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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  - Model misspecification, or financial frictions unimportant?

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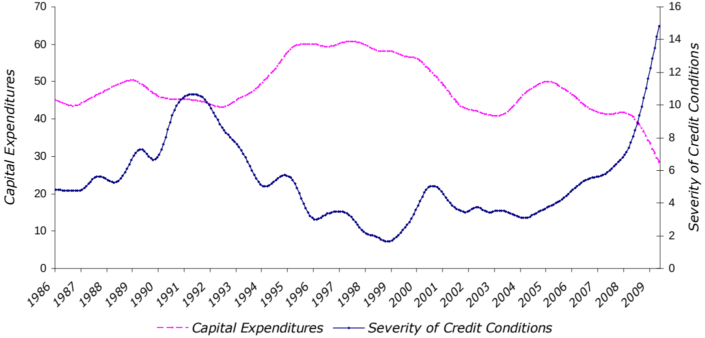
  - $\approx$ buffer stock behaviour of consumers

Empirical Motivation

CREDIT CONDITIONS AND SMALL FIRMS' INVESTMENT



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  - Capital expenditures: % maintaining or increasing
  - Credit conditions: % seeing a worsening of credit availability

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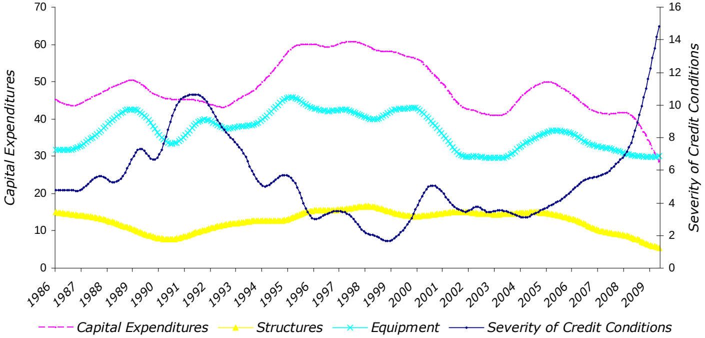

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R&D INVESTMENT ACROSS THE BUSINESS CYCLE

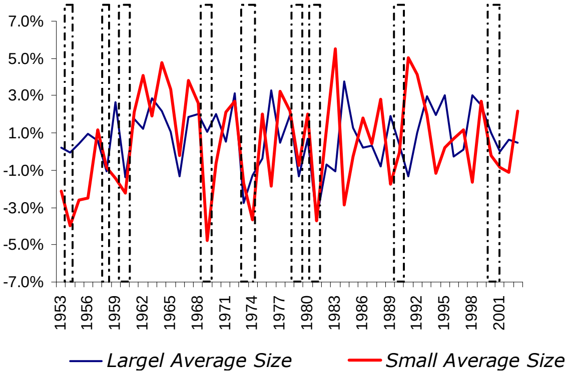

Figure: % variation in ratio of R&D expenditures as a share of total investment - Data for the United States from National Science Foundation

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:
  - Real decisions: Caggese and Cunat (2007), Almeida et al (2004), (2006)
  - Financial behavior: Graham and Harvey (2001), Bancel and Mittoo (2002)
  - Surveys: NFIB, Fed Board SSBF
- Small and Medium Enterprises a significant portion of economic activity (half of private sector GDP in the U.S.)

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  - Motive for risk management
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  - Financial constraints
    - Limited commitment and collateral constraints as in Kiyotaki and Moore (1997)

Main Findings

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- Novel amplification mechanism: composition of investment & endogenous productivity
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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
  - Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), Bernanke, Gertler and Gilchrist (1999), Krishnamurthy (2003)
- Corporate Finance: intertemporal links between financial constraints and investment
  - Thakor (1990), Froot, Scharfstein, and Stein (1993), Almeida, Campello and Weisbach (2004, 2008), Hennessy, Levy and Whited (2005), Caggese and Cuñat (2008)
- Effects on capital accumulation, real interest rates and output growth of uninsurable idiosyncratic risk
  - labor-income risk: Aiyagari (1994), Krusell and Smith (1998) / investment risk: Acemoglu and Zilibotti (1997), Angeletos and Calvet (2006)

Structure of Talk

1. Introduction
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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

$$\begin{aligned} M_{0,t} &= \text{stochastic discount factor} \\ d_t &= \sum_j [f(k_{j,t}) + (1-\delta)k_{j,t} - k_{j,t+1}] \\ &\quad + b_{t+1} - (1+r_t)b_t \\ j &= 1, ..., J \text{ are different projects firm can invest in} \end{aligned}$$

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

$$\begin{aligned} \lambda_t &= \text{shadow cost of equity finance} \\ \mu_t &= \text{shadow cost of debt finance} \end{aligned}$$

Financing Constraints only matter if shadow cost is time varying

- Effect of financial constraints fully captured by Ψ_{t+1} in

$$1 = E_t\{M_{t,t+1} R^I_{j,t+1} \Psi_{t+1}\}$$

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 $j = \{S, R\} = \{Safe, Risky\}$
    - $f(k_{S,t}) = z_S k_{S,t}^{\alpha}$
    - $f(k_{R,t}) = z_{R,t} k_{R,t}^{\alpha}$,
  - 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 $z_{j,t}$, λ_{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

$$\begin{aligned} 1 + \lambda_t &= E_t(M_{t,t+1}) E_t[\alpha z_{R,t+1} k_{R,t+1}^{\alpha-1} (1 + \lambda_{t+1})] \\ &= E_t(M_{t,t+1}) \alpha k_{R,t+1}^{\alpha-1} [Cov(z_{R,t+1}, \lambda_{t+1}) \\ &\quad + E_t\left(z_{R,t+1}\right) E_t(1 + \lambda_{t+1})] \end{aligned}$$

Future Binding Constraints and the Composition of Investment

- Ratio of risky to safe investment

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

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

Aggregate Risk

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

$$\begin{aligned} 1+\lambda_t &= E_t(M_{t,t+1}) E_t\left[\alpha\left(z_{R,t+1}+A_{t+1}\right) k_{R,t+1}^{\alpha-1}(1+\lambda_{t+1})\right] \\ &= E_t(M_{t,t+1})\alpha k_{R,t+1}^{\alpha-1}\left[Cov(z_{R,t+1},\lambda_{t+1})\right. \\ &\quad + Cov(A_{t+1},\lambda_{t+1}) \\ &\quad \left. + \left[E_t\left(z_{R,t+1}\right)+E_t\left(A_{t+1}\right)\right] E_t(1+\lambda_{t+1})\right] \end{aligned}$$

- Financing frictions: more important with good economic conditions?
  - Yes: Dow, Gorton, and Krishnamurthy (2003), Gomes, Yaron, and Zhang (2003)
  - No: Braun and Larrain (2005),...

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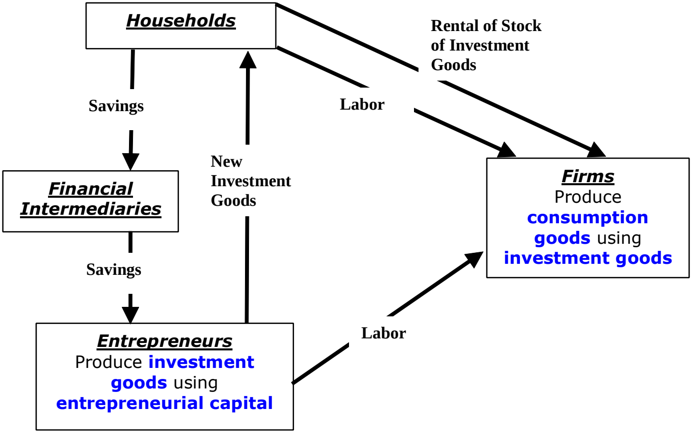
Model

- 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
Rental of Stock of Investment Goods
Savings
Labor
New Investment Goods
Financial Intermediaries
Firms
Produce consumption goods using investment goods
Savings
Labor
Entrepreneurs
Produce investment goods using entrepreneurial capital

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

t | t+1 | t+2

"Young" | ***"Old"*** | ***"Dying"***

<u>BEGINNING</u>

-Supply labor (w^e_t)

-Invest:

- -m_t (risky)
- -s_t (safe)

-Enter into state-contingent contract with bank

<u>END</u>

-Idiosyncratic production shock realized ("lucky" or "unlucky")

-State contingent payments to/from bank

"Old"

- Borrow

-Invest m_{t+1}

"Dying"

-Sell remaining entrepreneurial capital.

-Consume all remaining net worth.

Entrepreneurs

Budget constraint of "young":

$$p_t m_t + s_t = w_t^e + \sum_{i=L,U} \phi_t^i b_t^i,$$

Budget constraint of "old":

$$p_{t+1} m_{t+1}^i = n_{t+1}^i + b_{t+1}.$$

where:

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

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":

$$
\begin{aligned}
y_{t+1}^{old} &= f(m_{t+1}), \\
f'(\cdot) &> 0, \; f''(\cdot) < 0
\end{aligned}
$$

- 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: $b_t^L > 0$, $b_t^U < 0$, $b_t^L + b_t^U = 0$
- However, limited commitment and need to back all borrowing with physical assets:

$$b_t^i \leq \theta(1-\delta)\frac{p_{t+1}}{1+r_{t+1}}m_t$$

  - Source of lack of full insurance against idiosyncratic shock
  - May mean that $b_t^L + b_t^U < 0$.

Optimal Choice of Entrepreneurs I

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

$$R^U_{m,t+1}\left[\frac{x+p_{t+1}(1-\delta)}{p_t-0.5\theta(1-\delta)\frac{p_{t+1}}{1+r_{t+1}}}\right]$$

$$\begin{aligned} &= R^U_{m,t+1}\left(\frac{1}{\phi_t}\right) \\ &= R^U_{m,t+1}\left(1+r_{t+1}\right)+R^L_{m,t+1}\left(1+r_{t+1}\right) \end{aligned}$$

Equate marginal return to investment in risky technology, insurance, and safe asset.

Optimal Choice of Entrepreneurs II

where $R_{m,t+1}$ is marginal return to investment in entrepreneurial technology in the second period:

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

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

$$\frac{dm_t}{dp_{t+2}} > 0, \frac{db_t^U}{dp_{t+2}} > 0, \frac{ds_t}{dp_{t+2}} \gtrless 0.$$

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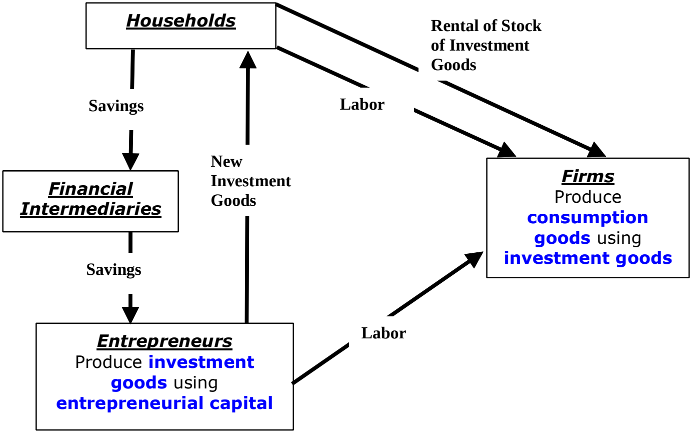
Entrepreneurial Capital Market

Endogenizing p

- Entrepreneurial capital is durable, depreciates at rate δ.
- 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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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:

$$Y_t = \theta_t F(K_t, H_t, H_t^e)$$

(K_t = stock of investment goods, H_t = aggregate labor supplied by households, and $H_t^e = H^e$ = labor supplied by entrepreneurial agents).
Perfect competition in the factor markets implies the following factor prices:

$$\begin{aligned} r_t &= \theta_t F_1(t) \\ w_t &= \theta_t F_2(t) \\ w_t^e &= \theta_t F_3(t) \end{aligned}$$

Recursive Competitive Equilibrium

Definition

The recursive competitive equilibrium is defined by decision rules for K_{t+1}, C_t, H_t, M_{it}^{Y}, M_{it}^{L}, M_{it}^{U}, Z_{it}^{L}, Z_{it}^{U}, Z_{it}^{OL}, $Z_{it}^{OU}, I_t, S_t, C_t^{E}$, B_{it}^{Y}, B_{it}^{L}, B_{it}^{U}, q_t, p_t, and ϕ_t, as a function of K_t, θ_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.
- Equilibrium solved numerically using the Parameterized Expectations Approach of den Haan and Marcet (1990).

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.

α^K	0.36	Capital Share
α^e	0.01	Entrepreneurial L Share
α	0.63	HH labor Share
δ	0.02	Depreciation
ρ	0.95	in $\log\theta_{t+1} = \rho\log\theta_t + \sigma_\varepsilon\varepsilon_{t+1}$
σ	0.01	in $\log\theta_{t+1} = \rho\log\theta_t + \sigma_\varepsilon\varepsilon_{t+1}$
γ	1	in $U = (c^{1-\gamma} - 1)/(1-\gamma) + v(1-L)$
v		Chosen to obtain $L = 0.3$

Calibration II

- Entrepreneurial sector parameters
  - Pledgeability of entrepreneurial capital (θ)
    - 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

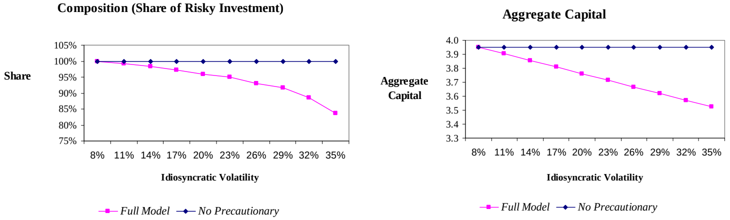


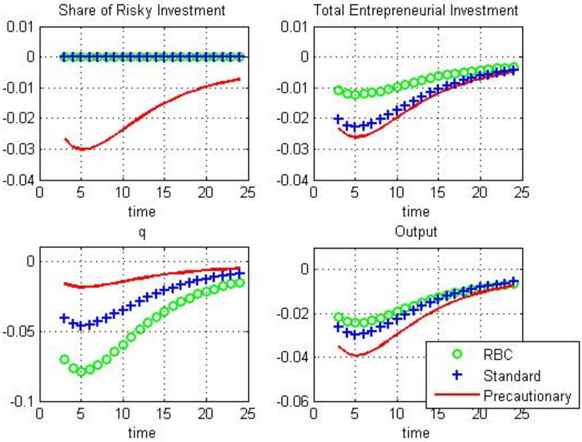
Figure: Composition of entrepreneurial investment and aggregate capital in the steady state, as a function of changes in idiosyncratic volatility.

- 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

	$\frac{\sigma_c}{\sigma_Y}$	$\frac{\sigma_i}{\sigma_Y}$	$\frac{\sigma_H}{\sigma_Y}$
Empirical Data	0.51	2.86	0.92
Model			
Standard Credit	0.71	2.97	0.61
Precautionary	0.74	3.05	0.64

Dynamics - Persistent aggregate shock

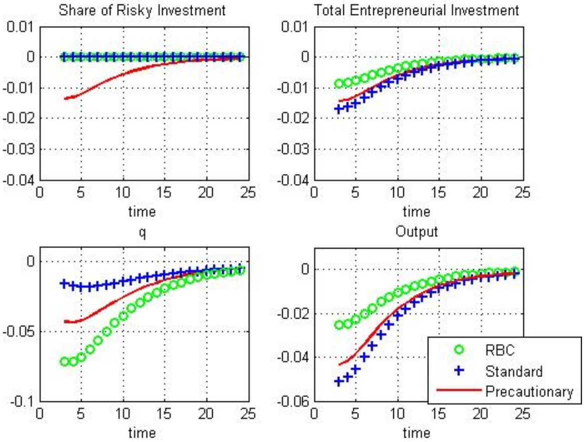


- Response to a negative 1% productivity shock, persistence $\rho = 0.95$

Intuition

- Negative shock hits
  - firms understand shock will be persistent $\Longrightarrow$ 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:
  - Capacity constraint models: Hansen and Prescott (2002), Danziger (2003)
  - Sticky price models: Devereux and Siu (2003).

Asymmetry

Table: Summary of Numerical Results - Comparison of Outcomes

	Full Model	Full Model	
		Recessions	Upturns
σ(Output) / σ(Tech Shock)	2.13	3.73	1.67
σ(Inv) / σ(Tech Shock)	6.48	8.36	5.71

- Asymmetric amplification mechanism: amplification of negative shocks stronger.

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

Role of Financial Intermediaries

- Need to collateralize all their obligations ('insurance' payments to the unlucky entrepreneurs):

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

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 $t+1$

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

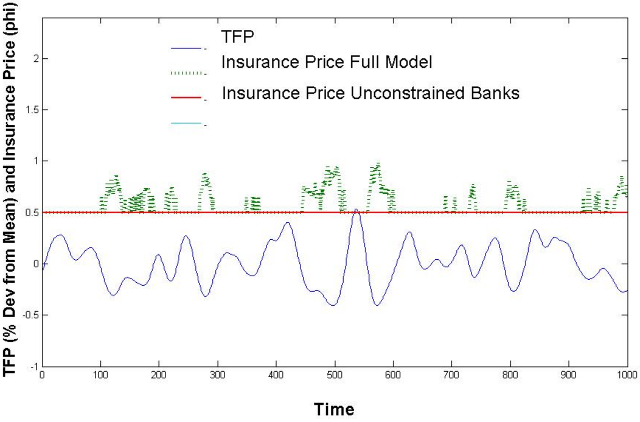
and if frictions in the supply of insurance are severe enough, and ϕ_t increases sufficiently as a result, then

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

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

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

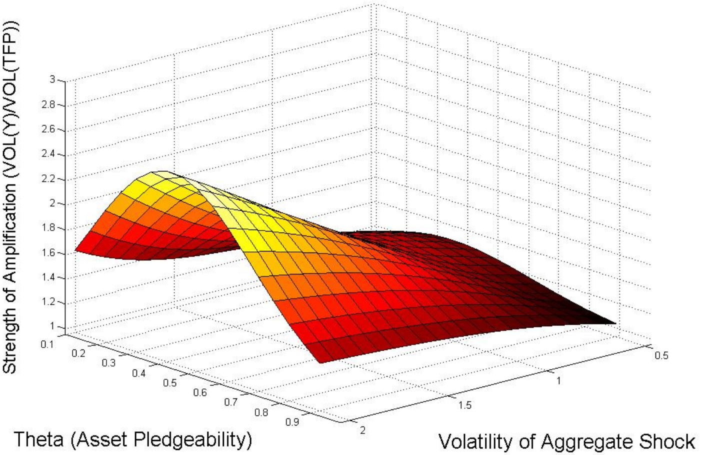
Dynamics



- 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

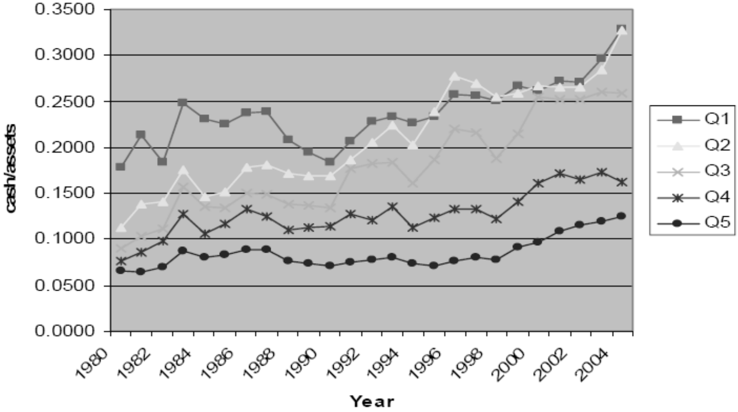
- Inventories small share of GDP, large share of GDP fluctuations (Blinder and Maccini (1991), Stock and Watson (1998))
- Inventories are more volatile than sales (Carpenter, Fazzari and Petersen (1993))
- Gertler and Gilchrist (94): following MP tightening:
  - Inventories (absolute) fall MORE for smaller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

Average Inventory Holdings

USD million	*Small Firms*	*Large Firms*
Inventories	23.7	279.5
Total Assets	98.1	1491.9
(I/TA)	24.2%	18.7%
Total Sales	36.8	488.7
(I/TS)	64.4%	57.2%

Carpenter, Fazzari and Petersen (1993)

Cash Holdings and Firm Size



Accuracy

- 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 χ^2 distribution.
    - Statistic $< 2.5\%$ and $> 97.5\%$ critical values in less than 5% of occasions.