Dynamic Collateralized Finance

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Aim: Tractable Dynamic Model of Collateralized Financing

- Key friction: **limited enforcement**
  - Enforcement of repayment by borrower limited to tangible assets
  - Implication: **collateral constraints**
    - Promises are not credible unless collateralized
  - Implementation: complete markets in one-period Arrow securities
    - Tractable!

- Key substantive implications
  1. **Capital structure**
     - Determinant: fraction tangible assets required for production
  2. **Risk management**
     - Involves state contingent promises and needs collateral
     - Opportunity cost: forgone investment
     - Severely constrained firms do not hedge
  3. **Leasing and rental markets**
     - Leasing has repossession advantage and permits greater borrowing
     - Severely constrained firms lease

- **Useful laboratory to study dynamics of financial constraints**
Papers on Dynamic Collateralized Finance

- **Corporate risk management, capital structure, and leasing**

- **Household insurance**

- **Other applications**
(1) Capital Structure

- **Collateral key determinant of capital structure**
  - Enforcement of repayment by borrower limited to tangible assets
  - Nature of assets required for production determines financing

- Key papers: Rampini/Viswanathan (2010, 2013)
(Frictionless) Neoclassical Theory of Investment

- Environment
  - Discrete time, infinite horizon
  - Investor/owner

- Preferences
  - Investor is risk neutral and discounts at rate $R^{-1} < 1$

- Endowments
  - Investor net worth $w \gg 0$, i.e., deep pockets

- Technology
  - Capital $k$ invested in current period
  - Payoff ("cash flow") next period $Af(k)$ where parameter $A$ is "total factor productivity" (TFP)
  - Strict concavity $f_k(k) > 0$ and $f_{kk}(k) < 0$; also:
    $\lim_{k \to 0} f_k(k) = +\infty; \lim_{k \to \infty} f_k(k) = 0$
  - Capital is durable and depreciates at rate $\delta$; capital $(1 - \delta)k$ remains next period
Neoclassical Investment: Investor’s Problem

- **Investor’s objective**
  - Maximize “value” – present discounted value of dividends

- **Investor’s problem - recursive formulation**
  - Choose current dividend $d$ and invest capital $k$ to solve
    \[
    \max_{\{d,w',k\}} d + R^{-1}v(w')
    \]
  - subject to budget constraints (but no limited liability constraints)
    \[
    w \geq d + k \\
    Af(k) + k(1 - \delta) \geq w'
    \]
Neoclassical Investment and User Cost of Capital

- First-order conditions (FOCs) (multipliers $\mu$ and $R^{-1}\mu'$)

\[
1 = \mu \\
R^{-1} = R^{-1}\mu' \\
\mu = R^{-1}\mu' [Af_k(k) + (1 - \delta)]
\]

- Investment Euler Equation

- Optimal investment/capital $k^*$ solves (combining FOCs)

\[
1 = R^{-1}[Af_k(k) + (1 - \delta)]
\]

or letting $R \equiv 1 + r$ and rewriting

\[
\underbrace{r + \delta}_{\text{user cost of capital}} = \underbrace{Af_k(k)}_{\text{marginal product of capital}}
\]

- Jorgenson’s (1963) user cost of capital (paid at end of period)

\[
u \equiv \underbrace{r}_{\text{interest rate}} + \underbrace{\delta}_{\text{depreciation rate}}
\]
Collateral Constraints as in Rampini/Viswanathan

- Environment with frictions (otherwise as before)

- Two types of agents
  - Owner/borrower
  - Investor/lender

- Borrower ("firm")
  - Preferences: risk neutral, impatient $\beta < R^{-1}$, and subject to limited liability
  - Endowment: borrower has limited funds $w > 0$

- Investor/lender has deep pockets (as before)

- Collateral constraints
  - Need to collateralize loan repayment with tangible assets
Question: Why does borrower need to collateralize loans?

- Enforcement is limited and it has to be incentive compatible for borrower to repay

Friction: Limited enforcement without exclusion

- Borrower can abscond with all cash flows and fraction $1 - \theta$ of (depreciated) capital
Limited Enforcement Implies Collateral Constraints

**Enforcement constraint**

- Ensure that borrower prefers to repay instead of absconding; heuristically,
  \[
  v(w') \geq v(Af(k) + (1 - \theta)k(1 - \delta))
  \]
  value when repaying \hspace{1cm} value when defaulting

  and since \(v(\cdot)\) is strictly increasing

  \[
  w' \geq Af(k) + (1 - \theta)k(1 - \delta)
  \]

  and using budget constraint to substitute for \(w'\) given borrowing \(b\)

  \[
  Af(k) + k(1 - \delta) - Rb = w' \geq Af(k) + (1 - \theta)k(1 - \delta)
  \]

  payoff when repaying \hspace{1cm} payoff when defaulting

**Collateral constraint**

- Canceling terms and rearranging enforcement constraint we obtain

  \[
  \theta k(1 - \delta) \geq Rb
  \]
Firm’s problem

\[ v(w) \equiv \max_{\{d,k,b,w'\}} d + \beta v(w') \]

subject to budget constraints and collateral constraint

\[ w + b \geq d + k \]
\[ Af(k) + k(1 - \delta) \geq w' + Rb \]
\[ \theta k(1 - \delta) \geq Rb \]

and limited liability \( d \geq 0 \)

Net worth next period \( w' = Af(k) + k(1 - \delta) - Rb \)
First Order Conditions and Investment Euler Equation

- First-order conditions (multipliers $\mu$, $\beta \mu'$, and $\beta \lambda'$)

$$1 \leq \mu, \quad v_w(w') = \mu'$$

$$\mu = \beta \mu'[Af_k(k) + (1 - \delta)] + \beta \lambda' \theta(1 - \delta),$$

$$\mu = \beta \mu' R + \beta \lambda' R$$

- Also: Envelope condition $v_w(w) = \mu$

**Investment Euler Equation**

$$1 = \beta \frac{\mu'}{\mu} \frac{Af_k(k) + (1 - \theta)(1 - \delta)}{1 - R^{-1} \theta(1 - \delta)}$$
“Minimal downpayment” (per unit of capital)

\[ \phi \equiv 1 - R^{-1} \theta (1 - \delta) \]

PV of \( \theta \times \text{resale value of capital} \)

- **Capital structure**
  - In deterministic case, collateral constraints always bind
  - Debt per unit of capital
    \[ R^{-1} \theta (1 - \delta) \]
  - Internal funds per unit of capital
    \[ \phi = 1 - R^{-1} \theta (1 - \delta) \]
Collateralizability vs. Tangibility

- **Collateralizability** $\theta$
  - Structures more collateralizable than equipment (composition varies by industry)
  - Financial development may raise $\theta$ and hence leverage

- **Tangibility** $\varphi$
  - Includes mainly structures (incl. land) and equipment
  - Suppose tangible assets are collateralizable (but not intangible assets)
  - Fraction tangible assets ($\varphi$) needed for production key

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

- **Investment Euler Equation** for dividend paying firm

\[ 1 = \beta \frac{Af_k(k) + (1 - \theta)(1 - \delta)}{\phi} \]

- Dividend paying firm: Capital \( \bar{k} \) solves equation above
  - Comparing FOC's can show \( \bar{k} < k^* \) (underinvestment)

- Non-dividend paying firm: \( k = \frac{1}{\phi} w \) (invest all net worth and lever as much as possible)
Dividend Policy

- Threshold policy

- Pay out dividends today ($d' > 0$) if $w \geq \bar{w}$
  
  - Can we show threshold is optimal? Suppose pay dividends at $w$ but not at $w^+ > w$

  - At $w$, invest $\bar{k}$; if not paying dividends at $w^+$, must invest more; can $IEE$ hold?
Value of Internal Funds

- **Value of internal funds** $\mu$ (remember the envelope condition?)
  - Premium on internal funds (unless firm pays dividends) since $\mu \geq 1$

- **User cost** $u(w)$
  - User cost such that $u(w) = R\beta \frac{\mu'}{\mu} Af_k(k)$ where

\[
  u(w) \equiv r + \delta + R\beta \frac{\lambda}{\mu} (1 - \theta)(1 - \delta) > u
\]

  internal funds require premium
Net Worth Accumulation and Firm Growth

- **Dividend policy and net worth accumulation**
  - Dividend policy is threshold policy
  - For $w \geq \bar{w}$, pay dividends $d = w - \bar{w}$
  - For $w < \bar{w}$, pay no dividends and reinvest everything ("retain all earnings")

- **Investment policy and firm growth**
  - For $w \geq \bar{w}$, keep capital constant at $\bar{k}$ (no growth)
  - For $w < \bar{w}$, invest everything $k = \frac{1}{\varphi} w$ resulting in net worth $w' > w$ next period

- **Firm age**
  - Young firms ($w < \bar{w}$) do not pay dividends, reinvest everything, and grow
  - Mature firms ($w \geq \bar{w}$) pay dividends and do not grow
Conclusions for Capital Structure

- **Tangible assets as collateral**
  - If debt needs to be collateralized, type of assets required determines capital structure

- **Dynamics of financing**
  - Accumulate net worth over time
  - Young firms grow and retain all earnings
  - Mature firms pay dividends and grow less
(2) Corporate Risk Management

- Financial constraints give rationale for corporate risk management
  - If firms’ net worth matters, then firms are as if risk averse
  - Collateral constraints link financing and risk management
  - More constrained firms hedge less and often completely abstain

- Key papers: Rampini/Viswanathan (2010, 2013)
  - Rampini/Sufi/Viswanathan (2014) consider input price risk management
Collateral and Corporate Risk Management

Why should firms hedge?

- Firms are risk neutral, why hedge?
- Financial constraints make firms risk averse
  - Firms’ value function concave in net worth

Financing vs. risk management trade-off

- Limited enforcement: Need to collateralize promises to financier and counterparties
- Collateral constraints link financing and risk management
- More constrained firms hedge less as financing needs dominate hedging concerns

Relatedly for households: Financing vs. insurance trade-off

- “The poor can’t afford insurance”
- Rampini/Viswanathan (2015)
Risk Management à la Rampini/Viswanathan

- Environment as before but here with uncertainty
  - Uncertainty: Markov chain state $s' \in S$ next period – transition probability $\Pi(s, s')$
  - Two types of agents, owner/borrower and investor/lender

- Preferences
  - Borrower is risk neutral, impatient $\beta$, and subject to limited liability
  - Lender is risk neutral and discounts at $R^{-1} \in (\beta, 1)$

- Endowments
  - Borrower has limited funds $w > 0$
  - Lender has deep pockets
Technology

- Capital $k$ invested in current period yields stochastic payoff (“cash flow”) in state $s'$ next period

$$A(s') f(k)$$

where $A' \equiv A(s')$ is realized “total factor productivity” (TFP)

- Strict concavity $f_k(k) > 0$; $f_{kk}(k) < 0$; also: $\lim_{k \to 0} f_k(k) = +\infty$; $\lim_{k \to \infty} f_k(k) = 0$

- Capital is durable and depreciates at rate $\delta$; capital $k(1 - \delta)$ remains next period

Collateral constraints

- Need to collateralize all promises to pay with tangible assets
- Can pledge up to fraction $\theta < 1$ of value of depreciated capital
Firm’s Debt Capacity Use Problem

- **State contingent borrowing** $b' \equiv b(s')$

- Collateral constraint for state contingent borrowing $b'$

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

- Firm’s debt capacity use problem

  $$\max_{\{d,w',k,b'\}} d + \beta \sum_{s' \in S} \Pi(s, s')v(w', s')$$

subject to budget constraints and collateral constraints, $\forall s' \in S$,

$$w + R^{-1} \sum_{s' \in S} \Pi(s, s')b' \geq d + k$$

  total borrowing

$$A'f(k) + k(1 - \delta) \geq Rb' + w'$$

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

and limited liability $d \geq 0$
Corporate Risk Management – Optimality Conditions

- **First-order conditions** (multipliers $\mu$, $\Pi(s, s')\beta \mu(s')$, and $\Pi(s, s')\beta \lambda(s')$)

\[
\varphi \mu = \sum_{s' \in S} \Pi(s, s')\beta \mu'[A' f_k(k) + (1 - \theta)(1 - \delta)], \quad \mu = \beta \mu' R + \beta \lambda' R
\]

\[
1 \leq \mu, \quad v_w(w', s') = \mu'
\]

- **Investment Euler equation**

\[
1 = \sum_{s' \in S} \Pi(s, s')\beta \frac{\mu'}{\mu} A' f_k(k) + (1 - \theta)(1 - \delta)
\]

- Firms are effectively risk averse about net worth
Corporate Risk Management Problem

- **Equivalent risk management formulation**
  - Collateral constraint for state contingent borrowing \( b' \)
    \[
    \theta k (1 - \delta) \geq R b'
    \]
  - Equivalently, borrow as much as possible and hedge
    \[
    h' \equiv \theta k (1 - \delta) - R b' \geq 0
    \]

- **Firm’s risk management problem**
  \[
  \max_{\{d, w', k, h'\}} \ d_0 + \beta \sum_{s' \in S} \Pi(s, s') v(w', s')
  \]
  subject to budget constraints and short sale constraints, \( \forall s' \in S, \)
  \[
  w \geq d + \phi k + R^{-1} \sum_{s' \in S} \Pi(s, s') h'
  \]
  \( A' f(k) + (1 - \theta) k (1 - \delta) + h' \geq w' \)
  \[
  h' \geq 0
  \]
  and limited liability \( d \geq 0 \)
Financing vs. Risk Management Trade-off

**Investment Euler equation**

\[
1 = \sum_{s' \in S} \Pi(s, s') \beta \frac{\mu'}{\mu} A' f_k(k) + (1 - \theta)(1 - \delta) \quad \geq \quad \Pi(s, s') \beta \frac{\mu'}{\mu} A' f_k(k) + (1 - \theta)(1 - \delta)
\]

- As \( w \to 0 \), capital \( k \to 0 \) and marginal product \( f_k(k) \to \infty \)
- Therefore, marginal value of net worth in state \( s' \) (relative to current period) \( \frac{\mu'}{\mu} \to 0 \)
- Using first order condition for hedging
  \[
  \lambda' / \mu = (\beta R)^{-1} - \frac{\mu'}{\mu} > 0
  \]
  so severely constrained firms do not hedge at all

**Financing risk management trade-off**

- Hedging uses up net worth which is better used to purchase additional capital
- IID case: If firms hedge, they hedge states with low net worth due to low cash flows
Why Was This Not Previously Recognized?

  - 5 reasons provided (beyond “transactions costs”)
    - (i) market power; (ii) serial correlation of profits; (iii) aggregate risk;
      (iv) asymmetric information; (v) incentives
  - Fact that hedging uses up net worth is not listed
    - That said, Holmström/Tirole (2000) come close

- No financing risk management trade-off in previous models
  - Models consider risk management using frictionless markets
    - Without imposing same frictions on financing and hedging, no trade-off
  - Models have no financing in first period where firms hedge
    - Without investment which requires financing, no trade-off

- Intuitive, but counterfactual, prediction: More constrained firms hedge more
  - Froot/Scharfstein/Stein (1993)

- In practice, more constrained (and smaller) firms hedge less!
Conclusions for Corporate Risk Management

- Rationale for **corporate risk management**
  - Financial constraints make firms as if risk averse

- Trade-off between financing and risk management
  - Promises to financiers and hedging counterparties need to be collateralized
  - Severely constrained firms hedge less or not at all
    - ... both in theory and in practice
  - Such firms may be more susceptible to downturns
(3) Leasing and Rental Markets

- Leasing has repossession advantage and permits greater borrowing
- Severely constrained firms (and households) lease
- Key papers: Rampini/Viswanathan (2013); Eisfeldt/Rampini (2009)
Financing Subject to Collateral Constraints

- Environment with collateral constraints but firms can lease
  - Three types of agents, owner/borrower, investor/lender, and lessor
  - Borrower is risk neutral, impatient $\beta < R^{-1}$, and subject to limited liability
  - Borrower has limited funds $w > 0$
  - Lender and lessor have deep pockets

- **Borrowing subject to collateral constraints**
  - Need to collateralize promises to pay with tangible assets (due to limited enforcement)
  - Promised repayment $\leq \theta \times$ resale value of tangible assets
Leasing as in Eisfeldt/Rampini and Rampini/Viswanathan

- **Leasing**: Borrower can rent capital

- **Repossession advantage**
  - Borrower cannot abscond with leased capital
  - In practice, repossession of rented capital easier than foreclosure on secured loan
  - Leasing allows borrower to borrow full resale value, not just fraction $\theta$

- **Monitoring cost** $m$ (per unit of capital)
  - Lessor needs to monitor to prevent abuse
  - Why? – Leasing separates ownership and control

- **User cost of leased capital** (assuming lessors, like lenders, discount at $R^{-1}$)
  $$w_l \equiv r + \delta + m$$
  needs to be paid in advance, i.e., at time 0
Firm's Problem with Leasing and Secured Lending

Firm's problem with leasing \((k_o \text{ owned capital}; k_l \text{ leased capital})\)

\[
\max_{\{d, w', k_o, k_l, b\}} \quad d + \beta v(w')
\]

subject to budget constraints and collateral constraint

\[
w + b \geq d + k_o + R^{-1} u_l k_l
\]

\[
Af(k_o + k_l) + k_o(1 - \delta) \geq Rb + w'
\]

\[
\theta k_o(1 - \delta) \geq Rb
\]

and non-negativity constraints \(k_o, k_l \geq 0\), as well as limited liability \(d \geq 0\)
First-order conditions (multipliers $\mu$, $\beta \mu'$, and $\beta \lambda$; let $k \equiv k_o + k_l$)

As before,

$$1 \leq \mu, \quad v_w(w') = \mu', \quad \mu = \beta \mu' R + \beta \lambda R$$

and almost as before (except inequality as borrower might not own any assets)

$$\mu \geq \beta \mu' [A f_k(k) + (1-\delta)] + \beta \lambda \theta (1-\delta) \quad \Leftrightarrow \quad u(w) \geq R \beta \mu^{-1} A f_k(k)$$

and finally new

$$R^{-1} u_l \mu \geq \beta \mu' A f_k(k) \quad \Leftrightarrow \quad u_l \geq R \beta \mu^{-1} A f_k(k)$$
Lease or Buy?

- Lease if $u_l < u(w)$ and buy otherwise ("choose capital with lower user cost")

- Recall:

  $$u_l = r + \delta + m$$

  monitoring cost

  and

  $$u(w) = r + \delta + \frac{\beta R \lambda}{\mu (1 - \theta) (1 - \delta)}$$

  premium on internal funds required
Leasing as Costly, Highly Collateralized Financing

- Incremental cash flows of buying vs. leasing

\[
\text{Time} \\
\text{Buying (secured loan)} & 0 & 1 - R^{-1} \theta (1 - \delta) & (1 - \theta) (1 - \delta) \\
\text{Leasing} & 1 - R^{-1} u_l & \phi - R^{-1} u_l & (1 - \theta) (1 - \delta) \\
\text{Diff buying - leasing} & = & = & \text{extra funds required up front} \\
& & & \text{extra amount recovered}
\]

- Implicit interest rate on additional amount borrowed when leasing

\[
R_l \equiv \frac{(1 - \theta) (1 - \delta)}{\phi - R^{-1} u_l} = R \frac{1}{1 - \frac{m}{(1 - \theta) (1 - \delta)}} > R
\]

- Leasing is costly financing since \( R_l > R \)
Lease or Buy?

- **Implicit “down payment” when leasing**

\[
R^{-1} u_l = 1 - R^{-1} \theta (1 - \delta) - R_l^{-1} (1 - \theta) (1 - \delta)
\]

- **Who leases?**
  - Severely constrained firms do!
  - As \( w \to 0, k \to 0 \) and \( f_k(k) \to +\infty \); hence, using FOC's, \( \mu'/\mu \to 0 \) and

\[
\beta R \lambda / \mu = 1 - \beta R \mu' / \mu \to 1 \quad \Rightarrow u(w) \to r + \delta + (1 - \theta)(1 - \delta)
\]

- Assuming \((1 - \theta)(1 - \delta) > m\), borrowers with sufficiently low \( w \) lease all their capital!
Conclusions for Leasing and Rental Markets

- Renting capital facilitates repossession
- Lessor is financier but retains ownership
- Leasing permits greater leverage which is beneficial for severely constrained firms