Financial Shocks, Productivity and Prices[1]

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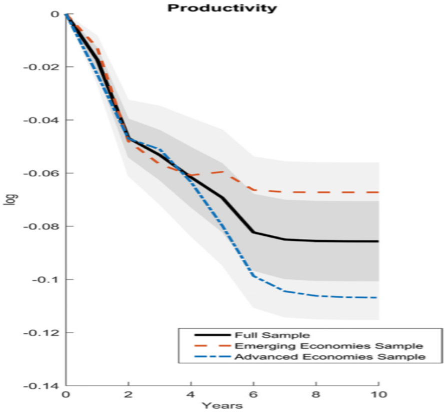
[1] The views expressed in this paper are those of the authors and do not necessarily reflect the views of the National Bank of Belgium, the Eurosystem, or any other institutions to which the authors are affiliated.

Financial Crisis and Aggregate Productivity Growth

- Financial crises are followed by a persistent slowdown in economic activity (Cerra and Saxena 2008; Reinhart and Reinhart 2010; Ball 2014;)
- Large fraction of output decline is accounted for by persistent drop in aggregate TFP (Queralto 2019; Aguiar and Gopinath 2007)



Impulse-response to a financial crisis (Queralto 2019)

Financial Crisis and Aggregate Productivity Growth

Several factors can account for slow aggregate productivity growth following financial crisis

- Contraction of demand
  (Mian and Sufi 2009;2014)
- Slowdown of innovation activity
  (Schmookler 1996; Aghion et al 2010; Bianchi et al 2017; Azoategui et al 2019; Reifschneider et al. 2015)
- Resource misallocation
  (Garcia-Macia 2015; Lenzu and Manaresi 2019; Sette et al 2019)
- Decline in business dynamism (Decker et al 2017)
- Loss of task-specific human capital (Labor hoarding, Giroud and Muller 2017)

Thanks to growing availability of micro-data, one explanation gained traction:

Credit supply shock $\Rightarrow$ Firm-level productivity $\downarrow$ $\Rightarrow$ Aggregate productivity $\downarrow$

- Quantitative models (Aghion et al 2010; Midrigan and Xu 2014; Buera and Moll 2015; Queralto 2019)
- Micro-evidence (Duval et al. 2017; Dörr et al. 2018; Manaresi and Pierri 2018; Levine and Warusawitharana 2019)

Credit Supply Shocks and the TFPR-TFPQ bifurcation

Available empirical evidence is inherently inconclusive:

It fails to account/ignores that firm might **adjust prices** in response to financial shocks

Data limitation: typically firm-level *output quantities* and *output prices* not separately observed

$$\underbrace{\ln(TFPR_{jt})}_{\substack{\textbf{Revenue} \\ \textbf{Productivity} \\ \Uparrow \\ \text{Common measure} \\ \text{of productivity}}} = \underbrace{\ln(TFPQ_{jt})}_{\substack{\textbf{Technical} \\ \textbf{Productivity} \\ \Uparrow \\ \text{Relevant measure} \\ \text{of productivity}}} + \underbrace{\ln(P_{jt})}_{\substack{\textbf{Output} \\ \textbf{Price} \\ \Uparrow \\ \text{Typically} \\ \text{unobserved}}}$$

Does the distinction between TFPR and TFPQ matter?

This paper (1)

Disentangles the causal effect of credit shocks on TFPQ and prices

1. Measurement: Observe product-level quantities and prices; measure TFPR and TFPQ
2. Causality: Address identification issue constructing firm-level credit supply shifters

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Core results

1. Immediate and persistent contraction of TFPR growth in response to credit tightening
2. Short-run: TFPR response is *totally uninformative*:
   - Firms respond adjusting prices (heterogeneously), entirely driving TFPR response
   - TFPQ is not affected
3. Long-run: Financial shocks have a persistent impact on TFPQ growth
   - TFPR and TFPQ co-move in the long-rum
   - Long-run TFPR response likely underestimates long-run TFPQ response (prices increase)

This paper (2)

Understanding economic forces driving prices and productivity response

1. Analyze empirical findings through the lens of a theoretical model

2. Model offers testable implications linking financial factors to *both* firm price-setting behavior and productivity growth

   - Short-run price adjustment is heterogeneous (prices can increase/decrease)

     Direction of pricing response depends on interplay of firms' assets (inventories), liabilities, and competitive environment

   - Credit shock cubs firms innovation activity

     Slowdown of investments in technology adoption can explain long-term TFPQ growth

Roadmap

1. Data

2. Prices and productivity measurement

3. Identification of firm-level credit supply shocks

4. Effect of credit supply shocks on productivity and prices
   - Short-run effects VS Long-run effects
   - Economic channels (Theory + Empirics)

5. Taking stock

Data

Comprehensive micro-level database merging administrative records of Belgian manufacturing

1. **Prices and quantity of output at the firm-product level**
   - PRODCOM database from Belgian statistical agency
2. **Firm-level data on firm assets, liabilities and income statement**
   - Firms' annual accounts
   - Value added fiscal declarations
3. **Firm-bank credit relationships**
   - Corporate credit register of the National Bank of Belgium
4. **Bank balance sheets**
   - Supervisory records from National Bank of Belgium
5. **Firm-to-firm transactions (firm-level input-output matrix)**
   - Universe of business-to-business transactions (customer-seller) from VAT declarations

Summary Statistics

Panel a: Firm characteristics

	Mean	SD
Total assets$_j$	92.722	308.623
Employees$_j$	215.407	1123.363
Age$_j$	32.401	19.044
Bank leverage$_j$	.210	.205
Share liabilities due$_j$	.347	.236
Cash$_j$	.064	.083
ROA$_j$	.022	.113
Number of products$_j$	2.485	2.944
Inventory$_j$	.145	.113
Multiple relationships$_j$	.635	.482
Number of relationships$_j$	2.090	1.097
Length of relationships	9.748	11.239
R&D rate$_j$	.062	.212
Technology adoption rate$_j$	.290	.933
Innovation rate$_j$	.351	.948
Length customer relationships$_j$	4.383	1.337
Customer share$_j$	.069	.071
Number of direct competitors$_j$	27.256	27.256
Customized goods$_j$	.094	.293
Firms	1,017	
Firm-year observations	5,486	

Panel b: Credit, Prices, and TFP growth rates

	Mean	SD
g(Credit$_j$)	-.153	.580
g_5(Credit$_j$)	-.822;	1.05
$\Delta \ln(P_j)$	.007	.156
$\Delta_5 \ln(P_j)$	.110	.322
$\Delta \ln(TFPR_j)$	.022	.112
$\Delta_5 \ln(TFPR_j)$	.028	.137
$\Delta \ln(TFPQ_j)$	.016	.188
$\Delta_5 \ln(TFPQ_j)$	-.082	.338

Panel c: Lender characteristics

	Mean	SD
Sov$_j$	.142	.045
Bank Size$_j$	17.692	.457
Tier1 ratio$_j$	.217	.010
Net interbank liabilities ratio$_j$	-.091	.073
Liquidity ratio$_j$	.847	.245
Deposits ratio$_j$	1.594	.122
Bad loans ratio$_j$	.004	.001
Firm-bank relationships	2,057	

▷ Industry partition

Prices and TFP estimation

Prices and TFP estimation

$$\Delta \ln(TFPR_j) = \Delta \ln(TFPQ_j) + \Delta \ln(P_j)$$

- **Prices** - Measurement of firms' "output price" is challenging for multi-product firms

  We construct different price measures building on product-level prices

  - Product-level prices
  - Firm-level price index

- **TFPR** - We estimate revenue productivity as residual from non-parametric gross output production functions (Gandhi et al 2019)

$$\ln(\widehat{TFPR}_{jt}) = \ln(PQ_{jt}) - f(k_{it}, l_{it}, m_{it}; \hat{\Theta})$$

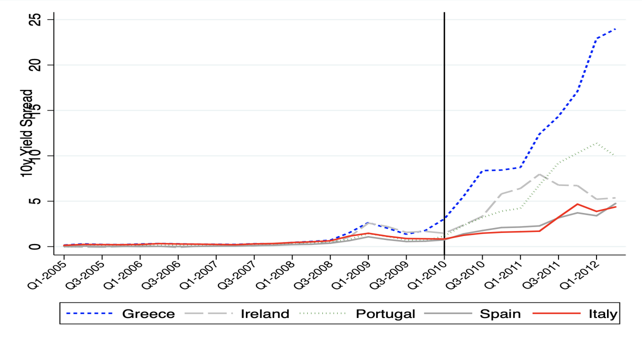
- **TFPQ** - $\Delta \ln(\widehat{TFPQ}_j) = \Delta \ln(\widehat{TFPR}_j) - \Delta \ln(P_j)$

Estimation of credit supply shocks

The burst of the sovereign crisis

We follow Bottero, Lenzu and Mezzanotti (2019), and exploit heterogeneity of banks' exposure to sovereign securities issued by GIPSI countries in the wake of Greek bailout request

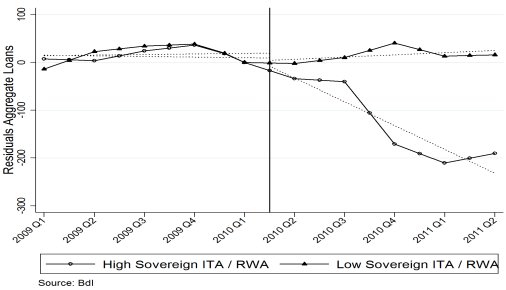
- April 2010: Bailout request advanced by Greek government
- Events in Greece triggered reassessment of country-specific risk in sovereign bond market
- Shortly after, investors began to be concerned with solvency of other peripheral EU countries

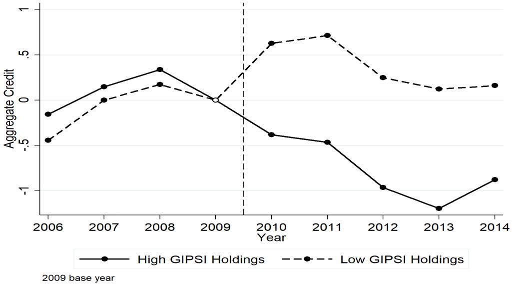


Yield-spread of sovereigns GIPSI countries vis-a-vis German sovereigns

Transmission of the sovereign shock to the banking sector

- The sudden change in the risk profile of sovereigns issued by GIPSI countries had a direct negative effect on the balance sheets of banks holding these assets
- Banks passed the shock through to their borrowers in the form of a credit tightening
  Bottero, Lenzu, Mezzanotti (2019), Acharya et al. (2018), and Balduzzi et al. (2018)





Italy (Bottero et al. 2019)

Belgium (This paper)

Identification strategy

- Construction of **firm-level credit supply shifters** and identification strategy follows Bottero, Lenzu, Mezzanotti (2019)

- Exploit variation in the presence and importance of firms' relationships with banks more/less exposed to GIPSI sovereigns (measured before Greek bailout (2010:Q1))

$$\text{Sov}_j = \sum_{b \in \mathcal{B}_j} \omega_{jb} \cdot \text{Sov}_{b,2010:Q1} \qquad w_{jb} = \frac{\text{Credit}_{jb,2010:Q1}}{\text{Credit}_{j\mathcal{B},2010:Q1}}$$

$$\mathbf{Y_j} = \beta \cdot \text{Sov}_\mathbf{j} + \Gamma_\mathbf{1}^{'} \mathbf{X_j} + \Gamma_\mathbf{2}^{'} \mathbf{K_j} + \Gamma_\mathbf{3}^{'} \mathbf{Z_j} + \mathbf{i_{ind}} + \mathbf{i_{reg}} + \mathbf{u_j}$$

$\mathbf{X}_j$ = Firm-level controls (Age, size, leverage, liquidity, number of products, productivity)
$\mathbf{K}_j$ = Bank-level controls (Size, capitalization, Interbank liabilities, ROA, non-performing loans)
$\mathbf{Z}_j$ = Relationship-level controls (Number and average length of lending relationships)

First Stage: $Y_j = g(Credit_j)$

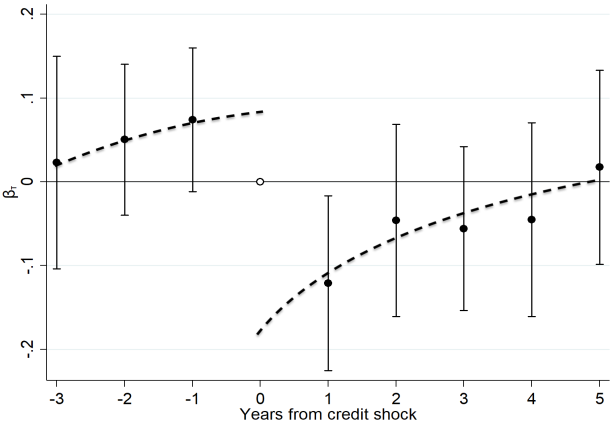
Second Stage: $Y_j = \{\Delta ln(TFPR_j),\ \Delta ln(P_j), \Delta ln(TFPQ_j)\}$

Credit response to the sovereign shock (first-stage)

	$g(\text{Credit}_j)$				$g(\text{Credit}_{jb})$	
	Firm-level				*Relationship-level*	
	(1)	(2)	(3)	(4)	(5)	(6)
Sov_j	-.121	-.0.56	-.022	.010	-.158	-.178
	(.050)	(.044)	(.049)	(.047)	(.062)	(.044)
Sov_j x Bank Leverage_j		-.343		-.268		
		(.102)		(.085)		
Sov_j x Share liabilities due_j			-.300	-.241		
			(.102)	(.090)		
R^2	.132	.146	.148	.156	.123	.487
Observations	1,017	1,017	1,017	1,017	2,021	2,532
Firm controls	Y	Y	Y	Y	N	N
Bank controls	Y	Y	Y	Y	Y	Y
Relationship controls	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	N	N
Geography FE	Y	Y	Y	Y	N	N
Firm FE	N	N	N	N	N	Y

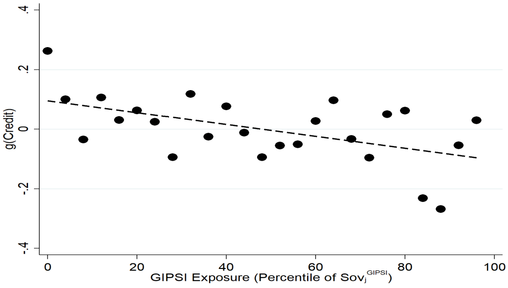
- On average, $+1\sigma$ exposure to sovereign shock leads to a reduction of **12 percent** in bank credit in the year following the burst of the sovereign crisis
- Effect larger for firms with more leverage and with a large share of debt due within one year (roll-over effect)

Credit shock was transitory in nature



Robustness

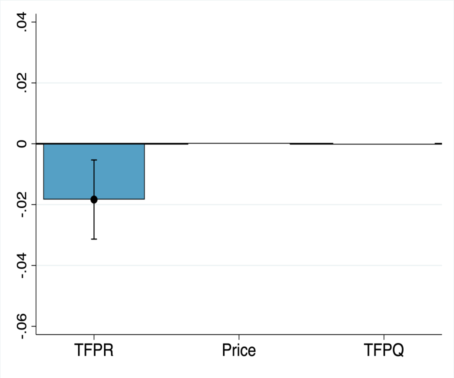
- Relationship between credit holds along the entire distribution



- Effect not driven by sorting of high-sovereign banks with worst borrowers
- Effect similar using alternative measures of sovereign exposure
- Placebo: exposure to sovereigns of "Core" EU countries have positive or no effect on lending

Effect of credit supply shock on productivity and pricing

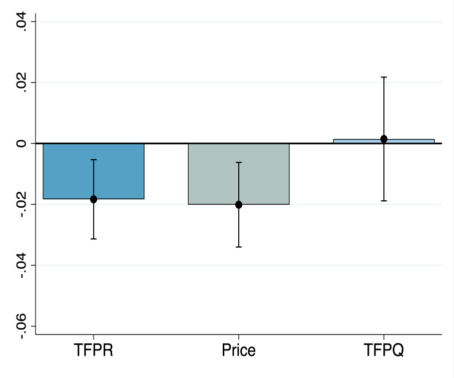
Short-term response to credit shock



Result #1: Sharp drop in firm-level TFPR growth (-10% credit $\Rightarrow$ -1.5% TFPR growth) (consistent with findings of previous literature)

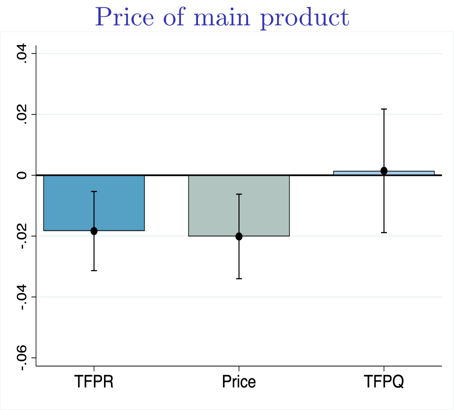
Short-term response to credit shock

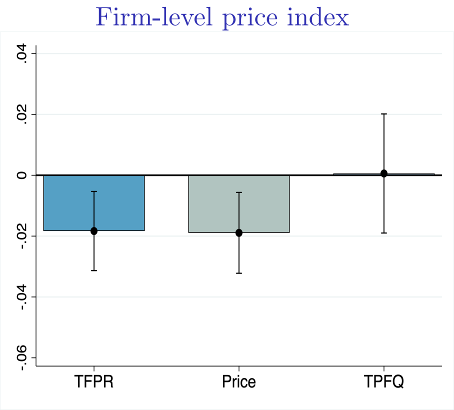
Price of main product



Result #2: Price adjustment drives short-run effect on TFPR (-10% credit $\Rightarrow$ -1.6% price)
Technical productivity growth is unaffected in the short-run (!!)

Short-term response to credit shock





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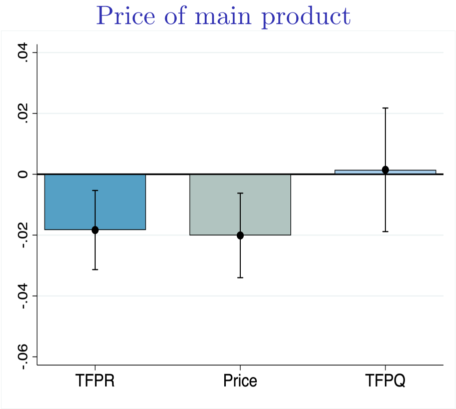
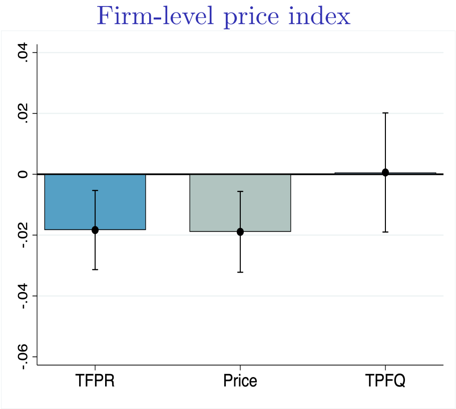
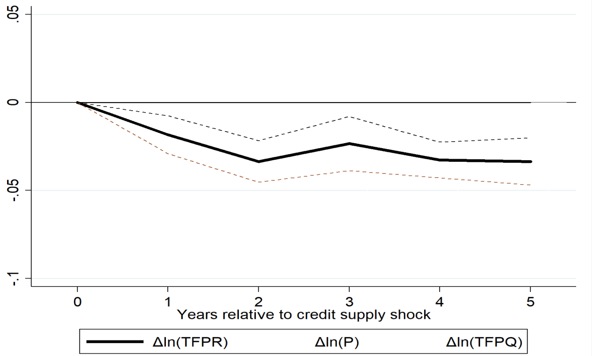




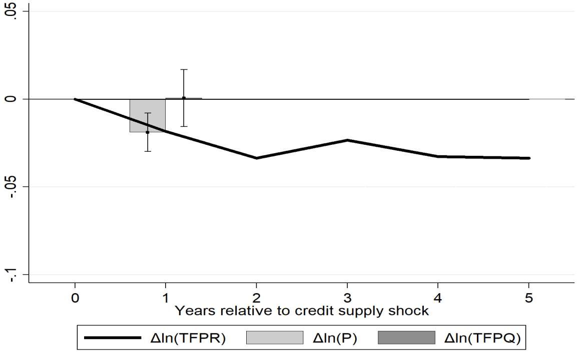
- Results are not affected by how prices are measured/aggregated ▷ Alternative prices
- Results are also robust to method of productivity measurement ▷ Alternative TFP
- Hold for single-product firms and multi-product firms that don't change product composition
- Are robust to control for firm products' quality adjustment (forthcoming)

Long-term response to credit shock



- Credit tightening impairs long-run TFPR growth

Long-term response to credit shock



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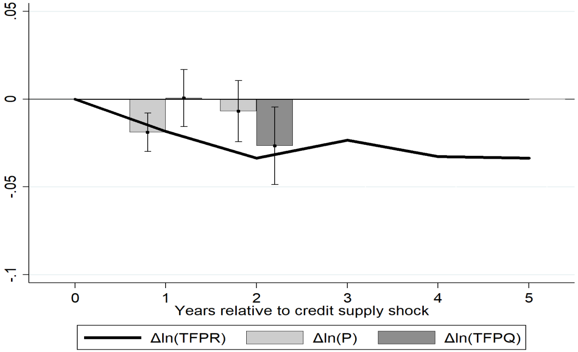

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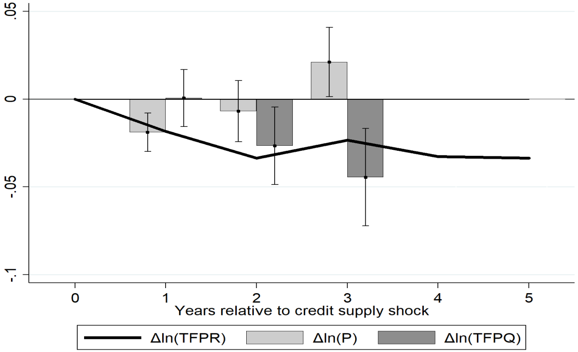

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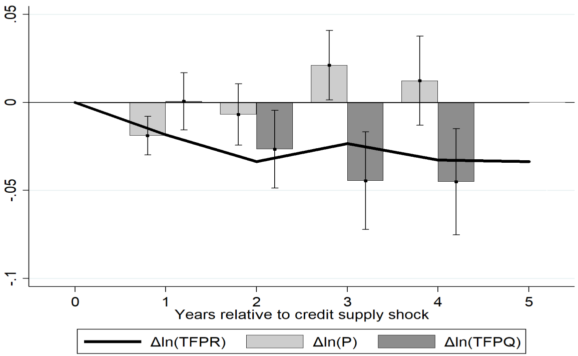

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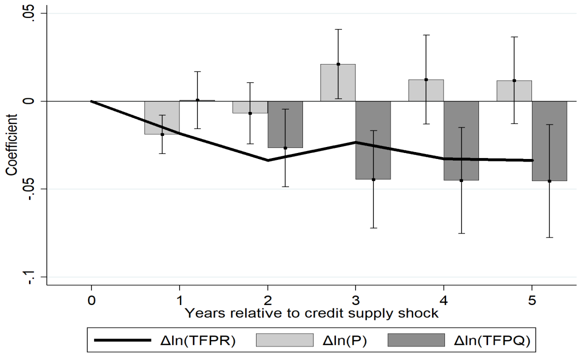


Result #3: Credit tightening impairs long-run productivity growth

- TFPQ effect kicks-in after 2-3 years
- $+1\sigma$ credit hock $\Rightarrow$ -6% TFPQ after 5 years
- Pricing effects reverses over time (although noisy)
- TFPR response *underestimates* true TFPQ response

Economic channels

What drives short-run pricing response and long-run TFPQ response?

Model highlights

- Leveraged firm sequentially decides production, pricing, and investments as uncertainty resolves
- Realization of unanticipated credit supply shock updates firm's prior about likelihood of default (default is costly, Modigliani & Miller does not apply)
- Firms can take actions to contrast effect of shock on probability of default:
  - Increase sales revenues ($P \downarrow$)
  - Reduce costs (investments in innovation $\downarrow$)
- But lower P and innovation have costs (trade-off):
  - Lower P reduces short-term profits
  - Lower innovation reduces productivity growth and therefore long-term profits

Prediction 1 - Pricing response to credit tightening is heterogeneous

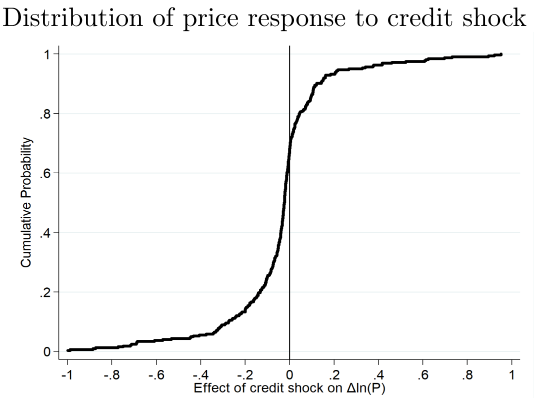
Direction of pricing response (increase or decrease P) determined by

1. A firm's ability to sell more output (capacity constraint)
2. Effectiveness of price adjustment in reducing default probability

Prediction 2 - Investments in innovation contract

Economic channels: short-term pricing response

Prediction 1 - Pricing response to credit tightening is heterogeneous



- On average, firms **reduce prices** in response to a tightening of financing conditions
- But, about 35 percent of firms appear to respond **increasing preces**

Economic channels: short-term pricing response

Inventory fire-sale channel + strength of liabilities

	(1)	(2)	(3)
		$\Delta \ln(P_j)$	
Sov_j	-.012	-.024	-.024
	(.007)	(.008)	(.008)
$\text{Sov}_j \times \text{Inventory}_j$	$\boxed{-.051}$		-.003
	$\boxed{(.018)}$		(.039)
$\text{Sov}_j \times \text{High Default Risk}_j$		.027	.056
		(.009)	(.018)
$\text{Sov}_j \times \text{Inventory}_j$			-.191
$\times \text{High Default Risk}_j$			(.084)
Marginal effects:			
High Default Risk and Low inventory			0.032
			(.014)
High Default Risk and High inventory			-.194
			(.056)
R^2	.124	.124	.131
Observations	1,017	1,017	1,017

- Inventory depletion allows firms to increase sales revenues (at no extra production cost) $\Rightarrow$ **Price decrease**

Economic channels: short-term pricing response

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- Inventory depletion allows firms to increase sales revenues (at no extra production cost) ⇒ **Price decrease**
- Firms w/ weak balance sheets (high net liabilities) are hit hard by credit shock: extra revenues from price reduction do little to mitigate default ⇒ **Price increase**

Economic channels: short-term pricing response

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Economic channels: short-term price response

Elasticity of customers' demand

- Take advantage of firm-to-firm transaction data to construct measurable proxies of residual elasticity of demand of individual firms

	(1)	(2)	(3)
		$\Delta \ln(P_j)$	
Sov_j	-0.043	-0.019	-0.025
	(0.001)	(0.005)	(0.008)
Sov_j × Length customer relationships_j	0.006		
	(0.001)		
Sov_j × Customized goods_j		0.052	
		(0.023)	
Sov_j × Customer share_j			0.115
			(0.049)
R2	0.126	0.131	0.125
Observations	1,017	1,017	1,017

If consumers' demand is inelastic

- Lower incentives to lower prices in response to credit shock: sales revenues do not increase much if $P \downarrow$
- Greater incentives to increase prices to raise liquidity: sales revenues do not drop much if $P \uparrow$

Economic channels: long-term TFPQ response

Investments in innovation and technology adoption

Previous literature

- Links productivity growth and productivity enhancing investments
  (Aghion et al. 2012, Garcia-Macia 2017, Huber 2018; Anzoategui et al. 2019)

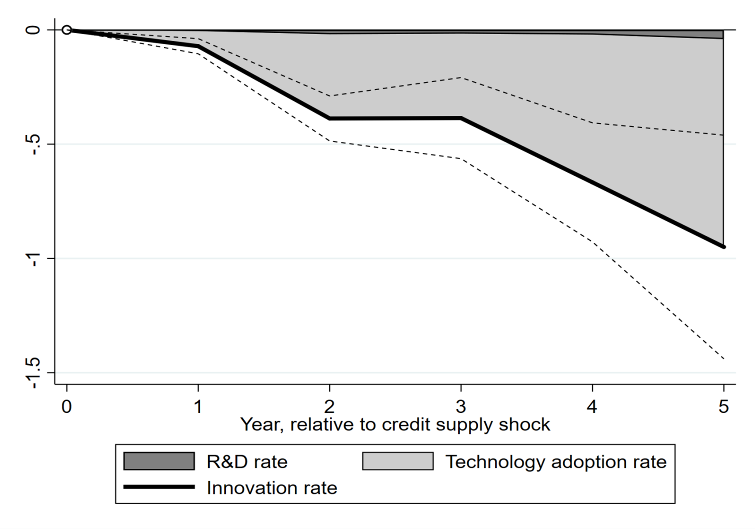
- Provides evidence consistent with financial constraints discouraging innovation
  (Hall and Lerner 2010; Kerr and Nanda 2015; Bond et al. 2005; Howell 2017; Comin and Nanda 2018)

We connect the two strands of the literature

1. Credit shock → investments in innovation (R&D and technology adoption)
2. Investments in innovation (driven by exposure to credit shock) → TFPQ growth

Economic channels: long-term TFPQ response

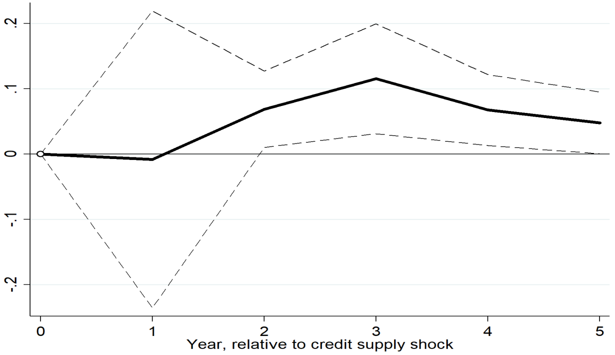
Prediction 2 - Credit shock leads to contraction of investments in innovation



Economic channels: long-term TFPQ response

Linking financial shocks to TFPQ via investment in innovation

IV regression, instrumenting cumulative investments in innovation with credit supply shock



- Contraction of innovation driven by tightening of financing conditions explains long-run TFPQ growth slowdown

Taking stock

Financing, pricing decisions, and productivity dynamics are tightly related.

1. Distinguishing between TFPQ and TFPR is of first-order importance to understand relationship between finance, productivity growth, and economic growth (Aghion et al. 2012, Garcia-Macia 2017; Huber 2018; Anzoategui et al. 2019; Queralto 2019)
   - The use of TFPR measures as proxies of TFPQ is ubiquitous
   - But confounding TFPR and TFPQ movements offers misleading insights into how firms respond to financial shocks
   - Observed short-run drop in TFPR is good (price adjustment is constrained optimum)

2. Emphasis on distinction b/w TFPR and TFPQ shared w/ empirical studies in other settings (Foster et al. 2008; Hsieh and Klenow 2009; Haltiwanger et al. 2018; Katayama et al. 2009; Eslava et al. 2013; Garcia-Marin and Voigtlander 2018; Eslava and Haltiwanger 2018)

3. This paper bridges the productivity literature with separate literatures
   - Response of prices/markups to financial shocks: Prices increase (Chevalier and Scharfstein 1995; Gilchrist et al 2017) vs Price decrease (Zingales 1998; Phillips and Sertsios 2013; Kim 2018)
   - Financing innovation (Hall and Lerner 2010; Kerr and Nanda 2015; Howell 2017; Comin and Nanda 2018)

Financial Shocks, Productivity and Prices

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Industry partition

Industry Code	Industry	Percentage of firms
7	Mining of metal ores	0.1
8	Other mining and quarrying	1.97
10	Manufacture of food products	25.07
11	Manufacture of beverages	2.06
12	Manufacture of tobacco products	0.88
13	Manufacture of textiles	7.87
14	Manufacture of wearing apparel	0.59
15	Manufacture of leather and related products	0.29
16	Manufacture of wood and of products of wood and cork, except furniture	3.93
17	Manufacture of paper and paper products	4.72
18	Printing and reproduction of recorded media	1.67
20	Manufacture of chemical and chemical products	12.88
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.2
22	Manufacture of rubber and plastic products	8.36
23	Manufacture of other non-metallic mineral products	7.18
24	Manufacture of basic metals	3.93
25	Manufacture of fabricated metal products, except machinery and equipment	6.59
26	Manufacture of computer, electronic, and optical products	2.95
27	Manufacture of electrical equipment	3.15
28	Manufacture of machinery and equipment nec	5.21
29	Manufacture of motor vehicles, trailers, and semi-trailers	0.2
31	Manufacture of furniture	0.1
32	Other manufacturing	0.1

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Production Function Estimates

NACE Code	Prod. Fun. Estimation, NP				Prod. Fun. Estimation, CD				Revenue Shares, CD			
(2-digits)	θ^L	θ^K	θ^M	RS	θ^L	θ^K	θ^M	RS	θ^L	θ^K	θ^M	RS
14	0.24	0.075	0.647	0.962	0.316	0.03	0.614	0.96	0.202	0.161	0.637	1
15	0.201	0.061	0.769	1.031	0.298	0.05	0.719	1.067	0.224	-0.157	0.934	1
16	.	.	.	.	.	.	.	.	0.119	0.088	0.793	1
17	0.295	0.037	0.683	1.015	0.277	0.128	0.66	1.065	0.256	0.058	0.686	1
18	0.276	0.057	0.726	1.059	0.482	0.109	0.601	1.192	0.329	0.033	0.638	1
19	.	.	.	.	.	.	.	.	0.262	0.053	0.685	1
20	0.226	0.06	0.718	1.005	0.152	0.201	0.676	1.029	0.239	0.069	0.692	1
21	0.207	0.076	0.702	0.985	0.335	0.005	0.692	1.032	0.222	0.081	0.697	1
22	0.265	0.047	0.699	1.01	0.22	0.025	0.685	0.93	0.225	0.058	0.718	1
23	.	.	.	.	.	.	.	.	0.152	0.073	0.775	1
24	0.238	0.059	0.702	0.998	0.346	0.027	0.707	1.08	0.211	-0.057	0.847	1
25	0.273	0.05	0.68	1.004	0.314	0.033	0.687	1.034	0.221	0.071	0.708	1
26	0.289	0.09	0.643	1.022	0.263	0.045	0.674	0.983	0.229	0.082	0.689	1
27	0.185	0.067	0.741	0.993	0.263	0.032	0.725	1.019	0.201	0.029	0.771	1
28	0.281	0.06	0.663	1.004	0.308	0.1	0.615	1.023	0.305	0.05	0.644	1
29	0.331	0.048	0.654	1.034	0.349	0.051	0.625	1.025	0.295	0.031	0.674	1
30	.	.	.	.	.	.	.	.	0.23	0.076	0.693	1
31	0.321	0.049	0.648	1.017	0.388	0.028	0.625	1.041	0.291	0.055	0.654	1
32	0.324	0.078	0.607	1.009	0.414	0.031	0.622	1.066	0.28	0.054	0.666	1
33	0.325	0.034	0.651	1.011	0.425	-0.036	0.609	0.999	0.306	0.057	0.637	1

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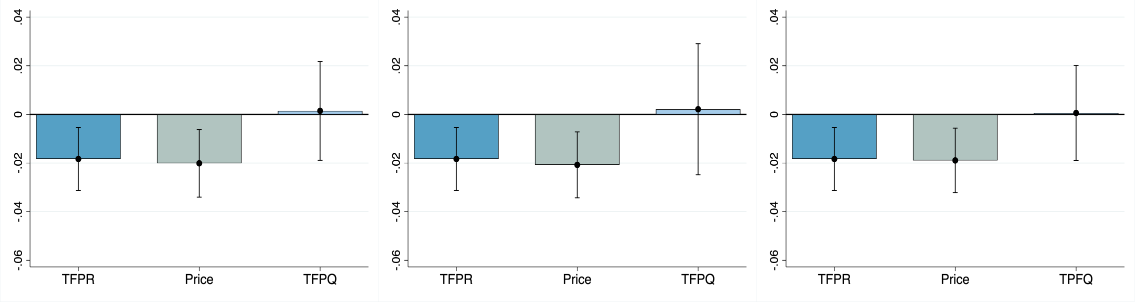
Short-term response to credit shock

Price of main product | Adj. price of main product | Firm-level price



- Results are not affected by how prices are measured/aggregated

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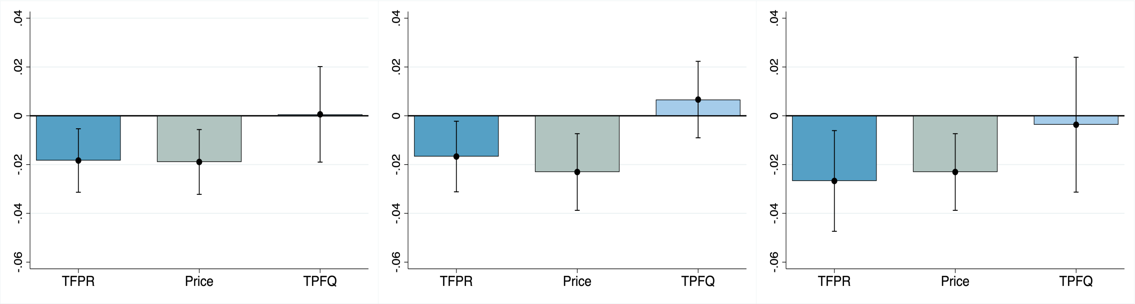
Short-term response to credit shock

Non-parametric
Prod. function estimation

Cobb-Douglas
Prod. function estimation

Cobb-Douglas
Revenue shares



- Results are also robust to method of productivity measurement

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