Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity

Khan and Thomas (2011)

Discussion by Fernando Leibovici
Introduction

Question

• What are the aggregate real effects of a credit supply shock?
• Can it account for the dynamics of US aggregates at the onset of the crisis?

This paper

• Focus on interaction between investment and financial decisions
• Real effects of aggregate credit supply shocks depend crucially on
  ▶ Use of external finance → Collateral constraints
  ▶ Dynamics of investments to be financed → Partial capital irreversibility
• Write and calibrate model featuring these frictions, use it to study:
  ▶ Credit supply shock vs US aggregate dynamics over the crisis vs TFP shock
Setup

Firms

- Unit measure
- Produce homogeneous output
- DRS technology → $y = z\varepsilon F(k, n)$
- Own capital
- Idiosyncratic shocks
  - Productivity $\varepsilon$, AR(1)
  - Exit with exogenous probability $\eta$ (replaced by new firm)
- Collateral constraints and partial capital irreversibility
- Cannot raise equity

Households

- Unit measure, homogeneous, own firms
- Cannot lend to or borrow from firms

Aggregate shocks

- Productivity $z$, AR(1)
Timing

1. Begin period in state \((k, b, \varepsilon; z, \mu)\)

2. Learn whether survive to the next period
   - Public knowledge \(\rightarrow\) If exit, then cannot borrow

3. All firms
   - Hire labor, produce, and pay wage bill
   - Pay debt / receive loan payments

4. Survivors
   - Invest \(\rightarrow i\)
   - Pay dividends \(\rightarrow d\)
   - Borrow / save \(\rightarrow b'\)

5. Households consume and reallocate ownership shares
Real and financial frictions

Partial capital irreversibility

- \( k' = (1 - \delta)k + i \)
- If buy capital, \( i \geq 0 \) → Spend \( i \) units of the good
- If sell capital, \( i < 0 \) → Earn \( \theta_ki \) units of the good, where \( \theta_k \in [0, 1] \)

Borrowing constraint

- \( b' \leq \theta_b \theta_k k \), where \( \theta_b \geq 0 \)

Firms cannot issue equity

- Non-negative dividends → \( d \geq 0 \)

Financial markets

- Households and firms participate in segmented financial markets
Firms’ problem

Start of the period

\[ v(k, b, \varepsilon; z, \mu) = \eta v^{exit}(k, b, \varepsilon; z, \mu) + (1 - \eta) v^{survive}(k, b, \varepsilon; z, \mu) \]

Exiting firms

\[ v^{exit}(k, b, \varepsilon; z, \mu) = \max_n z \varepsilon F(k, n) - wn + \theta_k (1 - \delta) k - b \]
Continuing firms

\[ v^{\text{survive}}(k, b, \varepsilon; z, \mu) = \max_{n, k', b', d, i} \quad d + E \left[ m' v(k', b', \varepsilon'; z', \mu') \right] \]

subject to

\[ d + \Phi(i)i + b + wn \leq z\varepsilon F(k, n) + qb' \]

\[ k' = (1 - \delta)k + i \]

\[ b' \leq \theta_b \theta_k k \]

\[ d \geq 0 \]

\[ \mu' = \Gamma(z, \mu) \]

\[ \Phi(i) \begin{cases} 1 & \text{if } i \geq 0 \\ \theta_k & \text{if } i < 0 \end{cases} \]
Households’ problem

\[ h(\lambda, z, \mu) = \max_{c, n^h, \tilde{\lambda}, \lambda'} U(c, 1 - n) + \beta E [h(\lambda', z', \mu')] \]

subject to
\[ c + \int_S \rho(k, b, \varepsilon)\tilde{\lambda}(k, b, \varepsilon) = w n^h + \int_S [\rho(k, b, \varepsilon) + d(k, b, \varepsilon)] \lambda(k, b, \varepsilon) \]
\[ \mu' = \Gamma(z, \mu) \]
\[ \lambda' = \Gamma(z, \tilde{\lambda}) \]
Labor and capital accumulation

Labor choice is efficient

- Since wage bill paid after production takes place
- \( z \in F_2(k, n) = w \)

Capital accumulation follows two-sided \((S, s)\) rules

- Partial irreversibility leads to
  1. Inaction region
  2. Lower adjustment, conditional on action

- Sunk component to investment decision decreases returns to adjustment
  - Due to negative future potential adjustments
Retained earnings vs dividends

- Bond interest rate equals the real interest rate \( q = \frac{1}{E(m')} \)
- Then, if borrowing constraint binds in some possible future state \( \rightarrow d = 0 \)

Idea

- With non-binding borrowing constraint in all possible future states
  - Return to \( b' = \frac{1}{E(m')} \), so indifferent between \( b' \) and \( d \)
  - Pick equilibrium with **minimum savings** such that constraints are non-binding in all possible future states of the world
  - These firms are **unconstrained**

- With binding constraint in some possible future state
  - Return to \( b' \) exceeds \( \frac{1}{E(m')} \), so \( d = 0 \)
  - \( b' \) pinned down from investment decision and budget constraint
  - These firms are **constrained**
Constrained firms: interaction between savings and investment

- New firms begin with low $k$ and $b = 0 \rightarrow$ Constrained

- Conditional on productivity, gradual increase in debt and capital
  - To increase capital stock, need to borrow
  - To borrow, need to increase capital stock

- Productivity shocks may force firms with high debt to sell capital
  - If debt is high enough, forced to sell capital to repay it

- Firms will underinvest to increase savings, even if constraint doesn’t bind
  - Reduce risk of being forced to sell off capital in the future
  - Reduce risk of forced underinvestment due to binding constraint
Stationary steady-state: Life-cycle dynamics
Credit supply shock

Question
• What are the aggregate real effects of a credit supply shock?

The experiment
• Unexpected drop in $\theta_b$
• Every subsequent period, agents expect $\theta_b$ back to normal with 40% probability

How do firms respond in partial eqm?
• Some unconstrained firms become constrained
• Those that remain unconstrained are not affected
• Constrained firms reduce investment, given ↑ risk of future binding constraint

→ Answer depends on the use of external finance, as well as the demand for finance
→ Discipline these to match key moments from US data
## Calibration: key parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Moment</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_b$</td>
<td>1.35</td>
<td>debt/assets ratio (US, 1952-2005 avg)</td>
<td>0.366</td>
</tr>
<tr>
<td>$\rho_\varepsilon$</td>
<td>0.653</td>
<td>$i/k$ (avg across US plants)</td>
<td>0.122</td>
</tr>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>0.135</td>
<td>$\sigma_{i/k}$ (avg across US plants)</td>
<td>0.337</td>
</tr>
<tr>
<td>$\theta_k$</td>
<td>0.95</td>
<td>$i/k$ autocorrelation (avg across US plants)</td>
<td>0.058</td>
</tr>
</tbody>
</table>

### New firms

- $\eta = 0.10$
- $k_0 = \chi \int_S k\mu_{ss}(dS) \rightarrow \chi = 0.10 \rightarrow \approx$ relative size of new firms in data
- $b_0 = 0$

### Functional forms

- $U(c, 1 - n) = \log c + \phi(1 - n)$
- Cobb-Douglas production function
Credit supply shock: $\theta_b$ from 1.35 to 0.8 with no recovery
Credit supply shock: misallocation and endogenous TFP fluctuations

FIGURE 11. Persistent financial crisis: marginal products of capital

- MPK: cross-sectional mean
- MPK: coefficient of variation

(level vs. time)

(time vs. date)
Credit supply shock vs TFP shock vs US data

Credit supply shock vs US aggregate dynamics

<table>
<thead>
<tr>
<th>x =</th>
<th>GDP</th>
<th>I</th>
<th>N</th>
<th>C</th>
<th>TFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>−4.14</td>
<td>−25.75</td>
<td>−6.89</td>
<td>−1.36</td>
<td>−0.60</td>
</tr>
<tr>
<td>Model (fig. 9)</td>
<td>−4.20</td>
<td>−22.98</td>
<td>−3.62</td>
<td>−0.58</td>
<td>−0.97</td>
</tr>
</tbody>
</table>

Negative exogenous TFP shock

• Similar response to shock as in frictionless economy
• No initial increase in C
• Need very large TFP shock to get drop in I and N as in the data
• Except for consumption, no hump-shaped response
Appendix
Capital accumulation

- FOC $i$ with extra $i \geq 0$ constraint $\rightarrow -\gamma^{bc} + \gamma^k \leq 0$
- FOC $i$ with extra $i \leq 0$ constraint $\rightarrow -\theta_k \gamma^{bc} + \gamma^k \geq 0$
- Then,

\[
i = \begin{cases} 
  i^+ > 0 & \text{if } \gamma^k > \gamma^{bc} \\
  = 0 & \text{if } \gamma^k \in [\theta_k \gamma^{bc}, \gamma^{bc}] \\
  i^- < 0 & \text{if } \gamma^k < \theta_k \gamma^{bc}
\end{cases}
\]
Unconstrained firms: minimum savings policy $b'_{min}$

- $b'_{min} \rightarrow$ Such that unconstrained future investment and never binding constraints
- $\tilde{b} \rightarrow$ Minimum start-of-period savings that allow to implement $b'_{min}$
- Recursive definition
  \[
  \tilde{b} = z\varepsilon F(k, n^*_{unc}) - wn^*_{unc} + q \min \{b'_{min}, \theta b\theta_k k\} - \Phi(i^*_{unc})i^*_{unc}
  \]

  \[
  b'_{min} = \min_{S'} \tilde{b}(S')
  \]

Dividends

- $b'_{min}$ determines $d$ from budget constraint
Market clearing conditions

Ownership shares

$$\lambda' = \mu'$$

Labor

$$n^h(\mu; z, \mu) = \int_S n(k, b, \varepsilon; z, \mu)\mu(k, b, \varepsilon)$$

Output

$$c(\mu; z, \mu) + (1 - \eta) \int_S \Phi(i(k, b, \varepsilon; z, \mu))i(k, b, \varepsilon; z, \mu)\mu(k, b, \varepsilon)$$

$$= \eta \int_S [z\varepsilon F(k, N(\varepsilon, k; z, \mu)) + \theta_k(1 - \delta)k - k_0] \mu(k, b, \varepsilon)$$
Stationary steady state: Misallocation over the life-cycle
US aggregate dynamics over the crisis

FIGURE 8. The Recent Recession

- GDP
- Total Hours
- Consumption
- Private Investment
- Business Investment
- TFP
TFP shock

FIGURE 7. Negative technology shock

- Exogenous TFP
- Output
- Measured TFP
- Employment
- Consumption
- Investment
Credit shock and recovery in period 5

FIGURE 13. Financial crisis and recovery

- Output: Red dashed line (top left)
- Capital: Blue solid line (top left)
- Employment: Red dashed line (top right)
- Consumption: Blue solid line (top right)
- Investment: Red dashed line (bottom left)
- Measured TFP: Red dashed line (bottom right)
- Exogenous TFP: Black dashed line (bottom right)