Market Access and Technology Adoption in the Presence of FDI

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Introduction

- Background
  - The increased contribution of developing countries to both world exports (24.2% in 1990 → 42.8% in 2011) and outward FDIs (4.9% in 1990 → 22.6% in 2011).
  - The improved access for those countries to foreign markets!
- A research question
  - Does improved market access drive the technological upgrading of exporting and FDI firms?

Introduction

The existing empirical studies:

- Trade liberalization
  - **Lileeva and Trefler (2010):** more product innovation and higher rate of technology adoption.
  - **Bustos (2011)**: adoption of more advanced technology.
  - **Aw, Roberts, Xu(2011)**: more investments in R&D.

- Outward FDIs
  - **Kimura and Kiyota (2006):** the positive impact on productivity.
  - **Hijzen, Inui, and Todo (2007)**: no significant effect.
  - **Bitzer and Gorg (2009):** negative effect.
  - **Barba Navaretti, et al. (2010)**: positive effect on Italian firms, but no significant effect on French firms.

The empirical results are mixed.

Introduction

The productivity effect of improved market access would depend on the firms' choices between exporting and FDI.

- There have been limited analyses of how improved market access affects firm's technology choices, given that firms' supply modes are endogenously determined.

  e.g., Saggi (1999), Petit and Sanna-Randaccio (2000), Xie (2011).

This paper tries to provide a new insight into the literature by using a simple oligopoly model.

- The effects of improved market access are examined in terms of both trade liberalization and liberalization of FDI.

Introduction

[A quick preview of the model]

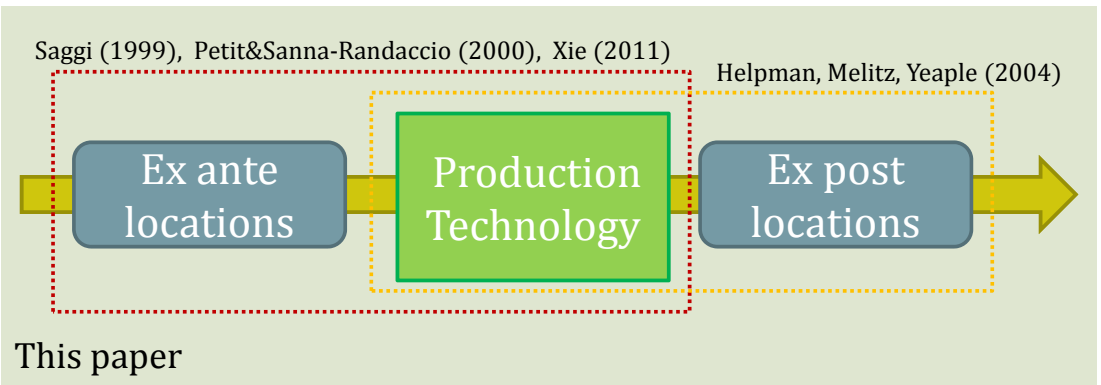
- A firm's technology choice is analyzed in a simple dynamic model of technology adoption.
  - Two foreign firms produce the same good and supply them to the domestic market.
  - One of the two foreign firms has not adopted an advanced technology and determines the timing of technology adoption.
  - The cost of technology adoption exogenously declines over time.
  - There are **no** technological spillovers.
    - ✓Our focus is improved **market** access, not improved access to superior technology or knowledge.

Introduction

[The features of the model]

A dynamic set-up has some advantages over a static model of trade and FDI with endogenous R&D.

① Both *ex ante* and *ex post* location choices affect technology upgrading.



Introduction

[The features of the model]

② We can explore not only whether improved market access enhances technology adoption, but also whether it speeds up the timing of technology adoption.

✓ Even if a new technology would be adopted in the long run, governments' policies may change the speed with which firms adopt it.

③ A dynamic model allows us to consider time-dependent policies such as temporary import protections or conditional protections.

cf. Miyagiwa and Ohno (1995)

Introduction

[Main Results]

	A single foreign firm	Two foreign firms
Liberalization of FDI	speeds up TA.	either speeds up or delays TA.
The fastest timing of TA is realized when	the fixed cost for FDI is sufficiently low.	the fixed cost for FDI is not so low and not so high.
Trade liberalization	either speeds up or delays TA	
The fastest timing of TA is realized when	tariff is eliminated both before and after TA.	tariff is not so low and not so high.

TA: Technology Adoption

Strategic interaction among firms in location choices changes the effects of improved market access on technology adoption.

Introduction

[Related papers]

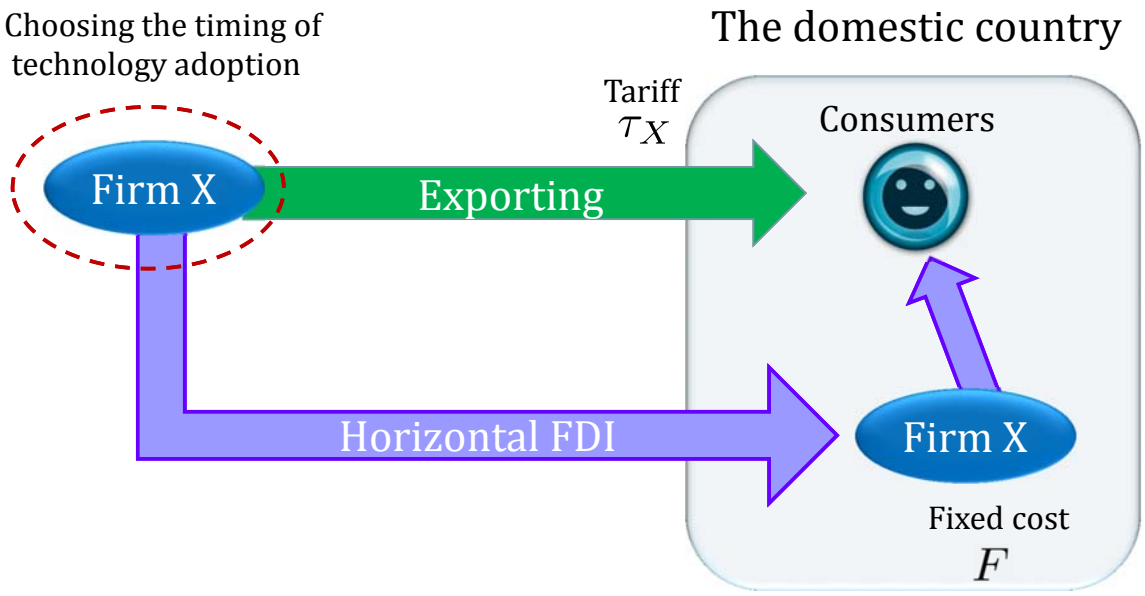
Endogenous technology adoption in the context of international trade.

- **Miyagiwa and Ohno (1995)** : Temporary protection.
- **Crowley (2006)** : Safeguard and antidumping.
- **Ederington and McCalman** (2008, 2009)
  : Endogenous firm heterogeneity.
- **Mukunoki (2012)** : Preferential trade agreements.

None of them has investigated technology adoption of a foreign firm when its location is endogenously determined.

cf. Miyagiwa and Ohno (1995) : Technology adoption of the domestic firm in the presence of a foreign firm's FDI.

The model with a single foreign firm



The model with a single foreign firm

- No domestic firms in the domestic country.
- Time t is a continuous variable defined on $t \in [0, +\infty)$.
- The Firm X's instantaneous profit from selling the good:

$$\pi_X = \{p(q_X) - c_X - \tau_X\}q_X$$

- Firm X has not adopted a new technology by $t = 0$ and its unit cost of production is given by $c_X = \bar{c}$.
- The new technology reduces the unit cost to $c_X = \underline{c}(< \bar{c})$.

The model with a single foreign firm

- A technology adoption is modeled based on Reinganum (1981) and Fudenberg and Tirole (1985).
- $K(t)$: A one-time fixed cost incurred to Firm X if it adopts the new technology at time t.
- The fixed cost is decreasing in t.
  - $K'(t) < 0$ for $t \in [0, \bar{t})$.
- The fixed cost hits the lower bound at $t = \bar{t}$.
  - $K(t) = \underline{K}$ and $K'(t) = 0$ for $t \in [\bar{t}, \infty)$.

The equilibrium

[Stage 3: Product market]

- The equilibrium instantaneous profit is given by $\pi_X(c_X, \tau_X)$.

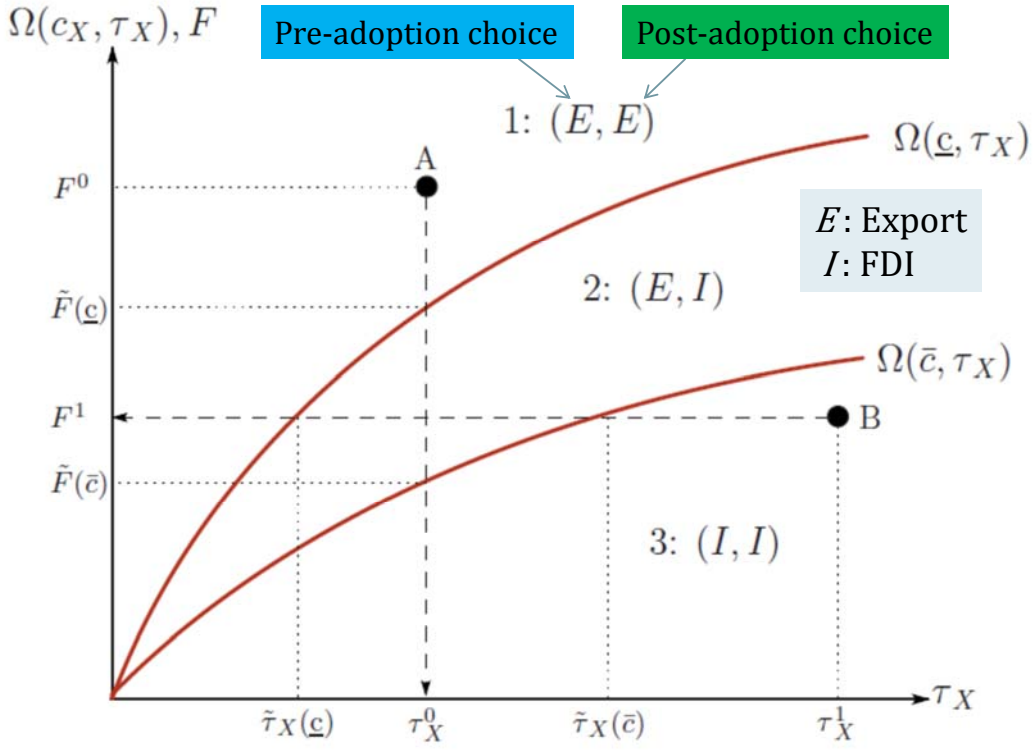
$$\begin{cases} c_X \uparrow \Longrightarrow \pi_X(c_X, \tau_X) \downarrow \\ \tau_X \uparrow \Longrightarrow \pi_X(c_X, \tau_X) \downarrow \end{cases}$$

[Stage 2: Choice between exporting and FDI]

- FDI incurs the fixed cost F per period.
- Firm X's current choice does not affect the future profits.
  - The maximization of instantaneous profit in each period is consistent with the intertemporal profit maximization.
- The operating profit under FDI : $\pi_X(c_X, 0)$.
- The gains from undertaking FDI:

$$\Omega(c_X, \tau_X) = \pi_X(c_X, 0) - \pi_X(c_X, \tau_X)$$

Figure 1: Choice between exporting and FDI (A single foreign firm)



The equilibrium

[Stage 1: Technology adoption]

- The pre-adoption profit (independent of t): $\bar{\pi}_X$
- The post-adoption profit (independent of t): $\underline{\pi}_X$
- **T** : the timing of technology adoption.
- The discounted sum of Firm X's profits:

$$\Pi_X(T) = \int_0^T e^{-rt}\bar{\pi}_X dt + \int_T^\infty e^{-rt}\underline{\pi}_X dt - e^{-rT}K(T).$$

- By differentiating this equation with respect to T, we have

$$\Pi'_X(T) = -e^{-rT}[(\underline{\pi}_X - \bar{\pi}_X) - \{rK(T) - K'(T)\}]$$

- The new technology is never adopted if $\underline{\pi}_X - \bar{\pi}_X < r\underline{K}$ holds.

The equilibrium

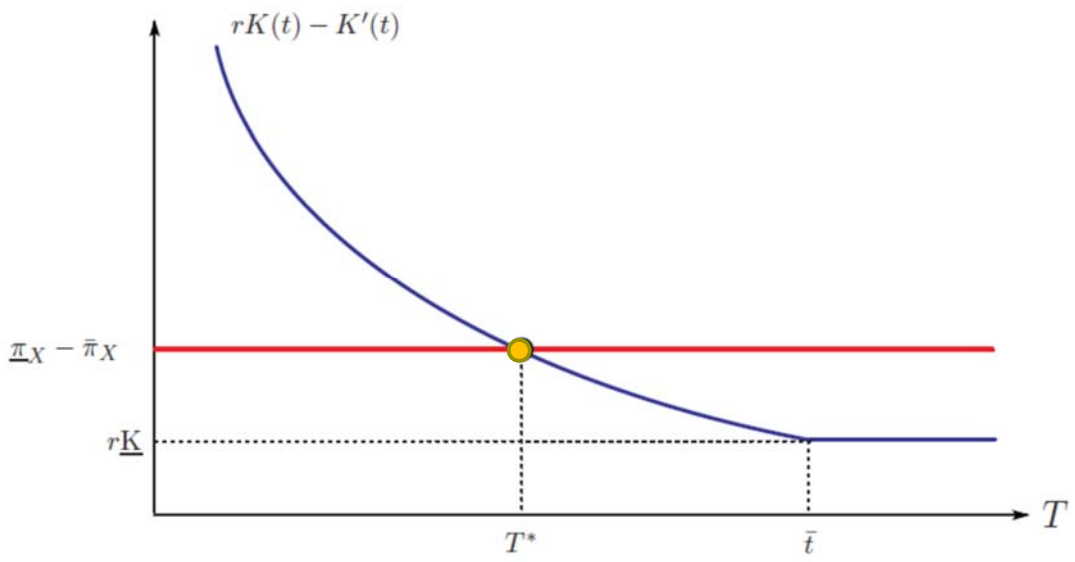
[Stage 1: Technology adoption](cont'd)

- If Firm X adopts the new technology at some point in time, the optimal timing of technology adoption, T^*, is determined by

$$\underline{\pi}_X - \bar{\pi}_X = rK(T^*) - K'(T^*).$$

- **LHS (the marginal gains):**
  By adopting the new technology at the current period, Firm X can earn higher profit.
- **RHS (the marginal cost):**
  By postponing the technology adoption until the next period, Firm X saves $rK(T)$ as the interest rate, and also gains from the decline in the adoption cost by $-K'(T)$.

Figure 2: The optimal timing of technology adoption



The comparison of gains from technology adoption

Region	The equilibrium location	$\underline{\pi}_X - \bar{\pi}_X$
1	(E, E)	$\pi_X(\underline{c}, \tau_X) - \pi_X(\bar{c}, \tau_X)$
2	(E, I)	$\{\pi_X(\underline{c}, 0) - F\} - \pi_X(\bar{c}, \tau_X)$
3	(I, I)	$\pi_X(\underline{c}, 0) - \pi_X(\bar{c}, 0)$

- In Region 2, Firm X's technology adoption triggers its FDI.

The effects of trade liberalization and liberalization of FDI

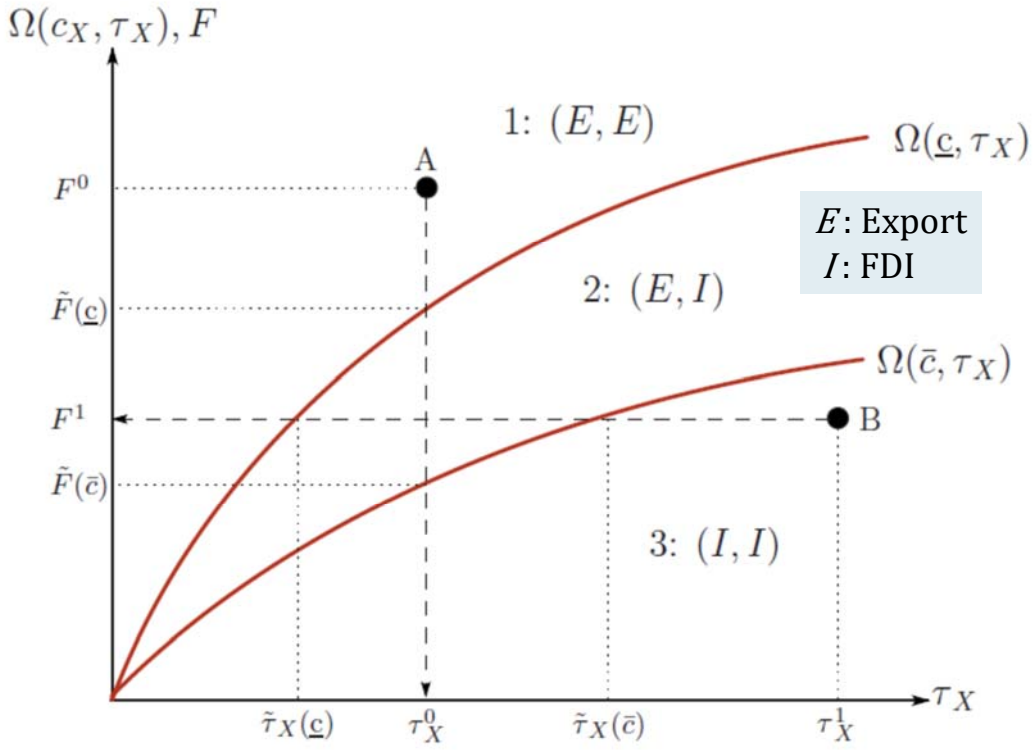
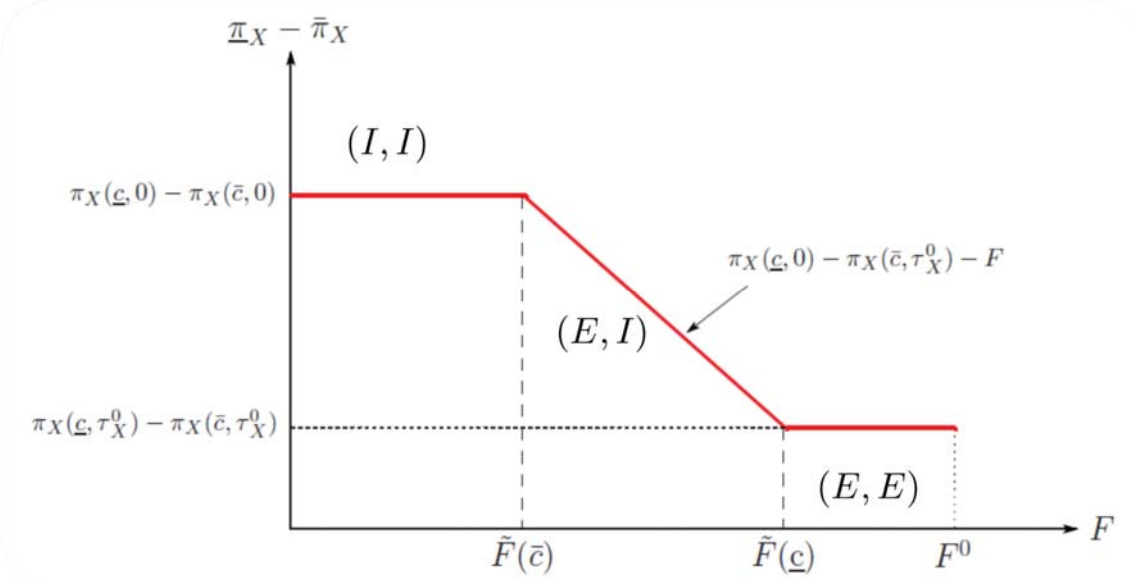


Figure 3: Liberalization of FDI (A Single Foreign Firm)

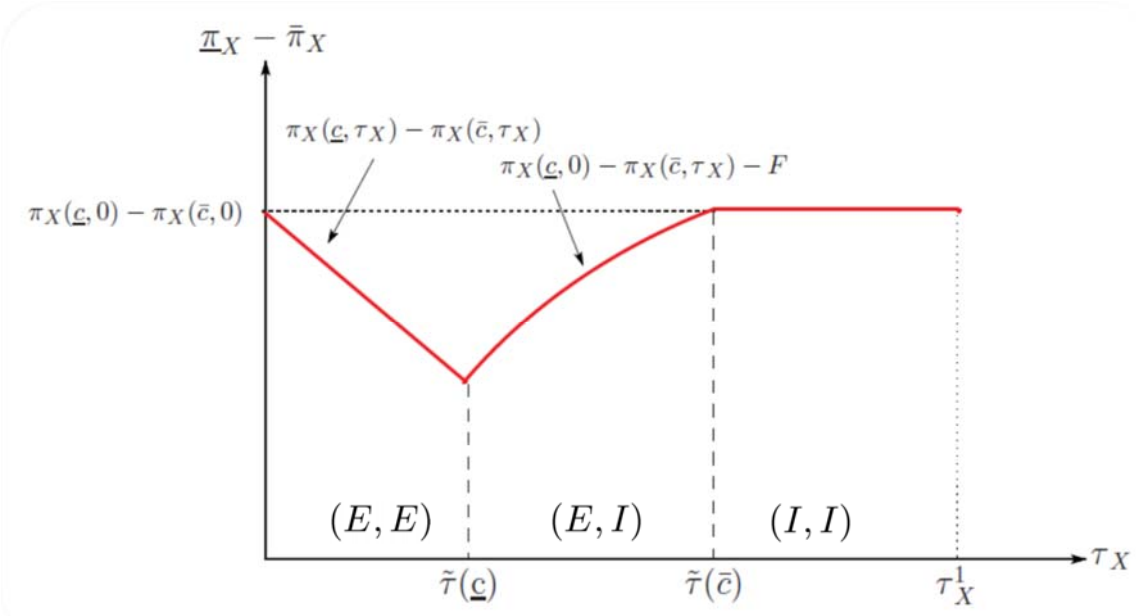


Results

Proposition 1
Given the tariff level:

- Liberalization of FDI never delays the equilibrium timing of the foreign firm's technology adoption.
- The fastest timing of technology adoption is realized when F reaches the level with which Firm X always undertakes FDI.

Figure 4: Trade Liberalization (A Single Foreign Firm)



Results

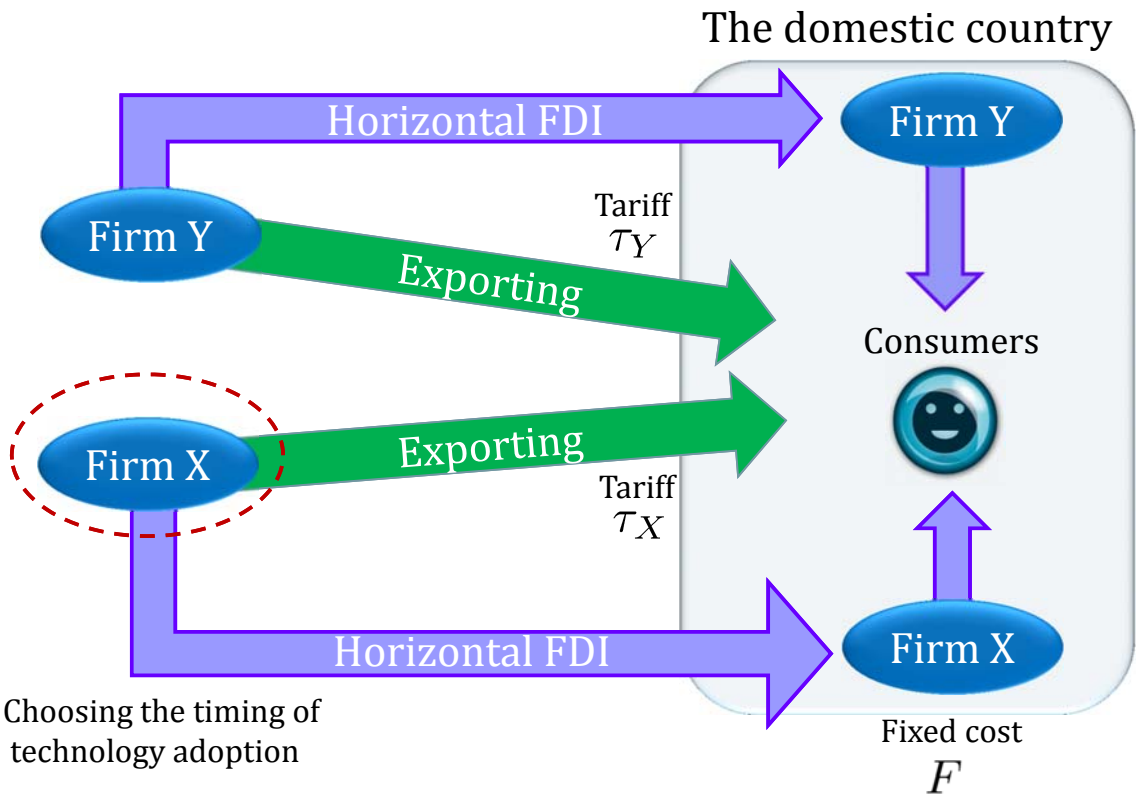
Proposition 2
Given the fixed cost for FDI:

- Trade liberalization of FDI either speeds up or delays the equilibrium timing of the foreign firm's technology adoption.
- The fastest timing of technology adoption is realized when the tariff is eliminated, or it is high enough to induce the foreign firm's FDI in all periods.

- If the lower bound of the fixed cost for adoption, $K(t) = \underline{K}$ is high, the new technology may not be adopted in some cases.

Corollary 1
If the new technology is adopted, it is always adopted when the foreign firm is free from tariff in both before and after technology adoption.

The model with two foreign firms



The model with two foreign firms

- Another foreign firm, Firm Y, produces the same good.
- Firm Y has already adopted the new technology at $t = 0$.

$$\pi_Y = \{p(Q) - \underline{c} - \tau_Y\}q_Y$$

- The Firm Y's instantaneous profit from selling the good:
  - The total supply: $Q = q_X + q_Y$
- A linear demand is assumed for simplicity.

The model with two foreign firms

The timing of the game.
There are three stages in each period.

- **Stage 1**: Firm X decides whether it adopts the new technology (if it hasn't adopted it until the previous period) .
- Stage 2: Firms X and Y simultaneously choose their supply modes between exporting and FDI.
- Stage 3: The two firms engage in a Cournot competition in the domestic market.

The equilibrium

[Stage 3: Product market competition]

- The equilibrium instantaneous profits are given by

$$\pi_X(c_X, \tau_X, \tau_Y), \quad \pi_Y(c_X, \tau_X, \tau_Y).$$

$$\begin{cases} c_X \uparrow \Longrightarrow \pi_X(c_X, \tau_X, \tau_Y) \downarrow, \ \pi_Y(c_X, \tau_X, \tau_Y) \uparrow \\ \tau_X \uparrow \Longrightarrow \pi_X(c_X, \tau_X, \tau_Y) \downarrow, \ \pi_Y(c_X, \tau_X, \tau_Y) \uparrow \\ \tau_Y \uparrow \Longrightarrow \pi_X(c_X, \tau_X, \tau_Y) \uparrow, \ \pi_Y(c_X, \tau_X, \tau_Y) \downarrow \end{cases}$$

- In exporting, the same tariff is applied to both firms:

$$\tau_X = \tau_Y = \tau$$

  - They might locate in the same foreign country.
  - The MFN principle of GATT/WTO.

The equilibrium

[Stage 2: The choices between exporting and FDI]

- The gains from FDI when the rival firm chooses exporting.

Firm X: $\Omega_X(c_X, \tau, \tau) = \pi_X(c_X, 0, \tau) - \pi_X(c_X, \tau, \tau)$

Firm Y: $\Omega_Y(c_X, \tau, \tau) = \pi_Y(c_X, \tau, 0) - \pi_Y(c_X, \tau, \tau)$

- The gains from FDI when the rival firm chooses FDI.

Firm X: $\Omega_X(c_X, \tau, 0) = \pi_X(c_X, 0, 0) - \pi_X(c_X, \tau, 0)$

Firm Y: $\Omega_Y(c_X, 0, \tau) = \pi_Y(c_X, 0, 0) - \pi_Y(c_X, 0, \tau)$

The equilibrium

- The Two firms' FDIs are strategic substitutes.

$$\Omega_X(c_X,\tau,\tau) > \Omega_X(c_X,\tau,0)$$
$$\Omega_Y(c_X,\tau,\tau) > \Omega_Y(c_X,0,\tau)$$

- Before Firm X adopts the new technology ($c_X = \bar{c}$), the Firm Y's gains from FDI are higher than the Firm X's gains.

$$\Omega_Y(\bar{c},\tau,\tau) > \Omega_X(\bar{c},\tau,\tau)$$
$$\Omega_Y(\bar{c},0,\tau) > \Omega_X(\bar{c},\tau,0)$$

- Assume $\Omega_Y(\bar{c},0,\tau) > \Omega_X(\bar{c},\tau,\tau)$ holds.
  - Firm Y always has an incentive to undertake FDI whenever Firm X undertakes FDI if Firm Y doesn't.
  - Without this assumption, either Firm X or Firm Y becomes the FDI-firm while the other firm chooses exporting when $\Omega_X(\bar{c},\tau,\tau) > F \geq \Omega_Y(\bar{c},0,\tau)$ holds.

The equilibrium

Firm X's choice before its technology adoption

Firm X's choice after its technology adoption

$$\left(s_X(\bar{c}), s_X(\underline{c}); s_Y(\bar{c}), s_Y(\underline{c})\right)$$

Firm Y's choice after the rival's adoption

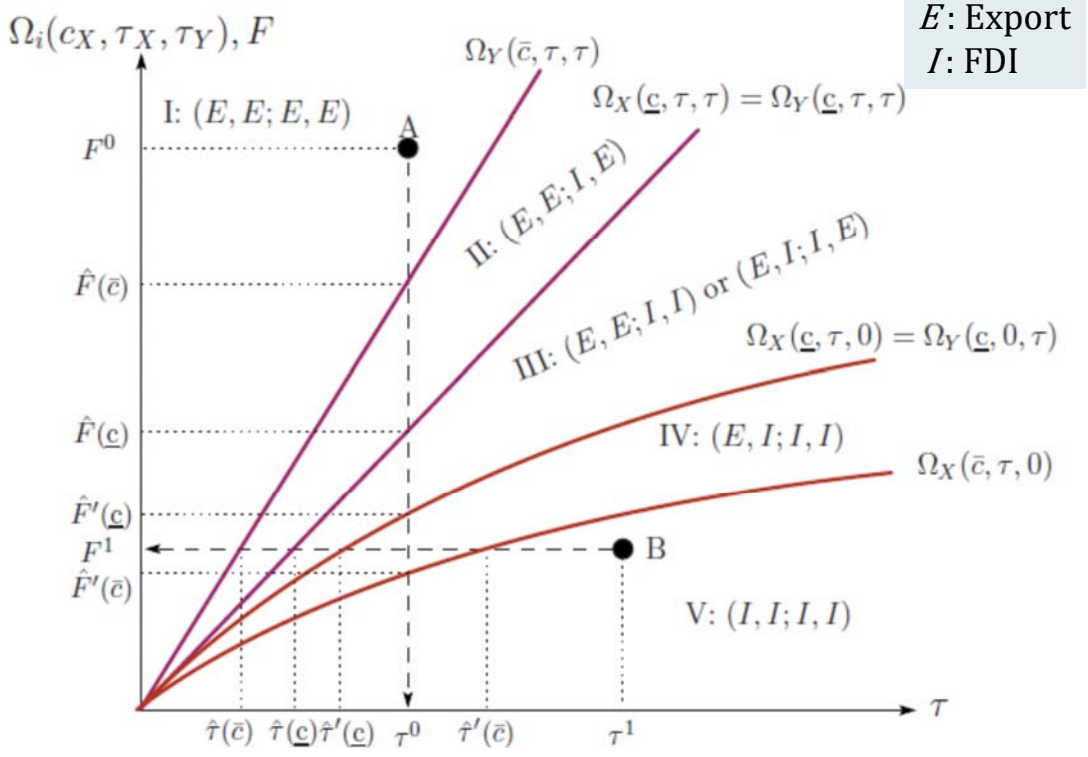
Firm Y's choice before the rival's technology adoption

$$s_i(c_X) \in \{E, I\}$$

E: Export
I: FDI

Figure 5: Choices between exporting and FDI (Two foreign firms)

E: Export
I: FDI



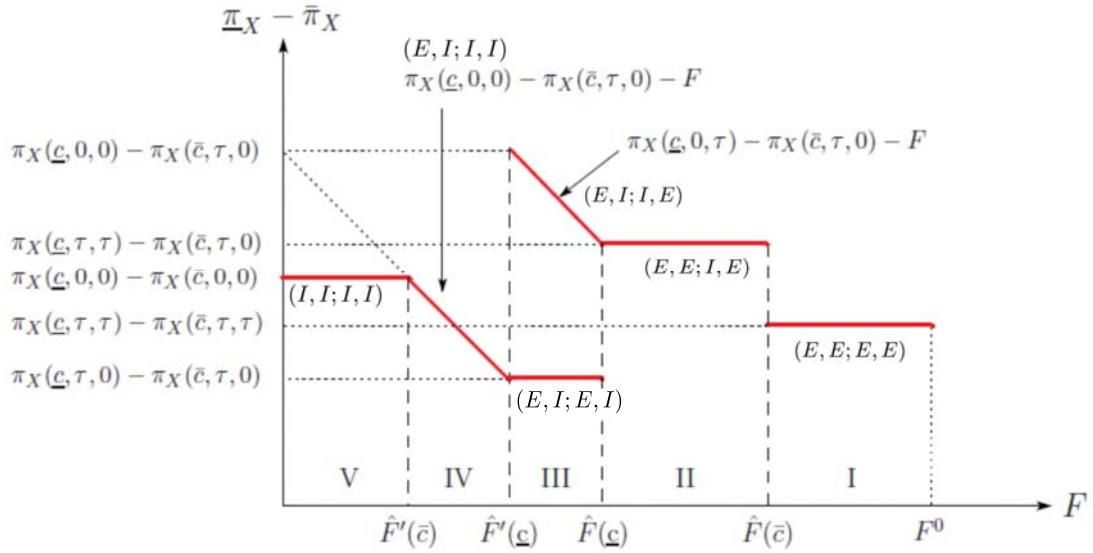
The comparison of gains from technology adoption

✓ The FOC to derive the optimal timing of technology adoption is identical to that in the single-firm model.

Region	The equilibrium location	$\underline{\pi}_X - \bar{\pi}_X$
I	$(E, E; E, E)$	$\pi_X(\underline{c}, \tau, \tau) - \pi_X(\bar{c}, \tau, \tau)$
II	$(E, E; I, E)$	$\pi_X(\underline{c}, \tau, \tau) - \pi_X(\bar{c}, \tau, 0)$
III	$(E, I; I, E)$	$\{\pi_X(\underline{c}, 0, \tau) - F\} - \pi_X(\bar{c}, \tau, 0)$
	$(E, I; E, I)$	$\pi_X(\underline{c}, \tau, 0) - \pi_X(\bar{c}, \tau, 0)$
IV	$(E, I; I, I)$	$\{\pi_X(\underline{c}, 0, 0) - F\} - \pi_X(\bar{c}, \tau, 0)$
V	$(I, I; I, I)$	$\pi_X(\underline{c}, 0, 0) - \pi_X(\bar{c}, 0, 0)$

- In **Region II**, the technology adoption blocks the rival's FDI.
- In **Region III**, it may triggers Firm X's FDI while crowding out the rival's FDI.
- In **Region IV**, it triggers Firm X's FDI without the crowding-out effect.

Figure 6: Liberalization of FDI (Two Foreign Firms)



Results

Proposition 3
Given the tariff level:

- Liberalization of FDI either speeds up or delays the equilibrium timing of Firm X's technology adoption.
- The fastest timing of technology adoption is realized with a positive fixed cost for FDI.

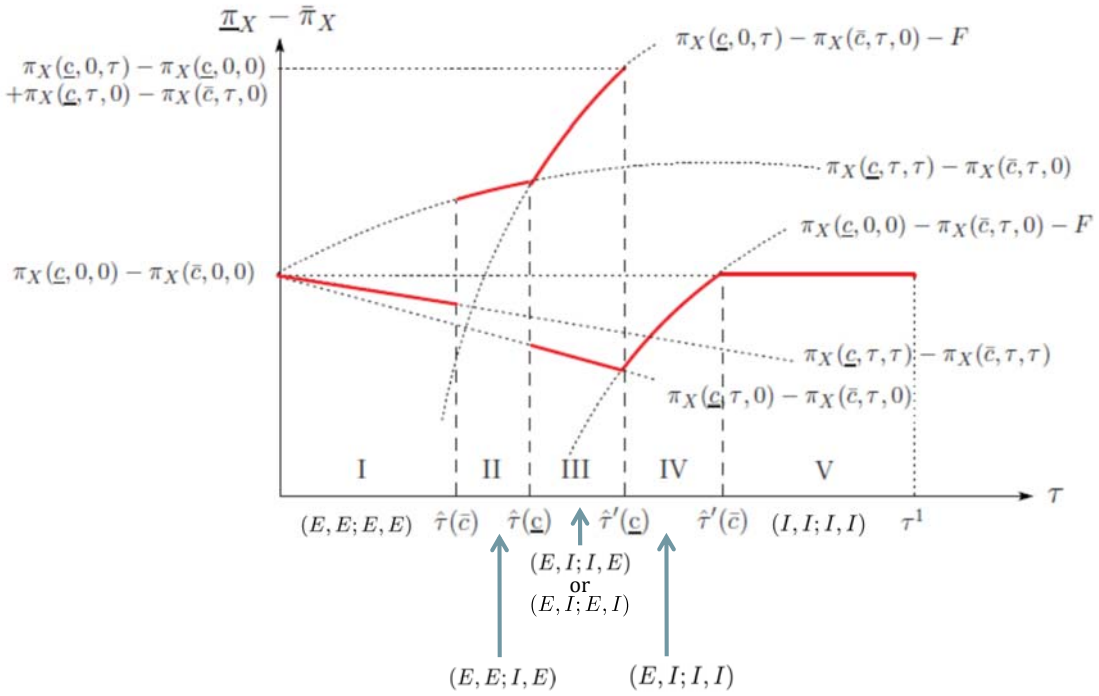
The Intuition behind the Result

- A reduction of the fixed cost basically promotes both firms' FDIs.
- It promotes Firm Y's FDI more in the pre-adoption periods, due to the technology gap.
- The rival's FDI reduces Firm X's gains from technology adoption because it intensifies the product market competition.
  - If F is sufficiently reduced such that Firm Y always chooses FDI while Firm X doesn't in the pre-adoption periods (Regions III and IV), the gains from technology adoption may become lower than those before the liberalization of FDI (Region I).

The Intuition behind the Result

- If F is reduced such that Firm Y chooses FDI in the pre-adoption periods but still large enough to block both firms' FDIs in the post-adoption periods(Region II),
  - the reduction of F gives Firm X an extra gain from technology adoption, since it blocks the rival's FDI.
- If the rival's FDI is replaced by its own FDI (Region III), the gains from adoption become even higher.
  - The gains from technology adoption in Regions II and III become higher than those when both firms always undertakes FDI (Region V).

Figure 4: Trade Liberalization (Two Foreign Firms)



Results

Proposition 4
Given the fixed cost for FDI:

- Trade liberalization either speeds up or delays the equilibrium timing of Firm X's technology adoption.
- The fastest timing of technology adoption is realized with a positive tariff.

- If the lower bound of the fixed cost for adoption is high, the new technology may not be adopted in some cases.

Corollary 2
There is a case where the foreign firm never adopts the new technology when it is free from tariff in all periods, but adopts the new technology when it faces tariff at least in some periods.

Summary and Conclusion

The first study to explore how trade liberalization and liberalization of FDI affects the timing of technology adoption, given firms' locations are endogenously determined.

- ✓ In the absence of strategic interaction between foreign firms in locations choices, free trade or promoting FDI is the best policy to accelerate technology adoption.
- ✓ In the presence of the strategic interaction, the fastest timing of technology adoption is realized when a tariff and the fixed cost for FDI are in the intermediate level.

(Tentative) policy implication:

- An ex-ante improvement of market access does not necessarily promote and speed up technology adoption.
- Policies should be designed such that technology adoption leads to an ex-post improvement of market access of the adopting firm.

Works in progress and possible extensions

- Welfare analysis
- Preferential liberalization of trade and FDI
- Licensing contracts
- Technology adoption games between two firms.
  - ➢ Endogenous technology gaps