

Financial Intermediary Capital

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Needed: A Theory of Financial Intermediary Capital

■ Question

- How does intermediary capital affect financing & macroeconomic activity?

■ Needed

- A dynamic theory of financial intermediary capital

■ Motivation

- Financial crisis and its aftermath

Our Theory of Financial Intermediary Capital

- **Financial intermediaries are collateralization specialists**
 - Intermediaries better able to collateralize claims than households
- **Financial intermediary capital**
 - ... required to finance additional collateralized amount

Our Theory of Financial Intermediary Capital: Implications

■ Two state variables

- Firm and intermediary net worth jointly determine dynamics of firm investment, financing, and loan spreads

■ Relatively slow accumulation of intermediary net worth

■ Compelling dynamics

- When corporate sector is very constrained,
 - ... intermediaries “hold cash” at low interest rates
- When intermediaries are very constrained,
 - ... firms’ investment stays low even as firms pay dividends

Literature: Models of Financial Intermediaries

■ Intermediary capital

- Holmström/Tirole (1997) – need capital at stake to commit to monitor
- Diamond/Rajan (2000), Diamond (2007) – ability to enforce claims due to better monitoring

■ Other theories of financial intermediation - no role for capital

- Liquidity provision theories – Diamond/Dybvig (1983)
- Diversified delegated monitoring theories – Diamond (1984), Ramakrishnan/Thakor (1984), Williamson (1986)
- Coalition based theories – Townsend (1978), Boyd/Prescott (1986)

Literature: Dynamic Models with Net Worth Effects

- **Firm net worth**

- Bernanke/Gertler (1989), Kiyotaki/Moore (1997a)

- **Intermediary net worth**

- Gertler/Kiyotaki (2010), Brunnermeier/Sannikov (2014)

- **Firm and intermediary net worth**

- This paper

Model: Environment

- Discrete time
- Infinite horizon
- 3 types of agents
 - Households
 - Financial intermediaries
 - Firms

Model: Households

- Risk neutral, discount at $R^{-1} > \beta$ where firms' discount rate is β
- Large endowment of funds (and collateral) in all dates and states

Model: Financing Subject to Collateral Constraints

■ Collateral constraints

- Complete markets in one period ahead Arrow securities
 - subject to collateral constraints
- Firms can issue state-contingent promises
 - ... up to fraction θ of resale value of capital to households
 - ... up to fraction θ_i of resale value of capital to intermediaries
- Related: Kiyotaki/Moore (1997a); but two types of lenders and allow risk management

■ Limited enforcement

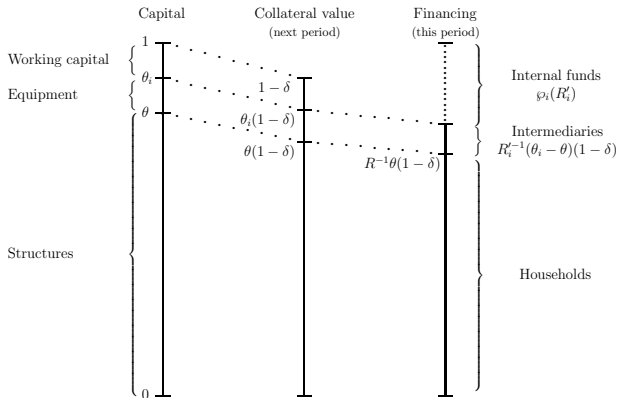
- We derive such collateral constraints from limited enforcement without exclusion - different from Kehoe/Levine (1993)
- Related: Rampini/Viswanathan (2010, 2013)

Model: Financial Intermediaries

- Risk neutral, discount at $\beta_i \in (\beta, R^{-1})$
- **Collateralization specialists**
 - Ability to seize up to fraction $\theta_i > \theta$ of (resale value of) collateral
- **Refinancing collateralized loans**
 - Idea: Intermediaries can borrow against their (collateralized) loans
 - ... but only to extent households can collateralize assets backing loans
 - Households can collateralize up to θ of collateral backing loans (“**structures**”)
 - Intermediaries need to finance $\theta_i - \theta$ out of own net worth (“**equipment**”)

Model: Collateral and Financing

■ Capital, collateral value, and financing



Model: Representative Firm (or “Corporate Sector”)

- Risk neutral, limited liability, discount at $\beta < 1$
- Capital k
 - Depreciation rate δ ; no adjustment costs
- Standard neoclassical production function
 - Cash flows $A'f(k)$ where $A' \equiv A(s')$ is (stochastic) Markov productivity with transition probability $\Pi(s, s')$
 - Strictly decreasing returns to scale ($f(\cdot)$ strictly concave)
- Two sources of outside finance
 - Households
 - Financial intermediaries

Firm's Problem

- Firm solves following dynamic program

$$v(w, Z) = \max_{\{d, k, b', b'_i, w'\} \in \mathbb{R}_+^2 \times \mathbb{R}^S \times \mathbb{R}_+^{2S}} d + \beta E[v(w', Z')] \quad (1)$$

subject to budget constraints

$$w + E[b' + b'_i] \geq d + k \quad (2)$$

$$A'f(k) + k(1 - \delta) \geq w' + Rb' + R'_i b'_i \quad (3)$$

and **collateral constraints**

$$\theta k(1 - \delta) \geq Rb' \quad (4)$$

$$(\theta_i - \theta)k(1 - \delta) \geq R'_i b'_i \quad (5)$$

- State-contingent interest rates R'_i determined in equilibrium

Firm's Problem: Comments

- Two sets of state-contingent collateral constraints restricting
 - ... borrowing from households b'
 - ... borrowing from financial intermediaries b'_i
- **State variables:** net worth w and state of economy $Z = \{s, w, w_i\}$
 - **Net worth of representative firm w and intermediary w_i**

Intermediary's Problem

- Representative intermediary solves

$$v_i(w_i, Z) = \max_{\{d_i, l', l'_i, w'_i\} \in \mathbb{R}_+^{1+3S}} d_i + \beta_i E[v_i(w'_i, Z')] \quad (6)$$

subject to budget constraints

$$w_i \geq d_i + E[l'] + E[l'_i] \quad (7)$$

$$Rl' + R'_i l'_i \geq w'_i \quad (8)$$

- State-contingent loans to households l' and to firms l'_i

Model with Limited Enforcement and Limited Participation

■ Timing

- Afternoon: repayments, investment, consumption
- Morning: cash flows, repayments

■ Limited participation

- Afternoon: Firms, intermediaries, and households present
- Morning: Firms and intermediaries present, not households

■ Limited enforcement

■ Afternoon

- Firms can abscond with cash flows and $1 - \theta$ of capital (not structures)
- Intermediaries can abscond with funds paid in morning

■ Morning

- Firms can abscond with cash flows and $1 - \theta_i$ of capital (not structures and equipment)

Equivalence: Limited Enforcement & Collateral Constraints

- Loans against $\theta_i - \theta$ (“equipment”) only enforceable in morning
 - Intermediaries must extend such loans
 - Loans must be repaid each morning (no rollover) – **new model of short term intermediated finance**
- Loans up to θ (“structures”) enforceable in afternoon
 - Households extend such loans w.l.o.g.
 - Rollover possible
- Two equivalent implementations with collateral constraints
 - Direct implementation
 - Households lend to firms directly
 - Indirect implementation
 - Households lend to intermediaries
 - Intermediaries lend to firms and borrow from households against collateralized corporate loans

Endogenous Minimum Down Payment Requirement

■ Minimum down payment requirement φ (or margin)

- Borrowing from households only

$$\varphi = 1 - R^{-1}\theta(1 - \delta)$$

- Borrowing from households and financial intermediaries

$$\varphi_i(R'_i) = \varphi - E[(R'_i)^{-1}](\theta_i - \theta)(1 - \delta)$$

■ Firm's investment Euler equation

$$1 \geq E \left[\beta \frac{\mu'}{\mu} \frac{A' f_k(k) + (1 - \theta_i)(1 - \delta)}{\varphi_i(R'_i)} \right] \quad (9)$$

User Cost of Capital with Intermediated Finance

- **Extension of Jorgenson's (1963) user cost of capital definition**

$$u \equiv r + \delta$$

- User cost would be rental cost in frictionless economy
- Premium on internal funds ρ : $1/(R + \rho) \equiv E[\beta\mu'/\mu]$
- Premium on intermediated finance ρ_i : $1/(R + \rho_i) \equiv E[(R'_i)^{-1}]$
- **Firm's user cost of capital u is**

$$u \equiv r + \delta + \frac{\rho}{R + \rho}(1 - \theta_i)(1 - \delta) + \frac{\rho_i}{R + \rho_i}(\theta_i - \theta)(1 - \delta),$$

where $1 + r \equiv R$

Premia on Internal and Intermediated Finance

- **Internal and intermediated funds are scarce**
- **Proposition 1 (Premia on internal and intermediated finance)**
 - *Premium on internal finance ρ (weakly) exceeds premium on intermediated finance ρ_i*

$$\rho \geq \rho_i \geq 0,$$

- *Premia equal, $\rho = \rho_i$, iff $E[\lambda'_i] = 0$.*
- *Premium on internal finance strictly positive, $\rho > 0$, iff $E[\lambda'] > 0$.*

Equilibrium

■ Definition 1 (Equilibrium) An **equilibrium** is

- allocation $x \equiv [d, k, b', b'_i, w']$ (for firm) and $x_i \equiv [d_i, l', l'_i, w'_i]$ (for intermediary)
- interest rate process R'_i for intermediated finance

such that

- (i) x solves firm's problem in (1)-(5) and x_i solves intermediary's problem (6)-(8)
- (ii) market for intermediated finance clears in all dates and states

$$l'_i = b'_i. \quad (10)$$

Essentiality of Financial Intermediation

- **Definition 2 (Essentiality of intermediation)** *Intermediation is **essential** if an allocation can be supported with a financial intermediary but not without.*
 - Analogous: Hahn's (1973) definition of essentiality of money
- **Intermediaries are essential**
- **Proposition 3 (Positive intermediary net worth)** *Financial intermediaries always have positive net worth in a deterministic or eventually deterministic economy.*
- **Proposition 4 (Essentiality of intermediaries)** *In any deterministic economy, financial intermediaries are always essential.*
 - Intuition: Without intermediaries, shadow spreads would be “high.”

Deterministic Steady State

■ Steady state spread and intermediary capitalization

- **Definition 3 (Steady state)** *A deterministic steady state equilibrium is an equilibrium with constant allocations, that is, $x^* \equiv [d^*, k^*, b'^*, b_i^*, w^*]$ and $x_i^* \equiv [d_i^*, l'^*, l_i^*, w_i^*]$.*

■ Proposition 5 (Steady state) *In steady state*

- *Intermediaries essential; positive net worth; pay positive dividends*
- *Spread on intermediated finance $R_i'^* - R = \beta_i^{-1} - R > 0$*
- *(Ex dividend) intermediary net worth (relative to firm's net worth)*

$$\frac{w_i^*}{w^*} = \frac{\beta_i(\theta_i - \theta)(1 - \delta)}{\varphi_i(\beta_i^{-1})}$$

(ratio of intermediary's financing to firm's down payment requirement)

Deterministic Equilibrium Dynamics

- Two main phases: **no dividend phase and dividend phase**

- Definition 6 (Deterministic dynamics)** Given w and w_i , there exists a unique deterministic dynamic equilibrium which converges to the steady state characterized by a no dividend region (ND) and a dividend region (D) (which is absorbing) as follows: [Region ND] $w_i \leq w_i^*$ (w.l.o.g.) and $w < \bar{w}(w_i)$, and (i) $d = 0$ ($\mu > 1$), (ii) the cost of intermediated finance is

$$R'_i = \max \left\{ R, \min \left\{ \frac{(\theta_i - \theta)(1 - \delta) \left(\frac{w}{w_i} + 1 \right)}{\varphi}, \frac{A' f_k \left(\frac{w + w_i}{\varphi} \right) + (1 - \theta)(1 - \delta)}{\varphi} \right\} \right\},$$

(iii) investment $k = (w + w_i)/\varphi$ if $R'_i > R$ and $k = w/\varphi_i(R)$ if $R'_i = R$, and

(iv) $w'/w'_i > w/w_i$, that is, firm net worth increases faster than intermediary net worth. [Region D] $w \geq \bar{w}(w_i)$ and (i) $d > 0$ ($\mu = 1$). For $w_i \in (0, \bar{w}_i)$, (ii) $R'_i = \beta^{-1}$, (iii) $k = \bar{k}$ which solves $1 = \beta[A' f_k(\bar{k}) + (1 - \theta)(1 - \delta)]/\varphi$, (iv) $w'_{ex}/w'_i < w_{ex}/w_i$, that is, firm net worth (ex dividend) increases more slowly than intermediary net worth, and (v) $\bar{w}(w_i) = \varphi \bar{k} - w_i$. For $w_i \in [\bar{w}_i, w_i^*]$, (ii) $R'_i = (\theta_i - \theta)(1 - \delta)k/w_i$, (iii) k solves

$1 = \beta[A' f_k(k) + (1 - \theta)(1 - \delta)]/(\varphi - w_i/k)$, (iv) $w'_{ex}/w'_i < w_{ex}/w_i$, that is, firm net worth (ex dividend) increases more slowly than intermediary net worth, and (v) $\bar{w}(w_i) = \varphi_i(R'_i)k$. For $w_i \geq w_i^*$, $\bar{w}(w_i) = w^*$ and the steady state of Proposition 5 is reached with $d = w - w^*$ and $d_i = w_i - w_i^*$.

Intermediary's Net Worth Dynamics

- Law of motion (as long as no dividends)

$$w'_i = R'_i w_i$$

- Intermediaries lend out all funds at interest rate $R'_i (\geq R)$
- **Relatively slow accumulation of intermediary net worth**
 - Intermediaries earn R'_i which is at most marginal return on capital (**collateral constraint**)
 - Firms earn average return (**decreasing returns to scale**)

Deterministic Dynamics: Initial Dividend

- **Lemma 2 (Initial intermediary dividend)** *The representative intermediary pays at most an initial dividend and no further dividends until the steady state is reached. If $w_i > w_i^*$, the initial dividend is strictly positive.*
- **Intuition: Low firm net worth limits loan demand**
 - Intermediaries save only part of net worth to meet future loan demand

Slow Intermediary Net Worth Accumulation

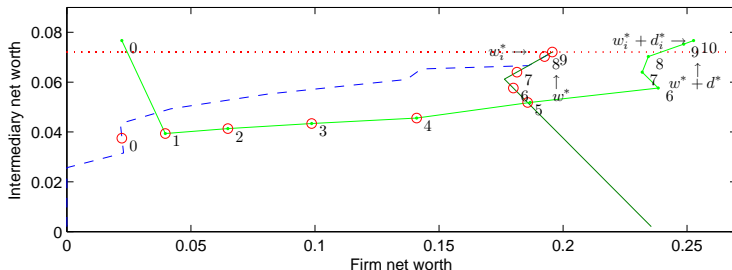
- Transition to steady state: Consider low initial firm net worth w
- Low firm net worth \Rightarrow low investment $k = w/\varphi_i(R)$ and low loan demand
 - **Intermediaries save at low interest rate** $R'_i = R$ (lend to households) to meet future loan demand
- **Firm net worth accumulates faster**
 - Investment $k = (w + w_i)/\varphi$, loan demand, and interest rate $R'_i = (\theta_i - \theta)(1 - \delta)/\varphi(w/w_i + 1)$ rise
 - When collateral constraint stops binding, interest rate $R'_i = [A' f_k(k) + (1 - \theta)(1 - \delta)]/\varphi$ falls
- When interest rate reaches β^{-1} , firms pay dividends and stop growing, **waiting for intermediary capital to catch up (“recovery stalls”)**
- Once intermediaries catch up, interest rate falls and investment rises; **corporate sector relevers** until steady state $R_i^* = \beta_i^{-1}$ reached

Dynamics of a Macroeconomic Downturn

■ Macroeconomic downturn

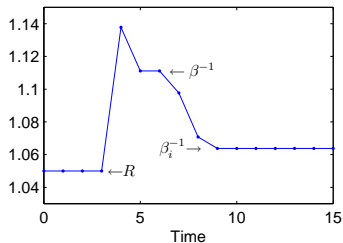
- Unanticipated drop in firm (and possibly intermediary) net worth from steady state (say due to surprise drop in productivity A')

■ Dynamics of net worth, spread, and investment

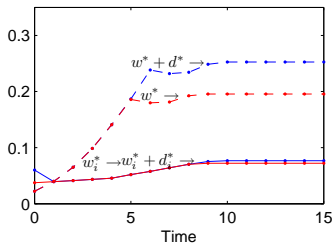


Dynamics of Net Worth, Spread, and Investment

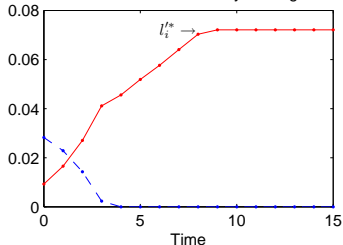
Panel B1. Cost of intermediated finance



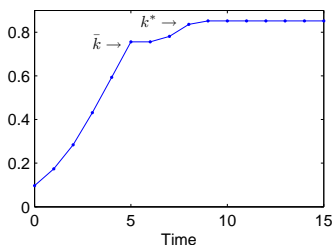
Panel B2. Firm and intermediary wealth



Panel B3. Intermediary lending



Panel B4. Investment



Dynamics of a Macroeconomic Downturn (Cont'd)

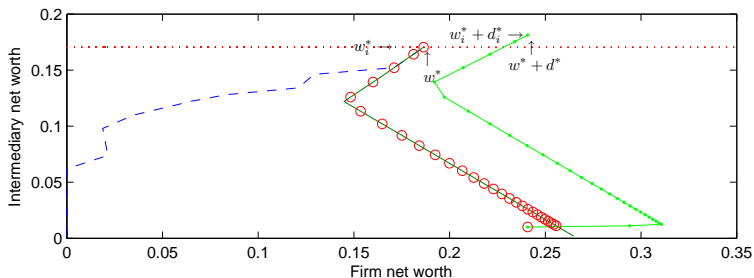
- **Persistent real effects**
 - Drop in real investment
- Spread on intermediated finance may fall (as loan demand falls)
- **Intermediaries may pay initial dividend when downturn hits!**

Dynamics of a Credit Crunch

■ Credit crunch

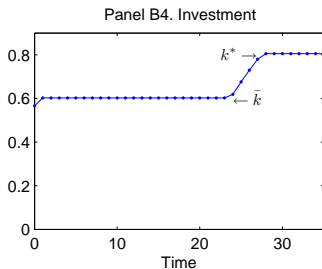
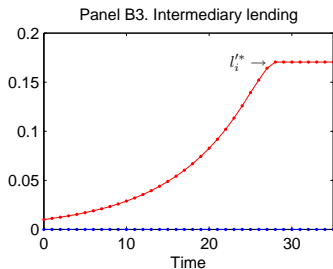
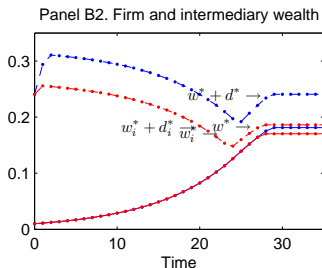
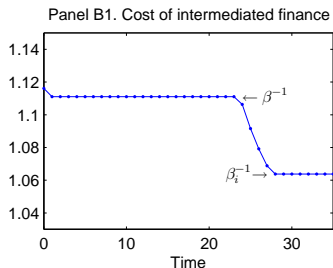
- Unanticipated drop in intermediary net worth w_i from steady state

■ Joint dynamics of firm and intermediary net worth



Dynamics of a Credit Crunch (Cont'd)

■ Dynamics of net worth, spread, and investment



Dynamics of a Credit Crunch (Cont'd)

- **Persistent real effects**
- Moderate drop: intermediaries cut dividends
- **“Delayed recovery”** (until intermediaries accumulate sufficient capital)
 - Suppose corporate sector still well capitalized
 - **Investment drops even as firms continue to pay dividends**
 - Why? – Higher interest rate $R'_i = \beta^{-1}$ increases cost of capital
- **“Recovery stalls”**
 - Suppose corporate sector no longer well capitalized
 - Investment drops more and interest rate R'_i even higher
 - Partial recovery until $R'_i = \beta^{-1}$ then **“waiting for intermediaries to catch up”**

Comovement of Firm and Intermediary Net Worth

■ Sufficient conditions for comovement

- Is value of intermediary net worth high when value of firm net worth high?

■ Proposition 7 (Comovement of value of net worth) *In economy which is deterministic from time 1 onward:*

- (i) *Representative firm collateral constrained for direct finance against at least one state at time 1.*
- (ii) *If $\lambda_i(s') = 0, \forall s' \in S$, marginal values comove:*
$$\mu(s')/\mu(s'_+) = \mu_i(s')/\mu_i(s'_+), \forall s', s'_+ \in S.$$
- (iii) *If $S = \{\hat{s}', \check{s}'\}$ and $\lambda(\check{s}') > 0 = \lambda(\hat{s}')$, then the marginal values must comove, $\mu(\hat{s}') > \mu(\check{s}')$ and $\mu_i(\hat{s}') \geq \mu_i(\check{s}')$.*

- Interpretation: neither firms nor intermediaries hedge fully

Conclusions

- **Theory of financial intermediaries as collateralization specialist**
 - Better ability to enforce claims
 - ... implies **role for financial intermediary capital**
 - Tractable dynamic model
 - Intermediated finance is short term
- **Dynamics of intermediary capital**
 - Economic activity and spreads **determined by firm and intermediary net worth jointly**
 - **Slow accumulation** of intermediary net worth
 - Credit crunch has **persistent real effects**

Characterization of Firm's Problem

■ Multipliers

- ... on (2) through (5): μ , $\Pi(Z, Z')\beta\mu'$, $\Pi(Z, Z')\beta\lambda'$, and $\Pi(Z, Z')\beta\lambda'_i$
- ... on $d' \geq 0$ and $b'_i \geq 0$: ν_d and $\Pi(Z, Z')R'_i\beta\nu'_i$
- (Redundant: $k \geq 0$ and $w' \geq 0$)

■ First order conditions

$$\mu = 1 + \nu_d \quad (11)$$

$$\mu = E[\beta\mu' ([A' f_k(k) + (1 - \delta)] + [\lambda'\theta + \lambda'_i(\theta_i - \theta)] (1 - \delta))] \quad (12)$$

$$\mu = R\beta\mu' + R\beta\lambda' \quad (13)$$

$$\mu = R'_i\beta\mu' + R'_i\beta\lambda'_i - R'_i\beta\nu'_i \quad (14)$$

$$\mu' = v'(w', Z') \quad (15)$$

■ Envelope condition

$$v'(w, Z) = \mu$$

Weighted Average User Cost of Capital

- User cost of capital with intermediated finance

$$u \equiv \frac{R}{R + \rho}(r_w + \delta)$$

where **weighted average cost of capital** r_w is

$$r_w \equiv (r + \rho)\rho_i(R'_i) + rR^{-1}\theta(1 - \delta) + (r + \rho_i)(R + \rho_i)^{-1}(\theta_i - \theta)(1 - \delta)$$

Characterization of Intermediary's Problem

■ Multipliers

- ... on (7) through (8): μ_i and $\Pi(Z, Z')\beta_i\mu'_i$,
- ... on $d'_i \geq 0$, $l' \geq 0$, and $l'_i \geq 0$: η_d , $\Pi(Z, Z')R\beta_i\eta'$, and $\Pi(Z, Z')R'_i\beta_i\eta'_i$
- (Redundant: $w'_i \geq 0$)

■ First order conditions

$$\mu_i = 1 + \eta_d, \quad (16)$$

$$\mu_i = R\beta_i\mu'_i + R\beta_i\eta', \quad (17)$$

$$\mu_i = R'_i\beta_i\mu'_i + R'_i\beta_i\eta'_i, \quad (18)$$

$$\mu'_i = v'_i(w'_i, Z'), \quad (19)$$

■ Envelope condition

$$v'_i(w_i, Z) = \mu_i$$

Financial Intermediation in a Static Economy

- (Representative) **firm's static problem** given R'_i

$$\max_{\{d, k, b', b'_i, w'\} \in \mathbb{R}_+^2 \times \mathbb{R} \times \mathbb{R}_+^2} d + \beta w' \quad (20)$$

subject to (2) through (5).

- (Representative) **intermediary's static problem**

$$\max_{\{d_i, l', l'_i, w'_i\} \in \mathbb{R}_+^4} d_i + \beta_i w'_i \quad (21)$$

subject to (7) through (8). R'_i determined in equilibrium.

Intermediated vs. Direct Finance in Cross Section

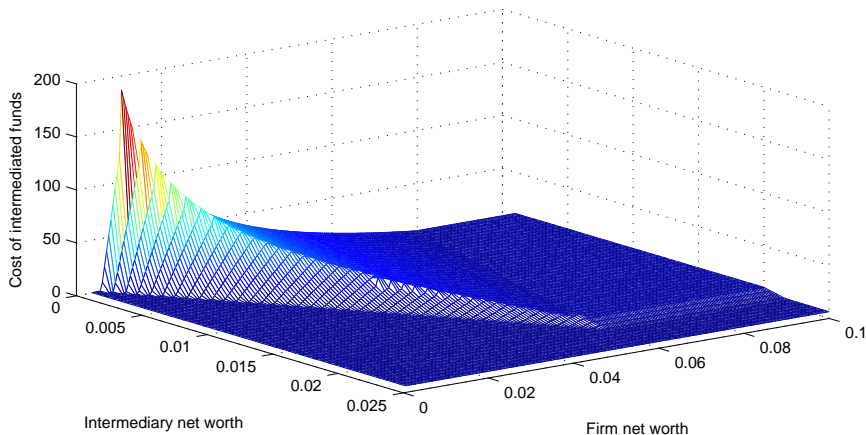
- **Poorly capitalized firms borrow from intermediaries**
- Suppose firms vary in their net worth w
- Partial equilibrium: interest rate on intermediated finance R'_i given
- **Proposition 8 (Intermediated vs. direct finance across firms)**
Suppose $R'_i > \beta^{-1}$.
 - **(i)** *Exist $0 < \underline{w}_l < \underline{w}_u$ such that firms with*
 - ... $w \leq \underline{w}_l$ *borrow as much as possible from intermediaries.*
 - ... $w \in (\underline{w}_l, \underline{w}_u)$ *borrow positive amount from intermediaries.*
 - ... $w \geq \underline{w}_u$ *do not borrow from intermediaries.*
 - **(iii)** *Investment increasing in w .*
- Mirrors results of Holmström/Tirole (1997)

Effect of Intermediary Net Worth on Spreads

- Firm and intermediary net worth determine spreads jointly
- Equilibrium in static economy with representative firm: R'_i determined endogenously
- Proposition 2 (Firm and intermediary net worth)
 - (i) For $w_i \geq w_i^*$, intermediaries well capitalized; minimal spread $\beta_i^{-1} - R > 0$.
 - (ii) Otherwise
 - If $w \leq \underline{w}(w_i)$ intermediaries still well capitalized; spread $\beta_i^{-1} - R$.
 - For $w > \underline{w}(w_i)$, intermediated finance scarce and spreads higher. For $w_i \in [\bar{w}_i, w_i^*)$, spreads increasing until $\hat{w}(w_i)$, then constant $\hat{R}'_i(w_i) - R \in (\beta_i^{-1} - R, \beta^{-1} - R]$. For $w_i \in (0, \bar{w}_i)$, spreads increasing until $\hat{w}(w_i)$, then decreasing until $\bar{w}(w_i)$, then constant $\beta^{-1} - R$.

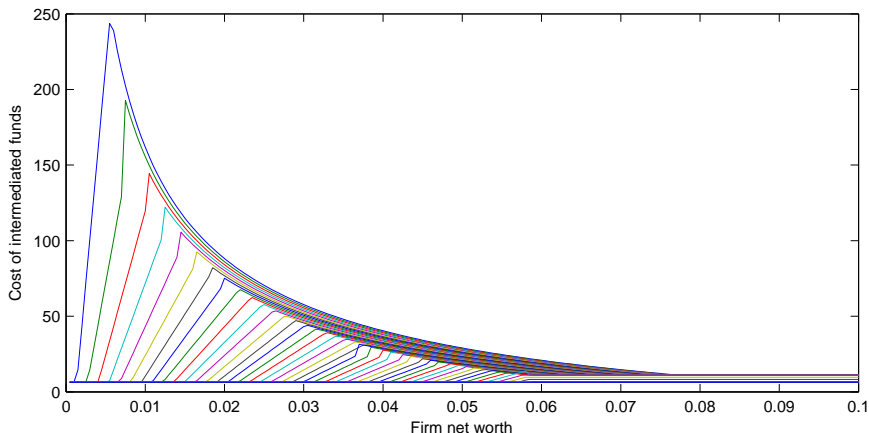
Role of Firm and Intermediary Net Worth

- Spreads high when firm and intermediary net worth low
 - ... and in particular when intermediary relative to firm net worth low
- Interest rate on intermediated finance $R'_i - 1$ (percent) as a function of firm (w) and intermediary net worth (w_i)



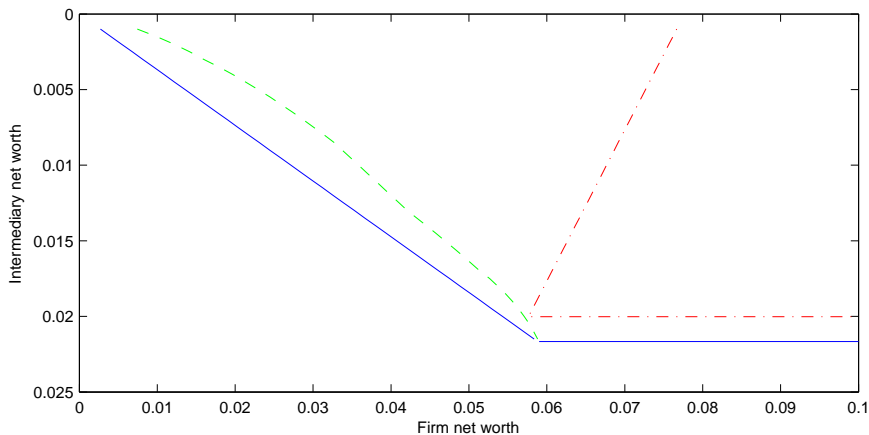
Role of Firm and Intermediary Net Worth (Cont'd)

- **Projection of interest rate on intermediated finance $R'_i - 1$** (percent) as a function of firm (w) for different levels of intermediary net worth (w_i)



Role of Firm and Intermediary Net Worth (Cont'd)

- Spreads determined by firm and intermediary net worth jointly
- Contour of area where spread exceeds $\beta_i^{-1} - R$: \bar{w}_i (solid) and $\underline{w}(w_i)$ (solid); $\hat{w}(w_i)$ (dashed); contour of area where spread equals $\beta_i^{-1} - \beta^{-1}$: \underline{w}_i (dash dotted) and $\bar{w}(w_i)$ (dash dotted).



Dynamics of Firm and Intermediary Net Worth

- Contours of regions describing deterministic dynamics of firm and financial intermediary net worth.

