Knowledge Transfer and Partial Equity Ownership

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Introduction

- Strategic alliances are often accompanied by partial equity ownership (PEO) in many cases (equity strategic alliances).
  - 2000: Vodafone 15% stake in Japan Telecom; benefit from Vodafone's global leadership in mobile communications, access to worldwide technology, content and expertise
  - 2004: Harvey World Travel 11% holding in Webjet; strategic development partner which would enhance Webjet's ability to capitalize on opportunities in rapidly changing travel market in Australian region
  - 2010: Groupe Aeroplan Inc (AIMIA since 2011) 20% stake in Club Premier (AeroMexico's frequent flyer program); benefit from Aeroplan's knowhow and develop the necessary skill sets critical to its successful transformation into profitable coalition program

Introduction (cont.)

- One objective of strategic alliances: Knowledge transfer.
- Licensing and contracting play important roles in transferring explicit or codified knowledge which is transmittable in formal, systematic language
- Equity ownership can play a critical role in facilitating the transfer of tacit knowledge.
  - Mowery, Oxley and Silverman (1996).
  - Gomes-Casseres, Hagedoorn and Jaffe (2006)

Introduction (cont.)

- Partial equity ownership induces transfer of knowledge between alliance partners.
- This paper explores oligopoly models that capture this important link.

Storyline

- Consider an industry consisting of $n+2$ firms, where firm 1 has superior knowledge. The knowledge is not contractible.
- Firms 1 and 2 have an option of forming an equity strategic alliance in which firm 1 owns a fraction $\theta \in [0,1]$ of firm 2's share, while other n firms are assumed to be independent.
- The equilibrium level of PEO, θ^*, is endogenously determined.
  - $\theta^* = 1 \Rightarrow$ Merger
  - $\theta^* \in (0, \frac{1}{2}] \Rightarrow$ Partial equity ownership (PEO)
  - $\theta^* = 0 \Rightarrow$ Independent/status quo

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  - $\theta^* = 0 \Rightarrow$ Independent/status quo
- **Q1**: Can PEO arise as an equilibrium outcome? [YES]
- **Q2**: Can endogenously determined PEO improve welfare? [YES]

Relationship to the literature

- Homogenous product Cournot oligopoly models with n firms and constant MC.
- *Exogenously* given levels of PEO: v_{ik}.
- Symmetric costs (Reynolds and Snapp, 1986)
  - PEO $\uparrow \Rightarrow$ Output $\downarrow \Rightarrow$ Consumer Surplus $\downarrow$, Welfare $\downarrow$
  - PEO involving two firms is never profitable
- Asymmetric costs (Farrell and Shapiro, 1990)
  - PEO involving two firms can be profitable only if a high-cost firm has PEO in a low-cost firm.

Relationship to the literature (cont.)

How does PEO affect the firms' ability to engage in tacit collusion?

- Malueg (1992).
- Gilo, Moshe and Spiegel (2006).

Relationship to the literature (cont.)

Several papers hinted at the link between PEO and knowledge transfer (Reynolds and Snapp, 1986; Reitman, 1994).

$\Rightarrow$ How?
$\Rightarrow$ Why form PEO and why not merge?
$\Rightarrow$ Are PEO (when endogenously determined) welfare improving?

Model

- An industry with $n+2$ firms.
- Inverse demand $P(Q)$ satisfying $P'(Q) < 0$ and $P'(Q) + QP''(Q) < 0$
- Firms 1 and 2 can form an equity strategic alliance, and firm 1 can transfer its knowledge to firm 2.
- Constant marginal costs:
  - $c_1 = c - x$
  - $c_3 = ... = c_{n+2} = c$
  - $c_2 = c - kx$ where $c > x > 0$ and $k = 1$ if there is knowledge transfer and $k = 0$ otherwise

Timing

Stage 1 [Alliance formation]:
Firms 1 and 2 jointly choose the level of firm 1's ownership in firm 2's equity, denoted θ ($\in [0,1]$), and the monetary terms of the equity transfer ($\Rightarrow$ common knowledge).

Stage 2 [Knowledge transfer]:
Firm 1 determines whether or not to transfer its knowledge to firm 2 ($\Rightarrow$ common knowledge); $k = 0$ or 1.

Stage 3 [Product market competition]:
If $\theta \in [0, \frac{1}{2}]$, each firm i chooses q_i.
If $\theta \in (\frac{1}{2}, 1]$, firm 1 chooses q_1 and q_2 and firm m $(= 3, ..., n+2)$ chooses q_m.

Stage 3: Product market competition

Define

$$\begin{aligned}\tilde{\pi}_1 &= [P(Q) - (c - x)]q_1 \\ \tilde{\pi}_2 &= [P(Q) - (c - kx)]q_2\end{aligned}$$

Profits of firms 1, 2 and $m(= 3, ..., n + 2)$ respectively are:

$$\begin{aligned}\pi_1 &= \tilde{\pi}_1 + \theta\tilde{\pi}_2 \\ &= [P(Q) - (c - x)]q_1 + \theta[P(Q) - (c - kx)]q_2, \\ \pi_2 &= (1 - \theta)\tilde{\pi}_2 = (1 - \theta)[P(Q) - (c - kx)]q_2, \\ \pi_m &= [P(Q) - c]q_m.\end{aligned}$$

Stage 3: Product market competition

Equilibrium quantities when $\theta \in [0, \frac{1}{2}]$:

$$\begin{aligned} q_1^*(\theta, k) &= -\frac{(1-\theta)(P(Q^*) - (c-x)) + \theta(1-k)x}{P'(Q^*)}, \\ q_2^*(\theta, k) &= -\frac{P(Q^*) - (c-kx)}{P'(Q^*)}, \\ q_m^*(\theta, k) &= -\frac{P(Q^*) - c}{P'(Q^*)}, \end{aligned}$$

where $m = 3, ..., n+2$, and Q^* is implicitly given by the following equation:

$$(n+2-\theta)(P(Q^*) - c) + x(1 + (1-\theta)k) + Q^* P'(Q^*) = 0.$$

Stage 3: Product market competition

Equilibrium quantities when $\theta \in (\frac{1}{2}, 1]$.

$$\begin{aligned} q_1^*(\theta, k) &= -\frac{P(Q^*) - (c - x)}{P'(Q^*)}, \\ q_2^*(\theta, k) &= 0, \\ q_m^*(\theta, k) &= -\frac{P(Q^*) - c}{P'(Q^*)}, \end{aligned}$$

where $m = 3, ..., n + 2$, and Q^* is implicitly given by the following equation:

$$(n + 2)(P(Q^*) - c) + x + Q^* P'(Q^*) = 0.$$

Joint profit decreasing in θ

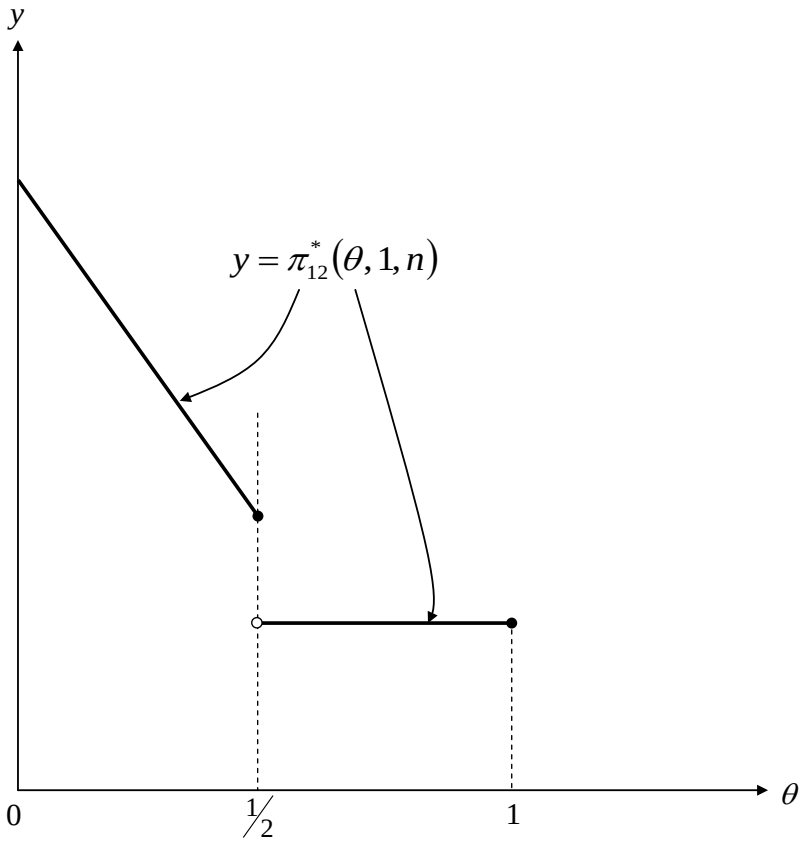
- $\pi_i^*(\theta, k)$: each firm i's profit in stage 3 equilibrium
- $\pi_{12}^*(\theta, k) \equiv \pi_1^*(\theta, k) + \pi_2^*(\theta, k)$: joint profit of firms 1 and 2 in stage 3 equilibrium.

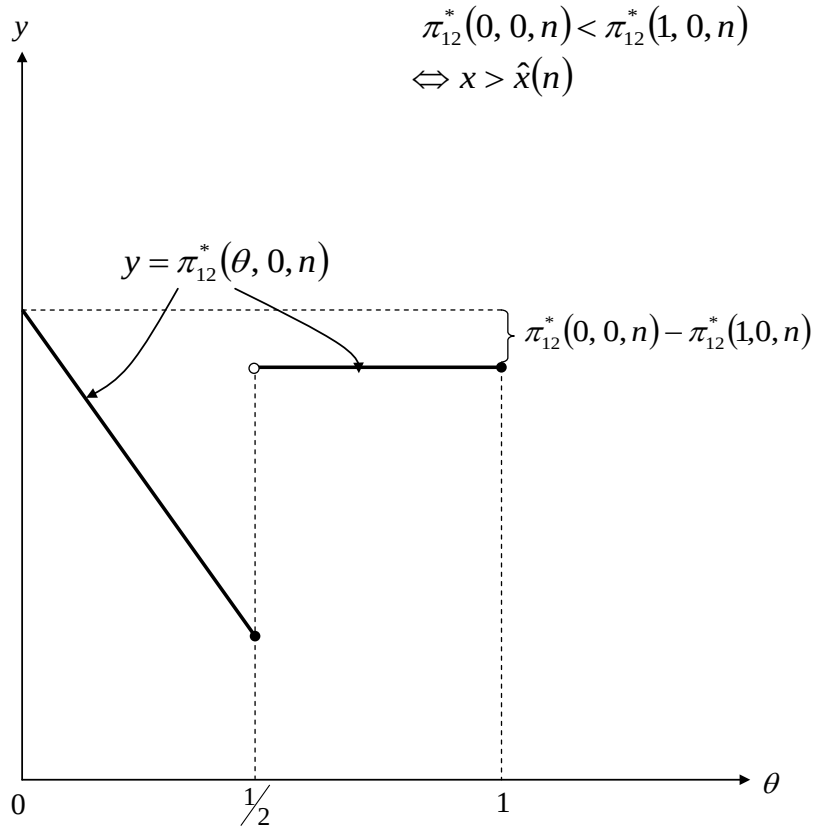
Lemma 1: Suppose that

(i) there are at least two firms outside the alliance, or
(ii) there is one firm outside the alliance and inverse demand is concave (i.e., $P''(Q) \leq 0$)

Then, joint profits of firm 1 and 2, $\pi_{12}^*(\theta, k)$ is strictly decreasing in θ for all $\theta \in [0, \frac{1}{2}]$.

Joint profit decreasing in θ





Stage 2: Knowledge transfer decision

- Let $\theta \in [0, \frac{1}{2}]$ be given.
- Firm 1 transfers knowledge to firm 2 $\Leftrightarrow \pi_1^*(\theta, 1) > \pi_1^*(\theta, 0)$:
- When does this condition hold? $\Rightarrow$ Proposition 1.

Minimum PEO for knowledge transfer: $\hat{\theta}(x, n)$

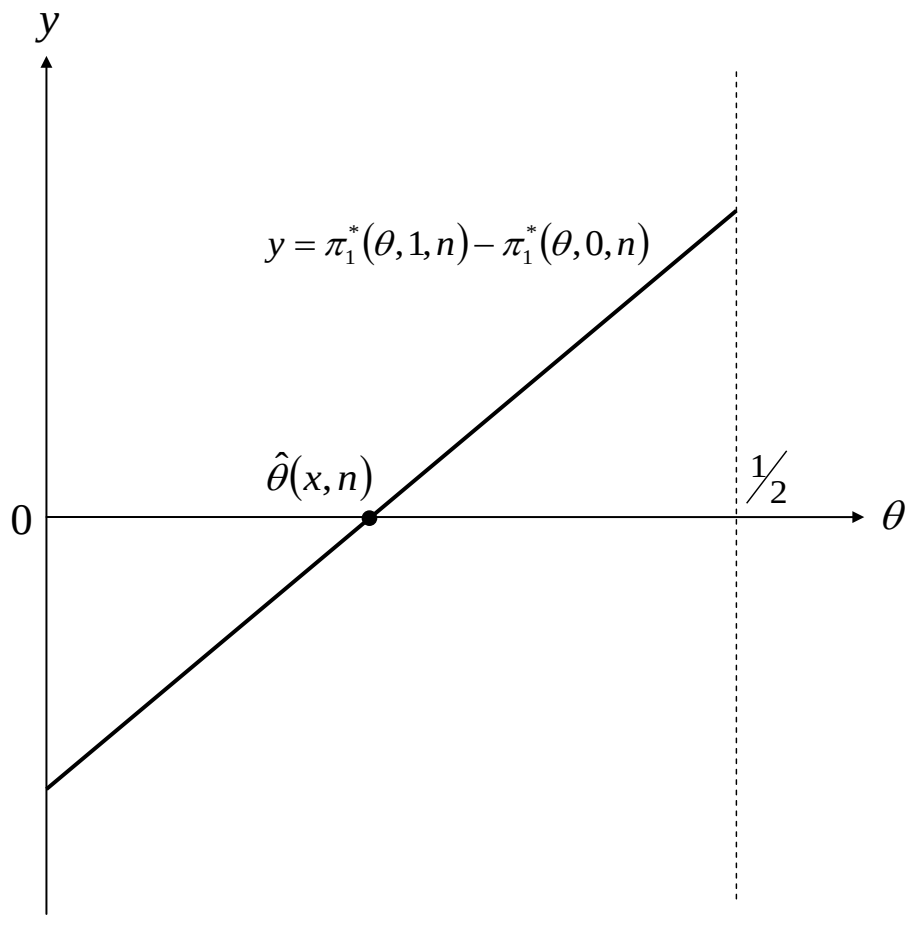
Proposition 1 [Knowledge transfer]: Suppose $\theta \in [0, \frac{1}{2}]$. There exists a threshold $x_{max} > 0$ with the following property: For any given $x < x_{max}$, there exists $\tilde{\theta}(x) \in (0, \frac{1}{2}]$ and $\bar{\epsilon} > 0$ such that

$$\pi_1^*(\tilde{\theta}(x)-\epsilon, 1)-\pi_1^*(\tilde{\theta}(x)-\epsilon, 0) \leq 0 \leq \pi_1^*(\tilde{\theta}(x)+\epsilon, 1)-\pi_1^*(\tilde{\theta}(x)+\epsilon, 0)$$

holds for all $\epsilon \in [0, \bar{\epsilon})$ and the equality holds if and only if $\epsilon = 0$.

Definition: Define $\hat{\theta}(x, n)$ the lowest value of $\tilde{\theta}(x, n)$ satisfying the inequality as the *minimum PEO for knowledge transfer*,

Figure 2: Minimum PEO for linear demand

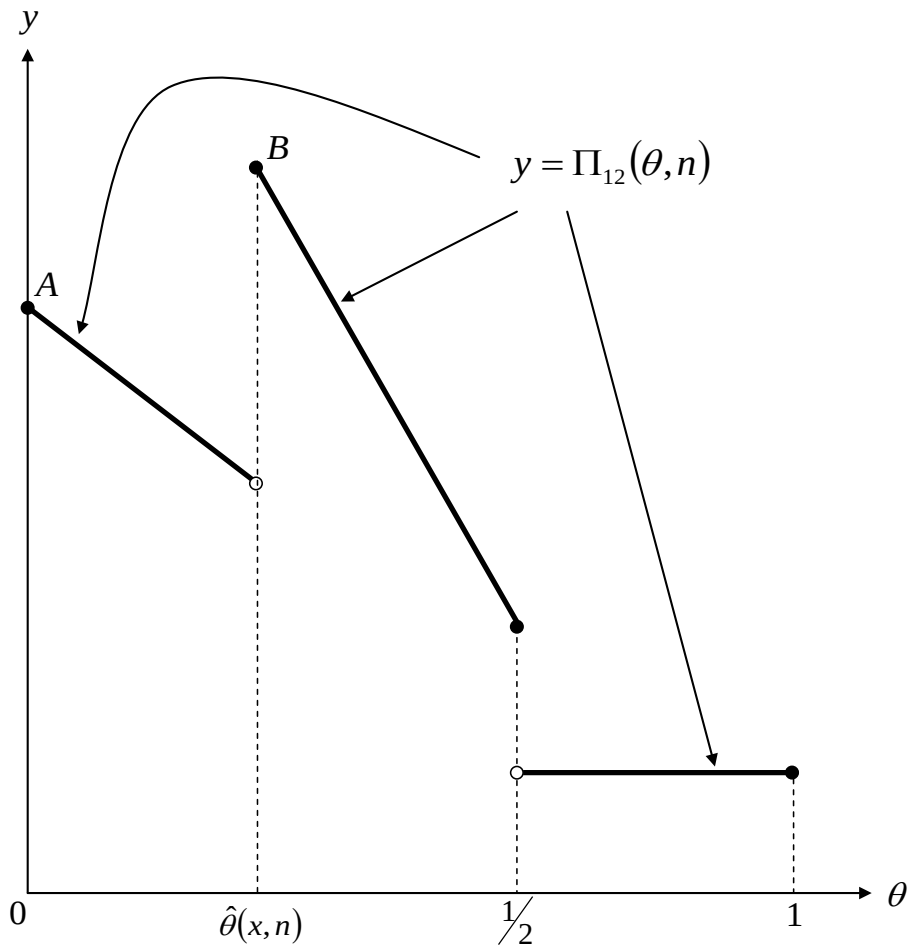


y: Firm 1's incremental profit by transferring its knowledge.

Stage 1: Choice of θ

- At Stage 1, firms 1 and 2 jointly choose θ to maximize their joint profit in the subsequent equilibrium.
- Let $\Pi_{12}(\theta)$ denote the joint profit of firms 1 and 2 in the equilibrium of stage 2 subgame.

Figure 3: Possible candidates for optimal θ



Equilibrium characterization for linear demand

There exists $x_{min} \in (0, x_{max})$ such that

(i) $0 < x \leq x_{min}$
$\Rightarrow \theta = \theta^*(x) \equiv 0$, no knowledge transfer.

(ii) $x_{min} < x \leq x_{max}$
$\Rightarrow \theta = \theta^*(x) \equiv \hat{\theta}(x)$, knowledge transfer.

(iii) $x_{max} < x < \bar{x}$
$\Rightarrow \theta = \theta^*(x) \equiv 1$ (merger).

PEO effect vs Knowledge transfer effect

- PEO itself implies joint profit $\downarrow$
- Knowledge transfer induced by PEO leads to ioint profit $\uparrow$
- For intermediate values of x knowledge transfer effect dominate and PEO is profitable

PEO as an equilibrium outcome

- $\hat{\theta} = \frac{\tilde{\pi}_1(c-x,c)-\tilde{\pi}_1(c-x,c-x)}{\tilde{\pi}_2(c-x,c-x)-\tilde{\pi}_2(c-x,c)}$

PEO as an equilibrium outcome

- $\hat{\theta} = \frac{\tilde{\pi}_1(c-x,c)-\tilde{\pi}_1(c-x,c-x)}{\tilde{\pi}_2(c-x,c-x)-\tilde{\pi}_2(c-x,c)}$
- $\lim_{x\to 0} \hat{\theta}(x) > 0$.
  For small x, adverse PEO effect dominates and hence firms prefer to stay independent.
- $\lim_{x\to \bar{x}} \hat{\theta}(x) > 1$;
  For large x, no θ high enough to induce PEO; merger is profitable.
- Thus, PEO, if profitable must be for intermediate values of x.

PEO as an equilibrium outcome

Proposition 2

Let $\theta^*(x)$ denote the equilibrium level of PEO. There exists a range of parameter values for x, denoted X, with the following property: For any given $x \in X$, there exists a value $n(x)$ such that firms 1 and 2 choose $\theta = \theta^*(x) = \hat{\theta}(x) \in (0, \frac{1}{2}]$ if $n \geq n(x)$.

Note: Proof relies on $\lim_{x \to 0, n \to \infty} \hat{\theta}(x) = 0$.

Welfare improving PEO

Proposition 3

There exists $X_W \subset X$, with the following property: For any given $x \in X_W$, there exists a value $n_W(x)(\geq n(x))$ such that $\theta^*(x,n) = \hat{\theta}(x,n)$ and $TS(\theta^*(x,n),n) > TS(0,n)$ if $n \geq n_W(x)$.

Linear demand: PEO can increase consumer surplus

- Compare CS at $\theta = \theta^*$ (> 0) and $\theta = 0$.
- PEO $\Rightarrow$ Weaker competition $\Rightarrow$ $CS \downarrow$.
- PEO induces knowledge transfer $\Rightarrow$ Reduce costs $\Rightarrow$ $CS \uparrow$.
- The latter effect dominates the former when x is in an intermediate range.

Linear demand: PEO can increase consumer surplus (cont.)

Proposition 3L [Consumer surplus]:
(A) If $n = 1$, PEO reduces CS for all x.

(B) Suppose $n \geq 2$.
(i) PEO reduces CS if x is small.
(ii) **PEO increases CS if x is in an intermediate range.**
(iii) If x is large, firms 1 and 2 merge, and the merger reduces CS.

Linear demand: PEO is more likely to increase CS as $n \uparrow$

- The "intermediate range" gets larger as $n \uparrow$.
  That is, PEO is more likely to increase CS as $n \uparrow$.
- Why? The minimum PEO $\hat{\theta}(x, n)$ decreases as $n \uparrow$.
- $\Rightarrow$ Holding x fixed, knowledge transfer can be induced at a lower PEO as $n \uparrow$.

Linear demand: PEO and total surplus

Proposition 4L [Total surplus]:

(A) Suppose $n = 1$.
(i) PEO reduces TS if x is small.
(ii) **PEO increases TS if x is in an intermediate range.**
(iii) If x is large, firms 1 and 2 merge, and,

- the merger reduces TS if x is not very large,
- the merger increases TS if x is very large.

(B) **If $n \geq 2$, PEO increases TS for all x.**

Implications for competition policy

- Consider an antitrust/competition authority whose objective is to maximize total surplus (or consumer surplus).
- At Stage 0, the authority can announce a maximum permissible level of PEO, denoted $\tilde{\theta} \in [0, 1]$.
- The authority announces $\tilde{\theta}$ only if it is necessary.

Implications (cont.)

- Firms 1 and 2 choose the minimum PEO $\hat{\theta}(x, n)$ whenever they intend to induce knowledge transfer.
- Both TS and CS are decreasing in the degree of PEO, θ, holding everything else constant.
- $\Rightarrow$ Competition authority's relevant option:
  Impose no restrictions on PEO or prohibit PEO.

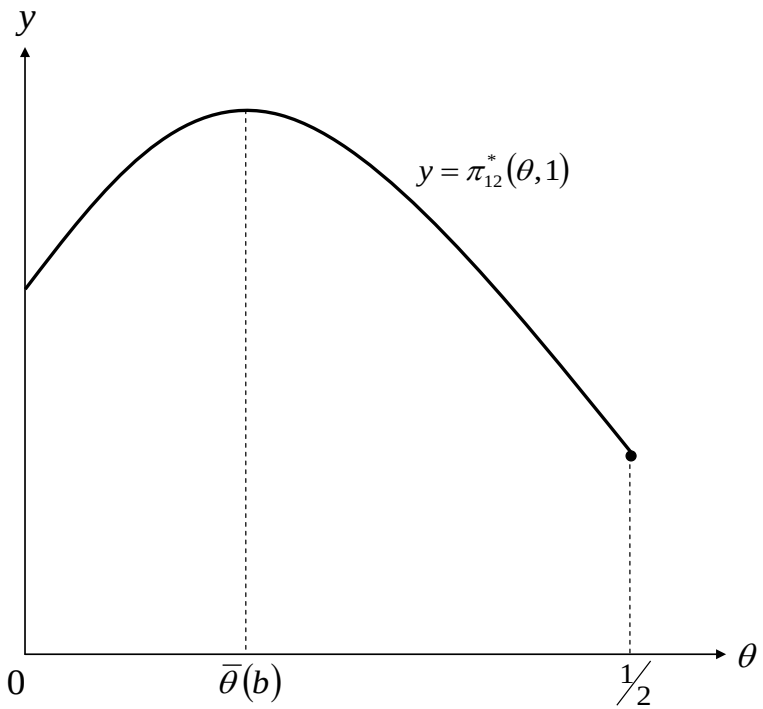
Product differentiation

- 3 firms
- Linear differentiated oligoply:

$$p_i = a - q_i - b(q_j + q_k), \qquad i, j, k \in \{1, 2, 3\}; i \neq j \neq k.$$

- $b \in (0, 1]$ denotes the degree of product differentiation
- $b = 1$ refers to homogenous product case; lower $b \Rightarrow$ higher degree of differentiation

Joint profits under b = 0.6



Partial permission of PEO

- Firms 1 and 2 might prefer PEO even without knowledge transfer.
- In the case of knowledge transfer, firms might prefer θ that is higher than minimum PEO required to induce knowledge transfer.
- Partial permission of PEO: Competition authority might agree to a lower level of PEO than the level most preferred by the firms

Policy Background

- In the U.S., cases of PEO in a competitor had gone mostly unchallenged by antitrust agencies (see Gilo, 2000).
- However, they have recently begun to pay increasing attention to the possible antitrust harms of PEO.
- Several legal scholars have argued that PEO results in antitrust harms (Gilo, 2000; O'Brien and Salop, 2000, 2001).
- European authorities are considering to review all PEO cases that involve more than 30% ownership

Concluding remarks

- Partial equity ownership (PEO) can play an important role for inducing knowledge transfer when knowledge is tacit
- We explored oligopoly models in which the level of PEO is endogenously determined through the link between PEO and knowledge transfer.
  - Partial equity ownership occurs in equilibrium when x is in the intermediate range, while merger occurs when x is large.
  - Endogenously determined levels of PEO can increase both total surplus and consumer surplus under a range of parameterizations.
- Competition policy is clear-cut in case of homogenous products: prohibit or permit PEO suggested by the alliance; Potential conflicts regarding the level of PEO in differentiated products