Spillovers, Investment Incentives and the Property Rights Theory of the Firm

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1 Previous Studies


- *Incomplete Contract: observable but not verifiable* ⇒ some aspects of the uses of nonhuman assets are not specified i.e. production process

- *Importance of Ownership of physical or non-human assets* ⇒ ownership is a source of power when contract is incomplete

→ owner of assets has right to decide the usage of asset (residual control rights)

(i.e.) Contract about the supply of intermediate good between final good producer and intermediate good producer: the divisions of surplus depends on ownership, or bargaining and threat power
• Relationship between asset ownership and investment

◊ Asset ownership:
  → Residual control rights ⇒ a greater fraction of *ex post* surplus
  → More investment incentives

◊ Non-ownership:
  → Fewer residual control rights ⇒ smaller fraction of *ex post* surplus
  → Less investment incentives

Chiu [1998], de Meza & Lockwood [1998]
• Nash Bargaining solution under the non-cooperative alternating-offer game depends on if payoff (utilities) from disagreement is considered as *inside option* or *outside option*
• With outside option, there might be some occasion that ownership demotivate
Problem

邵loover: the impact of an agent’s investment on the individual revenue of the other agent

- In many real cases, spillover exists (Example: a scientist makes a discovery but the company owns the patent)

=> Extend the model from the previous studies by considering the spillover
2 Model: Widget Model (Hart [1995])

2.1 Basic Setup

▷ two managers \{M1, M2\}, asset, \(a_i\) (machines), investment, \(e_i\), where \(i = 1, 2\)
  → M1 (resp. M2) produces final good (widget) with \(a_1\) \((a_2)\)
  → \(e_i\) is the money or time spent

▷ uncertainty: type of widget M1 required

▷ risk-neutral and unlimited wealth

▷ spillover: \(\lambda_i\) is the fraction of \(i\)'s investment that is embodies in the machine \(a_j\)

Possible Situations

(i) Team Production (firms can access both assets): managers trade "specialized" widget

\[
\begin{align*}
\text{M1: } & R(e_1) - P^* \\
\text{M2: } & P^* - C(e_2)
\end{align*}
\]

⇒ total surplus is \(\Pi = R - C\)
(ii) **Individual Production**: two managers do not agree to trade

- Based on the property rights theory, $\pi^i = \pi^i(e_1, e_2, a_i)$
- Leading Ownership Structure
  
  - Non-integration: M1 owns $a_1$ and M2 owns $a_2$
  - Type 1 integration: M1 owns both
  - Type 2 integration: M2 owns both

- Under no team production, if M1 owns both assets, M1 has three options
  1) Buy standard widget at price $p$
  2) produce standard widget
  3) produce specialized widget with $a_2$

Revenues: $r(e_1), \tilde{r}(e_1)$, Cost: $c(\lambda_2 e_2), \tilde{c}(\lambda_2 e_2)$

**Assumptions**

- If M1 owns both assets, it prefers to produce specialized widget no matter what the investment level is
- If M1 has only $a_1$, M1 buys a standard widget
- If M1 has no asset, M1 produces nothing
- $r(e_1) > \tilde{r}(e_1)$ and $c(\lambda_2 e_2) > \tilde{c}(\lambda_2 e_2)$
- $\tilde{r}(0) > p > \tilde{c}(0)$
M1’s Profit
\[
\begin{align*}
\pi^1(e_1, e_2; a_1, a_2) &= r(e_1) - c(\lambda_2 e_2) \\
\pi^1(e_1, e_2; a_1) &= \tilde{r}(e_1) - p \\
\pi^1(e_1, e_2; \phi) &= 0
\end{align*}
\]

M2’s Profit
\[
\begin{align*}
\pi^2(e_1, e_2; a_1, a_2) &= r(\lambda_1 e_1) - c(e_2) \\
\pi^2(e_1, e_2; a_1) &= p - \tilde{c}(e_2) \\
\pi^2(e_1, e_2; \phi) &= 0
\end{align*}
\]

Spillover: as long as $\lambda_1, \lambda_2 > 0$, spillover exist
\[
\begin{align*}
\frac{\partial \pi^1(e_1, e_2; a_1, a_2)}{\partial e_2} &= -\lambda_2 c'(\lambda_2 e_2) > 0 \\
\frac{\partial \pi^2(e_1, e_2; a_1, a_2)}{\partial e_1} &= \lambda_1 r'(\lambda_1 e_1) > 0
\end{align*}
\]

* However, with non-integration, there is no spillover $\Rightarrow$ spillovers are determined endogenously by the structure of asset ownership
Key Assumptions:

**Assumption 1** Gains from Trade: $\Pi(e_1, e_2) > \pi^1 + \pi^2$ or $R(e) - C(e) > r(e) - c(e)$

**Assumption 2** Marginal Return to Investment:

$$\frac{\partial \Pi(e_1, e_2)}{\partial e_i} > \frac{\partial \pi^i(e_1, e_2; a_1, a_2)}{\partial e_i} \geq \frac{\partial \pi^i(e_1, e_2; a_i)}{\partial e_i} \geq \frac{\partial \pi^i(e_1, e_2; \phi)}{\partial e_i}$$

**Lemma 1** *The payoff to individual production $\pi^i$ is non-decreasing in the number of assets owned by $M_i$*

**The order of events**

1. the non-contractible investments are made
2. agents bargain over the revenue from team production
3. production and consumption take place

$\Rightarrow$ Solve the model backwards to locate the subgame perfect equilibrium
2.2 Bargaining

**Inside options**: each individual engages in its production while bargaining
→ Net surplus is equally divided
→ Equilibrium payoff:
\[
v^1(e_1, e_2) = \pi^1 + \frac{1}{2} \left[ \Pi - \pi^1 - \pi^2 \right]
\]
\[
v^2(e_1, e_2) = \pi^2 + \frac{1}{2} \left[ \Pi - \pi^1 - \pi^2 \right]
\]

**Outside options**: agents cannot engage in individual production while bargaining
two cases
• i's outside option is *binding* if:
\[
\frac{\Pi(e_1, e_2)}{2} < \pi^i(e_1, e_2, \alpha_i)
\]
→ Equilibrium payoff
\[
w^i(e_1, e_2) = \pi^i
\]
\[
w^j(e_1, e_2) = \Pi - \pi^i
\]
3 Results on Investment and Asset Ownership

3.1 Inside-option case

At date 0, M1 and M2 choose $e_1$ and $e_2$, respectively to maximize their payoff

$\Rightarrow$ M1: $\max v^1 (e_1, e_2) - e_1$, M2: $\max v^2 (e_1, e_2) - e_2$

**First order condition**

\[
\begin{align*}
\text{M1:} & \quad \frac{\partial v^1(e_1, e_2, a_1, a_2)}{\partial e_1} : \frac{1}{2}r'(e_1) + \frac{1}{2}R'(e_1) = 1 \\
& \quad \frac{\partial v^1(e_1, e_2, a_1)}{\partial e_1} : \frac{1}{2}r''(e_1) + \frac{1}{2}R'(e_1) = 1 \\
& \quad \frac{\partial v^1(e_1, e_2)}{\partial e_1} : \frac{1}{2}R'(e_1) - \frac{\lambda_1}{2}r'(\lambda_1 e_1) = 1 \\
\text{M2:} & \quad \frac{\partial v^2(e_1, e_2, a_1, a_2)}{\partial e_2} : -\frac{1}{2}c'(e_2) - \frac{1}{2}C'(e_2) = 1 \\
& \quad \frac{\partial v^2(e_1, e_2, a_1)}{\partial e_2} : -\frac{1}{2}c'(e_2) - \frac{1}{2}C'(e_2) = 1 \\
& \quad \frac{\partial v^2(e_1, e_2, a_1, a_2)}{\partial e_2} : -\frac{1}{2}C'(e_2) - \frac{\lambda_2}{2}c'(\lambda_2 e_2) = 1
\end{align*}
\]

**Proposition 1** With inside options, M1’s (resp. M2’s) investment $e_1^*$ (resp. $e_2^*$) is (weakly) increasing in the number of assets he owns, even when spillovers are present. Moreover, the larger the spillovers $\lambda_i$, the lower is investment by the non-owner under integrated ownership.
3.2 Outside-option case

payoffs:
\[ M1: w^1(e_1, e_2) - e_1 \]
\[ M2: w^2(e_1, e_2) - e_2 \]

Note:
- there is strategic interaction at the investment stage: 
  \[ e_i = B_i(e_j) \]
- assume there is a unique pure strategy Nash equilibrium

Assumption 3 For either manager, there exists an asset allocation such that his outside option is binding in equilibrium. That is, it rules out a case where neither manager’s outside option ever binds

Proposition 2 Suppose Assumption 1-3 hold and there are no spillovers \((\lambda_1, \lambda_2 = 0)\). With outside options, the investment of either manager is strictly higher when he has no assets than when he has two assets, and weakly higher when he owns no assets rather than one.
Proposition 3 Suppose Assumptions 1-3 hold and that the return to investment in individual production is relatively high \( r'(e) > 0.5R'(e), \) \(-c'(e) > -0.5C''(e),\) all \( e).\) Then, with outside options, when spillovers are sufficiently strong \((1 > \lambda_1, \lambda_2 > \lambda_0, \text{for some } \lambda_0 < 1),\) the investment of either manager is strictly increasing in the number of assets owned, except in the special case where manager \( i \) already owns \( a_i \) and is given \( a_j \) and initially, \( j \)'s outside option is binding. In this case, manager \( i \)'s investment falls
4 Conclusions

1. The result from Grossman & Hart, and Hart & Moore is robust
2. The result from Chiu, and de Meza & Lockwood (the demotivating effect of ownership), relies on the assumption that a manager’s outside option only depends on it’s own investments

⇒ the conclusion of the earlier property rights literature (namely, asset ownership motivates) can be restored

Implications: even with outside options, it may be appropriate to give ownership to the party whose investment most influences team surplus