Prices and Monetary Policy: The Role of Financial Constraints*

Michael Bauer Alexander Czarnota Mathias Klein

March 19, 2026

Abstract

How does firm heterogeneity in financial constraints shape the transmission of monetary policy to prices and inflation? Using detailed microdata on Swedish firms and high-frequency monetary policy surprises for the Riksbank, we document a pronounced heterogeneity: Smaller, financially constrained firms adjust prices significantly less than larger firms in response to changes in monetary policy. This result is consistent with models of customer markets and financial frictions: Because the external finance premium rises after a monetary contraction, constrained firms lower prices less to maintain cash flows, resulting in a loss of market share. Additional evidence supports this channel. After a monetary policy shock, smaller firms exhibit a more negative response of their sales. They also have a higher share of bank debt, and their debt is significantly more responsive to monetary policy. Further evidence shows that alternative channels like the working capital channel or differences in marginal costs cannot explain the differential price response of small and large firms. Our results demonstrate that financial constraints significantly weaken the transmission of monetary policy to inflation and imply that the strength and distribution of financial constraints across firms is a key determinant of policy effectiveness.

Keywords: inflation, monetary transmission, firm heterogeneity, financial frictions.
JEL: E31, E32, E52, G32, L11.

*Bauer: Federal Reserve Bank of San Francisco and CEPR. Czarnota and Klein: Sveriges Riksbank. We thank Nils Gottfries, Christoph Hedtrich, Raphael Schoenle, Karl Walentin, Gabriel Züllig (discussant), Erik Öberg, and seminar participants at Stanford University Macro Lunch, Sveriges Riksbank, and Uppsala University for helpful comments. The views expressed here are those of the authors and do not necessarily reflect the views of others in the Federal Reserve System or the Riksbank.

1 Introduction

The ability of monetary policy to affect and control inflation has shifted into focus again after the recent global inflationary episode of 2021–2023. A thorough understanding of monetary transmission requires detailed micro-level empirical analysis, and a growing body of evidence has shed light on how individual firms respond to monetary policy changes. Given the pronounced heterogeneity in financial positions across firms, the role of financial constraints for heterogeneous effects of monetary policy has been of great interest in the macro-finance literature. Yet while the role of financial constraints has been studied extensively for the firm-level response of investment, employment, sales, and other outcomes, little is known about how they affect the price-setting of firms.[1] Understanding the role of financial constraints for price-setting is important because it bears directly on the effectiveness of monetary policy in controlling inflation and on the trade-off between price and output stabilization. This paper fills this gap by providing the first evidence that financial constraints dampen firm-level price responses to monetary policy, using detailed microdata and high-frequency monetary policy surprises from Sweden.

For estimating the effects of monetary policy on firm-level prices, we follow the monetary economics literature on high-frequency identification (e.g., Gürkaynak et al., 2005; Bauer and Swanson, 2023a). We measure the surprise component of Swedish monetary policy as changes in short-term interest rates around Riksbank monetary policy announcements. We validate our Riksbank surprises by establishing baseline results and connecting with the earlier literature in two different ways. First, we employ event-study regressions to estimate the effects of Swedish monetary policy on financial asset prices. Second, we estimate the dynamic effects on aggregate macroeconomic variables using Jordà (2005) local projections. Both exercises yield responses that are in line with the textbook prediction and standard empirical estimates: A surprise monetary policy tightening leads to an increase in interest rates across maturities, an appreciation of the Swedish currency, and a persistent decline in aggregate demand and prices over time.

To investigate the price responses of Swedish firms to monetary policy changes, we construct a comprehensive product- and firm-level panel data set that combines the microdata underlying the official Swedish Producer Price Index (PPI) with financial statements from

[1] Existing papers have studied the role of financial constraints for the transmission of monetary policy to firm-level investment (Ottonello and Winberry, 2020; Caglio et al., 2021; Durante et al., 2022; Cloyne et al., 2023; Jeenas, 2025; Jungherr et al., 2024), borrowing behavior (Oliner and Rudebusch, 1996), employment (Bahaj et al., 2022), sales (Gertler and Gilchrist, 1994) and stock prices (Ippolito et al., 2018; Ozdagli, 2017; Ozdagli and Velikov, 2020; Gürkaynak et al., 2022), among other outcome variables. Studies of the role of financial constraints for the price-setting of firms, such as Gilchrist et al. (2017) and Renkin and Züllig (2024), generally focus on financial shocks and the Great Financial Crisis.

a large number of firms. The price data are the product-level producer prices in the PPI, based on a representative sample of products within the manufacturing sector constructed by Statistics Sweden (SCB). The data cover the period from 2001 to 2023 and contain close to 340,000 month-product price observations from almost 4,400 unique products, produced by about 2,200 unique firms. We carefully validate our micro-level price data. A comparison of the inflation rates constructed from our product-level prices to aggregate PPI inflation shows that neither the sample selection nor the different weighting schemes (equal-weighted vs. sales-weighted) cause any material discrepancy for aggregate inflation rates. The dynamic response of inflation to a monetary policy shock is negative and hump-shaped, with a peak effect after around the two year horizon. The impulse responses look broadly similar for panel regressions with pooled product-level data and time series regressions with aggregate PPI inflation data for the manufacturing sector, both in terms of magnitude and persistence.

We leverage the institutional setting in Sweden and use unique firm-level data to match the product prices to data for both firm financials and sales. Our extensive firm data set—from the Swedish credit bureau and the Swedish Companies Registration Office—not only provides detailed information about the firms but also uniquely identifies them, enabling us to precisely match firms across different data sources. We merge the product-level price data with yearly firm-level financials to construct commonly-used measures of financial constraints: size, age, leverage, and liquidity. The firm-level data covers a large portion of the universe of Swedish firms including, crucially, privately held firms. This is a key advantage over studies that rely on Compustat data of public firms. Private firms tend to be smaller, more reliant on bank financing, and more likely to face binding financial constraints, with important implications for their response to monetary policy (Caglio et al., 2021). Given the monthly frequency of the pricing data, we can study the dynamic price responses to monetary policy and link the pricing behavior to measures of financial constraints.

Our main analysis provides cross-sectional evidence on the role of financial constraints in the transmission of monetary policy to prices. We estimate panel local projections for the response of product-level prices to monetary policy shocks, conditional on commonly used measures of financial constraints. Our central result is a heterogeneous price response depending on firm size: smaller firms exhibit a significantly less negative price response to changes in monetary policy. The firm-level heterogeneity is both statistically and economically highly significant. In response to a 25 basis point tightening surprise, firms that are one standard deviation smaller than the mean firm lower prices by 1.3 percentage points less, compared to the average firm. This difference is quantitatively meaningful in light of the average price decline of 2.7 percent at the trough. Splitting the price observations into quartiles based on the size of the producing firms and comparing the response of the top

and bottom quartile, we find that the price responsiveness of larger firms is roughly twice the magnitude as for smaller firms.

In addition to size, we also condition the price response on other common measures of financial constraints—age, leverage and liquidity—but find no meaningful heterogeneity for these other measures. In fact, the signs of the estimated interactions are generally inconsistent with the heterogeneity predictions of theories of financial constraints. These estimates suggest that size is the best available proxy for financial constraints in the context of heterogeneous monetary transmission to prices. This important empirical role of size is consistent with earlier literature on financial constraints (Gertler and Gilchrist, 1994; Oliner and Rudebusch, 1996; Hadlock and Pierce, 2010).

Our results survive a battery of robustness checks. In particular, they are robust to including more narrowly defined sector-by-time fixed effects, estimating a non-linear interaction between the measures of financial constraints and the monetary policy surprises, and excluding the recent high inflation period by ending the sample in December 2020. Given recent interest in the working capital channel, we also control for firms' working capital to capture potentially different effects on marginal costs, and we find the role of firm size unaffected.

The muted price response of smaller firms to monetary policy shocks that we document in this paper is consistent with theoretical models of customer markets and financial frictions as in Gottfries (1991), Chevalier and Scharfstein (1996), and Gilchrist et al. (2017). In models with customer markets, the customer base for a given product is sticky, for example, due to deep habits or search frictions. By setting a lower price today, firms can increase their market shares and, consequently, future profits at the expense of lower profits today. Financial frictions, on the other hand, create a trade-off between investing in the customer base and maintaining current cash flows to minimize the reliance on costly external finance. As shown by, e.g., Gertler and Karadi (2015) using aggregate data and Anderson and Cesa-Bianchi (2024) using firm-level data, the credit spread increases following a monetary policy tightening, consistent with the borrowing cost of constrained firms being more responsive to changes in monetary policy and hence why smaller firms adjust prices less. Intuitively, a monetary contraction reduces the ability of smaller, more constrained firms to invest into their customer base, so they cannot lower their prices as much as large firms. The theory predicts that as a consequence, these firms lose market share and see a decline in future sales.

In support of this theoretical explanation based on customer markets and financial frictions, we provide several additional pieces of evidence. While smaller firms lower prices less in response to contractionary policy, their sales indeed fall by more than the sales of larger

firms. This is the most direct evidence in support of the view that financial constraints cause smaller firms to make pricing decisions that lead to a loss of customer base, market share, and future revenues. The small firms in our data also tend to have a higher share of bank debt and adjust debt significantly more in response to changes in monetary policy, consistent with the existence of a substantive external finance premium.

We also consider alternative potential explanations of our main heterogeneity result. According to the working capital channel of Christiano and Eichenbaum (1992) and Christiano et al. (2015), differences in working capital can lead to heterogeneous effects of monetary policy across firms. If small firms rely more heavily on working capital financing, then this could explain their muted price response—but through a mechanism unrelated to financial constraints or customer markets. We investigate this possibility empirically and find no evidence for the working capital channel in our data. More generally, differences in cost structures and production processes could explain differential price responses. But additional estimates show that marginal costs of smaller firms are actually more responsive to monetary policy than for larger firms. This heterogeneity in the cost sensitivity is the opposite of what would be needed to explain the muted price effects of smaller firms. That is, we find no support for this alternative explanation. Instead, the marginal cost response indicates that smaller firms reduce their markups by less, or may even increase them, in response to tighter policy, consistent with models of financial frictions and differential investments into the customer base.

Our paper makes two main contributions to the empirical literature in monetary economics. First, previous studies, including Gilchrist et al. (2017) and Renkin and Züllig (2024), have documented that financially constrained firms set relatively higher prices than unconstrained firms following financial shocks, such as the credit crunch of the Great Financial Crisis. Our evidence is directionally consistent with this pattern and demonstrates that this type of heterogeneity is not confined to episodes of large financial distortions. Instead, financial constraints appear to play a role for price setting and inflation determination as part of standard monetary transmission.

Second, while previous studies have generally found that financial constraints *amplify* the firm-level investment response to monetary policy, we document the opposite for prices: financial constraints *dampen* the price response. This result has important implications for monetary transmission to inflation. Most importantly, it implies that financial constraints impede the effectiveness of monetary transmission to inflation, because the price response of constrained firms is significantly muted. Because they magnify the investment response but mute the inflation response, financial constraints also influence the monetary policy trade-off between price and output stabilization. Both the impediment to monetary policy

effectiveness and the impact on the output-inflation trade-off are likely exacerbated during times of financial distress, when the external finance premium rises and financial constraints become more severe.[2]

Our paper is related to a large literature on the role of financial frictions in the transmission of monetary policy. Several influential papers have shown that the proxies of financial frictions at the firm level—including age (Cloyne et al., 2023), leverage (Ottonello and Winberry, 2020; Durante et al., 2022), debt structure (Jungherr et al., 2024), and liquidity (Jeenas, 2025)—are related to the strength of the firm-level investment response to monetary policy. These papers generally find that more constrained firms adjust their investments relatively *more* compared to less constrained firms in response to changes in monetary policy.[3] Other related work has studied the heterogeneous effects of monetary policy on employment, debt, and stock prices (see earlier references). We extend this literature in a new direction by changing the focus to the differential price response. To the best of our knowledge, our paper is the first to document the more muted price response of constrained firms to monetary policy that is in line with theoretical models of financial constraints and customer markets.[4]

Our paper is also related to the growing literature that studies the role of financial constraints in influencing prices and price-setting behavior. The most closely related is Gilchrist et al. (2017), who study the response of pricing decisions by publicly listed U.S. firms to the credit crunch during the Great Financial Crisis (GFC). Their main finding is that companies with high liquidity were able to lower prices in response to the credit shock, while low liquidity firms actually raised their prices. Renkin and Züllig (2024) study the price-setting behavior of Danish manufacturing firms during the GFC. Using product-level price data merged with data on bank lending relationships, they show that firms that borrowed from banks that were more severely affected by the GFC experienced a relatively larger fall in loan supply and set relatively higher prices. Antoun de Almeida (2015) and Gilchrist et al. (2023) document a similar role for financial frictions in shaping inflation dynamics in the euro area during the GFC.[5] Gilchrist and Zakrajsek (2016) show that financial frictions

[2]Note that this channel is not present in conventional monetary models with financial frictions, e.g., Bernanke et al. (1999), where the direct effect of changes in the cost of external finance only affects investment.

[3]A notable exception is Ottonello and Winberry (2020), who find that the investment of financially constrained firms is less responsive to monetary policy. They argue that the difference between their results and, e.g., Jeenas (2025) is mainly driven by the fact that they consider within-firm changes in financial constraints over time, while he compares permanent differences across firms.

[4]Kim and Park (2024) find that firms with higher levels of short-term debt exhibit a stronger price response to a credit shock or change in monetary policy, in contrast with our results. Core et al. (2025) show that firms with a higher share of floating rate debt keep prices more elevated in response to the ECB's tightening over the period from 2021 to 2023.

[5]Additional evidence that is consistent with models of customer markets and financial frictions is provided by Chevalier and Scharfstein (1995), Duca et al. (2017), and Montero and Urtasun (2021), who show that sectors/firms that are more financially constrained raise markups more in response to a fall in aggregate

also influence the price-setting response to other financial shocks outside of the GFC, using data on credit spreads and the size-age measure of financial constraints proposed by Hadlock and Pierce (2010). Our results extend this evidence in an important direction: Financial constraints shape firms' pricing responses not only during episodes of financial distress and financial shocks, but also as part of standard monetary transmission.

The rest of the paper is structured as follows. Section 2 describes the construction of our Riksbank monetary policy surprises and empirically evaluates the effect of the surprises on Swedish financial markets and macroeconomic variables. Section 3 describes our microdata set, presents our new estimates of the effects of Riksbank monetary policy surprises on product-level producer prices, and documents our key result on the role of firm size in the heterogeneous price-setting response. Section 4 spells out a theoretical explanation of our main results that relies on financial constraints, based on a model of customer markets and financial frictions, and then provides additional empirical evidence in favor of size as a proxy for financial constraints. Section 5 concludes.

2 Riksbank policy surprises and aggregate effects

In this section, we present a new measure of monetary policy surprises for Sweden based on rate changes around Riksbank policy announcements. We then use this measure to estimate the response of asset prices and macroeconomic aggregates to unexpected changes in the Riksbank's monetary policy.

2.1 Construction of monetary policy surprises

Our analysis focuses on the Riksbank's monetary policy over the period from January 2001 to December 2023. During this period, Swedish monetary policy has been characterized by an official 2 percent inflation target and a flexible exchange rate regime. The Executive Board of the Riksbank meets at regular intervals to decide on monetary policy and announces its decision on the day after each meeting. The decision includes a numerical value for the Riksbank policy rate, which serves as a target for rates on overnight interbank lending and directly impacts other short-term interest rates, including repo rates. The number of scheduled meetings has varied between five and eight per year during our sample period, and our sample contains a total of 149 Riksbank announcements.

Following Kuttner (2001) and Gürkaynak et al. (2005), we estimate exogenous variation in Swedish monetary policy using high-frequency changes in interest rates around monetary

demand.

policy announcements. Intuitively, these changes reflect new information about the current stance and future course of monetary policy and can therefore be viewed as orthogonal to current economic conditions. Specifically, we measure monetary policy surprises as daily changes in the closing price of Forward Rate Agreement (FRA) contracts on monetary policy announcement dates. FRA contracts are tied to short-term interest rates, and therefore reflect market-based expectations of future Riksbank policy rates.[6] That is, changes in FRA rates capture the surprise about both the current and future policy rate as a result of the Riksbank's policy announcements.

Previous studies of Swedish monetary policy include Fransson and Tysklind (2016) and Iversen and Tysklind (2017), who estimated the effects on asset prices, Laséen (2020) and Almerud et al. (2024), who estimated macroeconomic effects using VARs, and Amberg et al. (2022), who documented distributional income effects. These studies also relied on high-frequency changes in interest rates around Riksbank announcements, but generally used changes in swap rates that settle on the Tomorrow/Next STIBOR rate. The advantage of using FRA contracts is that they are available farther back in time, allowing us to start our sample in 2001, several years earlier than other studies.[7]

The construction of our monetary policy surprise closely follows the approach of related work for the U.S., including Nakamura and Steinsson (2018), Bauer and Swanson (2023a), and Acosta et al. (2025). We compute the surprises as the first principal component of daily changes in FRA contracts with maturities of three, six, nine, and twelve months ahead (FRA1-FRA4) on announcement days. Finally, we rescale the principal component so that a one-unit change corresponds to a 1 percentage point change in the FRA4 rate. The standard deviation of the resulting surprise measure is 7.38 basis points. The announcement-level surprises are shown in Figure A.1 in Appendix A. Riksbank announcements caused sizable surprises in policy rate expectations, including during the period from October 2014 to May 2022 when the policy rate was at or below the zero lower bound.

[6] More specifically, FRA contracts offer cash settlement of the difference between the ex-ante agreed-upon fixed rate and the actual rate of the three-month Stockholm Interbank Offered Rate (STIBOR) on the settlement day. STIBOR, in turn, is a reference rate that shows the average interest rate at which a number of active banks on the Swedish money market are willing to lend to one another, without collateral, at different maturities. Given the close relationship between STIBOR and other short-term rates, changes in FRA rates on monetary policy announcement days are useful proxies for changes in the expected future policy rate.

[7] A third alternative would be to use high-frequency surprises in Riksbank (RIBA) futures, which have the policy rate as the underlying rate. However, these contracts were introduced in 2009.

2.2 Financial market effects

Using our new high-frequency Riksbank surprises, we carry out an event-study analysis of the effects of monetary policy on Swedish financial markets. This analysis mainly serves as an empirical validation of the newly constructed policy surprises in a familiar empirical setting similar to, e.g., Kuttner (2001) and Gürkaynak et al. (2005). To this end, we estimate the following event-study regression

$$\Delta y_t = \alpha + \beta mps_t + u_t, \tag{1}$$

where t indexes days with Riksbank announcements, Δy_t is the daily change or return in a given interest rate, exchange rate, or stock market index on announcement days, and mps_t is the monetary policy surprise. We estimate equation (1) for the change in the three-month, two-year, and ten-year government bond yields, the two- and five-year mortgage bond rates, the log-return in the EUR/SEK and USD/SEK exchange rates, as well as the trade-weighted KIX/SEK exchange rate[8], and the log-return of the OMXSPI and OMXS30 stock market indices.

Table 1 shows the results of the event-study regression. Panel (a) shows the interest rate responses to a one-unit (100 bp) unexpected tightening of monetary policy. All interest rates respond strongly, with coefficients between 0.50 and 0.91 that are significant at the 1-percent level and R^2 values between 0.38 and 0.79. Panel (b) shows that, in line with the standard theoretical prediction of the uncovered interest rate parity, the same 100 bp surprise leads to an appreciation of the SEK—as indicated by the negative coefficients—against the euro, the dollar, and the KIX currency basket of generally around 3 percent. All three responses are significant at the 1-percent level. The R^2 values are lower compared to the interest rate regressions, ranging from 0.13 to 0.22. These large and significant responses of interest rates and exchange rates are similar to those documented in the previous literature, including Fransson and Tysklind (2016) and Iversen and Tysklind (2017) for Sweden, Altavilla et al. (2019) for the euro area, Kuttner (2001), Gürkaynak et al. (2005), Faust et al. (2007), and Bauer and Swanson (2023a) for the U.S.

Contrary to the standard prediction, the stock market indices increase significantly following a surprise tightening, as evident from panel (b) of Table 1. However, the coefficients are only significant at the 10-percent level and the R^2 values are low.[9] Iversen and Tysklind (2017) also find a positive but statistically insignificant Swedish stock market response to

[8]The KIX/SEK exchange rate is the trade-weighted price of a basket of foreign currencies in Swedish kronor, where the basket comprises Sweden's 32 most important trade partners.

[9]Figure B.1 in Appendix B shows that the significant increase is short-lived and that the cumulative change in the stock market indices becomes negative around 15 days after the shock.

Table 1: Financial Market Response to Monetary Policy Surprises

(a) Interest Rates

	3m yield	2yr yield	10yr yield	2yr mrtg. bond rate	5yr mrtg. bond rate
β	0.63***	0.82***	0.50***	0.91***	0.73***
	(0.11)	(0.08)	(0.09)	(0.08)	(0.08)
R^2	0.46	0.75	0.38	0.79	0.68

(b) Exchange Rates and Stock Market Indices

	EUR/SEK	USD/SEK	KIX/SEK	OMXSPI	OMXS30
β	-2.88***	-3.31***	-2.68***	3.68*	4.31*
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
R^2	0.22	0.13	0.21	0.04	0.05

Notes: Estimated coefficients β and regression R^2 from high-frequency event-study regressions $\Delta y_t = \alpha + \beta mps_t + u_t$, where Δy_t is the daily change in a given asset return, exchange rate, or interest rate on monetary policy announcement days and mps_t is the estimated monetary policy surprise. Exchange rates are expressed as units of SEK per unit of foreign currency (or currency basket), so a negative coefficient indicates SEK appreciation. Heteroskedasticity-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sample period: 2001:1 to 2023:12. See text for details.

Riksbank surprises, and there are some institutional reasons to expect a different market response in Sweden than in the U.S.[10]

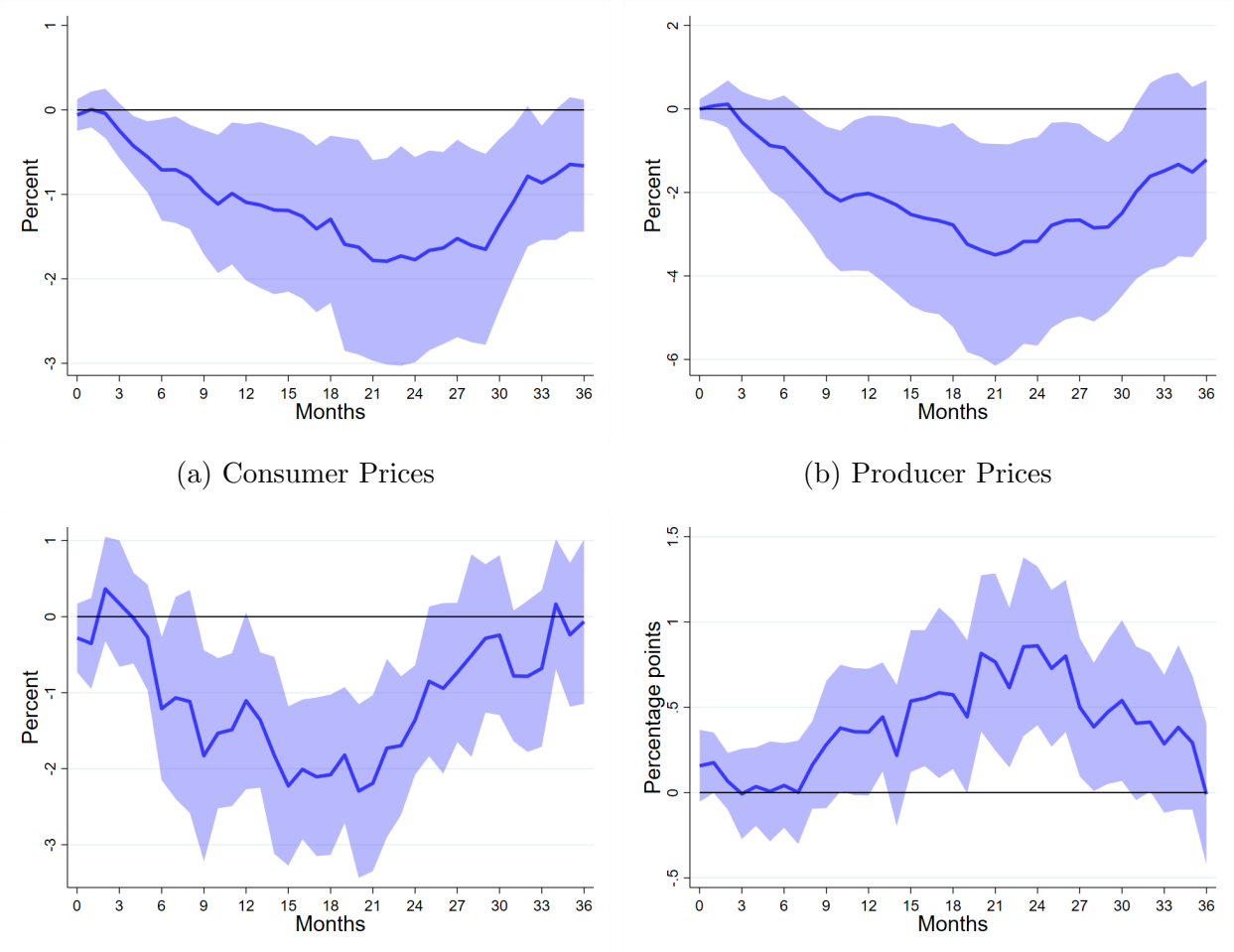
2.3 Macroeconomic effects

To further validate our measured surprises, we estimate the effect on monthly macroeconomic variables. We start by converting the daily surprises to a monthly series by summing the surprises that took place each month. We then estimate the following Jordà (2005) local projections:

$$\Delta_h Y_{t+h} = \alpha_h + \beta_h mps_t + \Gamma_h' X_{t-1} + u_{t+h}, \tag{2}$$

where $h = 0, ..., 36$ indexes the horizon of the impulse response function, $\Delta_h Y_{t+h} = Y_{t+h} - Y_{t-1}$ is the cumulative change, or "long difference", in the outcome variable Y_t. We estimate equation (2) for four different outcome variables: consumer prices with fixed interest rate

[10] As argued by Almerud et al. (2024), the Swedish stock market is heavily influenced by a number of large multinational corporations that derive most of their revenues from markets outside Sweden. It is therefore not obvious that the strong negative relationship between monetary policy and stock prices estimated on U.S. data by, e.g., Bernanke and Kuttner (2005) and Bauer and Swanson (2023a) and the somewhat weaker yet negative relationship estimated by Altavilla et al. (2019) for the euro area would be present in the Swedish data as well.



(a) Consumer Prices

(b) Producer Prices

(c) Monthly GDP Indicator

(d) Unemployment Rate

Figure 1: Impulse response functions of monthly macro variables.
Notes: Solid lines report point estimates from the local projections in equation (2) to a 25 bp unexpected tightening of monetary policy. Shaded regions report 90% confidence bands based on Newey-West standard errors with $h+1$ lags.

(CPIF), producer prices in the manufacturing sector (PPI), SCB's monthly GDP indicator (GDP), and the unemployment rate. We use log-levels for all variables other than the unemployment rate. Here mps_t denotes the monthly monetary policy surprise and X_{t-1} is a vector of controls, which includes 12 lags of the log of CPIF, GDP, Bloomberg commodity price index, the KIX/SEK exchange rate, and the OMXSPI stock market index.[11] We follow common practice and calculate Newey-West standard errors with $h+1$ lags.

Figure 1 shows the impulse response functions to a 25 bp unexpected tightening of monetary policy. The solid lines report point estimates and the shaded regions report 90 percent

[11]The purpose of the aggregate lagged controls is to remove any ex-post predictability of the surprises. As shown by Bauer and Swanson (2023a,b), monetary surprises can be ex-post predictable due to private learning about the central bank's unobserved and time-varying policy rule.

confidence bands. The tightening leads to a fall in prices and output and an increase in the unemployment rate. All variables display a typical hump-shaped response. These results are in line with the VAR estimates for Sweden by Laséen (2020) and Almerud et al. (2024) as well as VAR evidence from other countries/regions, including Gertler and Karadi (2015), Jarociński and Karadi (2020), and Bauer and Swanson (2023a) for the U.S. and Jarociński and Karadi (2020) for the euro area.

One important issue with high-frequency identification of monetary transmission is that monetary policy surprises may reflect not only exogenous policy shocks but also central bank information effects (Jarociński and Karadi, 2020) or differences between the perceived and actual policy reaction function (Bauer and Swanson, 2023b,a). In the presence of such additional drivers, monetary policy surprises can end up being correlated with non-policy shocks and predictable based on information observable before policy announcements, causing an omitted variable bias. In additional, unreported analysis we have investigated this issue, and found that indeed our Riksbank surprises are correlated with a similar set of predictors as documented by Bauer and Swanson (2023a) for the case of the US. However, when we follow the usual recommendation to orthogonalize the surprises, we found no material differences in the estimated impulse responses. While this issue may deserve some further investigation, it does not seem to be a first-order problem for the case of Sweden.

In summary, our new high-frequency Riksbank surprises generate responses of asset prices and macroeconomic variables that are generally in line with textbook predictions and previous empirical findings.

3 The heterogeneous response of firm-level prices

Having constructed a new measure of monetary policy surprises for Sweden and verified its empirical effect on aggregate variables, we now turn to the response of product-level prices and the role of firm fundamentals. Our goal is to estimate the role of financial constraints in the transmission of monetary policy to prices.

3.1 Product- and firm-level data

The data set for our main analysis is constructed from detailed data on producer prices merged with firm-level administrative data. A key advantage of our data is its breadth: Our sample covers a large and representative set of manufacturing firms, including the many private firms that are absent from publicly traded samples.

For the price data, we obtained the microdata underlying the official Swedish Producer

Price Index (*Prisindex i producent- och importled, PPI*) maintained by SCB. The PPI data consist of monthly product-level prices for a representative sample of products produced by Swedish firms. Sampled firms are asked to report the average transaction price of a representative product they sell within a narrowly defined product code, given by the 8-digit Combined Nomenclature (CN) classification, and are required by law to respond.[12] We use the PPI data for products within the manufacturing sector sold on the domestic market for a sample period from January 2001 to December 2023. As for other developed economies, manufacturing is a major part of the Swedish economy, accounting for 60 percent of goods production and 15 percent of Sweden's GDP, on average, over the sample period.

Swedish firms, whether publicly traded or privately held, are generally required to report their financials to public agencies that maintain detailed data records.[13] This allows us to match the product-level price data to a comprehensive data set of firm financials, including public and private Swedish firms. We can therefore merge the PPI data with yearly firm-level balance sheet and income statement data obtained from the credit bureau Upplysningscentralen (UC) and firms' registration year obtained from the Swedish Companies Registration Office (*Bolagsverket*). From these two data sets, we construct the firm characteristics relevant to our analysis.

A notable advantage of the Swedish firm data is that firms are uniquely identified with a firm ID, allowing us to accurately match price data to firm financials. Related analysis using price data for U.S. firms, by contrast, typically has to rely on fuzzy matching algorithms based on firm names (e.g., Gilchrist et al., 2017).

We measure financial constraints with four different commonly used proxies: size, age, leverage, and liquidity. Following the usual definitions (see, e.g., Cloyne et al., 2023), we define size as the log of total assets, age as the number of years since registration, leverage as the sum of short- and long-term debt over total assets, and liquidity as the sum of cash and short-term investments over total assets.

Other controls are constructed following standard methods, for example, sales growth is the yearly change in log total sales. We apply several standard filters to reduce the noise in our data.[14] Our final data set consists of 4,401 unique products produced by 2,190 unique

[12] An example of an 8-digit CN code is 40114000 "New pneumatic tyres, of rubber, of a kind used for motorcycles".

[13] More specifically, this reporting requirement applies to "limited companies" (aktiebolag), which is the dominant corporate form in Sweden and encompasses both publicly and privately held firms. Other companies, such as partnerships or sole proprietorships, have lighter reporting requirements.

[14] We start by removing a few observations with non-positive total assets or total sales. To match the length of the impulse responses, we also remove products that are observed for less than 36 months. Finally, we winsorize the cumulative log price changes, size, age, leverage, liquidity, and sales growth at the 1 percent level to remove outliers.

firms.

Summary statistics of the resulting data set are shown in Appendix C. Table C.1 shows summary statistics for the monthly price changes and the yearly firm characteristics. Table C.2 compares the mean values of the firm characteristics of the firms in our final data set with those of the universe of Swedish firms. These values show that the average firm in our sample is larger, faster-growing, older and holds less liquid assets compared to the average Swedish firm. Since the composition of our sample is tilted towards larger firms, it is possible that our subsequent results may be understating the size heterogeneity in firm-level price responses to monetary policy.

3.2 Comparison with aggregate inflation series

Before investigating the heterogeneous price response across firms conditional on financial constraints, we validate our price data to ensure that it is representative of economy-wide price trends. First, we compare an aggregate inflation measure to average inflation rates based on our micro data. Figure C.1 plots the year-on-year inflation rates for the aggregate PPI for the manufacturing sector, as well as two year-on-year inflation series constructed from product-level prices. An unweighted inflation series is constructed as the simple arithmetic average of product-level inflation rates. In addition, a weighted series is constructed using the same method as the aggregate PPI (see Statistics Sweden (2023) for details). Both the weighted and unweighted series follow the official PPI inflation series quite closely, with correlations of 0.99 and 0.94, respectively.

Our second validation is a comparison of the aggregate inflation response, estimated using time series regressions, and the average product-level price response estimated using unweighted panel regressions. We estimate the average dynamic product-level price response to our monthly monetary policy surprises using the following panel data local projections:

$$\Delta_h ln(P_{i,t+h}) = \alpha_{i,h} + \alpha_{m,h} + \beta_h mps_t + \Gamma'_{1,h} X_{t-1} + \Gamma'_{2,h} Z_{j,t-1} + u_{i,t+h}, \tag{3}$$

where $\Delta_h ln(P_{i,t+h}) = ln(P_{i,t+h}) - ln(P_{i,t-1})$ is the cumulative change in the log price of product i, $\alpha_{i,h}$ are product i fixed effects that control for time-invariant differences in price setting across products, $\alpha_{m,h}$ are monthly dummies that control for seasonal variation in price setting, X_{t-1} is the same vector of aggregate controls used in equation (2), and $Z_{j,t-1}$ is a vector of firm-level controls, including previous year's size, sales growth, leverage and liquidity of producing firm j. Standard errors are clustered two-way at the firm and time levels.

Figure 2 shows the impulse response function of average product-level producer prices to

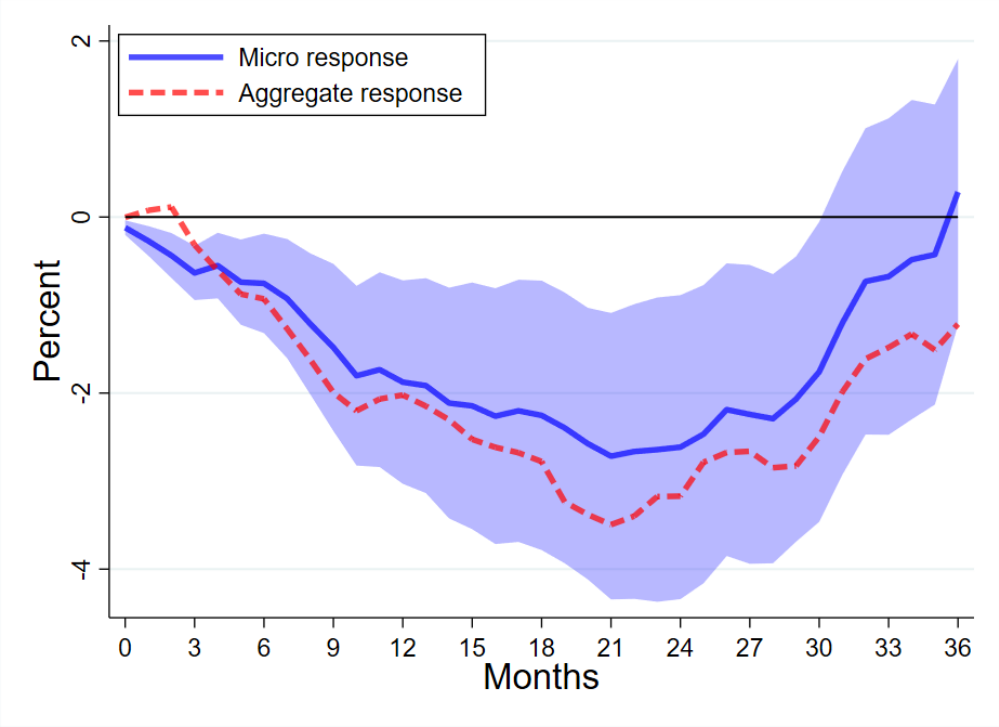


Figure 2: Impulse response functions of producer prices.
Notes: The blue solid line reports the point estimate of the average product-level price response from the panel local projection in equation (3) to a 25 bp unexpected tightening of monetary policy. The shaded region reports 90% confidence bands clustered two-way at the firm and time levels. The red dashed line shows the response of aggregate producer prices estimated using equation (2).

a 25 bp unexpected tightening of monetary policy. Prices fall significantly, reaching a trough of -2.7 percent after 21 months before reverting, displaying a typical hump-shaped response. The red dashed line shows the impulse response of the aggregate PPI from Figure 1. The two impulse responses are very similar, both in terms of magnitude and persistence.

Having confirmed that our microdata are representative of aggregate price dynamics, we now turn to the central question: does the price response to monetary policy differ systematically across firms with different financial positions?

3.3 Heterogeneity: linear interaction effects

Our key question about firm-level monetary transmission is whether the response of prices to changes in monetary policy depends on firms' financial positions. Theories of financial constraints and customer markets predict that after a monetary contraction, more constrained firms should adjust prices less, sacrificing market share to preserve cash flows. To test this, we interact our monetary policy surprises with measures of financial constraints in the panel local projection framework.

We estimate the following panel data local projections:

$$\Delta_h ln(P_{i,t+h}) = \alpha_{i,h} + \alpha_{t,h} + \beta_h(mps_t \times FC_{j,t-1}) + \Gamma_h' Z_{j,t-1} + u_{i,t+h}, \tag{4}$$

where the dependent variable is again the log price change for product i from t to $t+h$, the regression includes time fixed effects $\alpha_{t,h}$ that control for unobserved time-varying heterogeneity potentially related to monetary policy, $FC_{j,t-1}$ is a given measure of financial constraint for producing firm j, i.e., size, age, leverage, or liquidity[15], and $Z_{j,t-1}$ contains the same firm-level variables as in equation (3) as well as $FC_{j,t-1}$. Given the relatively short panel of yearly firm-level interaction variables, we cluster the standard errors one-way at the firm level when including time fixed effects (Petersen, 2009; Jordà, 2023).

To facilitate comparison, we standardize the measures of financial constraints so that the estimated interaction coefficients correspond to the differential price responses of firms one standard deviation above the mean. Moreover, we include the negative of size, age, and liquidity. In this way, the interaction coefficients correspond to firms one standard deviation smaller, younger, more leveraged, or less liquid compared to the mean. This is based on the results from the investment literature cited above, which show that these groups of firms behave as if they were more financially constrained.

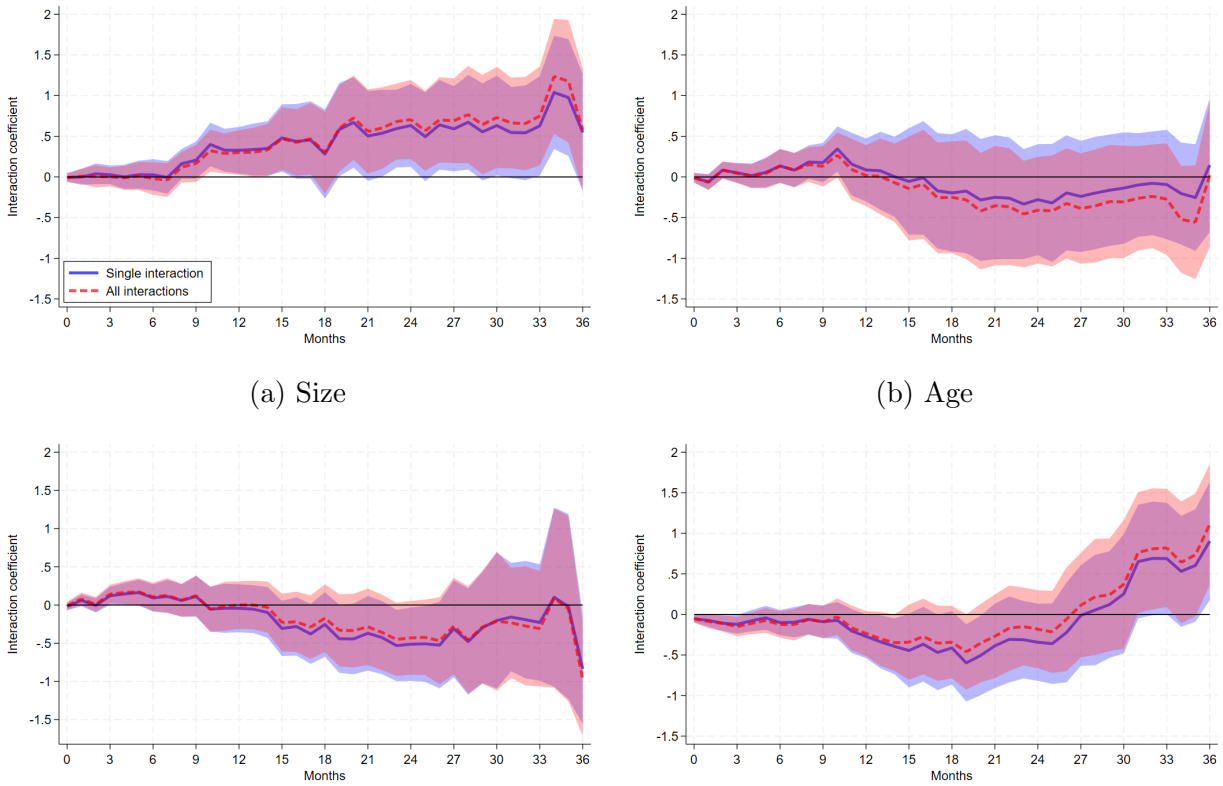
To account for the potential correlation between the measures and to test whether they have distinct and independent roles, we estimate the following version of the above specification, where we include the interaction between the monetary policy surprises and each measure together:

$$\begin{aligned} \Delta_h ln(P_{i,t+h}) = \alpha_{i,h} + \alpha_{t,h} - \beta_{1,h}(mps_t \times Size_{j,t-1}) - \beta_{2,h}(mps_t \times Age_{j,t-1}) \\ +\beta_{3,h}(mps_t \times Leverage_{j,t-1}) - \beta_{4,h}(mps_t \times Liquidity_{j,t-1}) + \Gamma_h' Z_{j,t-1} + u_{i,t+h}. \end{aligned} \tag{5}$$

Figure 3 shows how the response of prices to a 25 bp unexpected tightening of monetary policy varies across the size, age, leverage, and liquidity distributions. We plot the impulse response functions for both specifications: The blue solid lines show the response estimated using (4) with one interaction effect at a time, and the red dashed lines show the responses based on equation (5) when all interactions are jointly estimated.

The key result in Figure 3 is that a contractionary monetary policy shock causes smaller firms to reduce their prices by significantly less than larger firms. Panel (a) shows this significant difference in the price response across the size distribution. Focusing on the red

[15] We use the previous year's measure of size, age, leverage, and liquidity to ensure exogeneity with respect to the shock in period t.



(a) Size (b) Age

(c) Leverage (d) Liquidity

Figure 3: Differential price response of constrained firms to monetary policy shock.
Notes: Dynamics of the interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates when the interactions are estimated separately using the panel local projections in equation (4) and red dashed lines when they are estimated together using equation (5). Shaded regions report 90% confidence bands clustered at the firm level.

dashed line, we see that smaller firms lower prices significantly less for all but one period between the 10– and 35–month horizon.

In terms of magnitudes, firms that are one standard deviation smaller than the mean lower prices 0.6 percentage points less than the average firm at the 21–month horizon, which corresponds to the trough of the average response displayed in Figure 2. The peak differential response occurs at the 34–month horizon with a coefficient of 1.3. These differences are quantitatively meaningful, given the average price decline of 2.7 percent at the trough shown in Figure 2. That is, the price response of a firm with a size that is one standard deviation below the mean is muted by about 20-50%. Below, in Section 3.4, we provide further evidence on the magnitude of the differential price response of small and large firms.

In contrast, panels (b)-(d) show that there is no significant difference in the price response across the age, leverage, or liquidity distributions. The signs of the point estimates suggest

that firms with higher leverage and lower liquidity—more constrained firms—lower prices by *more* than other firms, in contrast to the predictions of theories of financial constraints.

3.4 Heterogeneity: semi-parametric estimates

Linear interaction effects based on firm characteristics impose strong parametric constraints on the possible patterns of heterogeneity. In the following, we investigate the heterogeneous price response without imposing this linearity assumption and instead estimate a "semi-parametric" specification similar to Cloyne et al. (2023). The basic idea is to group and compare the price observations for which the producing firms are most financially constrained to those that are least constrained.

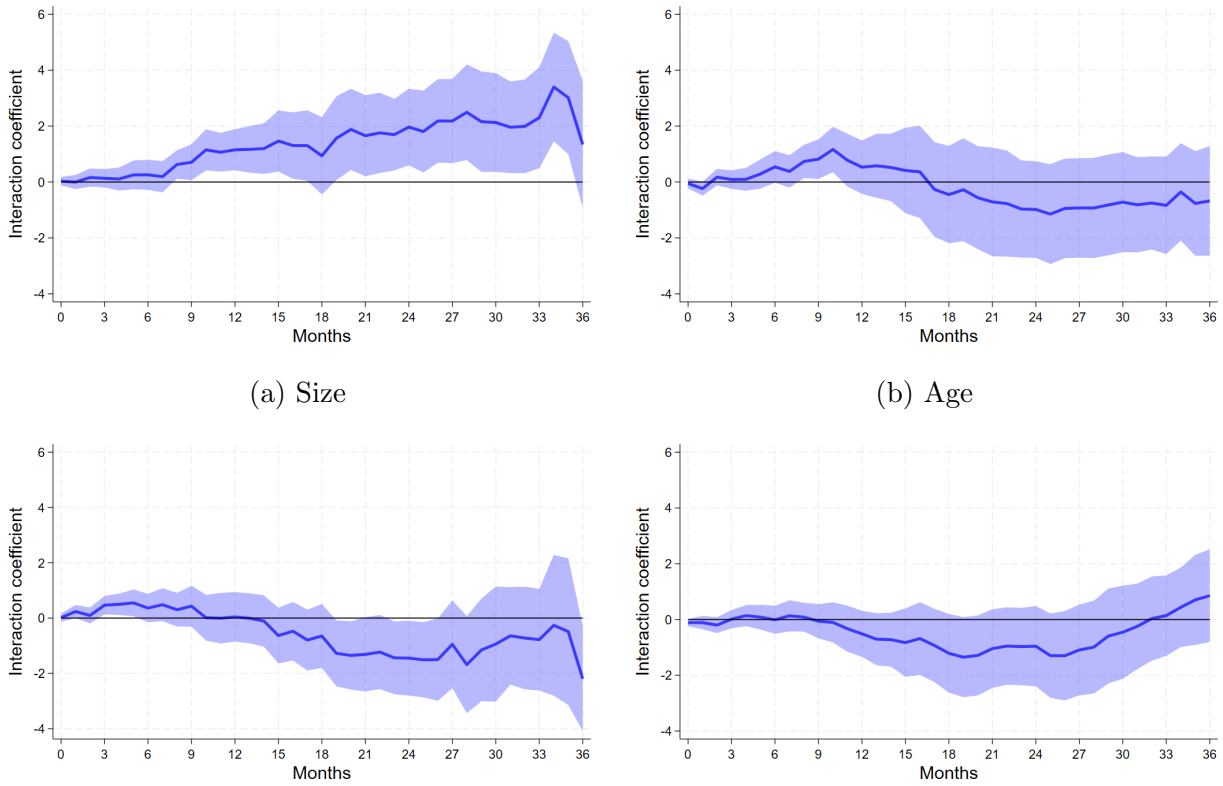
Specifically, we split the product-level price observations into *quartiles* based on the characteristics of the producing firm, and then compare the response of the top and bottom quartiles. As before, we consider the four most common proxies of financial constraints—size, age, leverage, and liquidity—as firm characteristics to condition the price response. We estimate the local projections

$$\Delta_h ln(P_{i,t+h}) = \alpha_{i,h} + \alpha_{t,h} + \beta_h(mps_t \times I^{FC}_{j,t-1}) + \Gamma'_h Z_{j,t-1} + u_{i,t+h}, \tag{6}$$

where $I^{FC}_{j,t-1}$ is an indicator variable that takes on the value one if a given proxy for financial constraints indicates that the firm is most constrained, i.e., belongs to the smallest, youngest, most leveraged, or least liquid firms. The indicator is zero for the quartile of prices set by the least constrained firms, and price observations in the middle two quartiles are excluded. The vector of lagged firm-level controls, $Z_{j,t-1}$, contains size, sales growth, leverage, liquidity, and $I^{FC}_{j,t-1}$. As before, the estimation includes product and time fixed effects.

Figure 4 shows the differential price response to a contractionary monetary policy shock between the top and bottom quartiles of prices split based on the size, age, leverage, or liquidity of the producing firm. As evident in Panel (a), these estimates confirm that the prices of products produced by small firms are significantly less responsive to monetary policy, that is, they remain relatively higher compared to the prices of larger firms. These semi-parametric estimates yield broadly similar empirical patterns for the differential dynamic price response as the earlier estimates using linear interaction effects. At the peak differential response, which occurs at the 34–month horizon, products produced by firms in the bottom quartile of the size distribution set 3.40 percentage points higher prices compared to the top quartile.

The semi-parametric specification also allows for the estimation of the group-specific impulse response of prices to monetary policy shocks. We estimate them using the semi-



(a) Size (b) Age

(c) Leverage (d) Liquidity

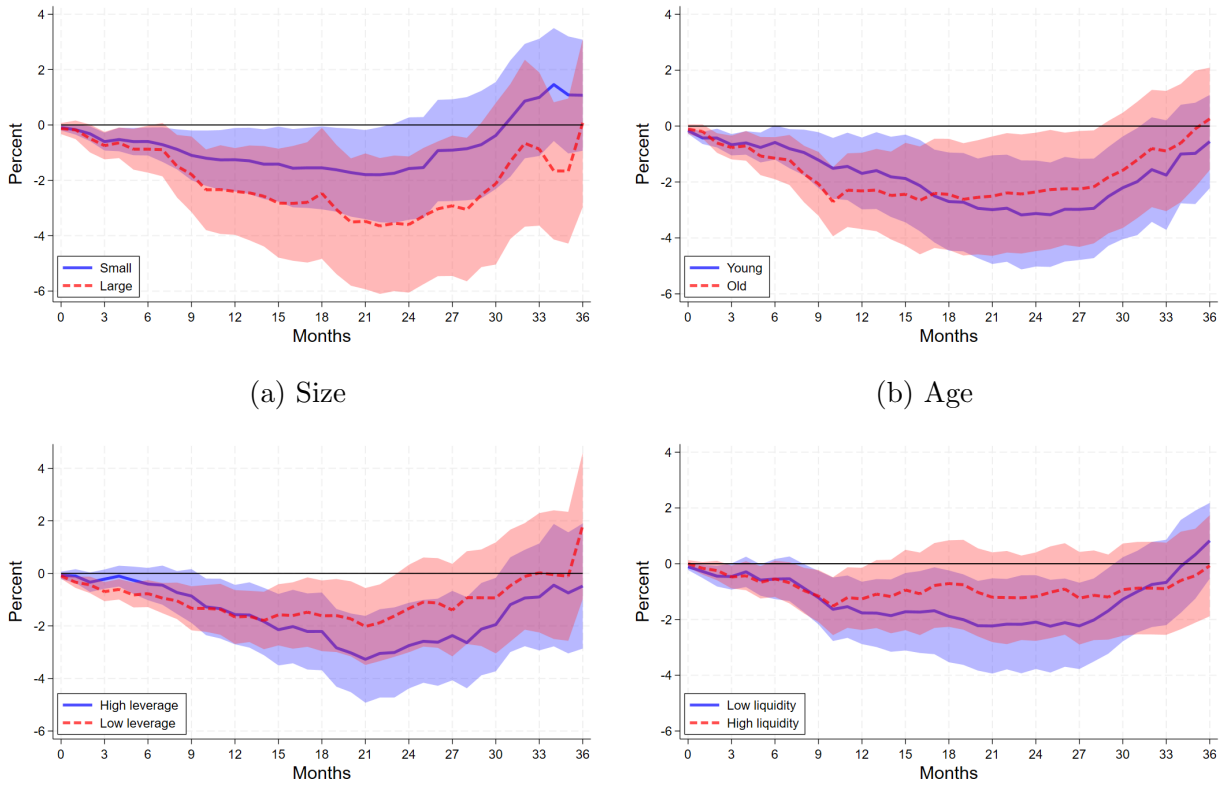
Figure 4: Differential price response of constrained firms: semi-parametric estimates.
Notes: Dynamics of the semi-parametric interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates from equation (6). Shaded regions report 90% confidence bands clustered at the firm level.

parametric panel local projections

$$\Delta_h ln(P_{i,t+h}) = \alpha_{i,h} + \alpha_{m,h} + \beta_{1,h}(mps_t \times I^{FC}_{j,t-1}) + \beta_{2,h}(mps_t \times I^{UC}_{j,t-1}) + \Gamma'_{1,h} X_{t-1} + \Gamma'_{2,h} Z_{j,t-1} + u_{i,t+h},$$

where the indicator variable $I^{UC}_{j,t-1}$ captures product-level observations in the quartile with the least constrained firms, that is, the largest, oldest, least leveraged, or most liquid firms, and $I^{FC}_{j,t-1}$ corresponds to the most constrained firms. The vector of lagged firm-level controls, $Z_{j,t-1}$, contains size, sales growth, leverage, liquidity, $I^{FC}_{j,t-1}$, and $I^{UC}_{j,t-1}$. It should be noted that for this estimation, we need to drop time fixed effects from the panel regressions, given that we want to estimate the group-specific response to mps_t. The panel regression includes product (i) and calendar-month (m) fixed effects.

The impulse responses in panel (a) of Figure 5 show that both small and large firms lower prices on average, but that small firms lower prices less in response to contractionary monetary policy. These estimates also provide more evidence on the quantitative impor-



(a) Size

(b) Age

(c) Leverage

(d) Liquidity

Figure 5: Group-specific impulse responses for prices of constrained vs. unconstrained firms. Notes: Impulse response functions of prices for the top and bottom quartiles of the size, age, leverage, and liquidity distributions to a 25 bp unexpected tightening of monetary policy. Blue solid lines show estimates of $\beta_{1,h}$, that is, the response of product prices for the most constrained firms, and red dashed lines show $\beta_{2,h}$, the response for the least constrained firms. Shaded regions report 90% confidence bands based on standard errors two-way clustered at firm and time levels.

tance of this crucial heterogeneity: For a wide range of horizons, the responsiveness of the prices of large firms is twice as large as that of small firms. Our evidence on magnitudes—here and above in Section 3.3—suggests that financial constraints meaningfully impede the transmission of monetary policy to the prices of smaller firms.

Panels (b)-(d) of Figure 4 and Figure 5 show that there is no clear differential price response when comparing prices of firms in the top and bottom of the age, leverage, or liquidity distributions, consistent with our earlier results using linear interactions.

3.5 Robustness

Our evidence so far has established that firm size is an important source of heterogeneity for the price response to changes in monetary policy, in contrast to other commonly used proxies for financial constraints.

We now turn to a range of robustness checks for these main results. A first issue to address is industry-level heterogeneity, which could partially account for our results. As shown by Durante et al. (2022), the response of investment to monetary policy differs across sectors. If firm size is correlated with differences in sector-specific demand elasticities, this could be what drives the differential price response across the size distribution. To test for this, we replace the time fixed effects equation (4) and equation (5) with two-digit product group-by-time fixed effects and estimate the interactions between the measures of financial constraints and monetary policy.[16] Figure D.1 in Appendix D shows that the main results are robust to including the more narrowly defined product group-by-time fixed effects. In fact, the differential response across the size distribution is even stronger, with a peak interaction coefficient of 1.40 at the 34–month horizon.

Another issue is the impact of the high-inflation period from 2021 to 2023. We show in Figure D.3 that our baseline results are robust to excluding this period by ending the sample in December 2020.

We also investigated the robustness of the semi-parametric, group-specific estimates. These results are robust to including two-digit product group-by-time fixed effects (see Figure D.2) as well as excluding the high inflation period (see Figure D.4). Figure D.5 also shows that results are qualitatively robust to comparing the top and bottom 33 and 50 percent of prices based on the distribution of the respective firm characteristic. The main quantitative difference across the size distribution, however, comes from the top and bottom quartiles.

We further analyze the differential price response between small and large firms for several different regression specifications. For each specification, Table 2 shows the estimated differential price response at the 24–month horizon. The first three columns show the baseline regression for different fixed effects and sample sizes, and the last three columns show estimates for specifications with non-linear interactions. Crucially, the interaction coefficient is stable across specifications and always significant at 5% level.

3.6 Taking stock: size and the price response to monetary policy

Our results so far establish the central finding of the paper: firm size is a strong predictor of the differential price response to monetary policy, while other commonly used proxies for financial constraints are not. This evidence, together with the additional results below in Section 4, suggests that size is a superior proxy for financial constraints in the context of heterogeneous monetary transmission to inflation.

[16] Examples of two-digit product groups include 11: Beverages and 29: Motor vehicles, trailers, and semitrailers.

Table 2: Size Interaction at the 24–Month Horizon

	Linear: $mps_t \times Size_{j,t-1}$			Non-linear: $mps_t \times I^{Size,C}_{j,t-1}$		
	(1)	(2)	(3)	(4)	(5)	(6)
β_{24}	0.71**	0.69**	0.73**	1.97**	1.43**	1.98**
	(0.30)	(0.31)	(0.30)	(0.83)	(0.67)	(0.83)
R^2	0.32	0.39	0.32	0.35	0.46	0.35
Obs.	231444	231198	219778	113196	112660	107274
Time fixed effects	Yes	No	Yes	Yes	No	Yes
Sector-by-TFE	No	Yes	No	No	Yes	No
End sample 2020:12	No	No	Yes	No	No	Yes

Notes: Coefficients from the estimated interaction between size and a 25 bp unexpected tightening of monetary policy on prices across different specifications at the 24–month horizon. The coefficients in columns (1)-(3) are estimated using the linear specification in equation (5) and the coefficients in columns (4)-(6) are estimated using the non-linear specification in equation (6). Standard errors clustered at the firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Why do our results show a pronounced, theory-consistent heterogeneity for firm size but not for other standard proxies of financial constraints?

A key reason is that size captures a firm's structural position in credit markets—specifically, its ability to access bond markets, commercial paper, and diversified sources of external finance—rather than the current state of its balance sheet. As shown by Gertler and Gilchrist (1994) and Oliner and Rudebusch (1996), small firms are disproportionately dependent on bank lending and cannot substitute toward market-based financing when monetary policy tightens. Our additional evidence below in Section 4 confirms this pattern. Leverage and liquidity, by contrast, reflect equilibrium outcomes of corporate financial decisions that can be high or low for reasons unrelated to the severity of financial constraints. For example, leverage may be elevated either because a firm is borrowing up to its limit or because it enjoys favorable access to cheap debt.

This distinction is consistent with Hadlock and Pierce (2010), who find that size and age are the most reliable predictors of financial constraint status, while balance-sheet-based measures perform poorly, motivating their widely used SA-index. Our results show that size drives the heterogeneity of the price responses, while age contributes little additional information. This suggests that it is credit market access, rather than information asymmetries that diminish with firm age, that shapes the differential price response to monetary policy.

A complementary reason is that size has better measurement properties. "Total assets" is a highly persistent firm characteristic that is straightforward to measure accurately, while leverage and liquidity depend on balance sheet positions that are more volatile and subject

to accounting discretion. This measurement concern is amplified in samples that include privately held firms, as ours does. Private firms face lighter reporting and auditing requirements, which introduces additional noise into balance-sheet-based measures like leverage and liquidity.

In the next section, we investigate the economic mechanisms behind the size heterogeneity in the firm-level price response to monetary policy, and provide support for the hypothesis that financial constraints and customer markets help explain this pattern.

4 Size and financial constraints

Having established that small firms adjust prices significantly less in response to changes in monetary policy, we now dig deeper into size as a proxy for financial constraints. Existing theories of financial constraints and customer markets are able to explain the muted price response of smaller firms to changes in monetary policy. This section first lays out this theoretical foundation for our empirical results in greater detail. Then we provide several pieces of supporting evidence for this channel of firm-level heterogeneity. Finally, we address some other candidate explanations of the documented pricing heterogeneity and show that they are inconsistent with key patterns in the data. Taken together, we provide strong support for the view that the differential price response between small and large firms documented in Section 3 is likely due to smaller firms facing tighter financial constraints, and therefore being less able to invest in their customer base, than larger firms.

4.1 Theory: customer markets and financial frictions

Models of customer markets and financial frictions (Gottfries, 1991; Chevalier and Scharfstein, 1996; Gilchrist et al., 2017) can rationalize our central empirical finding that small firms exhibit a muted price response to monetary policy. The core idea of these models is that the customer base is an asset that firms invest in, and when credit becomes more costly, firms reduce this investment, setting higher prices to generate additional cash flows and liquidity.

Gilchrist et al. (2017) develop a New Keynesian model with customer markets and financial frictions that clearly shows the mechanisms for the effects of financial shocks and demand shocks on pricing decisions, inflation, and output. In their model, firms face a sticky customer base due to deep habits of households. As a result, a lower price can be viewed as an investment in the customer base that yields higher market share and profits over the longer run. At the same time, firms also face costly external finance, meaning that there is

a wedge between the interest rate on external financing and the risk-free rate. Gilchrist et al. model this as an equity issuance friction, but other ways of modeling financial frictions, such as borrowing constraints, would likely lead to similar implications. The key is that financially constrained firms may find it optimal to set relatively higher prices to generate more current revenue and avoid the external finance premium, even though this means giving up market share in the future. In other words, financial frictions create a trade-off between, on the one hand, investing in the customer base, generating future profits and market shares, and, on the other hand, maintaining current cash flows to minimize the reliance on costly external finance.

In the model of Gilchrist et al. (2017), the price response to a financial shock or a demand shock depends on the balance sheet position of a firm. While financially unconstrained firms lower prices, constrained firms lower prices by less or even raise prices. As a result, constrained firms suffer a stronger decline in output relative to unconstrained ones, meaning that financial frictions amplify the aggregate output loss. The empirical evidence in Gilchrist et al. (2017) on the pricing behavior during the Great Financial Crisis of 2008 supports this channel. In particular, unconstrained firms cut their prices in 2008, whereas constrained firms actually increased prices despite the large drop in aggregate output. The muted aggregate inflation response together with an elevated output response to a financial or demand shock also implies that financial frictions change the inflation-output trade-off for monetary policy.

Our results on the effects of monetary policy can be viewed through the lens of this model by interpreting an unexpected tightening of monetary policy as an adverse demand shock. As overall output falls, the balance sheet position of financially constrained firms deteriorates further, the external finance premium increases, and, as a consequence, the financially constrained firms become more myopic, that is, less forward-looking.[17] Accordingly, they choose higher markups and set relatively higher prices, compared to the unconstrained firms, in order to boost current revenues. The consequence of this price-setting strategy is that constrained firms lose market shares to the unconstrained firms, sacrificing future revenues. It is straightforward to show that in the model of Gilchrist et al. (2017), the implications of a contractionary monetary policy shock are qualitatively similar to those of an adverse demand shock—a discount factor shock—in terms of the differential response of prices and output for constrained and unconstrained firms.[18]

Another intuitive interpretation of this key heterogeneity is that in response to a monetary

[17] See, e.g., Bauer et al. (2023) for the response of the external finance premium and risk premia in response to monetary policy.

[18] See also Gilchrist and Zakrajsek (2016), who show that customer markets and financial frictions have material effects on price-setting even if the original model is calibrated to more normal times, instead of the crisis episode that was the focus of Gilchrist et al. (2017).

contraction, financially constrained firms reduce their investment in the customer base by more than unconstrained firms. The more muted price response of constrained firms is therefore consistent with an amplified investment response, as in Jeenas (2025), who shows that constrained firms—with lower liquidity—exhibit a more negative investment response to a contractionary monetary policy shock.

Models of customer markets and financial constraints provide a natural candidate explanation for the heterogeneous price response that we document for large and small firms. While in these and other models of financial frictions, the degree of financial constraints of a firm is typically linked to liquidity (Gilchrist et al., 2017) or leverage (Bernanke et al., 1999), firm size is a widely used and arguably more reliable empirical proxy for financial constraints (see our discussion above in Section 3.6). It is therefore plausible that the smaller firms in our sample adjust their prices less in response to changes in monetary policy because changes in their cost of external finance lead them to adjust investment in their customer base.

To assess this explanation of our main empirical results, we consider several testable implications of the theory of customer markets and financial constraints. First, since tighter financial constraints in response to the interest rate increase cause smaller firms to set relatively higher prices and forgo investment in their customer base, they should also see their sales drop by more than larger firms.[19] We will therefore investigate the differential response of firm-level sales to monetary policy shocks.

Second, if financial constraints play an important role for the size heterogeneity in our results, then we would also expect differences in the debt response to monetary policy. In particular, the level of debt of smaller firms should be more sensitive to changes in monetary policy than the debt of larger firms. Existing research on the role of financial constraints in monetary transmission, including Gertler and Gilchrist (1994); Oliner and Rudebusch (1996); Cloyne et al. (2023) has documented that smaller, financially constrained firms reduce their debt more strongly in response to tighter monetary policy.[20] We will reassess this pattern in our data.

[19]For the financial shock of 2008, Gilchrist et al. (2017) indeed show prices of constrained firms do not fall like those of unconstrained firms, and that their sales fall by more. They measure financial constraints using the firms' liquidity, among other proxies.

[20]By contrast, Crouzet and Mehrotra (2020) question the usefulness of firm size as a proxy for financial constraints, and show that over the course of economic downturns, as well as in response to changes in monetary policy, there appears to be no significant difference in the share of debt between large and small firms.

4.2 Sales

The first testable hypothesis from the theory of customer markets and financial frictions is the response of sales. Constrained firms lower prices less in response to a monetary tightening to maintain current cash flow at the expense of lower market shares and sales in the future. Based on this, we expect sales of small firms to be relatively more responsive to changes in monetary policy.

We use monthly firm-level sales data from the microdata underlying the official Swedish Industrial Production Index (*Industriproduktionsindex, IPI*) maintained by SCB. The IPI data consist of total nominal net sales for a sample of firms. We merge the IPI data with our cleaned PPI data set, using only sales of the firms for which we also have monthly prices and yearly firm characteristics. Our matched IPI data set consists of 142,520 firm-month-year observations, which means that we have sales data for 73 percent of the 195,982 unique firm-month-year observations in our cleaned PPI data set.[21]

To construct real, inflation adjusted sales in our final IPI data set, we deflate firms' nominal sales with the firm-level average price. Given the relatively large monthly volatility of sales data, we winsorize cumulative monthly sales at the top and bottom five percent. In addition, we follow Ahlander et al. (2024) and smooth the data by taking a three-month centered moving average.[22]

To test the hypothesis that the sales of small firms are more responsive to changes in monetary policy, we use the same approach as for the price response. That is, we estimate the dynamic differential sales response across the size distribution using the following panel local projections

$$\Delta_h ln(Sales_{j,t+h}) = \alpha_{j,h} + \alpha_{t,h} - \beta_h(mps_t \times Size_{j,t-1}) + \Gamma_h' Z_{j,t-1} + u_{j,t+h}, \tag{7}$$

where the outcome variable is the log of real net sales of firm j, $\alpha_{j,h}$ are firm fixed effects, $\alpha_{t,h}$ are time fixed effects, mps_t is the monetary policy surprise aggregated to month t, and $Z_{j,t-1}$ is the same vector of firm-level controls described in Eq. (3). We also consider an

[21] Appendix Table E.1 compares the yearly firm characteristics of the firms for which we are able to match the IPI and PPI data to those firms in our cleaned PPI data set we are not able to match. While the firm characteristics for both groups are generally comparable, the firms for which we have both sales and prices are on average somewhat larger, older, less leveraged, and faster growing compared to the ones we cannot match.

[22] Appendix Figure E.1 shows the impulse response functions of sales to an unexpected tightening of monetary policy of smoothed and non-smoothed firm-level sales as well as the aggregate IPI index. The figure shows that all three measures of sales fall significantly and persistently on average. Both the smoothed and non-smoothed firm-level responses are close to the response of the aggregate index in terms of magnitude and persistence. However, smoothing the data helps reduce the month-to-month volatility of the firm-level response.

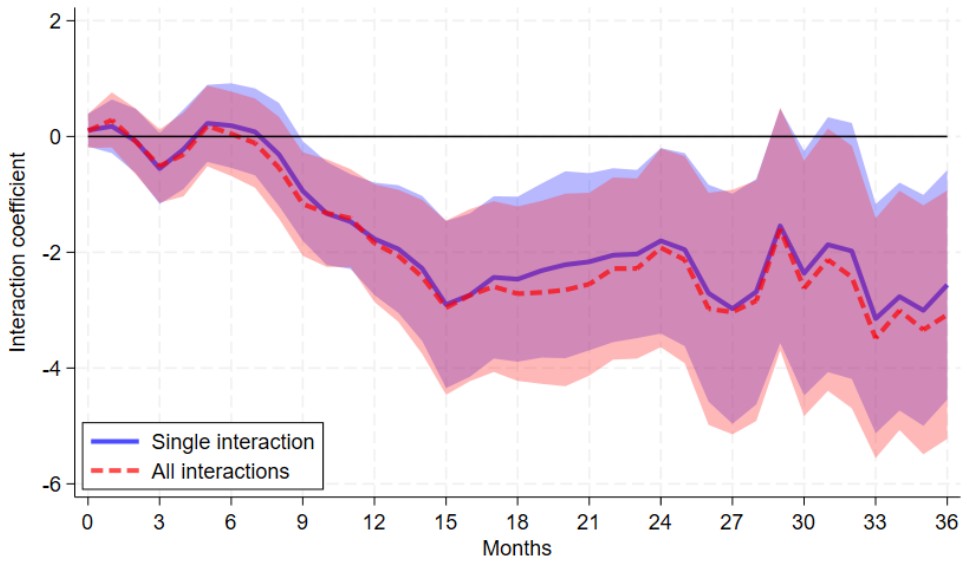


Figure 6: Dynamic differential sales response.
Notes: Dynamics of the interaction coefficients between size and a 25 bp unexpected tightening of monetary policy on sales. The blue solid line shows estimates when the interaction is estimated separately using the panel local projection in equation (7) and the red dashed line when the interaction with size, age, leverage, and liquidity are all included in the regression. Shaded regions are 90% confidence bands clustered at the firm level.

analogous specification that includes interactions with all four proxies of financial constraints, in order to determine whether size has a distinct and independent role from age, leverage, and liquidity.

Figure 6 shows how the differential response of real, firm-level sales to a 25 bp unexpected tightening of monetary policy varies across the size distribution. Consistent with the hypothesis that small firms lower prices less at the expense of future revenues, sales of smaller firms fall relatively more than the sales of larger firms. The differential response is persistently negative and statistically significant for most of the 36 months of horizons. The trough occurs 33 months after the shock, and the coefficient at that horizon indicates that sales of firms one standard deviation smaller than the average fall by an additional 3.6 percentage points compared to the average firm.[23]

The estimated differential sales response supports the explanation of our main results via financial frictions and differential investment in the customer base. After a monetary contraction, the rise in the external finance premium causes smaller firms to reduce their investment in the customer base by more than larger firms, meaning that they lower prices

[23]The dynamic differential sales responses across the age, leverage, and liquidity distributions are shown in Figure E.2 in Appendix E. There is no persistent significant difference across any of these distributions, consistent with the insignificant differential price response documented before.

by less and therefore their revenue and market share fall by more.

Taking the price and sales responses together reveals a broader implication for monetary policy. Because smaller firms exhibit both a muted price but an amplified sales response, they exhibit a flatter inflation-output relationship than larger firms. This variation across the size distribution has direct relevance for the aggregate effectiveness of monetary policy. An economy with a larger share of financially constrained firms faces a less favorable trade-off: monetary tightening achieves less disinflation per unit of output loss. In the language of the sacrifice ratio literature (Ball, 1994; Cecchetti and Rich, 2001), financial constraints effectively raise the sacrifice ratio by muting the price margin while amplifying the quantity margin of monetary transmission. The strength of this effect depends on the degree and distribution of financial constraints in the economy.

4.3 Borrowing behavior

To test whether size proxies for financial constraints in our dataset, we follow the earlier macro-finance literature (Oliner and Rudebusch, 1996; Crouzet and Mehrotra, 2020) and study how the borrowing behavior of firms differs across the size distribution.

First, we provide descriptive statistics of firm characteristics and the share of bank debt across the size distribution. Table 3 shows mean values of the monthly price data and the yearly firm characteristics for each quartile of the size distribution. Panel (a) shows that apart from the number of products per firm, the mean values are very similar across the size distribution. Combined with the group-specific average impulse response function of the firms in the top and bottom quartile of the size distribution, these results indicate that fundamental differences in the unconditional price-setting behavior of small and large firms are an unlikely driver of the differential price response across the size distribution. Panel (b) shows that size is negatively related to the share of bank debt, defined as the value of short- and long-term debt to credit institutes over total short- and long-term debt. The smallest firms, in the bottom quartile of the size distribution, have a mean share of bank debt that is three times as large as the largest firms in the top quartile. As this type of debt is generally assumed to be subject to more information asymmetries and therefore more sensitive to changes in monetary policy, these numbers provide further support for the view that firm size is closely related to the degree of financial constraints in our dataset. In addition, size is positively related to age and sales growth, negatively related to liquidity, and largely unrelated to leverage. These findings are qualitatively in line with those of Crouzet and Mehrotra (2020) for manufacturing firms in the U.S.

Next, we test for a size-dependent firm-level debt response following a monetary policy

Table 3: Summary Statistics by Size Group

Size group	Q1	Q2	Q3	Q4
(a) Monthly Prices				
100Δln(Price)	0.20	0.20	0.20	0.24
Share of price changes	0.47	0.47	0.47	0.47
Size of price changes	3.00	2.86	2.82	3.00
Products per firm	1.37	2.01	3.64	8.33
(b) Yearly Firm Characteristics				
Debt to credit institutes	0.21	0.15	0.11	0.07
Age	34.01	38.98	44.17	52.73
Leverage	0.57	0.54	0.53	0.54
Liquidity	0.07	0.06	0.05	0.04
100Δln(Sales)	2.51	4.17	4.49	5.02

Notes: Mean values of selected characteristics of the firms in our matched PPI dataset for each quartile of the size distribution. Debt to credit institutes is expressed as a fraction of total debt.

shock. In textbook monetary models with financial frictions, such as Bernanke et al. (1999), tighter monetary policy leads to a deterioration in firms' balance sheets, an increase in external finance, lower credit demand, and, with it, an amplification of the effect of monetary policy on aggregate variables. Applying this logic to the cross section of firms, we expect the debt of small firms to be more responsive to monetary policy if size is a proxy for financial constraints.

We test this hypothesis by estimating the role of size in the transmission of monetary policy to firm-level debt using panel local projections with yearly data. The outcome variable is the log change in yearly total debt, and we aggregate the monetary policy surprise variable to a yearly sum. We remove outliers by winsorizing the cumulative yearly change in debt at the top and bottom one percent.

Figure 7 indeed shows how the response of debt to a 25 bp unexpected tightening of monetary policy varies across the size distribution: small firms lower debt more following the interest hike. Firms that are one standard deviation smaller than the average firm lower debt by 0.85 percentage points more compared to the average firm at the one-year horizon. The response is persistent with coefficients of -0.54 and -1.23 at the two- and three-year horizons and significant at the one- and three-year horizons.

This response is consistent with the theoretical prediction that the cost of external finance increases relatively more for smaller firms following the monetary tightening, which makes them lower their debt holdings relative to less constrained (large) firms. Thus, the differential debt response of smaller firms provides additional evidence that size works as a proxy for

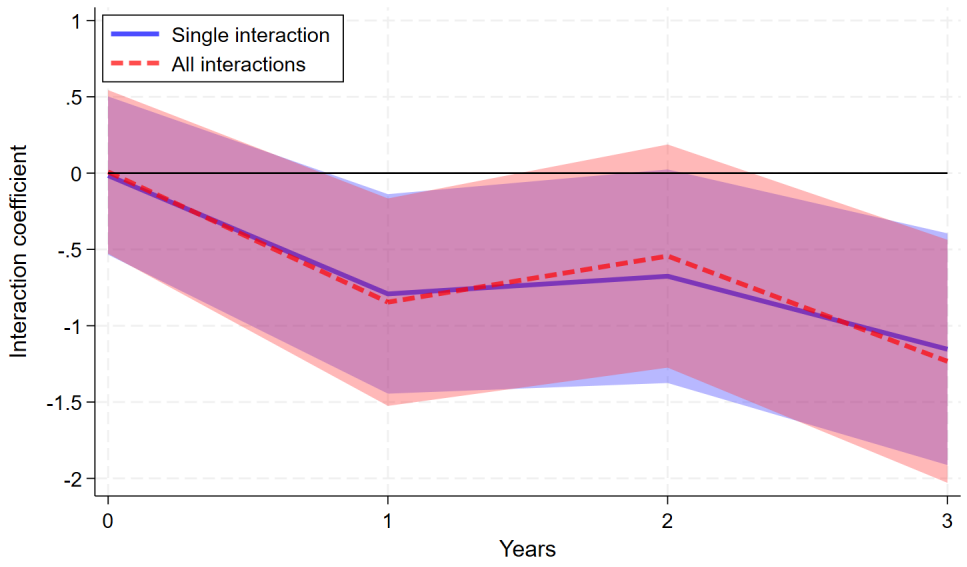


Figure 7: Dynamic differential debt response.
Notes: Dynamics of the interaction coefficients between size and a 25 bp unexpected tightening of monetary policy on debt. The blue solid line corresponds to a regression specification with only a size interaction effect, and the red dashed line corresponds to a regression that jointly includes interactions with size, age, leverage, and liquidity. Frequency is annual. Shaded regions report 90% confidence bands clustered at the firm level.

financial constraints in our dataset.

Additional results of the debt response are presented in Appendix F. Figure F.1 shows that debt falls on average following an unexpected tightening of monetary policy - although imprecisely estimated - and Figure F.2 shows that there are no significant differences in the debt responses across the age, leverage, or liquidity distributions.

4.4 Alternative channels

So far, we have argued that a financial frictions channel is consistent with the differential price response. However, alternative channels could also—at least in principle—lead to similar heterogeneous pricing dynamics and explain the observed differences between small and large firms following a monetary policy shock.

The so-called working capital channel of Christiano and Eichenbaum (1992) and Christiano et al. (2015) can lead to differences in firm-level sensitivity to monetry policy. It is based on the idea that firms have to pre-fund part of their variable production—their working capital—and an increase in interest rates will therefore raise marginal cost and consequently prices. The negative effects of changes in monetary policy on prices would therefore be muted. For firms that have a larger share of working capital, one would therefore expect a

diminished price response to monetary policy, and if size is correlated with working capital share, this could potentially explain the heterogeneity result we document in this apper.

To assess this hypothesis, we follow Barth and Ramey (2002) and measure working capital as the sum of inventories and accounts receivable net of payable over total sales. We then estimate its interaction with the monetary policy surprises, using the specifications analogous to those in equations (4)–(6), to test whether working capital share explains heterogeneity in the price response to policy shocks.[24] Appendix Figure F.3 shows that there is no evidence for the working capital channel in our data, that is, firms with a higher share of working capital do not choose higher prices after a contractionaty monetary policy shock. In fact, the point estimates tend to be negative for some horizons, suggesting that these firms have a more pronounced negative price response to monetary policy, though most estimates are statistically insignificant. Because differences in working capital do not explain heterogeneous monetary transmission to firm-level prices in our dataset, this channel has no hope of explaining our main heterogeneity results based on firm size.

Another alternative explanation for why small firms adjust prices less to changes in monetary policy is that their production structure could differ fundamentally from large firms in a way that their marginal costs are less responsive to monetary policy. Accordingly, a contractionary monetary policy shock would lead to a smaller decline in marginal costs of small firms and thus to a lower price decline. To test for this alternative explanation, we start by constructing a measure of marginal cost following the approach of Gagliardone et al. (2023). They show that a firm's nominal log-marginal cost is equal to the log of the average cost and a term reflecting short-run returns to scale. Assuming a Cobb-Douglas production function, the latter term is constant and can be controlled for using firm fixed effects.[25] Thus they use firms' average variable costs as a proxy for marginal cost. Analogously to Gagliardone et al. (2023), we measure average variable costs as total variable costs over real sales. Total variable costs, in turn, are measured as the sum of personnel costs, which consists of wages and social security contributions, raw materials and necessities, trading goods, and other external expenses, all taken from the UC data. Real sales are measured as total sales over a firm-specific yearly price index. The price index is measured as the firm-weighted average of the nominal value of output over quantity sold, both taken from SCB's Industrial Production Index (*Industrins varuproduktion, IVP*).

Our measure of marginal cost is only available for 7,296 of the 16,802 unique firm-year observations in our matched PPI sample. Table G.1 in Appendix G shows summary statistics

[24] As for the other firm characteristics, we winsorize working capital at the top and bottom one percent.

[25] Gagliardone et al. (2023) show that their results on the pass-through of marginal cost to prices are robust to allowing that the term related to short-run returns to scale to vary over time and with the scale of production, as would be the case under CES technology, using data on Belgian manufacturing firms.

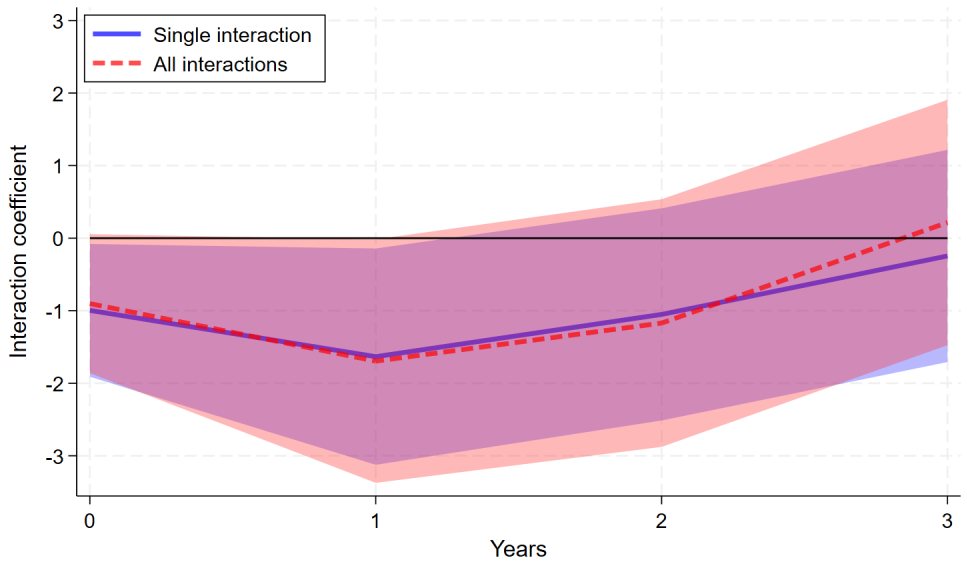


Figure 8: Dynamic differential marginal cost response.
Notes: Dynamics of the interaction coefficients between size and a 25 bp unexpected tightening of monetary policy on marginal cost. The blue solid line reports point estimates when only the size effect is included in the panel local projection, and the red dashed line when the interaction with age, leverage, and liquidity are included as well. The outcome variable is the change in log marginal cost. Frequency is annual. Shaded regions report 90% confidence bands clustered at the firm level.

for the monthly prices and yearly firm characteristics for the subsets of the sample with and without a measure of marginal cost. While the firms without a measure of marginal cost are somewhat larger on average, the monthly price data and the yearly firm characteristics in the two subsets are quite similar.

We estimate the role of size in the transmission of monetary policy to marginal cost by estimating similar local projections as before, using log changes in annual marginal cost as the outcome variable. Figure 8 shows how the response of marginal cost to a 25 bp unexpected tightening of monetary policy varies across the size distribution. The results do not indicate that the marginal costs of smaller firms are less responsive to monetary policy. On the contrary, the point estimates for the impact and one-year horizons are *negative* and statistically significant at the 10-percent level. That is, marginal costs of smaller firms are in fact more responsive to monetary policy than for larger firms.[26]

These results not only speak against the alternative explanation that differences in the production structure and different sensitivity of marginal cost to monetary policy of small firms are driving the differential price response. They in fact also provide further support

[26] Additional results of the marginal cost response are presented in Appendix G. Figure G.1 shows that marginal cost falls on average following an unexpected tightening of monetary policy and Figure G.2 shows that there are no significant differences in the marginal cost responses to monetary policy across leverage or liquidity distributions but that younger firms are somewhat less responsive.

for the explanation based on customer markets and financial frictions: The evidence on the price and marginal cost response together implies that smaller firms lower markups by less in response to a monetary contraction than larger firms, or might even increase markups. These patterns suggest that smaller firms, by keeping higher markups, generate additional liquidity instead of investing into their customer base and protecting their future market share.

In sum, these results indicate that alternative channels—like the working capital channel or differential sensitivity of marginal cost—are not consistent with the patterns in our data. The presence of customer markets and financial frictions is the most plausible explanation of the heterogeneous monetary transmission to firm-level prices that we document in this paper.

5 Conclusion

Understanding how monetary policy transmits to prices—and why this transmission varies across firms—is a central issue in monetary economics. This paper provides new evidence on the role of financial constraints for monetary transmission using detailed Swedish firm-level microdata on firms and their prices. We document that financially constrained firms exhibit a more muted negative price response to monetary policy, in contrast to their amplified investment response documented in the earlier literature. Firm size emerges as the best proxy for financial constraints, revealing a heterogeneous response that remains hidden when using other common proxies, such as age, leverage, or liquidity.

Our results are consistent with models of customer markets and financial frictions. In this class of models, the customer base of a given product is sticky and the cost of external finance depends on the strength of firms' balance sheets. Tighter monetary policy leads to an increase in the external finance premium, which causes financially constrained firms to reduce price markups by less—or even increase them—compared to unconstrained firms. The reason is that these firms try to avoid costly external finance and instead boost current revenues. This additional liquidity requires investing less in the customer base and comes at the cost of future sales and market shares.

Additional evidence supports the interpretation that size proxies for financial constraints, which mute firms' pricing response to monetary policy. Smaller firms see larger sales declines, hold more bank debt, and have a stronger debt response to policy. Our analysis also addresses several possible alternative explanations and shows that these are not consistent with the heterogeneity patterns in the data. For example, smaller firms do not exhibit a more muted marginal cost response to monetary policy, ruling out differences in production structure

as an explanation. Together, our findings clearly point to the customer-market mechanism: constrained firms sacrifice market share to preserve cash flows.

Our paper makes two key empirical contributions to the monetary economics literature. First, earlier work, including Gilchrist et al. (2017) and Renkin and Züllig (2024), has documented differential firm-level price setting during periods of financial stress, but we show that this heterogeneity goes beyond financial shocks and crises and in fact operates as part of standard monetary transmission. Second, empirical work on heterogeneous monetary transmission has documented that financial constraints amplify the firm-level investment response, while our evidence shows that they dampen the price response.

Our findings have important implications for monetary policy. They suggest that the effectiveness of monetary policy in controlling inflation is reduced by financial constraints, and that the strength of monetary transmission to inflation depends in part on the distribution of financial constraints across firms. Furthermore, financial constraints worsen the inflation-output trade-off for monetary policy and may increase the sacrifice ratio. These considerations may be especially relevant during periods of financial stress, when the external finance premium rises and the muted price response of constrained firms becomes more pronounced.

Our paper points to several promising directions for future research on the role of financial constraints for firm-level monetary transmission. The use of firm size as a measure for financial constraints is a matter of ongoing debate. While earlier work has often used firm size in this way, Crouzet and Mehrotra (2020) show evidence that calls into question the role of financial constraints for the different cyclical dynamics of large and small firms, and they do not find any significant differences in the debt response of small and large firms to changes in monetary policy. Future research should further investigate whether and how firm size captures financial constraints, and explore alternative proxies. Furthermore, our work focuses on Swedish manufacturing firms, due to the availability of rich microdata, but the generalization to other countries or sectors remains an open question. For this reason, we see much promise in extending our analysis to the United States. While such an endeavor faces the substantial hurdle of collecting suitable price data at the firm level, it would be particularly valuable given the paucity of evidence on the role of financial frictions for differential price responses to monetary policy. Finally, our heterogeneity results do not speak directly to the aggregate importance of these effects from financial constraints. How much stronger would the impact of monetary policy on inflation be if the price response of small firms was not muted by financial constraints? Quantifying the aggregate implications of these heterogeneous price responses—and understanding how they interact with the distribution of financial constraints over the business cycle—is a natural next step in this line of research.

References

Acosta, M., Ajello, A., Bauer, M., Loria, F., and Miranda-Agrippino, S. (2025). Financial market effects of fomc communication: Evidence from a new event-study database. Working Paper 2025-30, Federal Reserve Bank of San Francisco.

Ahlander, E., Klein, M., and Pappa, E. (2024). What flattens the supply curve? Working Paper.

Almerud, J., Krygier, D., Lundvall, H., and Njie, M. (2024). Measuring riksbank monetary policy: Shocks and macroeconomic transmission. Working Paper Series 445, Sveriges Riksbank.

Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R., and Ragusa, G. (2019). Measuring euro area monetary policy. *Journal of Monetary Economics*, 108:162–179.

Amberg, N., Jansson, T., Klein, M., and Picco, A. R. (2022). Five facts about the distributional income effects of monetary policy shocks. *American Economic Review: Insights*, 4(3):289–304.

Anderson, G. and Cesa-Bianchi, A. (2024). Crossing the credit channel: credit spreads and firm heterogeneity. *American Economic Journal: Macroeconomics*, 16(3):417–446.

Antoun de Almeida, L. (2015). Firms' balance sheets and sectoral inflation in the euro area during the financial crisis. *Economics Letters*, 135:31–33.

Bahaj, S., Foulis, A., Pinter, G., and Surico, P. (2022). Employment and the residential collateral channel of monetary policy. *Journal of Monetary Economics*, 131:26–44.

Ball, L. (1994). What determines the sacrifice ratio? In Mankiw, N. G., editor, *Monetary Policy*, pages 155–193. University of Chicago Press.

Barth, M. J. and Ramey, V. A. (2002). The cost channel of monetary transmission. *NBER Macroeconomics Annual 2001*, 16:199–240.

Bauer, M. D., Bernanke, B. S., and Milstein, E. (2023). Risk appetite and the risk-taking channel of monetary policy. *Journal of Economic Perspectives*, 37(1):77–100.

Bauer, M. D. and Swanson, E. T. (2023a). A Reassessment of Monetary Policy Surprises and High-Frequency Identification. *NBER Macroeconomics Annual*, 37(1):87–155.

Bauer, M. D. and Swanson, E. T. (2023b). An alternative explanation for the "fed information effect". *American Economic Review*, 113(3):664–700.

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

Bernanke, B. S. and Kuttner, K. N. (2005). What explains the stock market's reaction to federal reserve policy? *The Journal of finance*, 60(3):1221–1257.

Caglio, C. R., Darst, R. M., and Kalemli-Özcan, S. (2021). Collateral heterogeneity and monetary policy transmission: Evidence from loans to smes and large firms. Working Paper 28685, National Bureau of Economic Research.

Cecchetti, S. G. and Rich, R. W. (2001). Structural estimates of the U.S. sacrifice ratio. *Journal of Business & Economic Statistics*, 19(4):416–427.

Chevalier, J. A. and Scharfstein, D. S. (1995). Liquidity constraints and the cyclical behavior of markups. *The American Economic Review*, 85(2):390–396.

Chevalier, J. A. and Scharfstein, D. S. (1996). Capital-market imperfections and countercyclical markups: Theory and evidence. *The American Economic Review*, pages 703–725.

Christiano, L. J. and Eichenbaum, M. (1992). Liquidity effects and the monetary transmission mechanism. *American Economic Review*, Papers and Procedings 82:346–353.

Christiano, L. J., Eichenbaum, M. S., and Trabandt, M. (2015). Understanding the great recession. *American Economic Journal: Macroeconomics*, 7(1):110–167.

Cloyne, J., Ferreira, C., Froemel, M., and Surico, P. (2023). Monetary policy, corporate finance, and investment. *Journal of the European Economic Association*, 21(6):2586–2634.

Core, F., De Marco, F., Eisert, T., and Schepens, G. (2025). Inflation and floating-rate loans: Evidence from the euro-area. Working Paper 3064, European Central Bank.

Crouzet, N. and Mehrotra, N. R. (2020). Small and large firms over the business cycle. *American Economic Review*, 110(11):3549–3601.

Duca, I., Montero, J. M., Riggi, M., and Zizza, R. (2017). I will survive. pricing strategies of financially distressed firms. *Pricing Strategies of Financially Distressed Firms (March 28, 2017). Bank of Italy Temi di Discussione (Working Paper) No*, 1106.

Durante, E., Ferrando, A., and Vermeulen, P. (2022). Monetary policy, investment and firm heterogeneity. *European Economic Review*, 148:104251.

Faust, J., Rogers, J. H., Wang, S.-Y. B., and Wright, J. H. (2007). The high-frequency response of exchange rates and interest rates to macroeconomic announcements. *Journal of Monetary Economics*, 54(4):1051–1068.

Fransson, L. and Tysklind, O. (2016). The effects of monetary policy on interest rates. *Sveriges Riksbank Economic Review*, 2016(1):38–60.

Gagliardone, L., Gertler, M., Lenzu, S., and Tielens, J. (2023). Anatomy of the phillips curve: micro evidence and macro implications. Technical report, National Bureau of Economic Research.

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

Gertler, M. and Karadi, P. (2015). Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics*, 7(1):44–76.

Gilchrist, S., Schoenle, R., Sim, J., and Zakrajšek, E. (2017). Inflation dynamics during the financial crisis. *American Economic Review*, 107(3):785–823.

Gilchrist, S., Schoenle, R., Sim, J., and Zakrajšek, E. (2023). Financial heterogeneity and monetary union. *Journal of Monetary Economics*, 139:21–40.

Gilchrist, S. and Zakrajsek, E. (2016). Customer markets and financial frictions: Implications for inflation dynamics. In *Proceedings of the 2015 Jackson Hole Economic Policy Symposium, Federal Reserve Bank of Kansas City*.

Gottfries, N. (1991). Customer markets, credit market imperfections and real price rigidity. *Economica*, pages 317–323.

Gürkaynak, R. S., Sack, B., and Swanson, E. T. (2005). Do actions speak louder than words? the response of asset prices to monetary policy actions and statements. *International Journal of Central Banking*, 1(1):55–93.

Gürkaynak, R., Karasoy-Can, H. G., and Lee, S. S. (2022). Stock market's assessment of monetary policy transmission: The cash flow effect. *The Journal of Finance*, 77(4):2375–2421.

Hadlock, C. J. and Pierce, J. R. (2010). New evidence on measuring financial constraints: Moving beyond the kz index. *Review of Financial Studies*, 23(5):1909–1940.

Ippolito, F., Ozdagli, A. K., and Perez-Orive, A. (2018). The transmission of monetary policy through bank lending: The floating rate channel. *Journal of Monetary Economics*, 95:49–71.

Iversen, J. and Tysklind, O. (2017). The effect of repo rate path changes on asset prices. *Staff memo*, Sveriges Riksbank.

Jarociński, M. and Karadi, P. (2020). Deconstructing monetary policy surprises—the role of information shocks. *American Economic Journal: Macroeconomics*, 12(2):1–43.

Jeenas, P. (2025). Firm balance sheet liquidity, monetary policy shocks, and investment dynamics. Working Paper.

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

Jordà, Ò. (2023). Local projections for applied economics. *Annual Review of Economics*, 15(1):607–631.

Jungherr, J., Meier, M., Reinelt, T., and Schott, I. (2024). Corporate debt maturity matters for monetary policy. International Finance Discussion Paper 1402, Federal Reserve Board of Governors.

Kim, M. and Park, G. (2024). Corporate debt maturity and output price dynamics. Unpublished Working Paper.

Kuttner, K. N. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of monetary economics*, 47(3):523–544.

Laséen, S. (2020). Monetary policy surprises, central bank information shocks, and economic activity in a small open economy. *Working Paper Series 396*, Sveriges Riksbank.

Montero, J. M. and Urtasun, A. (2021). Markup dynamics and financial frictions: The spanish case. *International Review of Economics & Finance*, 71:316–341.

Nakamura, E. and Steinsson, J. (2018). High-frequency identification of monetary non-neutrality: the information effect. *The Quarterly Journal of Economics*, 133(3):1283–1330.

Oliner, S. D. and Rudebusch, G. D. (1996). Monetary policy and credit conditions: Evidence from the composition of external finance: Comment. *American Economic Review*, 86(1):300–309.

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

Ozdagli, A. (2017). Financial frictions and the stock price reaction to monetary policy. *The Review of Financial Studies*, 31(10):3895–3936.

Ozdagli, A. and Velikov, M. (2020). Show me the money: The monetary policy risk premium. *Journal of Financial Economics*, 135(2):320–339.

Petersen, M. A. (2009). Estimating standard errors in finance panel data sets: Comparing approaches. *The Review of financial studies*, 22(1):435–480.

Renkin, T. and Züllig, G. (2024). Credit supply shocks and prices: Evidence from danish firms. *American Economic Journal: Macroeconomics*, 16(2):1–28.

Statistics Sweden (2023). Production of the statistics. *Producer and import price index*.

Appendices

A Monetary policy surprises over time

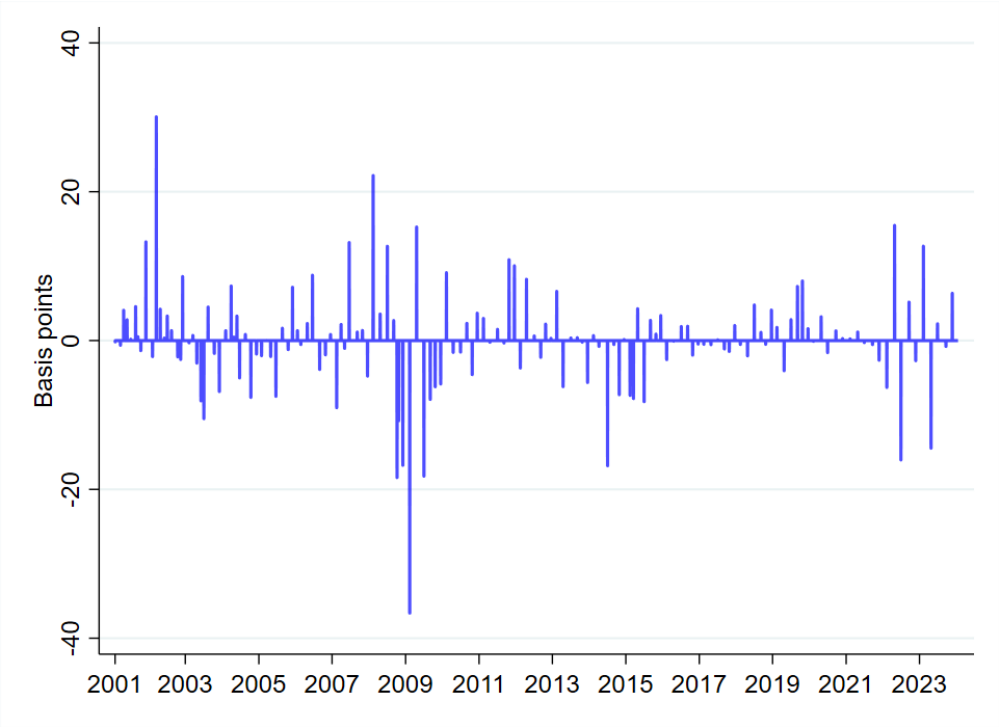
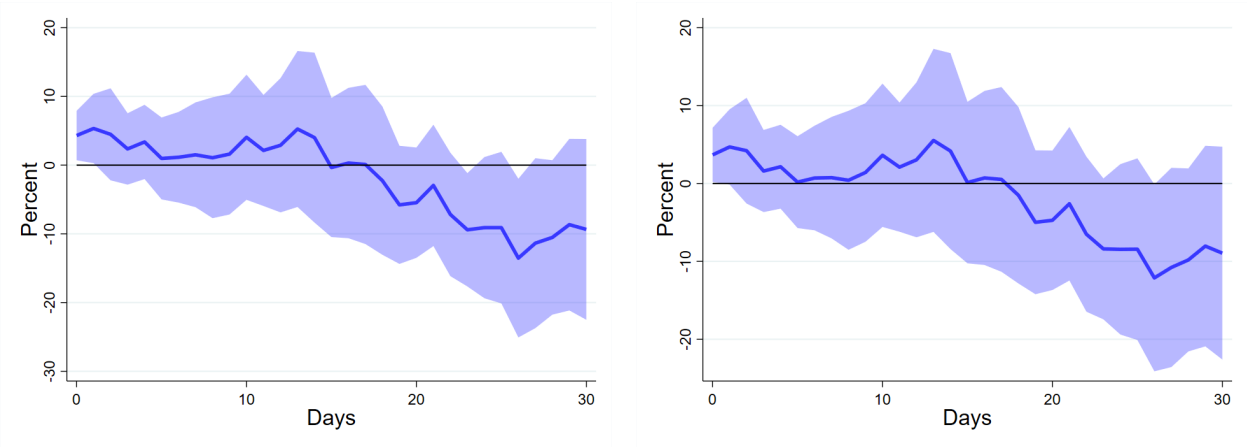


Figure A.1: Monetary policy surprises over time

Notes: Monetary policy surprises, calculated as the first principal component of daily changes around monetary policy announcements in forward rate agreements covering the subsequent four quarters. Sample period: 2001:1 to 2023:12. See the main text for details.

B Cumulative daily stock price changes



(a) OMXS30 (b) OMXSPI

Figure B.1: Impulse response functions of daily stock prices

Cumulative daily change of log stock market indices to a 100 bp positive monetary policy surprise from the local projections $\Delta_h Y_{t+h} = \alpha_h + \beta_h mps_t + u_{t+h}$. The blue solid line reports the point estimate and the shaded regions report 90% heteroskedasticity-consistent confidence bands.

C Summary statistics of the matched PPI data set

Table C.1: Summary Statistics

Variable	Obs.	Mean	Std.	Min	p25	p50	p75	Max
(a) Monthly Prices								
100Δln(Price)	338,264	0.21	3.03	-16.02	0.00	0.00	0.10	17.33
Share of price changes	338,264	0.47	0.07	0.36	0.41	0.48	0.51	0.67
Size of price changes	159,052	2.93	3.25	0	0.64	1.75	3.99	17.33
Products per firm	338,264	3.86	4.87	1	1	2	4	32
(b) Yearly Firm Characteristics								
Size	16,802	19.19	1.53	16.40	18.06	19.00	20.13	25.12
Age	16,802	42.47	25.60	4.00	23.00	37.00	57.00	117.00
Leverage	16,802	0.54	0.20	0.11	0.39	0.54	0.70	0.97
Liquidity	16,802	0.06	0.09	0.00	0.00	0.01	0.08	0.48
100Δln(Sales)	16,802	4.05	16.57	-63.36	-3.97	3.93	11.94	106.34

Notes: Summary statistics of the matched PPI and firm characteristics data set. Size is measured as the log of total assets. See the main text for details.

Table C.2: Mean Values of PPI Firms vs. Universe of Firms

Variable	PPI sample Mean	All firms Mean
Size	19.19	14.45
Age	42.47	13.40
Leverage	0.54	0.54
Liquidity	0.06	0.31
100Δln(Sales)	4.05	0.37
Observations	16,802	6,364,392

Notes: Mean values of the firms in the matched PPI data set compared to the universe of Swedish firms. Size is measured as the log of total assets. All variables are winsorized at the top and bottom one percent. See the main text for details.

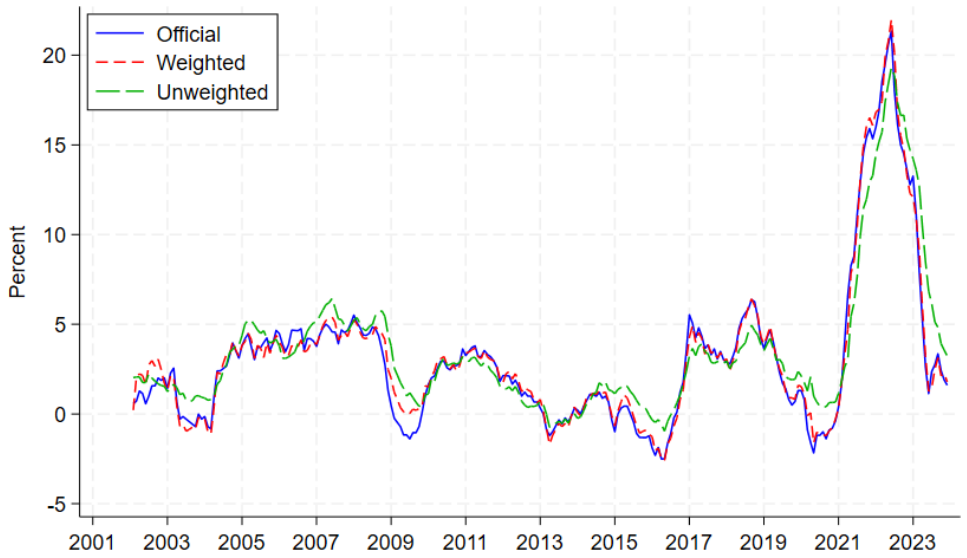
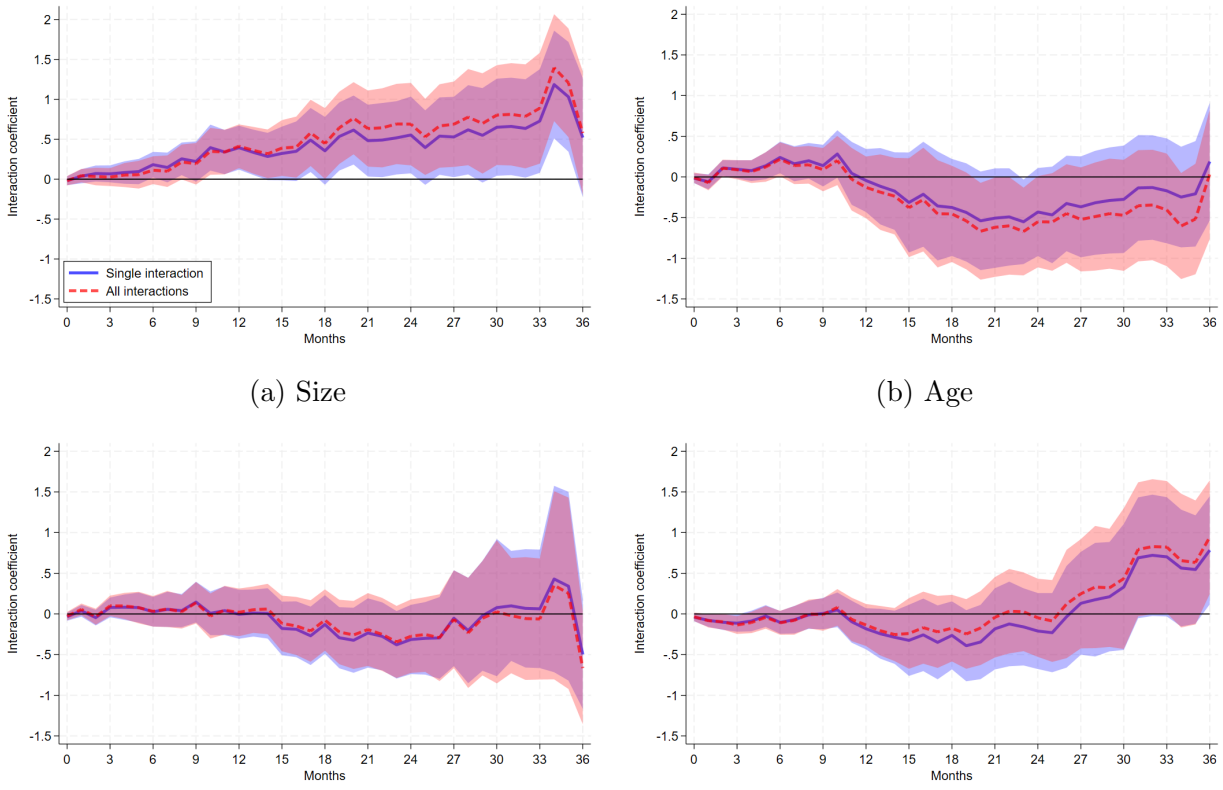


Figure C.1: Producer price inflation rates.
Notes: Year-on-year inflation rates from the official PPI index for the manufacturing sector published by SCB (blue solid line), the index recreated with the same weighting procedure using our final (cleaned) data set (red dashed line), and the unweighted index using our final data set (green dashed line).

D Robustness of the price responses



(a) Size

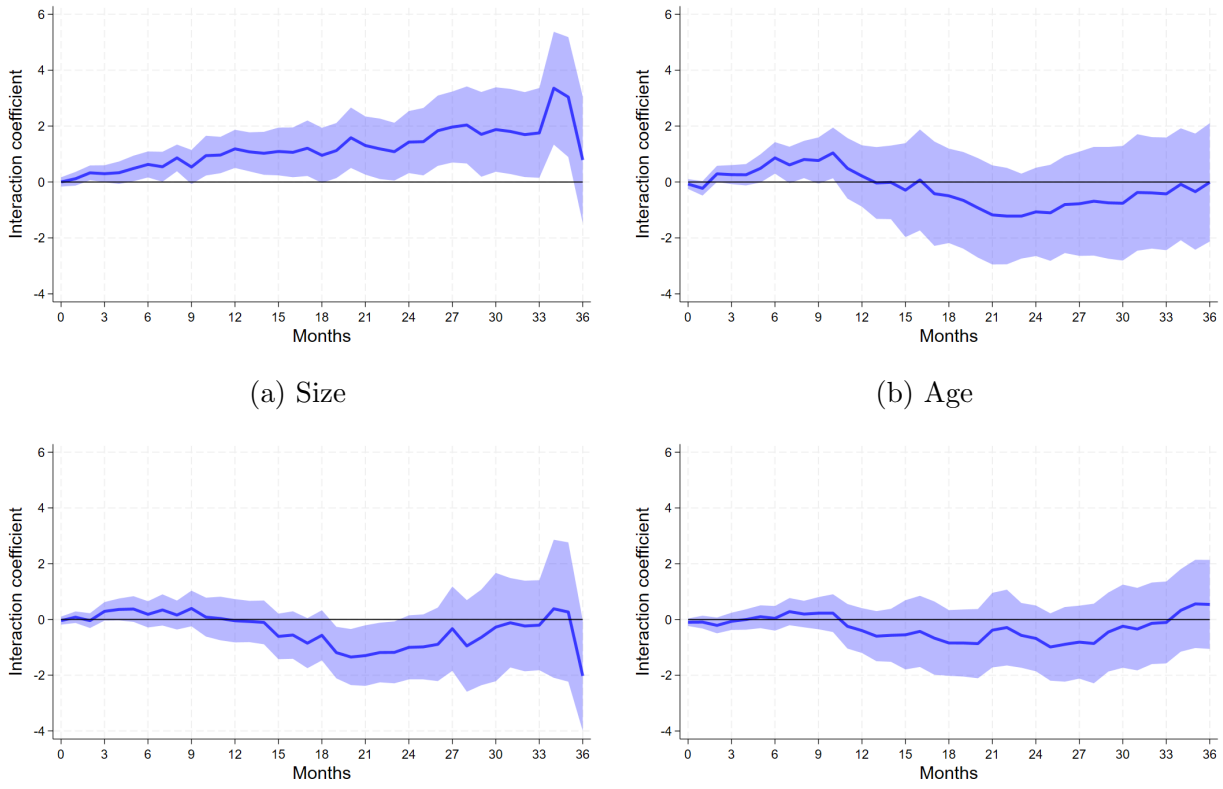
(b) Age

(c) Leverage

(d) Liquidity

Figure D.1: Dynamic differential price responses: Two-digit product group-by-time fixed effects.

Notes: Dynamics of the interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates when the interactions are estimated separately using the panel local projections in equation (4) and red dashed lines when they are estimated together using equation (5). In both equations, the time fixed effects have been replaced with two-digit product group-by-time fixed effects. Shaded regions report 90% confidence bands clustered at the firm level.



(a) Size

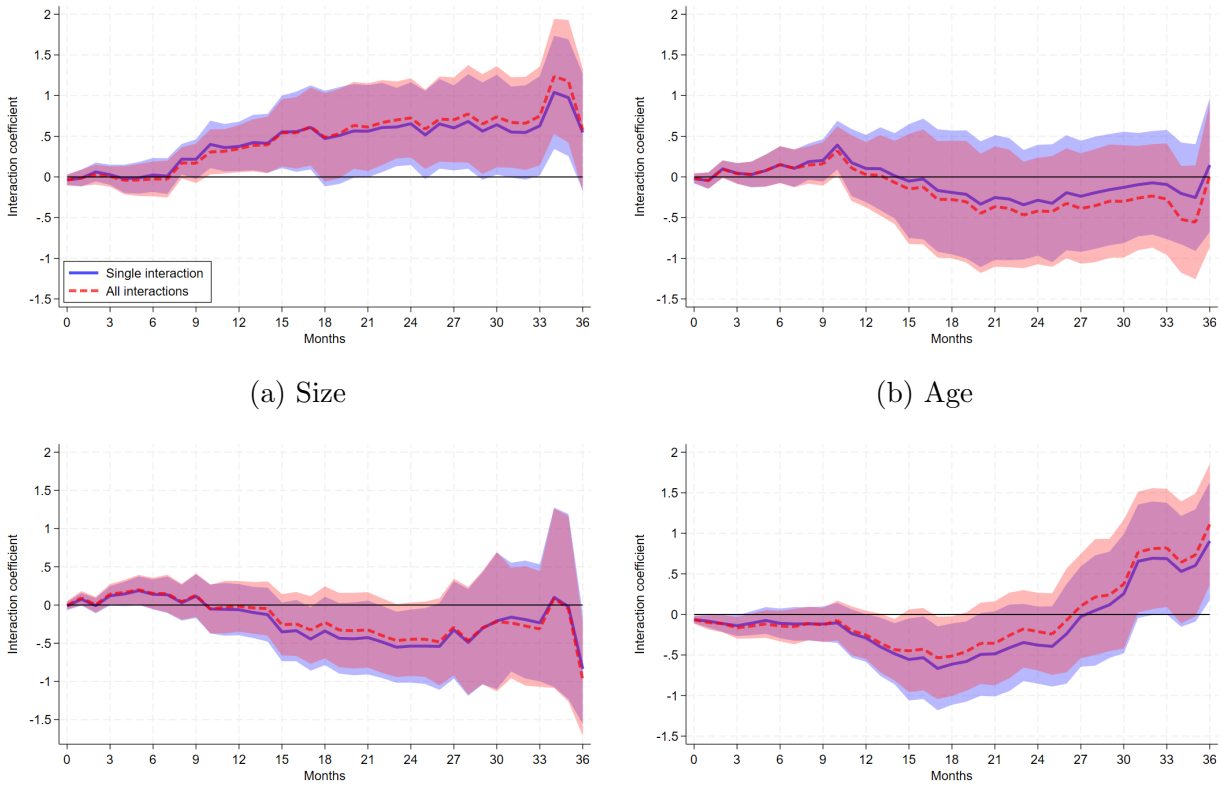
(b) Age

(c) Leverage

(d) Liquidity

Figure D.2: Dynamic differential price responses: Two-digit product group-by-time fixed effects.

Notes: Dynamics of the semi-parametric interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates from equation (6) where the time fixed effects have been replaced with two-digit product group-by-time fixed effects. Shaded regions report 90% confidence bands clustered at the firm level.



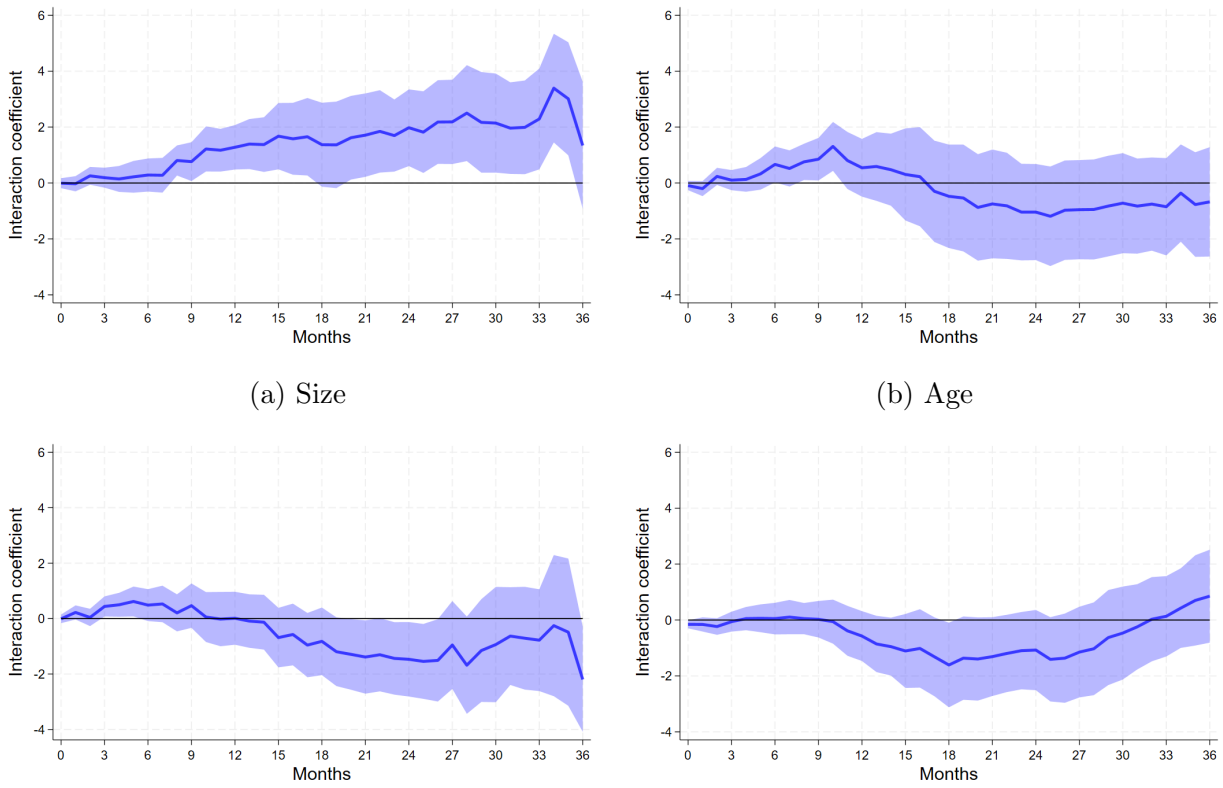
(a) Size

(b) Age

(c) Leverage

(d) Liquidity

Figure D.3: Dynamic differential price responses: Excluding the high inflation period.
Notes: Dynamics of the interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates when the interactions are estimated separately using the panel local projections in equation (4) and red dashed lines when they are estimated together using equation (5). Shaded regions report 90% confidence bands clustered at the firm level. Sample period: 2001:1 to 2020:12.



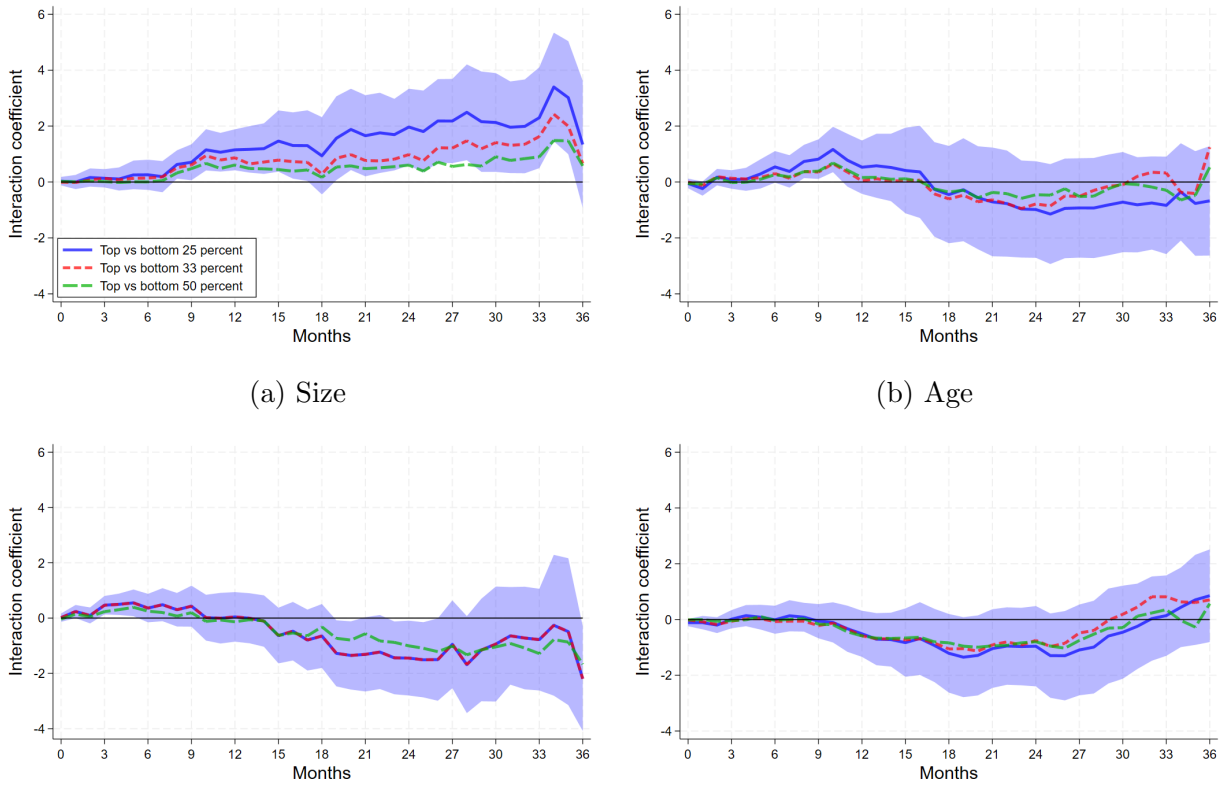
(a) Size

(b) Age

(c) Leverage

(d) Liquidity

Figure D.4: Dynamic differential price responses: Excluding the high inflation period.
Notes: Dynamics of the semi-parametric interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates from equation (6). Shaded regions report 90% confidence bands clustered at the firm level. Sample period: 2001:1 to 2020:12.



(a) Size

(b) Age

(c) Leverage

(d) Liquidity

Figure D.5: Semi-parametric estimates of differential price responses: alternative group splits for semi-parametric interaction.

Notes: Dynamics of the semi-parametric interaction coefficients between financial constraint proxies and a 25 bp unexpected tightening of monetary policy on prices. Blue solid lines report point estimates from equation (6). Shaded regions report 90% confidence bands clustered at the firm level. Red and green dashed lines report point estimates from equation (6) when the respective distribution have been split into the top and bottom 33 and 50 percent, respectively.

E Sales: Additional results

Table E.1: Summary Statistics: Non-Missing vs. Missing Observations

Variable	Obs.	Mean	Std.	Min	p25	p50	p75	Max
			(a) Non-missing					
Size	142,520	19.48	1.53	16.40	18.38	19.32	20.40	25.12
Age	142,520	43.64	25.88	4.00	24.00	38.00	59.00	117.00
Leverage	142,520	0.54	0.20	0.11	0.38	0.54	0.69	0.97
Liquidity	142,520	0.06	0.09	0.00	0.00	0.01	0.07	0.48
$100\Delta\ln$(Sales)	142,520	4.41	16.20	-63.36	-3.52	4.19	12.20	106.34
			(b) Missing					
Size	53,462	18.46	1.27	16.40	17.56	18.22	19.10	24.74
Age	53,462	39.72	24.67	4.00	21.00	35.00	53.00	117.00
Leverage	53,462	0.56	0.21	0.11	0.40	0.57	0.72	0.97
Liquidity	53,462	0.06	0.10	0.00	0.00	0.01	0.08	0.48
$100\Delta\ln$(Sales)	53,462	3.06	17.24	-63.32	-5.15	3.29	11.13	104.21

Notes: Summary statistics of firm characteristics of the firms in the matched PPI-IPI sample and the characteristics of the unique firms in our cleaned PPI sample for which the IPI data are not available. Size is measured as the log of total assets. See the main text for details.

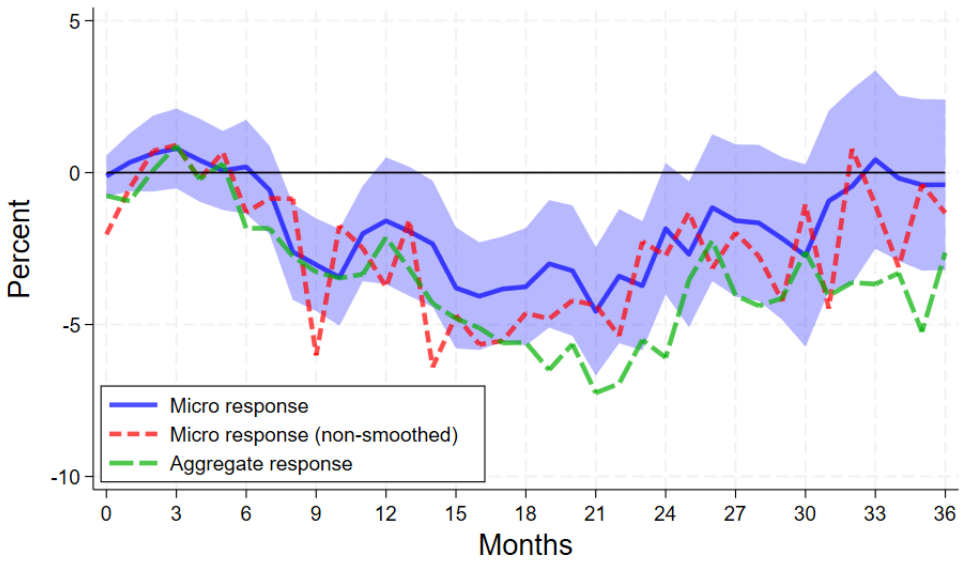
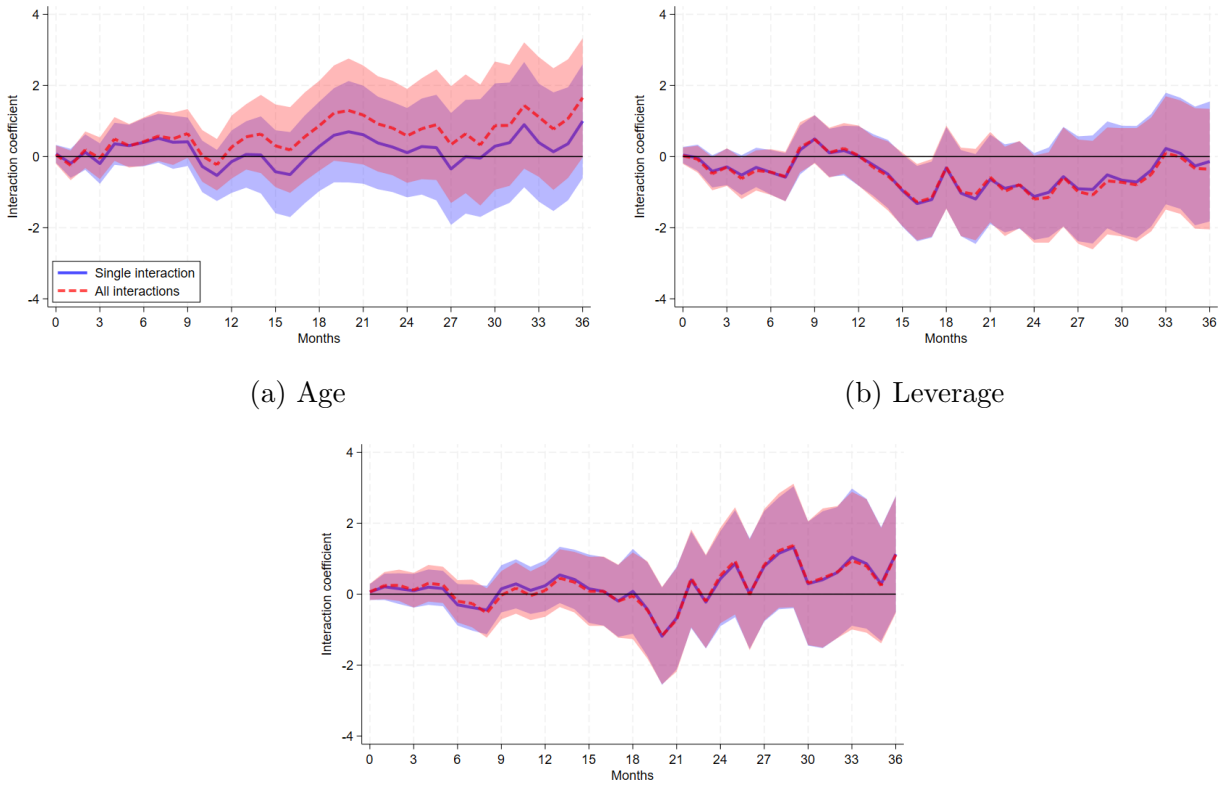


Figure E.1: Impulse response functions of firm-level and aggregate sales.
Notes: The blue solid line reports the point estimate of the average three-month centered moving average firm-level sales response to a 25 bp unexpected tightening of monetary policy from the panel local projection: $\Delta_h ln(Sales_{j,t+h}) = \alpha_{j,h} + \beta_h mps_t + \Gamma'_{1,h} Z_{j,t-1} + \Gamma'_{2,h} X_{t-1} + u_{j,t+h}$. The shaded region reports 90% confidence bands clustered two-way at the firm and time levels. The red dashed line shows the average firm-level sales response using non-smoothed sales. The green long dashed line shows the response of aggregate Industrial Production Index estimated using equation (2).



(a) Age

(b) Leverage

(c) Liquidity

Figure E.2: Dynamic differential sales response: The role of age, leverage, and liquidity.
Notes: Dynamics of the interaction coefficients between age, leverage, and liquidity and a 25 bp unexpected tightening of monetary policy on sales. Blue solid lines report point estimates when only one proxy for financial constraints is included at a time in the panel local projection, and red dashed lines show results for regressions with all four interactions (size, age, leverage, liquidity) jointly included. The outcome variable is the log change in sales. Shaded regions report 90% confidence bands clustered at the firm level.

F Debt: Additional results

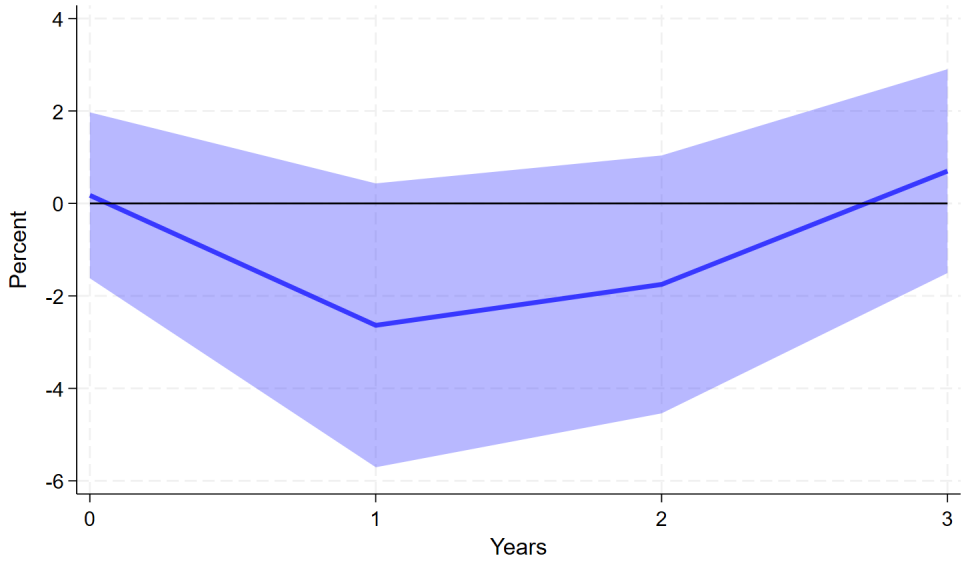
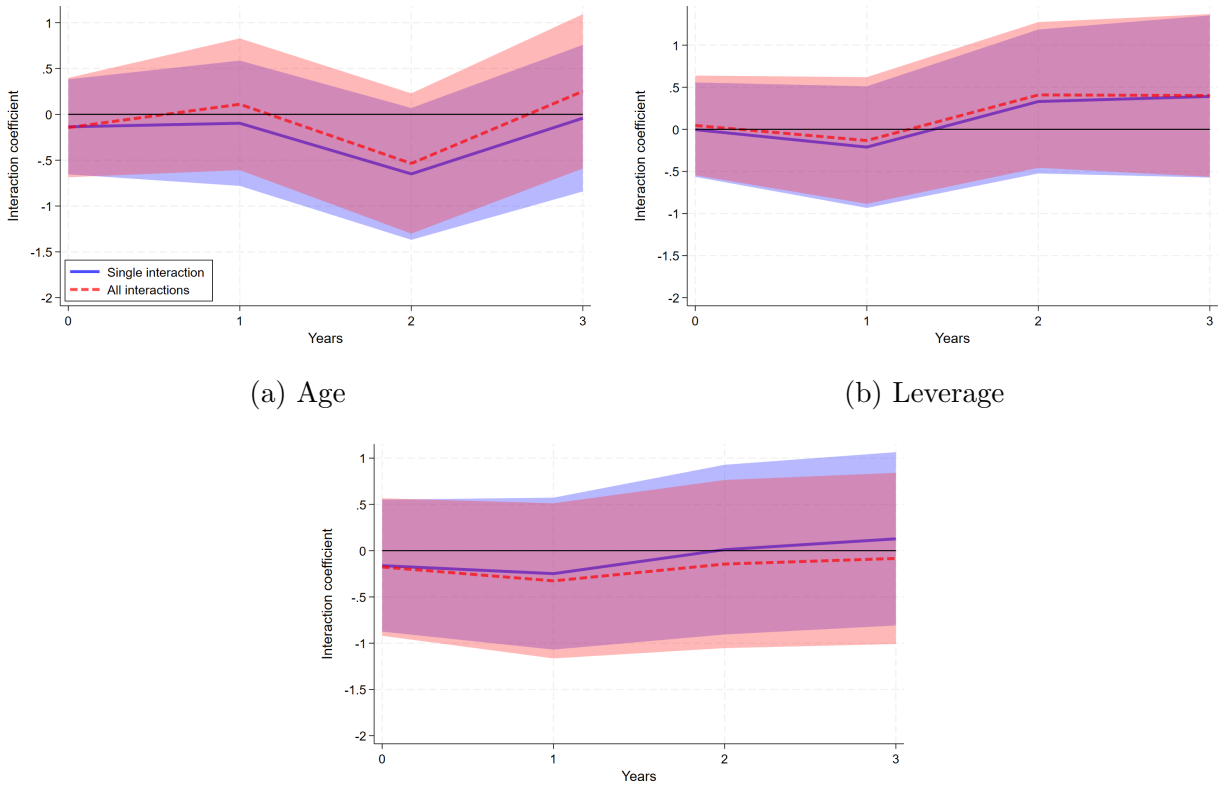


Figure F.1: Impulse response function of average firm-level debt to monetary policy.
Notes: The blue solid line reports the point estimate of the average firm-level debt response to a 25 bp unexpected tightening of monetary policy from the panel local projection: $\Delta_h ln(Debt_{j,t+h}) = \alpha_{j,h} + \beta_h mps_t + \Gamma'_{1,h} Z_{j,t-1} + \Gamma'_{2,h} X_{t-1} + u_{j,t+h}$, where mps_t is the yearly sum of the monetary policy surprises and X_{t-1} is the yearly average of the aggregate control variables described in equation (2). The shaded region reports 90% confidence bands clustered two-way at the firm and time levels.

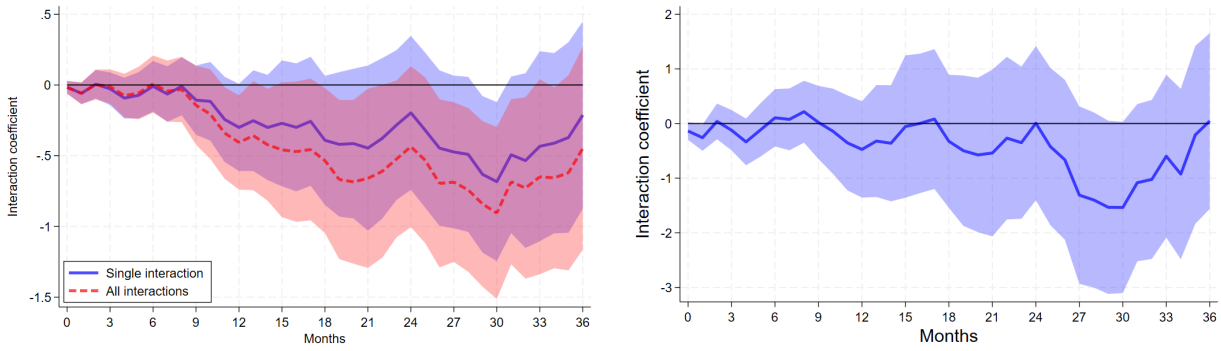


(a) Age

(b) Leverage

(c) Liquidity

Figure F.2: Dynamic differential debt response: The role of age, leverage, and liquidity.
Notes: Dynamics of the interaction coefficients between age, leverage, and liquidity and a 25 bp unexpected tightening of monetary policy on debt. Blue solid lines report point estimates when only one proxy for financial constraints is included at a time in the panel local projection, and red dashed lines show results for regressions with all four interactions (size, age, leverage, liquidity) jointly included. The outcome variable is log change in debt. Frequency is annual. Shaded regions report 90% confidence bands clustered at the firm level.



(a) Working capital (Linear)

(b) Working capital (Semi-parametric)

Figure F.3: Dynamic differential price responses: The role of working capital.

Notes: Dynamics of the interaction coefficients between working capital and a 25 bp unexpected tightening of monetary policy on prices. In panel (a), the blue solid line report the point estimate when the interaction is estimated separately using a version of the panel local projections in equation (4) with working capital as the main interaction and the red dashed line when it is estimated together using equation (5) with the working capital interaction as an additional regressor. In panel (b), the blue solid line report the point estimate comparing firms in the top quartile of the working capital distribution to those in the bottom quartile using an analogous semi-parametric panel local projection equation (6). Shaded regions report 90% confidence bands clustered at the firm level.

G Marginal cost: Additional results

Table G.1: Summary Statistics: Non-Missing vs. Missing Observations

Variable	Obs.	Mean	Std.	Min	p25	p50	p75	Max
Non-missing								
(a) Monthly Prices								
100Δln(Price)	140,669	0.22	3.14	-16.01	0.00	0.00	0.30	17.33
Share of price changes	140,669	0.47	0.07	0.36	0.41	0.48	0.51	0.67
Size of price changes	72,711	2.91	3.21	0	0.65	1.74	3.95	17.33
Products per firm	140,669	3.59	4.54	1	1	2	4	32
(b) Yearly Firm Characteristics								
Size	7,296	18.93	1.41	16.40	17.88	18.72	19.82	24.83
Age	7,296	39.52	23.80	4.00	22.00	34.00	53.00	117.00
Leverage	7,296	0.53	0.20	0.11	0.38	0.53	0.69	0.97
Liquidity	7,296	0.06	0.10	0.00	0.00	0.01	0.09	0.48
100Δln(Sales)	7,296	4.26	15.48	-63.36	-3.26	3.94	11.41	103.10
Missing								
(c) Monthly Prices								
100Δln(Price)	197,595	0.20	2.94	-16.02	0.00	0.00	0.00	17.33
Share of price changes	197,595	0.47	0.07	0.36	0.41	0.48	0.51	0.67
Size of price changes	86,341	2.94	3.27	0	0.64	1.75	4.02	17.33
Products per firm	197,595	4.05	5.08	1	1	2	5	32
(d) Yearly Firm Characteristics								
Size	9,506	19.39	1.59	16.40	18.23	19.19	20.32	25.12
Age	9,506	44.74	26.68	4.00	24.00	39.00	61.00	117.00
Leverage	9,506	0.55	0.20	0.11	0.40	0.56	0.71	0.97
Liquidity	9,506	0.05	0.09	0.00	0.00	0.01	0.06	0.48
100Δln(Sales)	9,506	3.89	17.36	-63.32	-4.58	3.92	12.43	106.34

Notes: Summary statistics of the firm characteristics of the non-missing vs. missing observations in the marginal cost sample.

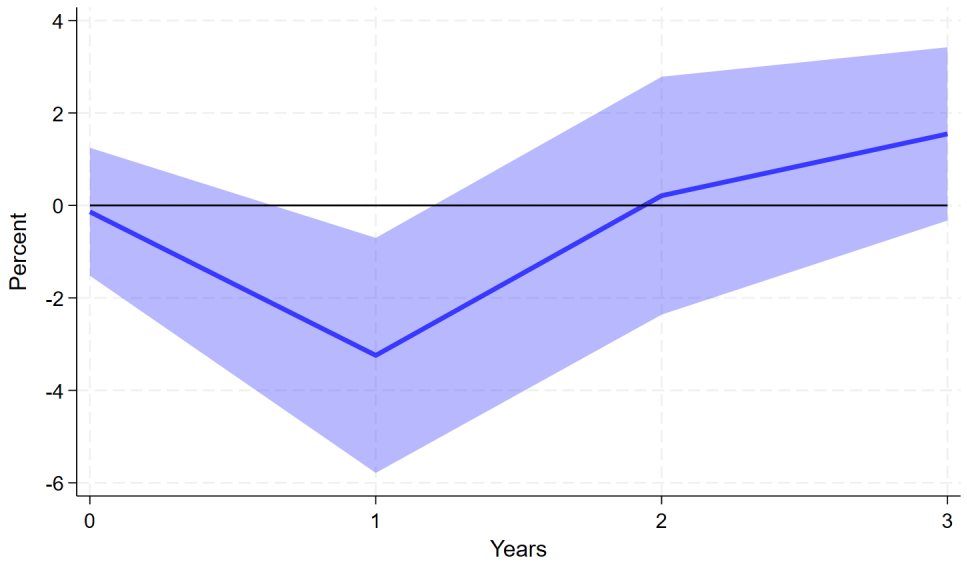
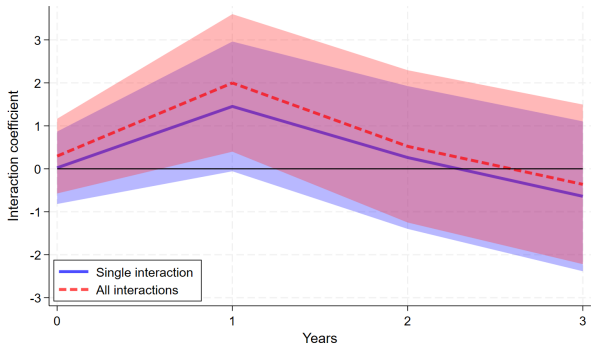
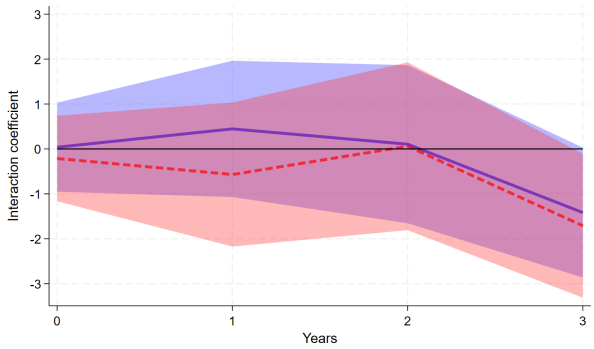


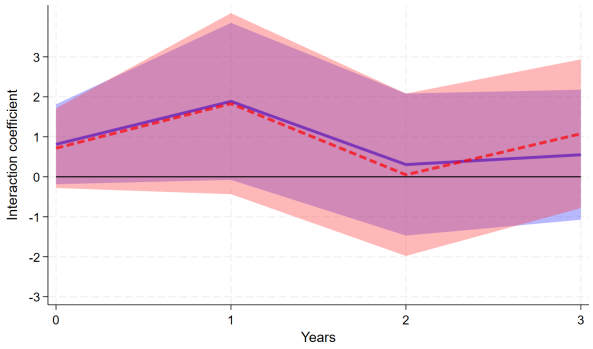
Figure G.1: Impulse response function of average firm-level marginal cost to monetary policy.
Notes: The blue solid line reports the point estimate of the average firm-level marginal cost response to a 25 bp unexpected tightening of monetary policy from the panel local projection: $\Delta_h ln(MC_{j,t+h}) = \alpha_{j,h} + \beta_h mps_t + \Gamma'_{1,h} Z_{j,t-1} + \Gamma'_{2,h} X_{t-1} + u_{j,t+h}$, where mps_t is the yearly sum of the monetary policy surprises and X_{t-1} is the yearly average of the aggregate control variables described in equation (2). The shaded region reports 90% confidence bands clustered two-way at the firm and time levels.



(a) Age



(b) Leverage



(c) Liquidity

Figure G.2: Dynamic differential marginal cost response: The role of age, leverage, and liquidity.

Notes: Dynamics of the interaction coefficients between age, leverage, and liquidity and a 25 bp unexpected tightening of monetary policy on marginal cost. Blue solid lines report point estimates when only one proxy for financial constraints is included at a time in the panel local projection, and red dashed lines show results for regressions with all four interactions (size, age, leverage, liquidity) jointly included. Outcome variable is log change in marginal cost. Frequency is annual. Shaded regions report 90% confidence bands clustered at the firm level.