

Endogenous timing game of mixed duopoly with partial foreign ownership: increasing marginal costs

Akio Kawasaki
Faculty of Economics, Oita Univ.
Takao Ohkawa
Faculty of Economics, Ritsumeikan Univ.
Makoto Okamura
Economics Department, Gakushuin Univ.

1

Introduction

- There exist many studies to address mixed duopoly market.
→ Some studies aggressively discuss the timing game between private firms and a public firm.
- In origin, simultaneous game was tacitly assumed and various problems were analyzed by many studies.
- At the same time, some studies assume sequential game and analyze various problems.
- Given these situations, various studies start to address the endogenous timing game.

2

Introduction

	Domestic private firm	Foreign private firm
Constant MC	<ul style="list-style-type: none"> • Pal (1989) → multiple equilibria • Matsumura and Ogawa (2010) → Private leadership (risk-dominant equilibrium) 	<ul style="list-style-type: none"> • Matsumura and Ogawa (2017) → Public leadership (risk-dominant equilibrium)
Increasing MC	<ul style="list-style-type: none"> • Tomaru and Kiyono (2010) → multiple equilibria • Our Study (KOO, 2018) → What's a risk-dominant equilibrium? 	<ul style="list-style-type: none"> • Our Study (KOO, 2018) → What's a risk-dominant equilibrium?

3

Introduction

- When assuming the increasing marginal cost with the difference of the production technology, do the same results obtained in Matsumura and Ogawa (2010, 2017) hold?
- Which, private leadership or public leadership, is socially preferable?
- When does the risk-dominant equilibrium change from private leadership to public leadership?
- Is the risk-dominant equilibrium socially preferable?

4

Related literature

- Matsumura and Ogawa (2010)
→ Private leadership (risk-dominant equilibrium) when a private firm is a domestic firm
- Matsumura (2003)
→ Private leadership (by using a different endogenous timing game)
- Matsumura and Ogawa (2017)
→ Public leadership (risk-dominant equilibrium) when a private firm is a foreign firm.
- Tomaru and Kiyono (2010)
→ Assuming increasing marginal cost.
- Tomaru and Saito (2010)
→ When introducing subsidy, private leadership cannot be an equilibrium.
- Lu (2006)
→ The public firm never chooses quantities simultaneously with domestic private firms.

5

Main results

- When the difference of production technology between the public and the private firms is large,
→ Public leadership is always the risk-dominant equilibrium.
- Otherwise
→ We obtain the same results obtained in Matsumura and Ogawa (2010, 2017).
- From the viewpoint of social welfare, similar results obtained in Matsumura and Ogawa (2017) hold.
- For the medium partial foreign ownership rate, although private leadership is socially preferable, public leadership becomes the risk-dominant equilibrium.

6

Model

- There exist two firms. (public firm=firm 0, private firm=firm 1)
- Both firms produce homogeneous goods
→ The number of goods supplied by firm $i = q_i$
- Demand function → $p = a - (q_0 + q_1)$
→ $CS = \frac{(q_0 + q_1)^2}{2}$
- Cost function of each firm
→ $C(q_i) = \frac{c_i}{2} q_i^2$ ($c_1 = 1, c_0 = c (\geq 1)$)
- Each firm's profit function
→ $\pi_i = p q_i - \frac{c_i}{2} q_i^2$

7

Model

- This study considers the partial foreign ownership of the private firm.
→ The share of foreign ownership of the private firm = s
→ We call s as "a foreign-ownership rate"
- That is, only $(1 - s) \times 100\%$ of the private firm's profit is included into the domestic social welfare.
→ $SW = CS + \pi_0 + (1 - s)\pi_1$
(If $s = 0(1)$, the private firm is a domestic (foreign) firm.)
- Firm 0 decides q_0 to maximize social welfare.
- Firm 1 decides q_1 to maximize the profit.

8

Model

- We analyze following three cases.
 - (i) Simultaneous game
→ Both firms simultaneously decide the quantity of production.
 - (ii) Public leadership game
→ The public firm decides the quantity of production, and then the private firm decides the quantity of production.
 - (iii) Private leadership game
→ The private firm decides the quantity of production, and then the public firm decides the quantity of production.
- We adopt the observable delay game formulated by Hamilton and Slutsky (1990).

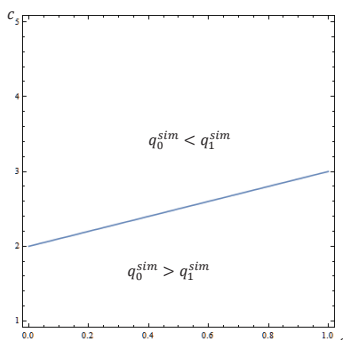
9

Simultaneous game

- Equilibrium outcomes
$$q_0^{sim} = \frac{a(2+s)}{2+3c+s}, \quad q_1^{sim} = \frac{ac}{2+3c+s}$$
- Firm 1's equilibrium profit
$$\pi_1^{sim} = \frac{3a^2c^2}{2(2+3c+s)^2}$$
- Equilibrium social welfare
$$SW^{sim} = \frac{a^2(c^2(4-3s) + c(4-s)(2+s) + (2+s)^2)}{2(2+3c+s)^2}$$

10

Comparison of quantity between firms 0 and 1 (Lemma 1)



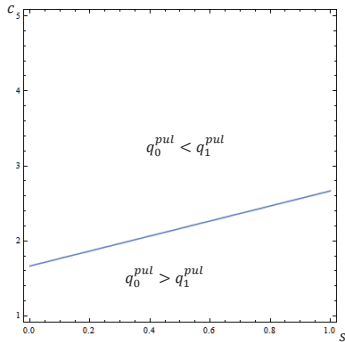
11

Public leadership game

- Equilibrium outcomes
$$q_0^{pul} = \frac{a(5+3s)}{5+9c+3s}, \quad q_1^{pul} = \frac{3ac}{5+9c+3s}$$
- Firm 1's equilibrium profit
$$\pi_1^{pul} = \frac{27a^2c^2}{2(5+9c+3s)^2}$$
- Equilibrium social welfare
$$SW^{pul} = \frac{a^2(5+3s+c(4-3s))}{2(5+9c+3s)}$$

12

Comparison of quantity between firms 0 and 1 (Lemma 2)



13

Private leadership game

- Equilibrium outcomes

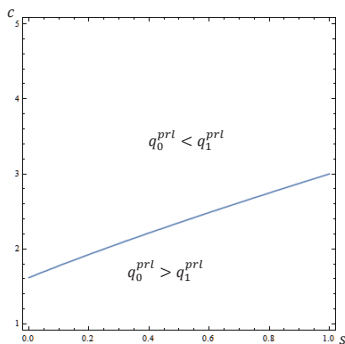
$$q_0^{prl} = \frac{a(1+2s+c(2+s))}{(1+c)(1+3c+2s)}, \quad q_1^{prl} = \frac{ac}{1+3c+2s}$$
- Firm 1's equilibrium profit

$$\pi_1^{prl} = \frac{a^2 c^2}{2(1+c)(1+3c+2s)}$$
- Equilibrium social welfare

$$SW^{prl} = \frac{a^2(c^3(4-3s) + 6c(1+2s) + (1+2s)^2 + c^2(10+3s-3s^2))}{2(1+c)(1+3c+2s)^2}$$

14

Comparison of quantity between firms 0 and 1 (Lemma 3)



15

Comparison of equilibrium quantity

- Lemma 4
 $q_0^{sim} > q_0^{prl} > q_0^{pul}$ holds.
- Lemma 5
 If $s \geq \frac{2}{3}$, $q_1^{pul} > q_1^{prl} > q_1^{sim}$ holds.
 Otherwise, $q_1^{prl} > q_1^{pul} > q_1^{sim}$ holds

16

Mechanism

- For firm 0...
 - Under simultaneous game, because firm 1 produces less, firm 0 must produce more. $\rightarrow q_0^{sim}$ is the largest among three cases.
 - If firm 0 which has the inferior production technology produces more, firm 1 produces less, which increases the total production costs.
 \rightarrow Under public leadership, considering the strategic substitutes, firm 0 can decrease the production.
 \rightarrow Therefore, q_0^{pul} is the smallest among three cases.

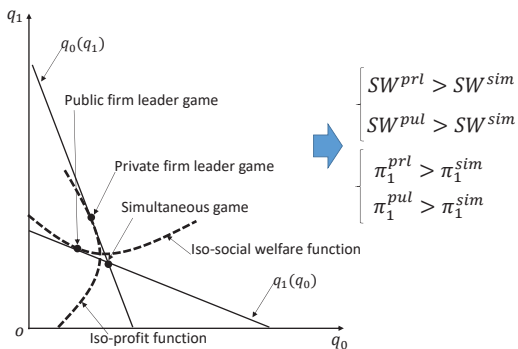
17

Mechanism

- For firm 1...
 - Under simultaneous game, because firm 1 worries to decrease the price, it produces less.
 $\rightarrow q_1^{sim}$ is the smallest among three cases.
 - Under private leadership..., firm 0 will produce less (more) if s is small (large) when firm 1 produces more.
 \rightarrow Because of the strategic substitutes, firm 1 produces more (somewhat less) in equilibrium.
 - Under public leadership..., firm 1 can act as a monopoly due to a follower.
 \rightarrow produces somewhat less.
 - As a result...
 \rightarrow if s is small (large), $q_1^{prl} > (<) q_1^{pul}$ holds.

18

Comparison of SW (firm 1's profit)



Nash-equilibrium

From the previous comparison results by using a figure...

		Firm 1	
		Leader	Follower
Firm 0	Leader	SW^{sim}, π_1^{sim}	SW^{pul}, π_1^{pul}
	Follower	SW^{pri}, π_1^{pri}	SW^{sim}, π_1^{sim}

Proposition 1 Multiple equilibria ("Private leadership" and "Public leadership")

We select the equilibrium of the above game by using a risk-dominant equilibrium (Harsanyi and Selten, 1988)

Risk-dominant equilibrium

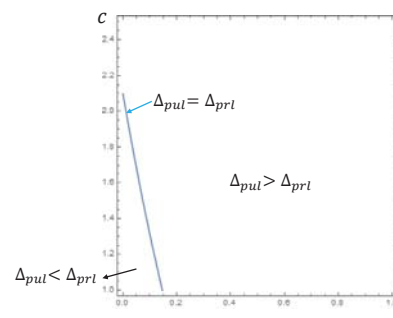
Defining that

$$\Delta_{pul} = (SW^{pul} - SW^{sim})(\pi_1^{pul} - \pi_1^{sim})$$

$$\Delta_{pri} = (SW^{pri} - SW^{sim})(\pi_1^{pri} - \pi_1^{sim})$$

- If $\Delta_{pul} > (<) \Delta_{pri}$, public leadership (private leadership) is a risk dominant equilibrium.
- Because of complex calculation results, we show this result by using a figure.

Risk-dominant equilibrium



Proposition 2

- When the difference of the production technology between the public and the private firms is large, public leadership is always the risk-dominant equilibrium.
- When its difference is small, for the small foreign ownership rate, private leadership is the risk-dominant strategy; for not the small foreign ownership rate, public leadership is the risk-dominant equilibrium.

Mechanism

- When c is large...
 - Due to the inferior production technology, firm 0 does not want to produce more.
 - Under public leadership, firm 0 produces less.
 - Firm 0 prefers public leadership to private leadership.
 - From the viewpoint of firm 1...
 - Under private leadership, firm 0 produces somewhat more. Under public leadership, firm 0 produces less.
 - Firm 1 also prefers public leadership to private leadership.
- As a result, public leadership is the risk-dominant equilibrium.

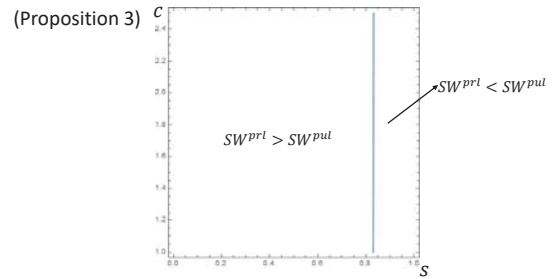
Mechanism

- When c is not large...
 - For small s , it is socially preferable that the public firm produces less and the private firm produces more.
 - Private leadership becomes the risk-dominant equilibrium.
 - For not small s , the public firm wants to decrease the firm 1's profit (because the firm 1's profit is not almost included into domestic social welfare).
 - Under private leadership, the firm 1's revenue largely decreases due to firm 0's aggressive production.
 - Public leadership becomes the risk-dominant equilibrium.

25

Social welfare

- Which, private leadership or public leadership, is socially preferable?



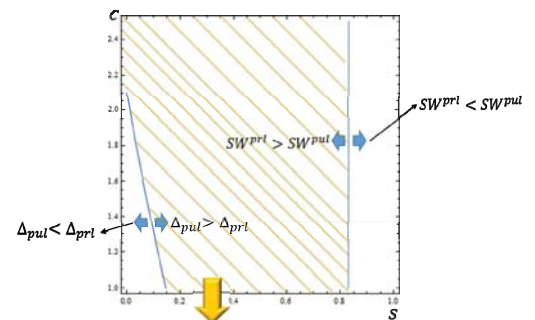
26

Mechanism

- For not large s ...
 - It is socially preferable that firm 0 produces less and firm 1 produces more in order to decrease the total production costs.
 - Private leadership is socially preferable.
- For large s ...
 - Firm 0 must decrease the firm 1's revenues.
 - At the same time, firm 0 wants to decrease the production costs.
 - As a result, public leadership is socially preferable.

27

Comparison



Although private leadership is socially preferable, public leadership is the risk-dominant equilibrium.

28

Concluding remarks

- If the difference of production technology between the public and the private firms is large, public leadership is always the risk-dominant equilibrium (which result is different from Matsumura and Ogawa, 2010).
- For the medium partial foreign ownership rate, although private leadership is socially preferable, public leadership becomes the risk-dominant equilibrium.

29