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

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II Bank of Italy Conference on Macro Modeling in the Policy Environment

Rome 30 June - 1 July, 2009

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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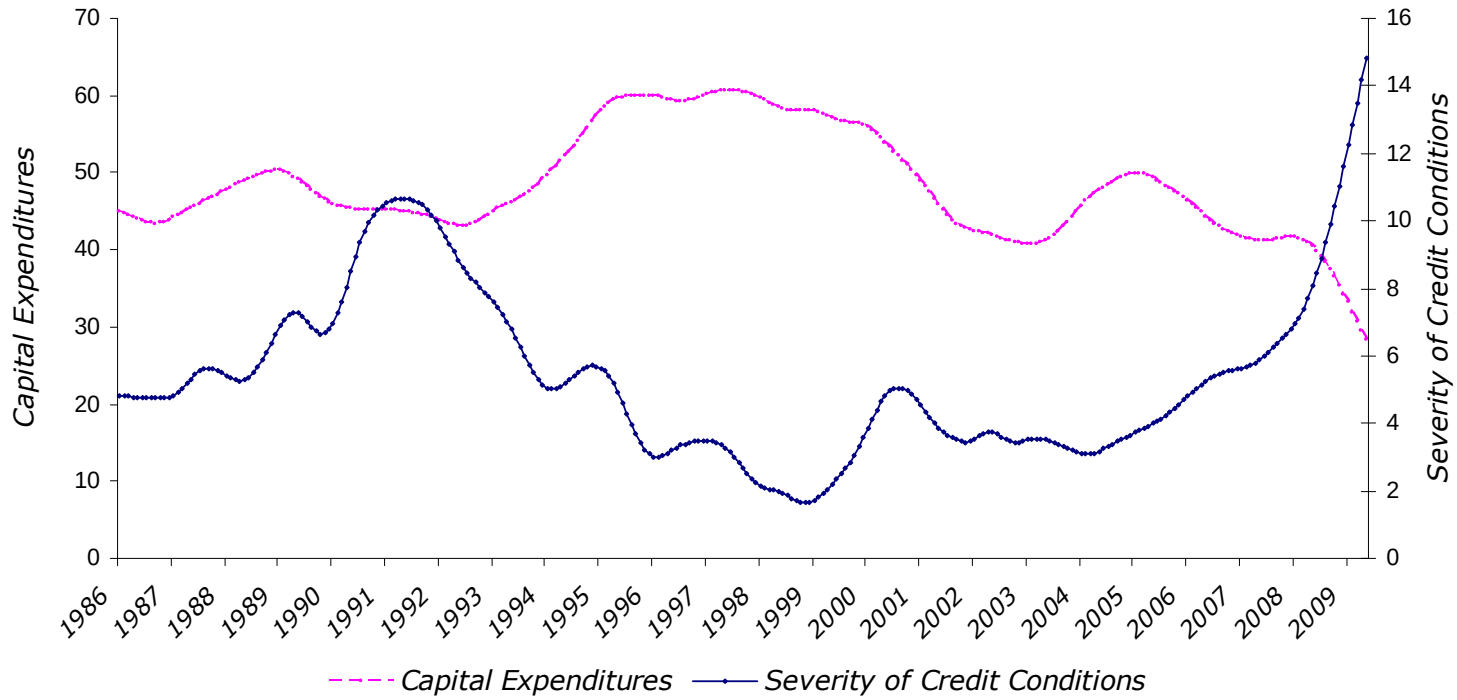
  - $\approx$ buffer stock behaviour of consumers

Empirical Motivation

CREDIT CONDITIONS AND SMALL FIRMS' INVESTMENT



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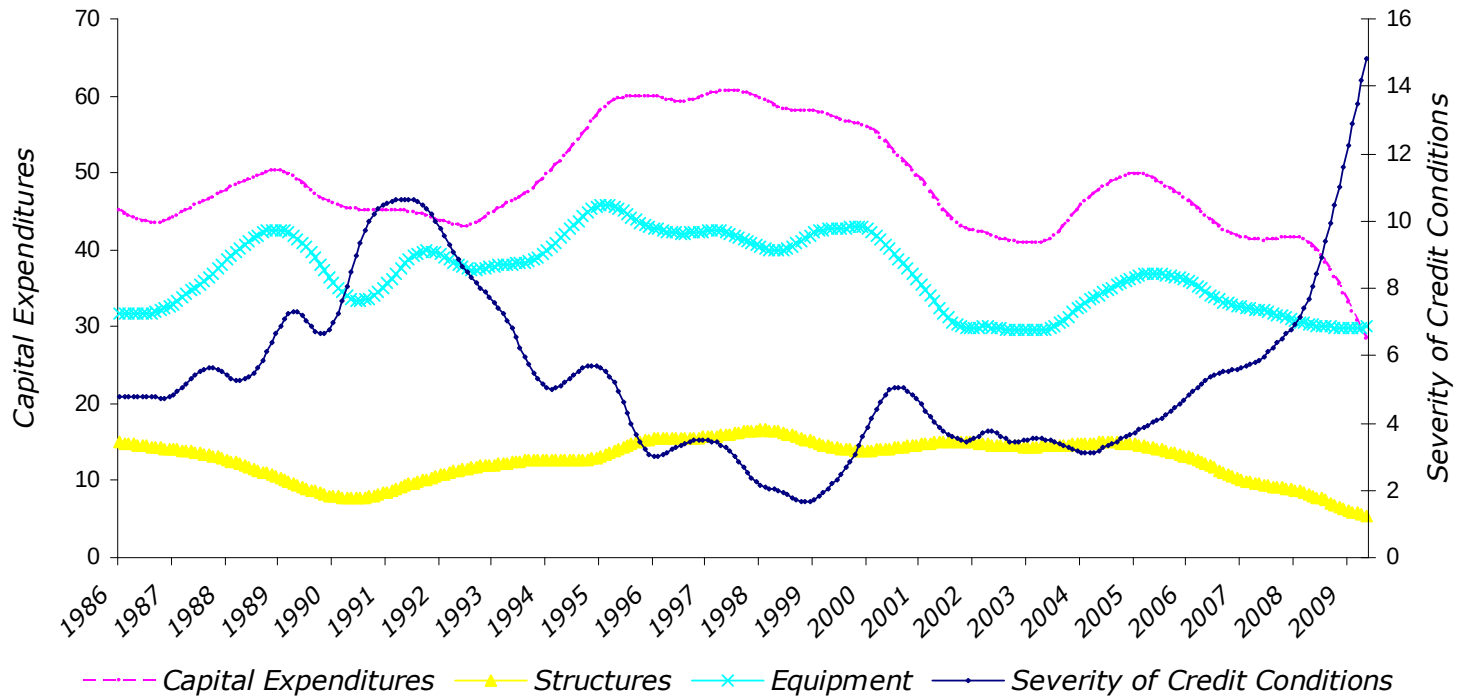

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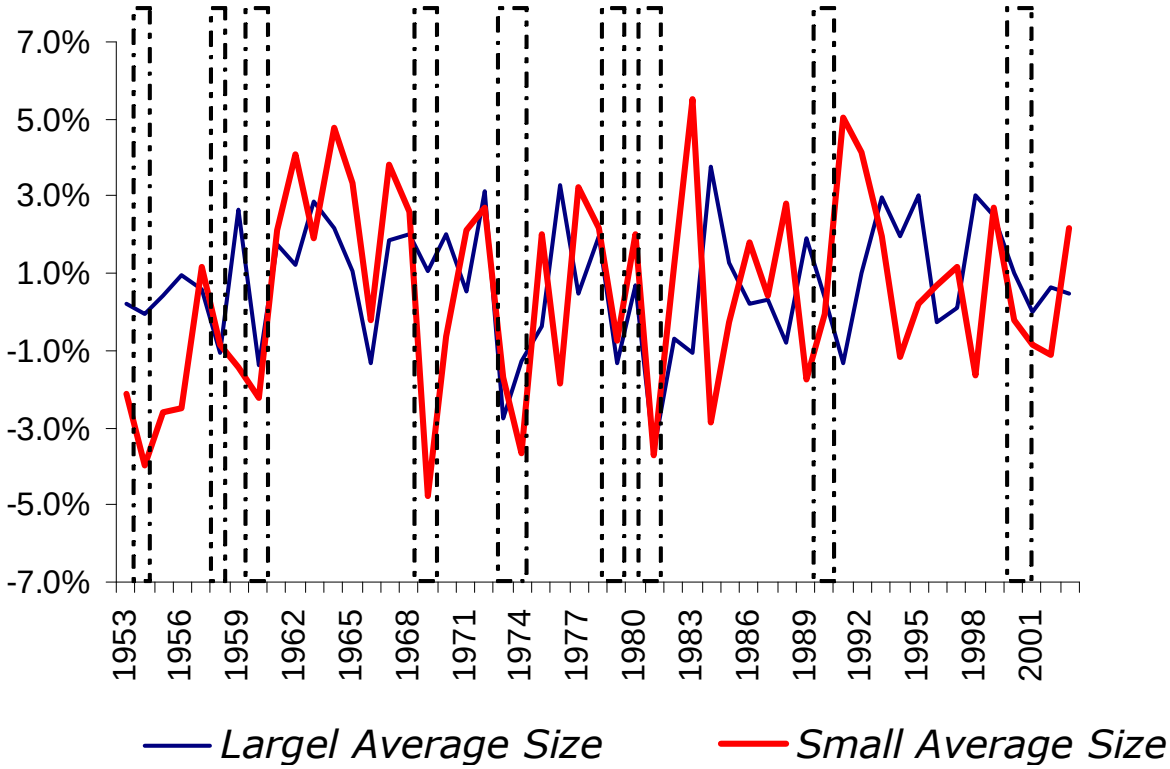

Figure: % variation in ratio of R&D expenditures as a share of total investment - Data for the United States from National Science Foundation

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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  - Financial constraints
    - Limited commitment and collateral constraints as in Kiyotaki and Moore (1997)

Main Findings

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  - Identification for ex-ante vs contemporaneous effect of credit constraints

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- Novel amplification mechanism: composition of investment & endogenous productivity
- Model accounts for cyclical variation in the composition of investment
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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)

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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

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

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

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

- 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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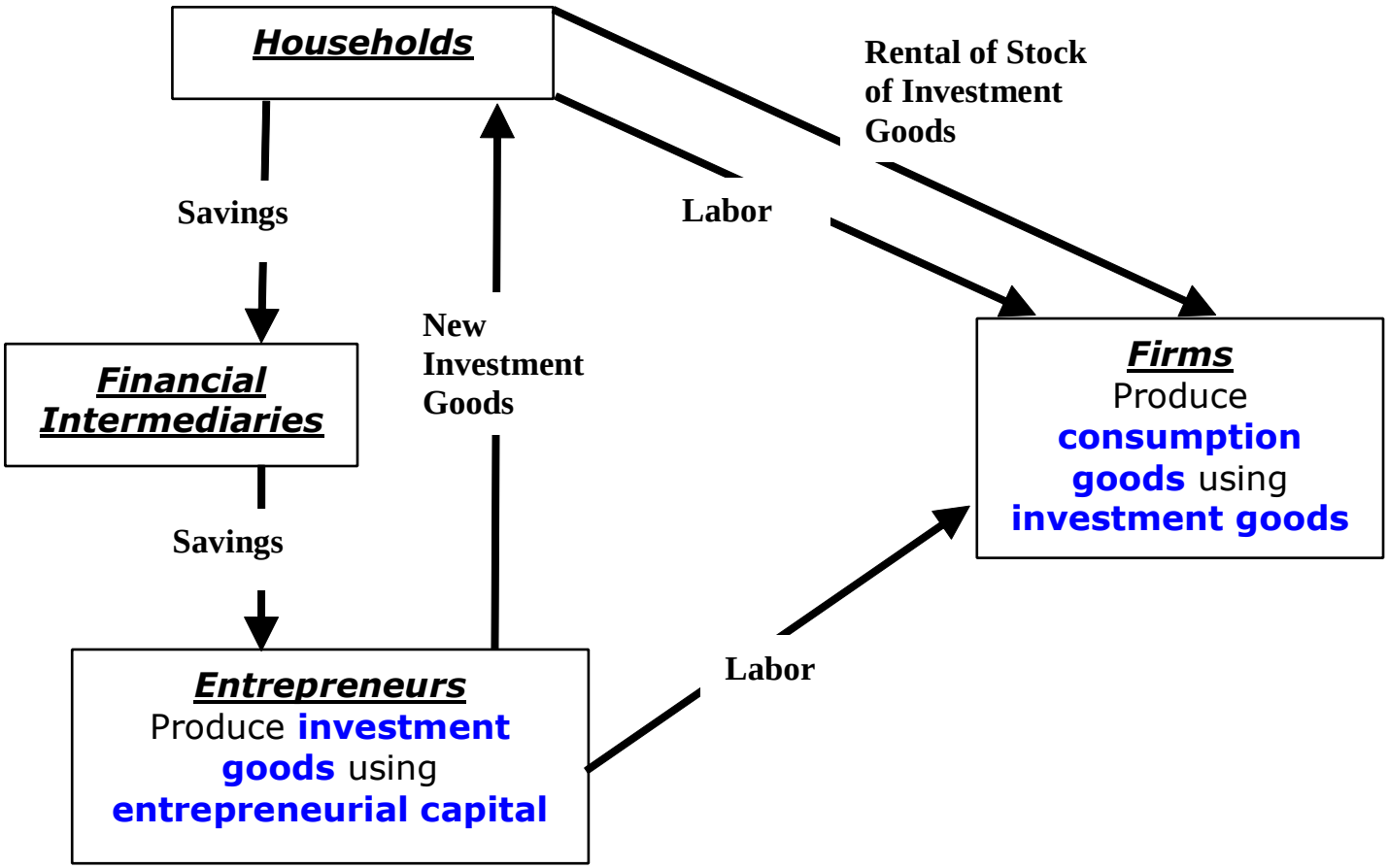
Model

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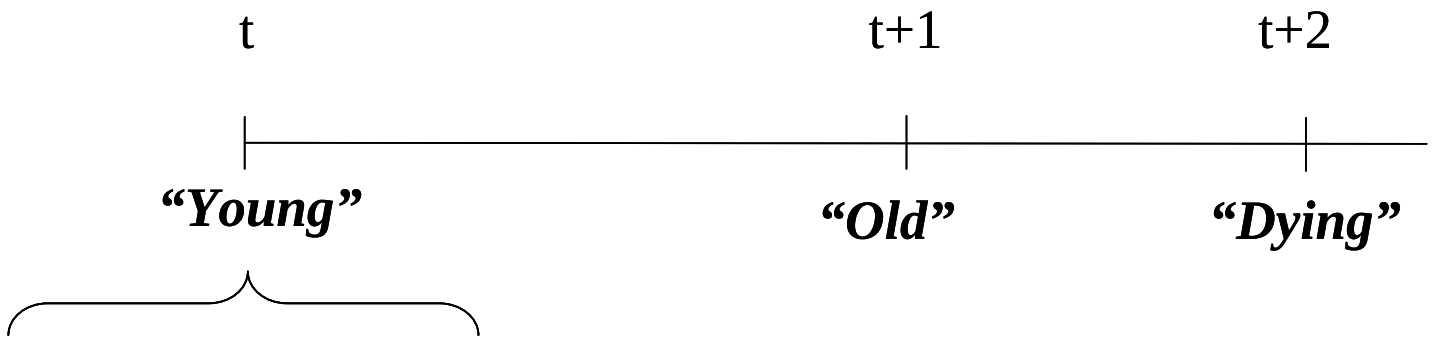
New Investment Goods
Financial Intermediaries
Firms
Produce consumption goods using investment goods
Savings
Entrepreneurs
Produce investment goods using entrepreneurial capital
Labor

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

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

-State contingent payments to/from bank

- Borrow

-Invest m_{t+1}

-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:

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

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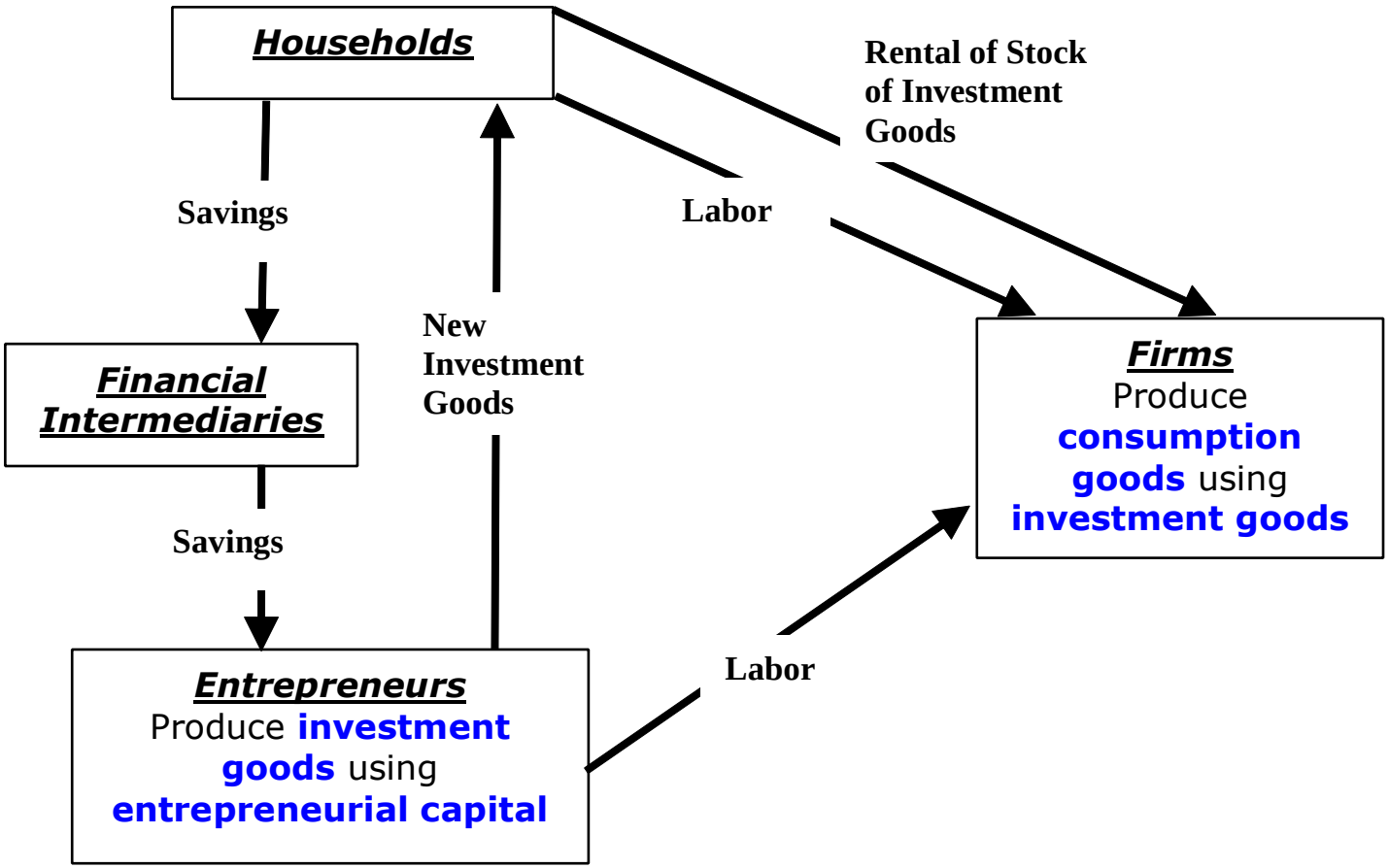
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Households

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

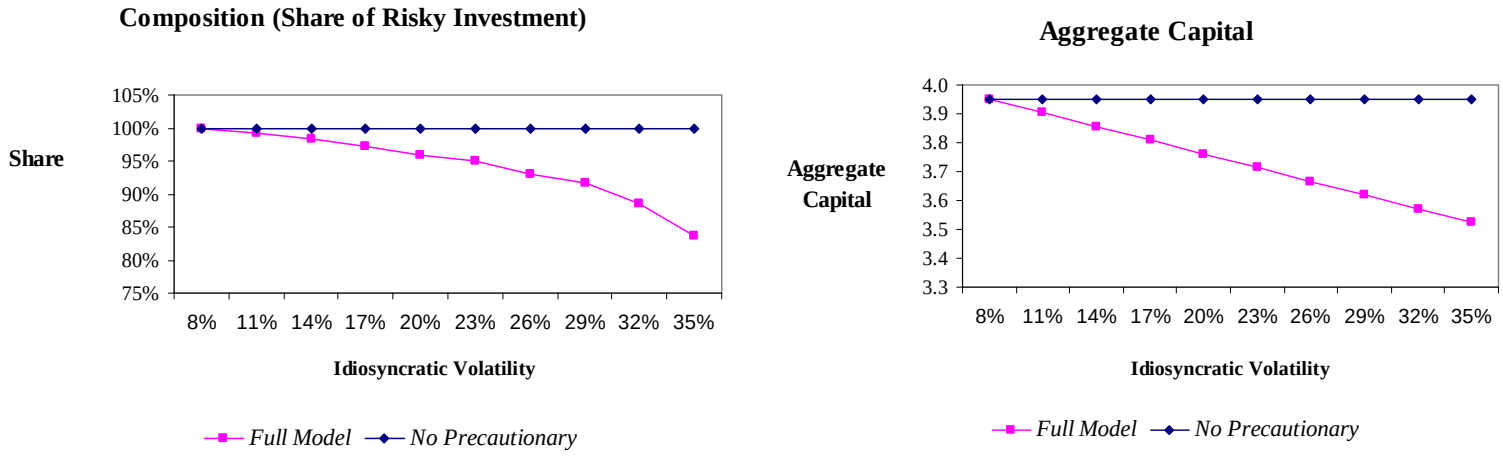


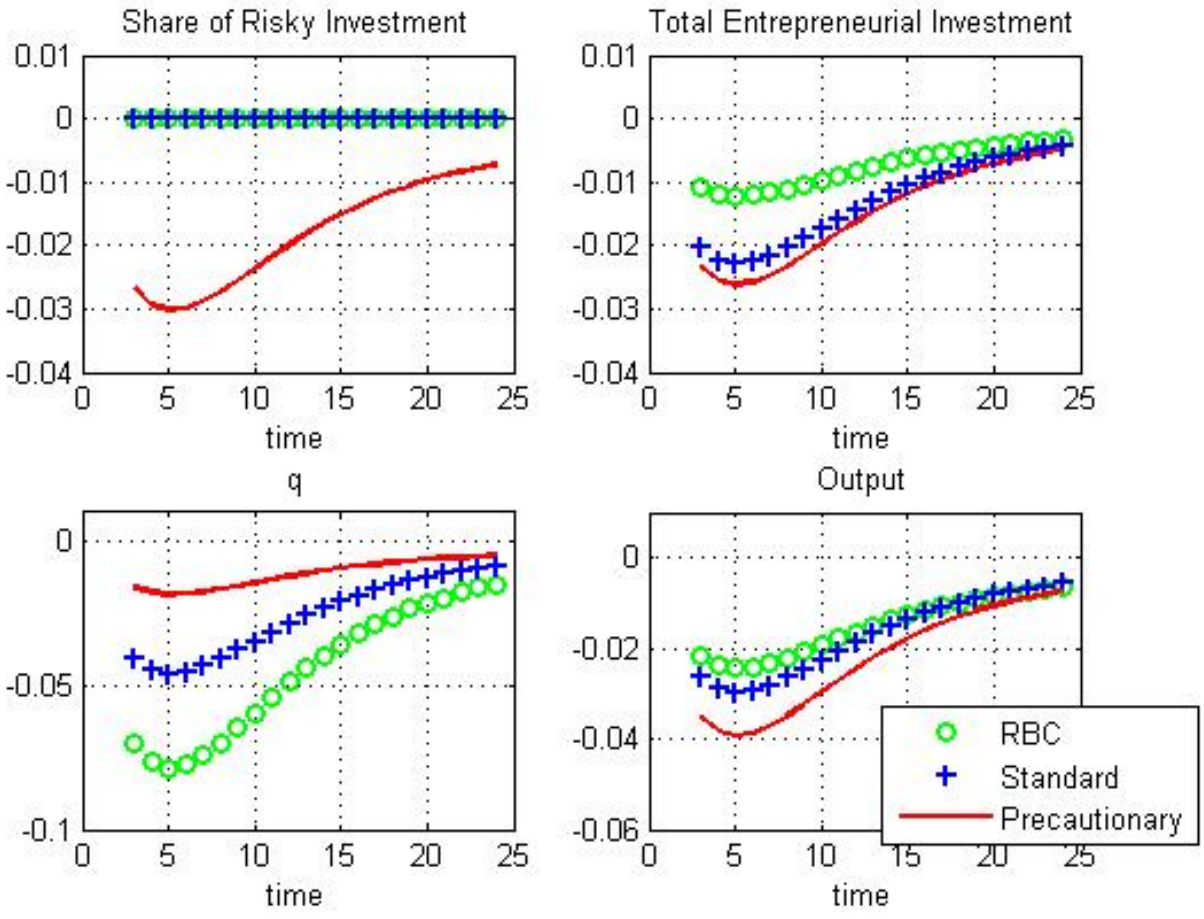
Figure: Composition of entrepreneurial investment and aggregate capital in the steady state, as a function of changes in idiosyncratic volatility.

- 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

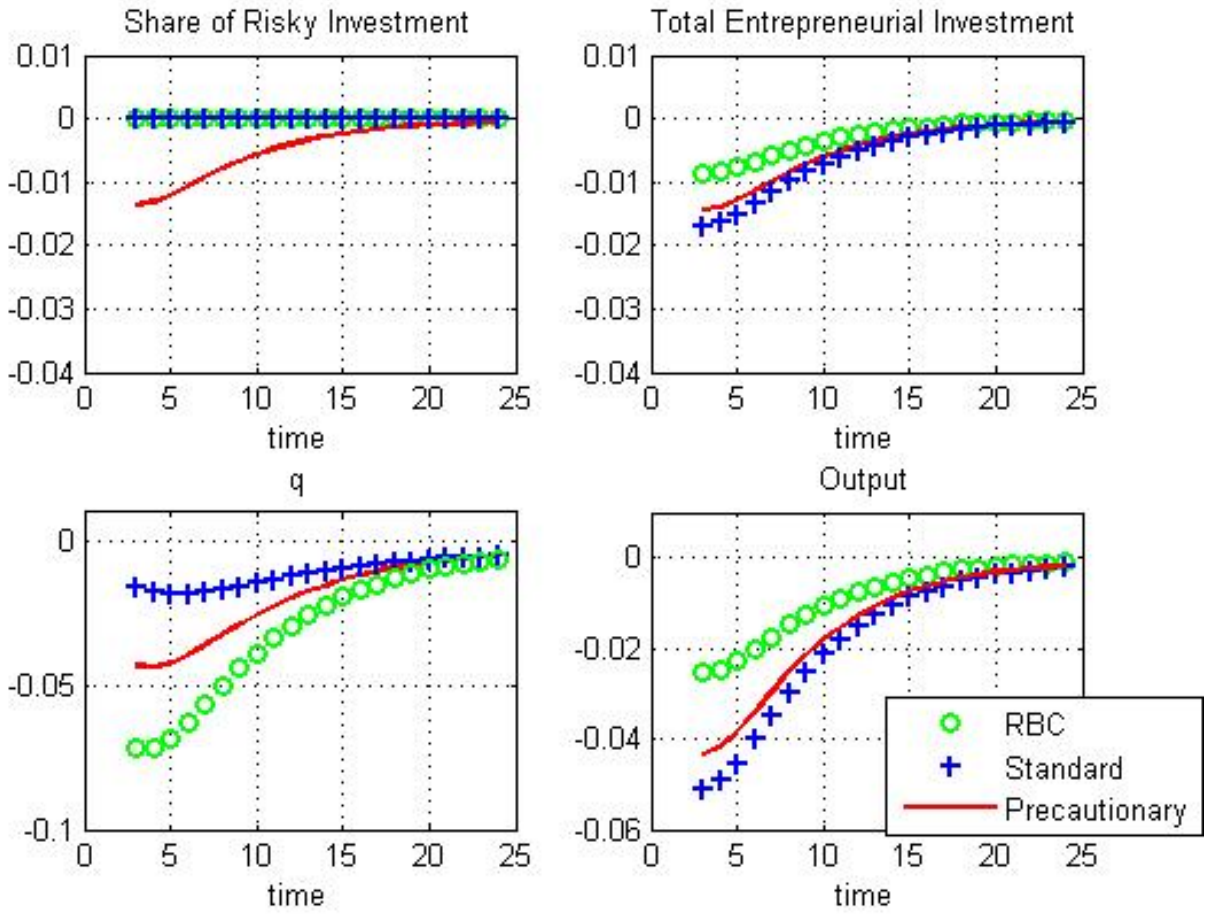


- Response to a negative 1% productivity shock, persistence $\rho = 0.95$

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 $t+1$

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

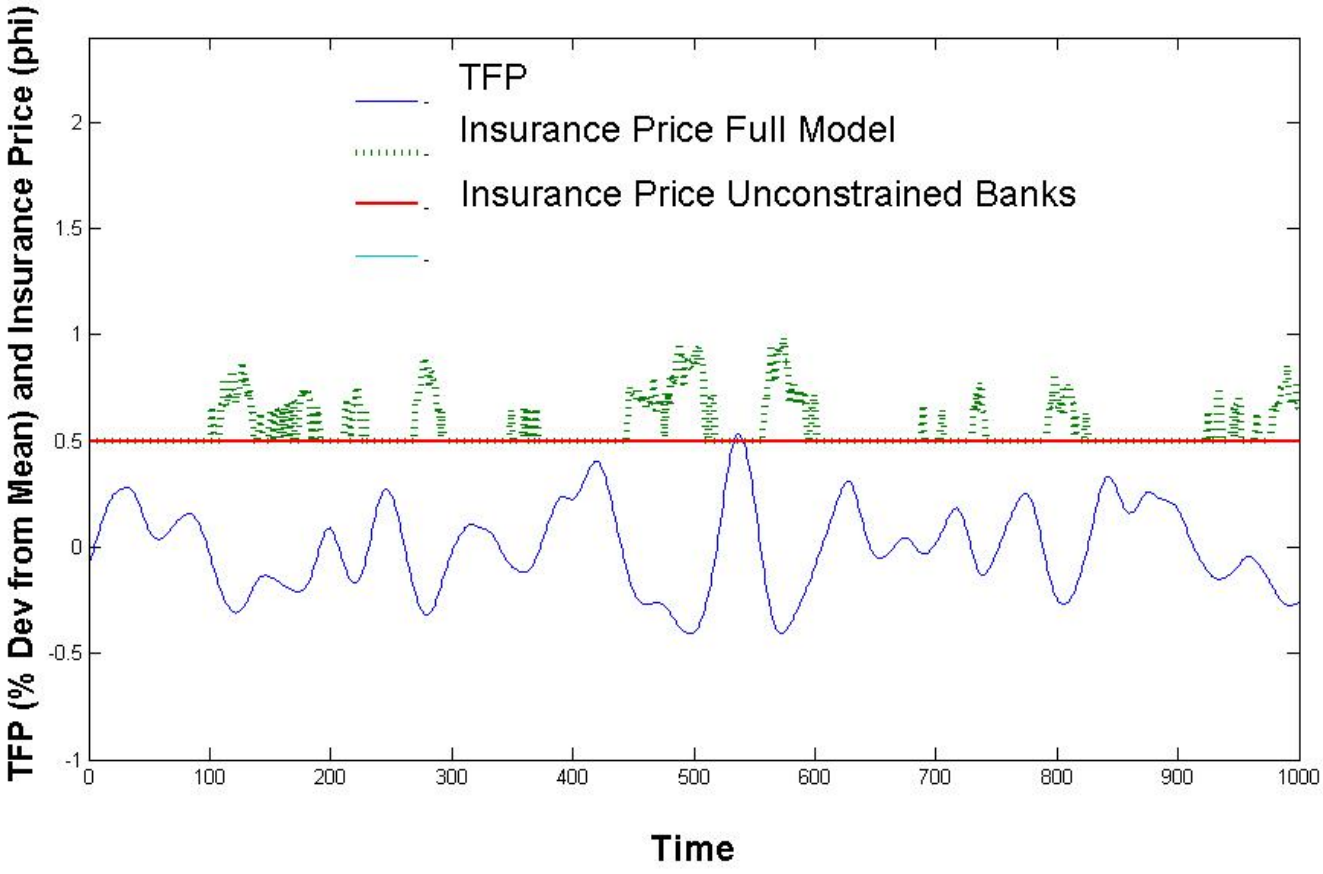
and if frictions in the supply of insurance are severe enough, and ϕ_t increases sufficiently as a result, then

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

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

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

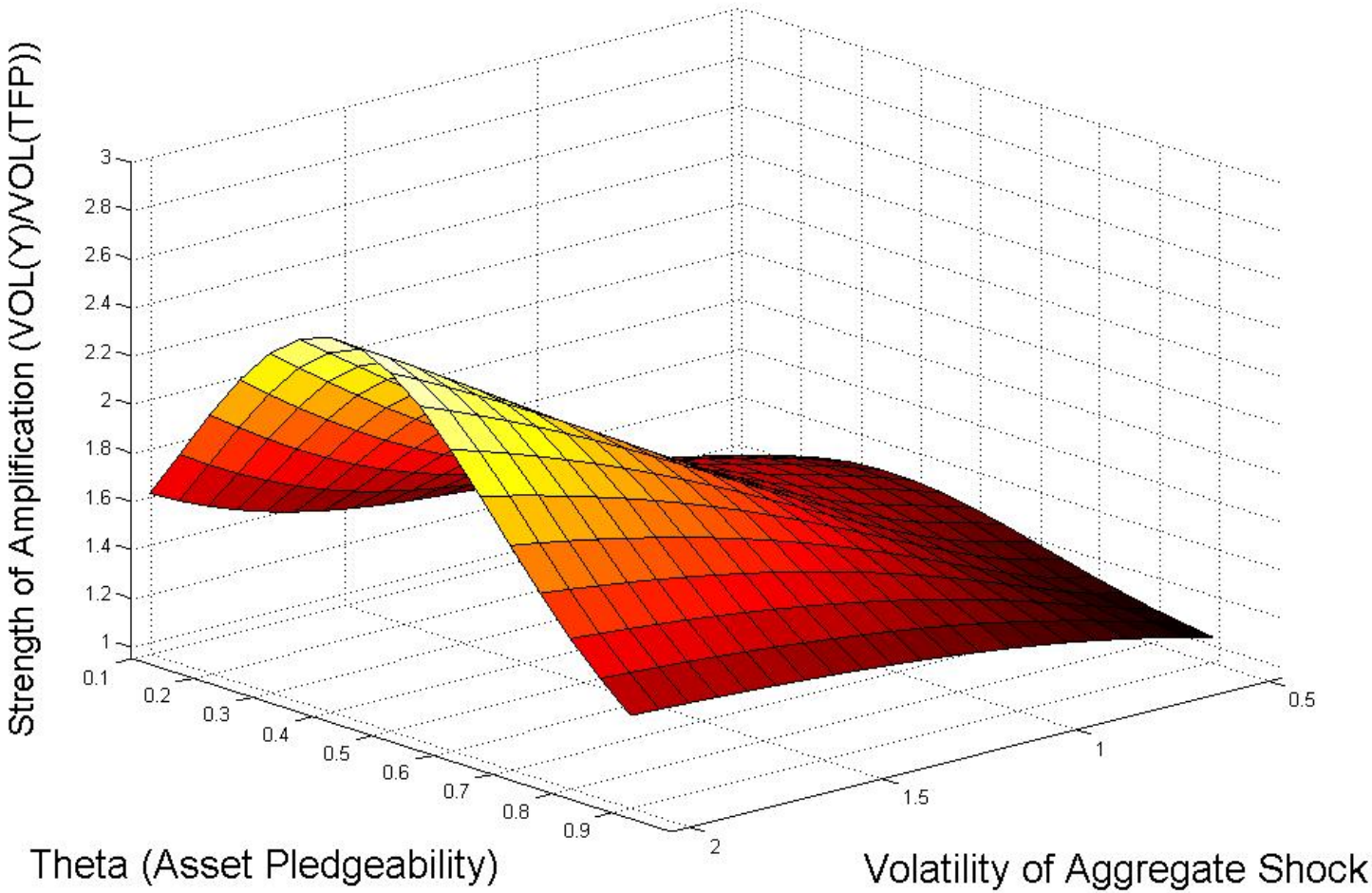
Dynamics



- 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

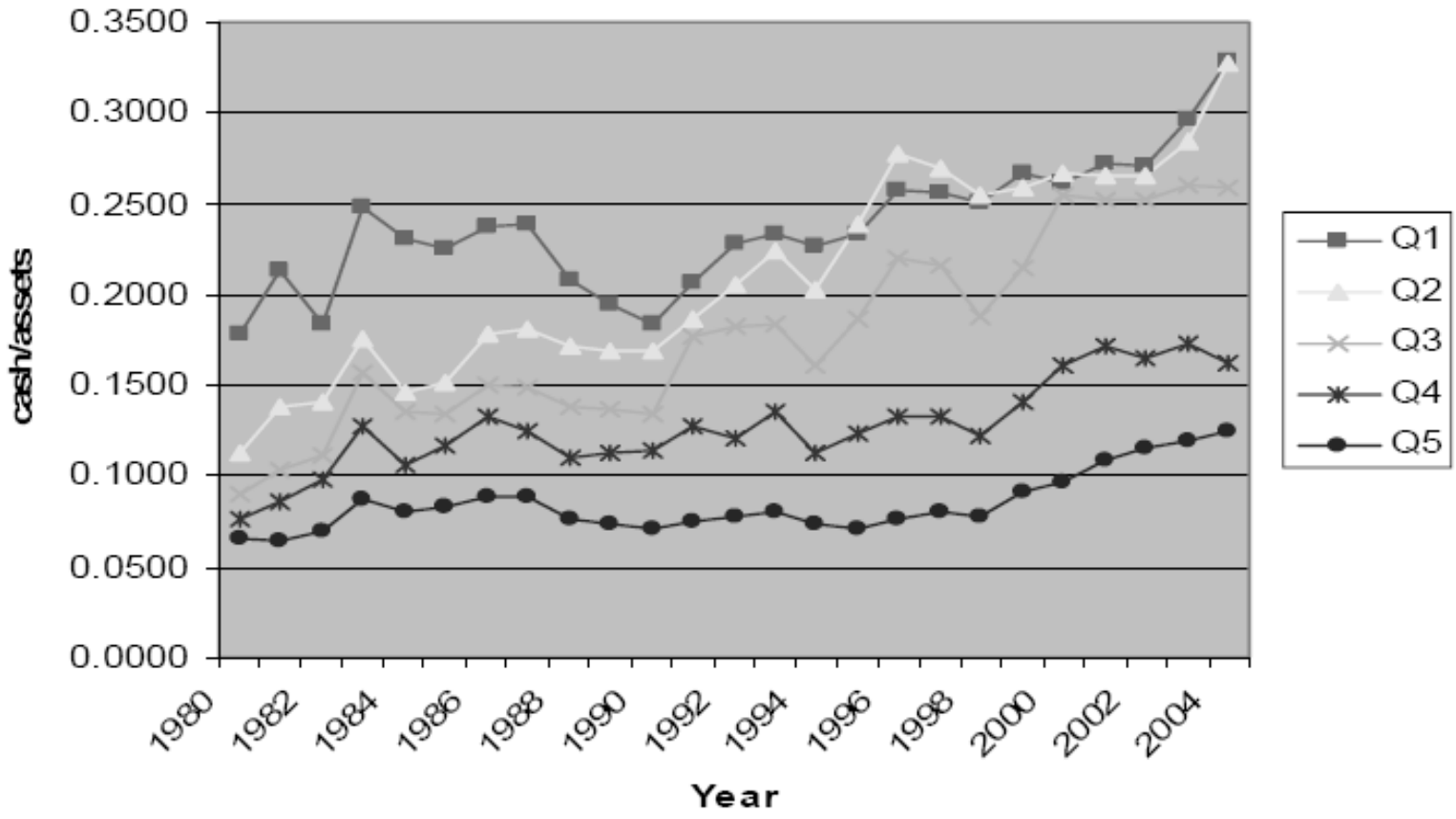
- Inventories small share of GDP, large share of GDP fluctuations (Blinder and Maccini (1991), Stock and Watson (1998))
- Inventories are more volatile than sales (Carpenter, Fazzari and Petersen (1993))
- Gertler and Gilchrist (94): following MP tightening:
  - Inventories (absolute) fall MORE for smaller 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.