countries.[5]

After separating firms into different groups as defined above, we estimate Equation (2) and present the differential impulse responses between high and low FX liability ratio firms ($\beta_{HighFX,h} - \beta_{LowFX,h}$) across different horizons in Figure (3). The blue line, depicting the differential response across two groups, suggests that the investment response after a U.S. monetary policy tightening shock is larger for firms that have a higher FX liability ratio and this effect is statistically significant. Our results are robust to using alternative thresholds suggested in the literature to group firms into high/low FX liability groups, for example, to using 12 and 20 percent as discussed in Finger and Murphy (2019).[6]

4.2.3. Role of Trade Channel

Finally, we consider the trade channel and use the export dependence of a sector as a proxy for the strength of the trade channel. Unlike the balance sheet channel and financial channel of the exchange rate, the trade channel has an ambiguous spillover effect on foreign firms. On the one hand, a U.S. monetary policy tightening decreases the demand for domestic and foreign goods, negatively impacting the firms operating in sectors with higher export dependence (expenditure reducing role). On the other hand, increasing U.S. interest rates depreciate the local currencies against the U.S. dollar, resulting in an increase in competitiveness (expenditure switching role). To empirically test the sign and significance of the trade channel, we assign firms into 3 categories (low, medium, high) depending on the average export dependence of the sectors they operate in and using within-country distribution of export dependence across sectors.

[5] We present country-specific distributions for FX liability share in Appendix B.
[6] Details are discussed in Appendix B.

Figure (4) displays the differential firm-level investment responses for high and low export dependence groups ($\beta_{HighDependence,h} - \beta_{LowDependence,h}$) to a U.S. monetary policy shock. Our results imply that the firms operating in sectors with higher export dependence are more negatively affected by a U.S. monetary policy tightening than their counterparts, suggesting a more significant expenditure reducing role. Results are significant up to the 8th quarter and become statistically insignificant afterwards.

4.2.4. Three Channels Together

So far, we have focused on the three channels discussed above separately, finding a significant role for each channel. While these results are indicative of a potential role for each channel, our results could be biased due to potential correlation between different exposure factors among firms, leading to an omitted variable bias. For example, if high leverage firms in our sample also have a high FX liability share, the estimated impact of leverage cannot be interpreted as the impact of the balance sheet channel. With this in mind, we next estimate a version of equation (2) which includes all three channels together:

$$logY_{fct+h} - logY_{fct-1} = \sum_{gc=1}^{G} \beta_{gch}^{Lev} \times Lev_{gc} \times i_t^{US} + \sum_{gc=1}^{G} \beta_{gch}^{FX} \times FX_{gc} \times i_t^{US} + \sum_{gc=1}^{G} \beta_{gch}^{Trade} \times Trade_{gc} \times i_t^{US} + \rho_h X_{fct-1} + \gamma_f + \gamma_{cst+h} + \epsilon_{fct+h} \quad (4)$$

where firms are assigned into three groups, as previously discussed, depending on their leverage, FX liability ratio and export dependence. Figure (5) displays differential impulse responses for each channel from estimating Equation (4) and Table (2) reports the cumulative impulse responses for each channel. Our results suggest that each channel has an independent and economically and statistically significant role in shaping spillovers from US monetary policy shocks and the impact of different channels are fairly similar in magnitude.

4.3. Cross Classifications

Having shown that our results hold when firm characteristics identifying the three different channels enter the same regression simultaneously, one may still be concerned by the fact that a given firm may face financial frictions on several fronts. Concretely, the leverage ratio of a firm may be correlated with its size or its liquidity position, making it difficult to identify a specific

channel along a single dimension. To alleviate these concerns and explore potential interactions between different channels, we pursue a more rigorous exercise by introducing cross-classifications. We estimate equation (3), in which an indicator function partitions the sample along several firm characteristics, e.g. low/high leverage combined with small/large firm size.

We run three main experiments. First, we examine the role of leverage in the transmission of U.S. monetary policy shocks depending on the size of the firm. As before, we group firms along two dimensions, leverage and size, to create four categories. Figure 9 (top panel) presents the impulse response of firms depending on their leverage ratio (blue line) and conditional on size (left versus right chart). The differential response of low versus high leverage firms is statistically significant for small firms and more pronounced than larger firms at any horizon. This suggests that the balance sheet channel is most powerful for small firms, which are more subject to financial frictions than larger firms.

Second, we examine the role of leverage in the transmission of U.S. monetary policy shocks along another dimension: liquidity. Firms are grouped in two categories conditional on their liquidity position, and equation (3) estimates the differential effect of monetary policy shocks depending on their leverage ratio. Results are reported in Figure 9 (bottom panel). The differential effect between low and high leverage firms is statistically significant for less liquid firms in the 6th quarter following a monetary policy shock, but not statistically significant for more liquid firms throughout the horizon. This suggests a role for liquidity as a shock absorber.

Finally, we repeat this exercise with the foreign currency liability ratio. In line with our previous approach, firms are grouped in two categories depending on their foreign currency exposure. Results are presented in Figure 10. The difference between the left and right panels is the most pronounced of all three exercises. We confirm that switching the order in which the sample is partitioned does not affect the results. We first partition the sample conditional on firm leverage and look at the differential response of firms with low versus high foreign-currency liability ratio in each subsample. The results, shown in Figure 11, confirm the previous finding: vulnerabilities arising from high leverage are compounded by a high foreign currency exposure.

4.4. Robustness

In this section, we discuss the robustness of our key results to different assumptions about proxy variables and classification of firms into different exposure groups. We also discuss the

robustness of our results if we restrict our sample to the period before the global financial crisis (Figure 8). Starting with the balance sheet channel, we consider several alternative proxies to capture dependence on external finance or sensitivity to the external finance premium. In particular, we consider liquidity, dependence on bank finance, firm age, size, and dividend payments both as alternative proxies and as controls together with leverage.[7] We classify firms into different groups based on the country-specific distributions and consider the differential impulse responses for high versus low exposure groups. Figures B3-8 in Appendix B present our estimates, which show that leverage as a proxy for balance sheet channel is robust to controlling for other proposed firm characteristics.

A concern regarding our firm grouping/classification approach is a possible endogeneity in these variables. For example, firms might become more leveraged when interest rates decrease in the U.S. or foreign firms might find it cheaper to borrow in foreign currency when monetary policy is more accommodative in the U.S. To address this concern, we classify firms using their characteristics from the first year they report data, as opposed to the average over the full sample period. Figure 6 shows that the significance of each channel is robust to this strategy, and suggest that firms with higher leverage, FX liability ratio or export dependence respond more to U.S. monetary policy shocks than other firms.

To show that our results are robust to focusing on different time periods, we run our analyses by focusing only on the period before the Great Recession. This exercise aims to understand whether there has been a change in firm investment behavior against the spillover shocks. Figure 8 shows that the results for FX liability ratio and export dependence are robust to focusing only the period before the Great Recession (GR). However, the role of leverage is insignificant for pre-GR period, suggesting that the role of balance sheet vulnerabilities became more important as a determinant in firm investment response after the Great Recession.

We also conduct a host of other robustness exercises, including considering alternative measures of investment—such as change in capital expenditures or the ratio of capital expenditures to total assets—and alternative measures of US monetary policy shocks—for example using alternative

[7] Our choice of alternative proxies for the balance sheet channel is motivated by other studies looking at monetary policy transmission in the US, including Jeenas (2019) and Cloyne (2020).

instruments and maturities for US interest rates in the proxy-SVAR used to identify monetary policy shocks.[8]

5. Conclusion

How do U.S. monetary policy shocks affect firm investment in foreign countries? What are the relative significance of the balance sheet channel, the financial channel of the exchange rate and the trade channel, and how do they interact? We proposed an approach which alleviates endogeneity concerns plaguing the macro-literature and addressed these questions using a rich quarterly firm-level dataset covering 63 different advanced and emerging market economies over 1996-2016.

Our results shed new light on the long-standing literature on monetary policy spillovers and transmission mechanisms. First, we found that each of the three channels play an important and independent role. U.S. monetary policy shocks have larger effects on investment for firms that are more leveraged (balance sheet channel), have a larger share of debt denominated in foreign currency (exchange rate channel) and operate in sectors with higher trade linkages (trade channel).

Second, we found that these channels are economically important and interact with each other. The balance sheet and the exchange rate channel, for example, amplify each other: firms with high leverage and a high ratio of foreign currency liabilities experience the largest impact on investment.

Our results are robust to a battery of tests, such as using alternative proxy variables and alternative approaches to classify firms in different group, considering different time samples, alternative measures of firm investment and different estimates of U.S. monetary policy shocks.

[8] The unreported results from these exercises are available from authors upon request.

REFERENCES

Aguiar, M. (2005). Investment, devaluation, and foreign currency exposure: The case of Mexico. *Journal of Development Economics*, *78*(1), 95-113.

Ammer, J., De Pooter, M., Erceg, C. J., & Kamin, S. B. (2016). *International spillovers of monetary policy* (No. 2016-02-08-1). Board of Governors of the Federal Reserve System (US).

Albagli, E., Ceballos, L., Claro, S., & Romero, D. (2019). Channels of US monetary policy spillovers to international bond markets. *Journal of Financial Economics*, *134*(2), 447-473.

Banerjee, S., & Mohanty, M. S. (2021). *US monetary policy and the financial channel of the exchange rate: evidence from India*. Bank for International Settlements, Monetary and Economic Department.

Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics*, *1*, 1341-1393.

Bleakley, H., & Cowan, K. (2008). Corporate dollar debt and depreciations: much ado about nothing?. *The Review of Economics and Statistics*, *90*(4), 612-626.

Bräuning, F., & Sheremirov, V. (2019). *Output spillovers from US monetary policy: The role of international trade and financial linkages* (No. 19-15). Working Papers.

Chen, M. J., Griffoli, M. T. M., & Sahay, M. R. (2014). *Spillovers from United States monetary policy on emerging markets: different this time?*. International Monetary Fund.

Cloyne, J., Ferreira, C., Froemel, M., & Surico, P. (2018). *Monetary policy, corporate finance and investment* (No. w25366). National Bureau of Economic Research.

Cloyne, J., Ferreira, C., & Surico, P. (2020). Monetary policy when households have debt: new evidence on the transmission mechanism. *The Review of Economic Studies*, *87*(1), 102-129.

Dao, M. C., Minoiu, C., & Ostry, J. D. (2021). Corporate investment and the real exchange rate. *Journal of International Economics*, *131*, 103437.

Desai, M. A., Foley, C. F., & Forbes, K. J. (2008). Financial constraints and growth: Multinational and local firm responses to currency depreciations. *The Review of Financial Studies*, *21*(6), 2857-2888.

Duval, M. R. A., Furceri, D., Lee, R., & Tavares, M. M. (2021). *Market Power and Monetary Policy Transmission*. International Monetary Fund.

Fan, J., & Kalemli-Özcan, Ş. (2016). Emergence of Asia: reforms, corporate savings, and global imbalances. *IMF Economic Review*, *64*(2), 239-267.

Georgiadis, G. (2016). Determinants of global spillovers from US monetary policy. *Journal of international Money and Finance*, *67*, 41-61.

Gertler, M., & Gilchrist, S. (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics*, *109*(2), 309-340.

Gilchrist, S., Yue, V., & Zakrajšek, E. (2019). US monetary policy and international bond markets. *Journal of Money, Credit and Banking*, *51*, 127-161.

Gilchrist, S., & Zakrajšek, E. (2012). Credit spreads and business cycle fluctuations. *American economic review*, *102*(4), 1692-1720.

Gourinchas, P. O. (2018). Monetary policy transmission in emerging markets: An application to chile. *Series on Central Banking Analysis and Economic Policies no. 25*.

Gürkaynak, R. S., Sack, B., & Swanson, E. (2005). The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. *American economic review*, *95*(1), 425-436.

Hoek, J., Kamin, S. B., & Yoldas, E. (2020). When is Bad News Good News? US Monetary Policy, Macroeconomic News, and Financial Conditions in Emerging Markets. *US Monetary Policy, Macroeconomic News, and Financial Conditions in Emerging Markets (January, 2020). FRB International Finance Discussion Paper*, (1269).

Iacoviello, M., & Navarro, G. (2019). Foreign effects of higher US interest rates. *Journal of International Money and Finance*, *95*, 232-250.

International Monetary Fund. 2021 "Shifting Gears: Monetary Policy Spillovers during the Recovery from COVID-19", Chapter 4, World Economic Outlook, April 2021

Jeenas, P. (2019). Firm balance sheet liquidity, monetary policy shocks, and investment dynamics. *Work*.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review*, *95*(1), 161-182.

Kalemli-Ozcan, S., Kamil, H., & Villegas-Sanchez, C. (2016). What hinders investment in the aftermath of financial crises: Insolvent firms or illiquid banks?. *Review of Economics and Statistics*, *98*(4), 756-769.

Kalemli-Özcan, Ş. (2019). *US monetary policy and international risk spillovers* (No. w26297). National Bureau of Economic Research.

Kalemli-Ozcan, S., Liu, X., & Shim, I. (*2021*). Exchange Rate Fluctuations and Firm Leverage. *IMF Economic Review*, *69*(1), 90-121.

Li, D., Magud, N. E., & Valencia, F. (2020). Financial shocks and corporate investment in emerging markets. *Journal of Money, Credit and Banking*, *52*(2-3), 613-644.

Kim, M., Mano, R. C., Mrkaic, M., Duttagupta, R., & Helbling, T. (2020). Do FX interventions lead to higher FX debt? Evidence from firm-level data. IMF Working Papers, 2020(197).

Miranda-Agrippino, S., & Rey, H. (2020). US monetary policy and the global financial cycle. *The Review of Economic Studies*, *87*(6), 2754-2776.

Miyajima, K., Mohanty, M. S., & Yetman, J. (2014). Spillovers of US unconventional monetary policy to Asia: the role of long-term interest rates.

Ottonello, P., & Winberry, T. (2020). Financial heterogeneity and the investment channel of monetary policy. *Econometrica*, *88*(6), 2473-2502.

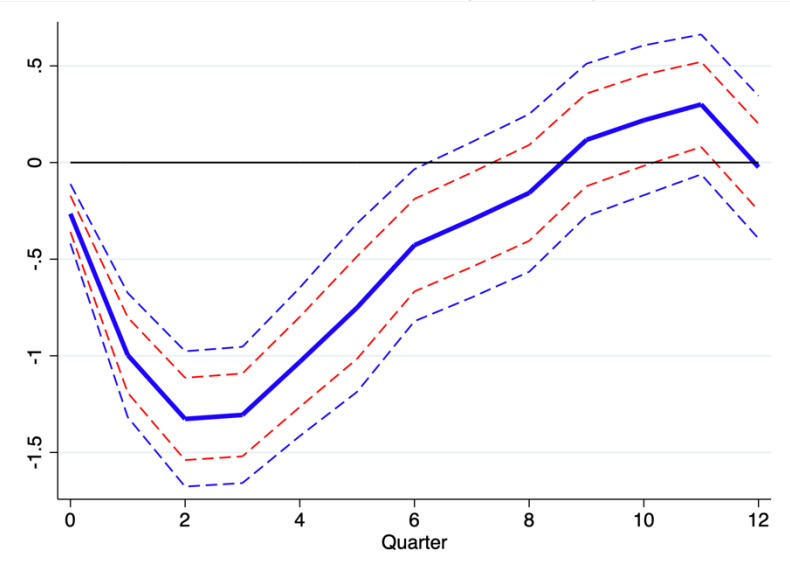
Rey, H. (2013). Dilemma not trilemma: The global financial cycle and monetary independece, Global Dimensions of Unconventional Monetary Policy. In *Economic Policy Symposium, Federal Reserve Bank of Kansas City*.

Rey, H. (2016). International channels of transmission of monetary policy and the Mundellian trilemma. *IMF Economic Review*, *64*(1), 6-35.

Serena, J. M., & Sousa, R. (2017). Does exchange rate depreciation have contractionary effects on firm-level investment?.

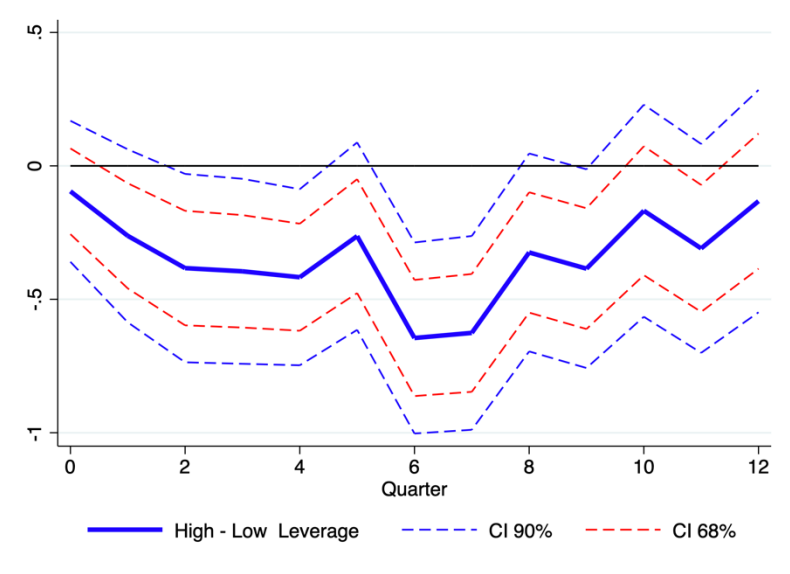
FIGURES

FIGURE 1: AVERAGE EFFECTS (INVESTMENT)



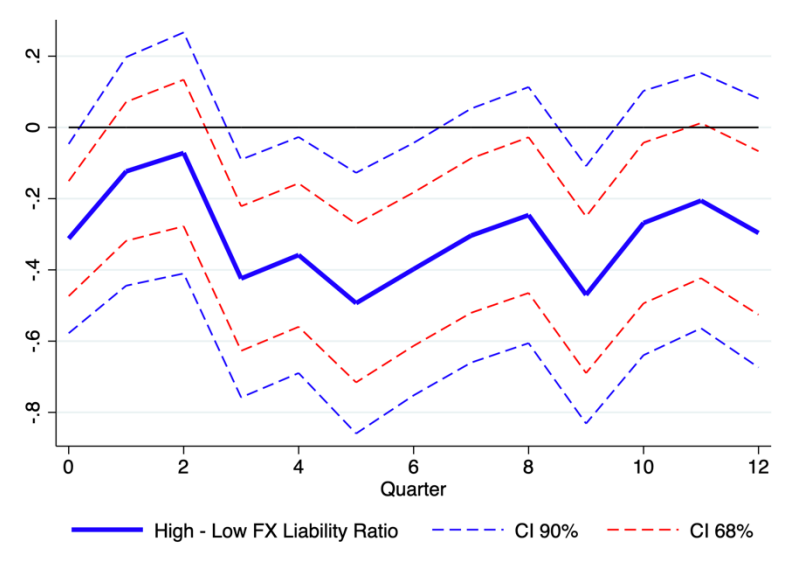
NOTE: RESULTS ARE FROM ESTIMATION OF EQUATION (1). THE SOLID BLUE LINES INDICATE THE AVERAGE RESPONSE INVESTMENT OF FIRMS AGAINST A 25BPS OF A U.S. MONETARY POLICY SHOCK. Y-AXIS IS IN PERCENTAGES. STANDARD ERRORS ARE TWO-WAY CLUSTERED ON FIRM AND COUNTRY-TIME. DASHED BLUE LINE AND DASHED RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS.

FIGURE 2: THE ROLE OF LEVERAGE (BALANCE SHEET CHANNEL)



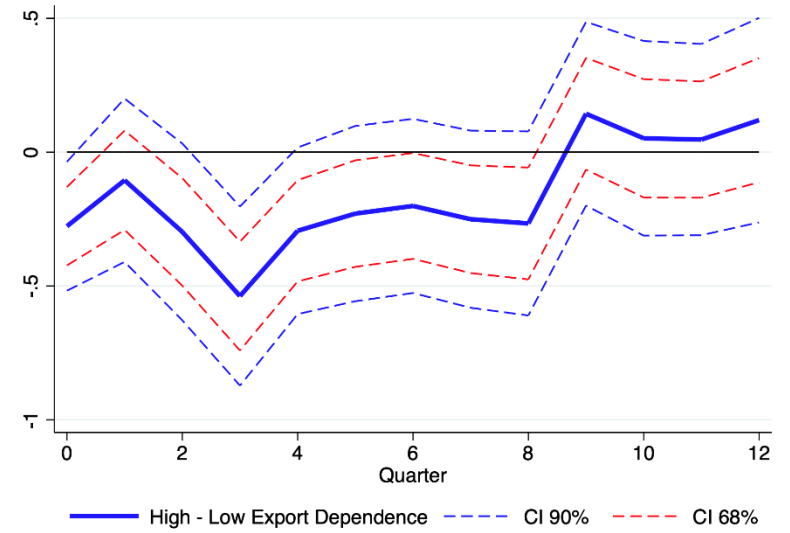
NOTE: THE RESULTS FOLLOW THE ESTIMATION OF EQUATION (2). DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW LEVERAGE GROUPS ($\beta_{HghLeveage,h} - \beta_{LowLeverage,h}$) REPRESENTED WITH THE BLUE LINE AND SHOWS THE RESPONSE AGAINST A 25BPS OF A U.S. MONETARY POLICY SHOCK. Y-AXIS IS IN PERCENTAGES. DASHED BLUE LINE AND DASHED RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS. WE CONTROL FOR FIRM AND SECTOR-COUNTRY-TIME FIXED EFFECTS AS WELL AS TIME-VARYING FIRM CHARACTERISTICS SUCH AS LEVERAGE, LIQUIDITY, SIZE, COLLATERAL ETC. THE STANDARD ERRORS ARE CLUSTERED ON FIRM.

FIGURE 3: ROLE OF FX LIABILITY RATIO



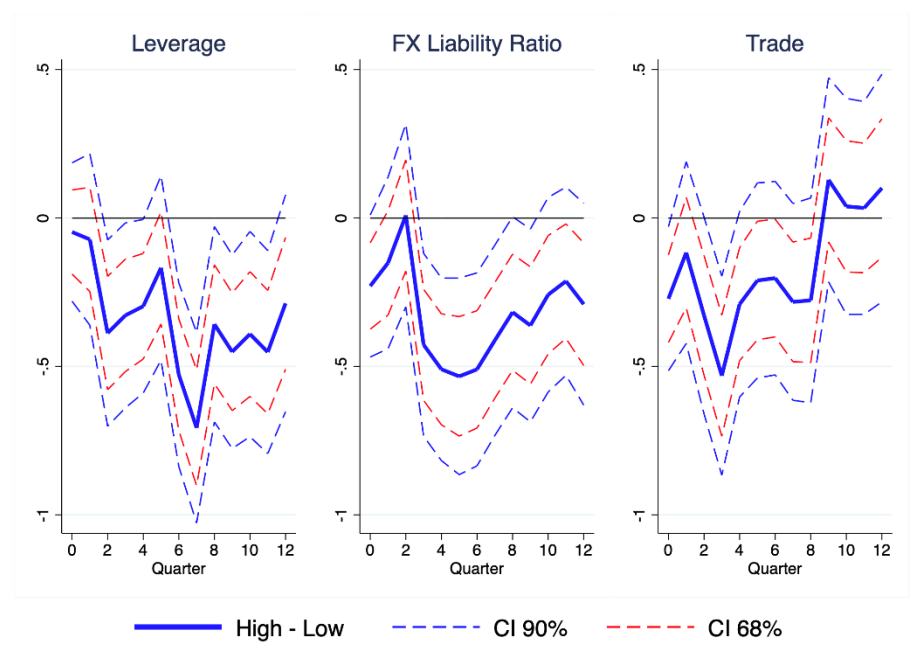
NOTE: THE RESULTS FOLLOW THE ESTIMATION OF EQUATION (2). DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW FX LIABILITY RATIO GROUPS ($\beta_{HighFX,h} - \beta_{LowFX,h}$) REPRESENTED WITH THE BLUE LINE AND SHOWS THE RESPONSE AGAINST A 25BPS OF A U.S. MONETARY POLICY SHOCK. Y-AXIS IS IN PERCENTAGES. DASHED BLUE LINE AND DASHED RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS. WE CONTROL FOR FIRM AND SECTOR-COUNTRY-TIME FIXED EFFECTS AS WELL AS TIME-VARYING FIRM CHARACTERISTICS SUCH AS LEVERAGE, LIQUIDITY, SIZE, COLLATERAL ETC. THE STANDARD ERRORS ARE CLUSTERED ON FIRM.

FIGURE 4: ROLE OF TRADE CHANNEL



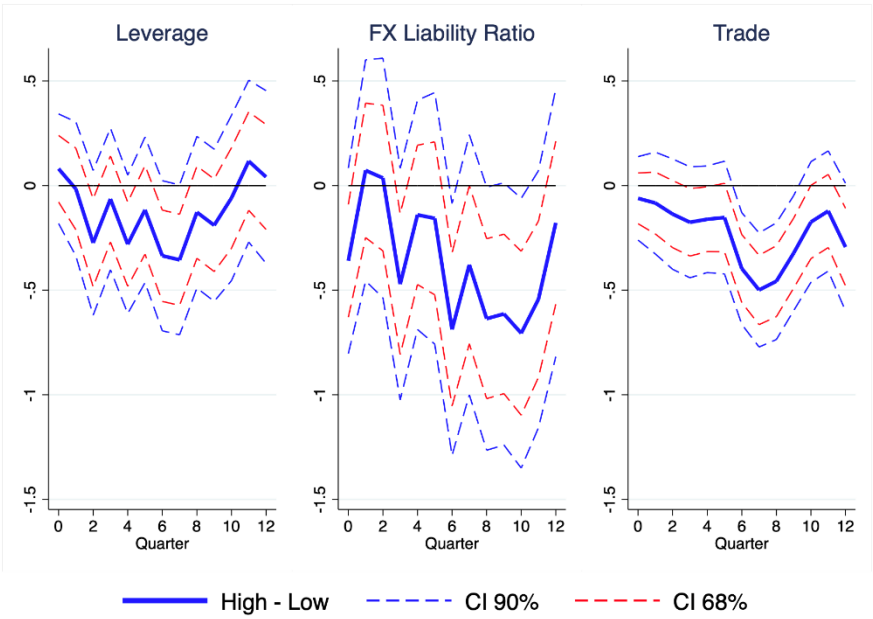
NOTE: THE RESULTS FOLLOW THE ESTIMATION OF EQUATION (2). DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW EXPORT DEPENDENCE GROUPS ($\beta_{HighDependence,h} - \beta_{LowDependence,h}$) REPRESENTED WITH THE BLUE LINE AND SHOWS THE RESPONSE AGAINST A 25BPS OF A U.S. MONETARY POLICY SHOCK. Y-AXIS IS IN PERCENTAGES. DASHED BLUE LINE AND DASHED RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS. THIS EXERCISE USES ONLY COUNTRY-TIME FIXED EFFECTS INSTEAD OF COUNTRY-SECTOR TIME FIXED EFFECTS SINCE WE CAN EXPLOIT THE VARIATION ONLY IN SECTOR-COUNTRY LEVEL. WE ALSO CONTROL FOR TIME-VARYING FIRM CHARACTERISTICS SUCH AS LEVERAGE, LIQUIDITY, SIZE, COLLATERAL ETC. THE STANDARD ERRORS ARE CLUSTERED ON FIRM.

FIGURE 5: COMPARISON OF THREE CHANNELS



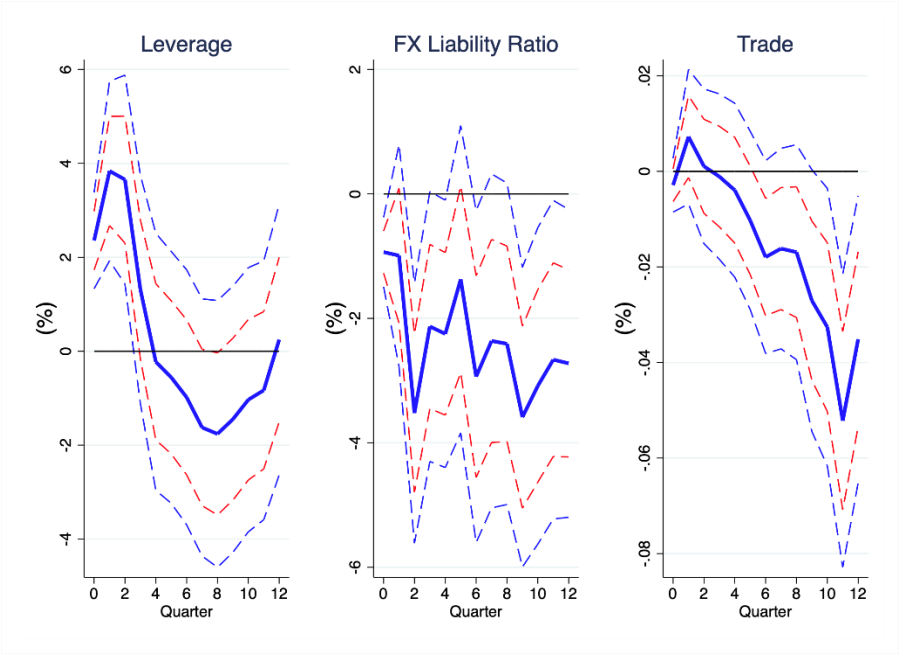
NOTE: THE RESULTS FOLLOW THE ESTIMATION OF EQUATION (4). THIS EXERCISE USES ONLY COUNTRY-TIME FIXED EFFECTS INSTEAD OF COUNTRY-SECTOR-TIME FIXED EFFECTS SINCE WE CAN EXPLOIT THE VARIATION ONLY IN SECTOR-COUNTRY LEVEL IN TRADE CHANNEL.

FIGURE 6: CLASSIFICATION BASED ON INITIAL LEVELS



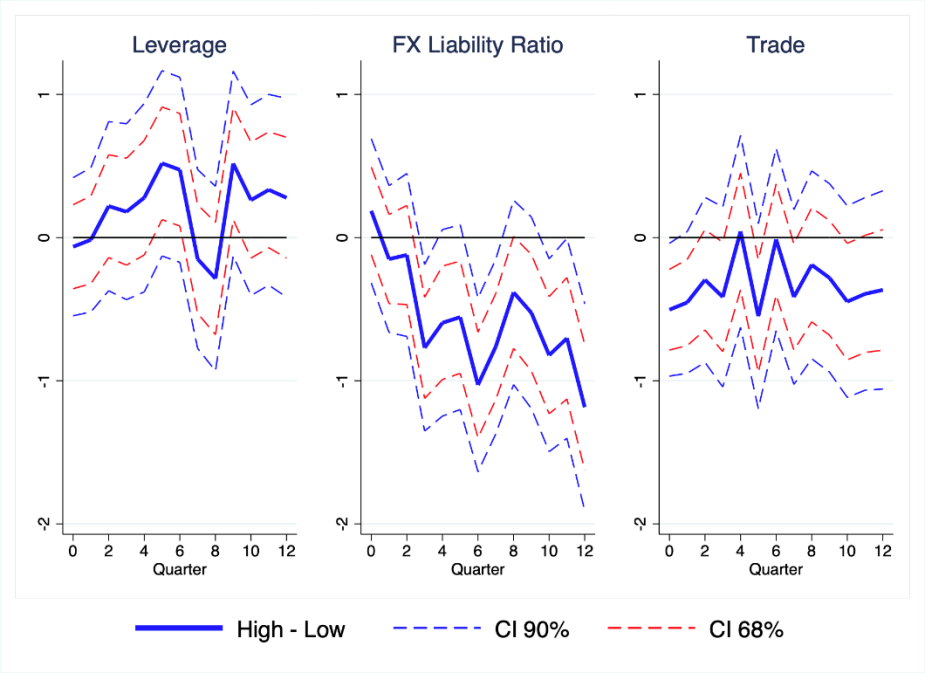
NOTE: FIRMS ARE ASSIGNED INTO GROUPS BASED ON THEIR INITIAL LEVERAGE, FX LIABILITY RATIO AND EXPORT DEPENDENCE OF FIRST TWO YEAR OF OBSERVATIONS. DASHED BLUE LINE AND DASHED RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS. THIS EXERCISE USES ONLY COUNTRY-TIME FIXED EFFECTS INSTEAD OF COUNTRY-SECTOR TIME FIXED EFFECTS SINCE WE CAN EXPLOIT THE VARIATION ONLY IN SECTOR-COUNTRY LEVEL. WE ALSO CONTROL FOR TIME-VARYING FIRM CHARACTERISTICS SUCH AS LEVERAGE, LIQUIDITY, SIZE, COLLATERAL ETC. THE STANDARD ERRORS ARE CLUSTERED ON FIRM.

FIGURE 7: ENDOGENEITY EXERCISE



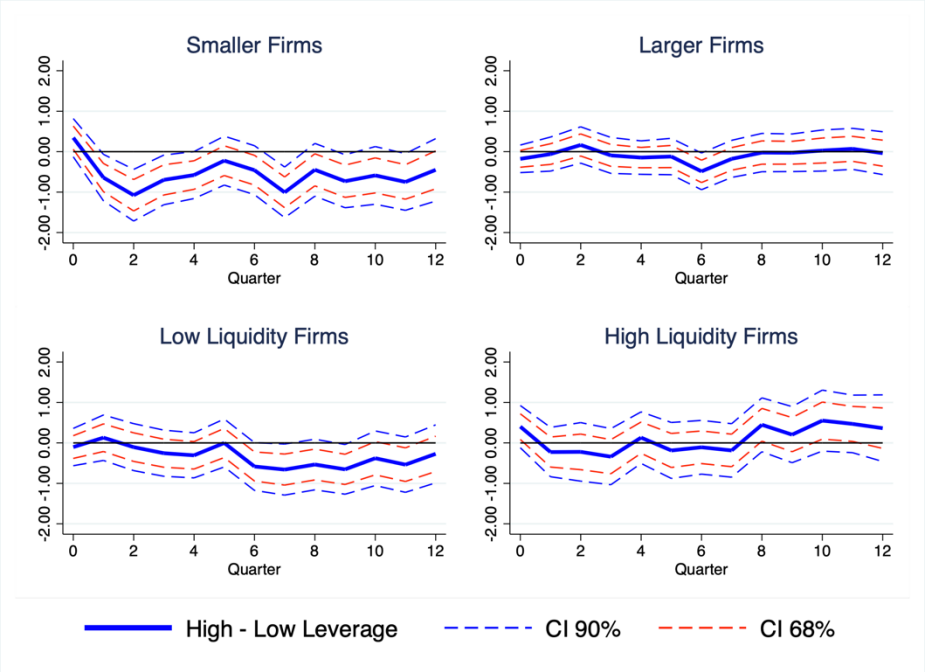
NOTE: DASHED BLUE LINE AND DASHED RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS. IN THIS EXERCISE WE REGRESS FIRM CHARACTERISTICS LEVERAGE AND FX LIABILITY RATIO AND SECTORAL EXPORT DEPENDENCE ON U.S. MONETARY POLICY SHOCK SEPERATELY. WE AIM TO TEST WHETHER THE PROXIES THAT ARE USED IN THE TEXT ARE ENDOGENOUS TO THE SHOCK.

FIGURE 8: MONETARY POLICY SPILLOVERS BEFORE THE GREAT RECESSION



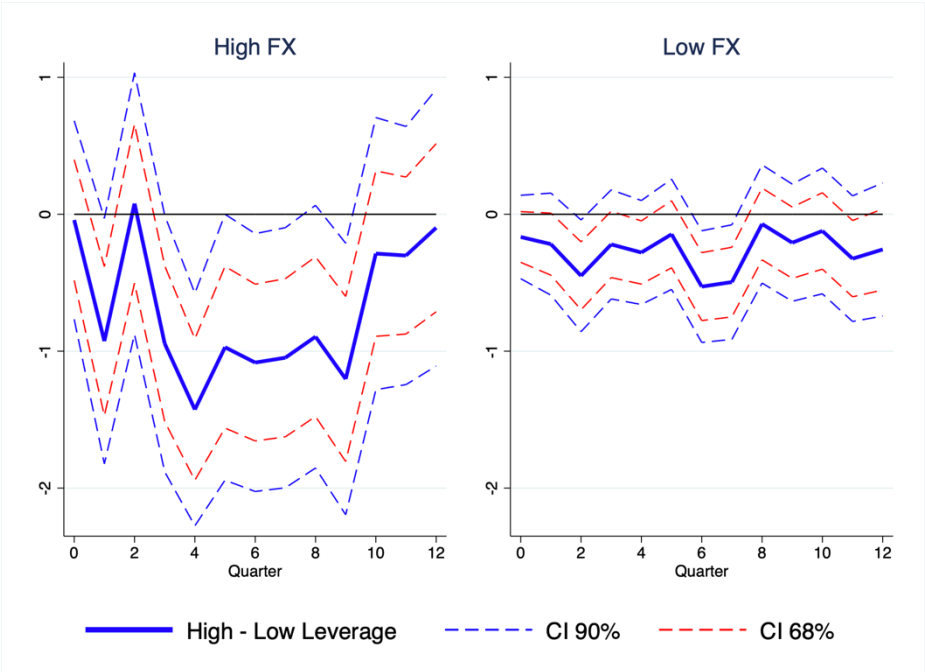
NOTE: DASHED BLUE AND RED LINE DISPLAY THE 90% AND 68% CONFIDENCE INTERVALS, RESPECTIVELY. THIS EXERCISE USES ONLY COUNTRY-TIME FIXED EFFECTS INSTEAD OF COUNTRY-SECTOR TIME FIXED EFFECTS SINCE WE CAN EXPLOIT THE VARIATION ONLY IN SECTOR-COUNTRY LEVEL. WE ALSO CONTROL FOR TIME-VARYING FIRM CHARACTERISTICS SUCH AS LEVERAGE, LIQUIDITY, SIZE, COLLATERAL ETC. THE STANDARD ERRORS ARE CLUSTERED ON FIRM.

FIGURE 9: BALANCE SHEET CHANNEL: THE ROLE OF SIZE AND LIQUIDITY



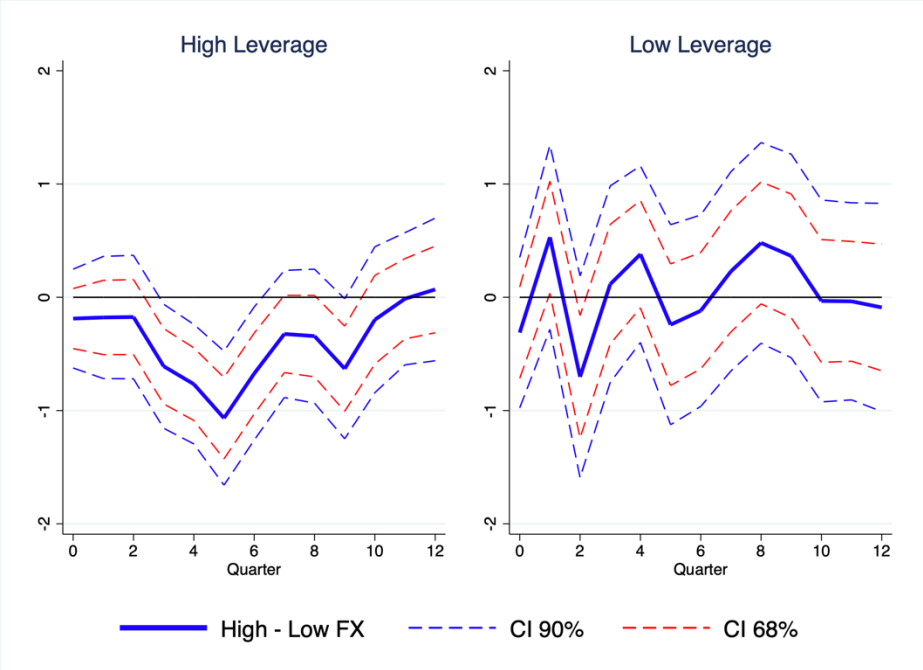
NOTE: THIS EXERCISE SEPARATES FIRMS INTO SMALL/MEDIUM/LARGE FIRMS AND LOW/HIGH LIQUIDITY FIRMS FOLLOWING THE CROSS-CLASSIFICATION STRATEGY DISCUSSED IN EQUATION 3. THE BLUE LINE REPRESENTS THE DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW LEVERAGE GROUPS.

FIGURE 10: BALANCE SHEET CHANNEL: THE ROLE OF THE FX LIABILITY RATIO



NOTE: THIS EXERCISE SEPARATES FIRMS INTO LOW/HIGH FX LIABILITY RATIO FIRMS FOLLOWING THE CROSS-CLASSIFICATION STRATEGY DISCUSSED IN EQUATION 3. THE BLUE LINE REPRESENTS THE DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW LEVERAGE GROUPS.

FIGURE 11: EXCHANGE RATE CHANNEL: THE ROLE OF LEVERAGE



NOTE: THIS EXERCISE SEPARATES FIRMS INTO LOW/HIGH LEVERAGE FOLLOWING THE CROSS-CLASSIFICATION STRATEGY DISCUSSED IN EQUATION 3. THE BLUE LINE REPRESENTS THE DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW FX LIABILITY RATIO FIRMS.

TABLES

TABLE 1: SUMMARY STATISTICS

	Number of Obs.	Mean	Std. Dev.	25th Pctile	Median	75th Pctile
Investment Rate	1,110,963	0.062	0.077	0.014	0.036	0.078
Leverage	1,519,275	0.198	0.184	0.021	0.164	0.327
FX Liability Ratio (%)	711,428	15.41	32.37	0	0	7.51
Trade Dep. Ratio (%)	1,824,966	14.2	17.9	3.7	8.2	15.8
Size ($ USD)	1,528,261	4.72	2.27	3.4	4.84	6.23
Bank Debt Ratio	1,528,261	0.172	0.170	0.047	0.117	0.241
Liquidity	661,823	0.763	0.292	0.596	0.904	1

APPENDIX A: DATA AND VARIABLE DEFINITIONS

FIGURE A1: DISTRIBUTION OF FIRMS ACROSS AES

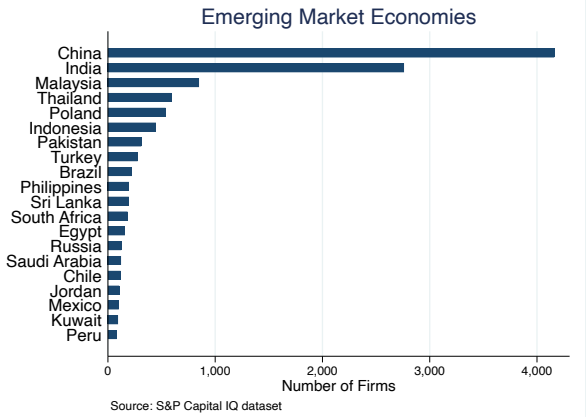


FIGURE A2: DISTRIBUTION OF FIRMS ACROSS AES

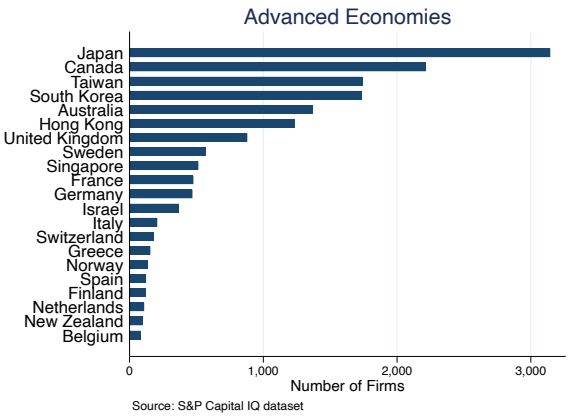


FIGURE A3: DISTRIBUTION OF FIRMS ACROSS NON-TRADABLE SECTOR

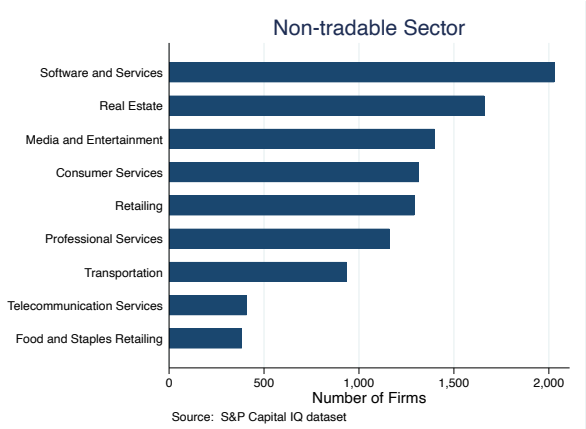


FIGURE A4: DISTRIBUTION OF FIRMS ACROSS NON-TRADABLE SECTOR

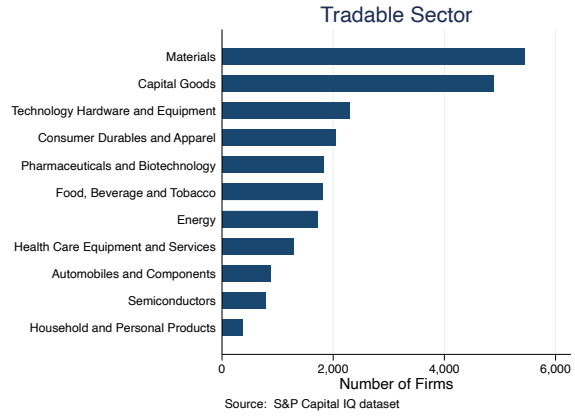
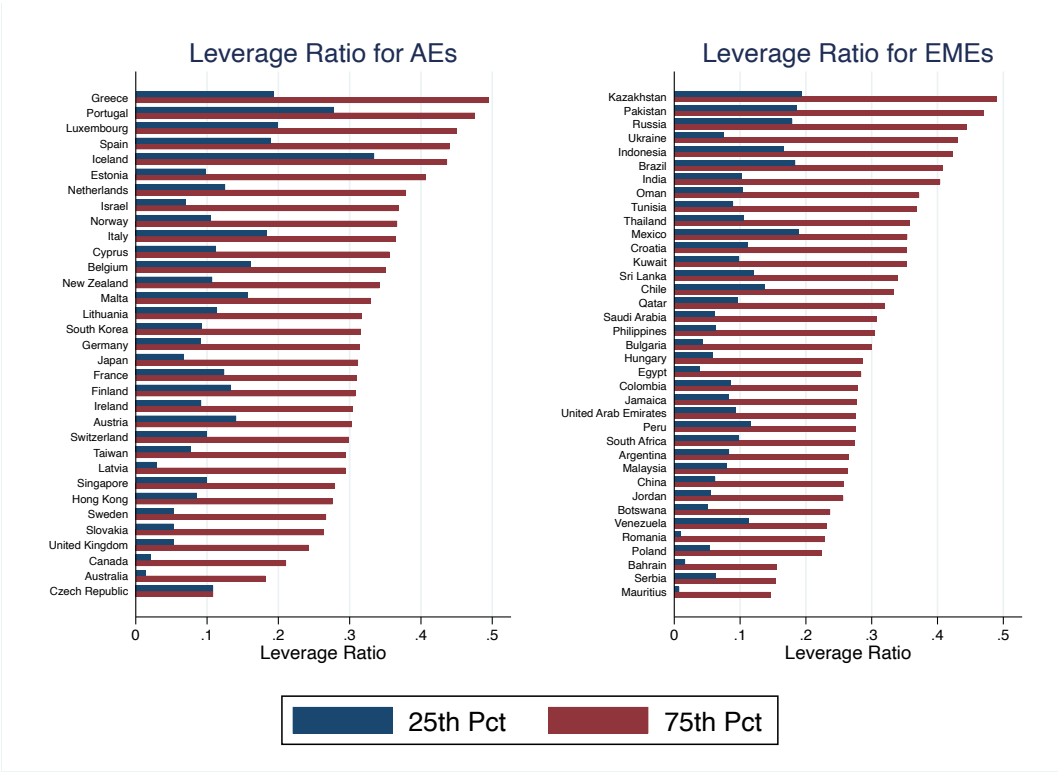


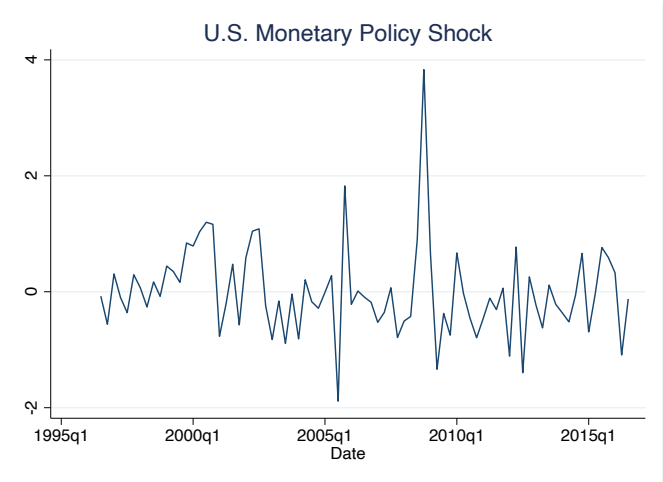
FIGURE A5: DISTRIBUTION OF FIRM LEVERAGE RATIO WITHIN COUNTRIES



NOTE: EACH BLUE AND RED LINE REPRESENTS THE LEVERAGE LEVEL AT 25TH AND 75TH PERCENTILE IN EACH COUNTRY.

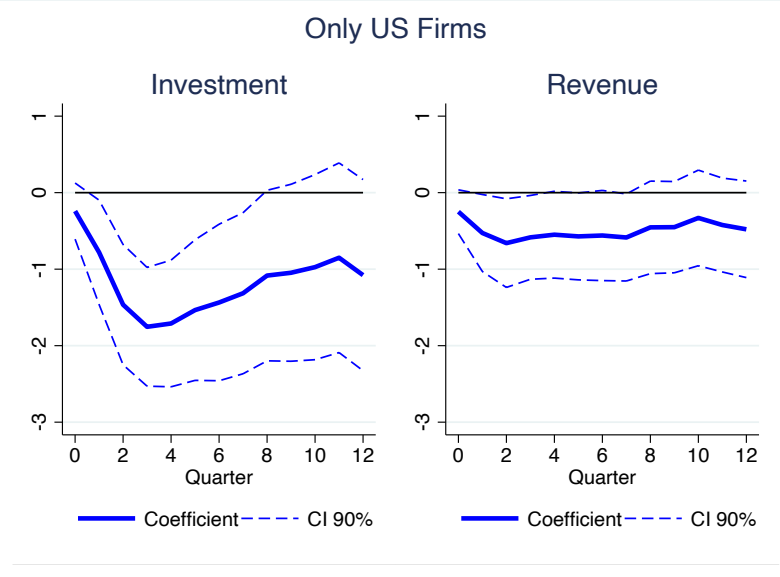
APPENDIX B: OTHER FIGURES AND ROBUSTNESS EXERCISES

FIGURE B1: IDENTIFIED U.S. MONETARY POLICY SHOCK



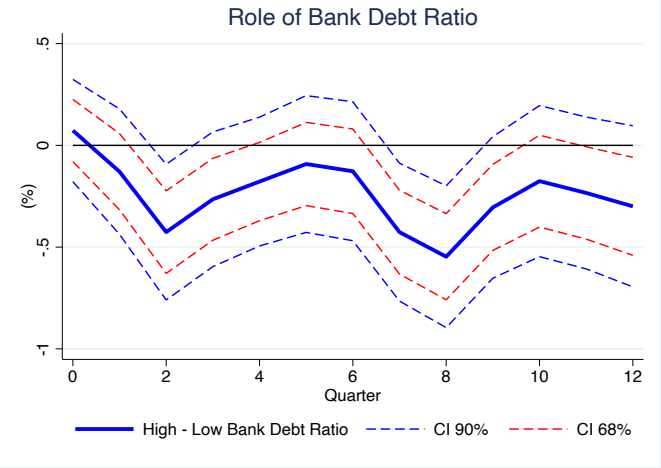
NOTE: THE SERIES IDENTIFIED FOR THE PERIOD 1996Q3-2016Q3 FOLLOWING DUVAL ET AL. (2021). DETAILS ARE PROVIDED IN SECTION 3.2.

FIGURE B2: AVERAGE INVESTMENT AND REVENUE RESPONSE FOR ONLY U.S. FIRMS



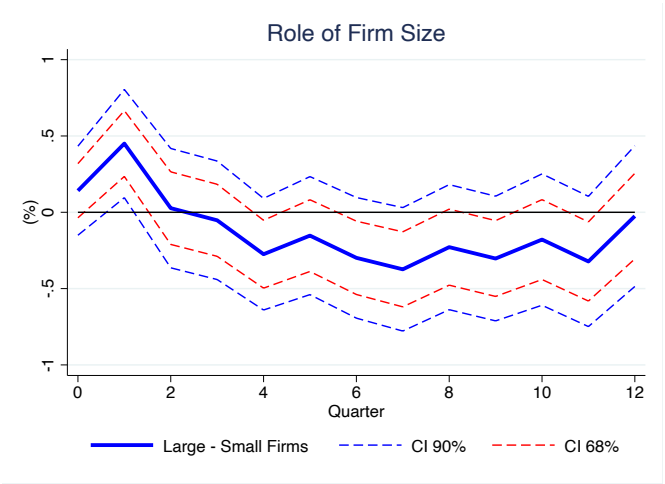
NOTE: WE ESTIMATE EQUATION (1) USING THE DATA FROM ONLY U.S. FIRMS. REVENUE VARIABLE IS DEFINED AS GROWTH IN TOTAL REVENUES.

FIGURE B3: ALTERNATIVE PROXY FOR BALANCE SHEET CHANNEL: BANK DEBT RATIO



NOTE: WE ESTIMATE EQUATION (2) AND FOLLOW SAME FIRM GROUP CLASSIFICATION STRATEGY. WE GROUP FIRMS IN EACH CATEGORY DEPENDING ON THEIR BANK DEBT TO TOTAL DEBT RATIO. BLUE LINE REPRESENTS DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW BANK DEBT RATIO GROUPS.

FIGURE B4: ROLE OF FIRM SIZE



NOTE: WE ESTIMATE EQUATION (2) AND FOLLOW SAME FIRM GROUP CLASSIFICATION STRATEGY. WE GROUP FIRMS IN EACH CATEGORY DEPENDING ON THEIR SIZE (TOTAL ASSETS IN USD). BLUE LINE REPRESENTS DIFFERENTIAL IMPULSE RESPONSES BETWEEN LARGE AND SMALL FIRMS.

Robustness to including other proxies for the balance sheet channel. As a robustness check, we add two three other proxies and estimate the following equation to control for a potential multicollinearity issue

$$logY_{fct+h} - logY_{fct-1} = \sum_{gc=1}^{G} \beta_{gch}^{Lev} \times Lev_{gch} \times i_t^{US} + \sum_{gc=1}^{G} \beta_{gch}^{BankDebt} \times BankDebt_{gch} \times i_t^{US} + \sum_{gc=1}^{G} \beta_{gch}^{Size} \times Size_{gch} \times i_t^{US} + \rho_h X_{fct-1} + \gamma_f + \gamma_{cst+h} + \epsilon_{fct+h}$$

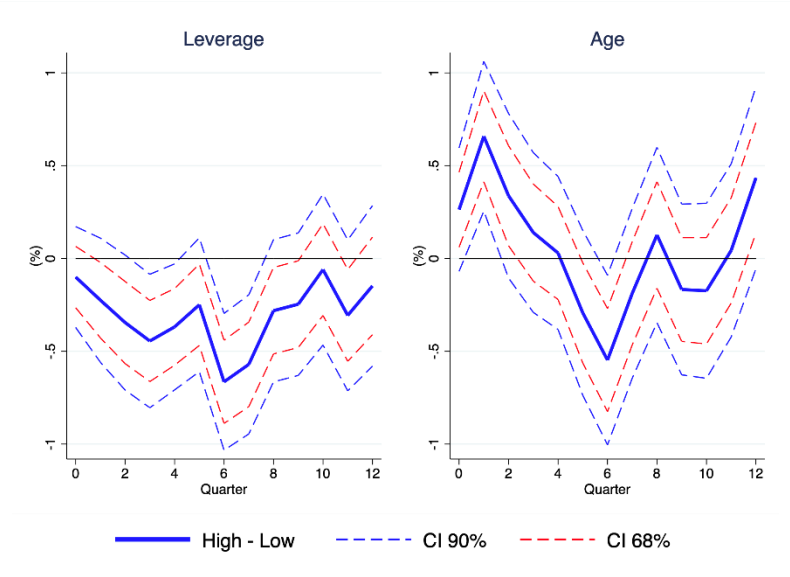
where firms are assigned into three groups depending on their leverage level, bank debt to total debt ratio and size, separately. The results from Figure (B5) show the robustness of the leverage channel explaining the differential investment responses of the firms after controlling for firm bank debt ratio and size (High - Low means "Large - Small" for the firm size).

FIGURE B5: ROBUSTNESS CHECK FOR THE ROLE OF LEVERAGE

NOTE: RESULTS FOLLOW THE ESTIMATION OF EQUATION ABOVE. BLUE LINES REPRESENT THE DIFFERENTIAL IMPULSE RESPONSES BETWEEN HIGH AND LOW GROUP FOR EACH CATEGORY SEPARATELY.

In addition, we control for the role of firm age and estimate the equation above by adding firm age instead of bank debt ratio and size. The results from Figure (B6) suggest that the role of leverage is still significant after controlling for the firm age.

FIGURE B6: ROLE OF LEVERAGE: CONTROLLING FOR FIRM AGE

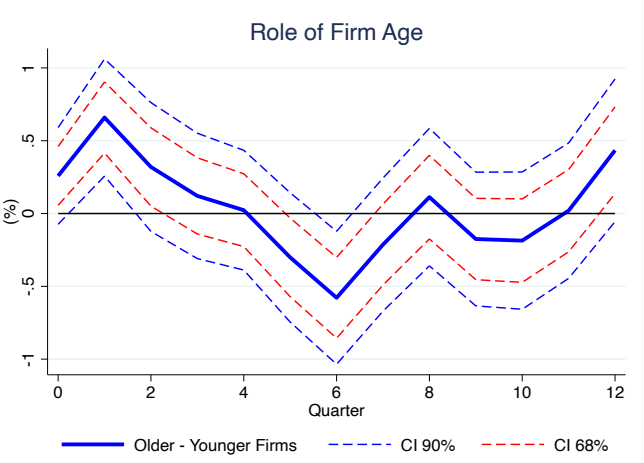


NOTE: WE ESTIMATE EQUATION (4) FROM THE TEXT BY USING ONLY LEVERAGE AND AGE AS FIRM CHARACTERISTICS.

Here, we discuss the independent role of firm age and whether firm pays dividend or not. Cloyne et al. (2020) shows that younger U.S. firms that do not pay dividend have been more responsive against the monetary policy shock. Here, we show the role of these two firm characteristics on the US monetary policy shock spillovers.

First, we calculate the age of each firm by subtracting the year of foundation of each firm from 2019 (the last period in our sample). Then, we group firms into old/middle/young categories depending on the firm age. Figure (B7) shows that response from the older firms have been more limited compared to younger firms for the first two quarters. Then the differential responses across the older and younger firms are insignificant.

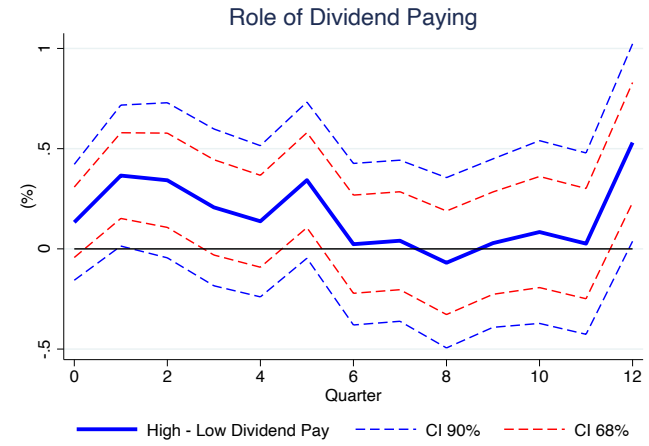
FIGURE B7: ROLE OF FIRM AGE



NOTE: RESULTS FOLLOW THE ESTIMATION OF EQUATION (2) USING THE AGE AS FIRM CHARACTERISTIC. WE CALCULATE THE AGE OF EACH FIRM IN 2016 AND ASSIGN INTO YOUNG/MEDIUM/OLD FIRM CATEGORIES AND ESTIMATE THE DIFFERENTIAL IMPULSE RESPONSES.

We also calculate the average amount of dividend payment by each firm through our sample. Then, we group firms into high/medium/low categories depending on average dividend payment values. Figure (B8) shows that firms that dividend have been less responsive to the US monetary policy shocks through the fourth quarter and the difference of responses between two groups are insignificant afterwards.

FIGURE B8: ROLE OF DIVIDEND PAYMENT



NOTE: RESULTS FOLLOW THE ESTIMATION OF EQUATION (2) USING THE AGE AS FIRM CHARACTERISTIC. WE ASSIGN EACH FIRM INTO LOW/MEDIUM/HIGH DIVIDEND PAYMENT CATEGORIES AND ESTIMATE THE DIFFERENTIAL IMPULSE RESPONSES.

Robustness Checks on FX Liability Ratio

As discussed in the main text, to present the role of exchange rate channel, we separate firms into High vs. Low groups depending on their FX liability ratio relative to the "mean" level of 15 percent (across all firms and countries.) To control for its robustness, we use 12 percent and 20 percent as different thresholds following the result from Finger and Murphy (2019) that exchange rate channel might act as a shock amplifier after exceeding these ratios. The results are robust to using different threshold levels.

FIGURE B9: THRESHOLD = 12%

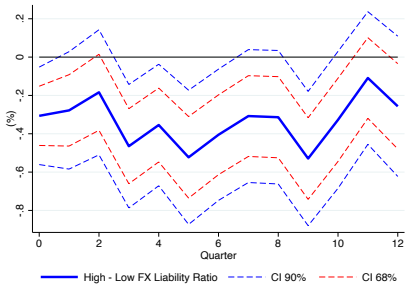


FIGURE B10: THRESHOLD = 15%

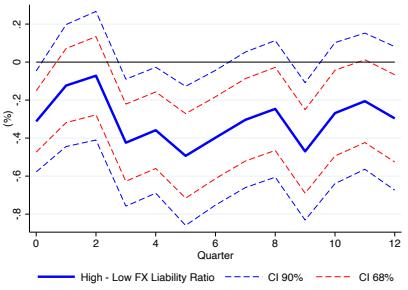
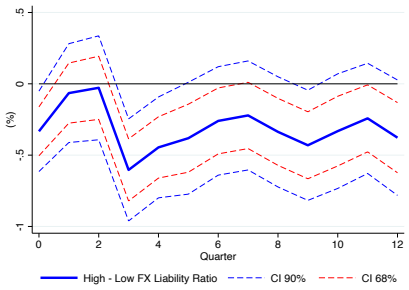


FIGURE B11: THRESHOLD = 20%

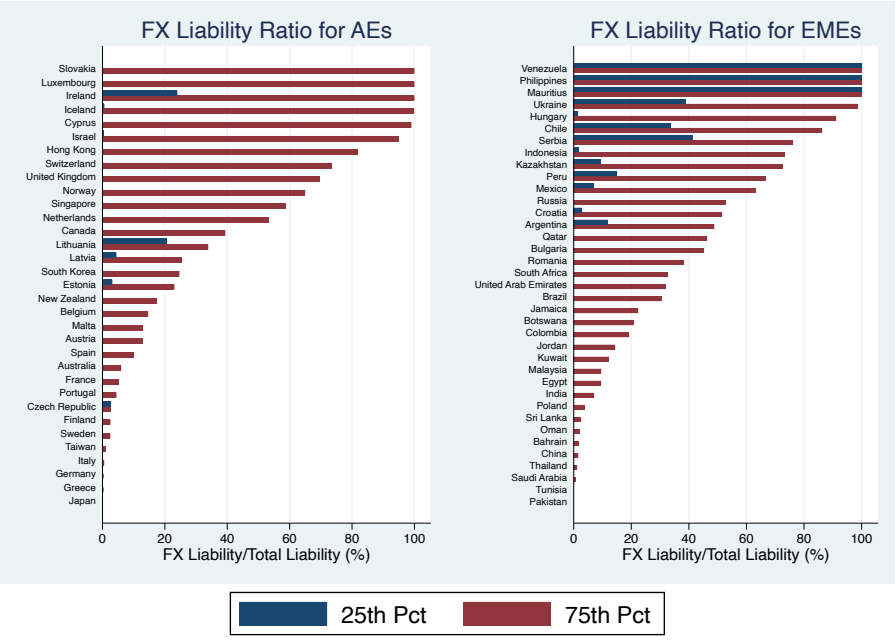


However, one can argue that financial development of a country is a significant determinant of the threshold that should govern the firm-level vulnerabilities. For example, a given FX liability

ratio can be considered as low in a financially developed country whereas the same level of FX debt share can pose risks in developing economies.

Our baseline firm grouping methodology, where firms are assigned into Low/Medium/High categories depending on relative firm characteristics compared to the 25th and 75th percentile of corresponding firm characteristic within-country would address this concern. However, the data limitations restrict us to follow this approach. The two graphs show the distribution of FX liability ratios across firms in each AE and EME countries respectively. In particular, we display the 25th percentile and the 75th percentile of distributions and show that most of the firms have FX liability ratio at 0 percent. For example, almost 0 percent of FX liability ratio at 75th percentile in Germany, China, and Japan, assigns firms with very Low FX liability ratios to "High" FX liability ratio group.

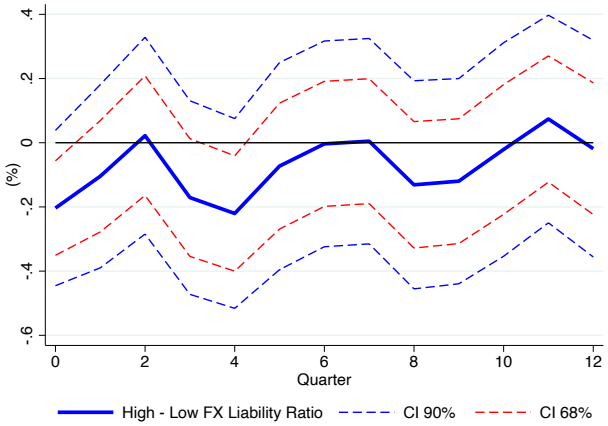
FIGURE B12: DISTRIBUTION OF FX LIABILITY RATIO WITHIN EACH COUNTRY



NOTE: WE CALCULATE THE AVERAGE FX LIABILITY RATIO FOR EACH FIRM AND DISPLAY THE DISTRIBUTION OF THESE RATIOS WITHIN EACH COUNTRY. BLUE AND RED LINES PRESENT THE 25TH AND 75TH PERCENTILES OF THE DISTRIBUTION.

To provide a comparison, we also follow our baseline methodology and group firms into low/med/high FX liability ratios depending on their relative foreign currency debt ratios within country. E.g., low (high) group, if FX liability ratio of the firm is below (above) 25th (75th) percentile. Figure (B13) shows that

FIGURE B13: FX LIABILITY RATIO: USING WITHIN COUNTRY DISTRIBUTION



NOTE: WE ASSIGN FIRMS INTO EACH CATEGORY FOLLOWING OUR STANDARD METHOD AND PRESENT THE DIFFERENTIAL IMPULSE RESPONSES.

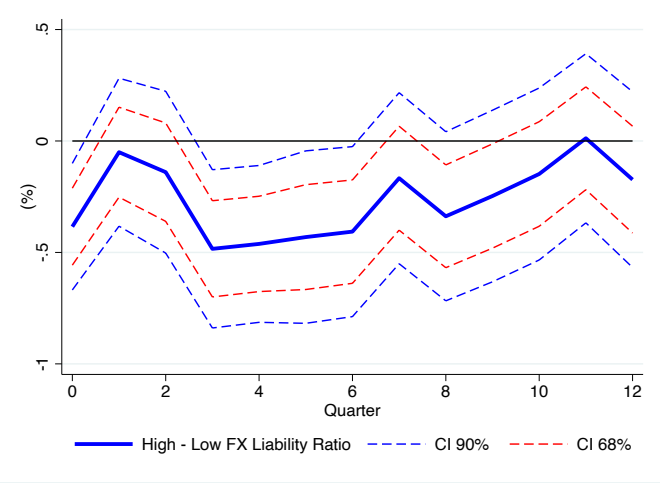
we cannot find significant role for exchange rate channel when we use our baseline methodology categorize firms into groups.

Another way to address cross-country FX hedging mechanisms is to use country-level mean FX liability ratios as thresholds while separating firms into low vs. high FX groups. Using firm-level total debt as the weights, we calculate weighted FX liability ratios in each country such that

$$FX_c = \sum_f \omega_{fc} FX_{fc}$$

where $\omega_{fc} = \frac{Debt_{fc}}{Debt_c}$ denote debt share of each firm in the country and FX_{fc} is the average FX liability ratio of firm *f* in country *c*. Then, we separate firms into low vs. high FX liability ratio groups using country-level FX liability ratio thresholds FX_c. Figure (B14) displays the negative role of exchange rate channel following this approach.

FIGURE B14: ROLE OF FX LIABILITY RATIO: AN ALTERNATIVE METHOD

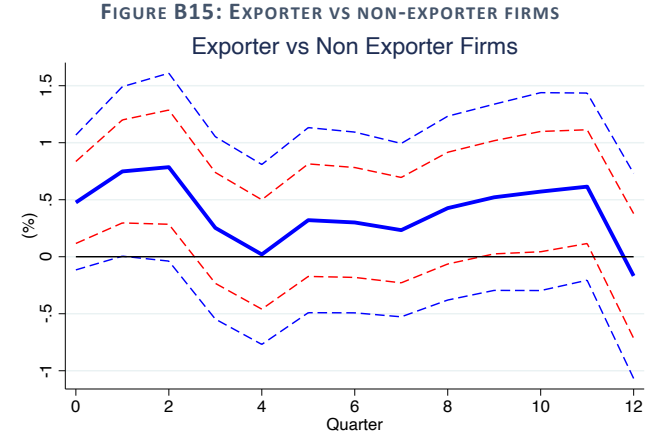


NOTE: FIRMS ARE ASSIGNED INTO CATEGORIES USING THEIR COUNTRY FX LIABILITY RATIO MEAN.

Extra Results on Trade Channel

Furthermore, we use the geographical source of revenue data from Capital IQ to find firm-level export dependence. However, we note that this data is available only around 20 percent of the full sample. For each firm that reports geographical source of revenue, we calculate the export revenues of the firm. Then, we divide export revenues with total revenue to calculate the export revenue

FIGURE B15: EXPORTER VS NON-EXPORTER FIRMS

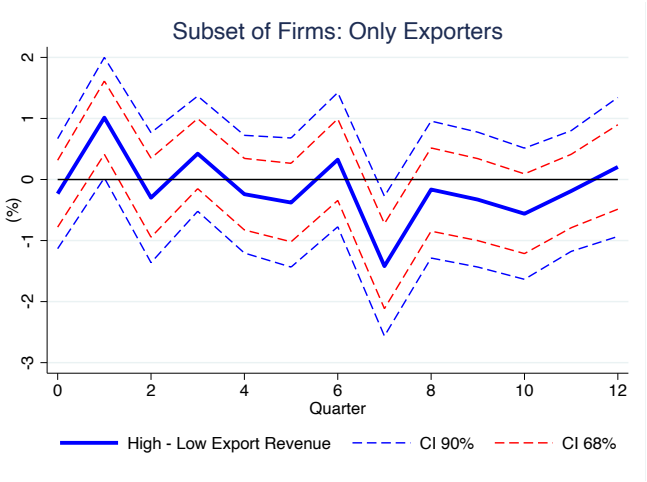


NOTE: WE USE ONLY A SMALL SUBSAMPLE OF FIRMS DUE TO DATA LIMITATIONS IN THIS EXERCISE. BLUE LINE REPRESENTS THE DIFFERENTIAL IMPULSE RESPONSES BETWEEN EXPORTER AND NON-EXPORTER FIRMS

dependence of the firm. If a firm reports positive export revenue at any time during our sample, we classify the firm as Exporter (Group 3). If the firm does not report any export revenue and operates in non-tradable sector, we classify the firm in group 1. Also, tradable sector firms with no export revenue are classified in group 2. We compare the impulse responses between group 1 and group 3 below. Figure (B15) shows that the firms with positive export revenues have been affected less compared to the firms with no export revenue and operating non-tradable sectors.

Here, we focus only on the firms that report positive export revenue. Then, we follow the same procedure to group firms into categories: low/medium/high export revenues. Figure (B16) displays the results that we cannot observe any significant difference between the impulses responses across high and low export revenue groups.

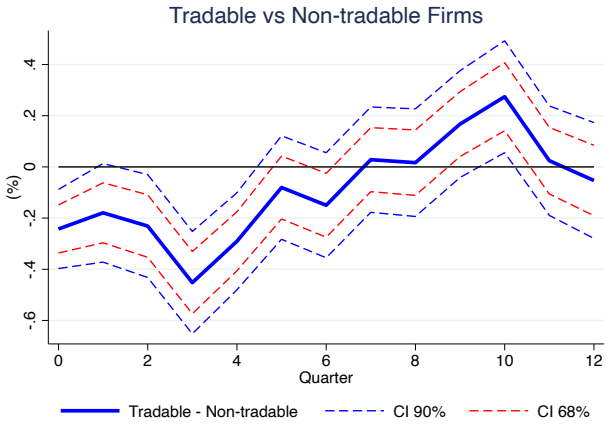
FIGURE B16: FOCUSING ONLY ON EXPORTER FIRMS



NOTE: HERE THE COMPARISON IS CONDITIONAL ON FIRMS HAVE POSITIVE EXPORT VALUES. THEREFORE ONLY 20% OF THE SAMPLE IS USED IN THIS ANALYSIS.

The Figure (B17) compares the impulse responses between firms in tradable and non-tradable sector where we follow the classification from Kim (2019). The results show tradable sector firms are more negatively affected but the effect becomes insignificant by the 5th quarter.

FIGURE B17: TRADABLE VS NON-TRADABLE FIRMS



NOTE: WE USE THE TRADABLE/NON-TRADABLE CLASSIFICATION FROM KIM (2019).