FDI, Technology Spillover, and Vertical Product Differentiation

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Presentation at ESAM09 - ANU, Jul 2009
Introduction

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- Northern firms with superior technology often introduce second-best or outdated technology in FDI affiliates.
- Example: The Japanese flying geese model; Hongkong’s FDI in China’s garment industry.
- Example: Chery Automobile hired a number of engineers from Nissan-Dongfeng joint venture which was established upon Nissan’s FDI in China. Technology spillover through these engineers significantly enhanced Chery’s product quality.
Research questions

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- How does spillover affect the Northern firm’s choice of product quality?
- Welfare consequences of trade policy and technology spillover (IPR) in this context.
Cost-reducing technology spillover:

Chin and Grossman (1990)

- Cournot duopoly in an integrated world economy.
- Firm $N$ and firm $S$. Homogeneous good. Constant MC.
- Firm $N$: cost-reducing R&D $\Rightarrow$ may spillover to firm $S$.
- North-South conflict with low R&D efficiency while consensus with high R&D efficiency.

International duopoly of vertical product differentiation

- Firm $N$ and firm $S$ compete in the South.
- Firm $S$ is in the South, while firm $N$ chooses HP or FDI.
- Let $q_k$ ($k = N, S$) denote the quality of firm $k$’s product.

Demand side

- Two group of consumers: Group $j$ with mass $m_j$, $j = H, L$.
- Each group $j$ consumer consumes 0 or 1 unit of the products. Gross benefit: $v_j q_k$, where $v_H > v_L > 0$. A simplification of Mussa and Rosen (1978).
Quality choice and technology spillover

- No fixed costs and constant MC, $c_k(q_k)$, $k = N, S$.
- $q_N$ can take any positive value while $q_S \leq \bar{q}_S$ must hold.

**HP subgame**
- $\hat{q}_S = \bar{q}_S$.
- $c_N(q_N) = c(q_N) + w$ and $c_S(q_S) = c(q_S)$.
- A specific tariff, $t$.

**FDI subgame**
- $\hat{q}_S = \max(\bar{q}_S + \theta(q_N - \bar{q}_S), \bar{q}_S), \theta \in [0, 1]$.
- Interpretation of $\theta$.
- $c_N(q_N) = c(q_N)$ and $c_S(q_S) = c(q_S)$.

Let $c(q_k) = \frac{1}{2} q_k^2$. 
[Stage 1] Firm $N$ chooses $HP$ or $FDI$.

[Stage 2] Firm $N$ chooses $q_N$. Having observed $q_N$, firm $S$ chooses $q_S$, subject to $q_S \leq \hat{q}_S$.

[Stage 3] Firm $N$ and firm $S$ simultaneously set prices for their own products, and then consumers make purchase decisions.
Proposition 1

Derive SPNE. Focus on *Segmentation Equilibria*, where firm $N$ sells its product to all type-H consumers only while firm $S$ sells its product to all type-L consumers only.

**Proposition 1:**

- There exist a unique value $\tilde{m}_H > 0$ such that the game has a segmentation equilibrium if and only if $m_H > \tilde{m}_H$.
- If $m_H > \tilde{m}_H$, the segmentation equilibrium is the unique equilibrium of the game.
Proposition 1 (cont.)

- In the segmentation equilibrium, 
  \[ p_S = v_L q_S \text{ and } p_N = v_H q_N - (v_H - v_L) q_S. \]
- Firm S extracts all surplus from type L consumers by charging 
  \[ p_S = v_L q_S. \]
Proposition 1 (cont.)

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- Firm S extracts all surplus from type L consumers by charging \( p_S = v_L q_S \).
- Firm N must give the rent \( (v_H - v_L)q_S \) to type H consumers.
- In the FDI equilibrium, profits of firms N and S are respectively \( \pi_N(q_N) = m_H [v_H q_N - (v_H - v_L)q_S - \frac{1}{2} q_N^2] \) and \( \pi_S(q_S) = m_L [v_L q_S - \frac{1}{2} q_S^2] \).
- At stage 2, firm S chooses \( q_S = \min \{ v_L, \hat{q}_S \} \).
- Therefore, if \( \hat{q}_S < v_L \), an increase in \( \theta \) increases firm S’s equilibrium quality, decreases firm N’s profit.
Proposition 2:

- Suppose $m_H > \tilde{m}_H$. There exists a value $\theta^* \in (0, 1]$ such that the equilibrium of the game is an FDI equilibrium if $\theta < \theta^*$, and it is an HP equilibrium if $\theta \geq \theta^*$.

- There exists a value $\Psi \geq 0$ such that $\theta^*(< 1)$ is strictly increasing in $t$ if $\bar{q}_S < v_L$ and $t + w \leq \Psi$, and $\theta^* = 1$ otherwise.
Effects of trade policy

- Comparative statics exercises in terms of $t$.
- Assume $m_H > \tilde{m}_H$ for all $t \geq 0 \Leftrightarrow$ The game has a segmentation equilibrium for all $t \geq 0$.
- Notations: $\pi_N(t)$, $\pi_S(t)$, $CS(t)$, $TS(t)$, and $WW(t)$.
- Analyze the case of $\bar{q}_S < v_L$, $w \leq \Psi$, and $\theta \geq \theta^*|_{t=0}$. Otherwise, firm $N$ chooses $FDI$ for all $t \geq 0$.

**Lemma 1.** Suppose $\bar{q}_S < v_L$, $w \leq \Psi$, and $\theta \geq \theta^*|_{t=0}$, there exists a threshold $\tilde{t}$ such that:
(i) The equilibrium of the game is an $HP$ equilibrium if $t \leq \tilde{t}$, and
(ii) The equilibrium of the game is an $FDI$ equilibrium if $t > \tilde{t}$. 
Proposition 3

For all \( t \in [0, \bar{t}] \),

- \( t \uparrow \Rightarrow \pi_N(t) \downarrow, \ TS(t) \uparrow \).
- \( t \uparrow \Rightarrow \) no effects on \( \pi_S(t), \ CS(t), \ WW(t) \).

For \( t \in [0, \bar{t}] \), tariff functions as a channel for welfare transfer between firm \( N \) and Southern government.
Proposition 4

Compare $t = \bar{t}$ (HP) and $t = t' > \bar{t}$ (FDI).

**Proposition 4.** $CS(t') > CS(\bar{t})$ and $\pi_S(t') > \pi_S(\bar{t})$ hold.

- Firm $S$'s profit: $\pi_S(q_S) = m_L[v_L q_S - \frac{1}{2} q_S^2]$.
- Consumer surplus: $CS = m_H(v_H - v_L) q_S$.
- $HP \Rightarrow$ No spillover $\Rightarrow q_S = \bar{q}$.
- $FDI \Rightarrow$ Spillover $\Rightarrow q_S > \bar{q}$. 
Proposition 5

\[ \pi_N(t') = \pi_N(\bar{t}) \text{ and } WW(t) = TS(t) + \pi_N(t) \]
\[ \Rightarrow TS(t') > TS(\bar{t}) \iff WW(t') > WW(\bar{t}) \]

Proposition 5. There exists values \( \hat{\nu}_L > \bar{\eta}_S \) and \( \bar{m}_H \geq \bar{m}_H \) with the following properties:

(i) If \( \nu_L \leq \hat{\nu}_L \), \( TS(t') > TS(\bar{t}) \) and \( WW(t') > WW(\bar{t}) \).
(ii) If \( \nu_L > \hat{\nu}_L \),

- \( TS(t') > TS(\bar{t}) \) and \( WW(t') > WW(\bar{t}) \) if \( m_H < \bar{m}_H \).
- \( TS(t') < TS(\bar{t}) \) and \( WW(t') < WW(\bar{t}) \) if \( m_H > \bar{m}_H \).
Logic behind Proposition 5

- Efficient (WW maximizing) quality levels:
  \( q_{NW} = v_H, \ q_{SW} = v_L \).
- Recall \( \pi_N(q_N) = m_H[v_H q_N - (v_H - v_L)q_S - \frac{1}{2}q_N^2] \).
- \( q_N = v_H \Rightarrow \hat{q}_S = \bar{q}_S + \theta(v_H - \bar{q}_S) \).
- By choosing \( q_N = q'_N < v_H \) instead of \( q_N = v_H \), firm \( N \) can reduce \( q_S \) from \( \min(\bar{q}_S + \theta(v_H - \bar{q}_S), v_L) \) to \( \bar{q}_S + \theta(q'_N - \bar{q}_S) \).
- Firm \( N \)'s benefit of choosing suboptimally low level of \( q_N \) decreases as \( v_L \) decreases.
- There exists \( \hat{v}_L \) (< \( \min(\bar{q}_S + \theta(v_H - \bar{q}_S), v_L) \)) such that
  \( q^*_N = v_H \) if \( v_L \leq \hat{v}_L \) and
  \( q^*_N = (1-\theta)v_H + \theta v_L \) (< \( v_H \)) if \( v_L > \hat{v}_L \).
- This implies Proposition 5.
**Figure 1a.** $v_L \in (\bar{q}_S, \hat{v}_L]$; or $v_L > \hat{v}_L$ and $m_H < \bar{m}_H$.

**welfare**

- $WW$ \uparrow
- $TS$ \uparrow
- $\pi_N$
- $G$
- $CS$ \uparrow
- $\pi_S$

0 \rightarrow HP \rightarrow \bar{t} \rightarrow FDI \rightarrow t
Figure 1b. \( v_L > \hat{v}_L, m_H > \bar{m}_H. \)

**welfare**

- **WW**
- **TS**
- **π₉**
- **G**
- **CS**
- **π₅**

0 \( \leftarrow \) HP \( \rightarrow \) \( \bar{t} \) \( \leftarrow \) FDI \( \rightarrow \) t
In the presence of technology spillover, trade policy of the South may affect not only location choice but also quality choice of the Northern firm.
 Effects of trade policy: Summary

- In the presence of technology spillover, trade policy of the South may affect not only location choice but also quality choice of the Northern firm.
- An increase in tariff may induce the Northern firm to undertake FDI, which benefits the Southern firm as well as Southern consumers.
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Induced FDI can increase or decrease the Southern welfare and the world welfare.
Effects of technology spillover

- Comparative statics exercises in terms of $\theta$.
- Assume $m_H > \tilde{m}_H$ for all $\theta \in [0, 1) \iff$ The game has a segmentation equilibrium for all $\theta \in [0, 1)$.
- Focus on the case of $v_L > \bar{q}_S$, because, if $v_L \leq \bar{q}_S$, technology spillover has no role to play.
- Notations: $\pi_N(\theta)$, $\pi_S(\theta)$, $CS(\theta)$, $TS(\theta)$, and $WW(\theta)$.

**Lemma 2.** Suppose that the equilibrium of the game is an FDI equilibrium. Then, there exists a threshold $\hat{\theta} \in (0, 1)$ such that $q^*_N = (1 - \theta)v_H + \theta v_L < v_H$ if $\theta < \hat{\theta}$ and $q^*_N = v_H$ if $\theta \geq \hat{\theta}$. 
Proposition 7. There exist parameterizations under which 
\[ 0 < \theta^{TS} < 1, \] 
where \( \theta^{TS} \) is the optimal level of technology spillover for the South.

- See figure 2b.
Proposition 7 (cont.)

Figure 2b

\[ \text{welfare} \]

\[ 0 \quad \tilde{\theta} \quad \theta^* \quad 1 \]

\[ \text{FDI} \quad (q_N < v_H) \quad \text{HP} \]

\[ \text{WW} \downarrow \]

\[ \text{TS} \downarrow \]

\[ \pi_S^* \downarrow \]

\[ \pi_N^* \downarrow \]

\[ \text{CS} \downarrow \]

\[ \theta \]
Proposition 9. \( \theta_{WW} \leq \theta_{TS} \) holds, where \( \theta_{WW} \) maximizes world welfare.

- Northern firm strictly prefers \( \theta = 0 \)
- Southern firm optimally chooses \( \theta > 0 \)
- The world planner chooses \( 0 < \theta_{WW} < \theta_{TS} \).
- See figure 2e.
Proposition 9 (cont.)

Figure 2e

\begin{figure}[h]
\centering
\begin{tikzpicture}
\begin{axis}[
width=\textwidth,
height=0.5\textwidth,
axis lines=left,
xtick={0, \tilde{\theta}, \hat{\theta}, \theta^* = 1},
xticklabels={0, \tilde{\theta}, \hat{\theta}, \theta^* = 1},
xticklabel style={align=center},
\]
\addplot [domain=0:1, samples=100, color=black, thick] {sin(deg(x))};
\addplot [domain=0:1, samples=100, color=red, thick] {cos(deg(x))};
\addplot [domain=0:1, samples=100, color=blue, thick] {tan(deg(x))};
\addplot [domain=0:1, samples=100, color=green, thick] {log(deg(x))};
\end{axis}
\end{tikzpicture}
\caption{welfare}
\end{figure}

\[\pi^*_S \uparrow\]
\[\pi^*_N \uparrow\]
\[CS \uparrow\]
\[TS \uparrow\]
\[WW \uparrow\]

\[\tilde{\theta} < \theta < \hat{\theta} \Rightarrow FDI \quad (q_N < v_H) \]
\[\theta^* = 1 \Rightarrow FDI \quad (q_N = v_H)\]
Effects of Technology spillover: Summary

- Spillover rate may affect not only location choice but also quality choice of the Northern firm.
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- Spillover rate may affect not only location choice but also quality choice of the Northern firm.
- An increase in spillover rate may induce Northern firm to switch from FDI to HP.
Effects of Technology spillover: Summary

- Spillover rate may affect not only location choice but also quality choice of the Northern firm.
- An increase in spillover rate may induce Northern firm to switch from $FDI$ to $HP$.
- Northern firm strictly prefers a zero spillover rate, while the spillover rate that maximizes world welfare is (weakly) less than that maximizes Southern welfare.
Trade protection in the South harms Northern firm but makes both Southern firm and consumers better-off. The impact on world welfare and Southern welfare is, however, ambiguous.
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The North strictly prefers a zero spillover rate, while the South may not necessarily choose spillover rate equal to 1.
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Conclusion

- Trade protection in the South harms Northern firm but makes both Southern firm and consumers better-off. The impact on world welfare and Southern welfare is, however, ambiguous.

- In *FDI* subgame, Northern firm may lower its product quality from the socially efficient level.

- The North strictly prefers a zero spillover rate, while the South may not necessarily choose spillover rate equal to 1.

- The spillover rate that maximizes world welfare is (weakly) less than that maximizes Southern welfare.

- Our model, therefore, yields more insights and is more relevant with reality than the homogeneous product approach.