Financing Durable Assets

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Effect of Durability on Financing

- **Durability essential feature of capital**
  - Fixed assets comprise as much as 72% of aggregate capital stock
  - Includes structures (both residential and non-residential) infrastructure, equipment, and consumer durable goods
  - Focus on tangible durable assets but intangible assets similar

- **Variation in durability**
  - Depreciation rates vary from as low as 1% (new residential structures) to as high as 31% (computing equipment)

- **How does durability affect financing?**
  - Can durable assets serve as collateral and facilitate financing?
  - “Intuitively, as the assets become more durable, they provide the creditor with the security to wait longer before being repaid. ... And hence the debtor need not set aside as much of his initial borrowing to finance early debt repayments, leaving more to finance the initial investment” – Hart/Moore (1994)
To the contrary: **durable assets are harder to finance**

- Durability increases resale/collateral value allowing more borrowing
- But durability also raises price of asset and hence financing need
- Net effect: raises down payments

**Implications**

- Choice between **vintages**: new, durable vs. used, non-durable assets
  - Trade in used capital goods
- **Technology adoption**: dominated technologies may be adopted
- **Rent** vs. buy decision
- Also: effect of **legal enforcement**

**Critical distinction between durability and pledgeability**

- Durability impedes financing
- Pledgeability facilitates financing
- Hart/Moore (1994) is about pledgeability not durability
Model of Durable Asset Financing

- Discrete time, infinite horizon, deterministic productivity

- **Entrepreneurs** ("borrowers" or "firms")
  - Measure $\rho \in (0, 1)$ enter each period; survive with probability $1 - \rho$; measure 1 alive
  - Preferences: $\sum_{t=0}^{\infty} \beta^t d_t$ with $\beta \in (0, 1)$, $d_t \geq 0$, and $\beta \equiv \hat{\beta}(1 - \rho)$
  - Initial net worth $w_0$ (cash-in-hand)

- In equilibrium, well capitalized entrepreneurs are financiers
  - Equilibrium (gross) interest rate $R = \beta^{-1}$

- **Limited enforcement**
  - Borrowers can default and abscond with all cash flows and fraction $1 - \theta$ of assets without exclusion where $\theta \in [0, 1)$
    - Optimal dynamic contract can be implemented with one-period ahead debt subject to **collateral constraints**
Model of Durable Asset Financing (Cont’d)

Technology
- New assets last for two periods
- **New, durable assets** $k_d$ last two periods – price 1
- **Used, non-durable assets** $k_{nd}$ one period of useful life left – price $q$
- Perfect substitutes in production; output $Af(k_d + k_{nd})$ where $A$ is TFP and $f$ is (strictly) increasing, concave, and $\lim_{k \to 0} f_k(k) = +\infty$
Entrepreneur’s Problem – Recursive Formulation

- Given net worth $w$, entrepreneur solves

$$v(w) \equiv \max_{d,k_d,k_{nd},b,w' \in \mathbb{R}_+^3 \times \mathbb{R}^2} d + \beta v(w')$$  

subject to budget constraints for current and next period

$$w + b \geq d + k_d + qk_{nd}$$  

$$Af(k_d + k_{nd}) + qk_d \geq Rb + w'$$

and the collateral constraint

$$\theta qk_d \geq Rb$$

- Endogenous state variable: net worth $w$
Characterization of Entrepreneur’s Problem

- Well-behaved dynamic program
  - Return function concave; constraint set convex
  - Operator defined by (1) to (4) satisfies Blackwell’s sufficient conditions
  - Solution: $\exists!$ value function $v$; strictly increasing; concave

- First order conditions
  - Denote multipliers on (2) and (3) by $\mu$ and $\beta \mu'$ and on (4) by $\beta \lambda'$
    
    $$
    \begin{align*}
    \mu &= 1 + \nu \\
    \mu &= \beta \mu' [Af_k(k_d + k_{nd}) + q] + \beta \lambda' \theta q + \nu_d \\
    \mu q &= \beta \mu' Af_k(k_d + k_{nd}) + \nu_{nd} \\
    \mu &= \mu' + \lambda' \\
    \mu' &= v_w(w')
    \end{align*}
    $$

- Envelope condition: $v_w(w) = \mu$
  - Value function continuously differentiable
Down Payment

- When collateral constraint binds, \( b = R^{-1} \theta q k_d \) and so

\[
\phi \equiv 1 - R^{-1} \theta q
\]

is minimal **down payment** required per unit of new, durable assets

- In equilibrium,

  - **Down payment on new, durable assets exceeds used capital price**

    \[
    \phi > q \iff \frac{R}{\theta + R} > q
    \]

  - Otherwise new, durable assets would dominate (arbitrage)

- Why do new, durable assets require larger down payment?

  \[
  \phi = 1 - R^{-1} \theta q = 1 - R^{-1} q + \underbrace{R^{-1}(1 - \theta)q}_{\text{user cost } u_d} + \underbrace{R^{-1} \theta q}_{\text{non-pledgeable part of resale value}}
  \]

  - New, durable assets down payment includes \( 1 - \theta \) of resale value
## Durability and Financing Need

- Financing need of new, durable and used, non-durable assets

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- **New, durable assets require more internal funds** $\varphi > q$
  - ... despite ability to borrow $R^{-1}\theta q > 0$
  - ... because they cost more $1 > q \Rightarrow$ larger financing need
Frictionless user cost (rental rate) of capital $u^*$ would be

$$1 = u^* + R^{-1}u^* \quad \Rightarrow \quad u^* = \frac{R}{1 + R}$$

Equilibrium user costs with collateral constraints

- User cost of used, non-durable assets: $u_{nd} \equiv q$
- In equilibrium

$$q \geq u^* = \frac{R}{1 + R}$$

- User cost of new, durable assets (for unconstrained borrowers):

$$u_d \equiv 1 - R^{-1}q \leq 1 - R^{-1} \frac{R}{1 + R} = u^* \leq q = u_{nd}$$

User cost of new, durable assets less than that of used ones
Durability and Depreciation Rate

- In first period, new assets depreciate at *depreciation rate* $\delta_d \equiv \frac{1 - q}{1} \leq 1 - \frac{R}{1 + R} = \frac{1}{1 + R} < 50\%$

- ... and in second period (when used) at rate

  $\delta_{nd} \equiv \frac{q - 0}{q} = 100\%$
Dividend Paying Firm

- Once firm starts to pay dividends, it always pays dividends and is unconstrained
  - Marginal value of net worth $v_w(w) = \mu = 1$
  - Firm is unconstrained going forward $v_w(w') = \mu' = 1$ and $\lambda' = 0$

- If $q > \frac{R}{1+R}$, unconstrained firm purchases only new assets
  \[
  u_d = \beta A f_k(k_d + k_{nd}) + \nu_d \\
  u_{nd} = \beta A f_k(k_d + k_{nd}) + \nu_{nd}
  \]

- Unconstrained firms simply compare user costs
- Unconstrained firms sell assets once they are old/used

- Capital stock of unconstrained firm $\bar{k}_d$ solves
  \[
  1 = \beta[A f_k(k_d) + q]
  \]
Severely constrained firm purchases only used capital

As \( w \to 0 \) so does \( k_d + k_{nd} \) and hence \( f_k \to +\infty \)

Using Investment Euler equations

\[
1 \quad = \quad \beta \frac{\mu'}{\mu} A f_k (k_d + k_{nd}) + (1 - \theta)q + \frac{\nu_d}{\mu q} \\
1 \quad = \quad \beta \frac{\mu'}{\mu} A f_k (k_d + k_{nd}) + \frac{\nu_{nd}}{\mu q}
\]

and combining Euler equations \( \Rightarrow \nu_d > 0 \)

\[
\varphi - q \quad = \quad \beta \frac{\mu'}{\mu} (1 - \theta)q + \frac{\nu_d}{\mu} - \frac{\nu_{nd}}{\mu}
\]

Incr. cost of new capital \hspace{1cm} Valuation of resale value

Severely constrained firms simply compare down payments
Equilibrium

- **Marginal investor in used capital**
  - Indifferent between investing in new and used capital: \( \nu_d = \nu_{nd} = 0 \)
  - Investment Euler equations imply
    \[
    1 - R^{-1}\theta q - q = \beta \frac{\mu'}{\mu} (1 - \theta)q
    \]
    \[
    \text{Down payment } \varphi
    \]
    \[
    \text{Incr. cost of new capital} \quad \text{Valuation of resale value}
    \]

- **If constrained firm prices used assets, then** \( q > \frac{R}{1+R} \)
  - \( \beta \frac{\mu'}{\mu} < R^{-1} \) implies \( q > \frac{R}{1+R} \) (or \( u_d < u_{nd} \))
  - Moreover, \( \beta \frac{\mu'}{\mu} > 0 \) so \( \frac{R}{\theta + R} > q \) (or \( \varphi > q \))

- **Market clearing condition in used capital market**
  \[
  \sum p(w)(1 - \rho)k_d(w) = \sum p(w)k_{nd}(w)
  \]
  \[
  \text{supply of used assets} \quad \text{demand for used assets}
  \]
  \[
  \text{where } p(w) \text{ is stationary net worth distribution}
  \]
Trade

- **World market for used capital** (at price $q > \frac{R}{1+R}$)

- **Weak legal enforcement economies net used capital importers**
  - Strong vs. weak legal enforcement economies: $\theta_H > \theta_L$
  - Unconstrained firms investment identical: $1 = \beta [Af(\bar{k}_{d}) + q]$
  - Constrained firms indifferent between new and used assets when
    \[
    \frac{Af_k(\bar{k}) + (1 - \theta)q}{\theta q} = \frac{Af_k(k)}{q}
    \]
  - With weak legal enforcement, firms indifferent
    - when their capital stock is larger $\bar{k}_L > \bar{k}_H$
    - at higher level of net worth
  - More firms use used assets in weak legal enforcement economies
Suppose **neoclassical capital** depreciates at rate $\delta$ per period

$$k' = k(1 - \delta) + q^{-1}i$$

where $q$ is price of capital and $i$ investment

**Firm’s problem with neoclassical investment:** Given $w$, solve

$$v(w) \equiv \max_{d,k,b,w' \in \mathbb{R}_+^2 \times \mathbb{R}^2} d + \beta v(w')$$  \hspace{1cm} (5)$$

subject to budget constraints and collateral constraint

$$w + b \geq d + qk$$ \hspace{1cm} (6)$$

$$Af(k) + qk(1 - \delta) \geq Rb + w'$$ \hspace{1cm} (7)$$

$$\theta qk(1 - \delta) \geq Rb$$ \hspace{1cm} (8)$$
Characterization of Entrepreneur’s Problem

- Well-behaved dynamic program

- **First order conditions**
  - Denote multipliers on (6) and (7) by $\mu$ and $\beta \mu'$ and on (8) by $\beta \lambda'$

  \[
  \mu = 1 + \nu \\
  \mu q = \beta \mu' [Af_k(k) + q(1 - \delta)] + \beta \lambda' \theta q(1 - \delta) \\
  \mu' = \mu' + \lambda' \\
  \mu' = v_w(w')
  \]

- **Envelope condition:** $v_w(w) = \mu$
  - Value function continuously differentiable
Effect of Durability on Down Payment and User Cost

- **Effect of durability on down payment**
  - Minimal **down payment** per unit of capital
    \[ \varphi = q - R^{-1} \theta q (1 - \delta) \]
  - \[ \frac{\partial \varphi}{\partial \delta} = R^{-1} q \theta > 0; \text{ more durable capital has lower down payment?} \]
  - But keeping \( q \) fixed, lower \( \delta \) reduces frictionless user cost of capital!
    \[ u \equiv R^{-1} q (r + \delta) \]

- **More durable capital requires larger down payment**
  - Fixing frictionless user cost \( u^* \) instead, price is \( q(\delta) = \frac{R u^*}{r + \delta} \)
  - Down payment keeping user cost fixed
    \[ \varphi(\delta) = q(\delta) - R^{-1} \theta q(\delta) (1 - \delta) \]
    \[ \frac{\partial \varphi(\delta)}{\partial \delta} = -q(\delta) \frac{1 - \theta}{r + \delta} < 0 \]
Adopting Dominated Technologies

- Suppose **two types of neoclassical capital of different durability**
  - depreciation rates \( \delta_d < \delta_{nd} \)
  - prices \( q_d > q_{nd} \)
  such that
  - frictionless user costs \( u_d < u_{nd} \), i.e., \( (r + \delta_d)q_d < (r + \delta_{nd})q_{nd} \)
  - down payments \( \phi_d > \phi_{nd} \), i.e.,
    \[ q_d(1 - R^{-1}\theta(1 - \delta_d)) > q_{nd}(1 - R^{-1}\theta(1 - \delta_{nd})) \]
- **Firm’s problem with two types of capital:** Given \( w \), solve
  \[
v(w) \equiv \max_{d,k_j,b,w' \in \mathbb{R}_+^3 \times \mathbb{R}^2} d + \beta v(w')
  \]
  subject to budget constraints and collateral constraint
  \[
w + b \geq d + \sum_j q_j k_j
  \]
  \[Af \left( \sum_j k_j \right) + \sum_j q_j k_j (1 - \delta_j) \geq Rb + w'
  \]
  \[\theta \sum_j q_j k_j (1 - \delta_j) \geq Rb\]
Effect of Durability on Down Payment and User Cost

- **Down payment – decomposition**

\[
\phi(\delta) = u^* + R^{-1}q(\delta)(1 - \theta)(1 - \delta)
\]

- **Jorgensonian user cost**

- **non-pledgeable part of resale value**

- **User cost depends on firm’s discount factor**

\[
u(w)(\delta) = \phi(\delta) - \beta \frac{\mu'}{\mu} (1 - \theta)q(\delta)(1 - \delta) = u^* + \beta \frac{\lambda'}{\mu} \frac{R u^*}{r + \delta} (1 - \theta)(1 - \delta)
\]
Constrained Firms Adopt Dominated Technologies

- User cost of type $j$ capital (for possibly constrained borrower)

$$u_j(w) = u_j + \beta \frac{\lambda'}{\mu} q_j (1 - \theta)(1 - \delta_j)$$

- Unconstrained never use less durable “low quality” capital

  - Since $\lambda' = 0$, so $u_j(w) = u_j$
  - Unconstrained firms simply compare user costs

- Severely constrained adopt dominated technology

  - As $w \to 0$, $\frac{\lambda'}{\mu} \to 1$, so

$$u_j(w) = u_j + R^{-1} q_j (1 - \theta)(1 - \delta_j) = \phi_j$$

  - Severely constrained firms simply compare down payments
Two countries with strong and weak legal enforcement ($\theta_H > \theta_L$)

As before two types of capital with $\delta_d < \delta_{nd}$ and $q_d > q_{nd}$ such that $u_d < u_{nd}$ but $\varphi_d > \varphi_{nd}$

More dominated technology use with weak legal enforcement

Firm indifferent between two types of capital

$$
\frac{Af_k(\sum_j k_j) + (1 - \theta)q_d(1 - \delta_d)}{\varphi_d} = \frac{Af_k(\sum_j k_j) + (1 - \theta)q_{nd}(1 - \delta_{nd})}{\varphi_{nd}},
$$

Lower $\theta$ implies indifferent at higher investment $\bar{k} = \sum_j k_j$ and hence higher net worth
Durability and Composition of Investment

- Suppose **two types of capital are imperfect substitutes**
  - Aggregator for capital with constant elasticity of substitution (CES)
    \[ k \equiv \left( \sum_j \sigma_j k_j^\gamma \right)^{1/\gamma} \]
  - Type-\(j\) capital \(k_j, j \in \{d, nd\}\)
  - Substitution coeff. \(\gamma; -\infty < \gamma < 1\); elasticity of subst. \(1/(1 - \gamma)\)
  - Factor shares \(\sigma_j > 0, \forall j; \sum_j \sigma_j = 1\)

- **Firm’s problem with two types of capital:** Given \(w\), solve
  \[
  v(w) \equiv \max_{d, k_j, b, w' \in \mathbb{R}^3_+ \times \mathbb{R}^2} d + \beta v(w')
  \]
  subject to budget constraints and collateral constraint

  \[
  w + b \geq d + \sum_j q_j k_j \]

  \[
  Af\left(\left( \sum_j \sigma_j k_j^\gamma \right)^{1/\gamma} \right) + \sum_j q_j k_j (1 - \delta_j) \geq Rb + w'
  \]

  \[
  \theta \sum_j q_j k_j (1 - \delta_j) \geq Rb
  \]
Composition Determined by User Cost or Down Payments

- First order condition for type $j$ capital

\[ u_j(w) = \beta \frac{\mu'}{\mu} A f_k(k) \frac{\partial k}{\partial k_j} \]

and dividing condition for $nd$ by condition for $d$ yields

\[ \frac{u_{nd}(w)}{u_d(w)} = \left( \frac{k_d}{k_{nd}} \right)^{1-\gamma} \frac{\sigma_{nd}}{\sigma_d} \]

- **Composition of investment** determined by

  - ... *(frictionless)* user costs $u_j(w) = u_j$ for unconstrained firms
  - ... down payments $u_j(w) = \varphi_j$ for severely constrained firms

- **Legal enforcement affects investment composition**

  - Ratio of down payments $\varphi_{nd}/\varphi_d$ and hence $k_d/k_{nd}$ increasing in $\theta$
  - No effect on unconstrained firms
“We say that the assets become longer lived, or more durable, if [the liquidation value] \( L(t) \) rises for all \( 0 \leq t \leq T \).”

**Durability \( \approx \) liquidation value** (price and use value fixed)

Interpretation of their liquidation value \( L \) in our model

\[
L_k \equiv \theta q(\delta) k (1 - \delta)
\]

Effect of \( L \) is effect of pledgeability \( \theta \) in our model not durability
Renting Durable Assets

- **Renting/leasing**
  - Benefit: higher leverage due to repossession advantage
  - Cost: monitoring cost

- Two types of capital $k_j$ (different $\delta_j$) required (fixed proportions)

- Severely constrained firms rent both types of assets

- Moderately constrained rent only more durable assets
Literature

- Hart/Moore (1994)
  - See above

- Eisfeldt/Rampini (2007)
  - Used capital is cheaper but requires ex-post maintenance cost
  - Durability plays no role

- Empirical evidence on used capital
  - Legal enforcement: Benmelech/Bergman (2011)
Literature: Durable Goods Theory

- **Optimal durability and planned obsolescence**
  - Conventional wisdom: monopolists produce less durable goods
  - Resuscitated: Barro (1972): impatience; Rust (1986): scrappage

- **Role of rental markets**
  - Coase (1972), Bulow (1982), Stokey (1981): Coasian dynamics
  - Hendel/Lizzeri (2002): leasing ameliorates adverse selection

- **Key driving force: market power**
  - Our theory: optimal competitive response to financial constraints
Conclusion

- **Durable assets are harder to finance**
  - Durability raises financing need and required down payments

- **Financial constraints especially salient for durable assets**
  - Structures (residential and non-residential) and infrastructure
  - Equipment, especially aircraft and ships
  - Consumer durables, especially motor vehicles and household durables
  - Similarly, durable intangible capital ($\theta = 0$), e.g., organization capital

- Constrained firms (and **households**) buy used assets, adopt dominated technologies, and rent durable assets

- Weak **legal enforcement** economies invest in dominated technologies and import used assets

- **Distinguish durability** $1 - \delta$ from **pledgeability** $\theta$
User Cost of New Capital for Financially Constrained Firm

- **User cost of durable assets depends on firm’s discount factor**

\[
ud(w) = \varphi - \beta \frac{\mu'}{\mu} (1 - \theta)q \\
= ud + \beta \frac{\mu'}{\mu} (1 - \theta)q
\]

- **User cost of new, durable assets for severely constrained firm**

  - As \(w \to 0\), \(\frac{\mu'}{\mu} \to 1\) so
  
  \[
  ud(w) \to \varphi
  \]
  
  - Severely constrained firms simply compare down payments
Effect of Durability on Down Payment and User Cost

- **Down payment** – decomposition

\[ \phi(\delta) = u^* + R^{-1}q(\delta)(1 - \theta)(1 - \delta) \]

- Jorgensonian user cost

- Non-pledgeable part of resale value

- **User cost depends on firm’s discount factor**

\[ u(w)(\delta) = \phi(\delta) - \beta \frac{\mu'}{\mu} (1 - \theta)q(\delta)(1 - \delta) = u^* + \frac{\lambda'}{\mu} \frac{u^*}{r + \delta} (1 - \theta)(1 - \delta) \]

- **Durable capital user cost sensitive to financial constraints**

- \( \frac{\partial u(w)(\delta)}{\partial \delta} = -q(\delta) \frac{\lambda'}{\mu} \frac{1 - \theta}{r + \delta} < 0 \)

- \( u(w)(1) = u^* \) independent of \( w \) (also if \( \theta = 1 \) but we assume \( \theta < 1 \))
Renting Durable Assets

- **Capital goods with different durability**
  - Capital $k_j, j = \{d, nd\}$, with depreciation rate $\delta_d < \delta_{nd}$ and price $q_j$
  - Leontief aggregator $k = \min\left\{\frac{k_d + k_{ld}}{\sigma_d}, \frac{k_{nd} + k_{ld}}{\sigma_{nd}}\right\}$
    - Implies $k_j + k_{lj} = \sigma_j k$ where $k$ is aggregate capital
  - Rental price $u_{lj} = R^{-1} q_j (r + \delta_j + m)$ where $m$ is monitoring cost
  - Firm cannot abscond with rented capital (repossession advantage)

- **Entrepreneur’s problem with rentals:** Given $w$, solve

  $$v(w) \equiv \max_{d, k_j, k_{lj}, b, w' \in \mathbb{R}_+^5 \times \mathbb{R}^2} d + \beta v(w')$$  (9)

  subject to budget, collateral, and technological constraints

  $$w + b \geq d + \sum_j q_j k_j + \sum_j u_{lj} k_{lj}$$  (10)

  $$Af(k) + \sum_j q_j k_j (1 - \delta_j) \geq Rb + w'$$  (11)

  $$\theta \sum_j q_j k_j (1 - \delta_j) \geq Rb$$  (12)

  $$k_j + k_{lj} \geq \sigma_j k$$  (13)
Renting Durable Assets (Cont’d)

- First order conditions with multipliers as before and $\beta \mu' \eta_j$ on (13)

\[
\begin{align*}
\sum_j \sigma_j \eta_j &= Af_k(k) \\
\mu q_j &= \beta \mu' \eta_j + \beta \mu' q_j (1-\delta_j) + \beta \lambda' \theta q_j (1-\delta_j) + \nu_j \\
\mu u^l_j &= \beta \mu' \eta_j + \nu^l_j
\end{align*}
\]

- Investment Euler equation (IEE)

\[
1 = \beta \frac{\mu' \eta_j + (1-\theta) q_j (1-\delta_j)}{\mu q_j} + \frac{\nu_j}{\mu q_j}
\]

- More constrained firms rent less durable assets

  - Suppose rent and own some type $j$ capital, so $\nu_j = \nu^l_j = 0$ and IEE

\[
\frac{\lambda'}{\mu} (1-\theta)(1-\delta_j) = m
\]

  - If $\delta_j$ higher, so multiplier on collateral constraint $\frac{\lambda'}{\mu}$ higher

Back to "Financing Durable Assets"
Literature: Durable Goods Theory

- **Optimal durability and planned obsolescence**
  - Conventional wisdom: monopolists produce less durable goods
  - Resuscitated: Barro (1972): impatience; Rust (1986): scrappage

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- **Key driving force: market power**
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- **Other features**
  - Adverse selection
  - Illiquidity