Credit Supply and Firms' Productivity Growth

Francesco Manaresi and Nicola Pierri

Bank of Italy, Stanford University

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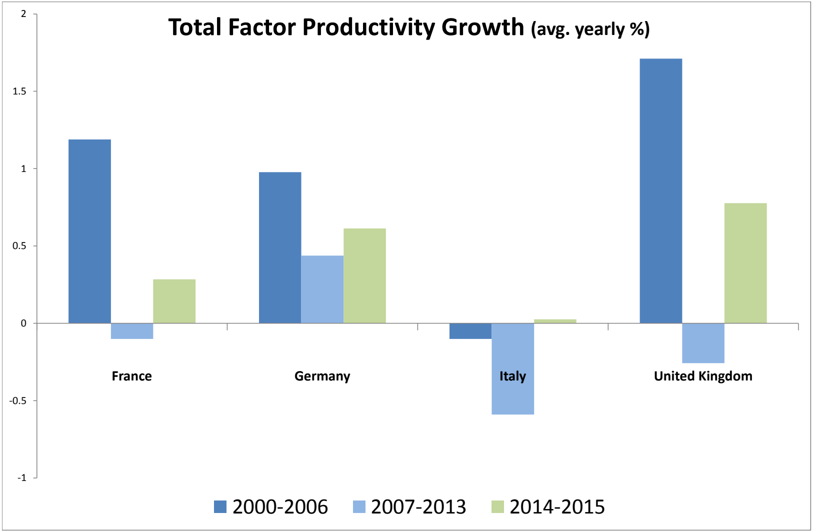
Introduction

- The financial and sovereign crises have witnessed significant TFP slowdown in Europe;
- Growth afterwards remained sluggish.



Total Factor Productivity Growth (avg. yearly %)
2
1.5
1
0.5
0
-0.5
-1
France
Germany
Italy
United Kingdom
2000-2006
2007-2013
2014-2015

Introduction

- Several explanations for recent TFP trends:
  - “secular” stagnation
  - faltering innovation
  - slowdown in business dynamism
  - output data fail to capture values of new digital products

Does credit supply play a role?

Research Question

Olley-Pakes decomposition of average productivity:

$$\sum_i \omega_{i,t} \cdot marketshare_{i,t} = \frac{1}{N} \sum_i \omega_{i,t} + cov \left(\tilde{\omega}_{i,t}, market\tilde{s}hare_{i,t} \right)$$

- **Credit Supply and TFP via Input Misallocation**: Midrigan and Xu (2014), Gopinath et al. (2016).
- Yet, there are reasons to expect also a **direct effect on firm-level TFP growth** $\omega_{i,t}$:
  through innovation (Amore et al. 2013), export (Paravisini et al. 2014), technology adoption, managerial practices.

The impact of credit supply shocks in the literature

Growing literature on identification of firm-level credit supply shocks from firm-bank matched data (Khwaja-Mian, Greenstone-Mas-Nguyen, Amiti-Weinstein)

- **Labor**: Chodorow-Reich (2014), Bentolilla et al. (2016).
- **Investments**: Gan (2007) Cingano et al. (2016), Acharyia et al. (2016); Bottero et al. (2016).

- So far, no study in this literature plugged results into a production function framework.

- Some contemporaneous papers on "credit constraints ⇒ TFP" (Dorr et al.; Duval et al.; de Sousa and Ottaviano)

This paper

1. **Identifying firm-level changes in credit supply**:
   - exploits bank-firm matched data + stickiness of lending relationships
2. **Estimates TFP allowing for an effect of credit supply on TFP**
   - productivity process allowed to be directly affected by credit supply
3. **Estimates the effect of credit supply on TFP**
   - **main results**: $\uparrow$ 1% cred supply $\Rightarrow$ $\uparrow$ 0.13% productivity growth More Results
   - BotE calculation: a drop in credit growth of around 12 p.p. (2006-2008) $\Rightarrow$ 25% aggregate reduction in TFP over the same period
   - persistent effect on productivity *levels*
4. **Beyond measurement: channels**
   - evidence that credit supply boosts Export & Innovation (R&D and Patenting)

Data

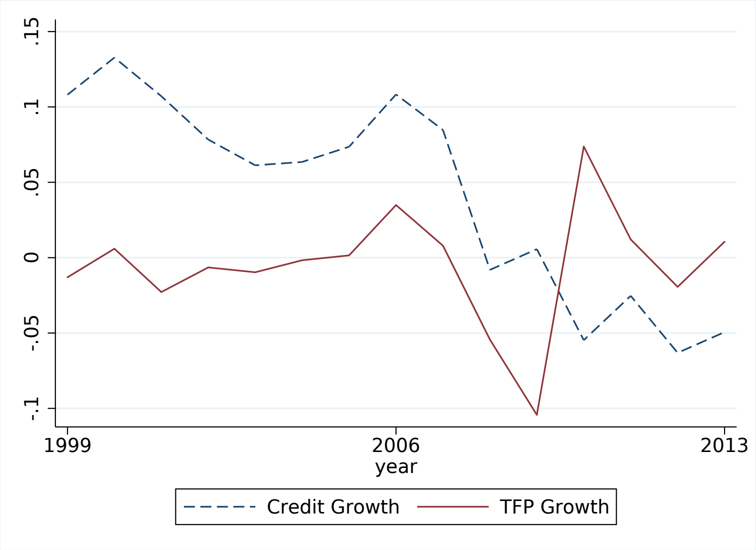
Credit Register: all credit relations in country

- report credit instruments, we use total
- focus on credit granted, yearly
- on average, per year:
  - 468,984 firms
  - 1,008 banks
  - 2.8 relationships per firm; 1,321 per bank

Balance-Sheets and Income Statement from CADS:

- large sample of small and large Italian manufacturers
- capital series reconstructed with perpetual inventory methodology
- sector-level deflators from National Accounts
  - $\Rightarrow$ measure of productivity based on revenues, not quantity (Foster, Haltiwanger, and Syverson, 2008)

TFP and Credit among Italian Firms



Notes: Data from ∼ 30K Italian firms from CADS dataset.

Estimated p.f.: Value Added Cobb-Douglas.

Identifying Credit Supply Shocks

Credit Supply: an Empirical Framework

Total credit granted to firm i at the end of year t is equal to

$$C_{i,t} = \sum_b C_{ib,t}$$

Assume, as a starting point:

$$\frac{C_{ib,t}}{C_{ib,t-1}} = \frac{C\left(\delta_t, U_{i,t}, U_{b,t}\right)}{C\left(\delta_{t-1}, U_{i,t-1}, U_{b,t-1}\right)}$$

Log-linearizing:

$$\Delta c_{ibt} = c_t + \Delta u_{it} + \Delta u_{bt} + \varepsilon_{ibt}$$

A Valid Decomposition?

We are assuming away:

- **no assortative matching:** firm demand is not bank-specific
- **no granularity in credit demand:** firms are sufficiently small
- **no spillover across banks** because of substitutability/complementarities btw banks.

$$\Delta c_{ibt} = c_t + \Delta u_{it} + \Delta u_{bt} + \Delta u_{ibt} + d\Delta u_{b't} + \varepsilon_{ibt}$$

Tackling Identification Assumptions

- **assortative matching:** test robustness of results against controlling for firm-bank (lagged) characteristics
  - length of lending relationship
  - share of collateral
  - share of drawn credit
  - interest rate charged
- **granularity in credit demand:** exclude top-borrowers
- **spillover across banks:** iterating procedure $\rightarrow$ include supply shocks of other banks (main bank or avg lenders) previously estimated

Resulting estimates of Δu_{bt} are very similar ($Corr. \approx .90$).
All results on productivity confirmed.

From Bank Shocks to Firm Credit Supply

- We compute firm-level credit supply shocks as:

$$\chi_{it} = \sum_b w_{ib,t-1} \Delta u_{bt}$$

  where $w_{ib,t-1} = C_{ib,t-1} / C_{i,t-1}$
- Logic of w_{ibt}: Borrower-lender relations mitigate asymmetric info & limited commitment
  - valuables, costly to establish and sticky
  - $\Rightarrow$ changes in lenders' credit supply affects financing ability of connected borrowers

Measuring Productivity

A simple theoretical model

Production function:

$$Y_{i,t} = \exp\{\omega_{i,t} + \epsilon^{Y}_{i,t}\} F\left(L_{i,t}, K_{i,t}, M_{i,t}, \beta\right)$$

s.t.

$$K_{i,t} = I_{i,t} + (1 - \delta_t) K_{i,t-1}$$

$$\tilde{\pi}_{i,t} + B_{i,t} = D_{it} + I_{i,t} + B_{i,t-1}\left(1 + r_{i,t}\right) + Adjustment$$

$$B_{i,t} \leq K_{i,t-1} \cdot \Gamma\left(\chi_{i,t}, \omega_{i,t}\right)$$

Taking logs:

$$y_{i,t} = \omega_{i,t} + \epsilon^Y_{i,t} + f(k_{i,t}, l_{i,t}, m_{i,t}, \beta)$$

Assuming intermediates $m_{i,t}$ are fully flexible and monotonic is monotonic in $\omega_{i,t}$, we invert its demand function

$$\omega_{i,t} = m^{-1}(m_{i,t}, k_{i,t}, l_{i,t}, z_{i,t}, \chi_{i,t}) \Rightarrow$$

$$y_{i,t} = m^{-1}(m_{i,t}, k_{i,t}, l_{i,t}, z_{i,t}, \chi_{i,t}) + f(k_{i,t}, l_{i,t}, m_{i,t}, \beta) + \epsilon^Y_{i,t} \Rightarrow$$

First stage estimation:

$$y_{i,t} = \Psi(m_{i,t}, k_{i,t}, l_{i,t}, z_{i,t}, \chi_{i,t}) + \epsilon^Y_{i,t}$$

Productivity law of motion

$$E\left[\omega_{i,t}|\mathcal{I}_{t-1}\right] = g_t\left(\omega_{t-1}, \chi_{i,t-1}\right)$$

approximate g with a polynomial

$$\zeta_{i,t} := \omega_{i,t} - g\left(\omega_{t-1}, \chi_{i,t-1}\right)$$

$$\Rightarrow E\left[\zeta_{i,t}|\mathcal{I}_{t-1}\right] = 0$$

what does it mean?

1. $\nexists$ persistent, firm-specific unobservable affecting input choices and productivity
   - violated if we did not include $\chi_{i,t}$.
2. shocks to ω are orthogonal to lagged variables
   - violated if e.g. company invested more in the past anticipating higher prod growth

Estimating moments

$$E\left[\zeta_{i,t} + \xi_{i,t} | \mathcal{I}_{t-1}\right] = 0 \Rightarrow$$

$$E\left[y_{i,t} - f(k_{i,t}, l_{i,t}, m_{i,t}, \beta) - g\left(\Psi_{i,t-1} - f(k_{i,t-1}, l_{i,t-1}, m_{i,t}, \beta), \chi_{i,t-1}, G_t\right) \middle| \begin{array}{c} l_{i,t-1} \\ inv_{i,t-1} \\ \Psi_{i,t-1} \\ m_{i,t-1} \\ .. \end{array} \right]$$

$\Rightarrow$ estimate, for each industry, both β and the ancillary coefficients G_t

- value added: average $\beta_k \approx 0.35$ and $\beta_l \approx 0.64$
- net revenues: average $\beta_k \approx 0.03$, $\beta_l \approx 0.10$ and $\beta_m \approx 0.87$

Results

Credit supply and input & output growth

For each (log) input or output measure we estimate:

$$\Delta x_{i,t} = \psi_i + \psi_{p,s,t} + \gamma \chi_{i,t} + \eta_{i,t}$$

VARIABLES	(1) Δva	(2) Δy	(3) Δk	(4) Δl	(5) Δn	(6) Δm
$\chi_{i,t}$	0.144***	0.0477***	0.0572***	-0.0271	-0.0126	0.0126
	(0.0227)	(0.0158)	(0.0192)	(0.0184)	(0.0127)	(0.0167)
Observations	293k	293k	293k	293k	293k	293k
R-squared	0.248	0.320	0.260	0.258	0.324	0.319

All sectors

Credit supply and productivity

Now we can run:

$$\Delta\omega_{i,t} = a_i + \psi_{p,s,t} + \gamma\chi_{i,t} + \eta_{i,t}$$

	(1)	(2)	(3)	(4)
$\chi_{i,t}$	0.133***	0.138***	0.0423***	0.0510***
	(0.0241)	(0.0205)	(0.00820)	(0.00749)
Output measure	va	va	y	y
Functional Form	CD	TL	CD	TL
Observations	278k	258k	286k	272k
R-squared	0.198	0.339	0.159	0.271

All sectors

On the effect of credit supply on productivity

- Results show that the effect is significant and positive: a 1 p.p. increase in credit supply triggers VA productivity by 0.13 p.p.
- Results less different between VA and revenues productivity, once effects are standardized.
- Effect stronger for smaller firms, and in manufacturing.

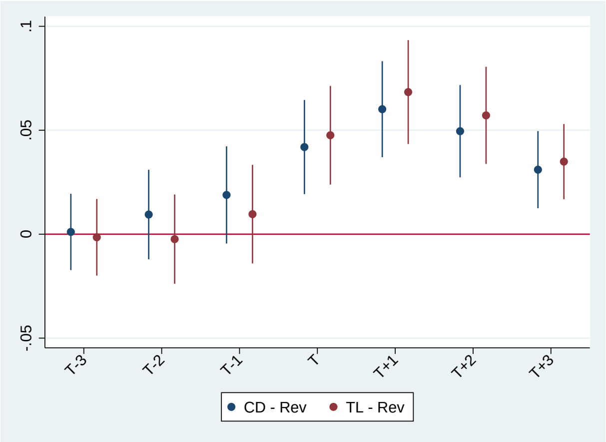
Estimated effect is remarkably robust

Results are unaffected by

- inclusion of firm-level controls;
- use of different Fixed-Effects structure (test for correlated unobservables);
- estimate of bank shocks net of spillovers & controlling for assortative matching btw firms and banks;
- exclusion of top-3% ("granular") borrowers;
- controlling for impact of credit supply on firm's demand ⇒ firms involved into global and local VC are NOT differently affected Results
- use of a different identification strategy for credit supply shocks: the 2007-2008 collapse of the interbank mkt.

Persistency and Pre-trend

$$\omega_{i,t} = \psi_i + \psi_{p,s,t} + \sum_{j=3}^{-3} \gamma_j \chi_{i,t-j} + \eta_{i,t}$$



No significant pre-trend, levels remain persistently higher after shock.

Effects over time

$$\Delta\omega_{i,t} = \psi_i + \psi_{p,s,t} + \sum_t \gamma_t \chi i, t + \eta_{i,t}$$

Effect peaks in 2009, but significant also before crisis

Why Does Credit Availability Enhance Productivity Growth?

Additional Data

INVIND

- survey conducted from '84 on panel of firms
- mostly>50 employees
- some waves have info on innovation and export activities
- neither questions nor respondents are fixed over time

Patents

- Patents registered at EPO by all Italian firms;
- Matched to fiscal codes by the Italian Chamber of Commerce (Unioncamere);
- Priority Dates : 1999-2012.

Possible Mechanisms? ICT adoption

Number of PC used by the firm available for years 1999, 2000, 2001

- do firms become more ICT intense when credit constraints are more relax

$$\log\left(\frac{PC}{employees}\right)_{i,t} = \gamma_i + \gamma_t + \alpha\chi_{i,t} + \eta_{i,t}$$

and

$$\log\left(\frac{PC}{K}\right)_{i,t} = \gamma_i + \gamma_t + \alpha\chi_{i,t} + \eta_{i,t}$$

Results

No statistically significant evidence of positive effect

VARIABLES	(1) $\log\left(\frac{PCs}{employees}\right)$	(2) $\log\left(\frac{PCs}{employees}\right)$	(3) $\log\left(\frac{PCs}{K}\right)$	(4) $\log\left(\frac{PCs}{K}\right)$
$\chi_{i,t}$	0.117	0.302	0.257	0.513
	(0.149)	(0.282)	(0.220)	(0.379)
Obs	6541	1969	6232	2193
Sample	All	Exclude top 25%	All	Exclude top 25%
R^2	0.935	0.932	0.939	0.921

Clustered standard errors in parentheses
Firm and year FE are included
*** p<0.01, ** p<0.05, * p<0.1

Possible Mechanisms? - R&D and Export

High quality information on size of R&D investment from INVIND

- we consider dicotomic variables
  - exporter vs non-exporter (dummy $Expt_{i,t}$)
  - positive versus zero R&D investment
- we have two measures of R&D
  - $R\&D_{i,t}$
  - $RD\&Etal_{i,t}$

LPM with firm fixed effect:

$$Pr(d_{i,t} = 1) = \gamma_i + \gamma_t + \alpha \chi_{i,t} + \eta_{i,t}$$

where $d_{i,t}$ is any of the dummies described above

Results

Companies are more likely to start (less to stop) exporting or doing R&D (only one of our measures) when credit availability increases

	(1)	(2)	(3)
VARIABLES	$Expt_{i,t}$	$R\&D_{i,t}$	$RD\&Etal_{i,t}$
$\chi_{i,t}$	0.152*	0.238*	-0.064
	(0.085)	(0.128)	(0.105)
Obs	13,249	5,991	15,177

Clustered standard errors in parentheses

Firm and year FE are included

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

Possible Mechanisms? Financial constraints to innovation

Innovative effort is much broader than just formal R&D or ITC adoption

- 2011 survey wave investigate which were the main constraints to innovative effort for previous year
- one question ask how important were difficulties to collect external funds in limiting innovation on a four-items scale
- $FinCon_{i,2010}$ equal to one iff difficulties to get external funds is thought to be "somehow important" or "very important" as obstacle to innovation

Result - Financial constraints to innovation

Linear Probability Model, using cross section

$$Pr(FinCon_{i,2010} = 1) = \gamma_{s,p} + \alpha\chi_{i,2010} + \eta_{i,t}$$

Estimates

- $\widehat{\alpha} = -1.111^*$
- $tstat = -1.75$
- N=628
- caveats: only regression with $\chi_{i,t}$ without firm FE (we include *province* $\times$ *sector*)

$\Rightarrow$ Innovation efforts are less likely to be constraints by lack of external funds when firms just received a positive credit shock

Possible Mechanisms? Patenting

$$\#Pat_{i,t} = a_i + \gamma_{s,p,t} + \alpha\chi_{i,t} + \varepsilon_{i,t}$$

	(1)	(2)	(3)
$\chi_{i,t}$	0.032***	0.038**	0.036**
	(0.010)	(0.018)	(0.017)
Firm FE	N	Y	Y
Sector FE	Y	Y	N
Province FE	Y	Y	N
Year FE	Y	Y	N
Sec-Prov-Year FE	N	N	Y
Obs	241K	241K	241K

Clustered standard errors in parentheses
Firm and year FE are included
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Conclusion

In this paper we

- exploit banks-firms connections to measure firm-specific shocks to credit supply
- estimate a simple model of production with heterogeneous credit frictions
- show that productivity growth is boosted by increase in credit supply
- document that productivity enhancing activities are stimulated by credit availability

What's next:

- improve our identification of possible mechanisms
- compute relative importance of credit frictions for allocative efficiency vs productivity growth

Thank You

francesco.manaresi@bancaditalia.it

All sectors

VARIABLES	(1) Δva	(2) Δy	(3) Δk	(4) Δl	(5) Δn	(6) Δm
$\chi_{i,t}$	0.106***	0.0424***	0.0531***	0.00461	0.00144	0.0233*
	(0.0182)	(0.0121)	(0.0144)	(0.0140)	(0.0104)	(0.0125)
Observations	552k	552k	552k	552k	552k	551k
R-squared	0.232	0.311	0.264	0.276	0.324	0.312

VARIABLES	(1) $\Delta\omega_{i,t}$	(2) $\Delta\omega_{i,t}$	(3) $\Delta\omega_{i,t}$	(4) $\Delta\omega_{i,t}$
$\chi_{i,t}$	0.0890***	0.106***	0.0173***	0.0244***
	(0.0175)	(0.0183)	(0.00523)	(0.00547)
Observations	552k	552k	551k	551k
R-squared	0.179	0.191	0.192	0.212
Output measure	va	va	revenues	revenues
Functional Form	CD	TL	CD	TL

Back - Productivity

Back - Inputs/Outputs

Direct Effect on Demand

Bank might directly affect borrowers demand because of correlation between lenders of suppliers and lenders of clients (e.g. local effect). Then we run

$$\Delta\omega_{i,t} = \psi_t + \psi_i + \gamma_0 \chi_{i,t} + \gamma_1 \frac{export_{i,t-2}}{y_{i,t-2}} + \gamma_2 \chi_{i,t} \cdot \frac{export_{i,t-2}}{y_{i,t-2}} + \eta_{i,t}$$

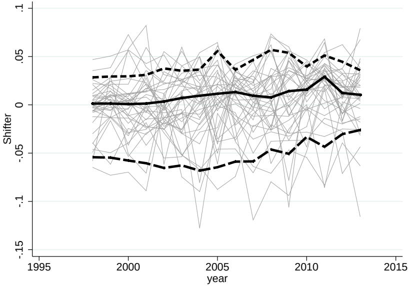
γ_2 capture the differential effect of the shock on exporters

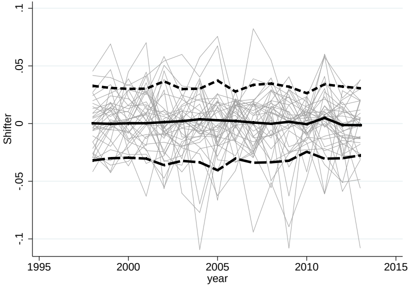
- less likely foreign buyers land from same back $\Rightarrow \gamma_2 < 0$
- results: not statistically different from zero
- $\Rightarrow$ effects does not come from direct effect on mark up

Back

"Visualizing" the relevant variation: RHS

Evolution of $\chi_{i,t}$ for a 5% random sample of manufacturers

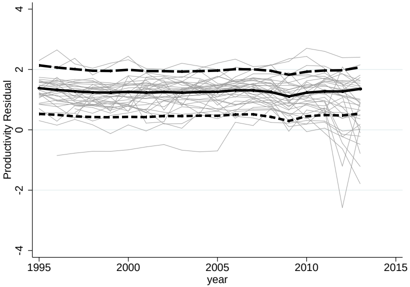


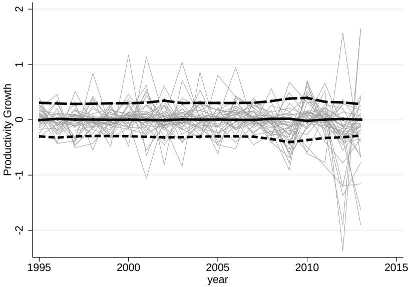


- Right panel shows residualized values after taking out FEs
- no clear pattern over time: $\chi_{i,t}$ makes sense only relatively

“Visualizing” the relevant variation: LHS

Evolution of $\omega_{i,t}$ for a 5% random sample of manufacturers

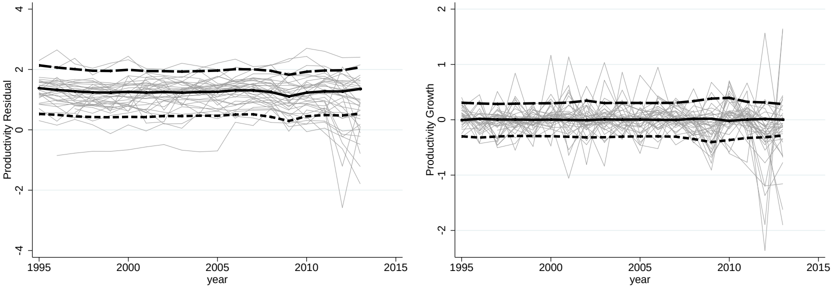




- Right panel shows residualized values after taking out FEs

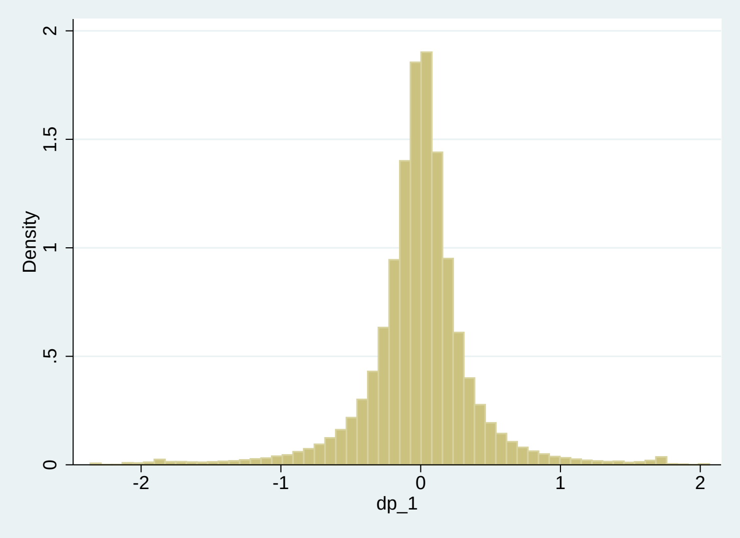
"Visualizing" the relevant variation: LHS

Evolution of $\omega_{i,t}$ for a 5% random sample of manufacturers



- Right panel shows residualized values after taking out FEs

Histogram of $\Delta\omega_{i,t}$



- Value Added - Cobb Douglas

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