Credit Constraints, Firms’ Precautionary Investment, and the Business Cycle

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Background

- *Broad theme*: Implications for aggregate investment dynamics of endogenous borrowing constraints for firms
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- **Standard theoretical approach**
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  - Credit multiplier $\rightarrow$ prediction about the *amount* of investment

- Quantitative significance questioned


- Model misspecification, or financial frictions unimportant?
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- New approach: precautionary investment motive

- Can precautionary motive resuscitate the financial accelerator?

- Can it account for observed behavior of the composition of investment across the business cycle?

- Brand new agenda: credit frictions relevant mainly because of what ...rms do to avoid them?

- Bu ... consumer behavior?
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  - \( \approx \) buffer stock behaviour of consumers
Empirical Motivation
CREDIT CONDITIONS AND SMALL FIRMS' INVESTMENT

- US Small Business Survey data (from NFIB)
  - Capital expenditures: % maintaining or increasing
  - Credit conditions: % seeing a worsening of credit availability
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R&D INVESTMENT ACROSS THE BUSINESS CYCLE

![Graph showing % variation in ratio of R&D expenditures as a share of total investment - Data for the United States from National Science Foundation](image.png)

**Figure:** % variation in ratio of R&D expenditures as a share of total investment - Data for the United States from National Science Foundation
Empirical Motivation

COMPOSITION OF INVESTMENT ACROSS THE BUSINESS CYCLE

- Firm-level evidence
  - Share of R&D and structural investment over total
    - Aghion et al. (2007), Barlevy (2007), Aghion et al. (2005)
  - Cash flow sensitivity of cash (Almeida et al. (2004))

- Aggregate evidence
  - Sensitivity of composition of investment to shocks in less financially developed countries (Aghion et al. (2005)).
Empirical Motivation
FIRMS’ PRECAUTIONARY BEHAVIOR AND IMPORTANCE OF THE QUESTION

- Anticipation of future financing constraints affects firms’ current behavior:
  - Surveys: NFIB, Fed Board SSBF

- Small and Medium Enterprises a significant portion of economic activity (half of private sector GDP in the U.S.)
What I do

- Introduce a Real Business Cycle model including:
  - Two sectors: corporate and entrepreneurial
  - Financial intermediaries
  - Motive for risk management
  - Financial constraints
    - Limited commitment and collateral constraints as in Kiyotaki and Moore (1997)
  - Avoid future constraints to avoid having to fore-go positive NPV projects.
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  - Identification for ex-ante vs contemporaneous effect of credit constraints
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  - Amplification vs. dampening: crucially depends on persistence of productivity shocks
  - Identification for ex-ante vs contemporaneous effect of credit constraints
  - Role of shocks to uncertainty in generating aggregate fluctuations
Contribution to the Literature

- **Aggregate business cycle implications of endogenous borrowing constraints for firms**

- **Corporate Finance: intertemporal links between financial constraints and investment**

- **Effects on capital accumulation, real interest rates and output growth of uninsured idiosyncratic risk**
Structure of Talk

1. Introduction
2. A General Investment Model to Fix Ideas
3. Partial Equilibrium Analysis of Entrepreneurial Investment
4. General Equilibrium and Dynamics: Response to Productivity Shock
5. The Role of Financial Intermediaries
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Partial-Equilibrium Investment Model - General Framework

- Firm maximizes
  \[ V_0 = E_0 \sum_{t=0}^{\infty} M_{0,t} d_t , \]
  where
  \[ M_{0,t} = \text{stochastic discount factor} \]
  \[ d_t = \sum_{j} [f(k_{j,t}) + (1 - \delta)k_{j,t} - k_{j,t+1}] \]
  \[ + b_{t+1} - (1 + r_t) b_t \]
  \[ j = 1, \ldots, J \text{ are different projects firm can invest in} \]
Financing Constraints

- Equity:
  \[ d_t \geq d^*, \text{ where } d^* \leq 0 \]

- Debt:
  \[ b_{t+1} \leq \overline{b}. \]
First Order Conditions

- **Investment** (one for each type $j$ of investment):

  $$1 + \lambda_t = E_t\{M_{t,t+1}[f'(k_{j,t+1}) + (1 - \delta)](1 + \lambda_{t+1})\}$$

- **Borrowing**:

  $$\mu_t = 1 + \lambda_t - E_t[M_{t,t+1}(1 + r_{t+1})(1 + \lambda_{t+1})]$$

- where

  $$\lambda_t = \text{shadow cost of equity finance}$$

  $$\mu_t = \text{shadow cost of debt finance}$$
Financing Constraints only matter if shadow cost is time varying

- Effect of financial constraints fully captured by $\Psi_{t+1}$ in

$$1 = E_t\{M_{t,t+1}R_{j,t+1}^l\Psi_{t+1}\}$$

where

$$\Psi_{t+1} = \frac{1 + \lambda_{t+1}}{1 + \lambda_t}$$

- Financing constraints only affect investment if they are time varying ($\Psi_{t+1} \neq 1$).
  - Shadow value of constraint today relative to tomorrow matters.
Future Binding Constraints and the Composition of Investment

- Assume
  - Two investment alternatives $j = \{S, R\} = \{\text{Safe, Risky}\}$
    - $f(k_{S,t}) = z_S k_{S,t}^\alpha$
    - $f(k_{R,t}) = z_R \lambda_{t+1} k_{R,t}^\alpha$
  - where
    - $\alpha < 1$
    - $z_{R,t}$ captures idiosyncratic risk
    - $E_t(z_{R,t+1}) > z_S$
    - $\delta = 1$
  - $M_{t,t+1}$ is independent of $z_j,t$, $\lambda_{t+1}$

- How is the share of risky vs. safe investment affected by future credit constraints?
Future Binding Constraints and the Composition of Investment

- **Safe investment**

\[
1 + \lambda_t = \alpha z_S k_{S,t+1}^{\alpha-1} E_t(M_{t,t+1}) E_t(1 + \lambda_{t+1})
\]

- **overinvestment?**

- **Risky investment**

\[
1 + \lambda_t = E_t(M_{t,t+1}) E_t[\alpha z_{R,t+1} k_{R,t+1}^{\alpha-1} (1 + \lambda_{t+1})]
\]
\[
= E_t(M_{t,t+1}) \alpha k_{R,t+1}^{\alpha-1} [Cov(z_{R,t+1}, \lambda_{t+1}) + E_t(z_{R,t+1}) E_t(1 + \lambda_{t+1})]
\]
Future Binding Constraints and the Composition of Investment

- Ratio of risky to safe investment

\[
\frac{k_{R,t+1}}{k_{S,t+1}} = \left( \frac{\text{cov}(z_{R,t+1}, \lambda_{t+1}) + E_t(z_{R,t+1})E_t(1 + \lambda_{t+1})}{z_S E_t(1 + \lambda_{t+1})} \right)^{\frac{1}{1-\alpha}}
\]

- Persistence of idiosyncratic productivity process
- Jensen and Meckling (1976) risk-shifting result
Aggregate Risk

- Add aggregate risk: \( f(k_{R,t}) = (A_t + z_{R,t}) k^\alpha_{R,t} \)
- Risky investment

\[
1 + \lambda_t = E_t(M_{t,t+1}) E_t[\alpha (z_{R,t+1} + A_{t+1}) k^{\alpha-1}_{R,t+1} (1 + \lambda_{t+1})]
= E_t(M_{t,t+1}) \alpha k^{\alpha-1}_{R,t+1} [\text{Cov}(z_{R,t+1}, \lambda_{t+1})
+ \text{Cov}(A_{t+1}, \lambda_{t+1})
+ [E_t(z_{R,t+1}) + E_t(A_{t+1})] E_t(1 + \lambda_{t+1})]
\]

- Financing frictions: more important with good economic conditions?
  - No: Braun and Larrain (2005),...
Structure of Talk

1. Introduction
2. A General Investment Model to Fix Ideas
3. Partial Equilibrium Analysis of Entrepreneurial Investment
4. General Equilibrium and Dynamics: Response to Productivity Shock
5. The Role of Financial Intermediaries
6. Conclusion
Model

- Infinite horizon, discrete time economy
- Four agents
  - Households
  - Firms: produce consumption good using labor and investment goods
  - Entrepreneurs: produce the investment goods. Overlapping generations.
  - Financial intermediaries: channel savings from households to entrepreneurs
- 3 goods: consumption good, investment good, entrepreneurial capital
The Economy

- **Households**
  - Produce investment goods using entrepreneurial capital
  - Savings

- **Financial Intermediaries**
  - Savings

- **Entrepreneurs**
  - Produce investment goods using entrepreneurial capital
  - Labor

- **Firms**
  - Produce consumption goods using investment goods
  - Rental of Stock of Investment Goods
  - Labor
Partial Equilibrium Analysis of Entrepreneurs

- Risk-neutral and live for two full periods
- Investment opportunity when young and old
- Supply labor inelastically when young, receive wage $w_t^e$.
- Maximize consumption at the end of their lifetimes.
Timeline of Events in the Lifetime of Entrepreneur

**BEGINNING**
- Supply labor \( w^e_t \)
- Invest:
  - \( m_t \) (risky)
  - \( s_t \) (safe)
- Enter into state-contingent contract with bank

**END**
- Borrow
- Invest \( m_{t+1} \)
- Idiosyncratic production shock realized ("lucky" or "unlucky")
- State contingent payments to/from bank

“Young”
“Old”
“Dying”

-Sell remaining entrepreneurial capital.
- Consume all remaining net worth.
Entrepreneurs

Budget constraint of "young":

\[ p_t m_t + s_t = w_t^e + \sum_{i=L,U} \phi_i^t b_i^t, \]

Budget constraint of "old":

\[ p_{t+1} m_{t+1}^i = n_{t+1}^i + b_{t+1}. \]

where:

\[
\begin{align*}
n_{t+1}^L &= q_t g(m_t) - b_t^L + p_{t+1}(1-\delta)m_t + s_t(1+r_{t+1}) \\
n_{t+1}^U &= x m_t - b_t^U + p_{t+1}(1-\delta)m_t + s_t(1+r_{t+1})
\end{align*}
\]

where \( m_t \): risky technology, \( s_t \): safe alternative (\( s_t \geq 0 \)), \( b_t^i \): state-contingent repayment to/from bank, \( r_t \): return on \( S \), \( q_t \): price of investment goods, \( x \): idiosyncratic liquidity shock. \( x \leq 0 \).
Precautionary Motive

- Production technology of "old":

\[
y_{t+1}^{old} = f(m_{t+1}),
\]

\[
f'(\cdot) > 0, \quad f''(\cdot) < 0
\]

- Demand for insurance to smooth net worth at beginning of "old" age (second period).
Financial Friction, Optimal Contract and Imperfect Insurance

- Contract fully state contingent
  - First best contract: $b^L_t > 0, b^U_t < 0, b^L_t + b^U_t = 0$

- However, limited commitment and need to back all borrowing with physical assets:

\[ b^i_t \leq \theta(1 - \delta) \frac{p_{t+1}}{1 + r_{t+1}} m_t \]

- Source of lack of full insurance against idiosyncratic shock
- May mean that $b^L_t + b^U_t < 0$. 
Optimal Choice of Entrepreneurs I

\[
R_{m,t+1}^L \left[ \frac{q_t g'(m_t) + (1 - \delta)p_{t+1} - \theta(1 - \delta)\frac{p_{t+1}}{1+r_{t+1}}}{p_t - 0.5\theta(1 - \delta)\frac{p_{t+1}}{1+r_{t+1}}} \right] + \\
\]

\[
R_{m,t+1}^U \left[ \frac{x + p_{t+1}(1 - \delta)}{p_t - 0.5\theta(1 - \delta)\frac{p_{t+1}}{1+r_{t+1}}} \right] \\
= R_{m,t+1}^U \left( \frac{1}{\phi_t} \right) \\
= R_{m,t+1}^U (1 + r_{t+1}) + R_{m,t+1}^L (1 + r_{t+1})
\]

Equate marginal return to investment in risky technology, insurance, and safe asset.
where $R_{m,t+1}$ is marginal return to investment in entrepreneurial technology in the second period:

$$R_{m,t+1}^i = \frac{q_{t+1} f'(m_{t+1}) + (1 - \delta) p_{t+2} - \theta (1 - \delta) \frac{p_{t+2}}{1 + r_{t+2}}}{p_{t+1} - \theta (1 - \delta) \frac{p_{t+2}}{1 + r_{t+2}}}$$

where $i = \{L, U\}$. 
Entrepreneurs’ Optimal Reaction to Changes in Expected Credit Conditions

PARTIAL EQUILIBRIUM

- A decrease in expected ex-post borrowing capacity in period $t + 1$, captured by a decrease in

$$\theta(1 - \delta) \frac{p_{t+2}}{1 + r_{t+2}}$$

may result in a decrease in risky investment in period $t$ as a share of total investment

$$\frac{dm_t}{dp_{t+2}} > 0, \quad \frac{db_t^U}{dp_{t+2}} > 0, \quad \frac{ds_t}{dp_{t+2}} \geq 0.$$
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Entrepreneurial capital market

Endogenizing $p$

- Entrepreneurial capital is durable, depreciates at rate $\delta$.
- Created instantaneously one-for-one using consumption goods
  - Upper bound on price: $p_t \leq 1$.
- In periods of low demand, price will decrease to absorb all existing stock of capital:

  $$\sum_i \pi_i M_{it}(p_t) = \sum_i \pi_i (1 - \delta) M_{it-1}, \text{ for } i = Y, L, U, DL, DU$$
The Economy

**Households**
- Produce investment goods using entrepreneurial capital
- Source of Savings

**Financial Intermediaries**
- Source of Savings

**Entrepreneurs**
- Produce investment goods using entrepreneurial capital
- Source of Labor

**Firms**
- Produce consumption goods using investment goods
- Source of Labor
- Source of Rental of Stock of Investment Goods
Households

Continuum of risk-averse households, maximizing:

\[ E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, 1 - L_t) \]

\[ c_t + q_t[k_{t+1} - (1 - \delta_k)k_t] = w_t L_t + r_t k_t \]

Optimal labor-leisure choice:

\[ \frac{u_L(t)}{u_c(t)} = w_t \]

Optimal savings-consumption choice:

\[ u_c(t) = \beta E_t \{ u_c(t + 1) \frac{q_{t+1}(1 - \delta) + r_{t+1}}{q_t} \} \].
Firms

Firms produce the consumption good using a constant returns to scale production function:

\[ Y_t = \theta_t F(K_t, H_t, H^e_t) \]

\((K_t = \text{stock of investment goods}, \ H_t = \text{aggregate labor supplied by households}, \text{and } H^e_t = H^e = \text{labor supplied by entrepreneurial agents}).\)

Perfect competition in the factor markets implies the following factor prices:

\[ r_t = \theta_t F_1(t) \]
\[ w_t = \theta_t F_2(t) \]
\[ w^e_t = \theta_t F_3(t) \]
Recursive Competitive Equilibrium

Definition

The recursive competitive equilibrium is defined by decision rules for $K_{t+1}, C_t, H_t, M^Y_{it}, M^L_{it}, M^U_{it}, Z^L_{it}, Z^U_{it}, Z^{OL}_{it}, Z^{OU}_{it}, I_t, S_t, C_t^E, B^Y_{it}, B^L_{it}, B^U_{it}, q_t, p_t$, and $\phi_t$, as a function of $K_t, \theta_t$, and $\{M_{i,t-1}\}$ and $\{Z_{it-1}\}$.

- Where $\{M_{i,t}\}$ is the distribution of entrepreneurial capital, and $\{Z_{i,t}\}$ is the distribution of end-of-period entrepreneurial net worth.

Calibration I

- Model parameterized at the non-stochastic steady state using values to replicate long-run empirical regularities in U.S. post-World War II macro data.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha^K$</td>
<td>0.36</td>
<td>Capital Share</td>
</tr>
<tr>
<td>$\alpha^e$</td>
<td>0.01</td>
<td>Entrepreneurial L Share</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.63</td>
<td>HH labor Share</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.02</td>
<td>Depreciation</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.95</td>
<td>$\log_\theta_{t+1} = \rho \log_\theta_{t} + \sigma_\epsilon \epsilon_{t+1}$</td>
</tr>
<tr>
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</tr>
<tr>
<td>$\gamma$</td>
<td>1</td>
<td>$U = (c^{1-\gamma} - 1)/(1 - \gamma) + \nu(1 - L)$</td>
</tr>
<tr>
<td>$\nu$</td>
<td></td>
<td>Chosen to obtain $L = 0.3$</td>
</tr>
</tbody>
</table>
Entrepreneurial sector parameters

- Pledgeability of entrepreneurial capital ($\theta$)
  - match empirically documented Loan-to-Value (LTV) ratios for commercial mortgage lending to small and medium-sized enterprises

- Remaining parameters relate to the entrepreneurial risky technology, calibrated to match
  - risk premium: average spread between the 3-month CP rate and prime rate: 187 basis points.
  - share of loans issued on commitment basis. Kashyap et al. (2002): 70% of bank lending by U.S. small firms through credit lines.
Steady State Properties

Figure: Composition of entrepreneurial investment and aggregate capital in the steady state, as a function of changes in idiosyncratic volatility.

- Mean-preserving increase in volatility of entrepreneurial activity decreases steady-state share of risky investment, and steady-state capital.
  - Not the case in model with no precautionary effects
Moments

<table>
<thead>
<tr>
<th></th>
<th>(\sigma_c/\sigma_Y)</th>
<th>(\sigma_i/\sigma_Y)</th>
<th>(\sigma^H/\sigma_Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical Data</td>
<td>0.51</td>
<td>2.86</td>
<td>0.92</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Credit</td>
<td>0.71</td>
<td>2.97</td>
<td>0.61</td>
</tr>
<tr>
<td>Precautionary</td>
<td>0.74</td>
<td>3.05</td>
<td>0.64</td>
</tr>
</tbody>
</table>
Dynamics - Persistent aggregate shock

- Response to a negative 1% productivity shock, persistence $\rho = 0.95$
Intuition

- Negative shock hits
  - firms understand shock will be persistent → probability of being financially constrained next period increases.
  - react by decreasing share of risky investment
- Larger contemporaneous response to shocks (more amplification)
- Standard financial accelerator framework, firms invest as much as they can at every point in time.
Dynamics - Low Persistence in aggregate shock

- Response to a negative 1% productivity shock, persistence $\rho = 0.70$
Asymmetry

- **Hansen and Prescott (2002) and Sichel (1993)**
  - evidence that positive shocks produce smaller positive output effects than negative shocks produce negative output effects.

- **Existing theory:**
  - Sticky price models: Devereux and Siu (2003).
Asymmetry

Table: Summary of Numerical Results - Comparison of Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Full Model</th>
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<tbody>
<tr>
<td></td>
<td>Recessions</td>
<td>Upturns</td>
</tr>
<tr>
<td>$\sigma$(Output) / $\sigma$(Tech Shock)</td>
<td>2.13</td>
<td>3.73</td>
</tr>
<tr>
<td>$\sigma$(Inv) / $\sigma$(Tech Shock)</td>
<td>6.48</td>
<td>8.36</td>
</tr>
</tbody>
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- Asymmetric amplification mechanism: amplification of negative shocks stronger.
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Need to collateralize all their obligations ('insurance' payments to the unlucky entrepreneurs):

\[
i_t \leq b_t = \sum_{i=L,U,DL,DU} \pi^i \theta (1 - \delta) E_t \left( \frac{p_{t+1}}{1 + r_{t+1}} \right) m_t^i
\]

where \( i_t = \int_{E} b_t^U \) are the 'insurance' commitments of the representative intermediary

- Only assets they can use to collateralize are the loans they extend to entrepreneurs.
Entrepreneurs’ Optimal Reaction to Worsening Expected Credit Conditions

- Following a decrease in expected borrowing capacity in $t + 1$

$$E_t \left[ \theta(1 - \delta) \frac{p_{t+2}}{1 + r_{t+2}} \right]$$

and if frictions in the supply of insurance are severe enough, and $\phi_t$ increases sufficiently as a result, then

$$m_t \downarrow, s_t \uparrow, i_t ?$$

in contrast to a situation where banks’ constraint is not binding, and in which:

$$m_t \downarrow, s_t ?, i_t \uparrow.$$
Dynamics

- Insurance is priced at a premium above actuarially fair price in severe downturns.
Cross Country Comparisons
Size of the amplification effect as a function of theta (non-monotonic) and volatility of aggregate shock (monotonic)
Conclusions

- I develop a dynamic stochastic general equilibrium model of entrepreneurial activity and intermediation with endogenous financial constraints.
- Describes a *novel amplification mechanism* of macro shocks based on firms’ precautionary behavior in anticipation of future credit constraints.
- Is able to account for observed pattern of *composition of investment* across the business cycle.
Conclusions and Further Research

- Can this mechanism capture the most significant effect of credit frictions in investment and output dynamics?
- Analysis of monetary policy shocks
- Capital structure implications of precautionary behavior
- Asset pricing implications: ‘Liquidity Asset Pricing Model’ (Holmstrom and Tirole (2001))
- Study precautionary behavior in other agents: eg. financial intermediaries in current episode of turbulence
Appendix Material
Working Capital Investment

- Inventories small share of GDP, large share of GDP fluctuations (Blinder and Maccini (1991), Stock and Watson (1998))
- Inventories are more volatile than sales (Carpenter, Fazzari and Petersen (1993))
- Gertler and Gilchrist (94): following MP tightening:
  - Inventories (absolute) fall MORE for smaller firms
  - Inventory /sales ratio falls MORE in small firms
- Inventory investment considerably more cyclical for durables than for nondurables
# Average Inventory Holdings

<table>
<thead>
<tr>
<th></th>
<th>Small Firms</th>
<th>Large Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inventories</strong></td>
<td>23.7</td>
<td>279.5</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>98.1</td>
<td>1491.9</td>
</tr>
<tr>
<td><em>(I/TA)</em></td>
<td>24.2%</td>
<td>18.7%</td>
</tr>
<tr>
<td><strong>Total Sales</strong></td>
<td>36.8</td>
<td>488.7</td>
</tr>
<tr>
<td><em>(I/TS)</em></td>
<td>64.4%</td>
<td>57.2%</td>
</tr>
</tbody>
</table>

Carpenter, Fazzari and Petersen (1993)
Cash Holdings and Firm Size
Den Haan and Marcet (1994) test

- Forecast errors of agents in RE models should be uncorrelated with past information.
- Regress forecast errors of three approximated expectational equations on lagged values of model variables.
- DM Statistic: Under the null that numerical solution is exact, the DM statistic has $\chi^2$ distribution.
  - Statistic < 2.5% and > 97.5% critical values in less than 5% of occasions.