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U.S. Monetary Policy Shock Spillovers: Evidence from Firm-Level Data

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Abstract

We examine three main channels through which U.S. monetary policy shocks affect firm investment in foreign countries: (1) the balance sheet channel; (2) the financial channel of the exchange rate; and (3) the trade channel. For this purpose, we use quarterly firm-level data for 63 advanced economies (AEs) and emerging market and developing economies (EMDEs) 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), for firms that have a higher share of debt in foreign currency (financial channel of the exchange rate), and for firms that operate in sectors with higher export dependence (trade channel). Back-of-the-envelope calculations suggest that the balance sheet channel is the most important channel of transmission of U.S. monetary policy shocks on aggregate firm investment.

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1. Introduction

Monetary policy in advanced economies, and in particular in the United States, has been identified as a key source of international spillovers (Rey 2013; Rey 2016; Kalemli-Ozcan 2019; Miranda-Agrippino and Rey 2020). It is, therefore, not surprising that the new monetary policy tightening cycle in the United States is seen as a significant risk for the global economic recovery (IMF 2021).

Spillovers effects will, however, depend on many factors—including the domestic policy response—and operate through multiple channels. As highlighted in extensions of the standard Mundell-Fleming framework (Gourinchas 2018; Kalemli-Özcan 2019), there are several financial and trade channels through which U.S. monetary policy can affect other countries.[2] Three key channels stand out. A first financial channel is often called the “balance sheet channel,” whereby U.S. monetary policy tightening leads to tighter financial conditions for firms in foreign countries, with a negative impact on investment, in particular for firms that are more leveraged and more dependent on external finance. The second financial channel (the “financial channel of the exchange rate”) operates through the effect of the resulting depreciation of the foreign currency vis-à-vis the U.S. dollar on firms’ balance sheets, if for example firms have large foreign-currency liabilities. While these two financial channels predict a negative effect of U.S. monetary policy tightening on foreign countries, the third key channel, the “trade channel,” has *a priori* ambiguous effects. On the one hand, tighter U.S. monetary policy can lower demand for imports in the United States (“expenditure reducing effect”). On the other hand, it can increase demand for imports through its impact on exchange rate depreciation in foreign countries (“expenditure switching effect”).

What is the strength of these channels? This paper tries to answer this question. Although there is a voluminous literature looking at U.S. monetary policy spillovers, empirical evidence on the importance of these transmission channels is much more limited and often performed using country-level data. In this paper, we contribute to this literature by quantifying and comparing the relative strength of these channels, for a large set of 63 advanced economies (AEs) and emerging market and developing economies (EMDEs) over a 20-year period, using a comprehensive quarterly firm-level dataset.

[2] See Annex 1 for a formal exposition of the different channels.

The use of this firm-level data is especially important because it allows for a better identification of the transmission channels using firm (and industry) characteristics. For example, we use observable measures of firm leverage (such as the debt-to-assets ratio) to identify the balance sheet channel, and foreign currency liabilities to analyze the financial channel of the exchange rate. The large dimension of the dataset (more than 20,000 firms are covered in our estimation sample) and the extensive firm heterogeneity therein permit the identification of the role played by these channels and their relative strength with much higher precision than would otherwise be possible using country-level data. Our empirical approach involves a difference-in-difference framework—assigning firms into different groups (for example, low, medium, high) based on their exposure to the different channels—with country-sector-time fixed effects. The use of these fixed effects limits potential endogeneity concerns, as it effectively controls for domestic macro-economic shocks (such as the policy response in the domestic economy) and their differential effect across sectors—something that is not possible using country-level data. In particular, we build on the semi-parametric approach of Cloyne et al. (2019) and Duval et al. (2021) to estimate differential impulse responses for each group of firms using local projections (Jorda 2005). To identify exogenous U.S. monetary policy shocks, we follow Duval et al. (2021) and use high-frequency movements in U.S. interest rate futures around Federal Open Market Committee (FOMC) meetings as instruments for the one-year bond yield in a proxy-Structural Vector Autoregression (SVAR) framework.

Our results suggest an important, statistically significant, and independent role for all three channels. In particular, we find that 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 trade linkages (trade channel). Back-of-the-envelope calculations suggest that the balance sheet channel is the one contributing the most to the aggregate investment response to U.S. monetary policy shocks.

We also find that some of these channels amplify each other. For example, we find that the spillover effects are larger for the more leveraged firms if they also have higher foreign-currency liabilities. In addition, we find that the role of leverage is larger for smaller firms and firms with lower liquidity, which is consistent with the argument that leverage is likely to pose tighter borrowing constraints for smaller and less liquid firms. Moreover, as expected, we find that the financial channel of the exchange rate is statistically significant only for countries with flexible exchange rates. Finally, we find that trade exposure is the most relevant transmission channel for firm revenue. These results are robust to a host of different checks, such as using alternative proxy variables for the transmission channels, alternative approaches for classifying firms into different exposure groups, different sets of controls and other measures of U.S. monetary policy shocks.

This paper contributes to three strands of literature. The first strand analyzes the international macroeconomic spillovers of U.S. monetary policy. This voluminous literature has typically relied on country-level data and VAR models, or event study approaches, to examine how spillover effects vary by income group, exchange rate regimes, or country characteristics such as macroeconomic fundamentals, financial and trade integration (for example, Mishra et al. 2014; Georgiadis 2016; Bräuning and Sheremirov 2019; Iacoviello and Navarro 2019). Some studies have also looked at how the magnitude of spillovers depends on the state of the business cycle, the source of the interest rate shock (Zdzienicka et al. 2015; Carceres et al. 2016; Hoek et al. 2020; Arbatli-Saxegaard et al. 2022) or whether the Fed conducts conventional or unconventional monetary policy (Chen et al. 2014; Gilchrist, et al. 2019). Although some of these macro-level studies analyze the different channels of monetary policy transmission (for example, Ammer et al. 2016; Albagli et al. 2019; Kalemli-Ozcan 2019), as discussed above, aggregate data are not well suited to properly identify the causal effect of monetary policy through these transmission channels. Moreover, while this literature has largely focused on financial spillovers (examining bond yields in particular), analyses applied to real outcomes such as real output and investment are more limited (Bräuning and Sheremirov 2019; Arbatli-Saxegaard et al. 2022).

The second related strand of literature examines the heterogeneous effects of monetary policy across firm characteristics. The paper most closely related to ours is Li et al. (2020), who examine U.S. monetary policy spillovers to emerging market economies using firm-level data. The authors find a role for leverage suggesting, as does our study, the existence of a balance sheet channel of monetary policy. We expand their analysis by considering a larger sample, which also includes AEs, by studying the dynamic effects of U.S. monetary policy shocks with quarterly data and by factoring in other key transmission channels. Other contributions to this literature focus on spillovers to firms in specific countries (for example, Banerjee and Mohanty 2021, in the case of India). A larger strand exploits firm-level heterogeneity in a domestic context. Three recent studies find that firm characteristics such as leverage, liquidity, distance-to-default and age play a role in monetary policy transmission (Jeenas 2019; Cloyne et al. 2019; Ottonello and Winberry 2020). In addition, Duval et al. (2021) find a role for firm markups, suggesting that market power interacts with the transmission of monetary policy.

Finally, our paper adds to the literature on the effects of exchange rate fluctuations, in particular with respect to two transmission channels: the trade channel and the less-studied financial channel of the exchange rate, which operates through firms' foreign-currency exposure. The empirical papers most closely related to ours examine firms' heterogeneous responses to exchange rate fluctuations (Aguiar 2005; Bleakley and Cowan 2008; Kim et al. 2015; Agarwal 2018; Serena and Sousa 2018; Avdiev et al. 2019; Banerjee et al. 2020; Dao et al. 2021; Kalemli-Ozan et al 2021).[3] We contribute to this literature by analyzing the exchange rate channel simultaneously with another conduit of monetary policy transmission, the firm balance sheet channel, and how they interact with each other.

The remainder of the paper proceeds as follows: section 2 describes our data, identification of monetary policy shocks and our empirical strategy; section 3 presents the results; and section 4 concludes.

2. Data and Empirical Framework

This section describes our firm-level data as well as other data sources used in the analysis. We introduce the variables used throughout the paper and how we identify U.S. monetary policy shocks. Finally, we present our empirical approach for estimating the spillovers on firm investment and the role of the different channels.

2.1. Data

Our main source of data is S&P Capital IQ (CIQ), which provides detailed firm balance sheet and income statement information. CIQ has two key advantages compared with other leading corporate data providers such as Orbis or Worldscope. First, the data are available at the quarterly frequency, which is more suited to identify the firm-level responses to high frequency shocks—such as

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

monetary policy shocks. Second, CIQ contains information on foreign-currency liabilities which allows us to quantify the importance of the financial channel of the exchange rate. The main limitation of the data is that the coverage of non-listed firms is insufficient in many countries. To maximize the consistency and reliability of the data, we therefore restrict our sample to listed firms—both active and inactive. In addition, we do not observe which financial institutions firms borrow from and are therefore not able to control for credit constraints arising from the supply side.

Our dataset covers a long time span and a broad set of countries—20 years of data, from 1996Q3 to 2016Q3, for 63 countries (29 AEs and 34 EMDEs). Firms in our dataset 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 Figures A2.1 and A2.2. Data are collected by CIQ 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. To clean the data, we mainly follow Kim (2019) and Kim et al. (2020). Firms with negative total assets or total debt in a given year are entirely dropped from the sample, while firm-observations with unexpected signs for capital expenditure, for net property plant and equipment (NPPE), and for revenue are also 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 & cash equivalents and that of tangible assets are greater than total assets. All variables are winsorized at 5 percent to exclude outliers. After filtering, the sample consists of 23,482 firms.[4] The panel, however, is highly unbalanced. The size of the economy and different filing requirements across countries also introduces large disparities in firm coverage across countries.

Our main variable of interest, the investment rate, is defined as the ratio of capital expenditures to NPPE. To cross-validate our firm-level investment data, we compare it with investment data at the macro level. We do this for the log-level of investment as well as its growth rate. In Table A2.3, we report the estimation results from regressing the log-investment calculated by aggregating our firm-level data against the log-investment from macro data. The results show

[4] The distribution of firms across countries and sectors are shown in Tables A2.1 and A2.2. Note that we have dropped the countries with fewer than 15 firms from our sample.

that the level of investment is highly correlated (R-squared above 0.7) across the two sources. In addition, we find that the relation between these variables remains strong and highly statistically significant when we control for country fixed effects, and when considering growth rates.

To identify the role of the financial channel of the exchange rate, we define the foreign-currency liability ratio as foreign-currency liabilities to total liabilities. Foreign-currency liabilities are computed using data from CIQ's Capital Structure module and, unlike the vast majority of studies, cover both bank debt and bond issuance.[5] It is worth noting that we do not observe the extent to which firms hedge their foreign-currency exposures. However, a few studies suggest that foreign exchange hedging practices are not widespread in EMDEs (for example, Chui et al. 2014; Chuaprapaisilp et al. 2018) and, if undertaken, their effect would in fact work against finding a significant effect.

Data limitations prevent us from exploiting firm-level heterogeneity when it comes to the trade channel. Although CIQ provides export revenue data for firms, the coverage is very limited. To obviate this data limitation, in the baseline we use the World Input Output Database (WIOD), which provides cross-country trade data for 56 sectors in 43 countries between 2000 and 2014.[6] We calculate the average export dependence for each sector-country pair during this period such that:

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

where *c* and *s* denote country and sector, respectively. $ExportDependence_{cs}$ denotes the average share of exports ($Exports_{cs}$) in sector *s* and country *c* in the value of total output ($Output_{cs}$).[7] In the robustness check section, we repeat the analysis using a firm-level measure of export dependence and find that the results are qualitatively the same.

[5] CIQ collects liability data at the debt instrument level. We download these data for each quarter in our sample and aggregate the data by repayment currency. In cases where the currency is not specified, we assume that debt is denominated in U.S. dollars. Kim et al. (2020) find that the foreign-currency liability ratio obtained from CIQ's micro-level data is consistent with the aggregate level data compiled by the BIS. We check that our main results hold when we assume that European firms hold debt in euros when the currency of denomination is not available.

[6] Note that we have 63 countries in our sample. Only 35 out of 63 countries have data from WIOD. Therefore, we use the average sectoral export dependence ratios for the remaining 28 countries from our sample.

[7] The sectoral classification of CIQ is in Standard Industry Classification (SIC), but WIOD defines sectors in NACE REV. 2 classification. We manually apply a many-to-one matching between the two classifications.

The regressions also include several additional firm-level characteristics: leverage, liquidity, size, and collateral. The definitions of all variables and their summary statistics are provided in Table 1.

2.2. U.S. Monetary Policy Shocks

We follow Duval et al. (2021) and Albrizio et al. (2021) in order to identify exogenous U.S. monetary policy shocks. In particular, we rely on high-frequency monetary policy surprises—that is, changes in Federal fund futures around FOMC announcements within a tight window of 30 minutes following Gürkaynak et al. (2005)—as a measure for unexpected monetary policy shocks. 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 use these surprises in a proxy-SVAR framework to instrument one-year government bond yield together with industrial production, consumer price index and a measure of the excess bond premium from Gilchrist and Zakrajsek (2012).

We estimate this 4-variable proxy-SVAR over the period 1973M1-2016M8 at a monthly frequency to retrieve the structural monetary policy shocks (Ramey 2016).[8] By using the one-year government bond yield, we are able to capture the impact of forward guidance to a larger extent than using simply the Fed funds rate, which had remained constant and close to zero during the post-global financial crisis period. In addition, we allow for a structural break in the VAR coefficients to account for the post zero-lower bound period and the beginning of quantitative easing in November 2008. Since the firm-level dataset is at a quarterly frequency, we aggregate the series of structural shocks within each quarter (see Figure A2.3 for the evolution of the estimated monetary policy shocks).

2.3. Empirical Strategy

Our empirical approach to quantifying U.S. monetary spillovers consists of three steps. In the first step, we estimate the average (unconditional) effect of U.S. monetary policy shocks on firm

[8] 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 as this provides the higher first stage F-statistic and above the associated Stock-Yogo critical value for strong instruments. The results are, however, robust to alternative combinations of Fed fund futures and government bond yields (see Figure A3.7).

investment using Jorda's (2005) local projections. Specifically, we estimate the following specification:

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

where the dependent variable, Y_{ft}, is the investment ratio or revenue of firm f at time (quarter) t; i_t^{US} denotes the exogenous U.S. monetary policy shock at time t; γ_f indicates firm fixed effects to control for unobservable time-invariant firm characteristics; and γ_{csq} are country-sector-quarter dummies to account for cross-sector variations across countries as well as seasonality in the data.

We then expand Equation (1) to estimate how the effect of U.S. monetary policy shocks varies across firms according to the transmission channels discussed earlier. We follow the semi-parametric approach of Cloyne et al. (2019) and Duval et al. (2021), which allows us to estimate the impact of U.S. monetary policy shocks in a more flexible way, without making assumptions about the functional form of the relationship between firms' characteristics and spillovers. In particular, we estimate the following specification:

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

where I is an indicator function which equals one if the observation associated with the firm characteristic X_f falls within a specific group g. For example, if the average leverage of a firm is above (below) the 75th (25th) percentile of average leverage across all firms, then the firm is classified in the "high leverage" ("low leverage") group. We use the average over time of the firm characteristics to reduce endogeneity due to the potential time-varying response of firm characteristics to monetary policy shocks. γ_{cst+h} are country-sector-time fixed effects to account for macro-economic shocks and their differential effects across sectors (such as, for example, the sectoral differential effect of monetary policy shocks, both domestic and originating from the U.S.) as well as sector-specific shocks at the country level (such as, for example, changes in country regulations affecting a given sector). Z_{ft-1} are firm-specific characteristics (leverage, liquidity, size and collateral) potentially affecting firm investment or revenues, 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, and then considering all three channels together.[9]

Finally, we are also interested in examining whether the differential response related to a given transmission channel (for example, the balance sheet channel) varies with other firm characteristics, including those that relate to another transmission channel (for example, foreign-currency liabilities). To this end, we estimate the following equation:

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

where the indicator function, *I*, uses two criteria that are interacted with each other, for example, low/high leverage and small/medium/large firms. Note that this approach also allows us to further validate the importance of a given channel. For example, if we observe a statistically significant differential response in investment between low and high leverage firms for different levels of foreign-currency liabilities, we can conclude that leverage is a spillover transmission mechanism independent of foreign-currency liabilities.

Equations (1)-(3) are estimated using OLS and standard errors are two-way clustered on firm and country-time.

3. Results

3.1. Average Effects

Figure 1 shows the average investment response to a 25-basis points U.S. monetary policy tightening. As expected, a U.S. monetary policy tightening is followed by an economically and statistically significant decline in foreign firms' investment, with a peak impact of -1.3 percent

[9] Sine our measure of trade exposure is based on a sectoral classification, Equation (2) for this channel is estimated using country-year fixed effects instead of country-sector-year fixed effects.

after two quarters. The estimated investment response of foreign firms is comparable to, albeit slightly smaller than, the response of the U.S. firms in our sample (Figure A3.1). The effect is also similar to estimates in other studies using similar data, for example, Jeenas (2019) and Cloyne et al. (2019).

We conduct a range of robustness checks to confirm that our estimates are not driven by specific countries and are robust to alternative specifications. In particular, the results are robust to removing countries with the highest number of firms among AEs and EMDEs, one at a time (Figure A3.2).[10] The results are also robust to alternative specifications, including: alternative lags of the dependent variable (Figure A3.4), alternative measures of monetary policy shocks (Figure A3.5), the addition of time-varying firm characteristics—such as leverage, collateral, liquidity and size—as controls (Figure A3.6), alternative measures of investment—such as the change in capital expenditures (Figure A3.7) or the ratio of capital expenditures to total assets (Figure A3.8) . Finally, we also find that U.S. monetary policy shocks have sizeable spillovers on firm revenue—a 25-basis points U.S. monetary policy tightening leads to a peak decline in revenue of about 0.6 percent after two quarters (Figure A3.9).

3.2. Spillover Channels and Firm Characteristics

In this subsection, we explore the role of the three key transmission channels—the balance sheet channel, the financial channel of the exchange rate, and the trade channel—by considering the differential responses of firms having different degrees of exposure to these channels. We assign firms into different exposure groups (low/medium/high) by using the cross-country distribution of firms with respect to different proxy variables. As discussed earlier, all firms with an average exposure variable below (above) the 25th (75th) percentile are classified into the low (high) group.[11] We begin our analysis by focusing on the role of the firm balance sheet channel, using firm leverage as the main exposure variable.[12] Figure 2 displays the differential investment response

[10] The estimated impact on investment is larger for EMDEs (excluding China) than for advanced economies (see Figure A3.3).

[11] See Table 1 for the specific estimates of the 25th and 75th percentiles for the different exposure variables considered.

[12] While leverage is an intuitive proxy for the balance sheet channel, we also consider the robustness of our results (discussed in section 3.3) to alternative proxies for the external finance premium that have been highlighted in the literature—such as firm size, bank debt to total debt ratio, dividend payment status and firm age.

between firms in the high leverage group and the low leverage group ($\beta_{HighLeverage,h} - \beta_{LowLeverage,h}$) following a 25-basis points U.S. monetary policy shock, estimated using Equation (2). Consistent with the presence of a significant balance sheet channel, the results suggest that highly leveraged firms are more responsive to U.S. monetary policy shocks than firms with low leverage. The differential impulse responses are statistically significant over most of the estimation horizons, suggesting a persistent differential effect. The effects are quantitatively large: the difference in the one-year-ahead response of investment to a 25-basis points monetary policy shock between the top and bottom quartiles of the firm leverage distribution is about 0.5 percentage point. Next, we look at the role of the financial channel of the exchange rate by focusing on firms' foreign-currency debt to total debt ratio (foreign-currency liability ratio). Figure 3 presents the differential impulse responses between firms with high and low foreign-currency liability ratios ($\beta_{HighFX,h} - \beta_{LowFX,h}$). The differential response is statistically significant, suggesting a larger decline in investment for firms that have a higher foreign-currency liability ratio. The magnitude of the differential response between the top and bottom quartiles is about 0.5 percentage point and is of similar size to that obtained with leverage.

Finally, we examine the role of the trade channel, using the export dependence of a sector as a proxy. Unlike the balance sheet channel and the 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 firms operating in sectors with higher export dependence (expenditure reducing channel). On the other hand, an increase in the U.S. interest rate depreciates local currencies against the U.S. dollar, resulting in an increase in competitiveness (expenditure switching channel). Figure 4 shows the differential impulse response to a U.S. monetary policy shock for the high and low export dependence groups ($\beta_{HighDependence,h} - \beta_{LowDependence,h}$). Our results imply that both channels are at play. While in the short term, firms operating in sectors with higher export dependence are more negatively affected than firms operating in sectors with lower export dependence, the opposite holds about two years after the U.S. monetary policy shock. In other words, while the expenditure reducing channel seems to dominate in the short term, the expenditure switching channel dominates in the medium term.[13] This seems consistent with the lagged effect of exchange rate fluctuations on exports, as found in the literature (for example, Leigh et al. 2017).

3.3. Robustness Checks

To check the robustness of our results, we perform a number of sensitivity tests across alternative samples and specifications. First, to check whether each channel plays a distinct and independent role in the transmission of U.S. monetary policy shocks, we extend Equation (2) by including all three channels together in the same specification:

$$logY_{ft+h} - logY_{ft-1} = \sum_{g=1}^{G} \beta_{gh}^{Lev} \times I\left[Lev_f \in g\right] \times i_t^{US} + \sum_{g=1}^{G} \beta_{gh}^{FX} \times I\left[FX_f \in g\right] \times i_t^{US} + \sum_{g=1}^{G} \beta_{gh}^{Trade} \times I\left[Trade_f \in g\right] \times i_t^{US} + \rho_h Z_{ft-1} + \gamma_f + \gamma_{cst+h} + \epsilon_{ft+h} \quad (4)$$

where Lev_f, FX_f, and $Trade_f$ denote the average leverage ratio, foreign-currency liability ratio, and export dependence ratio of the firm.[14]

Figure 5 displays the differential impulse responses for each channel from estimating Equation (4). The results are qualitatively similar to, and not statistically different from, those obtained from estimating each channel separately, suggesting that each channel has an independent and economically and statistically significant role in shaping spillovers from U.S. monetary policy.

Second, we expand the set of control variables to include the interactions of monetary policy shocks with other firm characteristics capturing the firm's financial strength—such as firm size, bank debt to total debt ratio, dividend payment status and firm age. While we do find that these factors contribute to amplify the spillover effects of U.S. monetary policy shocks (Figure A4.1)—with smaller, younger firms paying lower dividends experiencing a larger decline in investment—their inclusion as control variables in our specification does not significantly affect the results for the differential impact of leverage, foreign-currency liability and trade exposure (Figure A4.2).

[13] Note that we find a similar impact on firm revenue (Figure A4.7), which is consistent with the expenditure reducing effect dominating in the short term.

[14] Recall that $Trade_f$ is calculated at the sectoral level and firms are assigned to groups depending on the export dependence of the sectors in which they operate.

Third, we show that our results are robust to alternative methods for classifying firms into different groups. We find similar results if we use the country-specific distribution instead of the full cross-country distribution to determine the thresholds for classifying firms into low/medium/high groups (Figure A4.3) or if we only consider a low/high group based on the median of the distribution (Figure A4.4).

A concern regarding our firm classification approach is the fact that our exposure variables may be endogenous to monetary policy shocks. For example, firms might become more leveraged when interest rates decrease in the United States or foreign firms might find it cheaper to borrow in foreign currency when U.S. monetary policy is more accommodative. 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 A4.5 shows that the significance of each channel is robust to this strategy.

Next, to show that the significance of the spillover channels discussed in the text is not driven by any particular country, we drop from our sample, one at a time, the six countries with the highest number of firms (Canada, China, Hong Kong, India, Japan, Taiwan) while estimating Equation (2). The results are similar to, and not statistically different from, those obtained in the baseline (Figure A4.6).

Finally, we examine the response of revenue through these channels. The results suggest that, as expected, the trade channel plays a larger role for revenue than for investment, while the opposite is true for the two other channels (Figure A4.7).

3.4. Back-of-the-Envelope Calculations

Our results suggest a statistically significant role for all three channels, but how important are these channels in terms of explaining the aggregate investment response to U.S. monetary policy shocks? To answer this question, we follow Ciminelli et al. (2020); we quantify the contribution of each channel to the average investment response by using our estimates of Equation (4) and calculate the contribution of each channel.

For any given channel, the average response of investment can be written as the weighted average of investment for the three groups (for example, high/medium/low leverage):

$$K_t = \omega_1 K_t^1 + \omega_2 K_t^2 + \omega_3 K_t^3$$

where K denotes investment, ω_i and K_t^i are the capital expenditure share and investment of firms in group i, respectively. Taking the partial derivative of the equation above and using the fact that $\omega_3 = 1 - \omega_1 - \omega_2$ yields the following expression:

$$\frac{\partial K_t}{\partial i_t^{US}} = \omega_1 \frac{\partial K_t^1}{\partial i_t^{US}} + \omega_2 \frac{\partial K_t^2}{\partial i_t^{US}} + \omega_3 \frac{\partial K_t^3}{\partial i_t^{US}} = \omega_1 \left(\frac{\partial K_t^1}{\partial i_t^{US}} - \frac{\partial K_t^3}{\partial i_t^{US}}\right) + \omega_2 \left(\frac{\partial K_t^2}{\partial i_t^{US}} - \frac{\partial K_t^3}{\partial i_t^{US}}\right) + \frac{\partial K_t^3}{\partial i_t^{US}}$$

From Equation (4) we have estimates of $\left(\frac{\partial K_t^1}{\partial i_t^{US}} - \frac{\partial K_t^3}{\partial i_t^{US}}\right)$ for each channel. Assuming that $\frac{\partial K_t^3}{\partial i_t^{US}} = 0$ and $\left(\frac{\partial K_t^2}{\partial i_t^{US}} - \frac{\partial K_t^3}{\partial i_t^{US}}\right) = 0$ yields the following expression for the contribution of a given channel to the overall investment response: $\left(\omega_1 \frac{\frac{\partial K_t^1}{\partial i_t^{US}}}{\frac{\partial K_t}{\partial i_t^{US}}}\right)$. For $\frac{\partial K_t}{\partial i_t^{US}}$, we rely on our estimates of Equation (1) and calculate the contribution of each channel accordingly. Note that by assuming that $\frac{\partial K_t^2}{\partial i_t^{US}} = 0$ and $\frac{\partial K_t^3}{\partial i_t^{US}} = 0$, we significantly under-estimate the contribution of each channel to the average investment response. Therefore, the results of this exercise, while useful to examine the relative strength of each channel, should be considered as a lower bound of the true general equilibrium effect of each channel.

Table 2 reports the cumulative (unconditional and conditional) investment response to U.S. monetary policy shocks and the contribution of each channel. The results suggest that the balance sheet channel accounts for the largest share of the total investment response, followed by the exchange rate and trade channels. In contrast, consistent with the estimation results for revenue, back-of-the-envelope calculations suggest that the trade channel accounts for the largest share of the total revenue response (Table A4.1).

3.5. Interactions Between Channels

In this subsection, we explore potential interactions between channels using the cross-classifications described in Equation (3), where firms are partitioned along multiple firm characteristics capturing different channels.

We first consider the interaction between the balance sheet channel and the financial channel of the exchange rate. To do so, we first partition the sample conditional on the firms' foreign-currency liability ratio and consider the differential response of firms with low versus high leverage (Figure 6 top panel); and then partition the sample conditional on firms' leverage and consider the differential response between firms with a high and low foreign-currency liability ratio (Figure 6 bottom panel). The results in Figure 6 suggest that both the leverage and foreign-currency liability ratio have a significant differential impact on firm investment, irrespective of each other. As expected, we also find that the transmission channel through higher leverage is amplified by a higher foreign-currency exposure.[15]

Next, we explore the interaction between the balance sheet and the trade channels. In the upper panels of Figure 7, we present the differential impulse responses between high and low leverage firms after splitting the sample into groups: firms with low (left panel) and high (right panel) export dependence ratios. The results show that leverage has an important role, independent of the firms' export dependence ratio. The bottom panels in Figure 7 show the role of the export dependence ratio among firms with low and high leverage. This exercise shows that the role of the export dependence ratio is not statistically significant after firms are grouped based on their leverage—suggesting that trade exposure is a less robust channel of monetary spillovers on firm investment. On the other hand, Figure A4.9 suggests that the role of trade is important and statistically significant on firm revenue irrespective of the leverage group of the firm.

The next exercise examines the interaction between the financial channel of the exchange rate and the trade channel. Figure 8 shows the difference in responses between firms with a high versus low foreign-currency liability ratio, among low versus high export dependence ratio groups. The results suggest a significant role for the financial channel of the exchange rate for firms operating in sectors with high export dependence, but the foreign-currency debt share has no statistically significant role among firms in the low export dependence group. Figure 8 bottom

[15] However, the role of leverage and foreign-currency liability ratios becomes insignificant when the firm revenue growth is used in Equation (3) as the dependent variable (Figure A4.8).

panel displays the role of the trade channel among low and high foreign-currency liability ratio firms. As for leverage, the results from this exercise suggest that the trade channel does not have a significant differential impact on investment after firms are grouped based on their foreign-currency liability ratios. At the same time, for firm revenue we find a significant role for trade exposure independent of the firms' foreign-currency liability ratio group (Figure A4.10).

3.6. Extensions

In this section, we consider additional potential interactions. First, we consider the role of other firm characteristics, for example, firm size and liquidity, which may amplify the role of leverage in the transmission of U.S. monetary policy spillovers. Using cross-classifications described in Equation (3), we group firms along two dimensions, first by leverage and size, and then by leverage and firm liquidity. Figure A4.11 top and bottom panels present the differential impulse responses for the leverage ratio, conditional on size and liquidity position (left versus right chart), respectively. Our results suggest that the impact of leverage is more pronounced for smaller and less liquid firms, consistent with financial frictions being more binding for smaller and less liquid firms.

To further investigate the role of the financial channel of the exchange rate, we look at how our estimates depend on a country's exchange rate regime. In other words, we partition firms based on their foreign-currency liability ratio and the exchange rate regime (flexible vs. fixed) of the country where they are located. As expected, a firm's foreign-currency borrowing has a more pronounced impact on its balance sheet and investment in response to U.S. monetary policy shocks in countries with more flexible exchange rate regimes (Figure A4.12).

4. Conclusions

How do U.S. monetary policy shocks affect firm investment in foreign countries? What is the role of different transmission channels, and how do they interact with each other? We propose an approach that alleviates endogeneity concerns plaguing the macro-literature and addresses these questions using a rich quarterly firm-level dataset, covering 63 countries (AEs and EMDEs) over 1996–2016.

Our results shed new light on the long-standing literature on monetary policy spillovers and transmission mechanisms. First, we find that each channel plays 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 (financial channel of the exchange rate), and operate in sectors with higher trade linkages (trade channel). Back-of-the-envelope calculations suggest that the balance sheet channel is the most important channel of transmission of U.S. monetary policy on aggregate investment.

The difference between the top and bottom quartiles of firm distribution in leverage in the one-year-ahead response of the firm investment rate to a 25-basis points U.S. monetary policy shock is about 0.5 percentage points. Furthermore, the role of leverage is larger for smaller firms, consistent with the idea that the external finance premium may be more sensitive to a firm's balance sheet strength among smaller firms. The role of leverage is also larger for firms with lower liquidity, highlighting the role of liquidity as a shock absorber.

A similarly large differential impact is estimated for firms that are in the high foreign-currency debt share group, and firms that operate in sectors that are in the upper quartile of dependence on exports. As expected, we find that the financial exchange rate channel is only statistically significant for countries with flexible exchange rates. We also find important interactions between different channels. For example, the balance sheet and financial channel of the exchange rate tend to amplify each other, with firms that have both high leverage and a high foreign-currency liability ratio experiencing the largest negative impact on investment. Finally, we find that trade exposure is the most relevant transmission channel for firms' revenue.

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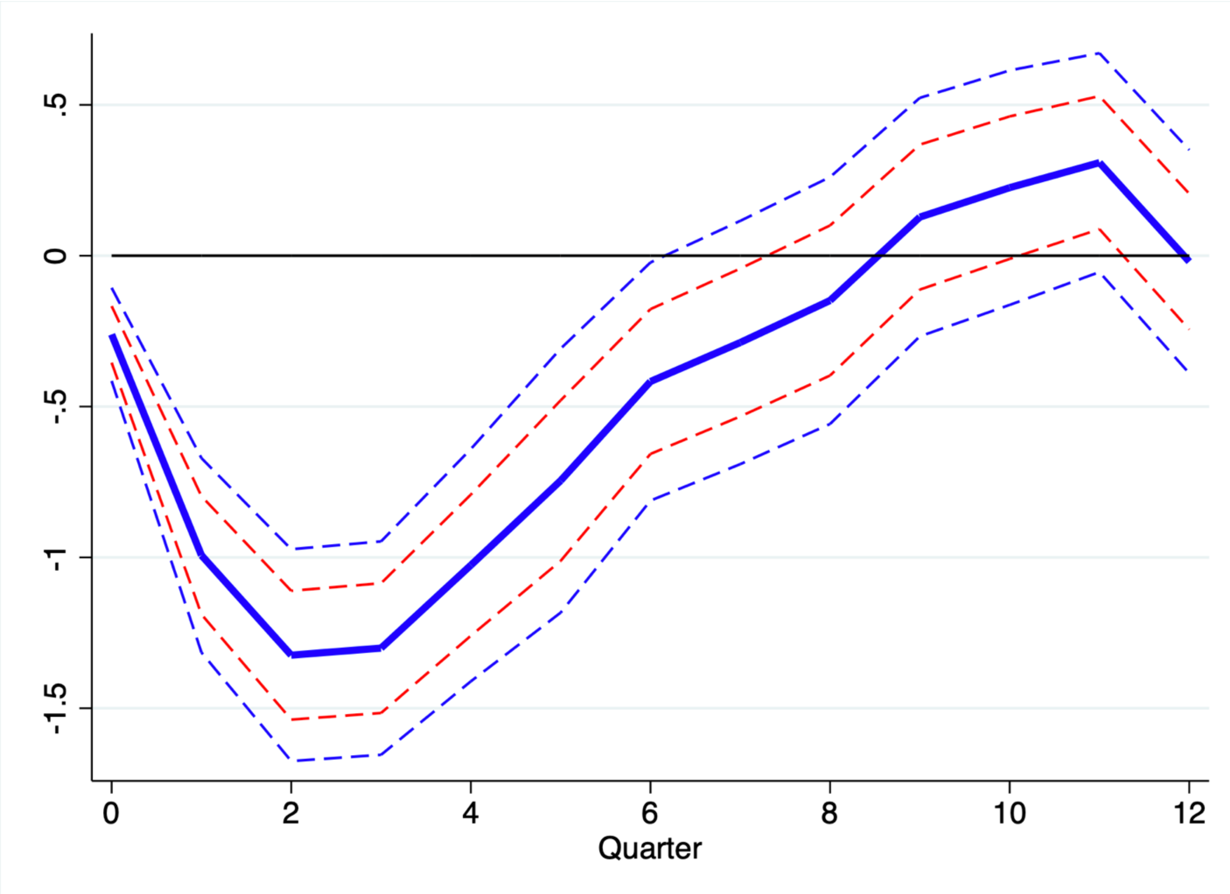
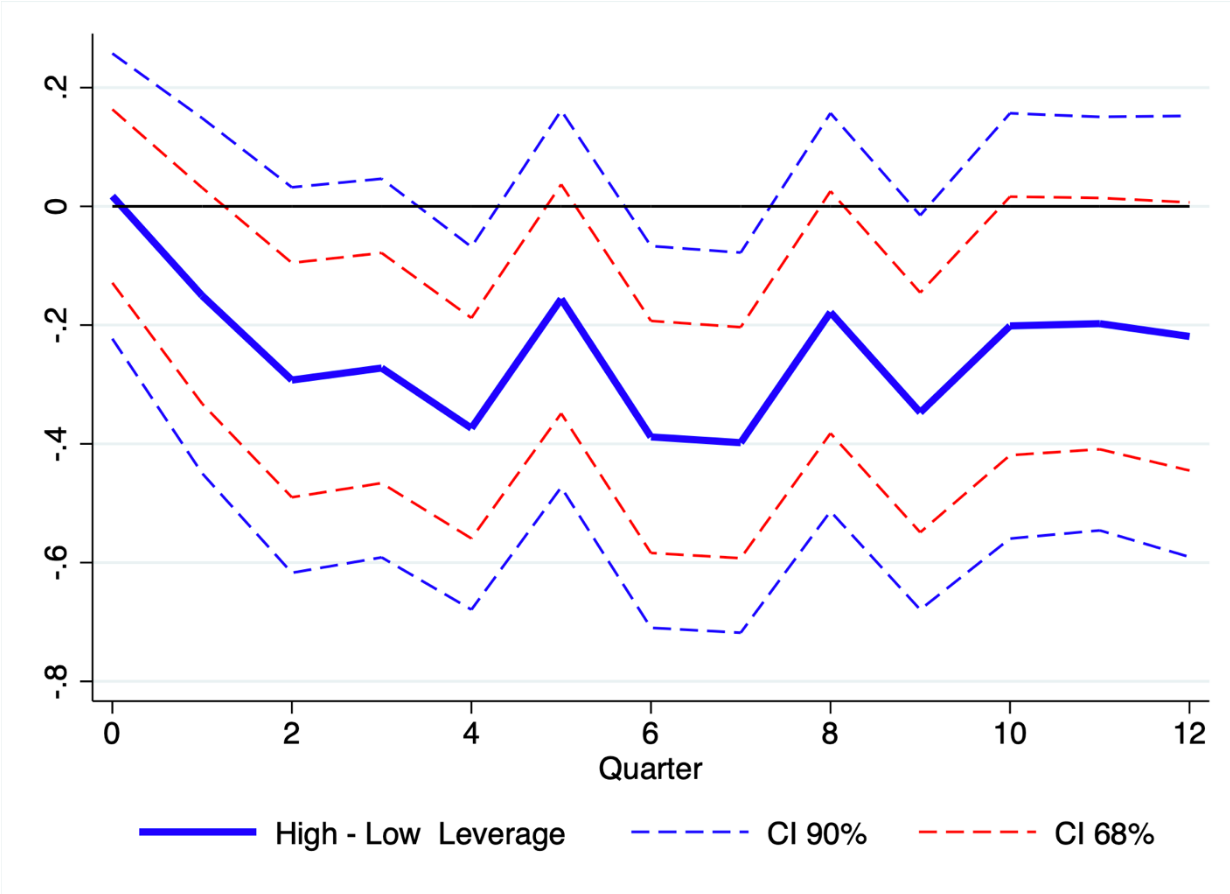
Figures

Figure 1. Average Investment Response to U.S. Monetary Policy Shocks



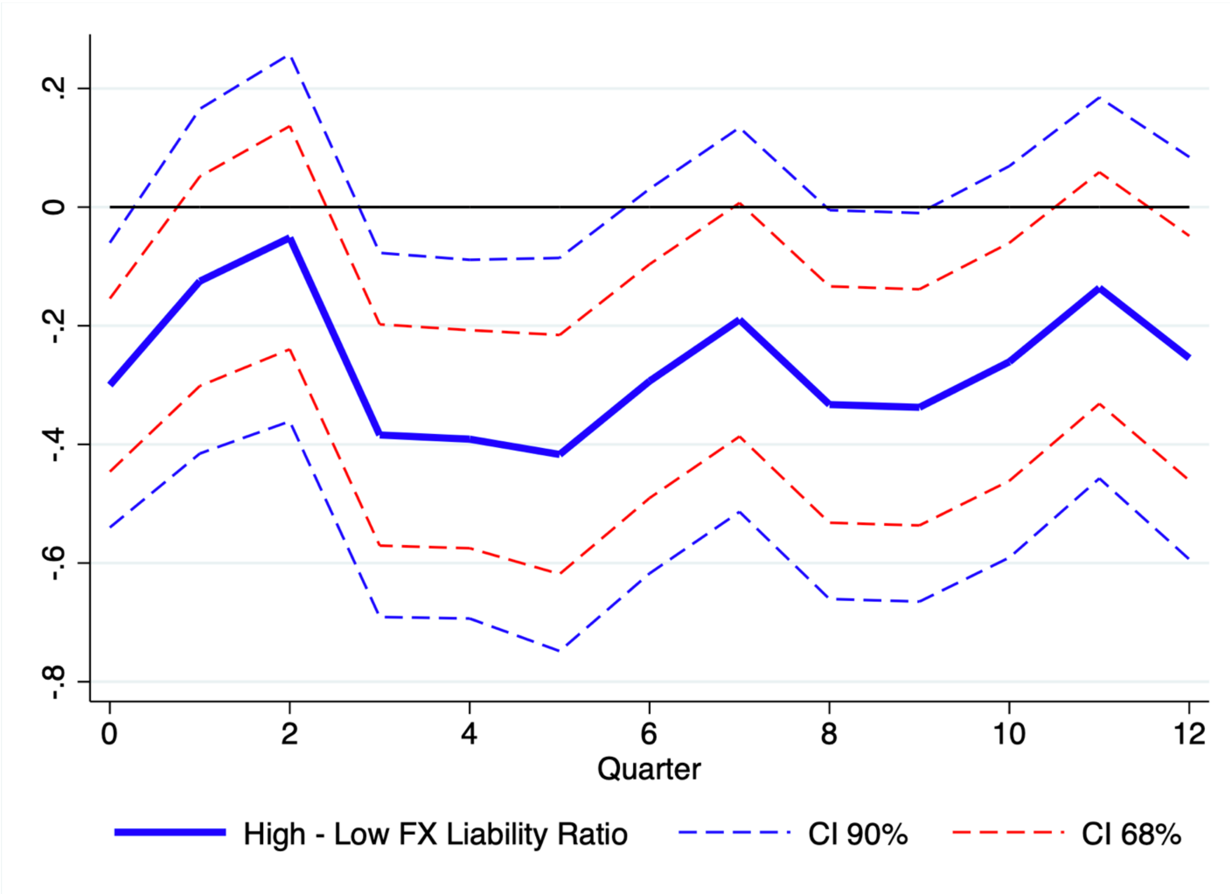
Note: Y axis in percent. The results follow from the estimation of Equation (1). The solid blue line indicates the average investment response of firm investment against a 25-bps U.S. monetary policy shock. Standard errors are two-way clustered on firms and country-time. The dashed blue and red lines display the 90% and 68% confidence intervals.

Figure 2. Role of Leverage (Balance Sheet Channel)



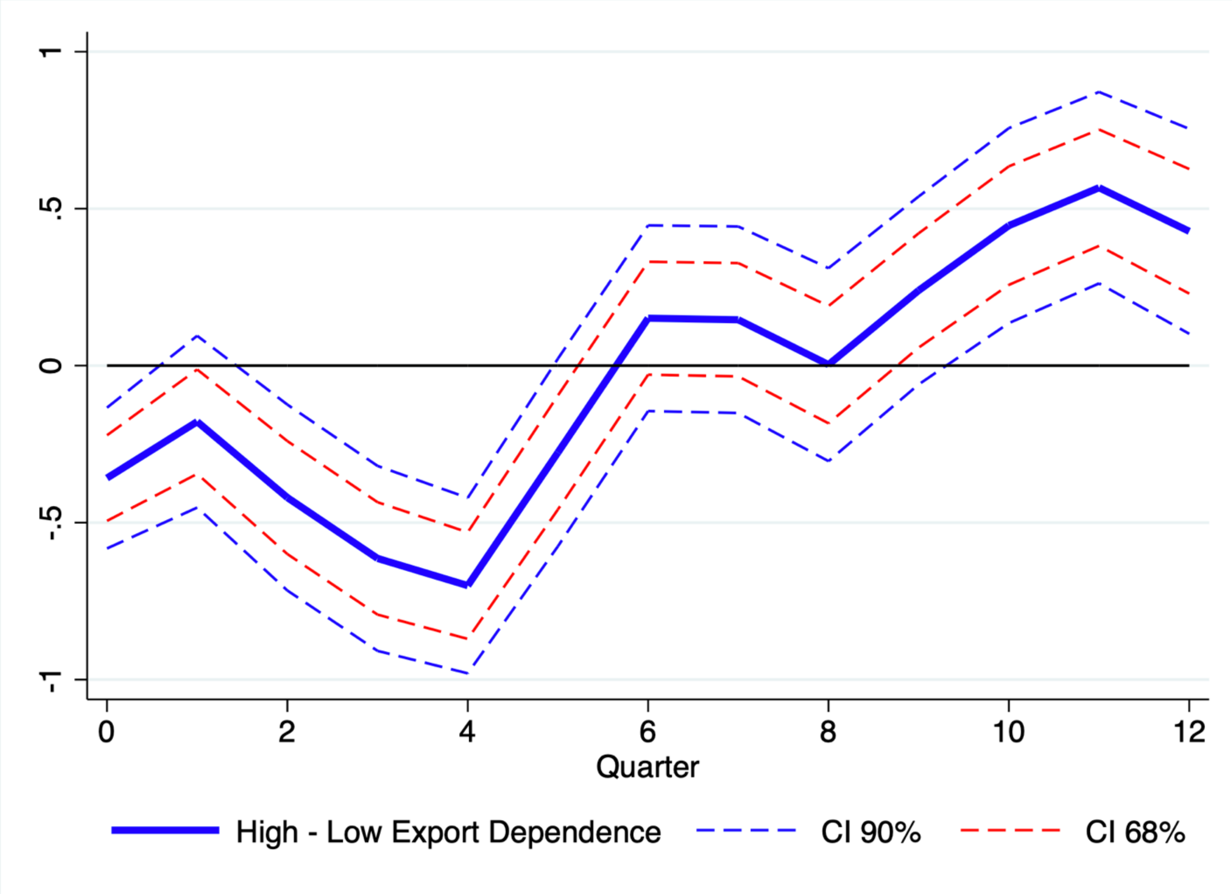
Note: Y-axis in percent. The results follow from the estimation of Equation (2). The differential impulse responses between the high and low leverage groups ($\boldsymbol{\beta_{HighLeverage,h} - \beta_{LowLeverage,h}}$) to a 25-bps U.S. monetary policy shock are represented by the solid blue line. The dashed blue and red lines display the 90% and 68% confidence intervals. We control for firm and sector-country-time fixed effects as well as time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure 3. Role of Foreign-Currency Liability Ratio (Financial Channel of the Exchange Rate)



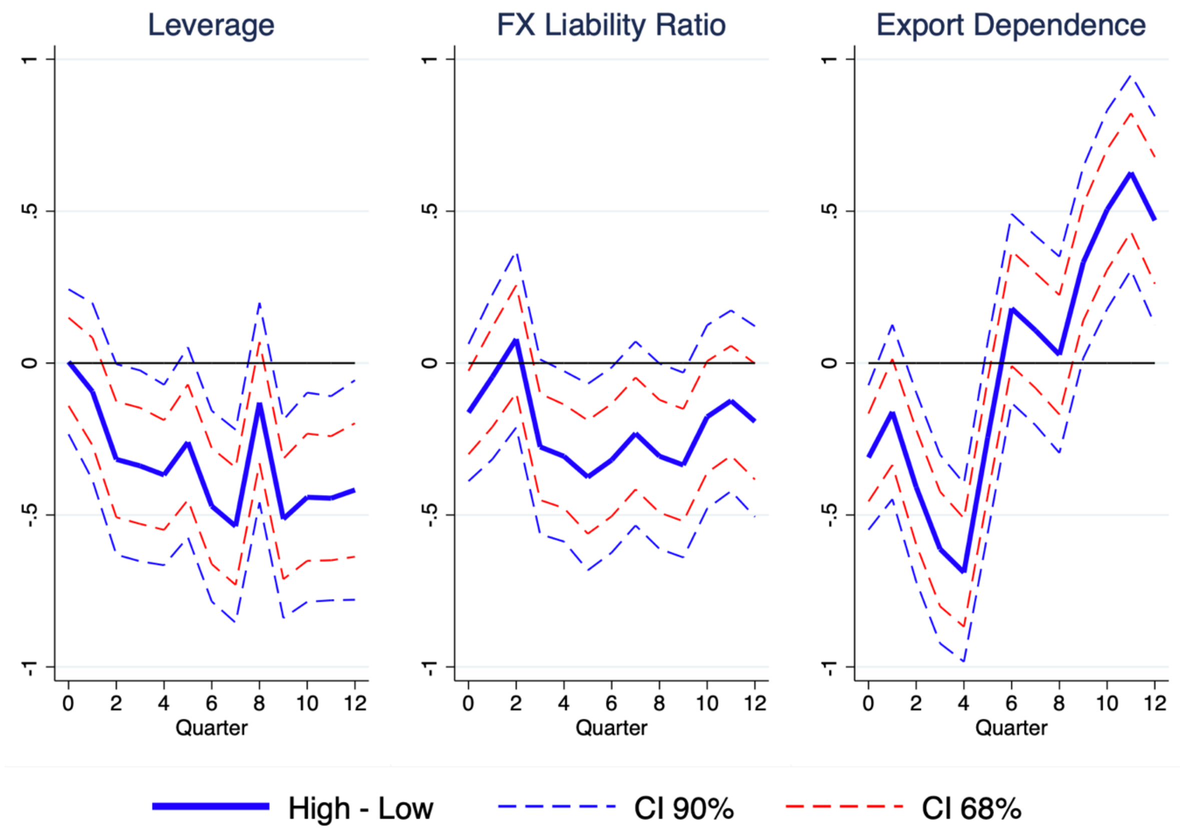
Note: Y-axis in percent. The results follow from the estimation of Equation (2). The differential impulse responses between the high and low foreign-currency liability ratio groups ($\boldsymbol{\beta_{HighFX,h} - \beta_{LowFX,h}}$) to a 25-bps U.S. monetary policy shock are represented by the solid blue line. The dashed blue and red lines display the 90% and 68% confidence intervals. We control for firm and sector-country-time fixed effects as well as time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure 4. Role of Export Dependence (Trade Channel)



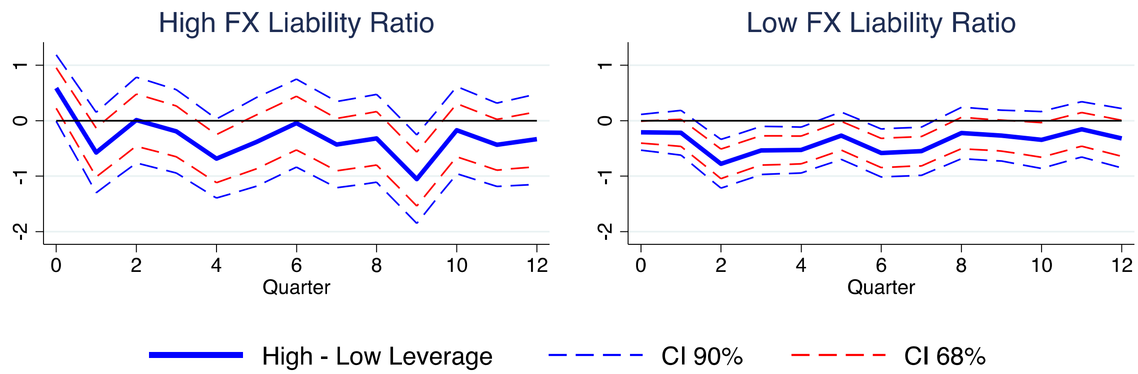
Note: Y-axis in percent. The results follow from the estimation of Equation (2). The differential impulse responses between the high and low export dependence groups ($\boldsymbol{\beta}_{\boldsymbol{HighDependence,h}} - \boldsymbol{\beta}_{\boldsymbol{LowDependence,h}}$) to a 25-bps U.S. monetary policy shock are represented by the solid blue line. The dashed blue and red lines 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 the sector-country level. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

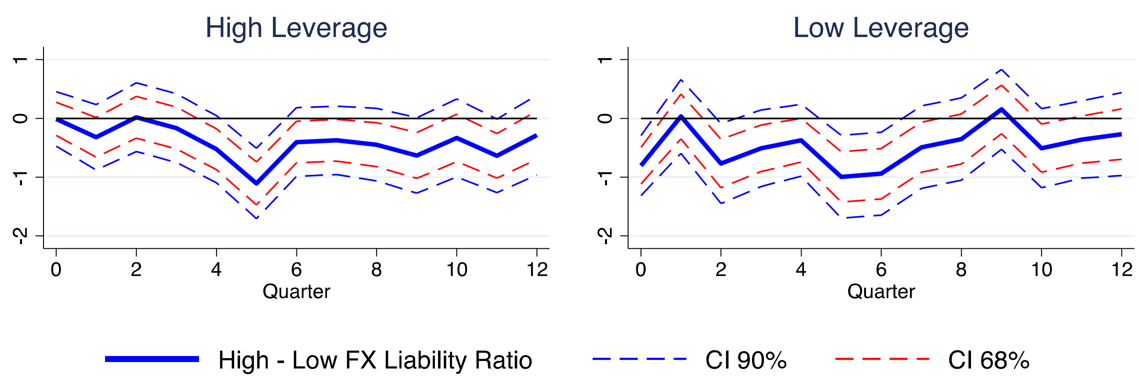
Figure 5. Comparison of the Three Channels



Note: Y-axis in percent. The results follow from 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 at the sector-country level. The differential impulse responses between the high and low groups ($\boldsymbol{\beta_{High} - \beta_{Low}}$) for each channel, represented by the solid blue line, show the response to a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristic (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

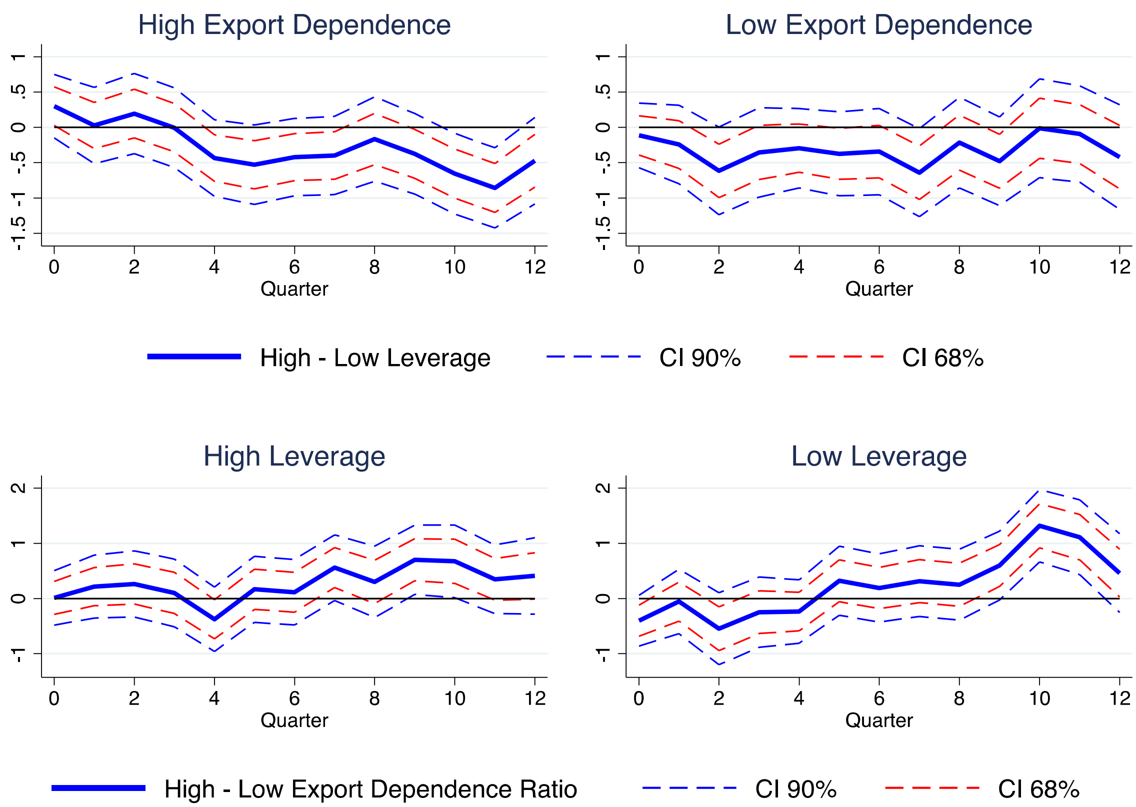
Figure 6. Leverage and Foreign-Currency Liability Ratio





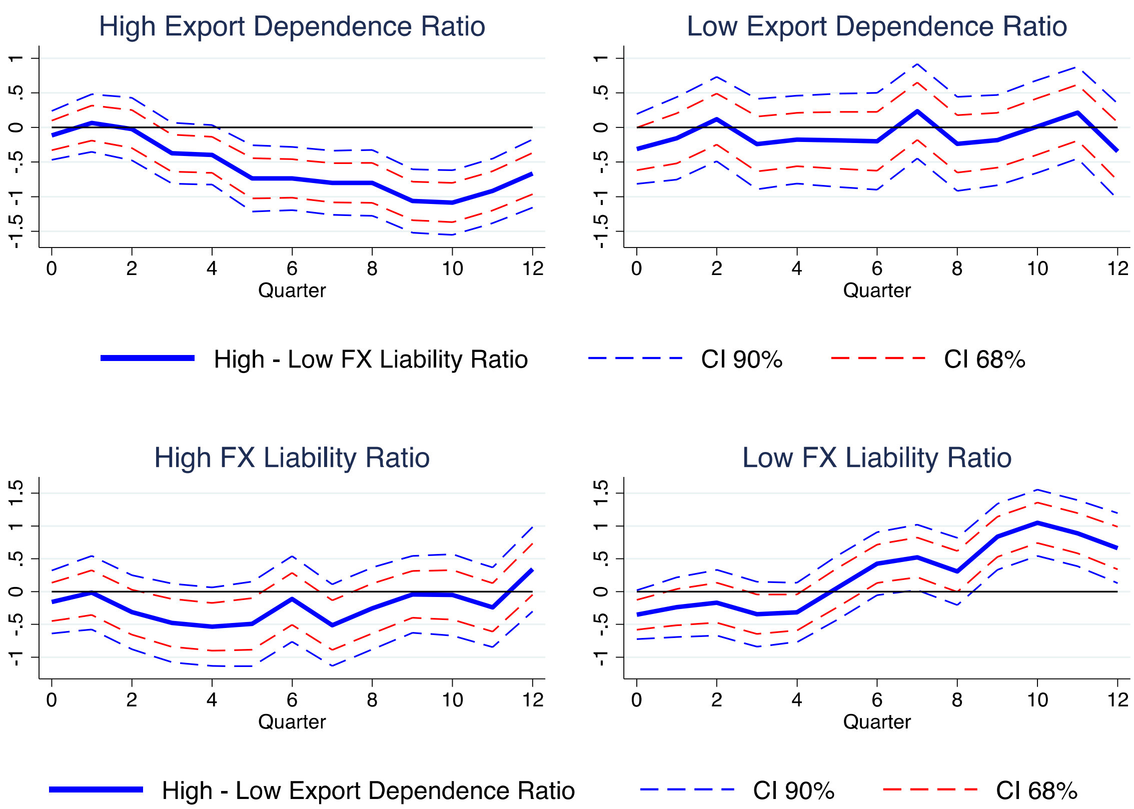
Note: Y-axis in percent. This exercise separates firms into groups along two dimensions: leverage (low/medium/high) and foreign-currency liability ratio (low/medium/high). The results follow from the estimation of Equation (3). In the upper row, the solid blue line represents the differential impulse responses between high and low leverage groups within firms with a high (upper-left panel) and low (upper-right panel) foreign-currency liability ratio. In the lower row, the solid blue line represents the differential impulse responses between the high and low foreign-currency liability ratio groups among firms with high (lower-left panel) and low (lower-right panel) leverage. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure 7. Leverage and Export Dependence



Note: Y-axis in percent. This exercise separates firms into groups along two dimensions: leverage (low/medium/high) and export dependence (low/medium/high). The results follow from the estimation of Equation (3). In the upper row, the solid blue line represents the differential impulse responses between the high and low leverage groups within firms with high (upper-left panel) and low (upper-right panel) export dependence. In the lower row, the solid blue line represents the differential impulse responses between the high and low export dependence groups among firms with high (lower-left panel) and low (lower-right panel) leverage. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure 8. Foreign-Currency Liability Ratio and Export Dependence



Note: Y-axis in percent. This exercise separates firms into groups along two dimensions: foreign-currency liability ratio (low/medium/high) and export dependence (low/medium/high). The results follow from the estimation of Equation (3). In the upper row, the solid blue line represents the differential impulse responses between the high and low FX liability ratio groups within firms with high (upper-left panel) and low (upper-right panel) export dependence. In the lower row, the solid blue line represents the differential impulse responses between the high and low export dependence groups among firms with high (lower-left panel) and low (lower-right panel) foreign-currency liability ratio. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Tables

Table 1. Summary Statistics

	No. of Obs.	Mean	Std. Dev.	25th Pctile	Median	75th Pctile
Investment rate (log)	887,901	-3.514	1.346	-4.324	-3.366	-2.571
Revenue (log USD)	1,156,564	5.728	3.182	3.786	5.695	7.856
Leverage	1,250,768	0.197	0.182	0.021	0.162	0.324
Foreign-currency liability ratio (%)	708,800	15.371	32.335	0	0	1.964
Export dep. ratio (%)	2,298,087	25.024	23.36	5.752	16.735	43.686
Size (log USD)	1,258,486	4.701	2.253	3.389	4.818	6.200
Bank debt ratio	542,363	0.763	0.292	0.597	0.903	1
Liquidity	1,224,032	0.176	0.171	0.050	0.121	0.246
Collateral	1,161,006	0.513	0.237	0.325	0.502	0.700
Age	2,141,964	40.593	33.863	20	30	50
Dividend payment (USD)	481,827	23.201	912.921	0.027	0.830	4.465

Note: **Investment rate** = Capital Expenditure/Net Property Plant and Equipment; **Revenue** is in log USD; **Leverage** = Total Debt/Total Asset; **Foreign-currency Liability Ratio** = Total foreign-currency Liabilities/Total Debt; **Export Dependence Ratio** = Exports/Output; **Size** is the log of Total Assets; **Bank Debt Ratio** = Bank Debt/Total Debt; **Liquidity** = (Cash + Short-term Investment)/Total Assets; **Collateral** = Tangible Assets/Total Assets; **Age** = 2019 – Foundation year; **Dividend payment** is in USD.

Table 2. Back-of-the-Envelope Calculations (Investment)

	Unconditional	**Leverage**	**Foreign-Currency Liability Ratio**	**Export Dependence**
Cumulative Responses (%)	**-5.86**	**-4.33**	**-2.77**	**-0.18**
Capital Expenditure Share of High Group		**34.2%**	**28.4%**	**13.8%**
Contribution to the Average Response $\left(\omega_1 \frac{\partial K_t^1}{\partial i_t^{US}}\right) / \left(\frac{\partial K_t}{\partial i_t^{US}}\right)$		**25.5%**	**13.4%**	**0.41%**

Note: We use the estimation results from Equation (4). The cumulative responses are computed as the sum of the impulse responses over 12 quarters to a 25- bps U.S. monetary policy shock. The first column (“unconditional”) refers to the estimation of Equation (1).

Annex

Annex 1: Mundell-Fleming Framework

In this section, we introduce a framework discussed in Gourinchas (2018) and Kalemli-Ozcan (2019), which are built on the spirit of the Mundell-Fleming framework with financial spillovers, to explore the different channels of U.S. monetary policy spillovers. Using this framework, we present the transmission channels, which are discussed empirically in Section 3.

In this simple framework, we assume that there are two countries: a small domestic economy and a large foreign economy (the United States). We closely follow Kalemli-Ozcan (2019) and assume that there exist financial spillovers from the U.S. to the small domestic economy. Differently, we assume that domestic output is the sum of tradable and non-tradable sector output.

To provide more details about the framework and our assumptions, we present the following system of equations which show how domestic and foreign output are determined:

$$Y_c = Y_c^T + Y_c^N$$
$$Y_c^N = DD_c^N$$
$$DD_c^N = \xi^N - bR_c - sE_c$$
$$Y_c^T = DD_c^T + NX$$
$$DD_c^T = \xi^T - bR_c - sE_c$$
$$NX = f(Y^* - Y_c^T) + dE_c$$
$$Y^* = DD^* = \xi^* - bR^*$$

where foreign variables are denoted by the superscript * and country-level variables are denoted by the subscript c. Domestic output Y_c is equal to the sum of tradable and non-tradable sector outputs.

The main difference across sectors is that the non-tradable sector output Y_c^N equals only domestic demand DD_c^N whereas the tradable sector output Y_c^T equals the sum of domestic demand DD_c^T and net exports NX. Domestic demand in both sectors varies positively with a demand shifter ξ, and negatively with the domestic interest rate R_c and the nominal exchange rate E_c. The parameters b and s govern the sensitivity of output on the interest rate (balance sheet channel) and the exchange rate (financial channel of the exchange rate). The differential roles of both financial spillovers are captured by the sensitivity of output to the changing cost of finance (bR_c) and exchange rate fluctuations (sE_c).[16] The United States is assumed to be a closed economy, with output Y^* equaling U.S. demand DD^*, which is a positive function of the demand shifter (ξ^*) and a negative function of the U.S. interest rate R^*. Net exports (NX) varies positively with the depreciation of domestic currency E_c and with U.S. output Y^*. Following Gourinchas (2018), we assume that the exchange rate is determined by:

$$E_c = g(R^* - R_c) + \chi_c$$

where $\chi_c = hR^* + \gamma_c$. This equation shows that the exchange rate depends on the policy rate differential between the United States and the small domestic economy and the country-specific risk premium shock χ_c. The interest rate differential captures the standard Uncovered Interest Parity (UIP) condition, and the second term captures the role of the risk premium. Furthermore, the domestic risk premium (χ_c) is assumed to increase with the U.S. policy rate. Therefore, an increase in the U.S. policy rate leads to a depreciation of the domestic currency, and the increase in the domestic risk premium further amplifies the exchange rate depreciation.

Following Kalemli-Özcan (2019), we also assume that there is a wedge between corporate borrowing rate and government bond rate such that:

$$R_c = R_{pc} + \chi_c = R_{pc} + hR^* + \gamma_c$$

where R_{pc} is the government policy rate, χ_c denotes the wedge between corporate and government bond yields, and γ_c is domestic country-specific risk premium.

Solving the equations above, output in tradable and non-tradable sectors can be presented as:

$$Y_c^T = \left(\frac{1}{1+f}\right)\left[(\xi^T + f\xi^*) - \big(b + g(d-s)\big)R_{pc} - \big(b + (s-d)(1-g)\big)\gamma_c - \left[bh + bf + (s-d)\big(h + g(1-h)\big)\right]R^*\right]$$

$$Y_c^N = \left[\xi^N - (bh + s(h + g(1-h)))R^* - (b - sg)R_{pc} - (b - s(g-1))\gamma_c\right]$$

[16] Note that financial spillover vanishes when $d = 0$ (usual Mundell-Fleming case).

Partial derivatives imply the following expressions:

$$\frac{\partial Y_c^T}{\partial R^*} = \left(\frac{1}{1+f}\right)\left[\underbrace{-bh}_{\textit{Balance Sheet Channel}} \quad \underbrace{-s\big(h+g(1-h)\big)}_{\textit{Financial Channel of the Exchange Rate}} \quad + [\underbrace{d\big(h+g(1-h)\big)-bf}_{\textit{Trade Channel}}]\right]$$

$$\frac{\partial Y_c^N}{\partial R^*} = \underbrace{-bh}_{\textit{Balance Sheet Channel}} \quad \underbrace{-s\big(h+g(1-h)\big)}_{\textit{Financial Channel of the Exchange Rate}}$$

Transmission Channels

While these channels are presented in this stylized model using their impact on output in the tradable and non-tradable sectors, our focus is mainly on how these channels affect firm investment. However, we also look at the impact of different channels for firm revenue. Using the expression above, we obtain the following transmission channels to be analyzed empirically:

- The role of the balance sheet channel is negative for both sectors and these adverse effects are greater for firms with higher vulnerabilities (b) to the changing cost of finance:

$$\frac{\partial Y_f^T}{\partial R^* \partial b} < 0, \qquad \frac{\partial Y_f^N}{\partial R^* \partial b} < 0$$

We proxy the b coefficient with firm leverage (debt-to-assets ratio) assuming that firms with higher leverage are closer to default risk than their counterparts and face greater external finance premium during turbulent times (higher R^*).

- The role of the financial channel of the exchange rate is negative on both sectors and these adverse effects are greater for firms with higher vulnerability to exchange rate fluctuations s:

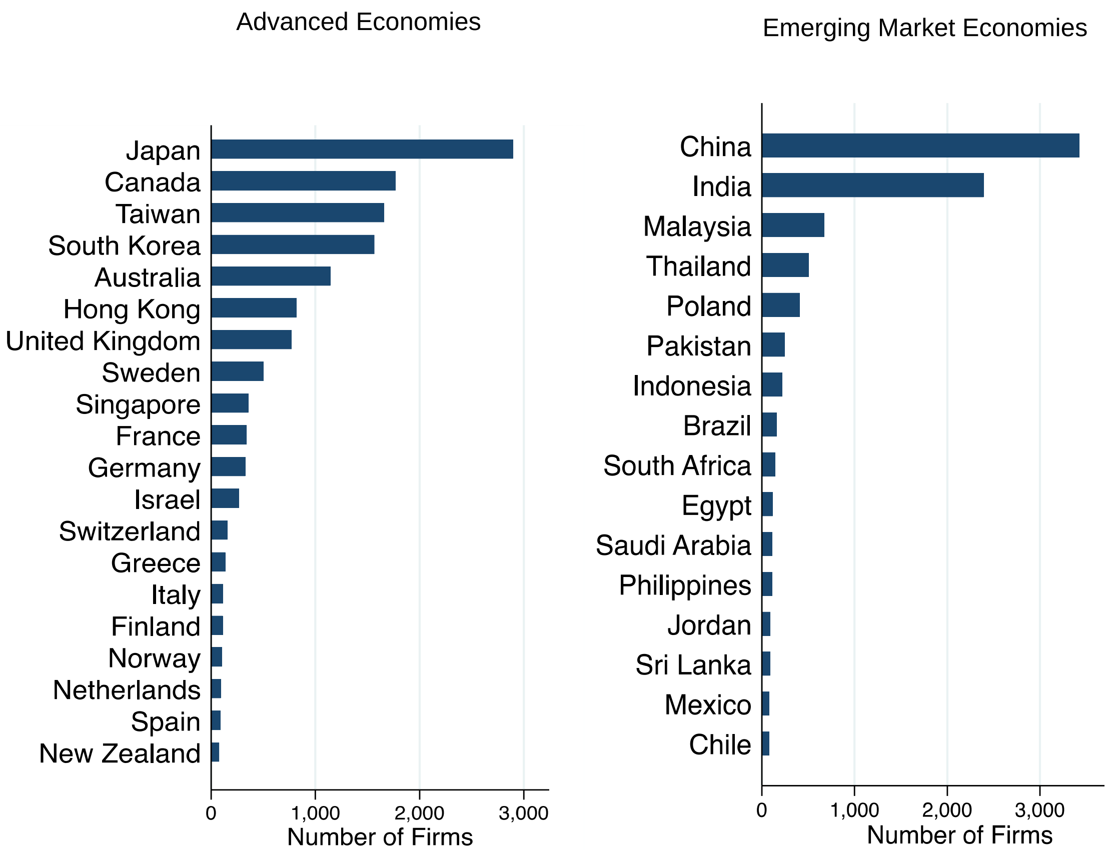
$$\frac{\partial Y_f^T}{\partial R^* \partial s} < 0, \qquad \frac{\partial Y_f^N}{\partial R^* \partial s} < 0$$

We proxy this channel with the foreign-currency debt-to-total debt ratio. We assume that firms with a higher foreign-currency debt ratio are more vulnerable to exchange rate fluctuations caused by increasing U.S. rates.

- The additional effect on the tradable sector [$\underbrace{d\big(h + g(1-h)\big) - bf}_{\textit{Trade Channel}}$ through the trade channel is ambiguous. Overall effects of the trade channel depend on which sub-channel dominates: $\underbrace{d\big(h + g(1-h)\big)}_{\textit{Expenditure Switching Channel}}$ or $\underbrace{bf}_{\textit{Expenditure Reducing Channel}}$. We therefore test the role of the trade channel empirically by comparing the differential effects of U.S. monetary policy shocks on each sector's trade dependence on the United States.

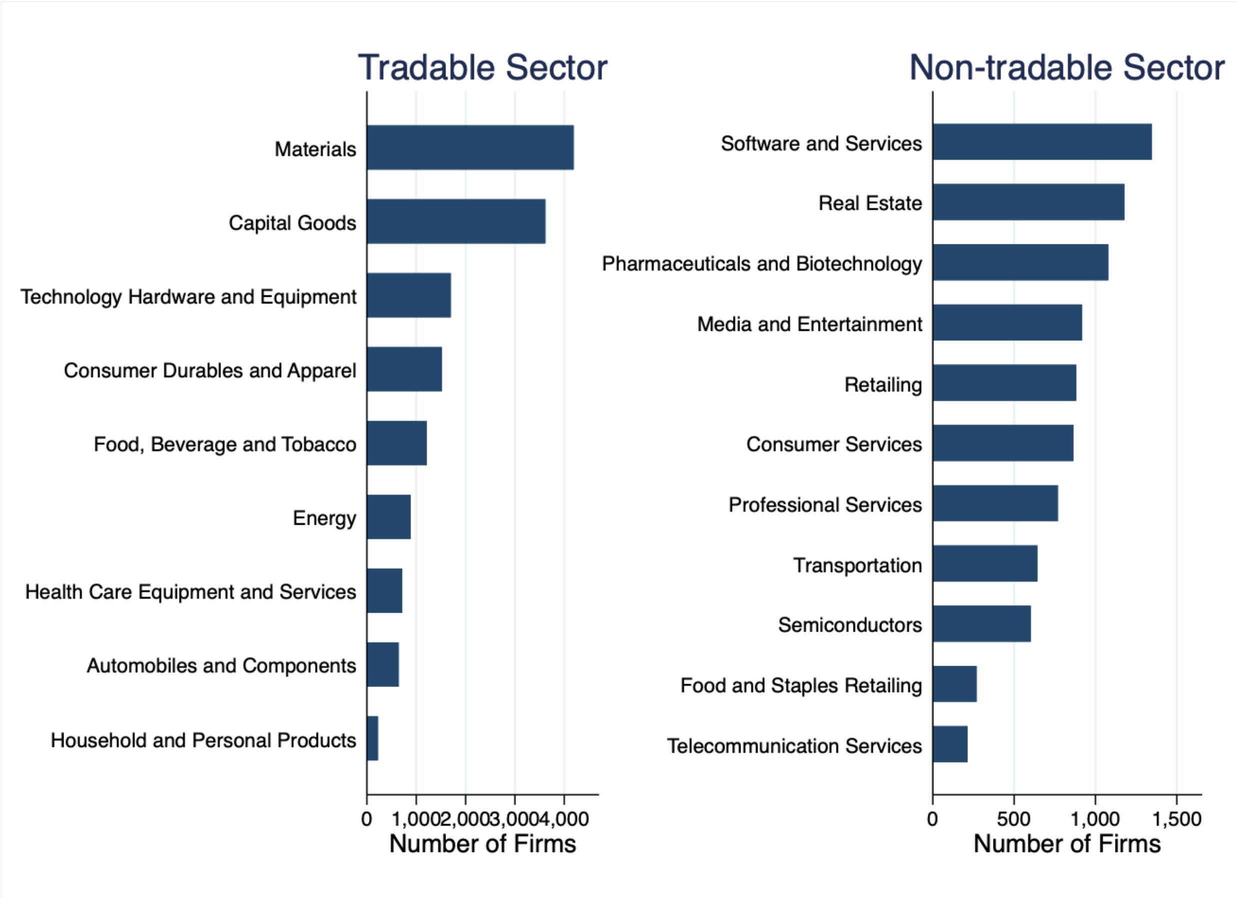
Annex 2: Data

Figure A2.1. Distribution of Firms Across Income Groups



Sources: S&P Capital IQ, authors' calculations.

Figure A2.2. Distribution of Firms Across Sectors



Sources: S&P Capital IQ, authors' calculations.

Table A2.1. Number of Firms and Observations by Country

Country	Number of firms	Obs.
United States	4,740	388,680
China	4,077	334,314
Japan	3,085	252,970
India	2,672	219,104
Canada	2,213	181,466
South Korea	1,747	143,254
Taiwan	1,693	138,826
Australia	1,356	111,192
Hong Kong	1,106	90,692
United Kingdom	870	71,340
Malaysia	771	63,222
Thailand	555	45,510
Sweden	525	43,050
Poland	522	42,804
Singapore	471	38,622
France	467	38,294
Germany	450	36,900
Vietnam	412	33,784
Indonesia	399	32,718
Israel	322	26,404
Pakistan	321	26,322
Turkey	280	22,960
Brazil	246	20,172
Italy	220	18,040
Sri Lanka	183	15,006
Bangladesh	178	14,596
South Africa	178	14,596
Russia	177	14,514
Switzerland	168	13,776
Philippines	157	12,874
Greece	155	12,710
Egypt	134	10,988
Norway	129	10,578
Chile	128	10,496
Spain	119	9,758
Finland	117	9,594
Saudi Arabia	114	9,348

Table A2.1 (continued). Number of Firms and Observations by Country

Country	Number of firms	Obs.
Netherlands	105	8,610
New Zealand	105	8,610
Mexico	98	8,036
Peru	87	7,134
Jordan	83	6,806
Belgium	75	6,150
Ireland	71	5,822
Oman	71	5,822
Argentina	65	5,330
Romania	63	5,166
Kuwait	61	5,002
Croatia	57	4,674
Bulgaria	54	4,428
Colombia	49	4,018
Austria	45	3,690
Cyprus	45	3,690
United Arab Emirates	45	3,690
Mauritius	44	3,608
Luxembourg	39	3,198
Jamaica	37	3,034
Portugal	36	2,952
Tunisia	27	2,214
Lithuania	23	1,886
Qatar	21	1,722
Malta	20	1,640
Hungary	18	1,476
Bahrain	17	1,394
Kazakhstan	15	1,230
Estonia	14	1,148
Iceland	14	1,148
Latvia	14	1,148
Trinidad & Tobago	14	1,148
Serbia	12	984
Ukraine	11	902
Macau	10	820
Botswana	7	574
Czech Republic	6	492
Slovakia	6	492

Table A2.2. Number of Firms and Observations by Sector

Sector	Number of Firms	Obs.
Materials	5,433	445,506
Capital Goods	4,888	400,816
Technology Hardware and Equipment	2,286	187,452
Consumer Durables and Apparel	2,032	166,624
Software and Services	2,027	166,214
Pharmaceuticals and Biotechnology	1,833	150,306
Food, Beverage and Tobacco	1,800	147,600
Energy	1,714	140,548
Media and Entertainment	1,398	114,636
Consumer Services	1,315	107,830
Retailing	1,291	105,862
Health Care Equipment and Services	1,287	105,534
Professional Services	1,160	95,120
Transportation	933	76,506
Automobiles and Components	865	70,930
Utilities	854	70,028
Semiconductors	774	63,468
Telecommunication Services	407	33,374
Food and Staples Retailing	383	31,406
Household and Personal Products	361	29,602

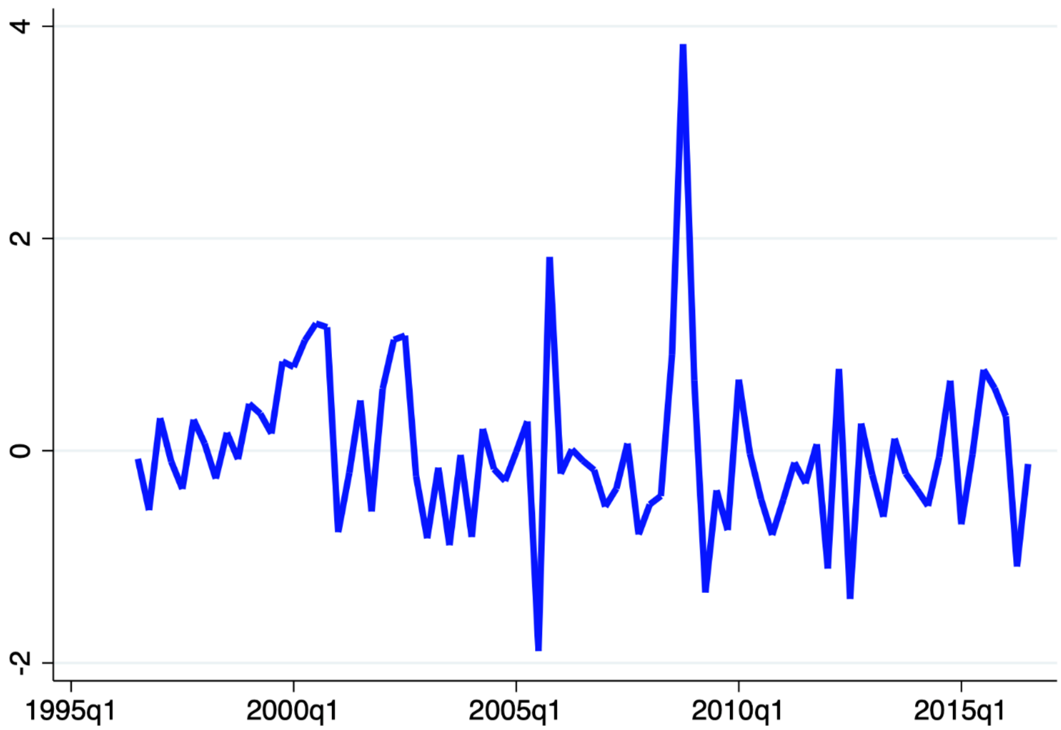
Table A2.3. Correlation of Investment between Capital IQ and World Economic Outlook Data

	(1)	(2)	(3)	(4)
VARIABLES	**Log Investment USD (CIQ)**		**Investment Growth (CIQ)**	
Investment Growth (WEO)			0.942***	0.867***
			(0.207)	(0.211)
Log Investment USD (WEO)	1.173***	1.350***		
	(0.0218)	(0.0693)		
Constant	3.240***	2.556***	14.65***	15.29***
	(0.106)	(0.276)	(2.432)	(2.588)
Observations	1,107	1,107	1,107	1,107
R-squared	0.717	0.925	0.032	0.101
Country FE	NO	YES	NO	YES

Note: Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

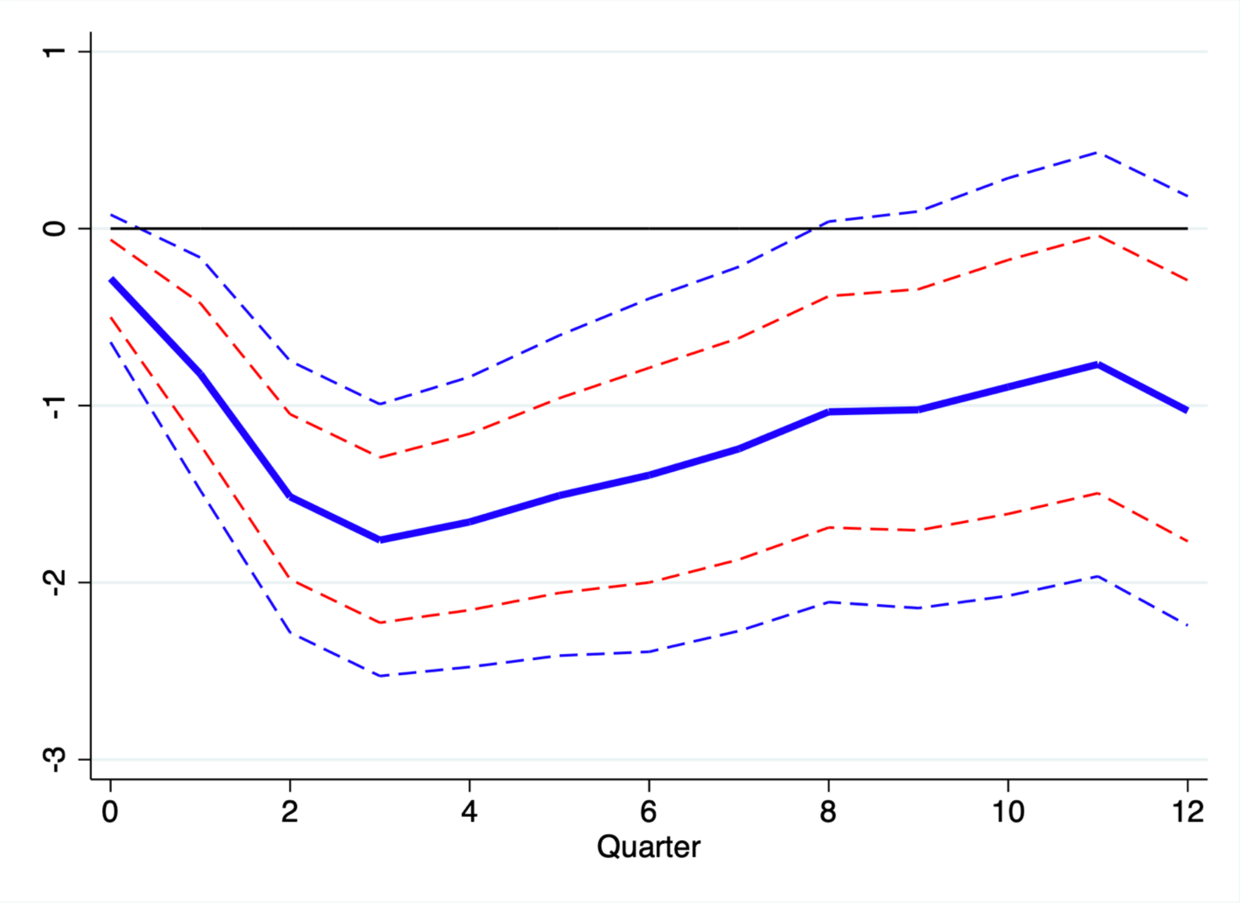
Figure A2.3. Estimated U.S. Monetary Policy Shocks



Note: Y-axis in percent. Exogenous monetary policy shocks over 1996Q3-2016Q3, following Duval et al. (2021) and Albrizio et al. (2021). Details are provided in section 2.2.

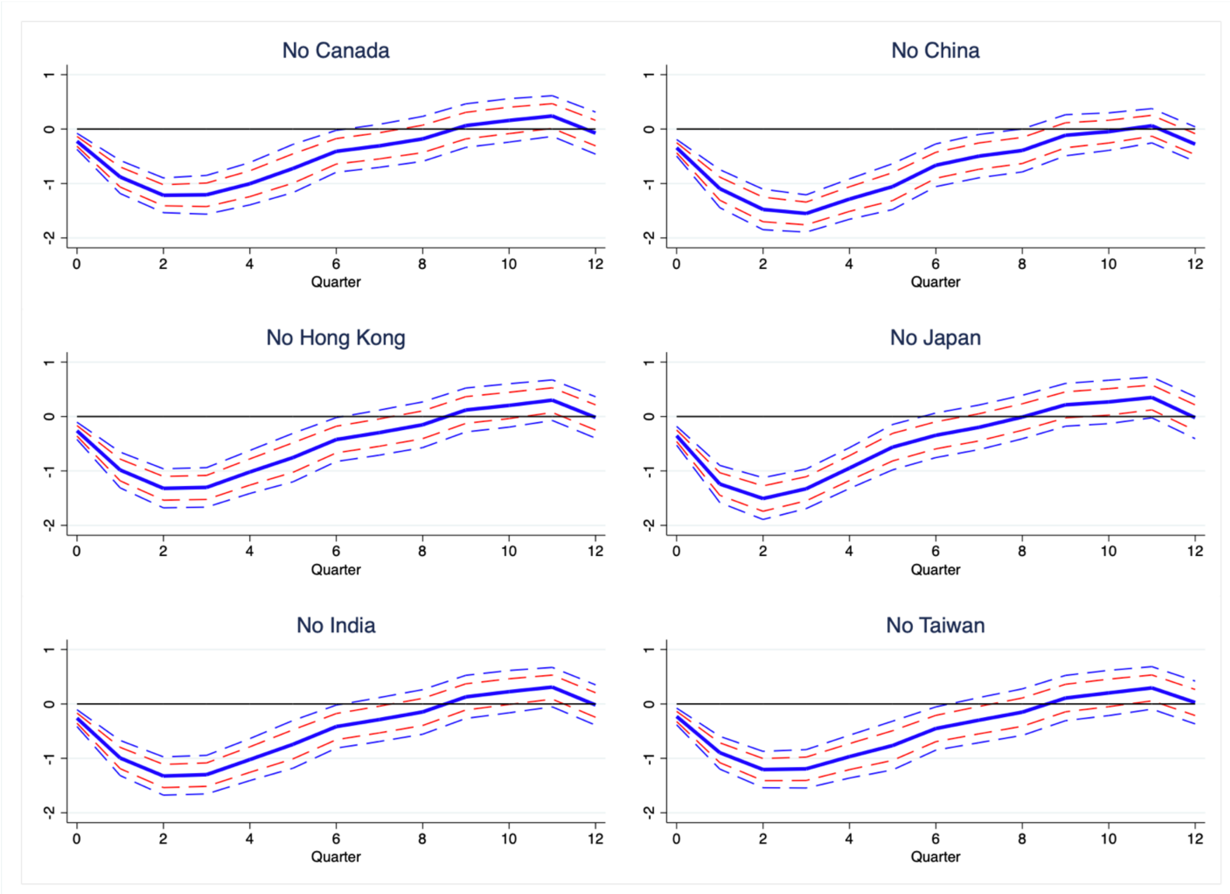
Annex 3: Unconditional Analysis

Figure A3.1. Average Investment Response for U.S. Firms



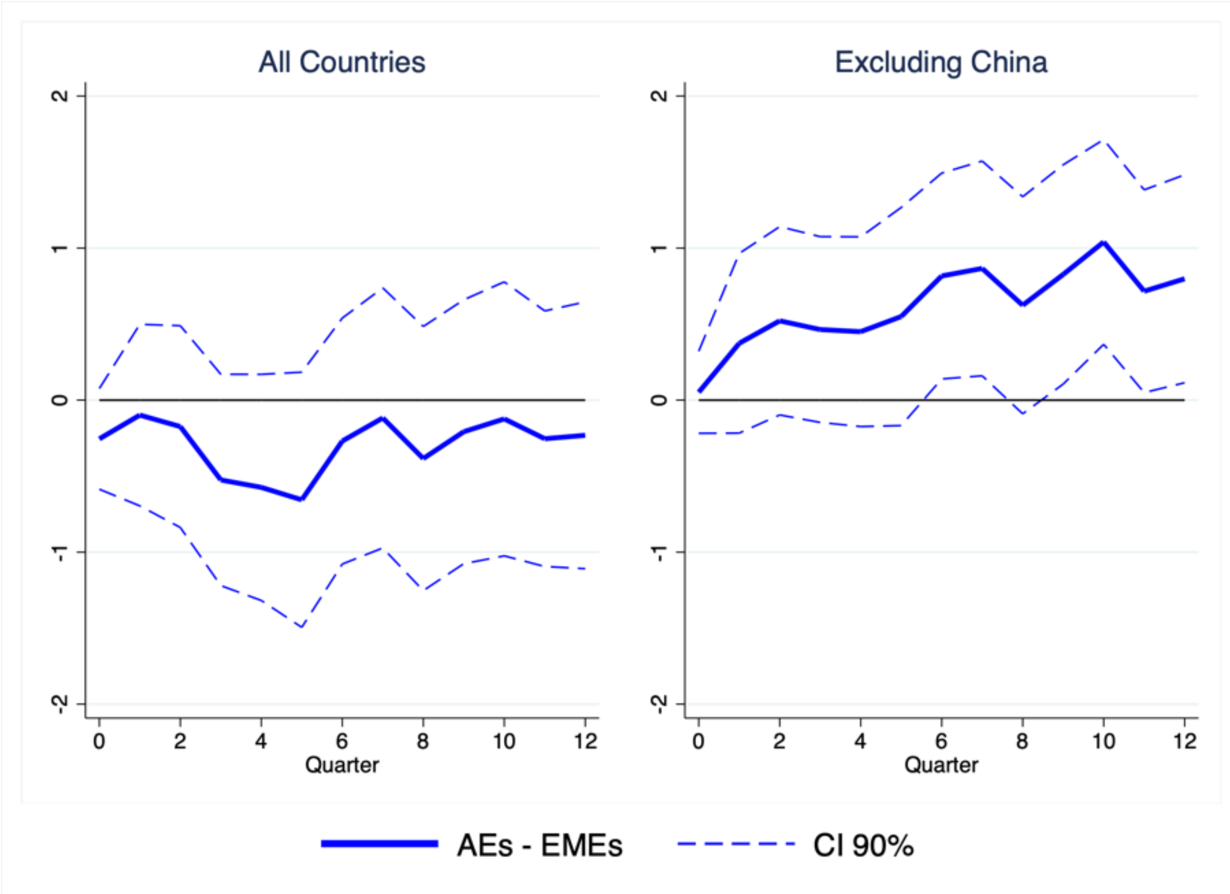
Note: Y-axis in percent. Results follow from the estimation of Equation (1), using the sample of U.S. firms only. The solid blue line indicates the average investment response of firms against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. Standard errors are two-way clustered on firm and country-time.

Figure A3.2. Investment Response—Dropping Countries with the Largest Number of Firms (%)



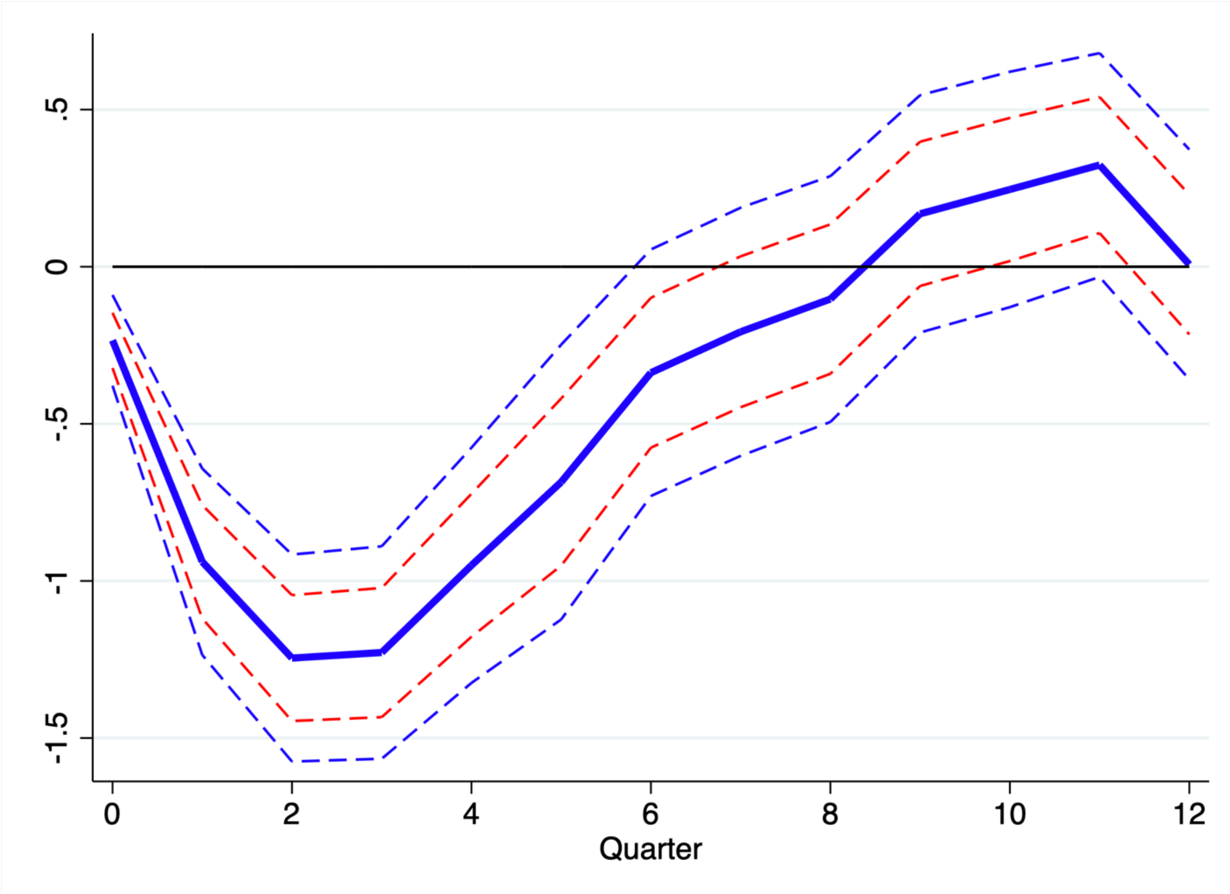
Note: Y-axis in percent. We estimate Equation (1) on the whole sample and drop (one at a time) the countries with the largest number of firms. The solid blue line indicates the average investment response of firms against a 25-bps U.S. monetary policy shock. Standard errors are two-way clustered on firm and country-time. Dashed blue line and dashed red line display the 90% and 68% confidence intervals.

Figure A3.3. Differential Investment Response of AE vs. EMDEs



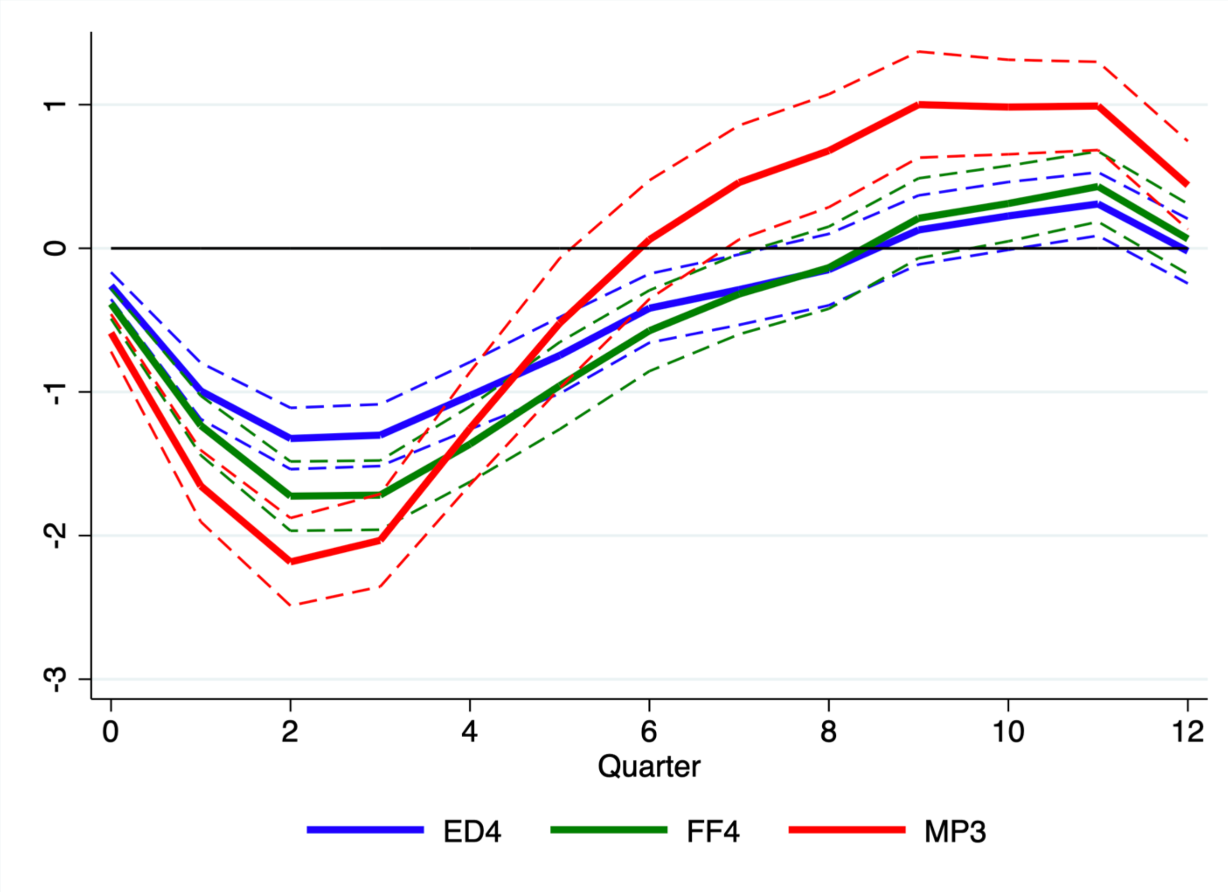
Note: Y-axis in percent. We estimate Equation (1) by interacting the monetary policy shock with a country group dummy, equal to 1 if the country is in EMDE group. The solid blue line represents the average differential impulse response between the firms in AEs versus EMDEs ($\boldsymbol{\beta_{AE,h} - \beta_{EMDE,h}}$). When the line is in the negative area, firms in AEs are more responsive to the shock than firms in EMDEs. The left panel includes all countries in the sample; the right panel excludes China in the EMDE group.

Figure A3.4. Average Investment Response: Adding Monetary Policy Shock Lags



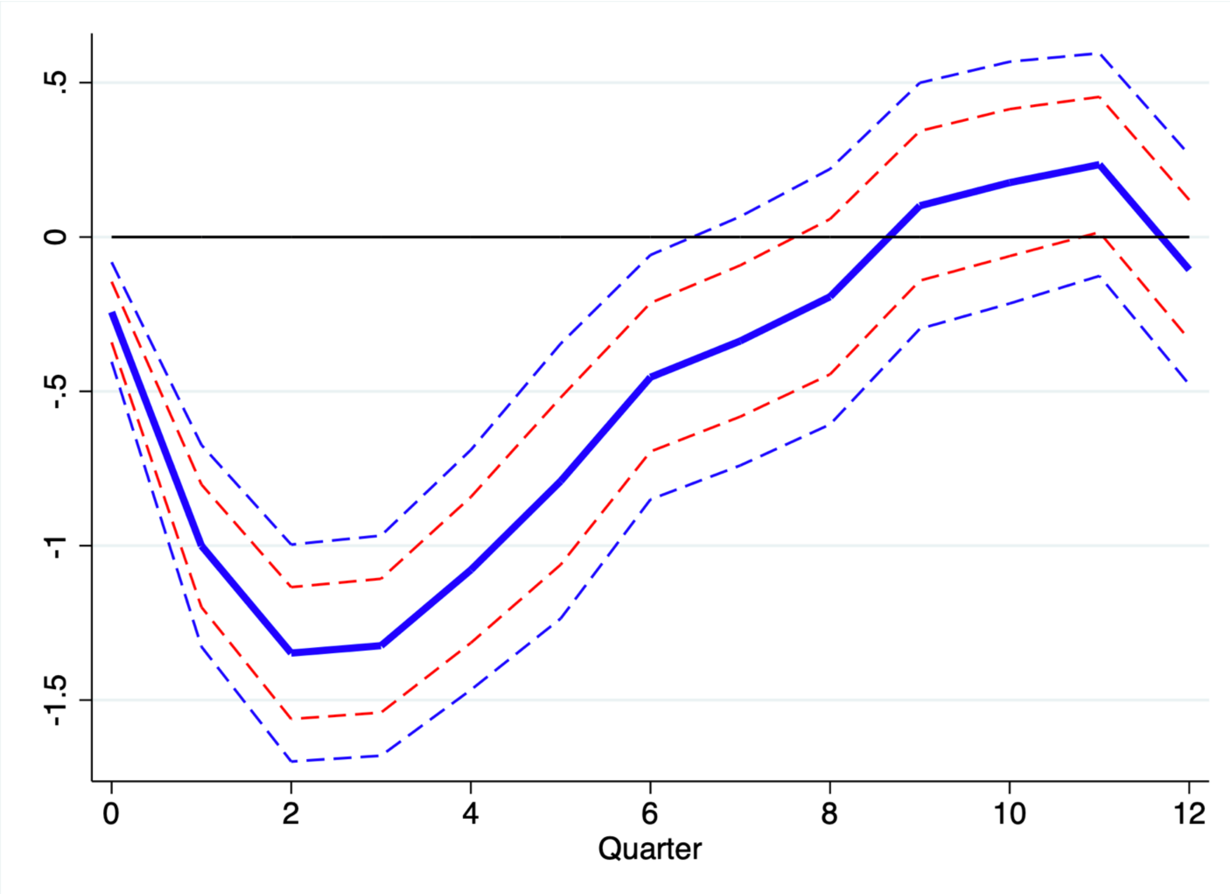
Note: Y-axis in percent. The results follow from the estimation of Equation (1), with the inclusion of two lags of the monetary policy shock. The solid blue line indicates the average investment response of firms against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. Standard errors are two-way clustered on firms and country-time.

Figure A3.5. Average Investment Response: Alternative Monetary Policy Shock



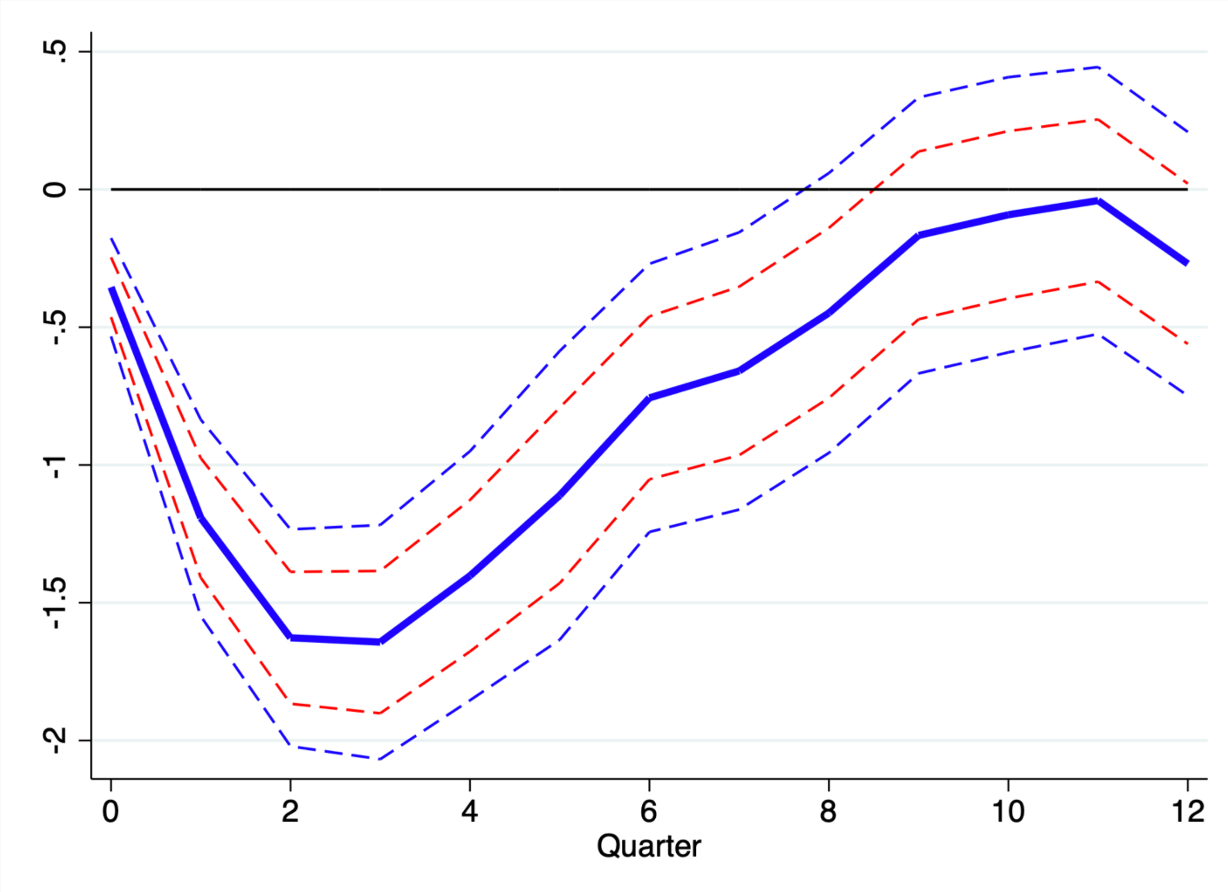
Note: Y-axis in percent. The results follow from the estimation of Equation (1) by using alternative monetary policy shocks from Duval et al. (2021). The solid lines indicate the average investment response of firms against a 25-bps U.S. monetary policy shock with different instruments: the one-year ahead changes in Eurodollar deposits (ED4), the four-month ahead Fed Fund futures (FF4), and changes in expected policy rates inferred from Fed fund futures rates following procedures described in Bernanke and Kuttner (2005), for three months, (MP3). The dashed blue and green lines display the 68% confidence intervals. Standard errors are two-way clustered on firms and country-time.

Figure A3.6. Average Investment Response: Adding Time-Varying Firm Characteristics



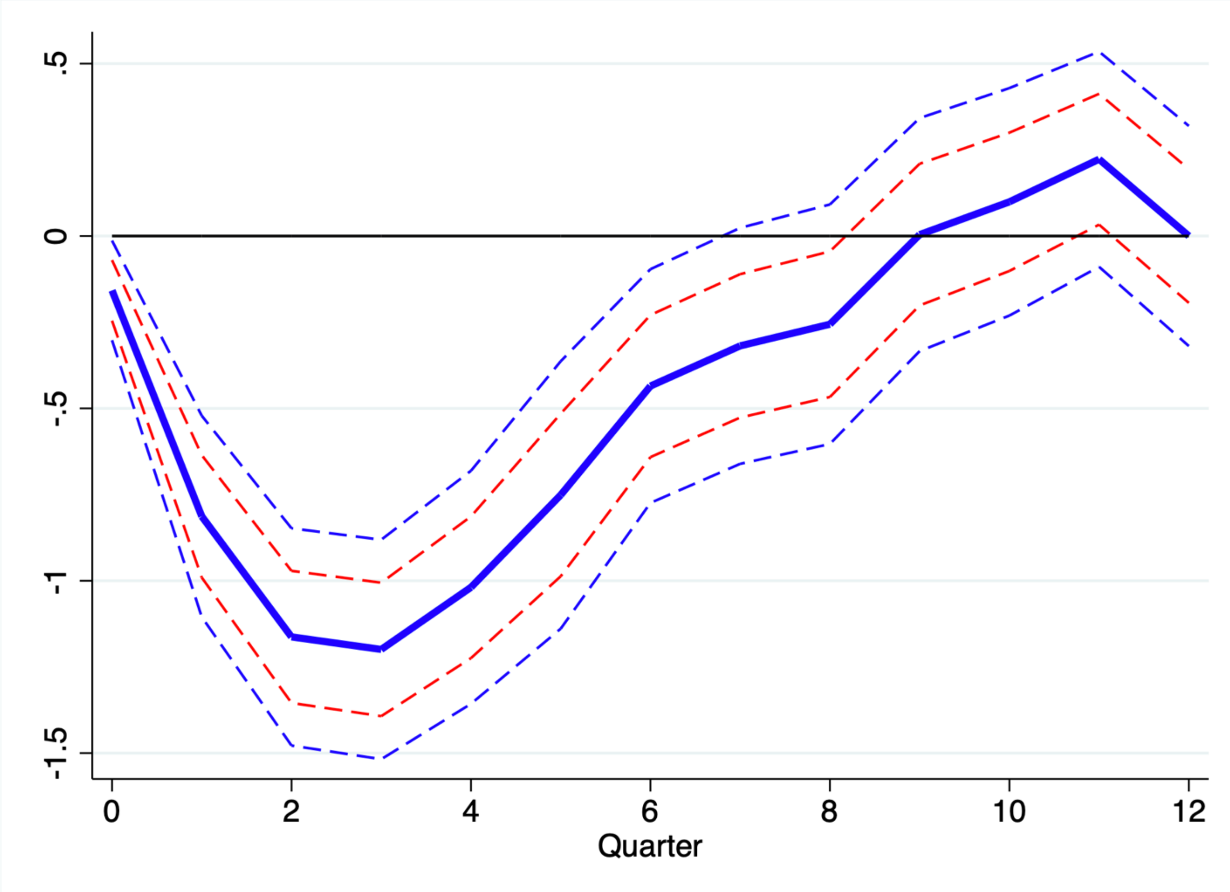
Note: Y-axis in percent. The results follow from the estimation of Equation (1), where time-varying firm characteristics (leverage, collateral, liquidity, size) as added as regressors. The solid blue line indicates the average investment response of firms against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. Standard errors are two-way clustered on firms and country-time.

Figure A3.7. Average Investment Response: Log Change in Capital Expenditure



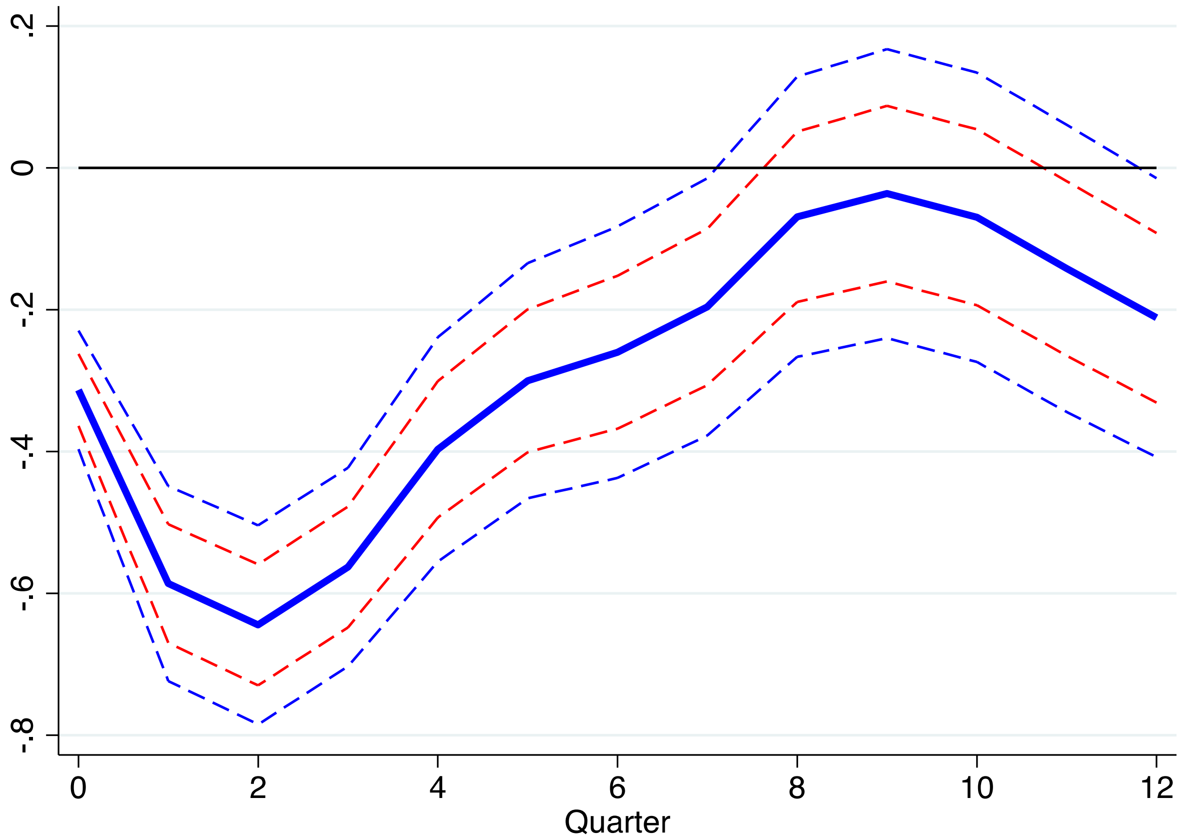
Note: Y-axis in percent. The results follow from the estimation of Equation (1), but the baseline dependent variable (Capital Expenditure/Net Property Plant and Equipment) is substituted by the log change in capital expenditure. The solid blue line indicates the average investment response of firms against a 25- bps U.S. monetary policy shock. The dashed blue and red line display the 90% and 68% confidence intervals. Standard errors are two-way clustered on firms and country-time.

Figure A3.8. Average Investment Response: Capital Expenditure to Total Assets Ratio



Note: Y-axis in percent. The results follow from the estimation of Equation (1), but the baseline dependent variable (Capital Expenditure/Net Property Plant and Equipment) is substituted by Capital Expenditure/Total Assets. The solid blue line indicates the average investment response of firms against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. Standard errors are two-way clustered on firms and country-time.

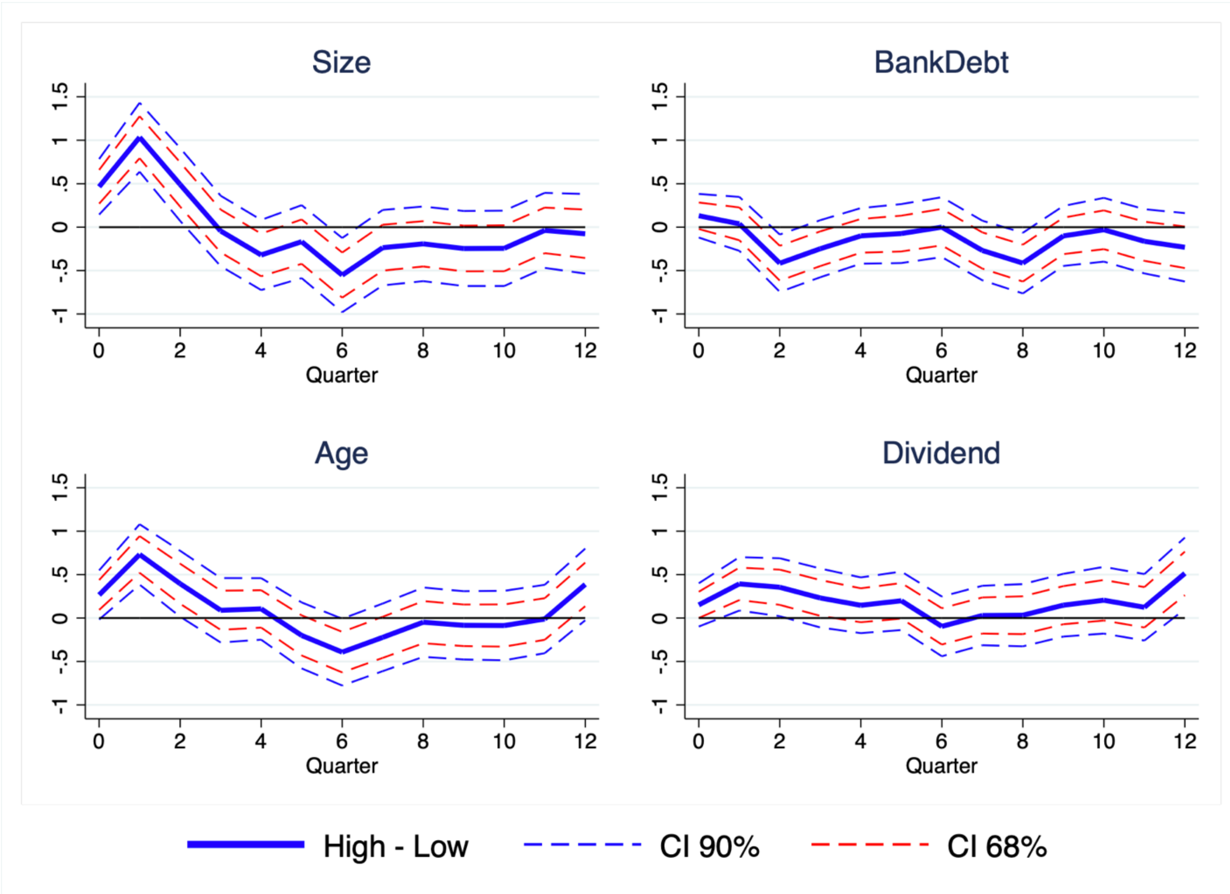
Figure A3.9. Average Revenue Response to U.S. Monetary Policy Shocks



Note: Y-axis in percent. Results follow from the estimation of Equation (1). The solid blue line indicates the average firm revenue response against a 25-bps U.S. monetary policy shock. Revenue is defined as growth in total revenues. The dashed blue and red lines display the 90% and 68% confidence intervals. Standard errors are two-way clustered on firms and country-time.

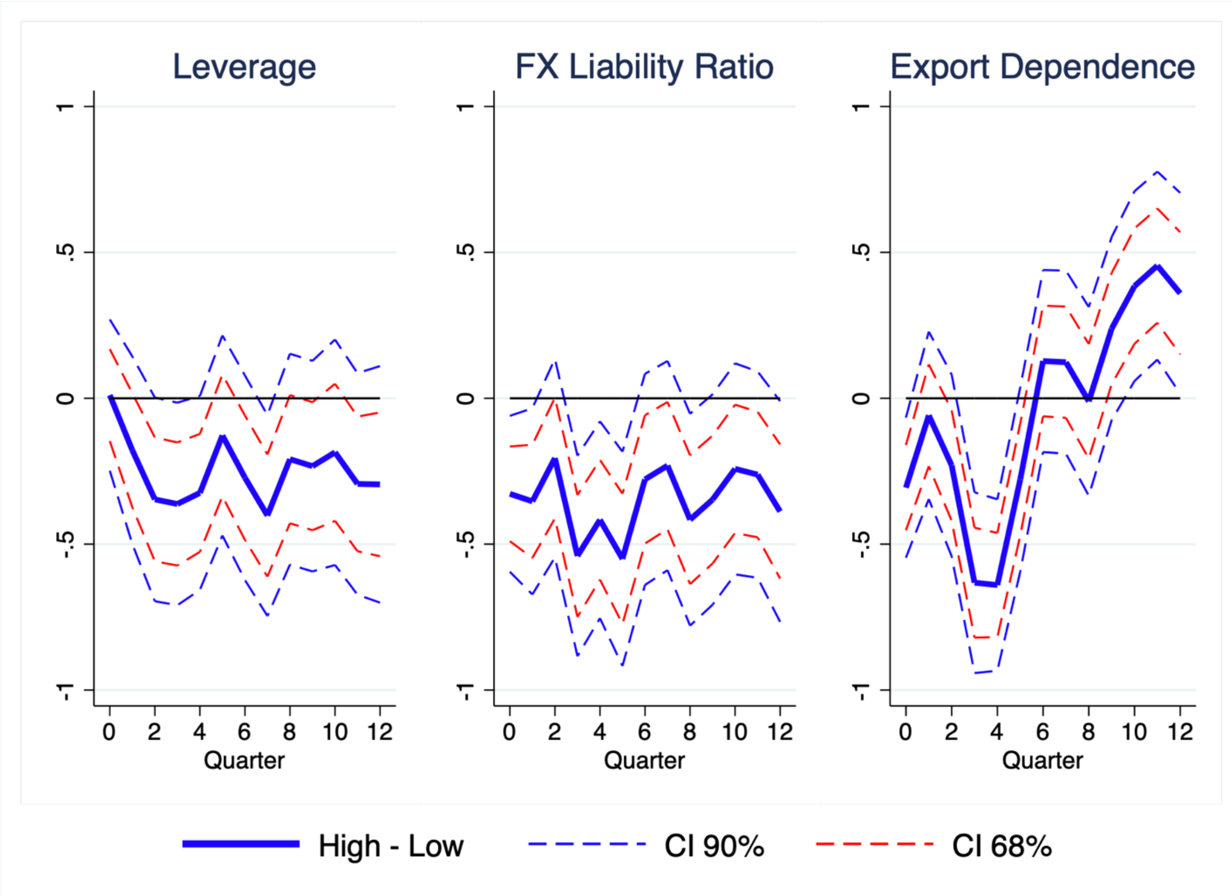
Annex 4: Conditional Analysis

Figure A4.1. Investment: Role of Other Firm Characteristics



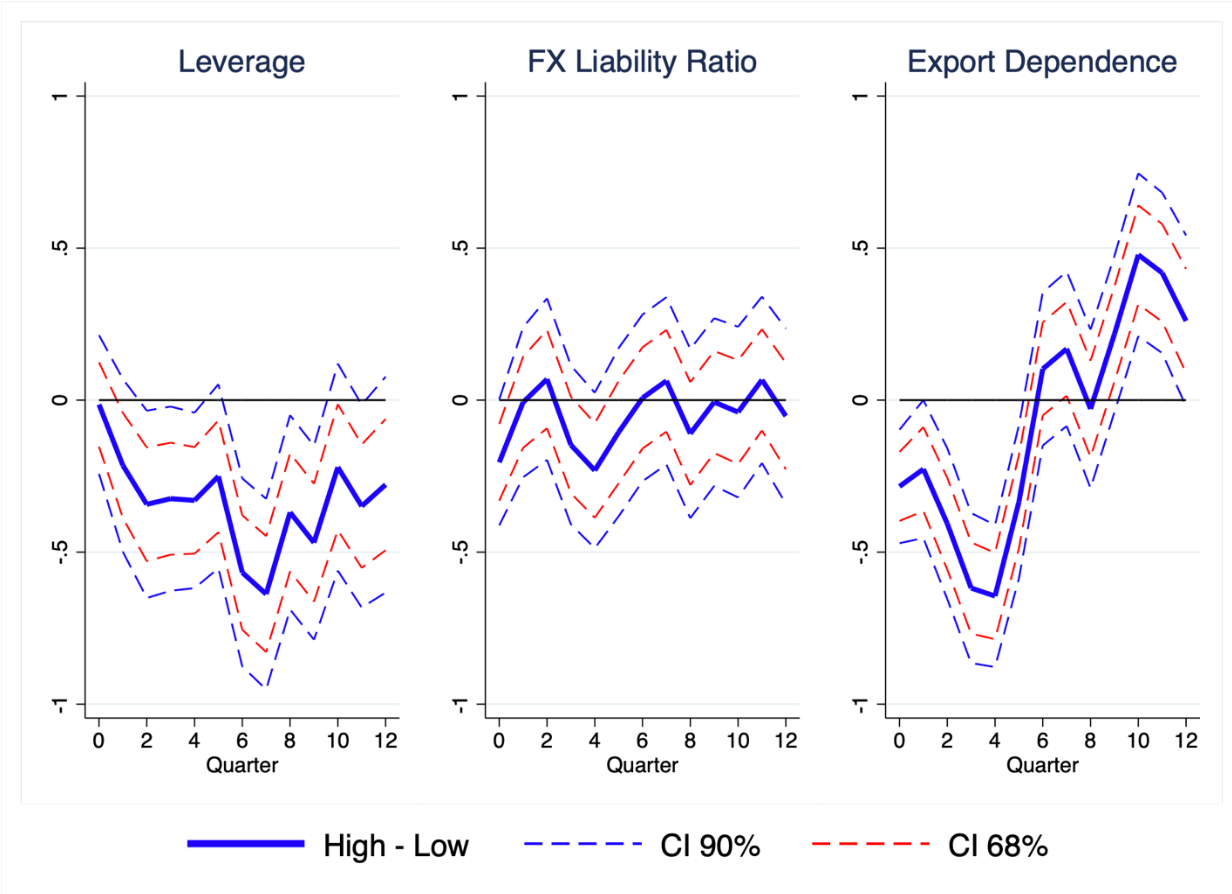
Note: Y-axis in percent. The results follow from the estimation of Equation (2), where the monetary policy shock is interacted with different firm characteristics. Firms are split into three categories (low/medium/high) for each firm characteristic following the baseline methodology, i.e. using the 25th and 75th percentile of the distribution across countries. For example, the solid blue line on the upper-left panel represents the differential impulse responses between larger and smaller firms and the solid blue line on the lower-left panel represents the difference in responses of younger and older firms. The dashed blue and red lines display the 90% and 68% confidence intervals. The standard errors are clustered on firms.

Figure A4.2. Role of Each Channel - Controlling for Other Characteristics



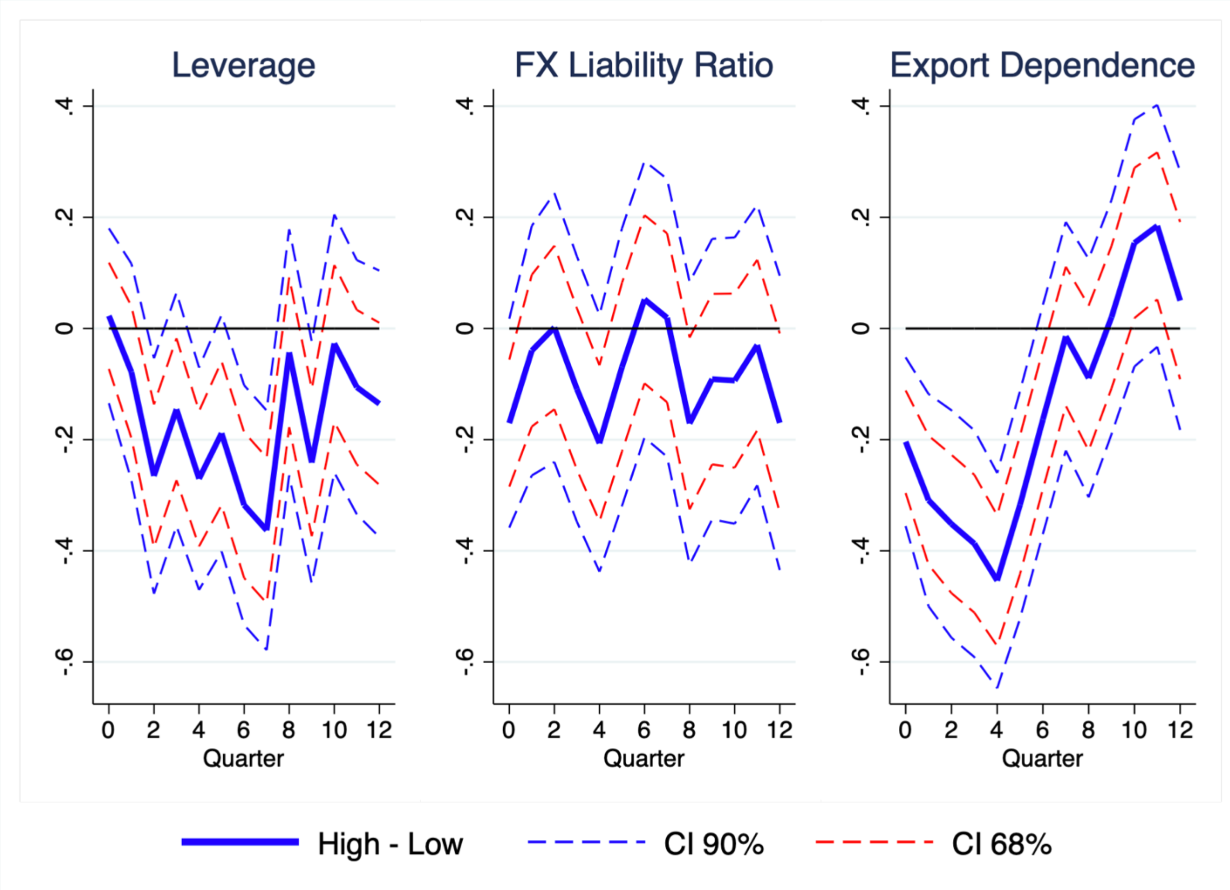
Note: Y-axis in percent. The panels show the role of each channel after controlling for the interaction of different firm characteristics (size, age and bank debt) with the monetary policy shock. The solid blue line represents the differential impulse response between the high and low groups for each channel. The dashed blue and red lines display the 90% and 68% confidence intervals. The standard errors are clustered on firms.

Figure A4.3. Role of Each Channel - Country-Specific Thresholds



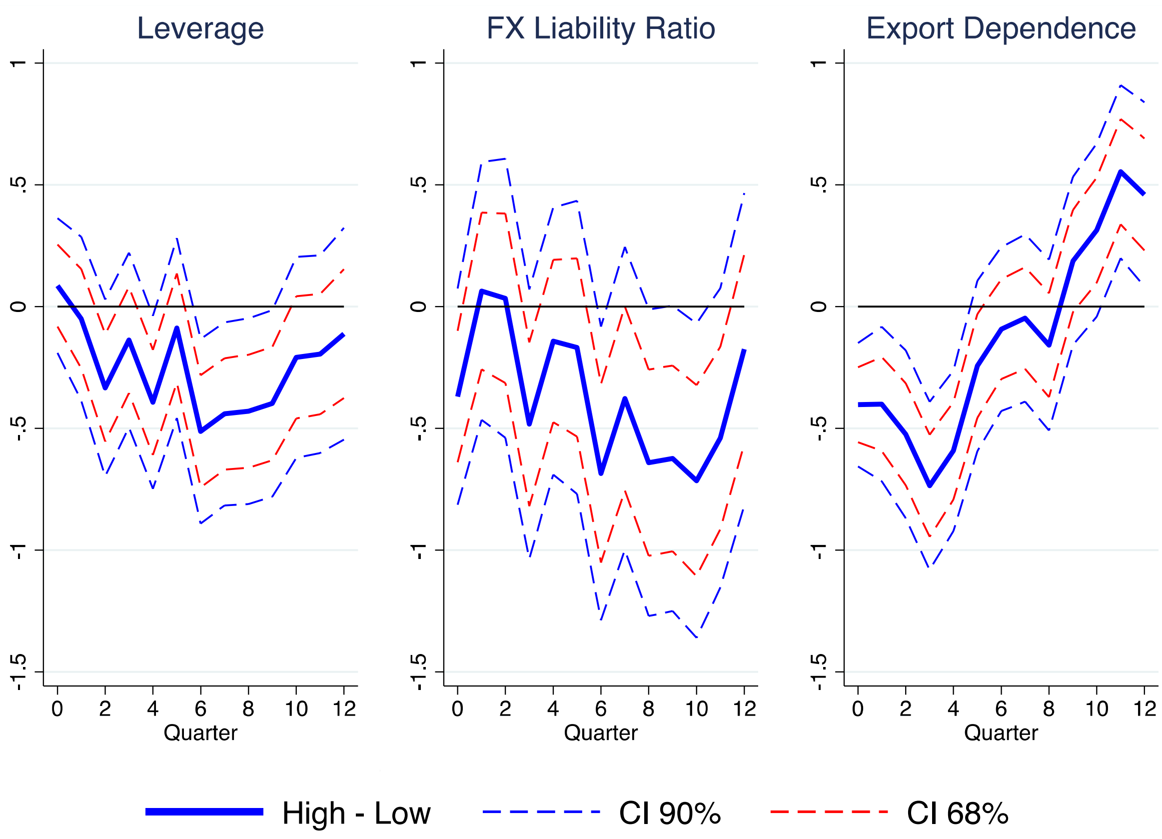
Note: Y-axis in percent. The results follow the estimation of Equation (2). Firms are split into three categories (low/medium/high) using country-specific thresholds, i.e. the 25th and 75th percentiles of the distribution in each country. The differential impulse response between the high and low groups (e.g., $\boldsymbol{\beta}_{\boldsymbol{HighLeverage,h}} - \boldsymbol{\beta}_{\boldsymbol{LowLeverage,h}}$) is represented by the solid blue line, which shows the response against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. We control for firm and sector-country-time fixed effects as well as time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.4. Role of Each Channel – Alternative Thresholds



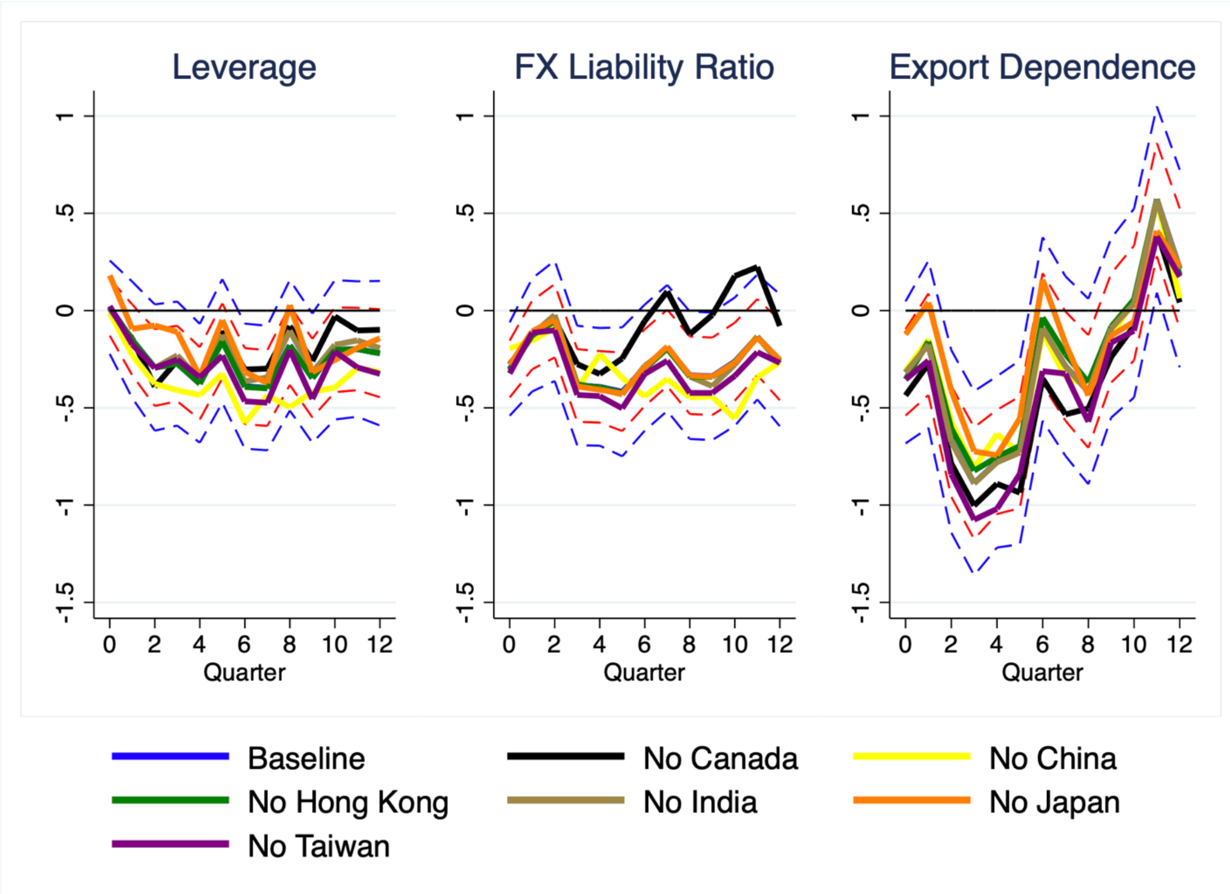
Note: Y-axis in percent. The results follow from the estimation of Equation (2). Firms are split into two categories (low/high) based on the median. The differential impulse response between the high and low groups (e.g.,$\boldsymbol{\beta}_{HighLeverage,h} - \boldsymbol{\beta}_{LowLeverage,h}$) is represented by the solid blue line, which shows the response against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. We control for firm and sector-country-time fixed effects as well as time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.5. Role of Each Channel – Classification Based on Initial Levels



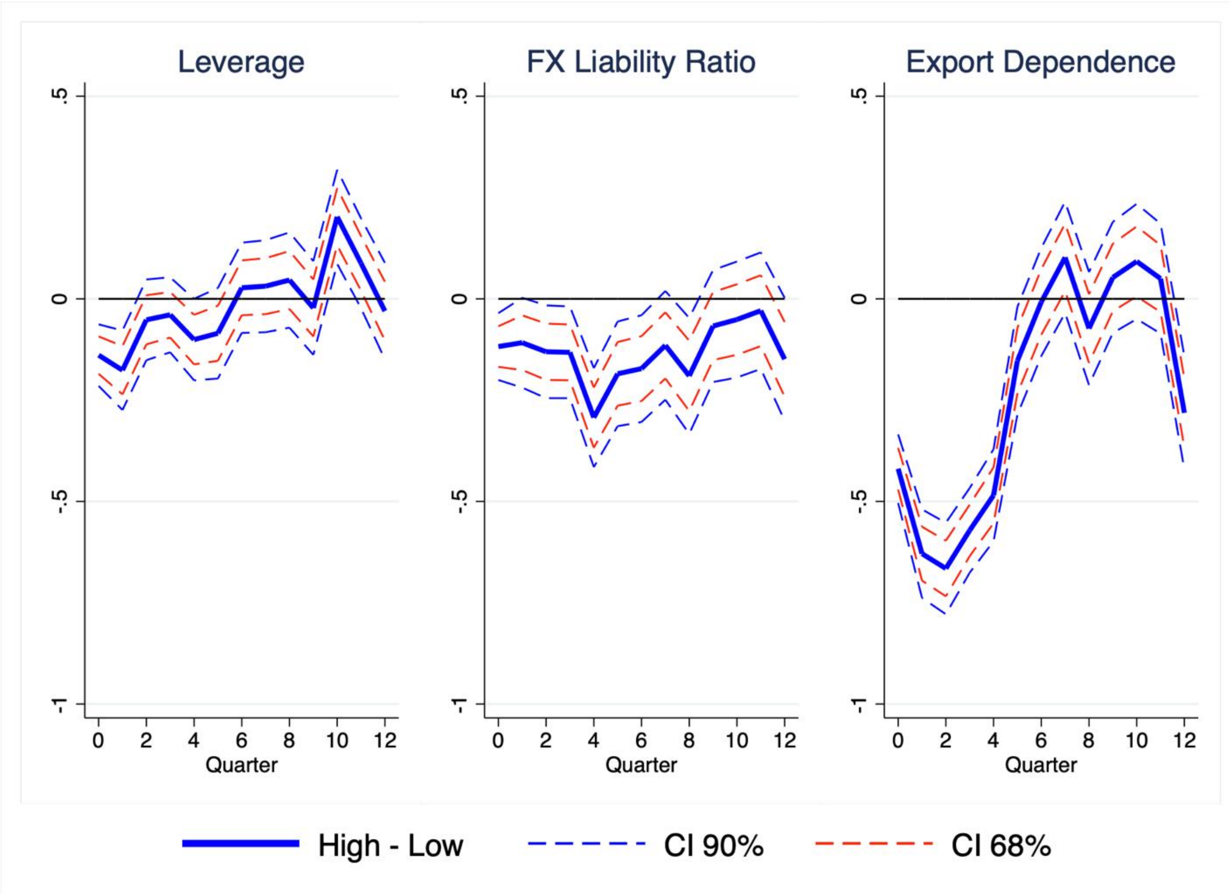
Note: Y-axis in percent. Firms are assigned into groups based on their initial leverage, foreign-currency liability and export dependence ratio in the first year observed in the sample. The dashed blue and red lines display the 90% and 68% confidence intervals. This exercise uses only country-time fixed effects instead of country-sector time fixed effects given that we can only exploit the variation in sector-country level. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.6. Role of Channel – Dropping Countries from the Sample



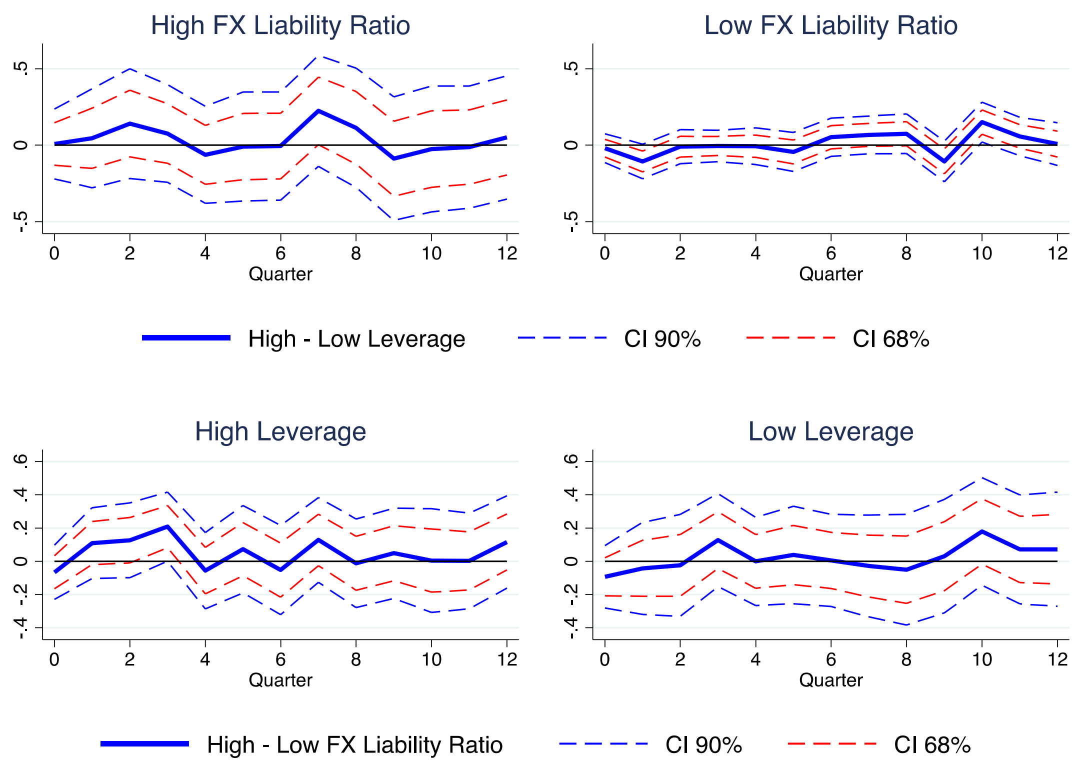
Note: Y-axis in percent. The results follow from the estimation of Equation (2), where we drop each large country separately. The baseline differential impulse responses between the high and low groups (e.g., $\boldsymbol{\beta}_{\boldsymbol{HighLeverage,h}} - \boldsymbol{\beta}_{\boldsymbol{LowLeverage,h}}$) are represented by the solid blue line, which shows the response against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. We control for firm and sector-country-time fixed effects (only country-time for the trade channel) as well as time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.7. Revenue: All Channels Together



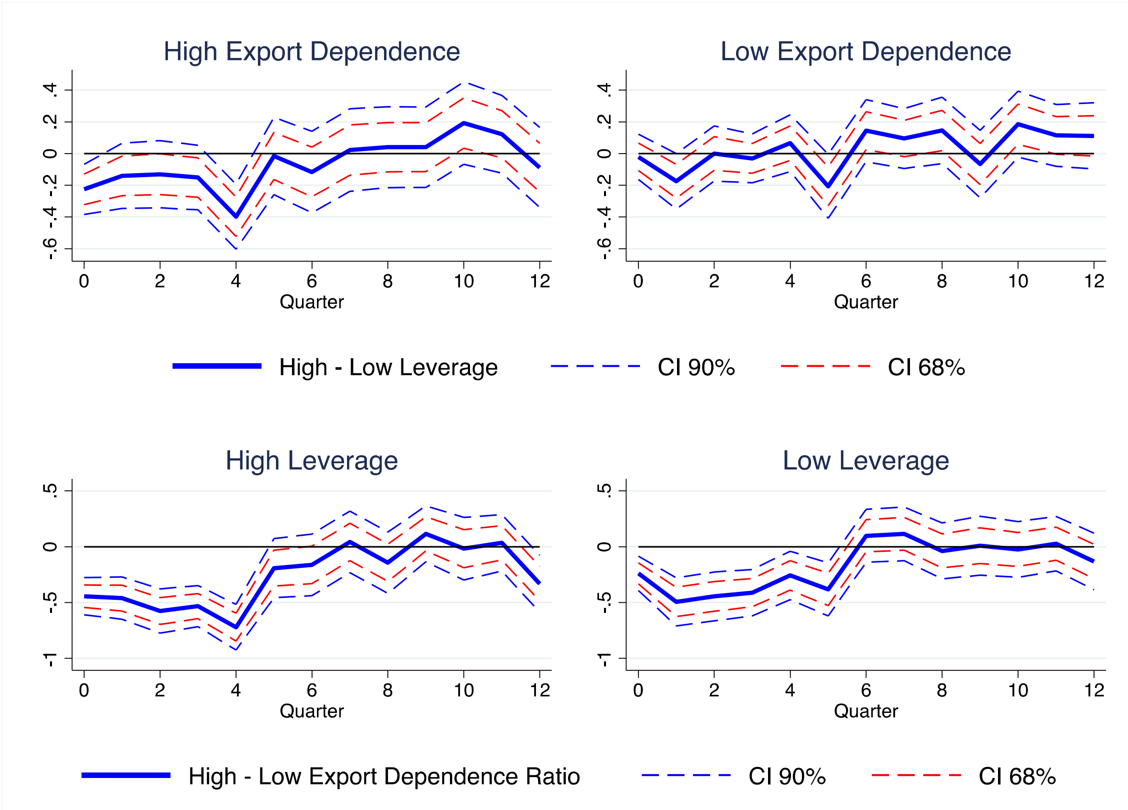
Note: Y-axis in percent. The results follow from the estimation of Equation (4) using firm revenue growth as the dependent variable. This exercise uses only country-time fixed effects instead of country-sector-time fixed effects given that we can only exploit the variation at the sector-country level in the trade channel. The differential impulse responses between the high and low groups ($\boldsymbol{\beta_{High} - \beta_{Low}}$) for each channel, represented by the solid blue line, show the response against a 25-bps U.S. monetary policy shock. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.8. Leverage and Foreign-Currency Liability Ratio (Revenue)



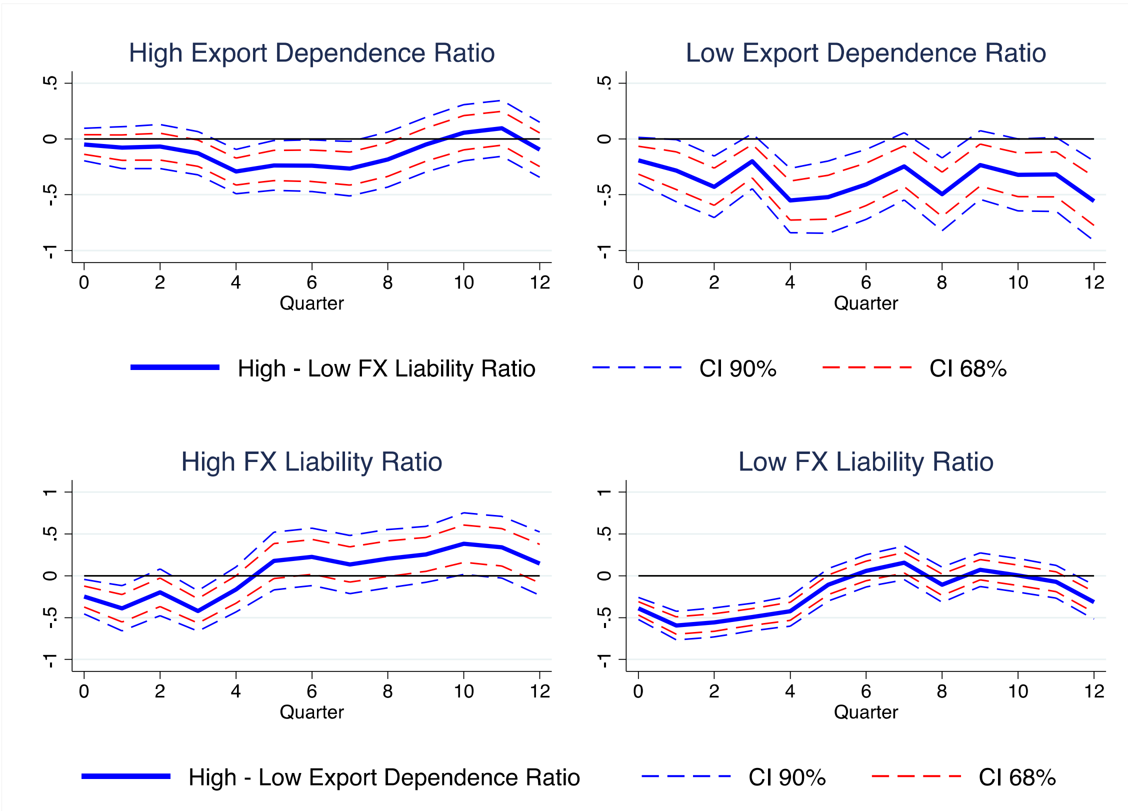
Note: Y-axis in percent. This exercise separates firms into groups along two dimensions: leverage (low/medium/high) and foreign-currency liability ratio (low/medium/high). The results follow from the estimation of Equation (3) using log change in revenues. In the upper row, the solid blue line represents the differential impulse responses between high and low leverage groups within firms with a high (upper-left panel) and low (upper-right panel) foreign-currency liability ratio. In the lower row, the solid blue line represents the differential impulse responses between the high and low foreign-currency liability ratio groups among firms with high (lower-left panel) and low (lower-right panel) leverage. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.9. Leverage and Export Dependence (Revenue)



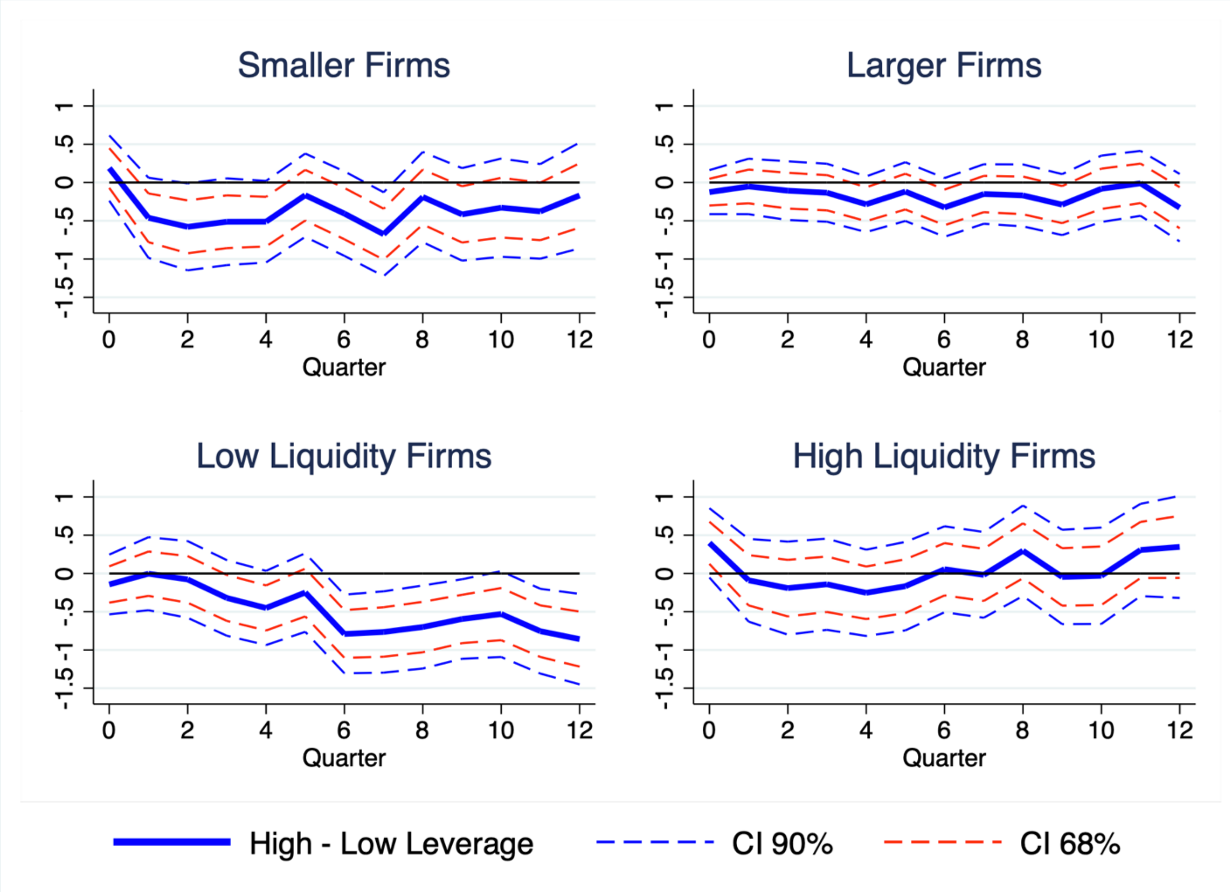
Note: Y-axis in percent. This exercise separates firms into groups along two dimensions: leverage (low/medium/high) and export dependence (low/medium/high). The results follow from the estimation of Equation (3) using log change in revenues. In the upper row, the solid blue line represents the differential impulse responses between the high and low leverage groups within firms with high (upper-left panel) and low (upper-right panel) export dependence. In the lower row, the solid blue line represents the differential impulse responses between the high and low export dependence groups among firms with high (lower-left panel) and low (lower-right panel) leverage. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.10. Foreign-Currency Liability Ratio and Export Dependence (Revenue)



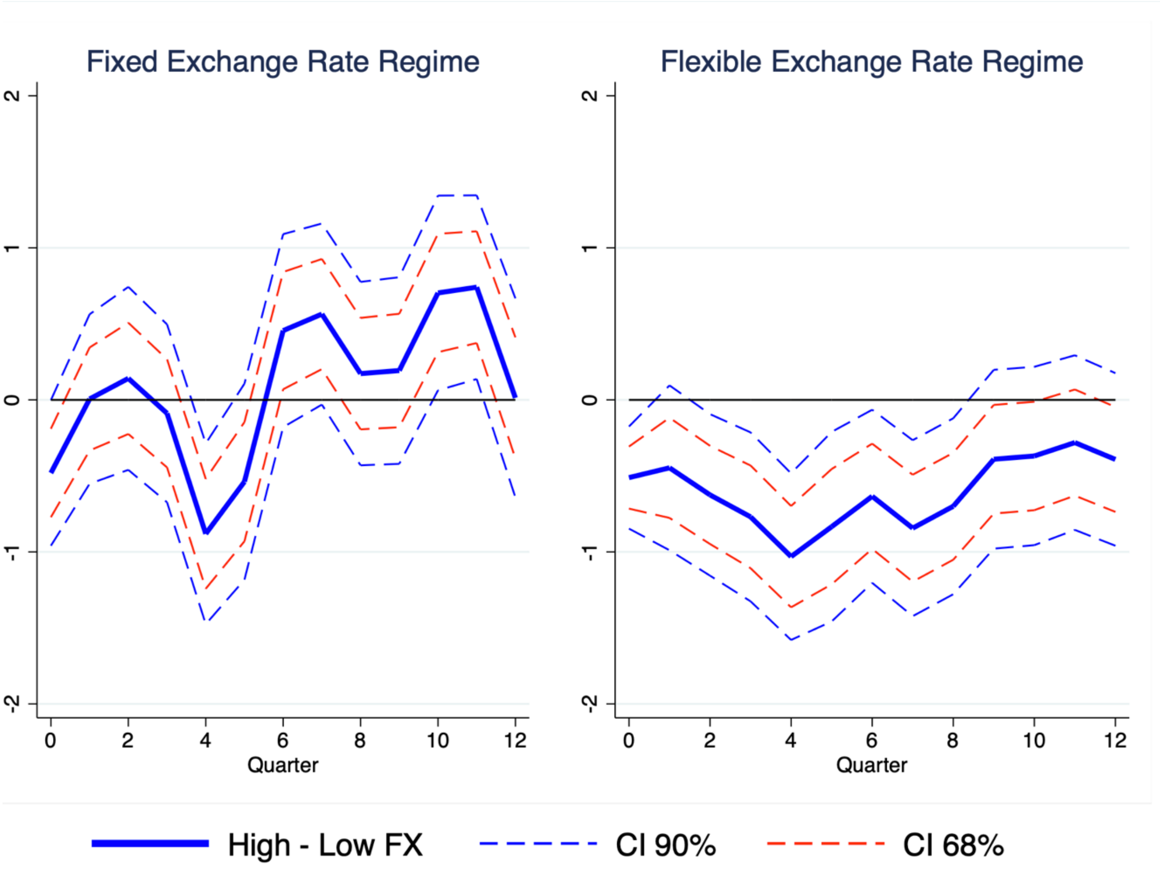
Note: Y-axis in percent. This exercise separates firms into groups along two dimensions: foreign-currency liability ratio (low/medium/high) and export dependence (low/medium/high). The results follow from the estimation of Equation (3) using log change in revenues. In the upper row, the solid blue line represents the differential impulse responses between the high and low FX liability ratio groups within firms with high (upper-left panel) and low (upper-right panel) export dependence. In the lower row, the solid blue line represents the differential impulse responses between the high and low export dependence groups among firms with high (lower-left panel) and low (lower-right panel) foreign-currency liability ratio. The dashed blue and red lines display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.11. Leverage and Size and Liquidity



Note: Y-axis in percent. This exercise separates firms into groups with two criteria: low/medium/high leverage and low/medium/high size (upper row) or liquidity (lower row) of the firms. The results follow from the estimation of Equation (3). In the upper row, the solid blue lines represent the differential impulse responses between the high and low leverage groups within smaller (upper-left panel) and larger (upper-right panel) firms. In the lower row, the solid blue lines represent the differential impulse responses between the high and low leverage groups among low (lower-left panel) and high (lower-right panel) liquidity firms. The dashed blue and red line display the 90% and 68% confidence intervals. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Figure A4.12. Foreign-Currency Liability Ratio and Exchange Rate Regime



Note: Y-axis in percent. Results follow from the estimation of Equation (3). Firms are assigned into groups along two dimensions: the foreign-currency liability ratio of the firms and the exchange rate regime of the country that they operate in. Information on country exchange rate arrangements is from the IMF ARAER Database. The solid blue lines display the differential impulse responses between firms with high and low foreign-currency liability ratio within countries with fixed and flexible exchange rate regimes. The dashed blue and red lines display the 90% and 68% confidence intervals. This exercise uses only country-time fixed effects. We also control for time-varying firm characteristics (leverage, liquidity, size, collateral). The standard errors are clustered on firms.

Table A4.1. Back-of-the-Envelope Calculations (Revenue)

	Unconditional	Leverage	Foreign-Currency Liability Ratio	Export Dependence
Cumulative Responses	-3.77	-0.25	-1.74	-2.99
Capital Expenditure Share of High Group		27.9%	19.8%	17.1%
Contribution to the Average Response $\left(\omega_1 \frac{\partial K_t^1}{\partial i_t^{US}}\right) / \left(\frac{\partial K_t}{\partial i_t^{US}}\right)$		1.8%	9.2%	13.5%

Note: We use the estimation results from Equation (4). The cumulative responses are the sum of the impulse responses over 12 quarters. The "Unconditional" column refers to the estimation from Equation (1).

PUBLICATIONS

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