

Prices and Monetary Policy: The Role of Financial Constraints

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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.

Monetary transmission to inflation

- Ability of monetary policy to influence prices and control inflation shifted back into focus since 2021
- Deep understanding of monetary transmission requires micro-level evidence on households/firms/banks
- Growing body of evidence on firm-level response to monetary policy
 - Heterogeneous impact on investment, employment, sales, stock prices, ...
 - Strong focus on role of financial constraints
 - *Little to no evidence on heterogeneous effects on prices*
- How does monetary policy affect firm-level prices?
- What is the role of firm heterogeneity, especially in financial constraints, for monetary transmission to inflation?

New analysis using Swedish microdata

- Construct high-frequency identified monetary policy surprises for Sweden
- Comprehensive firm-level panel data with product prices and sales matched to firm financials
- *Heterogeneity*: prices of smaller firms are less responsive to monetary policy
 - In response to a contractionary policy shock, prices of smaller firms *fall by about half as much* as the prices of larger firms
 - Other common proxies for financial constraints—leverage, liquidity, age—do not capture any meaningful heterogeneity
- *Aggregate relevance*: absent financial constraints, the PPI response to monetary policy would be 14–34% larger
- *Contrast with investment*: financial constraints *amplify* the investment response but *mute* the price response

Customer markets and financial frictions

- What explains muted price response of smaller, financially constrained firms?
 - Sticky customer base → set low prices to invest into future market share
 - Financial frictions create trade-off: invest in customer base to generate future revenue or generate higher cash flows today and avoid costly external finance
 - Monetary contraction → increases external finance premium → smaller, more constrained firms invest less in customer base and set higher prices
- Supporting evidence for this channel
 - Sales of smaller firms have stronger negative response, lose market share
 - Smaller firms have more bank debt, and they lower debt more
 - Markups of smaller firms increase relative to large firms
- Rule out other explanations (less sophisticated price setting, working capital, market share, export share, and cost structure)

Related literature

- **Financial frictions and heterogeneous monetary transmission to investment:** Gertler and Gilchrist (1994), Ottonello and Winberry (2020), Durante et al. (2022), Cloyne et al. (2023), Jungherr et al. (2024), Jeenas (2026)
- **Size as a proxy for financial constraints:** Gertler and Gilchrist (1994), Oliner and Rudebusch (1996), Hadlock and Pierce (2010), Crouzet and Mehrotra (2020)
- **Heterogeneous price response to financial shocks:** Gilchrist and Zakrajšek (2016), Gilchrist et al. (2017), Gilchrist et al. (2023), Renkin and Züllig (2024)
- **Heterogeneous price response to monetary policy:** Aruoba and Drechsel (2024), Kim and Park (2024), Core et al. (2025)
- **Models of customer markets and financial frictions:** Gottfries (1991), Chevalier and Scharfstein (1996), Gilchrist et al. (2017)

Riksbank policy surprises

High-frequency surprises for the Riksbank

- “*Monetary policy surprises*” — high-frequency changes in interest rates around central bank policy announcements
 - Widely used in macro-finance to estimate *causal effects* on financial markets, expectations, and macroeconomic outcomes
 - For the Fed: [U.S. Monetary Policy Event-Study Database](#) (Acosta et al., 2025) — reference data source for FOMC surprises with regular updates
- Riksbank targets 2% inflation; Executive Board meets 5–9 times per year and announces decision day after meeting
- Daily change of *Forward Rate Agreements* on Riksbank announcement days
 - 3-month STIBOR as underlying asset
 - First principal component of FRA contracts with maturity 1–4 quarters
 - Normalize surprise to have one percentage point effect on 4-quarter FRA
- Sample: 149 announcement surprises over 2001–2023

Effects on asset prices: event-study regressions

$$\Delta y_t = \alpha + \beta mps_t + u_t$$

Δy_t : daily change in interest rate or log asset return

mps_t : monetary policy surprise, normalized to 100 bp. t announcement days

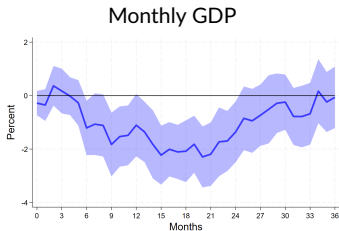
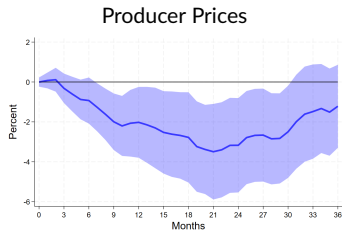
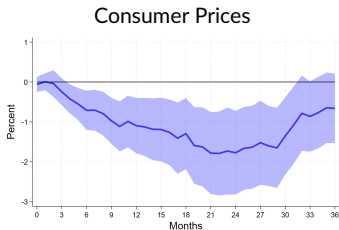
(A) Interest Rates

	3m yield	2yr yield	10yr yield	2yr mrtg. rate	5yr mrtg. rate
β	0.63*** (0.11)	0.82*** (0.08)	0.50*** (0.09)	0.91*** (0.08)	0.73*** (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*** (0.75)	-3.31*** (0.72)	-2.68*** (0.58)	3.68* (2.14)	4.31* (2.21)
R^2	0.22	0.13	0.21	0.04	0.05

Effects of a contractionary monetary policy shock



Response to 25 bp tightening surprise

LP specification

Response of firm-level prices to monetary policy

Data on product prices

- Product-level microdata underlying Statistics Sweden's *Producer Price Index* for manufacturing
 - Manufacturing sector, goods sold on domestic market
 - 60% of goods production and 15% of GDP
 - Monthly frequency, January 2001 to December 2023
- Unbalanced panel: 340,600 product-month price observations, 4,397 products, 2,195 unique firms
- Each observation: average transaction price in a given month of representative product within 8-digit CN code
 - Example: "New pneumatic tyres, of rubber, of a kind used for motorcycles"

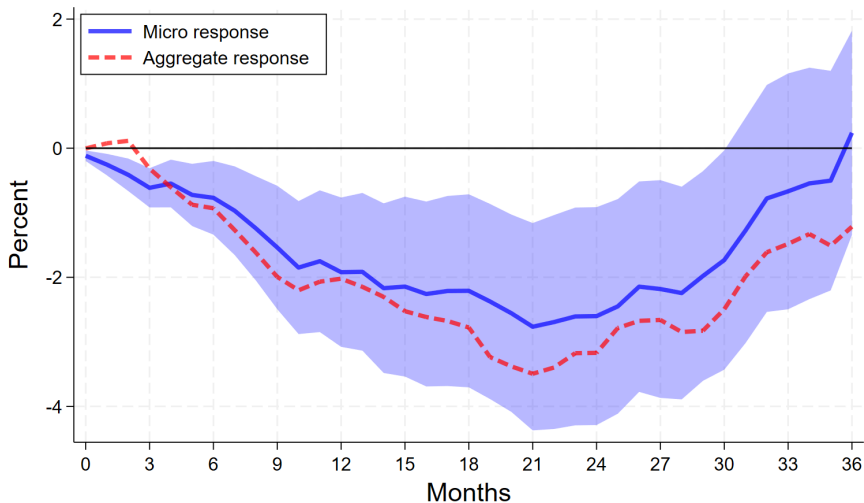
PPI inflation: micro vs. macro

Firm financials

- Yearly financial statements—balance sheets and income statements
- Source: Swedish credit bureau (Upplysningscentralen) and Swedish Companies Registration Office (Bolagsverket)
- Coverage: near universe of Swedish companies (public and private)
 - Firms uniquely identified with firm ID that allows matching across datasets
- Firm characteristics
 - Size: log total assets
 - Liquidity: (Cash and bank + short-term investments)/Total assets
 - Leverage: (Short- + long-term debt)/Total assets
 - Age: years since registration
 - Sales growth: log change in annual total revenue

Descriptive statistics

Micro vs. macro response of goods inflation



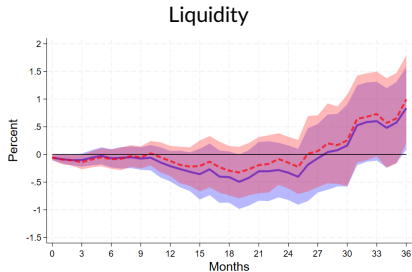
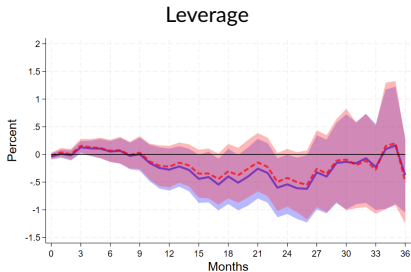
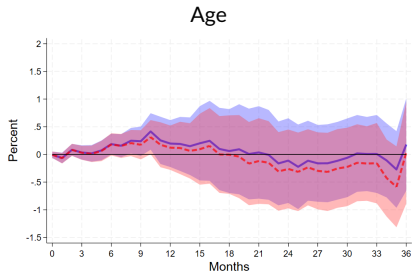
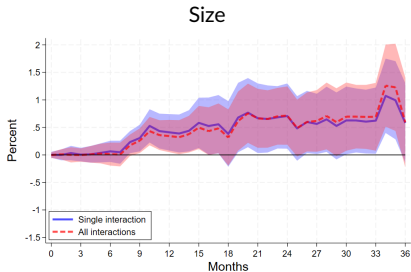
Specification

Differential price response conditional on financial constraints proxies

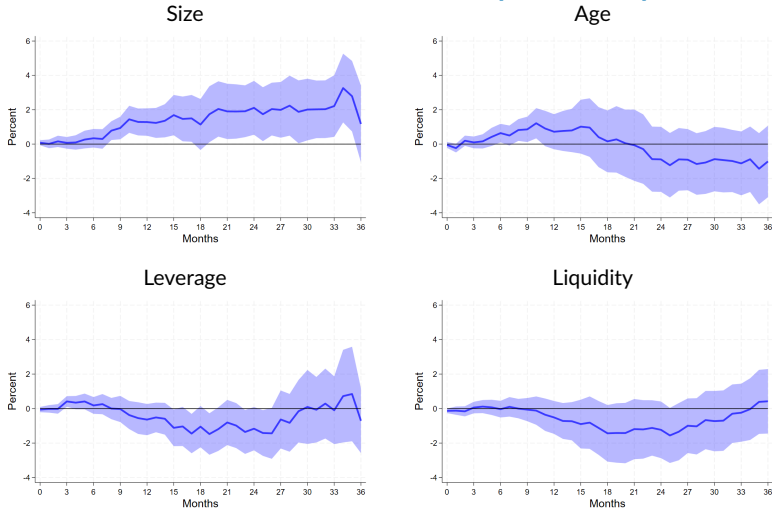
$$\Delta_h \ln(P_{i,t+h}) = \alpha_{i,h} + \alpha_{t,h} + \beta_h(mps_t \times FC_{j,t-1}) + \Gamma'_h Z_{j,t-1} + u_{i,t+h}$$

- $\alpha_{i,h}$: product fixed effects
- $\alpha_{t,h}$: time fixed effects
- $FC_{j,t-1}$: proxies for financial constraints, measured in previous year
 - Size, Age, Leverage, Liquidity (all standardized)
 - *Sign: higher values indicate more constrained*
(smaller, younger, less liquid, more levered)
- $Z_{j,t-1}$: size, sales growth, liquidity, leverage, $FC_{j,t-1}$
- Standard errors clustered at firm level (Petersen, 2009)
- Alternative specification: include all four interactions jointly
 - Does each proxy have a distinct and independent role?

Differential price response by financial constraint proxy



Semi-parametric estimates of differential price response



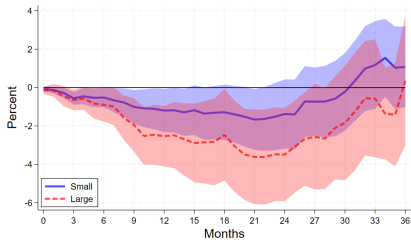
Interaction with indicator for most constrained quartile; middle two quartiles dropped

Specification

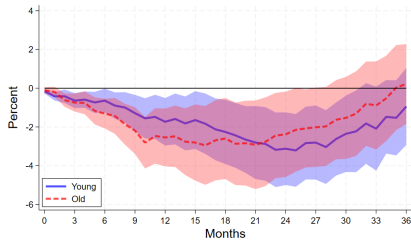
Alternative splits

Group-specific price response

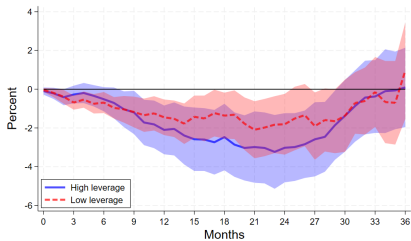
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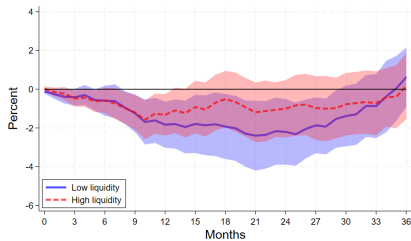
Age



Leverage



Liquidity



Prices of smaller firms respond less to monetary policy

- Difference is statistically and economically significant
 - Firms one SD below average size lower prices about a *quarter less* at the trough ($h = 21$)
 - Top size quartile roughly *twice* as responsive as bottom quartile
- Quantitatively relevant for *aggregate producer prices*
 - Smallest size quartile accounts for 22% of aggregate PPI weights
 - Absent financial constraints, aggregate PPI response would be *14–34% larger*
Counterfactuals
- *Robust* across specifications
 - Sector-by-time fixed effects absorb industry differences in demand elasticity
 - Semi-parametric interactions, sample ending 2020:12, interactions with export share, market share, working capital **Estimates**

Understanding the mechanism:
customer markets and financial frictions

Financial frictions, customer markets, and price setting

- *Financial accelerator*: monetary tightening weakens balance sheets and raises the *external finance premium* (EFP), most for constrained firms (BGG, 1999)
 - Amplifies their *investment* response (Durante et al., 2022; Cloyne et al., 2023; Jeenas, 2026)
- *Customer markets*: customer base is an asset firms invest in (Gottfries, 1991; Chevalier and Scharfstein, 1996; Gilchrist et al., 2017)
 - Base is sticky through deep habits or switching costs
 - Lower price today $\Rightarrow$ larger future base, market share, and profits
- Together: a trade-off between *customer base and current cash flow*
 - Cutting prices requires liquidity; higher EFP raises shadow value of internal funds
 - Constrained firms become more myopic, set higher prices to generate current revenue, and sacrifice future market share

Testable predictions

If customer markets and financial frictions drive the muted price response of smaller firms, then after a *monetary tightening* these firms should also:

- Lose *market share*: larger decline in sales
 - They forgo investment in the customer base
- Reduce debt more
 - Stronger sensitivity of their external finance premium
- Muted price response does not reflect costs but *markups*
 - Marginal costs of smaller firms at least as responsive as for larger firms
 - Set *higher markups* than larger firms

Why is size our best proxy for financial constraints?

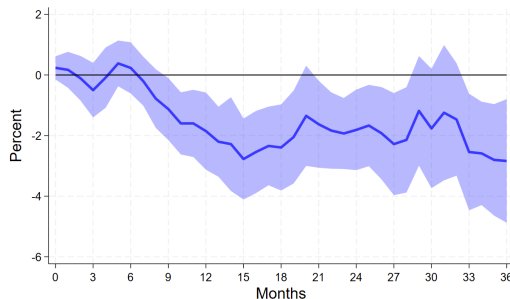
- Size captures a firm's *structural position in credit markets*
 - Small firms depend on bank lending and cannot substitute toward capital markets when policy tightens (Gertler and Gilchrist, 1994; Oliner and Rudebusch, 1996)
 - Hadlock and Pierce (2010): *size and age* the most reliable predictors of constraint status $\Rightarrow$ SA index
- Leverage and liquidity are *outcomes* of financial decisions
 - High leverage: borrowing up to the limit, or cheap credit access?
 - Both respond to monetary policy, so ex-post heterogeneity partly reflects the shock itself
- Size is measured more cleanly
 - Size is highly persistent
 - Balance sheet ratios volatile, noisy, subject to accounting discretion (especially for private firms)
 - Farre-Mensa and Ljungqvist (2016): standard indices fail on public firms; among private firms, the *smallest* behave as constrained

Smaller firms are more financially constrained

Size group	Q1	Q2	Q3	Q4
<i>(A) Firm Characteristics</i>				
Debt to credit institutes	0.28	0.19	0.14	0.09
Collateral over total debt	1.14	0.75	0.47	0.25
Utilized credit lines	0.40	0.36	0.37	0.24
Default probability (%)	0.65	0.56	0.53	0.50
Age	34.1	38.9	44.1	52.7
Leverage	0.40	0.39	0.39	0.40
Liquidity	0.07	0.06	0.05	0.04
<i>(B) Financial Constraint Indices</i>				
FCP index (Schauer et al., 2019)	-0.98	-1.16	-1.25	-1.35
WW index (Whited and Wu, 2006)	-0.10	-0.15	-0.19	-0.27
SA index (Hadlock and Pierce, 2010)	-2.39	-3.20	-3.85	-4.76

- Smaller firms rely more on *bank debt*, pledge more collateral, and use more of their granted credit lines
- *Leverage* essentially unrelated to size; smaller firms hold somewhat *more liquidity*, as in Crouzet and Mehrotra (2020)
- All three composite indices classify smaller firms as *more constrained*

Differential sales response by size



- Sales of smaller firms fall more after MP tightening
- At trough ($h = 35$): sales of firms one SD smaller fall by additional 3.1 pp
- Differential price response builds up *earlier* than differential sales response
- Output cost of disinflation about *five times* larger for small firms ($h = 21$)

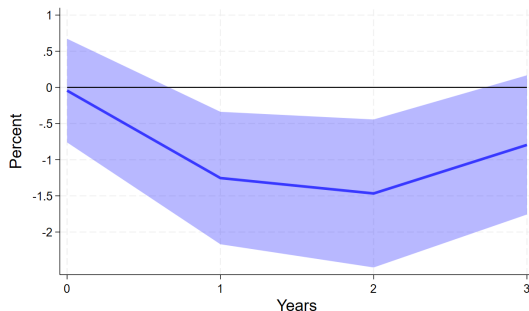
Data and specification

Average response

Age, Leverage, Liquidity

Sacrifice ratios

Differential debt response of smaller firms



- Smaller firms lower debt more in response to monetary policy tightening
- Firms one SD smaller lower debt by 1.3 pp more at the one-year horizon
- Points to more responsive *external finance premium* (not just weaker loan demand): smaller firms rely more on bank debt, pledge more collateral, and draw more on credit lines

Average response

Age, Leverage, Liquidity

Alternative explanations

Differences in price adjustment patterns?

- Rational inattention and costly information acquisition: firms with *coarser pricing policies* respond less to aggregate shocks (Stevens, 2020)
- Survey evidence *suggests* smaller Swedish firms adjust prices less often (Apel et al., 2005)

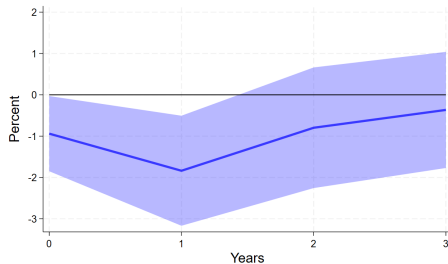
Size group	Q1	Q2	Q3	Q4
Mean price change (%)	0.20	0.20	0.20	0.24
Share of price changes	0.47	0.47	0.47	0.47
Size of price changes	3.03	2.86	2.81	3.00

- Frequency and size of price changes *virtually identical* across the size distribution
- Group-specific responses react with similar *persistence*; small firms simply respond less

Results robust to accounting for size-related firm characteristics

- Working capital
 - Firms pre-fund variable production $\Rightarrow$ higher interest rates raise marginal cost $\Rightarrow$ prices *increase* (Christiano and Eichenbaum, 1992; Christiano et al., 2015)
 - Working capital = (inventories + accounts receivable – accounts payable) / sales (Barth and Ramey, 2002) [Results](#)
- Market share
 - Large firms have higher markups and absorb cost shocks into markups rather than adjust prices (Atkeson and Burstein, 2008; Amiti et al., 2019)
 - Market share = firm-level sales / 3-digit sector sales [Results](#)
- Export share
 - Large firms have higher export shares and are more exposed to exchange rates
 - Export share = sum of exports / sales [Results](#)

Differential response of marginal cost?

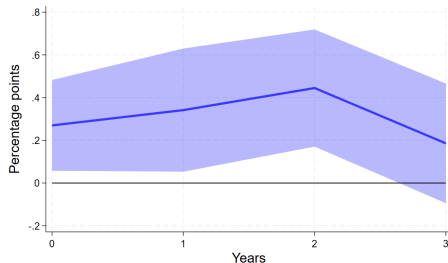


- Could differences in *production structure* explain the muted price response?
 - If MC of small firms *less responsive* to MP, prices would also respond less
- Measure firm-level marginal cost as *average variable cost* following Gagliardone et al. (2025): $(\text{Personnel costs} + \text{materials} + \text{other external expenses}) / \text{Real sales}$
- MC of smaller firms falls *more* than for larger firms at the one-year horizon
- Suggests smaller firms set *higher markups* than larger firms, consistent with theory

Average response

Age, Leverage, Liquidity

Differential gross profit margin response by size



- Use gross profit margins as a proxy for markups (Renkin and Züllig, 2024)
 - Profit margins of smaller firms remain *higher* after monetary contraction
 - Same magnitude as the average decline: margins of smaller firms roughly *flat*, those of larger firms *fall*
- ⇒ Smaller firms set *higher markups* and generate liquidity rather than invest in customer base

Average response

Age, Leverage, Liquidity

Conclusion

- Smaller/more constrained firms exhibit *muted* price response, in contrast to *amplified* investment response previously documented
- Evidence consistent with models of *customer markets and financial frictions*
 - Constrained firms invest less in customer base and lose market share
 - Their financing cost appears more responsive to changes in monetary policy
 - Smaller firms set higher markups to generate liquidity
 - Robust to alternative explanations
- Financial constraints weaken monetary transmission to inflation and worsen output-inflation trade-off for monetary policy
 - Aggregate PPI response would be 14–34% larger absent financial constraints
 - Output cost of disinflation about five times larger for small firms
 - Dampening should be strongest during periods of financial stress

Appendix

How much does this heterogeneity matter for aggregate PPI?

- Combine group-specific responses with PPI weights (22% smallest quartile, 35% largest)
 - No “missing intercept” problem here: differential estimates with and without time fixed effects are similar (Wolf, 2023; Krusell et al., 2026)

At $h = 21$	Price response	Contribution to PPI
Largest quartile	−3.9%	47%
Smallest quartile	−2.1%	16%
Implied aggregate	−2.9%	
<i>Counterfactuals</i>		
Small firms respond like large	−3.3%	+14%
All firms respond like largest quartile	−3.9%	+34%

Financial constraints *materially dampen* the aggregate price effect of monetary policy

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Alternative regression specifications and robustness

Estimates of differential price response depending on size, horizon $h = 21$ months:

	Linear: $mps_t \times Size_{j,t-1}$			Semi-parametric: $mps_t \times I_{j,t-1}^{FC}$		
	(1)	(2)	(3)	(4)	(5)	(6)
β_{21}	0.67** (0.33)	0.65** (0.30)	0.71** (0.33)	1.90* (0.98)	1.47** (0.66)	1.96** (1.00)
R^2	0.29	0.37	0.29	0.32	0.44	0.31
Obs.	246,773	246,577	231,152	121,098	120,662	113,229
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

- Different demand elasticities across sectors? 2-digit product group-by-time fixed effects [Linear](#) [Semi-parametric](#)
- Driven by the high-inflation period? End sample in December 2020 [Linear](#) [Semi-parametric](#)

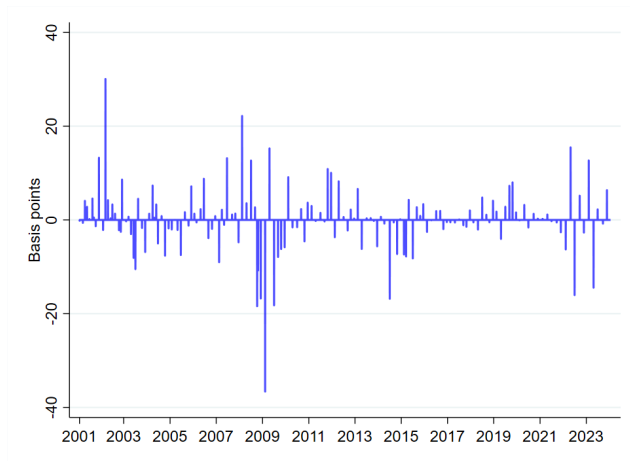
Muted prices and amplified sales: a worse trade-off

- Group-specific *sacrifice ratio*: cumulative sales decline over cumulative price decline (Ball, 1994)

	$H = 9$	$H = 12$	$H = 15$	$H = 18$	$H = 21$	$H = 24$
<i>Large firms (top size quartile)</i>						
Avg. prices	-0.82	-1.21	-1.49	-1.68	-1.91	-2.11
Avg. sales	-0.37	-0.50	-0.52	-0.66	-0.66	-0.62
Sacrifice ratio	0.45	0.42	0.35	0.39	0.35	0.29
<i>Small firms (bottom size quartile)</i>						
Avg. prices	-0.50	-0.65	-0.76	-0.84	-0.94	-1.01
Avg. sales	-0.46	-0.88	-1.18	-1.51	-1.78	-1.72
Sacrifice ratio	0.92	1.35	1.56	1.79	1.90	1.71

- At $h = 21$: roughly *five times* as much output loss per unit of disinflation for small firms
- Financial constraints worsen the aggregate output-inflation trade-off

Monetary policy surprises over time



Mean: 0 bp Std.: 7.34 bp

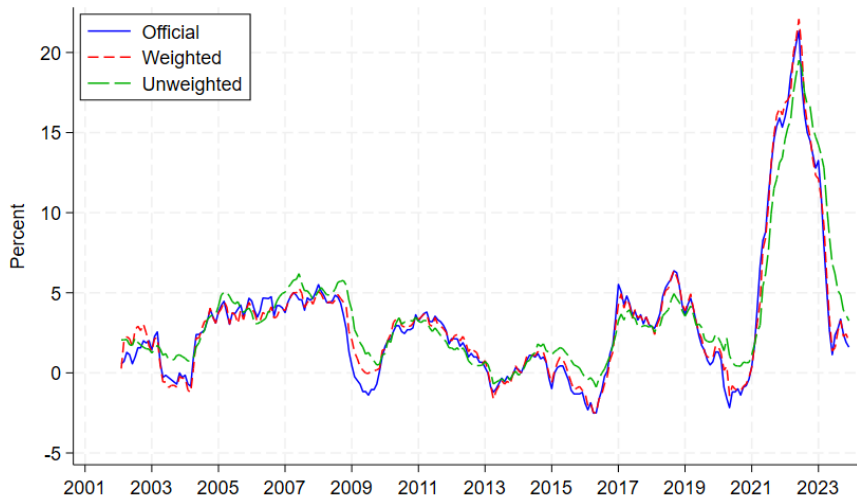
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Effects on the macroeconomy: Jordà local projections

$$Y_{t+h} - Y_{t-1} = \alpha_h + \beta_h mps_t + \Gamma'_h X_{t-1} + u_{t+h}$$

- Y : log CPIF (consumer prices), PPI (producer prices), or GDP; unemployment rate
- mps_t : monthly monetary policy surprise. Now normalized to 25 basis point unexpected tightening.
- X_{t-1} : 12 lags of log GDP, CPIF, commodity price index, KIX/SEK exchange rate, OMXSPI stock market index
- Heteroskedasticity-robust (White) SEs (Montiel Olea and Plagborg-Møller, 2021). We show 90% confidence intervals.

PPI inflation according to macro series and our micro data



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Average product-level price response: specification

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

- $\alpha_{i,h}$: product fixed effects, $\alpha_{m,h}$: calendar-month fixed effects
- X_{t-1} : same aggregate controls as in the aggregate local projections
- $Z_{j,t-1}$: size, sales growth, leverage, liquidity of producing firm j
- Standard errors clustered two-way at firm and time levels

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Semi-parametric interactions: specification

- Linear interactions impose strong parametric constraints on heterogeneity
- More flexible: “semi-parametric” specification (e.g., Cloyne et al., 2023)
 - Split prices into quartiles based on the characteristics of the producing firm
- Estimate differential price response of products produced by most constrained firms:

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

- $I_{j,t-1}^{FC}$: equal to one if producing firm j were in most constrained quartile
- Drop observations in middle two quartiles
- Can also estimate group-specific response to monetary policy shocks (dropping time fixed effects)

Estimating the response of firm-level sales

- Monthly firm-level sales from microdata underlying Sweden's Industrial Production Index (IPI)
 - Matched to PPI data using firm ID; covers 73% of our PPI sample
 - Deflated by firm-level average price to obtain real sales
 - Winsorize at 5% level and take the three-month centered moving average

- Same local projection approach as for prices, with sales as outcome:

$$\Delta_h \ln(\text{Sales}_{j,t+h}) = \alpha_{j,h} + \alpha_{t,h} - \beta_h(\text{mps}_t \times \text{Size}_{j,t-1}) + \Gamma'_h Z_{j,t-1} + u_{j,t+h}$$

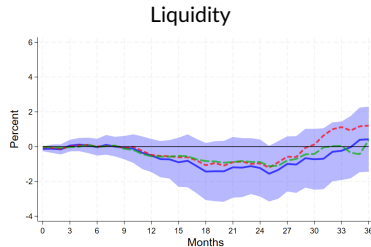
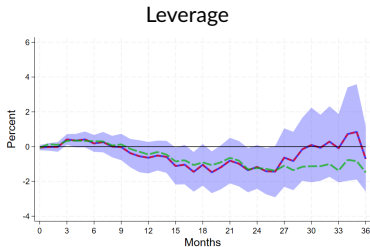
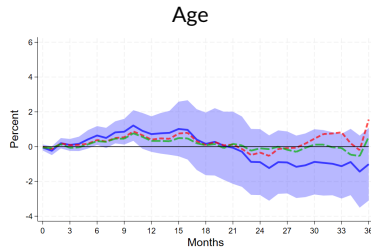
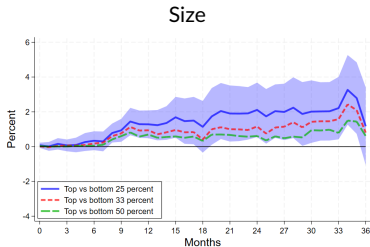
- $\alpha_{j,h}$: firm fixed effects, $\alpha_{t,h}$: time fixed effects

Descriptive statistics

Variable	Obs.	Mean	Std.	Min	p25	p50	p75	Max
<i>(A) Monthly Prices</i>								
100 $\Delta\ln(\text{Price})$	340,600	0.21	3.02	-15.98	0.00	0.00	0.10	17.29
Share of price changes	340,600	0.47	0.07	0.35	0.41	0.48	0.50	0.67
Size of price changes	159,908	2.92	3.24	0	0.64	1.75	3.98	17.29
Products per firm	340,600	3.87	4.88	1	1	2	4	32
<i>(B) Yearly Firm Characteristics</i>								
Size	16,919	19.19	1.53	16.40	18.06	19.00	20.13	25.12
Age	16,919	42.43	25.65	4.00	23.00	37.00	57.00	117.00
Leverage	16,919	0.40	0.20	0.04	0.23	0.39	0.55	0.89
Liquidity	16,919	0.06	0.09	0.00	0.00	0.01	0.08	0.46
100 $\Delta\ln(\text{Sales})$	16,919	3.55	17.27	-99.68	-4.18	3.84	11.80	99.75

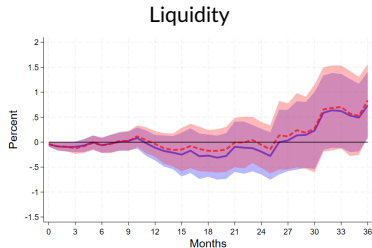
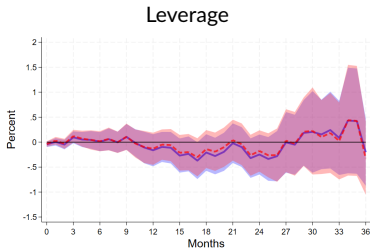
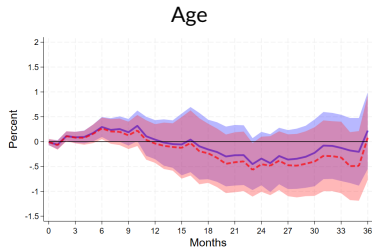
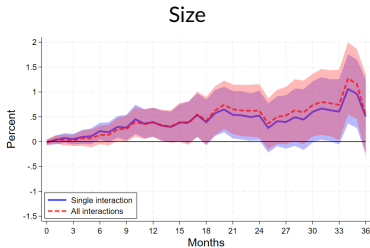
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Impulse response functions: alternative splits



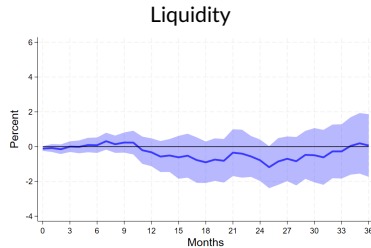
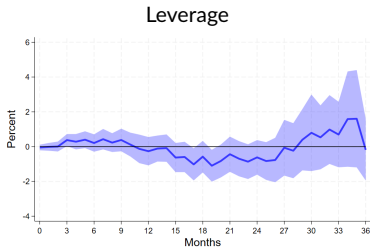
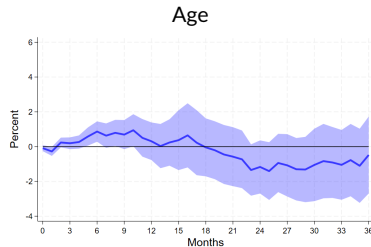
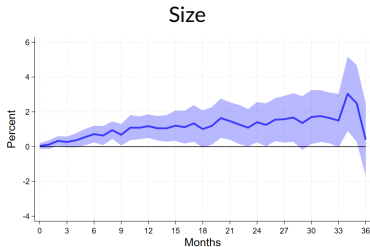
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Impulse response functions: 2-digit pg tfe



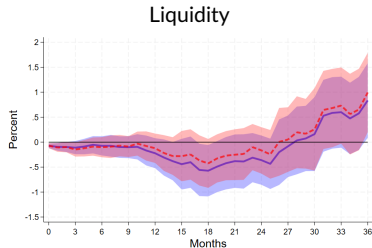
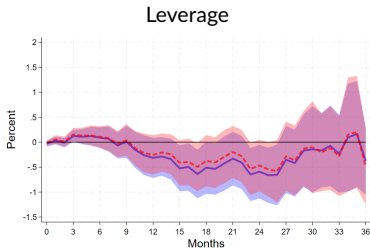
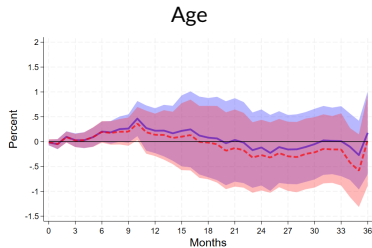
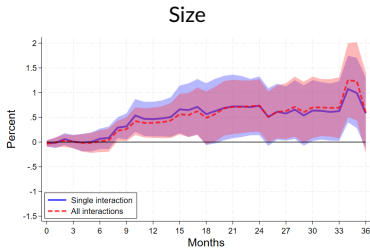
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Impulse response functions: 2-digit pg tfe, semi-parametric



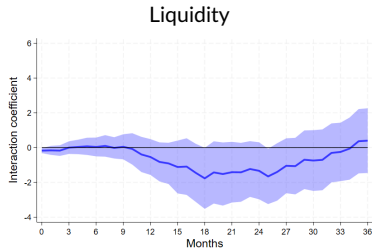
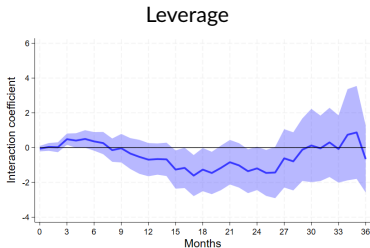
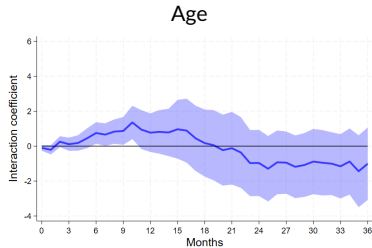
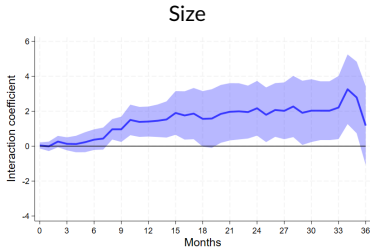
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Impulse response functions: Stop 2020:12



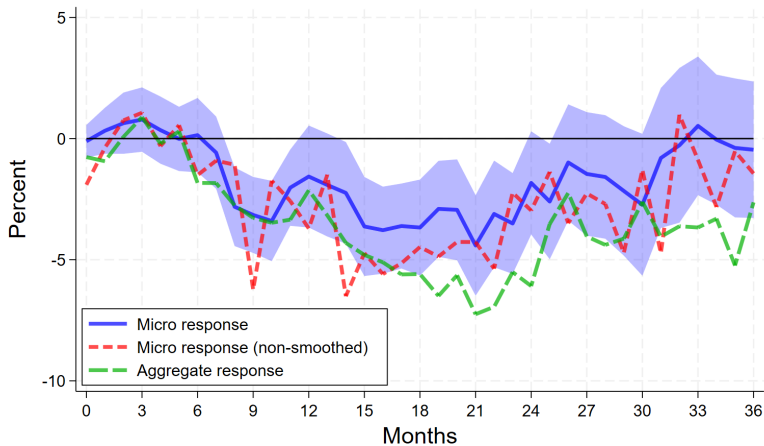
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Impulse response functions: Stop 2020:12, semi-parametric



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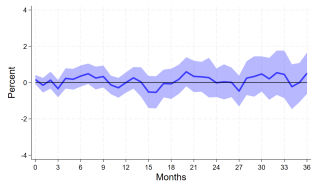
Impulse response function: Average sales



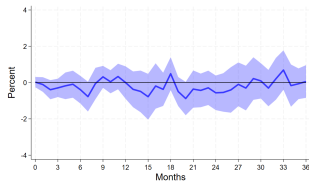
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Impulse response functions: Sales, other interactions

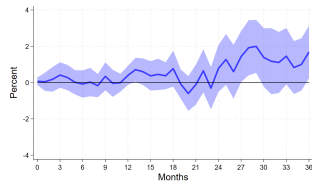
Age



Leverage

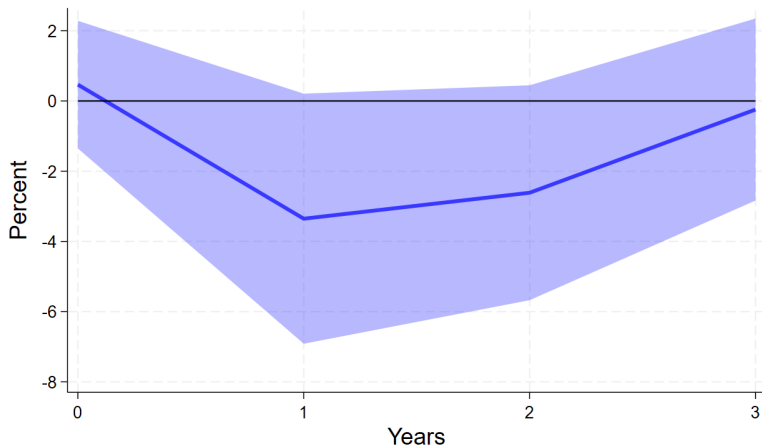


Liquidity



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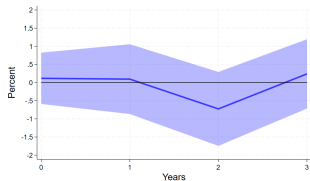
Impulse response function: Average debt



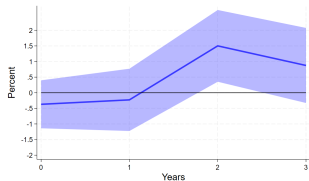
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Impulse response functions: Debt, other interactions

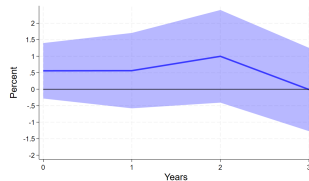
Age



Leverage

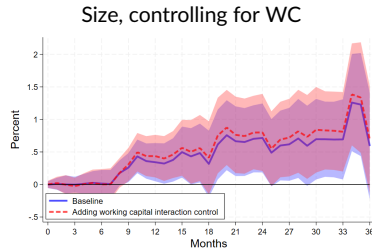
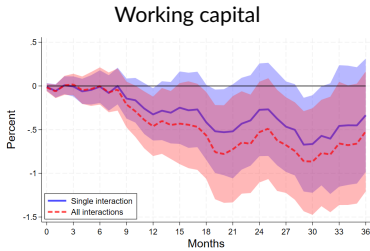


Liquidity



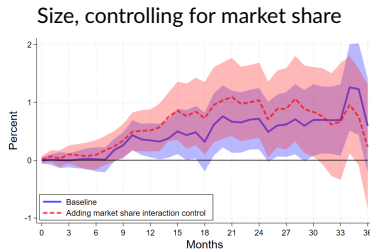
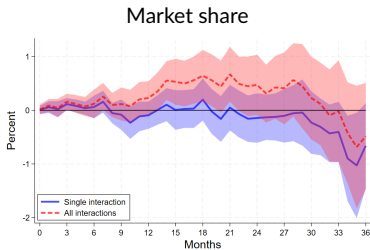
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Differential price response conditional on working capital



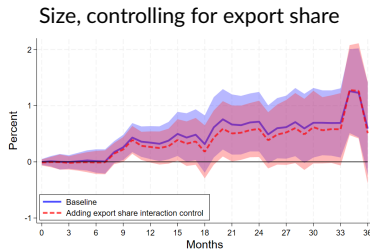
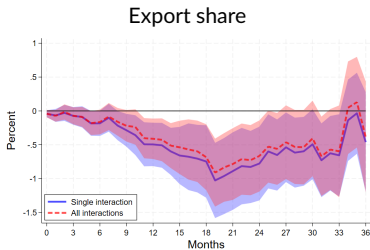
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Differential price response conditional on market share



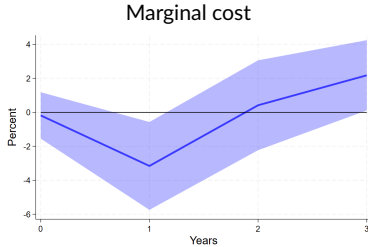
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Differential price response conditional on export share



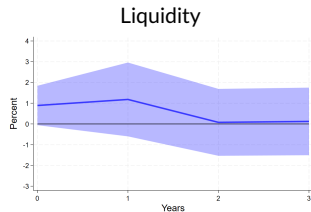
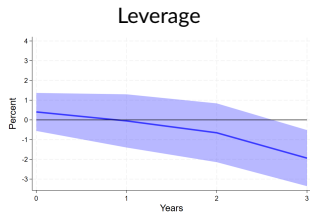
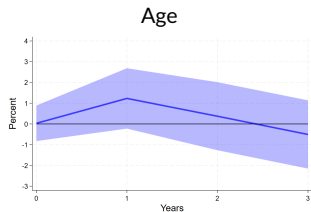
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Average marginal cost and gross profit margin responses



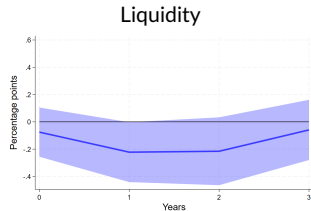
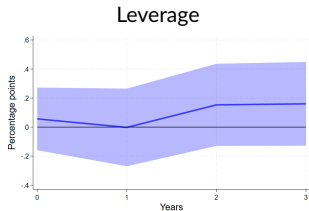
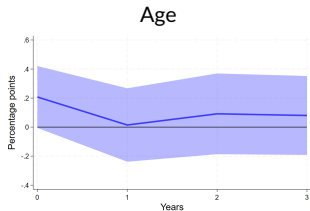
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Impulse response functions: MC, other interactions



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Impulse response functions: Markups, other interactions



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