

# Competition for Access Provision: Infrastructure Upgrades with Spillovers\*

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# Outline of Talk

- Introduction: the issue of this research, related literature, main findings.
- Model Framework
- Analyses and Policy Implications
- Concluding Remarks

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# An Issue of This Research

\*We re-examine **a game of competition among facility-based firms (vertically integrated firms) and service-based firms (vertically separated firms) in two-tier structures.**

E.g.

- (i) In broadband & the Internet, regional telephone companies, cable TV companies, and independent internet service providers.
- (ii) In mobile telephone, mobile network operators (MNOs) and mobile virtual network operators (MVNOs).
- (iii) In licensing, firms with IP protected technologies and firms without them.

A basic question: **“Do we need *a government intervention* when there is competition for access provision between facility-based firms?”**

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# Related Literature

- Ordoover & Shaffer (2007); when access is granted?
- Höffler & Schmidt (2008); granting access is always welfare enhancing?
- Brito & Pereira (2009) (2010); endogenous determination of *horizontal* product differentiation.
- Bourreau et al (2011); the input to be priced above marginal cost. Discuss several regulatory tools such as wholesale price cap, entry, and vertical separation.

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# Departure from the Existing Literature

This paper has the following 3 features:

1. Facility-based firms have **an opportunity to invest for infrastructure upgrades.**
2. ***Vertical product (or service) differentiation*** is endogenously determined through infrastructure upgrades.
3. Service-based firms can enjoy ***spillovers*** of quality upgrades through access to an incumbent's infrastructure.

# Main Findings

- *In the free competition regime*, two types of equilibria emerge: the asymmetric access provision equilibrium (**AAPE**) and the foreclosure equilibrium (**FE**) (or the *constrained* foreclosure equilibrium (**CFE**)).

Cf. Here, “*constrained*” means that a facility-based firm cannot choose its profit-maximizing investment due to the foreclosure constraint.

- The **AAPE** (with access charge > access cost) occurs irrespective of the degree of spillover. The **FE** can also occur *when the degree of spillover is small and the investment cost is low*.
- When the **AAPE** occurs, *access regulation* is socially desirable *only when the degree of spillover is small and the investment cost is high*. Moreover, *access regulation* is not necessary when the **FE** occurs (except the **CFE**).

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# Model Framework

Consider the free competition regime.

- Upstream (wholesale) sector and downstream (retail) sector.
- 3 firms

**Firm 1, Firm 2:** a vertically integrated firm that has infrastructure upstream. Sets access charge. Invests for infrastructure upgrades.

**Firm S:** a downstream firm that has only a production facility.

Cf. For comparison, we also consider a (cost-based) access regulation regime.

- Firm 1's (or firm 2's) investment in infrastructure has demand-enhancing effect (by upgrading the quality of service) and spillover effect through access,  $s$ , to firm  $S$ .

**\*\* The degree of spillover effect  $s$ :** reflects firm  $S$ 's retail production technology (i.e., how many kinds of value-added services, such as interactive TV, it can provide).

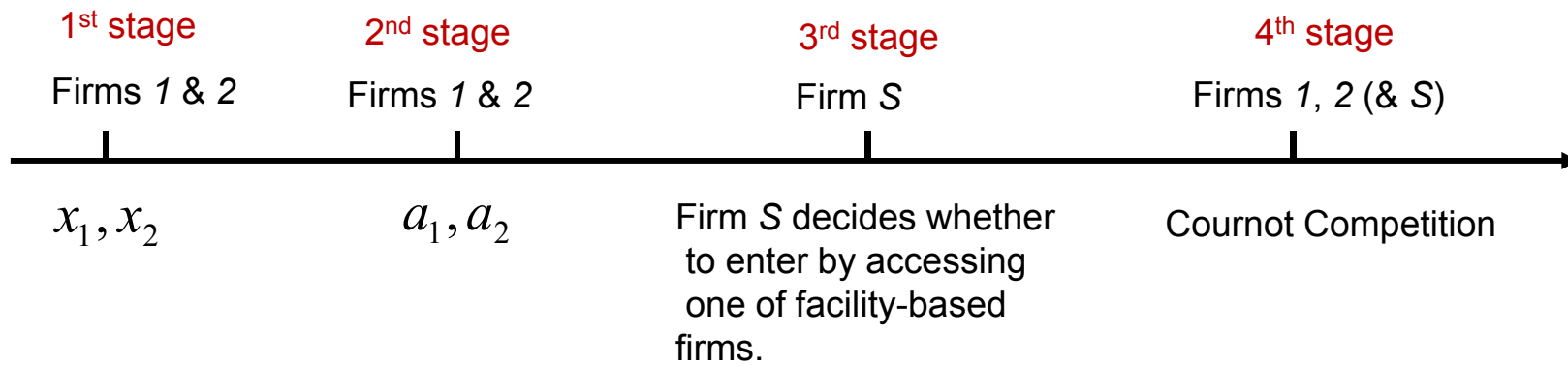
Firm 1's (or firm 2's) investment technology:  $I(x_k) = (\gamma x_k^2) / 2$

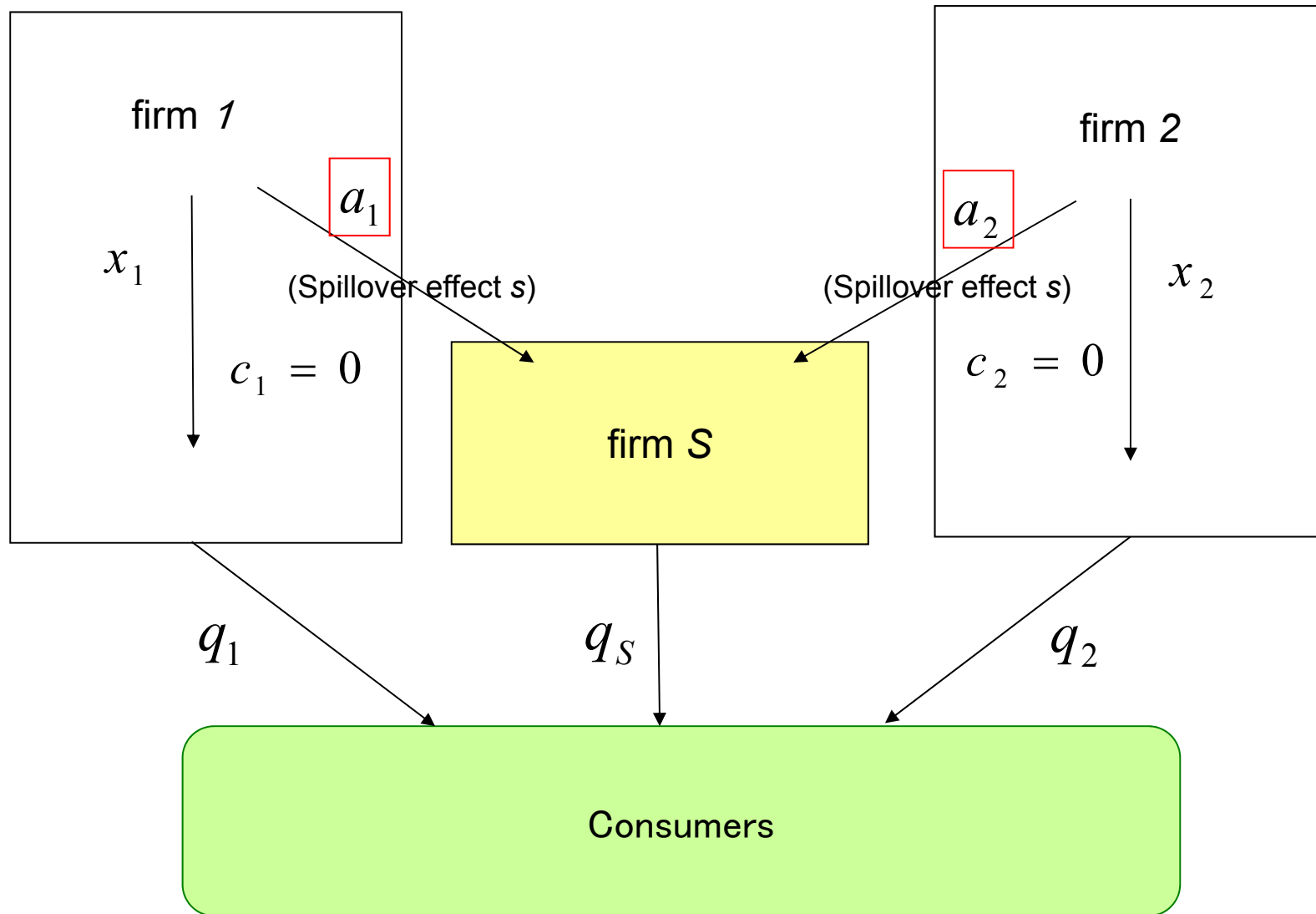
- A linear demand system with vertically differentiated services (as shown later).

### Assumptions:

- (i)  $a_k \geq c_k = 0$  ( $k = 1, 2$ ), (ii)  $\gamma > 3/2$ , (iii)  $0 \leq s \leq 2$ .







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Following Foros (2004), we employ a linear inverse demand system with vertically differentiated services by supposing that heterogeneous consumers with unit demand for a service are uniformly distributed.<sup>4</sup> The inverse demand function for service  $j$  ( $j = 1, 2, S$ ) is given by

$$p_j = v_j - Q, \quad (j = 1, 2, S)$$

where  $v_j$  represents the quality of service  $j$  and  $Q \equiv q_1 + q_2 + q_S$ . Here,  $v_j$ s ( $j = 1, 2, S$ ) are given by, respectively,

$$v_1 = \alpha + x_1, \quad v_2 = \alpha + x_2, \quad v_S = \alpha + sx_k$$

spillover



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The profit function of a facility-based firm  $k$  that firm  $S$  accesses and that of a facility-based firm  $l$  that firm  $S$  does not access are represented by, respectively,

$$\pi_k = p_k q_k + a_k q_S - I(x_k), \quad \pi_l = p_l q_l - I(x_l), \quad k, l = 1, 2, \text{ and } k \neq l.$$

The profit function of firm  $S$  if it enters the market is represented by

$$\pi_S = (p_S - a_k) q_S,$$

and  $\pi_S = 0$  if firm  $S$  does not enter the market.

# Equilibria in the 4<sup>th</sup> and 3<sup>rd</sup> stages

When firm  $S$  enters the market;

$$q_k(a_k; x_k, x_l) = \frac{\alpha + a_k + (3 - s)x_k - x_l}{4}, \quad (1)$$

$$q_l(a_k; x_k, x_l) = \frac{\alpha + a_k - (1 + s)x_k + 3x_l}{4}, \quad (2)$$

$$q_S(a_k; x_k, x_l) = \frac{\alpha - 3a_k - (1 - 3s)x_k - x_l}{4}, \quad (3)$$

$$Q(a_k; x_k, x_l) = \frac{3\alpha - a_k + (1 + s)x_k + x_l}{4}. \quad (4)$$

$$\pi_k(a_k; x_k, x_l) = (q_k(a_k; x_k, x_l))^2 + a_k q_S(a_k; x_k, x_l) - I(x_k), \quad (5)$$

$$\pi_l(a_k; x_k, x_l) = (q_l(a_k; x_k, x_l))^2 - I(x_l), \quad (6)$$

$$\pi_S(a_k; x_k, x_l) = (q_S(a_k; x_k, x_l))^2. \quad (7)$$

When firm  $S$  does not enter the market;

$$\tilde{q}_1(x_1, x_2) = \frac{\alpha + 2x_1 - x_2}{3}, \quad \tilde{q}_2(x_1, x_2) = \frac{\alpha + 2x_2 - x_1}{3}. \quad (8)$$

$$\tilde{\pi}_1(x_1, x_2) = (\tilde{q}_1(x_1, x_2))^2 - I(x_1), \quad \tilde{\pi}_2(x_1, x_2) = (\tilde{q}_2(x_1, x_2))^2 - I(x_2).$$

The condition for firm  $S$  to enter the market by accessing firm  $k$  ( $=1, 2$ );

$$a_k \leq \overline{a_k} \equiv \frac{1}{3} (\alpha - (1 - 3s) x_k - x_l), \quad (9)$$

$$a_k - s x_k \leq a_l - s x_l. \quad (10)$$

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# Equilibrium Access Charges in the 2<sup>nd</sup> Stage

**Lemma 1** *The equilibrium access charges  $a_1^*$  and  $a_2^*$  in the second stage of the game are characterized as follows:<sup>7</sup>*

$$a_k^* = a_l^* = 0 \text{ if } x_k = x_l,$$

$$a_k^* = s(x_k - x_l) \text{ and } a_l^* = 0 \text{ if } x_k > x_l, \text{ } k, l = 1, 2, \text{ and } k \neq l.$$

Moreover, when  $s < 7/9$ ,  $\alpha - (7 - 9s)x_1 - x_2 < 0$  and  $\alpha - (7 - 9s)x_2 - x_1 < 0$ , there are also pairs of equilibrium access charges  $(a_1^*, a_2^*)$  where  $a_k^* \geq \overline{a_k} \equiv \frac{1}{3}(\alpha - (1 - 3s)x_k - x_l)$  ( $k, l = 1, 2, k \neq l$ ) in addition to those mentioned above.

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## Remarks:

1. *Price competition* occurs for access provision.
2. *Equilibrium access charge* depends on the relative magnitude of investments between two facility-based firms.
3. When  $s < 7/9$  and the total investments are large, we have two kinds of equilibrium access charges: *competitive access charge* and *access charge that induces foreclosure*.  
→ Since multiple equilibria emerge in the subgame, *multiple equilibrium path* can be possible in the whole game.



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# Equilibrium Investment and Market Structure

## Proposition 1

There are two types of equilibria; the **asymmetric access provision equilibrium (AAPE)** and the **foreclosure equilibrium (FE)** (or the *constrained* **foreclosure equilibrium (CFE)**).

- (i) The **AAPE** occurs irrespective of the degree of spillover and the investment cost.
- (ii) The **FE** occurs when the degree of spillover is small and the investment cost is low.
- (iii) The **CFE** occurs in the intermediate range.

Cf. Here, “*constrained*” means that a facility-based firm cannot choose its profit-maximizing investment under the foreclosure constraint.

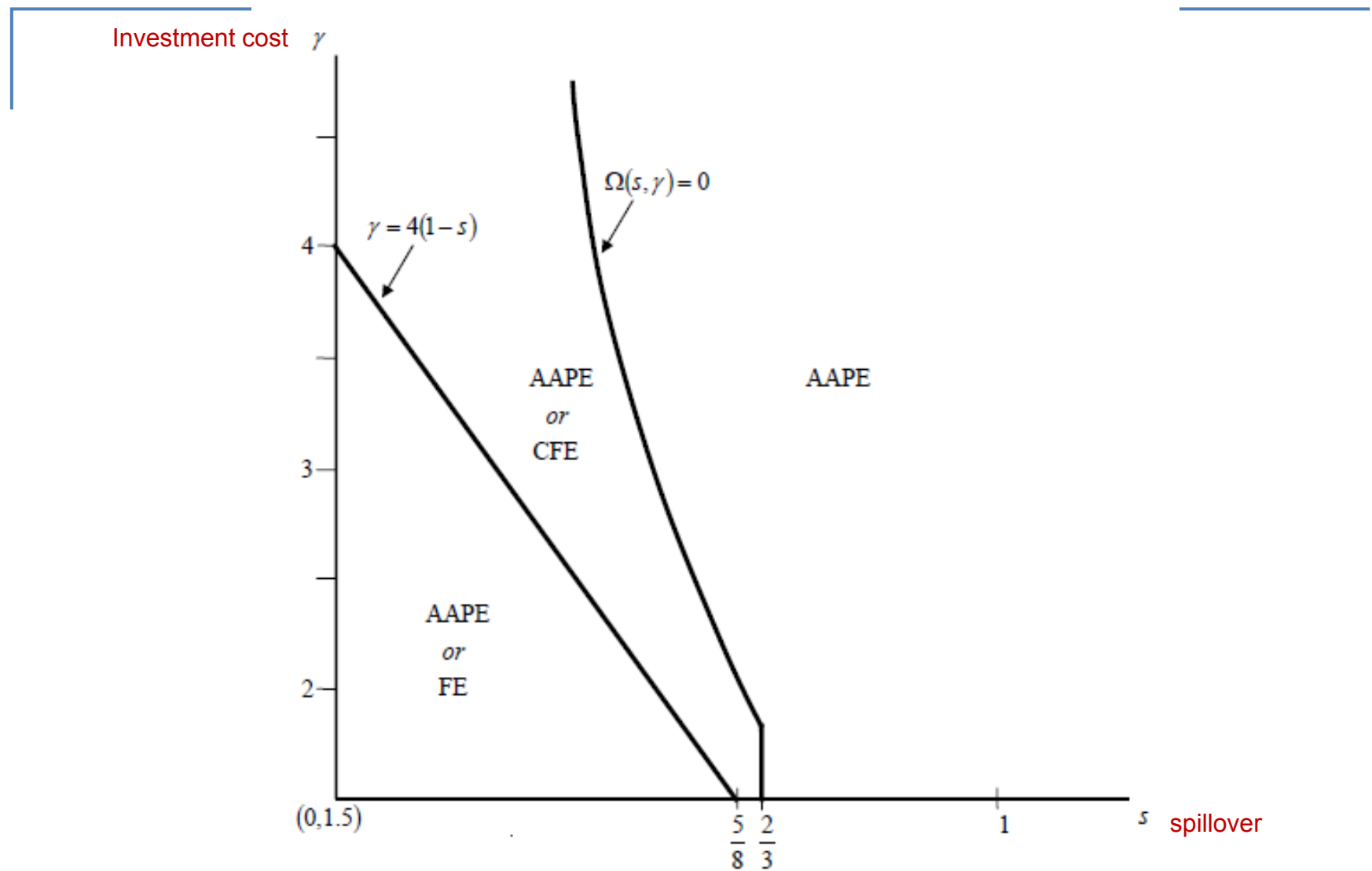


Figure 3 Equilibria in the Free Competition Regime

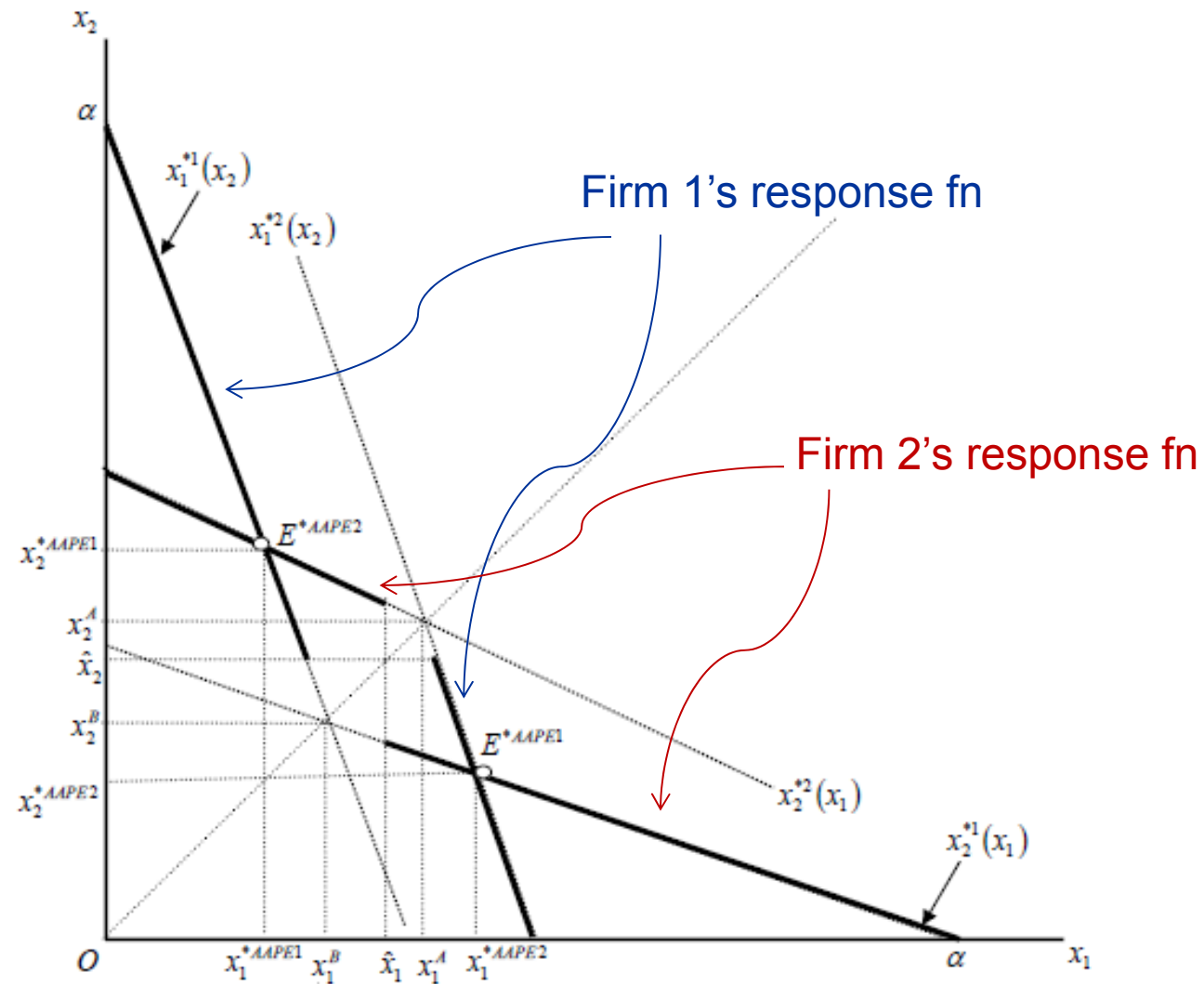


Figure 1 Asymmetric Access Provision Equilibrium (AAPE)

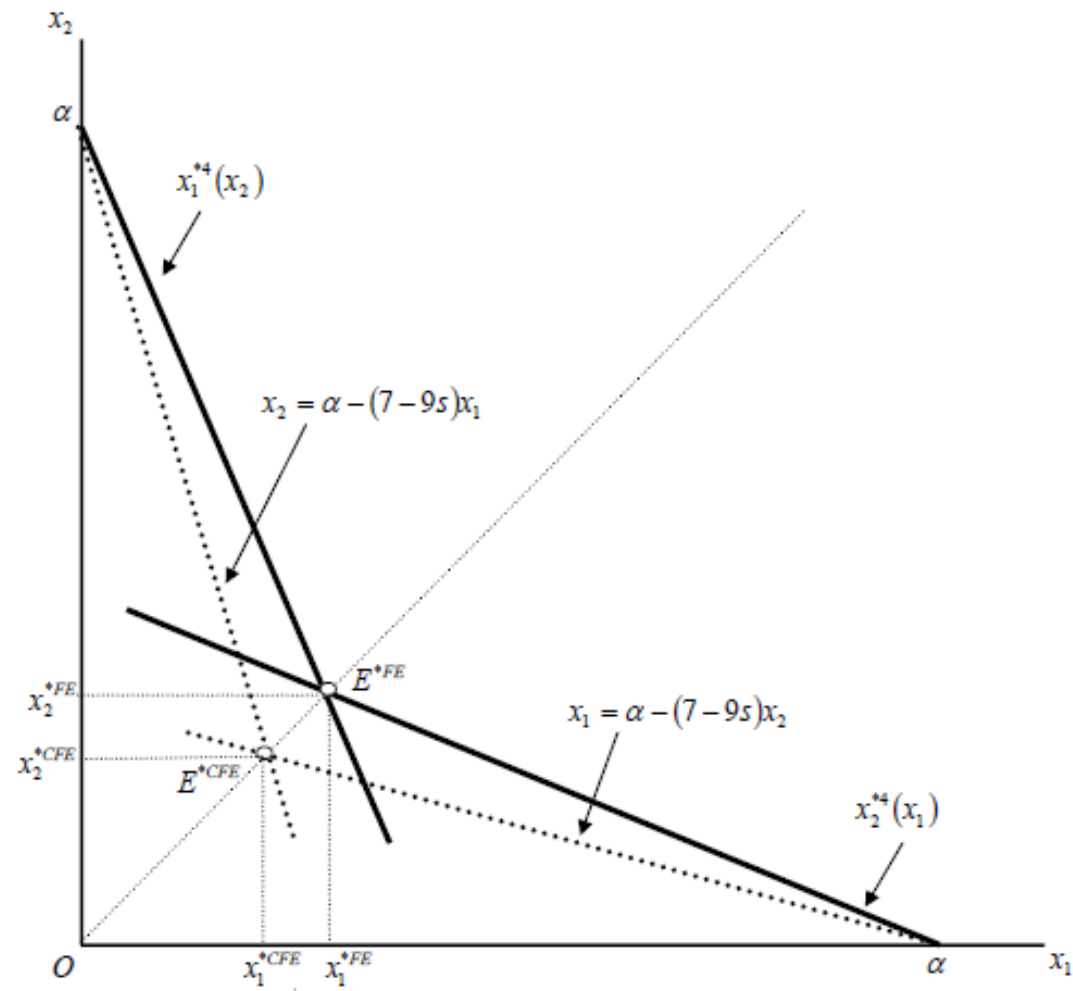
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## Remarks on AAPE

1. In the **AAPE**, each of facility-based firms has **stronger** incentive to invest *when it is accessed by firm S* than when it is not accessed.

(This is because each of facility-based firm has a chance to obtain positive access profit by investing more and giving spillovers to firm *S*.)

2. In the **AAPE**, the equilibrium access charge is higher than access cost.



**Figure 2 Foreclosure Equilibrium (FE) and Constrained Foreclosure Equilibrium (CFE)**

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## Remarks on FE

1. The **FE** occurs *when the degree of spillover is small and the investment cost is low.*
2. Moreover, **the facility-based firms** can obtain *higher profit under foreclosure* than under the AAPE by setting high access charge with larger investment than its profit-max under the foreclosure constraint in the intermediate range of  $(s, \gamma)$ .  
→ That is the **CFE**. (*Total investments in the CFE are larger than those in the FE.*)

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# Comparison with the (Cost-Based) Access Regulation Regime

## (Cost-Based) Access regulation equilibrium (ARE):

A regulator determines the access charge instead of each of facility-based firms in the 2<sup>nd</sup> stage.

$$\rightarrow a^* = 0$$

Cf. 4 justifications of cost-based access regulation

- (i) Under the sunk cost of investment, it is optimal from welfare viewpoint in some range of  $(s, \gamma)$ .
  - (ii) Avoid *double-marginalization*.
  - (iii) Induce an entrant's choice of productively efficient technology under Cournot competition (if it has bypass).
  - (iv) *Easy to implement*.
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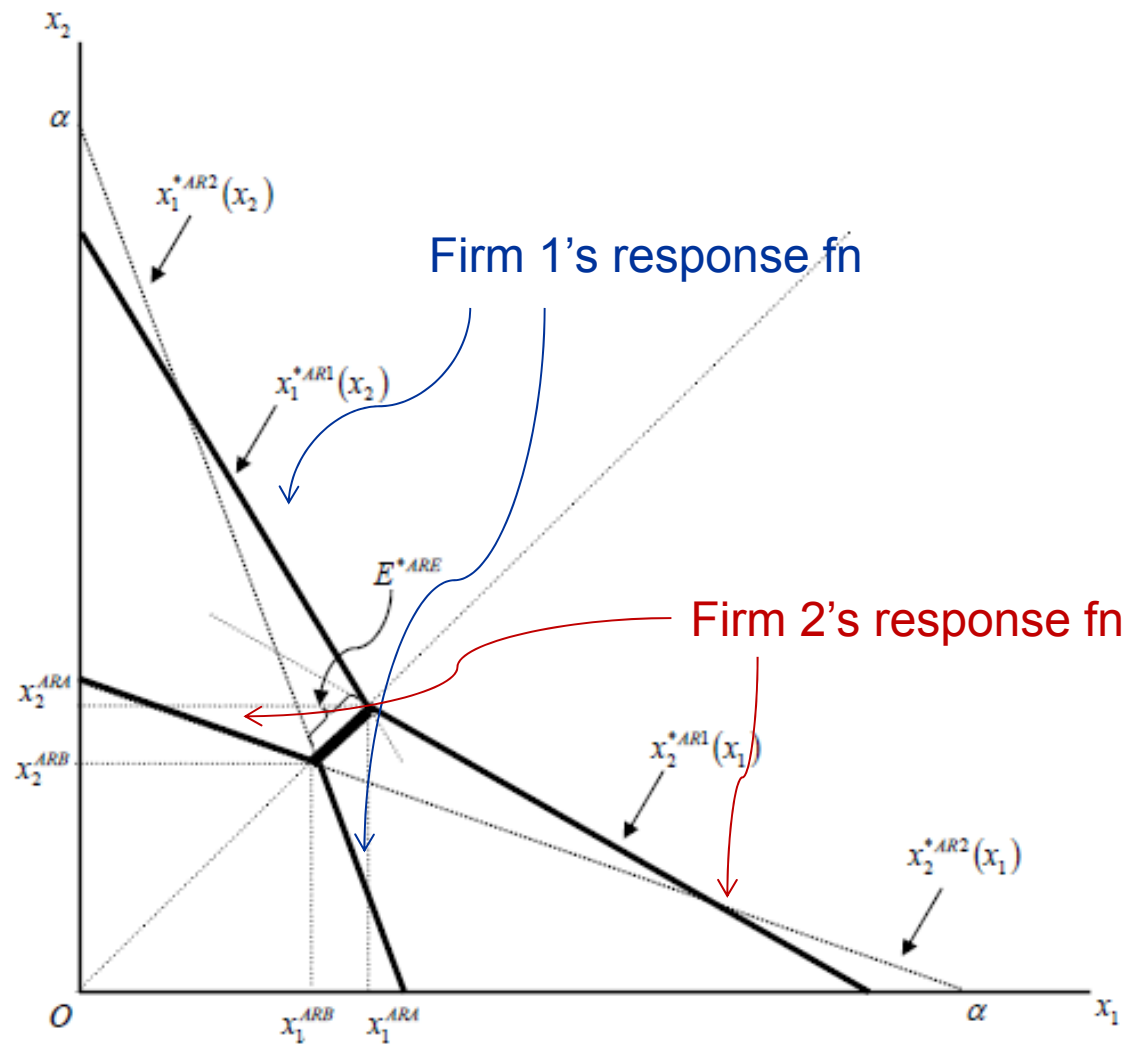


Figure 4 (Cost-Based) Access Regulation Equilibrium (ARE)



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## Remarks on ARE

1. In the **ARE**, each of facility-based firms has **weaker** incentive to invest *when it is accessed by firm S* than when it is not accessed.  
(This is due to “*free-rider effect*” through spillovers.)
2. There are *multiple* equilibrium investments.

## Welfare Comparison between the AAPE and the ARE

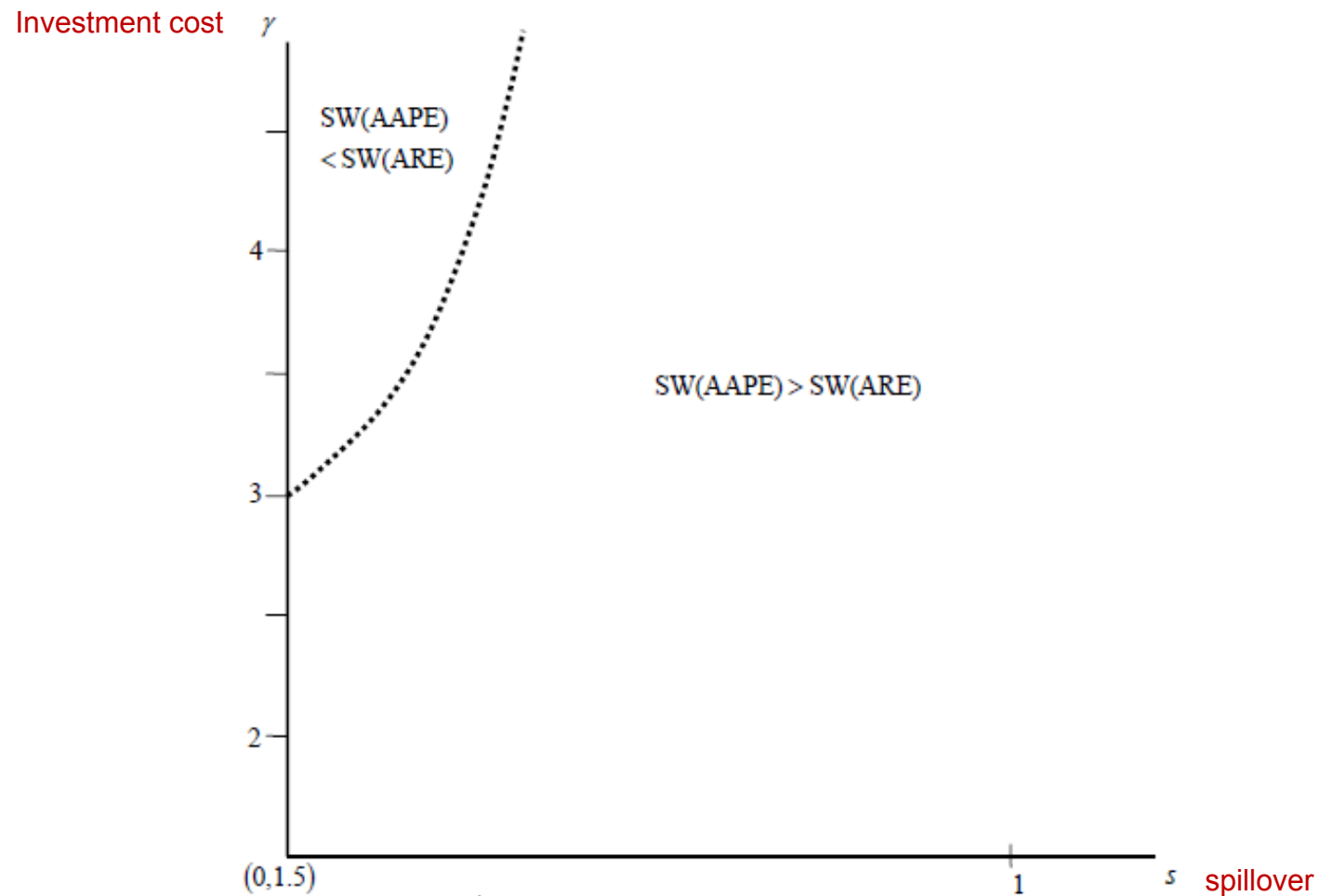


Figure 5-1 Welfare Comparison between AAPE and ARE

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## Remarks

1. *Social welfare* in the **AAPE** is higher than that in the **ARE** in the substantial parts of  $(s, \gamma)$ .  
→ This is because the facility-based firms have *higher incentive for investment* in the **AAPE** than in the **ARE**.
2. **(Cost-Based) Access regulation** is socially desirable *only when the degree of spillover is small and the investment cost is high*.

# Welfare Comparison between the FE (or the CFE) and the ARE

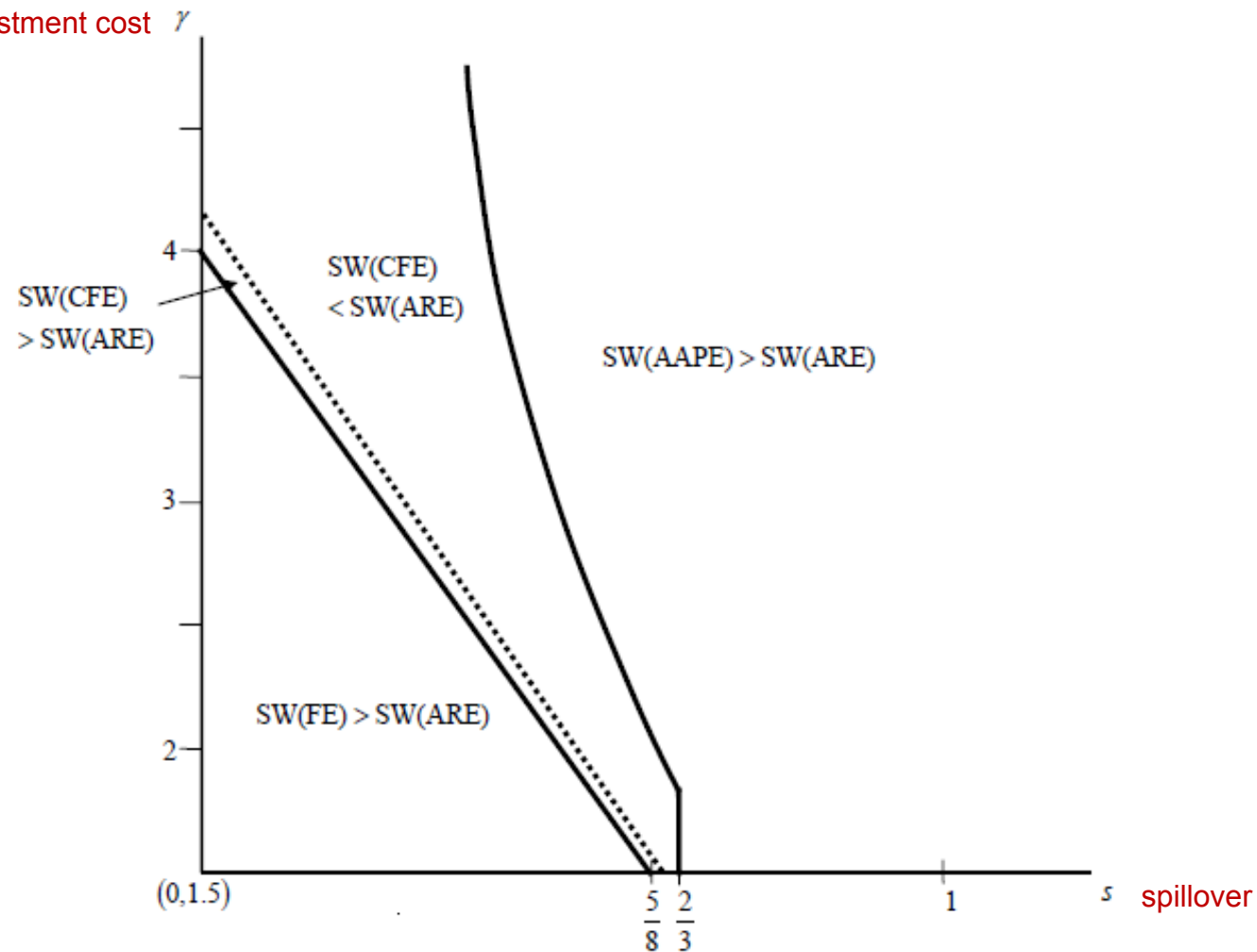


Figure 5-2 Welfare Comparison between FE (or CFE) and ARE

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## Remarks

1. *Social welfare* in the **FE** is higher than that in the **ARE**.  
→ Two factors; (i) high profits achieved by *two strategic tools*, i.e., *access charge* and *investment*. (ii) the facility-based firms have *higher incentive for investment* in the **FE** than in the **ARE**.
2. *Social welfare* in the **CFE** is lower than that in the **ARE**.  
→ This is because the incentive of facility-based firms for investment is not enough to overcome the negative effect of foreclosure and the profits of facility-based firms are not large.

# Concluding Remarks

- *In the free competition regime*, two types of equilibria emerge: the asymmetric access provision equilibrium (**AAPE**) and the foreclosure equilibrium (**FE**) (or the *constrained* foreclosure equilibrium (**CFE**)).

Cf. Here, “*constrained*” means that a facility-based firm cannot choose its profit-maximizing investment due to the foreclosure constraint.

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