The Spill-back and Spillover Effects of US Monetary Policy: Evidence on an International Cost Channel

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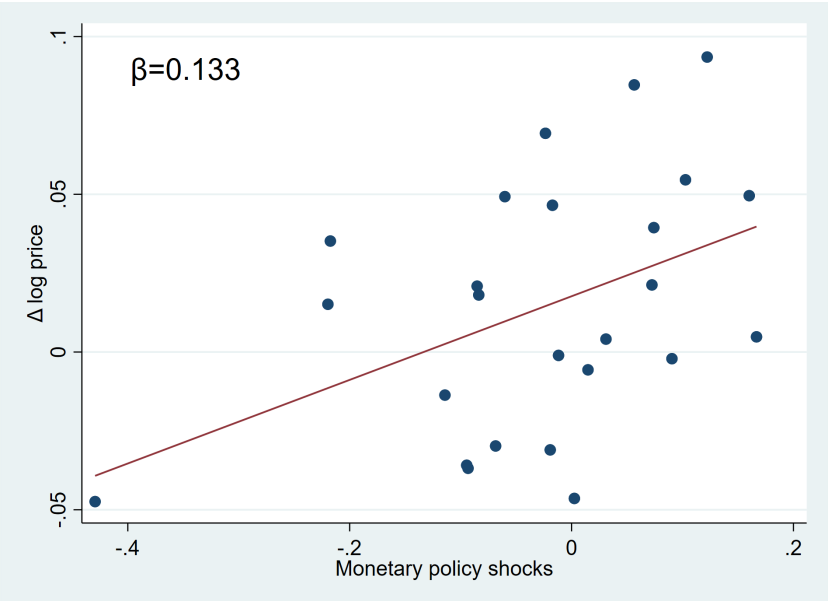
Outline

Fact I: Spill-back Effects (to the U.S.)

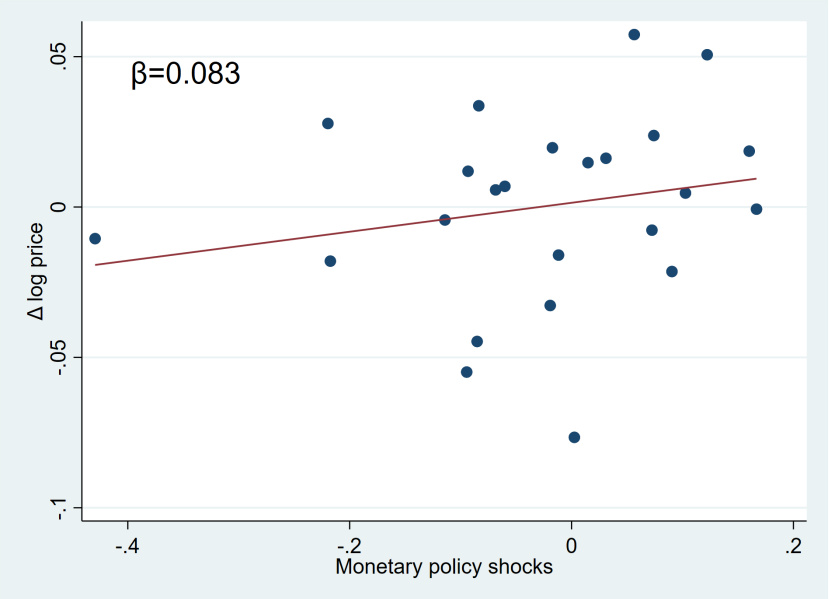
- **Standard Open-economy Macro Models**: Monetary tightening leads to a decline $\downarrow$ in import prices through either a demand or exchange rate effect.
- **This paper** documents an opposite pattern in the data — US import prices $\uparrow$ after an unanticipated US monetary tightening. —"Spill-back effect"
- **Implications**: This counteracts the Fed's efforts to control domestic inflation and weakens the purchasing power of domestic consumers.

▸ Histogram of spill-back

US Monetary Policy Shocks and US Import Prices



(a) Unconditional Correlations

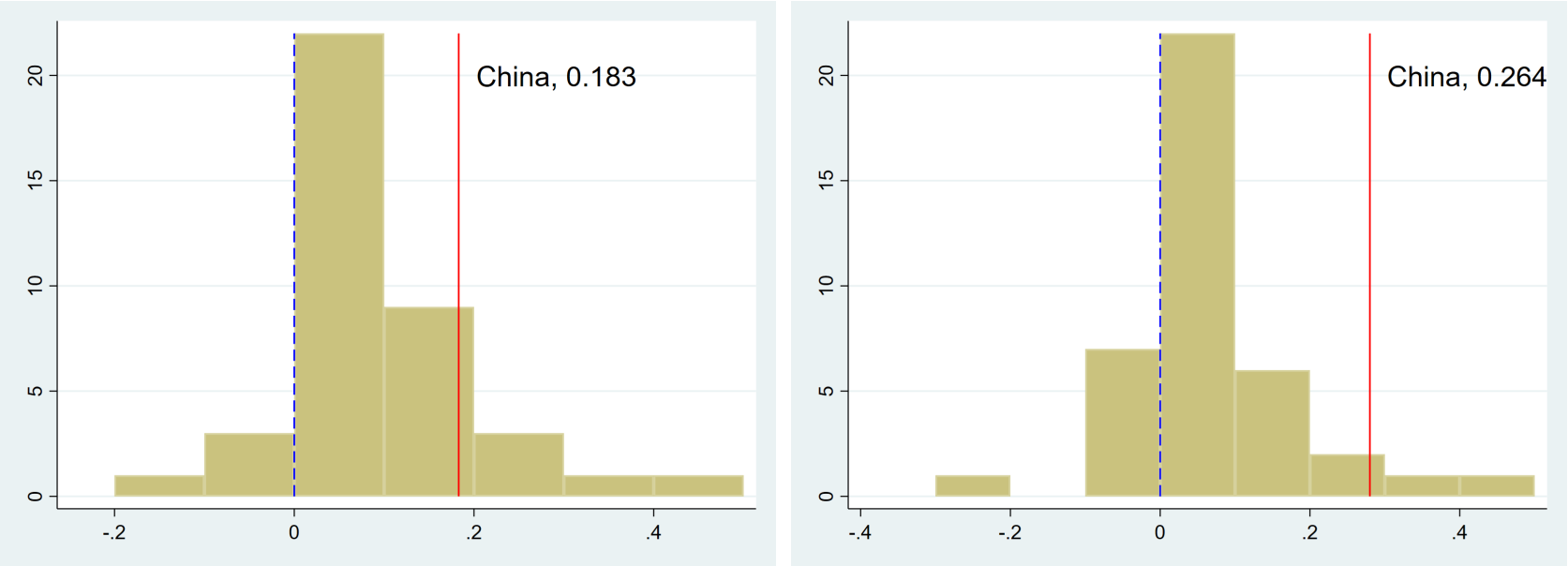


(b) Conditional Correlations (with controls)

Figure 1: US Monetary Policy Shocks and US Import Prices

Data source: Import price data (product-country-year level) from the US Census Bureau (Schott, 2008). US monetary policy shocks from Bu, Rogers and Wu (2021). Period: 1995-2019. Controls in (b): US GDP growth, exchange rate changes, and lagged changes in import prices.

Price Response of US Imports from a Country to US Monetary Policy Shocks



(a) Unconditional Responses (b) Conditional Responses (with controls)

Figure 2: US import price responses from 40 major countries

Top 40 countries (excluding the US) in terms of nominal GDP in 2006 (in USD price)
Red vertical line represents import price from China.

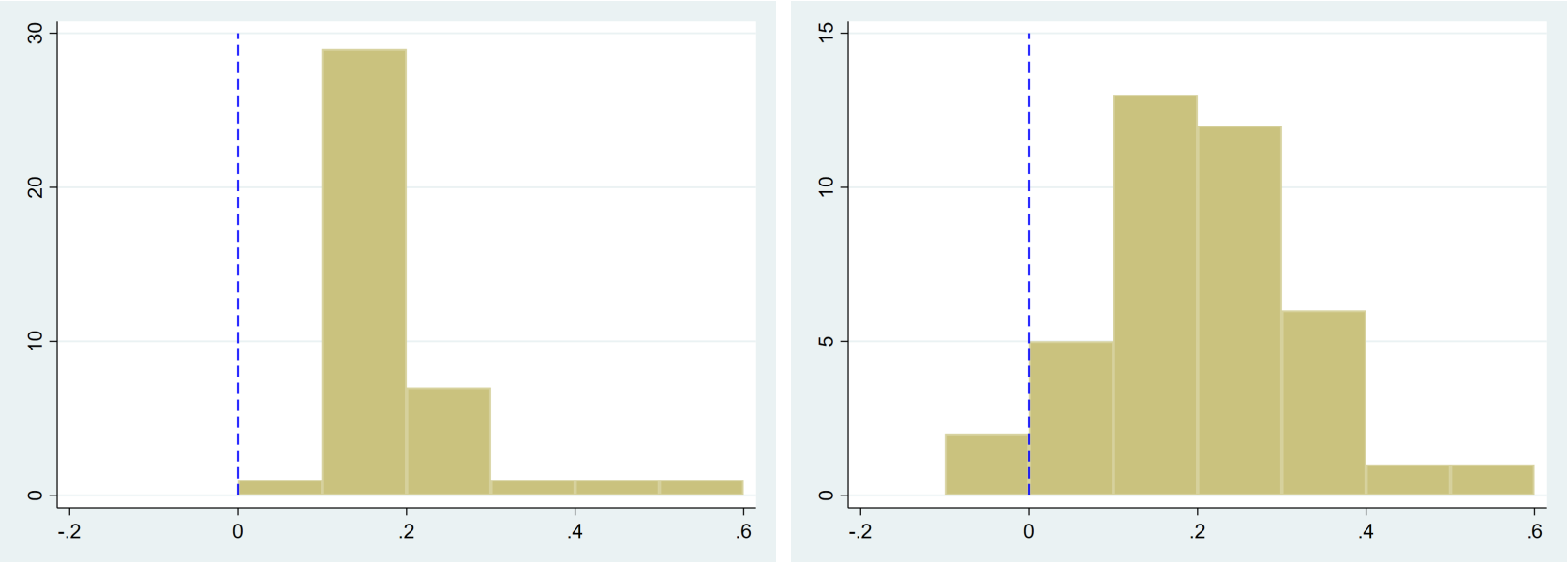
Back

Fact II: Spillover Effects (to Other Countries)

- **This paper** also finds a new spillover effect – Foreign import prices also ↑ after US tightening.
- This causes import inflation, lowers other countries' real income and harms exporters' sales.
- Existing literature highlights US monetary spillover through financial channels (asset prices or capital flows), this paper suggests an additional import price channel.

▸ Histogram of spillover

Price Response of Other Countries' Imports to US Monetary Policy Shocks



(a) Unconditional Responses (b) Conditional Responses (with controls)

Figure 3: Import price responses of 40 major countries

Top 40 countries (excluding the US) in terms of nominal GDP in 2006 (in USD price).

Back

Research Questions

- **Question**: Why did the aggregate product-level import prices increase? Markup or marginal cost change? Compositional effects? Others?
- To answer these questions, it is necessary to use granular foreign firm-product-destination level data to investigate the foreign exporters' price responses.
- Case study of Chinese exporters. The largest exporting country. Combination of monthly customs data and balance sheet data.

Remainder of the Paper

- *Main findings*:
  - **Spill-back effect:** US unexpected tightening ↑ the dollar prices of Chinese exports to the US.
  - **Spillover effect:** US unexpected tightening ↑ the dollar prices of Chinese exports to other countries.

- *Key mechanism - Borrowing cost channel*:
  - We build a parsimonious model of exporters with financial frictions and foreign monetary shocks.
  - US monetary tightening worsens firms' liquidity conditions.
  - This forces the foreign exporters to rely more on external financing, leading to higher borrowing costs.
  - The impact is bigger for firms facing higher borrowing costs or tighter liquidity conditions.

Literature and contribution (1)

Domestic cost channel of monetary transmission

- Sims (1992), Boehl, Goy and Strobel (2022), Beaudry, Hou and Portier (2024)
- This paper: International cost channel; Present even with restrictive capital controls; borrowing proportion rather than interest rate

International spillover of monetary policy shocks

- spillover: Miranda-Agrippino and Rey (2020);
- spillback: Breitenlechner, Georgiadis and Schumann (2022)
- This paper: transmission through export price

Determinants of export prices

- Exchange rate, trade liberalization, and firm features
  - Amiti, Itskhoki and Konings (2014), Manova and Zhang (2012)
  - This paper: global monetary policy shocks
- Pricing-to-market (PTM) and markup adjustments
  - Gopinath and Itskhoki (2011), Auer, Chaney and Sauré (2018)
  - This paper: markup barely changes, cost-driven price adjustments, markup level doesn't matter for price changes

Literature and contribution (2)

Financial frictions and international trade

- Already known that credit constraints are important for exports: e.g., Manova (2013), Manova, Wei and Zhang (2015), Lin and Ye (2018*b*)
- This paper: (i) financial conditions of foreign export firms are tied to US monetary tightening; (ii) the linkage is present even with restrictive capital controls;

International exposure and capital control

- Ambiguous effectiveness: Miniane and Rogers (2007), Forbes, Fratzscher and Straub (2015), Dias et al. (2020), Ha, Liu and Rogers (2023), Lin and Ye (2018*a*)
- This paper: even under capital control, exporters are still exposed to global shocks through trade connections and financial frictions

Outline

Data: Monetary Policy Shocks

- Bu, Rogers and Wu (2021).
  - It uses Fama and MacBeth (1973) two-step partial-least squares estimation using FOMC announcements.
- Advantages of BRW shocks:
  1. Unpredictable from past available information (exogenous);
  2. No significant Fed information effect (pure policy shock);
  3. Bridge conventional and unconventional monetary policy regimes.
- Sample: 2000 to 2006 (84 months).
- Alternative measures of US monetary policy shocks:
  - Nakamura and Steinsson (2018);
  - Gürkaynak, Sack and Swanson (2005), extended by Acosta (2022);
  - Jarociński and Karadi (2020).
- For ease of comparison, all shocks are rescaled to that one unit increase is equivalent to a rise in the daily yield on 2-year US treasury by 100 basis points.

▸ Alternative measures

Monetary Policy Shocks by Bu, Rogers, and Wu

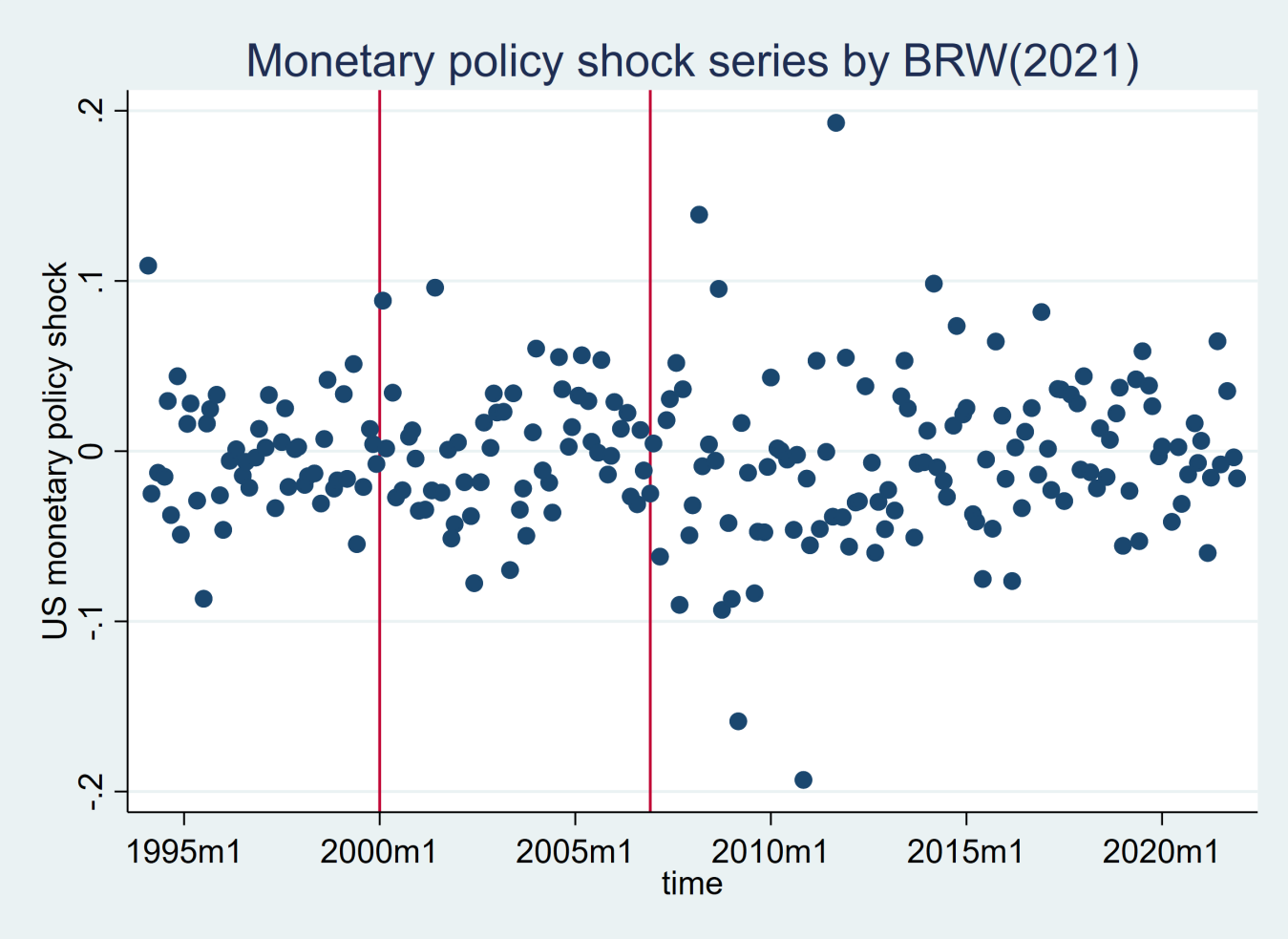


Figure 4: US Fed Monetary policy shocks from Bu, Rogers and Wu (2021)

Data: Firm-level and Customs data

- Annual surveys of industrial enterprises from the National Bureau of Statistics of China
  - Sample: all state-owned enterprises and above-scale firms (sales >5 million RMB), 1999 to 2007
  - Information: balance sheet variables, implying borrowing cost and liquidity conditions
- Monthly customs data of China
  - Sample: all exporting firms (except whole-sellers), 2000-2006
  - Information: import and export values, quantities, product names and codes, source and destination countries, and firm types

Export price index

- We compute the unit value of each firm-product-country observation as the proxy of export prices:

$$P_{ihct} = \frac{V_{ihct}}{Q_{ihct}}$$

- We construct the firm-level Tornqvist price index:
  1. The firm-product-level price, $P_{iht} = \sum_c s_{c,iht} P_{ihct}$.
  2. The firm-product-level price change: $\Delta_n \ln P_{iht} = \ln P_{iht} - \ln P_{ih(t-n)}$.
  3. The firm-level price index change:

$$\Delta_n \ln P_{it} = \sum_h \frac{s_{h,i(t-n)} + s_{h,it}}{2} \Delta_n \ln P_{iht}$$

  where $s_{c,iht} = V_{ihct}/V_{iht}$ and $s_{h,it} = V_{iht}/V_{it}$.
  - In baseline regressions using year-on-year price changes, the time gap n means 12 months (1 year).

▸ Summary statistics

Outline

Specification

- We study the impact of US monetary policy shocks on Chinese export prices.
- The baseline specification:

$$\Delta \ln P_{it} = \alpha + \beta \cdot m_t + \Gamma \cdot \mathbf{Z}_{it-12} + \eta \cdot \Delta lnP_{it-1} + \Psi \cdot \Omega_t + \xi_i + \varepsilon_{it} \quad (1)$$

  - $\Delta \ln P_{it}$: the **year-over-year** export price index change;
  - m_t: the unexpected monetary policy shock at time t;
  - $\mathbf{Z}_{it-12}$: a vector of firm-level lagged control variables;
  - Ω_t: time-varying control variables;
  - ξ_i: firm-level (time-invariant) fixed effects;
  - β: coefficient of interest, the average export price response to the concurrent monetary policy surprises.

Spill-back Effects of US Monetary Policy

Table 1: Price response of Chinese exporters to the US market

	(1)	(2)	(3)	(4)
	To the US market			
Dependent Var	Monthly ΔlnP_{it}		Annual ΔlnP_{it}	
brw_t	0.130**	0.103*	0.142***	0.218***
	(0.064)	(0.060)	(0.028)	(0.026)
$Sales_{it-n}$		-0.010***		-0.028***
		(0.003)		(0.006)
ΔlnP_{it-1}		0.299***		-0.348***
		(0.007)		(0.033)
$\Delta lnNER_t^{US}$	-1.080***	-0.888***	-1.026***	-1.791***
	(0.209)	(0.230)	(0.225)	(0.224)
Firm FE	Yes	Yes	Yes	Yes
Observations	319773	247028	59695	35639
Number of Firms	40292		46529	

Notes: The dependent variables in columns (1)-(2) are changes in monthly prices exporting to the US, while those in columns (3)-(4) are changes in annual prices. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

▸ Dynamic responses ▸ Value and quantity

Spill-over Effects of US Monetary Policy

Table 2: Price response of Chinese exporters to non-US markets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	To non-US markets				To all countries			
Dependent Var	Monthly ΔlnP_{it}		Annual ΔlnP_{it}		Monthly ΔlnP_{it}		Annual ΔlnP_{it}	
brw_t	0.184**	0.151**	0.175***	0.248***	0.180**	0.150**	0.177***	0.244***
	(0.077)	(0.068)	(0.040)	(0.053)	(0.075)	(0.064)	(0.038)	(0.048)
$Sales_{it-n}$		-0.003		-0.014*		-0.005*		-0.015**
		(0.003)		(0.006)		(0.003)		(0.005)
ΔlnP_{it-1}		0.281***		-0.313***		0.299***		-0.303***
		(0.006)		(0.031)		(0.006)		(0.030)
$\Delta lnNER_t^{US}$	-0.740***	-0.629***	-0.688**	-1.103**	-0.777***	-0.654***	-0.717**	-1.119**
	(0.201)	(0.208)	(0.269)	(0.312)	(0.195)	(0.201)	(0.260)	(0.297)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1016974	834168	146735	92927	1100400	917419	151542	96296
Number of Firms	75523		86882		76811		88425	

Notes: The dependent variables in columns (1)-(2) and (5)-(6) are changes in monthly prices, while columns (3)-(4) and (7)-(8) are changes in annual prices. Columns (1)-(4) and (5)-(8) are samples of the non-US markets and all countries respectively. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

▸ Visualization

Alternative Measures of US Monetary Policy Shocks

Table 3: Alternative US monetary policy shocks

Panel A: monthly	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var					Monthly ΔlnP_{it}			
NS_t	0.111***	0.105***						
	(0.041)	(0.037)						
BS_t			0.130***	0.126***				
			(0.044)	(0.043)				
$Target_t^{Acosta}$					0.047	0.044		
					(0.035)	(0.028)		
$Path_t^{Acosta}$					0.101***	0.097***		
					(0.037)	(0.034)		
MP_t^{JK}							0.062	0.068
							(0.039)	(0.047)
CBI_t^{JK}							0.137***	0.094*
							(0.047)	(0.049)
Observations	1100400	917419	1100400	917419	1100400	917419	1100400	917419
Panel B: annual	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var					Annual ΔlnP_{it}			
NS_t	0.126***	0.227***						
	(0.023)	(0.014)						
BS_t			0.092**	0.320***				
			(0.026)	(0.019)				
$Target_t^{Acosta}$					0.044	0.077***		
					(0.030)	(0.012)		
$Path_t^{Acosta}$					0.115***	0.221***		
					(0.021)	(0.012)		
MP_t^{JK}							0.029***	0.245**
							(0.005)	(0.083)
CBI_t^{JK}							0.099***	0.148***
							(0.006)	(0.009)
Observations	151542	96296	151542	96296	151542	96296	151542	96296
Firm Controls	No	Yes	No	Yes	No	Yes	No	Yes
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: In this table, we replace the BRW shock with other monetary shocks. In panels A and B, the dependent variables are changes in monthly and annual prices, respectively. The monetary policy shocks in columns (1)-(2), (3)-(4), (5)-(6) and (7)-(8) are from Nakamura and Steinsson (2018), Bauer and Swanson (2023), Acosta (2022), and Jarociński and Karadi (2020), respectively. For ease of comparison, we re-scale all the other shocks so that one unit increase is equivalent to a rise in the daily 2-year US treasury yield by 100 basis points. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Additional Robustness Checks

a Different measures of price changes

1. Alternative **aggregation levels** of price index ▸ Alternative aggregation
2. **Approximate time match** approach ▸ Approximate time match
3. **End-of-year price** response to annual shocks ▸ End-of-year price
4. Export prices denominated in **Chinese RMB** ▸ RMB prices

b Different samples

1. Single product firms ▸ Single product firms
2. Different **ownership** (SOE/DPE/MNE/JV) ▸ Ownership
3. **Two-way traders** vs pure exporters ▸ Two-way traders

c More econometrics and controls

1. Alternative **standard error cluster levels and fixed effects** ▸ Alternative SE clusters and FEs
2. Additional **macro time-series controls** ▸ Macro controls

Outline

Mechanism overview

Borrowing cost channel:

1. US monetary tightening worsens exporters' liquidity conditions (sales revenue decline and trade credit cut in the market)

2. Deteriorating liquidity conditions force the exporters to rely more on external financing, raising their financing costs.

3. Most exporters (in China and most developing countries) are barely able to adjust their markup to absorb the cost shock, so they pass the higher borrowing cost to export prices.

Conceptual framework: firm's problem and optimal price

The firm's problem:

$$\max_{p} \left(p - \frac{\tau w(1-\delta+\delta R^{\alpha})}{\phi}\right)\frac{p^{-\sigma}}{P^{-\sigma}}Y$$

The optimal price:

$$p = \frac{\sigma}{\sigma-1}\frac{\tau w[c^{\gamma}+(1-c^{\gamma})R^{\alpha}]}{\phi} \tag{2}$$

where τ is iceberg cost, w is input price, δ is borrowing proportion, c is liquidity condition, R is borrowing interest rate, and ϕ is productivity.

- Monetary tightening, reduces firms' liquidity c, thus increasing borrowing proportion $1-c^{\gamma}$, and then drives up export prices.
- It reduces to $p = \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}$ if R=1, similar to Melitz (2003).

▸ Preference ▸ Demand ▸ Firm setting ▸ Proposition ▸ Extension

Steps to verify the mechanism

Main evidence:

1. Tightening shocks worsen firms' liquidity.
2. Borrowing costs and borrowing proportions increase.
3. Firms with higher borrowing costs and tighter liquidity conditions would raise their prices by a greater amount.

Additional data patterns:

1. Marginal cost matters more than markup does;
2. Changes in borrowing costs are more important than changes in other input costs;
3. Changes in borrowing costs are driven by the proportion of borrowing rather than the interest rate itself.

▸ Measurements

Liquidity conditions worsen after a tightening shock

$$\Delta Liq_{it} = \alpha + \beta \cdot m_t + \Gamma \cdot \mathbf{Z}_{it-1} + \xi_i + \varepsilon_{it} \tag{3}$$

Table 4: Liquidity changes of exporters

Dependent Var	(1) Direct measures $\Delta Cash_{it}$	(2) Direct measures $\Delta Liquid_{it}$	(3) Indirect measures $\Delta APay_{it}$	(4) Indirect measures $\Delta ARec_{it}$
brw_t	-0.018***	-0.012**	-0.025***	-0.012***
	(0.004)	(0.005)	(0.006)	(0.004)
$Sales_{it-1}$	-0.003***	-0.011***	-0.016***	-0.018***
	(0.001)	(0.001)	(0.002)	(0.001)
$Debt_{it-1}$	-0.014***	0.630***	-0.310***	-0.066***
	(0.005)	(0.007)	(0.008)	(0.004)
Firm FE	Yes	Yes	Yes	Yes
Observations	155699	155699	88076	155699

Notes: The dependent variables in columns (1)-(4) are changes in cash over total assets, net liquidity assets over total assets, accounts payable over total assets, and accounts receivable over total assets, respectively. Z_{it-1} is firm-specific one-year lagged control variables, including log real sales income (a proxy for firm size) and the ratio of total debt to total assets.

Borrowing cost increases after a tightening shock

Table 5: Borrowing cost changes of exporters

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)
	Borrowing costs				Liability	
	$\Delta \frac{IE}{L}_{it}$	$\Delta \frac{IE}{CL}_{it}$	$\Delta \frac{FN}{L}_{it}$	$\Delta \frac{FN}{CL}_{it}$	$\Delta Debt_{it}$	$\Delta CDebt_{it}$
brw_t	0.005***	0.007***	0.014***	0.015***	0.039**	0.038**
	(0.001)	(0.001)	(0.002)	(0.003)	(0.017)	(0.019)
$Sales_{it-1}$	-0.000*	-0.001	-0.001*	-0.002**	-0.144***	-0.147***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.005)	(0.006)
$Debt_{it-1}$	0.033***	0.038***	0.069***	0.077***	-2.318***	-2.208***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.024)	(0.025)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	155008	153219	155008	153219	154908	153086

Notes: The specification is similar to Table 4. The dependent variables in columns (1)-(4) are changes in interest expense over the total liability ratio, interest expense over the current liability ratio, total financial expense over the total liability ratio, and total financial expense over the current liability ratio, respectively. The dependent variables *Debt* and *CDebt* in columns (5)-(6) are changes in total and current liability over total asset ratios.

▸ lag interaction

Impact is bigger under a higher borrowing cost

Table 6: Interactions with borrowing cost

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Monthly ΔlnP_{it}				
$brw_t \times \frac{IE}{L}_{st-12}$	7.645***	6.959***						
	(2.259)	(2.141)						
$brw_t \times \frac{IE}{CL}_{st-12}$			6.269***	5.614***				
			(1.902)	(1.803)				
$brw_t \times \frac{FN}{L}_{st-12}$					6.288***	3.694*		
					(2.387)	(2.245)		
$brw_t \times \frac{FN}{CL}_{st-12}$							5.153***	3.069*
							(1.953)	(1.841)
$Sales_{it-12}$		-0.017***		-0.017***		-0.017***		-0.017***
		(0.001)		(0.001)		(0.001)		(0.001)
ΔlnP_{it-1}		0.296***		0.296***		0.296***		0.296***
		(0.003)		(0.003)		(0.003)		(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1072227	917419	1072227	917419	1072227	917419	1072227	917419

Notes: The specification is $\Delta \ln P_{it} = \alpha + \beta \cdot m_t \cdot X_{st-12} + \Gamma \cdot \mathbf{Z} + \xi_i + \xi_t + \varepsilon_{it}$. The interaction terms in columns (1)-(2), (3)-(4), (5)-(6), and (7)-(8) are changes in interest expense over the total liability ratio, interest expense over the current liability ratio, total financial expense over the total liability ratio and total financial expense over the current liability ratio, respectively. $\mathbf{Z}$ is firm-specific controls, including one-year lagged log real sales income and one-month lagged price changes. ξ_i and ξ_t are firm and time-fixed effects respectively. All regressions include firm and time-fixed (year-month pair) effects.

▸ liquidity interaction

Decomposition of prices: markup vs marginal cost

- Only marginal costs respond significantly while markup adjustment is not the driver of price changes.

Table 7: Decomposition of prices: markup vs marginal cost

	Markup & marginal cost		Monthly price		Annual price	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	$\Delta ln\mu_{it}$	$\Delta lnMC_{it}$	ΔlnP_{it}		ΔlnP_{it}	
brw_t	-0.011*	0.168***	0.153***	0.026***	0.250***	0.094***
	(0.006)	(0.010)	(0.012)	(0.006)	(0.011)	(0.006)
$\Delta ln\mu_{it}$			0.009**		0.014***	
			(0.003)		(0.005)	
$\Delta lnMC_{it}$				0.788***		0.618***
				(0.003)		(0.004)
ΔlnP_{it-1}			0.279***	0.063***	-0.312***	-0.119***
			(0.003)	(0.001)	(0.005)	(0.003)
$Sales_{it-n}$	-0.019***	0.014***	-0.005**	-0.019***	-0.014***	-0.020***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
NER Control	No	No	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	110510	105098	663876	662132	81348	81098

Notes: This table shows the responses of markup and marginal cost to the US monetary shock. The specification in Columns (1)-(2) is $\Delta Y_{it} = \alpha + \beta \cdot m_t + \gamma \cdot Sales_{it-1} + \xi_i + \varepsilon_{it}$, where the dependent variables are annual changes in markup and marginal cost. The specification in Columns (3)-(6) is similar to the baseline and here we additionally control the change of markup and marginal cost. The dependent variables in columns (3)-(4), (5)-(6) are monthly and annual changes in prices, respectively.

More evidence on the channel

Markup, other costs and interest rate

- Responses of exporters with different markup ▸ firm markup
- Other costs: material, labor, and imported inputs ▸ other costs
- Interest rate itself barely responds. ▸ bond market response

Cross-sectional evidence

- FDI firms are less affected ▸ FDI
- Firms exporting more to financially developed countries have a weaker price change ▸ Financial development
- Processing trade responses are smaller ▸ Processing trade

Alternative stories

- Demand shift ▸ Rauch
- Competitive advantages
- Exchange rate pass-through ▸ Alternative aggregation ▸ RMB prices

Outline

Extension

China's monetary policy stance:

- Chinese domestic tightening also causes exporters to raise prices.
- A US contractionary shock would have a larger impact conditional on a tighter domestic monetary environment.

▸ China MP

ECB monetary policy:

- Chinese export prices barely move in response to the monetary policy shocks from the European Central Bank.

▸ ECB

Outline

Conclusion

- Spill-back effect – US import prices (from major trading partners) tend to rise in response to an unanticipated US monetary tightening.
- Spillover effect – Foreign import prices also rise in response to an unanticipated US monetary tightening.
- **Mechanism**: borrowing cost channel – US monetary tightening leads to a deterioration of most foreign exporters' liquidity conditions, causing them to raise their export prices.

Summary statistics of Chinese firms

Table A1: Summary statistics of firm information

	Mean	SD	p50	p25	p75
ΔlnP^{all}	0.03	0.42	0.01	-0.11	0.17
ΔlnP^{US}	0.04	0.34	0.02	-0.11	0.19
Number of HS6 Products	6.29	10.31	3.00	2.00	7.00
Sales (*million RMB)	160	1201	34.91	15.35	90.85
Employment (persons)	449	1210	197	96	418
ϕ^{exp} (Export/Sales)	0.46	0.38	0.36	0.07	0.89
Firm-year observations			270271		
Number of Firms			88425		

Notes: This table shows the summary statistics of firms in the matched sample. The first two rows ΔP^{all} and ΔP^{US} indicate monthly price changes exporting to all other countries and to the US market respectively, while all other rows describe annual-level firm variables. The third row denotes the number of HS6 product types a company exports in a given year. ϕ^{exp} represents the export intensity, which is the firm-level ratio of exports to total sales.

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Correlations of MPS measures

Table A2: Correlations of alternative monetary policy shock measures

	brw	*NS*	*BS*	$Target^{Acosta}$	$Path^{Acosta}$	MP^{JK}	CBI^{JK}
brw	1						
NS	0.5398	1					
BS	0.4863	0.8636	1				
$Target^{Acosta}$	0.2793	0.6259	0.5495	1			
$Path^{Acosta}$	0.4702	0.7901	0.6768	0.0178	1		
MP^{JK}	0.4210	0.6391	0.8591	0.4361	0.4798	1	
CBI^{JK}	0.1512	0.4245	0.3768	0.3457	0.2680	-0.0897	1

Notes: The monetary policy shock measures are from Bu, Rogers and Wu (2021), Nakamura and Steinsson (2018), Bauer and Swanson (2023), Acosta (2022), and Jarociński and Karadi (2020), respectively.

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Measurements of credit conditions

Liquidity condition:

1. *Cash* (cash holding over total asset ratio),
2. *Liquid* (net liquidity asset over total asset ratio),
3. *Apay* (accounts payable over total asset),
4. *Arec* (accounts receivable over total asset);

Borrowing cost:

1. IE/L (interest expense over the total liability ratio),
2. IE/CL (interest expense over the current liability ratio),
3. FN/L (total financial expense over the total liability ratio),
4. FN/CL (total financial expense over the current liability ratio).

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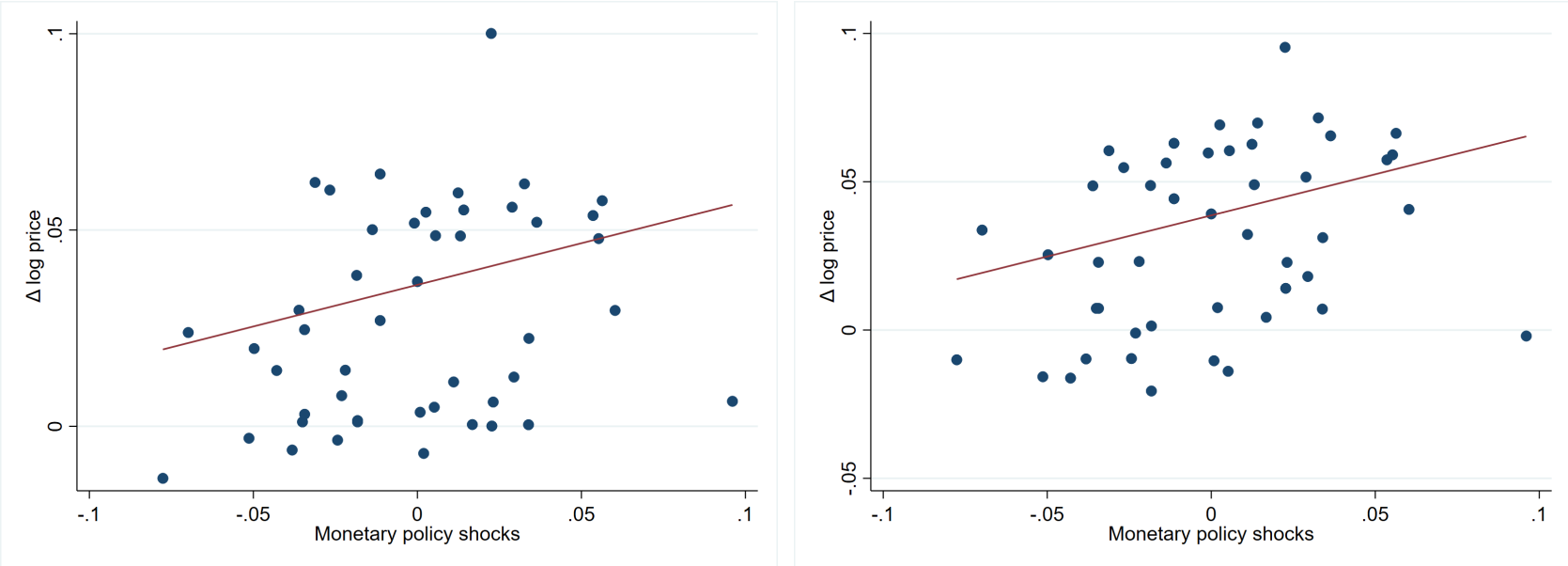
US Monetary Policy Shocks and Chinese Export Prices



(a) To the US market

(b) To non-US markets

Figure B1: Average price response of Chinese exporters to US MP shocks

▸ Back ▸ Top 20 partners

Price responses to top 20 trading partners

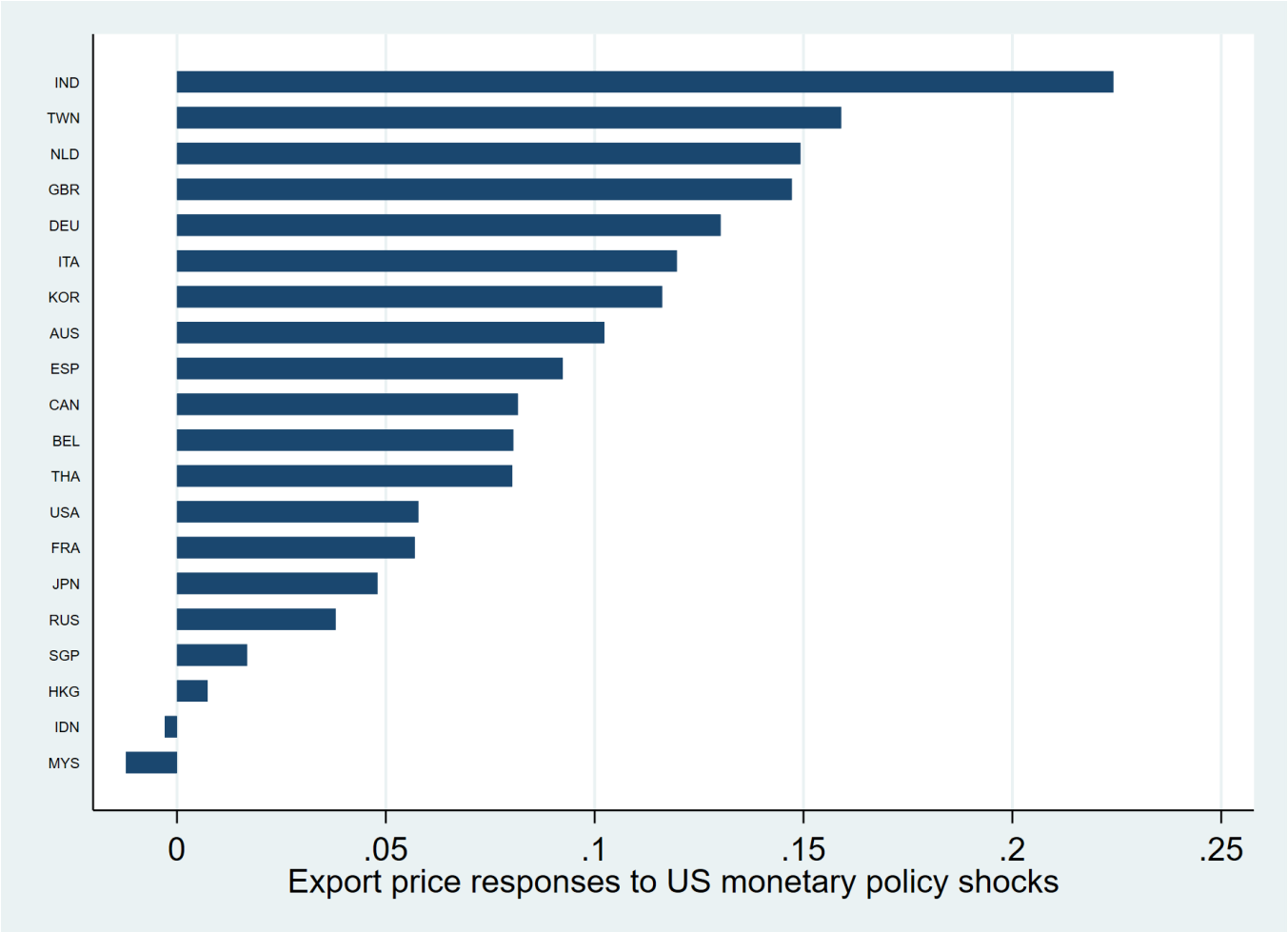


Figure B2: China's export price responses to top 20 trading partners

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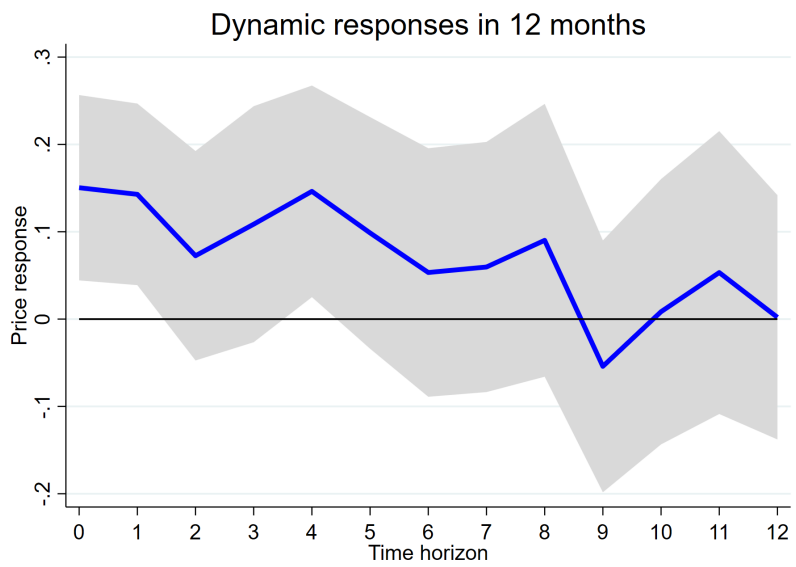
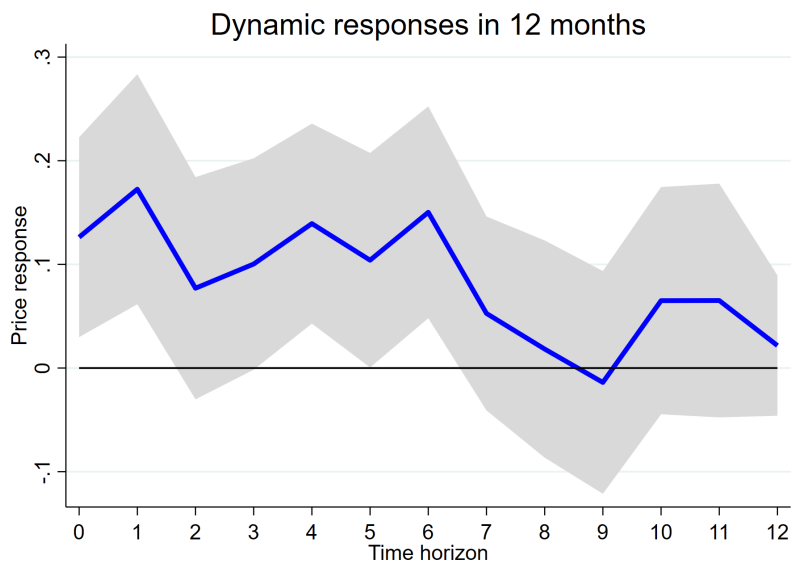
Dynamic price responses to US monetary policy shocks



(a) Dynamic responses: forward prices



(b) Dynamic responses: lagged shocks

Figure B3: Dynamic responses to monetary policy shocks

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Value and quantity responses

Table B1: Export value and quantity responses to US monetary policy shocks

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firm level value ΔlnV_{it}				Firm-product level quantity ΔlnQ_{iht}			
	Monthly		Annual		Monthly		Annual	
brw_t	0.133	0.211	-0.628**	-0.184	-0.018	0.036	-1.930*	-2.011
	(0.372)	(0.366)	(0.221)	(0.242)	(0.398)	(0.333)	(0.960)	(1.084)
$Sales_{it-n}$		-0.254***		-0.245***		-0.264***		-0.059
		(0.014)		(0.038)		(0.016)		(0.188)
ΔlnP_{it-1}		0.210***		-0.456***		0.203***		-0.387***
		(0.005)		(0.093)		(0.005)		(0.025)
NER control	Yes	Yes	Yes	Yes	No	No	No	No
Firm FE	Yes	Yes	Yes	Yes	No	No	No	No
Firm-Product FE	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1140624	986757	154732	99751	2359502	1751828	571830	314287

Notes: Here we investigate the value and quantity responses to the US monetary shocks using samples of all countries. The specification is similar to the baseline. The only difference lies in the dependent variable. Columns (1)-(4) show results of firm-level value, while columns (5)-(8) show results of firm-product-level quantity. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Weighted shocks using announcement dates

Table B2: Weighted shocks using announcement dates

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}			Annual ΔlnP_{it}		
$brw_t^{weighted}$	0.210**	0.212**	0.133*	0.159***	0.167***	0.265***
	(0.093)	(0.095)	(0.072)	(0.033)	(0.035)	(0.054)
$Sales_{it-12}$		-0.004	-0.005*		-0.015**	-0.020*
		(0.003)	(0.003)		(0.004)	(0.009)
ΔlnP_{it-1}			0.299***			-0.318***
			(0.006)			(0.033)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1100400	1072227	917419	151542	147471	97987

Notes: The specification is similar to the baseline. Here we use samples of all countries and replace the original shocks with the weighted shocks, which are calculated according to the exact announcement dates. The frequency of shocks in columns (1)-(3) and (4)-(6) are monthly and annually, respectively. Please refer to the text for more details on the construction. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Alternative aggregation levels of export prices

Table B3: Alternative aggregation levels of export prices

Panel A: monthly	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Firm-product level monthly ΔlnP_{iht}			Firm-product-country level monthly ΔlnP_{ihct}		
brw_t	0.140**	0.147**	0.127*	0.099*	0.104*	0.091
	(0.067)	(0.070)	(0.064)	(0.058)	(0.060)	(0.058)
$Sales_{it-12}$		-0.009***	-0.009***		-0.010***	-0.010***
		(0.003)	(0.003)		(0.003)	(0.003)
$\Delta lnP_{ih(c)t-1}$			0.273***			0.274***
			(0.006)			(0.006)
Observations	2420018	2360154	1758341	3478000	3478000	2140247
Panel B: annual	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Firm-product level annual ΔlnP_{iht}			Firm-product-country level annual ΔlnP_{ihct}		
brw_t	0.168***	0.175***	0.247***	0.152***	0.164***	0.200***
	(0.039)	(0.043)	(0.051)	(0.026)	(0.029)	(0.041)
$Sales_{it-12}$		-0.016***	-0.008		-0.022***	-0.011*
		(0.002)	(0.004)		(0.003)	(0.005)
$\Delta lnP_{ih(c)t-1}$			-0.426***			-0.449***
			(0.025)			(0.017)
Observations	573904	559749	315161	1138465	1086596	473955
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Country-time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm-product FE	Yes	Yes	Yes	No	No	No
Firm-product-country FE	No	No	No	Yes	Yes	Yes

Notes: The specification is similar to the baseline. In panel A, the dependent variables in columns (1)-(3) are monthly changes in firm-product level price, while in columns (4)-(6) are monthly changes in firm-product-country (transaction) level price. For the latter columns, we additionally control changes in bilateral nominal exchange rates, CPI inflation, and real GDP growth for the destination countries. In panel B, we report the annual version. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Approximate time match

Table B4: Approximate time match

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)
	Monthly ΔlnP_{it}					
	YoY +− 1 month			YoY +− 2 months		
brw_t	0.176**	0.197**	0.167**	0.187**	0.202**	0.172**
	(0.079)	(0.083)	(0.072)	(0.080)	(0.085)	(0.073)
$Sales_{it-12}$		-0.010***	-0.007**		-0.011***	-0.008**
		(0.004)	(0.003)		(0.004)	(0.003)
ΔlnP_{it-1}			0.342***			0.342***
			(0.007)			(0.007)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1275434	1121510	943499	1358899	1130947	945449

Notes: The specification is similar to the baseline. The dependent variables in columns (1)-(3) are approximate year-on-year changes in monthly prices with time gaps from 11 to 13 months, while columns (4)-(6) are approximate year-on-year changes in monthly prices with time gaps from 10 to 14 months. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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End-of-year export price responses

Table B5: End-of-year export price responses

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)
	ΔlnP_{it}					
	To the US market		To non-US market		To all countries	
brw_t	0.118*	0.205**	0.147*	0.186*	0.144*	0.192**
	(0.051)	(0.049)	(0.064)	(0.068)	(0.062)	(0.066)
$Sales_{it-12}$		-0.041**		-0.010		-0.012
		(0.012)		(0.008)		(0.009)
ΔlnP_{it-1}		-0.403***		-0.372***		-0.372***
		(0.024)		(0.035)		(0.033)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25087	12282	82226	42072	89141	46061

Notes: The dependent variables in all columns are December-to-December changes in monthly prices (except for those in 2005 due to missing data, which are replaced by approximate time matches). Columns (1)-(2), (3)-(4) and (5)-(6) include exports to the US, non-US markets, and all countries, respectively. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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RMB price responses to monetary policy shocks

Table B6: RMB price responses to monetary policy shocks

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}^{RMB}			Annual ΔlnP_{it}^{RMB}		
brw_t	0.180**	0.183**	0.150**	0.180***	0.195***	0.263***
	(0.075)	(0.077)	(0.065)	(0.040)	(0.054)	(0.044)
$Sales_{it-n}$		-0.004	-0.005*		-0.021*	-0.024***
		(0.003)	(0.003)		(0.009)	(0.006)
ΔlnP_{it-1}			0.299***			-0.317***
			(0.006)			(0.032)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1100399	1072223	917424	155049	150863	97987

Notes: The specification is similar to the baseline. The dependent variables in columns (1)-(3) are changes in monthly prices denominated in the Chinese RMB, while columns (4)-(6) are changes in annual prices denominated in the Chinese RMB. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Alternative sample: only single-product firms

Table B7: Alternative sample: only single-product firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}			Annual ΔlnP_{it}		
brw_t	0.233***	0.219**	0.177**	0.210***	0.212***	0.312***
	(0.083)	(0.086)	(0.073)	(0.042)	(0.048)	(0.053)
$Sales_{it-n}$		-0.003	-0.006		-0.019*	-0.025**
		(0.005)	(0.004)		(0.008)	(0.008)
ΔlnP_{it-1}			0.272***			-0.344***
			(0.008)			(0.027)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	359864	265249	187491	21567	14675	8690

Notes: The specification is similar to the baseline using the samples of single-product firms. The dependent variables in columns (1)-(3) are changes in monthly prices, while columns (4)-(6) are changes in annual prices. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression and year for annual regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Different ownership

Table B8: Alternative sample: different ownership

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Monthly ΔlnP_{it}				Annual ΔlnP_{it}			
	SOE	DPE	MNE	JV	SOE	DPE	MNE	JV
brw_t	0.215***	0.222***	0.136**	0.129**	0.201	0.274**	0.231***	0.248***
	(0.099)	(0.083)	(0.060)	(0.064)	(0.117)	(0.070)	(0.045)	(0.047)
$Sales_{it-n}$	0.015	0.008*	-0.012***	0.001	0.015	-0.005	-0.026***	-0.009
	(0.011)	(0.005)	(0.003)	(0.003)	(0.020)	(0.006)	(0.006)	(0.007)
ΔlnP_{it-1}	0.167***	0.186***	0.378***	0.286***	-0.314***	-0.346***	-0.280***	-0.290***
	(0.024)	(0.007)	(0.007)	(0.007)	(0.057)	(0.029)	(0.033)	(0.029)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13429	197037	390138	316814	1613	25069	36565	33049

Notes: The specification is similar to the baseline using the samples of different ownerships. The ownership types of firms in columns (1)-(4) are state-owned enterprises, domestic private enterprises, multinational enterprises, and joint ventures, respectively. Columns (5)-(8) report the annual results. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Two-way traders

Table B9: Alternative sample: two-way traders vs pure exporters

Panel A: monthly	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var			Monthly ΔlnP_{it}			
		Two-way traders			Pure exporters	
brw_t	0.163**	0.165**	0.136**	0.189**	0.192**	0.173**
	(0.073)	(0.076)	(0.063)	(0.073)	(0.073)	(0.067)
$Sales_{it-12}$		-0.004	-0.004		-0.001	-0.004
		(0.003)	(0.003)		(0.004)	(0.004)
ΔlnP_{it-1}			0.320***			0.186***
			(0.006)			(0.008)
Observations	840092	817078	718544	259669	254523	198297
Panel B: annual	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var			Annual ΔlnP_{it}			
		Two-way traders			Pure exporters	
brw_t	0.171***	0.185***	0.232***	0.196***	0.198***	0.272***
	(0.036)	(0.038)	(0.045)	(0.046)	(0.049)	(0.051)
$Sales_{it-12}$		-0.017***	-0.013**		-0.013**	-0.015*
		(0.003)	(0.005)		(0.004)	(0.007)
ΔlnP_{it-1}			-0.278***			-0.368***
			(0.028)			(0.034)
Observations	101007	97980	66073	41899	40982	24084
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The specification is similar to the baseline. In panel A, the dependent variables are year-over-year changes in monthly price while in panel B, the dependent variables are changes in annual price. Columns (1)-(3) cover the sub-sample with two-way traders (both export and import), while columns (4)-(6) cover the sub-sample with pure exporters (only export). All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression). *, *,*, and *** indicate significance at 10%, 5%, and 1% levels.

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Alternative SE clusters and fixed effects

Table B10: Alternative standard error clusters and fixed effects

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Monthly ΔlnP_{it}							
	FE 1		FE 2		Cluster 1		Cluster 2	
brw_t	0.034***	0.054***	0.219***	0.181***	0.180**	0.150**	0.180***	0.150***
	(0.010)	(0.010)	(0.012)	(0.012)	(0.076)	(0.066)	(0.021)	(0.022)
$Sales_{it-12}$		-0.017***		-0.005***		-0.005*		-0.005**
		(0.001)		(0.001)		(0.003)		(0.002)
ΔlnP_{it-1}		0.296***		0.299***		0.299***		0.299***
		(0.003)		(0.006)		(0.006)		(0.019)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No	No	No	No	No
Month FE	No	No	Yes	Yes	No	No	No	No
Cluster	Firm	Firm	Firm	Firm	Time	Time	Sector	Sector
Observations	1100400	917419	1100400	917419	1100400	917419	1100400	917419

Notes: The specification is similar to the baseline. Robust standard errors are clustered at the firm level for columns (1)-(4) and the time (year-month) level for columns (5)-(6), and industry level for columns (7)-(8); *, **, and *** indicate significance at 10%, 5%, and 1% levels. Regressions for columns (1)-(2) include firm fixed effects and year fixed effects, while those for columns (3)-(4) include firm fixed effects and month fixed effects, and only the firm level for columns (5)-(8).

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Additional control variables

Table B11: Additional macro time-series controls

Dependent Var	(1) CN CPI	(2) CN Value Added	(3) Monthly ΔlnP_{it} VIX	(4) Input Price	(5) All
brw_t	0.152***	0.155**	0.157**	0.157**	0.156**
	(0.057)	(0.068)	(0.072)	(0.061)	(0.065)
CPI_{t-1}^{China}	0.221**				-0.043
	(0.099)				(0.143)
IVA_{t-1}^{China}		-0.014			-0.013
		(0.038)			(0.035)
$ln(VIX)_{t-1}^{US}$			-0.013**		-0.012**
			(0.006)		(0.005)
$\Delta ln(P)_{t-1}^{input}$				0.067***	0.072***
				(0.011)	(0.021)
$Sales_{it-12}$	-0.006*	-0.005	-0.005*	-0.009***	-0.010***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ΔlnP_{it-1}	0.287***	0.287***	0.287***	0.286***	0.286***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
NER Control	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	815538	815538	815538	815538	815538

Notes: The specification is similar to the baseline. The control variables in columns (1)-(5) are CPI inflation in China, industrial value-added growth in China, log of CBOE volatility index (VIX), and global industrial input (agriculture and mineral goods) price change. All the variables have a one-month lag. The control variables in columns (5) are all above. All regressions include firm fixed effects. Robust standard errors are based on two-way clustering at both the firm and time levels (year-month for monthly regression). *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Dynamic panel GMM

Table B12: Dynamic panel GMM estimations

Dependent Var	(1)	(2)	(3)	(4)
	Monthly ΔlnP_{it}			
	Difference GMM		System GMM	
brw_t	0.057***	0.057***	0.057***	0.057***
	(0.014)	(0.015)	(0.014)	(0.014)
$Sales_{it-12}$		-0.029***		-0.020***
		(0.006)		(0.005)
ΔlnP_{it-1}	0.639***	0.639***	0.646***	0.637***
	(0.024)	(0.007)	(0.007)	(0.007)
NER Control	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	836117	816461	942113	919483

Notes: In this table, we use Arellano-Bond estimation, where unobserved panel-level effects are associated with the lag of the dependent variable, to account for possible biases in the dynamic panel regressions. Columns (1)-(2) and (3)-(4) show the results with difference GMM and system GMM, respectively. *, **, and *** indicate significance at 10%, 5%, and 1% levels.

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Chinese Domestic Monetary Policy

Table B13: Domestic monetary tightness in China

Dependent Var	(1)	(2)	(3)	(4)
	Monthly ΔlnP_{it}			
	Year-on-year tightness		Month-on-month tightness	
brw_t	0.145**	0.125*	0.261***	0.204***
	(0.072)	(0.065)	(0.084)	(0.075)
$brw_t \times tightness_{t-1}^{YoY}$	0.132**	0.075*		
	(0.051)	(0.045)		
$brw_t \times tightness_{t-1}^{MoM}$			0.106**	0.075*
			(0.044)	(0.040)
$tightness_{t-1}^{YoY}$	0.006***	0.004**		
	(0.002)	(0.002)		
$tightness_{t-1}^{MoM}$			0.001	0.000
			(0.002)	(0.002)
$Sales_{it-12}$		-0.006**		-0.005**
		(0.002)		(0.003)
ΔlnP_{it-1}		0.298***		0.299***
		(0.006)		(0.006)
NER Control	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1100400	917419	1100400	917419

Notes: In this table, compared with the baseline, we control the stance of Chinese monetary policy and its interaction term with BRW shock. Chinese monetary policy stance *tightness* in columns (1)-(2) is measured by the minus year-on-year M2 growth rate, while in columns (3)-(4) it is the minus month-on-month M2 growth rate. Robust standard errors are based on two-way clustering at both the firm level and time level (year-month for monthly regression); *, **, and *** indicate significance at 10%, 5%, and 1% levels.

ECB shocks produce weaker effects

Table B14: Export price responses to EU monetary policy shocks

	(1)	(2)	(3)	(4)
	To ECB markets	To US market	To other countries	To all countries
Dependent Var	Monthly ΔlnP_{it}			
$US - brw_t$	0.146*	0.103*	0.163**	0.151**
	(0.077)	(0.060)	(0.068)	(0.065)
$ECB - MP_t$	0.078	-0.003	0.017	0.011
	(0.064)	(0.062)	(0.056)	(0.056)
$ECB - CBI_t$	-0.025	0.012	-0.038	-0.018
	(0.063)	(0.063)	(0.058)	(0.056)
$Sales_{it-12}$	0.003	-0.010***	-0.004	-0.005*
	(0.005)	(0.003)	(0.003)	(0.003)
ΔlnP_{it-1}	0.195***	0.299***	0.279***	0.299***
	(0.007)	(0.007)	(0.006)	(0.006)
NER Control	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	183189	247028	779883	917419

Notes: This table investigates the impact of the European Central Bank shock. The specification is similar to the baseline and we additionally include the ECB shocks, including the pure monetary policy shock *MP* and the central bank information shock *CBI*. The ECB shocks in all columns are from Jarociński and Karadi (2020), which are re-scaled so that each interest rate surprise has the standard deviations of the 1-year OIS swap rate. Columns (1)-(4) use the changes in export prices to the ECB market, the US market, other countries, and all countries, respectively.

Back

Firms with higher borrowing costs will suffer more

Table C1: Borrowing cost changes with lag interaction

Dependent Var	(1)	(2)	(3)	(4)
	Borrowing cost measures			
	$\Delta \frac{IE}{L}_{it}$	$\Delta \frac{IE}{CL}_{it}$	$\Delta \frac{FN}{L}_{it}$	$\Delta \frac{FN}{CL}_{it}$
$brw_t \times \frac{IE}{L}_{it-1}$	0.716***			
	(0.190)			
$brw_t \times \frac{IE}{CL}_{it-1}$		0.866***		
		(0.221)		
$brw_t \times \frac{FN}{L}_{it-1}$			1.076***	
			(0.201)	
$brw_t \times \frac{FN}{CL}_{it-1}$				1.156***
				(0.226)
$Sales_{it-1}$	-0.001***	-0.002***	-0.004***	-0.006***
	(0.000)	(0.000)	(0.001)	(0.001)
$Debt_{it-1}$	0.033***	0.038***	0.069***	0.076***
	(0.001)	(0.002)	(0.002)	(0.003)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	155008	153219	155008	153219

Notes: This table displays the heterogeneous responses of borrowing costs across exporters. The specification is $\Delta Y_{it} = \alpha + \beta \cdot m_t \cdot Y_{it-1} + \Gamma \cdot \mathbf{Z} + \xi_i + \xi_t + \varepsilon_{it}$, where m is monetary shock, Y in columns (1)-(4) are interest expense over the total liability ratio, interest expense over the current liability ratio, total financial expense over the total liability ratio, and total financial expense over the current liability ratio, Z is firm-level control including lagged sales income and debt ratio. All regressions include firm and year fixed effects.

Back

Impact is bigger under a stricter liquidity condition

Table C2: Interactions with liquidity

	(1)	(2)	(3)	(4)
Dependent Var		Monthly ΔlnP_{it}		
$brw_t \times Cash_{st-12}$	-1.765***	-2.181***		
	(0.505)	(0.476)		
$brw_t \times Liquid_{st-12}$			-1.133***	-1.062***
			(0.259)	(0.242)
$Sales_{it-12}$		-0.017***		-0.017***
		(0.001)		(0.001)
ΔlnP_{it-1}		0.296***		0.296***
		(0.003)		(0.003)
Firm FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
Observations	1072227	917419	1072227	917419

Notes: The specification is similar to Table 6. The interaction terms in columns (1)-(2), (3)-(4) are the lag of cash over total asset ratio and net liquidity asset over total asset ratio respectively. All regressions include firm and time (year-month pair) fixed effects.

Back

Firms' markup levels have no significant effect

Table C3: Within-sector and across-sector markup

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Monthly ΔlnP_{it}						
$brw_t \times \mu_{it_0}$	0.072						
	(0.047)						
$brw_t \times \mathbf{1}\{\mu_{it_0} > \bar{\mu}_{cic4,t_0}\}$		0.004					
		(0.021)					
$brw_t \times \mathbf{1}\{\mu_{it_0} > \bar{\mu}_{cic2,t_0}\}$			0.006				
			(0.021)				
$brw_t \times \mu_{cic2,t-12}$				0.154			
				(0.191)			
$brw_t \times \mu_{cic2,t_0}$					0.280		
					(0.200)		
$brw_t \times \mu_{cic4,t-12}$						0.156	
						(0.178)	
$brw_t \times \mu_{cic4,t_0}$							0.274
							(0.190)
$Sales_{it-12}$	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔlnP_{it-1}	0.295***	0.295***	0.295***	0.296***	0.296***	0.296***	0.296***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	901462	901462	901462	917419	917419	917410	917419

Notes: The specification is similar to Table 6. The interaction terms in columns (1)-(7) are firm-level markup at its initial export year, firms' above-median dummy within the CIC 2-digit and 4-digit sector, the median markup of each CIC 2-digit and 4-digit sector in which the firm operates, in the last year or its initial year, respectively. All regressions include firm and time fixed effects.

Back

Other production costs responses are insignificant

Table C4: Discussion about other production costs

Dependent Var	(1) $\Delta \frac{Input}{Sales}_{it}$	(2) $\Delta \frac{Wage}{Sales}_{it}$	(3)	(4) Monthly ΔlnP_{it}	(5)
brw_t	0.075	0.003	0.145***	0.162***	0.161***
	(0.055)	(0.007)	(0.011)	(0.013)	(0.014)
$brw_t \times \frac{Input}{Sales}_{it}$			0.007		
			(0.005)		
$brw_t \times \frac{Wage}{Sales}_{it}$				-0.104	
				(0.076)	
$brw_t \times \phi_{it}^{imp}$					-0.039
					(0.030)
$Debt_{it-n}$	-0.044***	-0.014**			
	(0.180)	(0.162)			
ΔlnP_{it-1}			0.299***	0.299***	0.299***
			(0.003)	(0.003)	(0.003)
$Sales_{it-n}$	0.081***	0.037***	-0.005***	-0.005***	-0.005***
	(0.262)	(0.187)	(0.001)	(0.001)	(0.001)
NER Control	No	No	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	155699	155699	917419	917419	917419

Notes: The specification in Columns (1)-(2) is similar to Table 4. The specification in Columns (3)-(5) is similar to Table 6. The dependent variables in columns (1)-(2) are changes in intermediate input cost over sales ratio and wage expense over sales ratio, respectively. ϕ^{imp} represents the import intensity, which is the firm-level ratio of imports to total material inputs.

Back

China's bond index responses are mild

Table C5: China's bond index responses

	(1)	(2)	(3)	(4)
Period	2003-2006		2003-2022	
Price index	treasury	corporate bond	treasury	corporate bond
brw_t	-0.070	-0.381	-0.031*	-0.052
	(0.093)	(0.364)	(0.018)	(0.037)
Constant	Yes	Yes	Yes	Yes
Observations	27	25	137	135

Notes: The specification is $y_t = \alpha + \beta \cdot m_t + \varepsilon_t$, where y_t is the bond index overnight return (from last day's close price to today's open price), m_t is the daily BRW monetary policy shock, and t is Fed FOMC announcement date. The heteroskedasticity-adjusted robust standard errors are used here. *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Back

Verification 1: FDI firms are less affected

- **FDI firms**: usually have more stable liquidity conditions and better capacities in hedging risks, thus are less affected.

Table C6: FDI VS non-FDI firms

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)
	Monthly ΔlnP_{it}					
	Domestic		FDI		Comparison	
brw_t	0.220***	0.222***	0.166***	0.131***	0.219***	
	(0.024)	(0.025)	(0.012)	(0.011)	(0.025)	
$brw_t \times FDI$					-0.086***	-0.107***
					(0.027)	(0.027)
$Sales_{it-12}$		0.009***		-0.007***	-0.005***	-0.017***
		(0.003)		(0.001)	(0.001)	(0.001)
ΔlnP_{it-1}		0.185***		0.336***	0.299***	0.296***
		(0.005)		(0.003)	(0.003)	(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	No	No	No	No	No	Yes
Observations	269743	210467	830657	706952	917419	917419

Notes: The samples in columns (1)-(2) and (3)-(4) include domestic firms and FDI firms, respectively. The interaction term in columns (5)-(6) is the FDI dummy variable, which takes a value of 1 for multinational firms or joint ventures and 0 for domestic Chinese firms, identified one year ago. All regressions include firm fixed effects. Column (6) additionally incorporates time-fixed (year-month pair) effects. Robust standard errors are clustered at the firm level. *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Back

Verification 2: financially developed areas are less affected

- We use the ratio of private credit as an indicator of market financial development, fd_{ct}, and then aggregate to firm-level fd_{it}. Back

Table C7: Financial development of export markets

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)
	Monthly ΔlnP_{it}					
	Exporters selling more to undeveloped markets		Exporters selling more to developed markets		Comparison	
brw_t	0.194***	0.181***	0.149***	0.122***	0.182***	
	(0.017)	(0.017)	(0.014)	(0.013)	(0.017)	
$brw_t \times \mathbf{1}\{fd_{it} > \bar{fd}_t\}$					-0.052**	-0.060***
					(0.021)	(0.021)
$Sales_{it-12}$		0.002		-0.009***	-0.005***	-0.017***
		(0.002)		(0.002)	(0.001)	(0.001)
ΔlnP_{it-1}		0.227***		0.338***	0.298***	0.295***
		(0.004)		(0.004)	(0.003)	(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	No	No	No	No	No	Yes
Observations	484334	392014	610852	520009	912476	912476

Notes: We define the firm-level financial development indicator, which takes 1 if $fd_{it} > \bar{fd}_t$ and 0 otherwise. In columns (1)-(2), we limit our sample to firms with $fd_{it} \leq \bar{fd}_t$ (selling more to financially undeveloped markets). In columns (3)-(4), we limit our sample to firms with $fd_{it} > \bar{fd}_t$ (selling more to financially developed markets). In columns (5)-(6), we use the whole sample but additionally include the interaction term of monetary shock and the median dummy of firm-level financial development indicator. All regressions include firm fixed effects. Column (6) additionally incorporates time-fixed (year-month pair) effects. Robust standard errors are clustered at the firm level. *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Verification 3: processing trade responses are weaker

- **Processing trade**: imports raw materials and intermediate inputs from a foreign firm for processing and re-exports to the same firm. It is less dependent on external financing (Manova and Yu (2016)).

Table C8: Ordinary trade vs processing trade

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)
	Monthly ΔlnP_{it}					
	Only ordinary trade		Only processing trade		Comparison	
brw_t	0.194***	0.181***	0.100***	0.071***	0.190***	
	(0.018)	(0.019)	(0.019)	(0.016)	(0.016)	
$brw_t \times process$					-0.088***	-0.102***
					(0.023)	(0.024)
$Sales_{it-12}$		-0.001		-0.011***	-0.005***	-0.017***
		(0.002)		(0.002)	(0.001)	(0.001)
ΔlnP_{it-1}		0.189***		0.473***	0.299***	0.296***
		(0.003)		(0.005)	(0.003)	(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	No	No	No	No	No	Yes
Observations	499448	391356	283934	242572	917419	917419

Notes: In columns (1)-(2), we limit our sample to firms doing only ordinary trade. In columns (3)-(4), we limit our sample to firms doing only processing trade. In columns (5)-(6), we use the whole sample but additionally include the interaction term of monetary shock and the processing trade intensity. A higher value of *process* means a firm is more involved in processing trade. All regressions include firm fixed effects. Column (6) additionally incorporates time-fixed (year-month pair) effects. Robust standard errors are clustered at the firm level. *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Alternative story: global demand shift

Table C9: Homogeneous good vs differentiated good

Dependent Var	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Monthly ΔlnP_{it}							
	Conservative classification				Liberal classification			
brw_t	0.177***	0.149***	0.156***	0.137***	0.175***	0.147***	0.155***	0.139***
	(0.011)	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)	(0.013)	(0.012)
$brw_t \times ToE$	0.154	0.117			0.265***	0.243***		
	(0.129)	(0.126)			(0.086)	(0.082)		
$brw_t \times Ref$			0.209***	0.125***			0.167***	0.083***
			(0.033)	(0.032)			(0.031)	(0.030)
$Sales_{it-12}$		-0.005***		-0.005***		-0.005***		-0.005***
		(0.001)		(0.001)		(0.001)		(0.001)
ΔlnP_{it-1}		0.298***		0.298***		0.298***		0.298***
		(0.003)		(0.003)		(0.003)		(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1014106	850165	1014106	850165	1014106	850165	1014106	850165

Notes: The specification is $\Delta \ln P_{it} = \alpha + \beta_1 \cdot m_t + \beta_2 \cdot m_t \cdot X_{it} + \Gamma \cdot \mathbf{Z} + \xi_i + \varepsilon_{it}$. The variables *ToE* and *Ref* represent the value share of goods traded on an organized exchange and the value share of reference-priced goods of firm i. Columns (1)-(4) use the "conservative" classification, while columns (5)-(8) use the "liberal" classification, both referring to Rauch (1999). $\mathbf{Z}$ denotes lagged controls of firm-level time-variant variables, including price changes in the previous month and real sales income in the previous year. All regressions include firm fixed effects. Robust standard errors are clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Back

Preference

Following Melitz (2003)and Manova and Zhang (2012), the source and destination countries are denoted by i (e.g. China) and j, respectively.

A representative consumer in country j has preferences over locally produced goods Y_j^h and foreign products Y_j, and $U = U(Y_j^h, Y_j)$. The import bundle aggregates products from all countries:

$$Y_j = \left(\int Y_{ij}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \tag{4}$$

while each bilateral import flow Y_{ij} includes a continuum of unique products $\omega \in [0, 1]$:

$$Y_{ij} = \left(\int Y_{ij}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{5}$$

where $Y_{ij}(\omega)$ is country j's consumed quantity of variety ω originated from country i, and $\sigma > 1$ is the elasticity of substitution between varieties.

Back

Demand

Consumer optimization yields the following demand function for variety ω:

$$Y_{ij}(\omega) = \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}} Y_j \tag{6}$$

where $p_{ij}(\omega)$ is the price of the variety ω, $P_j = (\int p_{ij}^{1-\sigma} di)^{\frac{1}{1-\sigma}}$ is the import price index of country j, which is the aggregate of export prices $P_{ij} = (\int p_{ij}(\omega)^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$ across all other countries.

Back

Exporting firm

The settings for preference and demand are standard. Here we mainly introduce the settings for firms. Preference Demand
Assumption: working capital constraint

A fraction δ_i ($\in [0, 1]$) of the input costs should be borrowed from outside financial institutions and paid in advance.

$$\delta_i \equiv 1 - c_i^{\gamma}$$

where $c_i \in [0, 1]$ is the liquidity condition, $\gamma > 0$ reflects the elasticity. We assume:

$$c_i = \bar{c}_i + \rho_c^i m + \epsilon_c^i, \ \ \rho_c^i < 0$$

where m is the US monetary shock, and US tightening will worsen the firm's liquidity condition.

Back

Exporting firm

The production function:

$$y_i = \phi_i L_i$$

where ϕ_i is productivity and L_i is input.The firm in country i minimizes its cost to satisfy the demand in the country j, $Y_{ij}(\omega) = \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}} Y_j$.

The cost function:

$$C_{ij} = \frac{\tau_i w_i (1 - \delta_i + \delta_i R_i^{\alpha})}{\phi_i} \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}} Y_j$$

where τ_i is the iceberg cost, w_i is the price of input and R_i is the gross borrowing interest rate in country i.

Back

Proposition

Proposition 1. The export price decreases with liquidity conditions and increases with the borrowing interest rates: $\frac{\partial p}{\partial c} < 0$, $\frac{\partial p}{\partial R} > 0$.

Proposition 2. The export price would increase in response to a tightening US monetary policy shock (that is, $\frac{\partial p}{\partial m} > 0$) if the supply side effect dominates. ▸ Proof

Proposition 3. The impact of the US monetary shock on export price (i.e., $\frac{\partial p}{\partial m}$) depends on the financial conditions of the firms. If supply-side factors dominate, it is greater when the firms' liquidity conditions (c) are worse, and their average borrowing costs (δR) are higher given some parameter conditions.

▸ Back

Model extension

Our conclusion is robust to:

- Two factors ▸ Two factors
- Binding credit constraint ▸ Credit constraint
- Dynamic optimization and sticky price: ▸ Dynamic
- Currency invoicing: PCP, DCP, LCP ▸ PCP ▸ DCP ▸ LCP

▸ Back

Proof of Proposition 2

Proof

$$\begin{aligned}\frac{\partial p}{\partial m} =& \frac{\partial p}{\partial c}\frac{\partial c}{\partial m} + \frac{\partial p}{\partial R}\frac{\partial R}{\partial m} + \frac{\partial p}{\partial w}\frac{\partial w}{\partial m} \\ =& \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}\gamma(1-R^{\alpha})c^{\gamma-1}\rho_c + \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}[\alpha(1-c^{\gamma})R^{\alpha-1}]\rho_R + \\ & \frac{\sigma}{\sigma-1}\frac{\tau}{\phi}[c^{\gamma}+(1-c^{\gamma})R^{\alpha}]\rho_w\end{aligned}$$

The first two parts $\frac{\partial p}{\partial c}\frac{\partial c}{\partial m}$ and $\frac{\partial p}{\partial R}\frac{\partial R}{\partial m}$ are positive, while the third part $\frac{\partial p}{\partial w}\frac{\partial w}{\partial m}$ is negative. The former two parts are related to the supply-side effect, and the last part reflects the power of demand shrink. When the supply-side cost-push effect dominates the demand effect, the net impact of global monetary policy shock should be positive. This prediction is verified in the empirical part.

Back

Two factors

Suppose we include capital as an input factor. The production function of the firm is a Cobb–Douglas type $y = \phi K^{\chi} L^{1-\chi}$, where K is capital with a rental rate of r, χ is the share of income for capital. The associated marginal cost becomes:

$$MC = (\frac{1}{\chi})^{\chi}(\frac{1}{1-\chi})^{1-\chi}\frac{\tau r^{\chi}\left[w(1-\delta+\delta R)\right]^{1-\chi}}{\phi}$$

The optimal price is:

$$p = \frac{\sigma}{\sigma-1}MC = \frac{\sigma}{\sigma-1}(\frac{1}{\chi})^{\chi}(\frac{1}{1-\chi})^{1-\chi}\frac{\tau r^{\chi}\left[w(1-\delta_i+\delta R)\right]^{1-\chi}}{\phi}$$

In this case, monetary shocks can also affect the price through the rental rate r. As long as other effects are dominated by the cost-side impact, the export price will increase.

Back

Credit constraint

We assume firms cannot borrow more than a fraction θ of the expected cash flow from exporting. The firm's problem is:

$$\max_{p} \left(p - \frac{\tau w(1-\delta+\delta R^{\alpha})}{\phi}\right)\frac{p^{-\sigma}}{P^{-\sigma}}Y$$

$$\text{s.t. } \theta\frac{p^{1-\sigma}}{P^{-\sigma}}Y \geq (1-c^{\gamma})\frac{\tau w}{\phi}\frac{p^{-\sigma}}{P^{-\sigma}}Y \tag{7}$$

If the borrowing constraint is binding, rewrite it:

$$p = \frac{(1-c^{\gamma})}{\theta}\frac{\tau w}{\phi} \tag{8}$$

Monetary shock increases firms' credit needs, thus motivating them to increase prices to get more cash flow to meet the credit requirements. Consistent with the efficiency sorting theory (see Manova and Zhang (2012)), which predicts that more stringent credit conditions (here, smaller c) would raise optimal prices. Now, θ also plays a role by harming credit access. Back

Dynamic optimization and sticky price

We use the classical Calvo (1983) sticky price setting, and the firm's problem is to maximize its expected real profits:

$$\max_{p_t} \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^{\alpha}_{t+i})}{\phi_{t+i} P_{t+i}} \right] \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i}$$

where $\Omega_{t,t+i}$ is the real stochastic discount factor, and λ is the probability of a firm keeping its price unchanged in each period. The optimal price can be expressed as:

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} \varphi_{t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{P_{t+i}^{1-\sigma}} Y_{t+i}} \tag{9}$$

If $\lambda = 0$, $p_t = \frac{\sigma}{\sigma - 1} \frac{\tau_t w_t (1 - \delta_t + \delta_t R^{\alpha}_t)}{\phi_t}$, which is exactly the same as the static version.

Back

Credit constraint: dynamic

The firm's problem is:

$$\max_{p_t} \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R_{t+i}^{\alpha})}{\phi_{t+i} P_{t+i}} \right] \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i}$$

$$\text{s.t. } \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \theta_{t+i} \frac{p_t^{1-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} \geq$$

$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[(1 - c_{t+i}^{\gamma}) \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} \right]$$

The left-hand side of the borrowing constraint is the weighted sum of credit access, and the right-hand side reflects the corresponding external credit demands. If the borrowing constraint is binding, rearrange it:

$$p_t = \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{Y_{t+i}}{P_{t+i}^{1-\sigma}} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} \delta_{t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{Y_{t+i}}{P_{t+i}^{1-\sigma}} \theta_{t+i}} \tag{10}$$

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Invoicing currency: PCP

The firm's problem is:

$$\max_{p_t} \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^{\alpha}_{t+i})}{\phi_{t+i} P_{t+i}} \right] \left(\frac{p_t}{e^j_{t+i} P^j_{t+i}} \right)^{-\sigma} Y^j_{t+i}$$

where p is the price in the producer currency, e_j is the nominal exchange rate, P and P^j is the price index in the producer country and country j respectively, and Y^j is the total import in country j. The optimal price is:

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} \varphi_{t+i} (e^j_{t+i})^{\sigma}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{1}{P_{t+i}} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} (e^j_{t+i})^{\sigma}} \tag{11}$$

Apart from φ_{t+i}, it is also affected by e^j and the price indexes P and P^j. If $\lambda = 0$, $p_t = \frac{\sigma}{\sigma - 1} \frac{\tau_t w_t (1 - \delta_t + \delta_t R^{\alpha}_t)}{\phi_t}$, which is exactly the same as the static version.

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Invoicing currency: DCP

The firm's problem is:

$$\max_{p_t} \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t e^{us}_{t+j}}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^{\alpha}_{t+i})}{\phi_{t+i} P_{t+i}} \right] \left(\frac{p_t e^{us}_{t+i}}{e^j_{t+i} P^j_{t+i}} \right)^{-\sigma} Y^j_{t+i}$$

where p is the price in the US dollar, e^{us} is the nominal exchange rate against the US, defined as the price of the US dollar in terms of the producer currency. The optimal price is:

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} \varphi_{t+i} (e^j_{t+i} / e^{us}_{t+i})^{\sigma}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{1}{P_{t+i}} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} (e^j_{t+i} / e^{us}_{t+i})^{\sigma} e^{us}_{t+i}} \tag{12}$$

It is affected by both the bilateral exchange rate e^j and the US exchange rate e^{us}. If $\lambda = 0$, $p_t e^{us}_t = \frac{\sigma}{\sigma - 1} \frac{\tau_t w_t (1 - \delta_t + \delta_t R^{\alpha}_t)}{\phi_t}$, the price in terms of home currency (here RMB) is identical to the PCP version.

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Invoicing currency: LCP

The firm's problem is:

$$\max_{p_t} \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t e^j_{t+j}}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^{\alpha}_{t+i})}{\phi_{t+i} P_{t+i}} \right] \left(\frac{p_t}{P^j_{t+i}} \right)^{-\sigma} Y^j_{t+i}$$

The optimal price is:

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} \varphi_{t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{1}{P_{t+i}} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} e^j_{t+i}} \tag{13}$$

It is also affected by the bilateral exchange rate e^j, but slightly different from the PCP and DCP case. when $\lambda = 0$, $p_t e^j_t = \frac{\sigma}{\sigma - 1} \frac{\tau_t w_t (1 - \delta_t + \delta_t R^{\alpha}_t)}{\phi_t}$, the price in terms of home currency (here RMB) is identical to the PCP version.

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