Credit Supply and Firms’ Productivity Growth

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13th CompNet Annual Conference

Brussels, June 29, 2017
Introduction

- The financial and sovereign crises have witnessed significant TFP slowdown in Europe;
- Growth afterwards remained sluggish.
Total Factor Productivity Growth (avg. yearly %)

- France
- Germany
- Italy
- United Kingdom

2000-2006
2007-2013
2014-2015

Legend:
- Dark blue: 2000-2006
- Light blue: 2007-2013
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:

\[ \sum_{i} \omega_{i,t} \cdot marketshare_{i,t} = \frac{1}{N} \sum_{i} \omega_{i,t} + \text{cov} \left( \tilde{\omega}_{i,t}, \text{marketshare}_{i,t} \right) \]

- **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).

▶ 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:** ↑ 1% cred supply ⇒ ↑ 0.13% productivity growth
   ▶ BotE calculation: a drop in credit growth of around 12 p.p. (2006-2008) ⇒ 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
  - ⇒ measure of productivity based on revenues, not quantity (Foster, Haltiwanger, and Syverson, 2008)
Notes: Data from ~ 30K Italian firms from CADS dataset.
Estimated p.f.: Value Added Cobb-Douglas.
Identifying Credit Supply Shocks
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:

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

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 → include supply shocks of other banks (main bank or avg lenders) previously estimated

Resulting estimates of $\Delta u_{bt}$ are very similar ($Corr. \approx .90$). All results on productivity confirmed.
We compute firm-level credit supply shocks as:

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

where \( w_{ib,t-1} = \frac{C_{ib,t-1}}{C_{i,t-1}} \)

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:

\[ Y_{i,t} = \exp\{\omega_{i,t} + \epsilon_{i,t}^Y\} F (L_{i,t}, K_{i,t}, M_{i,t}, \beta) \]

s.t.

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

\[ \tilde{\pi}_{i,t} + B_{i,t} = D_{it} + I_{i,t} + B_{i,t-1} (1 + r_{i,t}) + \text{Adjustment} \]

\[ B_{i,t} \leq K_{i,t-1} \cdot \Gamma (\chi_{i,t}, \omega_{i,t}) \]
Taking logs:
\[ y_{i,t} = \omega_{i,t} + \epsilon_{i,t} + f(k_{i,t}, l_{i,t}, m_{i,t}, \beta) \]

Assuming intermediates \( m_{i,t} \) are fully flexible and monotonic is monotonic in \( \omega_{i,t} \), we invert its demand function
\[ \omega_{i,t} = m^{-1}(m_{i,t}, k_{i,t}, l_{i,t}, z_{i,t}, \chi_{i,t}) \Rightarrow \]
\[ y_{i,t} = m^{-1}(m_{i,t}, k_{i,t}, l_{i,t}, z_{i,t}, \chi_{i,t}) + f(k_{i,t}, l_{i,t}, m_{i,t}, \beta) + \epsilon_{i,t} \Rightarrow \]

First stage estimation:
\[ y_{i,t} = \Psi(m_{i,t}, k_{i,t}, l_{i,t}, z_{i,t}, \chi_{i,t}) + \epsilon_{i,t} \]
Productivity law of motion

\[ E [\omega_{i,t} | I_{t-1}] = g_t (\omega_{t-1}, \chi_{i,t-1}) \]

approximate \( g \) with a polynomial

\[ \zeta_{i,t} := \omega_{i,t} - g (\omega_{t-1}, \chi_{i,t-1}) \]

\[ \Rightarrow E [\zeta_{i,t} | I_{t-1}] = 0 \]

what does it mean?

1. \( \not\exists \) persistent, firm-specific unobservable affecting input choices and productivity
   - violated if we did not include \( \chi_{i,t} \).

2. shocks to \( \omega \) are orthogonal to lagged variables
   - violated if e.g. company invested more in the past anticipating higher prod growth
Estimating moments

\[ E [\zeta_{i,t} + \xi_{i,t} | I_{t-1}] = 0 \Rightarrow \]

\[ E \left[ y_{i,t} - f(k_{i,t}, l_{i,t}, m_{i,t}, \beta) - g (\Psi_{i,t-1} - f(k_{i,t-1}, l_{i,t-1}, m_{i,t}, \beta), \chi_{i,t-1}, G_t) \right] \]

\[ \Rightarrow \text{estimate, for each industry, both } \beta \text{ and the ancillary coefficients } G_t \]

- 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:

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

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) $\Delta v_{a}$</th>
<th>(2) $\Delta y$</th>
<th>(3) $\Delta k$</th>
<th>(4) $\Delta l$</th>
<th>(5) $\Delta n$</th>
<th>(6) $\Delta m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_{i,t}$</td>
<td>0.144*** (0.0227)</td>
<td>0.0477*** (0.0158)</td>
<td>0.0572*** (0.0192)</td>
<td>-0.0271 (0.0184)</td>
<td>-0.0126 (0.0127)</td>
<td>0.0126 (0.0167)</td>
</tr>
<tr>
<td>Observations</td>
<td>293k</td>
<td>293k</td>
<td>293k</td>
<td>293k</td>
<td>293k</td>
<td>293k</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.248</td>
<td>0.320</td>
<td>0.260</td>
<td>0.258</td>
<td>0.324</td>
<td>0.319</td>
</tr>
</tbody>
</table>
Credit supply and productivity

Now we can run:

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

- 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);
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

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

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

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

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

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) $Expt_{i,t}$</th>
<th>(2) $R&amp;D_{i,t}$</th>
<th>(3) $RD&amp;Etal_{i,t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_{i,t}$</td>
<td>0.152*</td>
<td>0.238*</td>
<td>-0.064</td>
</tr>
<tr>
<td></td>
<td>(0.085)</td>
<td>(0.128)</td>
<td>(0.105)</td>
</tr>
<tr>
<td>Obs</td>
<td>13,249</td>
<td>5,991</td>
<td>15,177</td>
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</tbody>
</table>

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

\[ Pr(\text{FinCon}_{i,2010} = 1) = \gamma_{s,p} + \alpha \chi_{i,2010} + \eta_{i,t} \]

Estimates

- \( \hat{\alpha} = -1.111^* \)
- \( tstat = -1.75 \)
- \( N=628 \)
- 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

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

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi_{i,t} )</td>
<td>0.032***</td>
<td>0.038**</td>
<td>0.036**</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.018)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Firm FE</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Sector FE</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Province FE</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Sec-Prov-Year FE</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Obs</td>
<td>241K</td>
<td>241K</td>
<td>241K</td>
</tr>
</tbody>
</table>

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

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### All sectors

<table>
<thead>
<tr>
<th>VARIABLES</th>
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<th>(5) $\Delta n$</th>
<th>(6) $\Delta m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi_{i,t}$</td>
<td>0.106*** (0.0182)</td>
<td>0.0424*** (0.0121)</td>
<td>0.0531*** (0.0144)</td>
<td>0.00461 (0.0140)</td>
<td>0.00144 (0.0104)</td>
<td>0.0233* (0.0125)</td>
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<tr>
<td>Observations</td>
<td>552k</td>
<td>552k</td>
<td>552k</td>
<td>552k</td>
<td>552k</td>
<td>551k</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.232</td>
<td>0.311</td>
<td>0.264</td>
<td>0.276</td>
<td>0.324</td>
<td>0.312</td>
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</table>

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

$$\Delta \omega_{i,t} = \psi_t + \psi_i + \gamma_0 x_{i,t} + \gamma_1 \frac{\text{export}_{i,t-2}}{y_{i,t-2}} + \gamma_2 x_{i,t} \cdot \frac{\text{export}_{i,t-2}}{y_{i,t-2}} + \eta_{i,t}$$

$\gamma_2$ 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
“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