Agglomeration or Hollowing-Out

- Global Post (8/6/2012): “Taiwan’s highly educated workforce has been moving to China for more lucrative employment and business endeavors, but the result is a brain drain in Taiwan.”
Motivation

- Persistent trend in production fragmentation and intermediate goods trade (Jones 2000):
  - intensity of intermediate goods trade rose from < 2% in the 1960s to > 15% in the 1990s (Hummels-Ishii-Yi 2001)
  - share of intermediate trade exceeds 2/3 (Yi 2003)
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Is trade liberalization harmful for the health of the manufacturing sector?

This important issue cannot be addressed without an integrated theory of international trade, endogenous agglomeration and industry clustering.
Final goods trade:

- Helpman (1988): reduction in final goods trade costs induces international deglomeration (immobile land)
- Ottaviano-Tabuchi-Thisse (2002): reduction in final goods trade costs promotes regional agglomeration (variety effect)
- Behrens and Robert-Nicoud (2011): reduction in final goods trade costs promotes international agglomeration (selection effect)
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- Are the variety effect in NEG models crucial for the agglomeration effect of trade liberalization?
- Are firm selection in the sense of BEJK (2003), Melitz (2003) and Melitz-Ottaviano (2008) important for the relationship between trade costs and agglomeration outcomes?
Basic Structure

- 2 ex ante identical countries: labeled $l = A, B$
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- 2 types of workers:
  - unskilled: immobile, mass $L$
  - skilled: freely mobile, mass $M^l = \mu^l M$
    - $\mu^l \in (0, 1)$: fraction of skilled in $l$
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    - produced with unskilled labor
    - monopolistically competitive
  - final good:
    - homogeneous
    - produced with unskilled labor and intermediate goods
    - managed by skilled labor
    - perfectly competitive.
Final Good Sector

- Generalized quadratic production: \( Y_1^l = D_1^l \ln (\ell_1^l) \),

\[
D_1^l = \alpha \int_0^{N_l} q_1^l(j) \, dj - \frac{\gamma}{2} \int_0^{N_l} \left[ q_1^l(j) \right]^2 \, dj - \frac{\eta}{2} \left( \int_0^{N_l} q_1^l(j) \, dj \right)^2
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- \( q^l_1(j) = \) the amount of intermediate good \( j \) used (possibly produced or imported)
- \( \gamma > 0 \Rightarrow \) positive variety effect (similar to Ethier)
- \( \eta > 0 \Rightarrow \) intermediate good inputs are Pareto substitutes (consistent with NEG)
- without \( \ln (\ell^l_1) \), it reduces to Peng-Thisse-Wang (2006)
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- Profit or skilled compensation:

$$\nu^l = D_1^l \ln (\ell_1^l) - \int_0^{N_l} p^l(j) q_1^l(j) dj - \omega^l \ell_1^l$$
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- Final goods: freely traded across countries (numeraire).
Intermediate Goods Sector

- After paying a fixed input of $\kappa$ units of the final good, an entrant obtains a “new” intermediate good blueprint with productivity $z$
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- Distribution of marginal cost $c = 1/z$:

$$G(c) \equiv \Pr \left[ \frac{1}{Z} \leq c \right] = \Pr \left[ Z \geq \frac{1}{c} \right] = \left( \frac{c}{c_M} \right)^k$$

where $c \in (0, c_M]$, $c_M \equiv 1/z_M$ is the upper bound of $c$ corresponding to the lower bound of productivity $z_M$
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- Intermediate goods are tradable, but subject to an iceberg trade cost if trade occurs across borders: to deliver one unit across borders need to ship $\tau > 1$ units.
Final Good Sector

- Demand for unskilled labor:

\[ \ell_1^l = \frac{D_1^l}{w^l} \]
Final Good Sector

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- Demand for intermediate goods:

\[ p^l (j) = b^l \left[ \alpha - \eta \tilde{Q}_1^l - \gamma q_1^l (j) \right] \]

where \( b^l \equiv MPQ = \ln (\ell_1^l) = \ln \left( \frac{L}{\mu M} \right), \tilde{Q}_1^l \equiv \int_0^{N_l} q_1^l (j) dj \)
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- Linear inverse demand function for intermediate good \( j \):

\[ p^l (j) = p_{\text{max}}^l - \gamma b^l q_1^l (j) \]

where \( p_{\text{max}}^l \equiv \frac{\alpha \gamma b^l + \eta N^l \bar{p}^l}{\gamma + \eta N^l} \), \( \bar{p}^l \) = average intermediate price.
Intermediate Goods Sector

- Domestic sales ($D$) vs. exports ($X$):

\[
p^l_D(c) = \frac{p^l_{\text{max}} + c}{2}
\]
\[
p^l_X(c) = \frac{p^h_{\text{max}} + \tau c}{2}
\]
Intermediate Goods Sector

- Domestic sales ($D$) vs. exports ($X$):

  \[
  p_D^l(c) = \frac{p_{\text{max}}^l + c}{2} \]
  \[
  p_X^l(c) = \frac{p_{\text{max}}^h + \tau c}{2}
  \]

- Define $c_D^l \equiv p_{\text{max}}^l$ and $c_X^l \equiv p_{\text{max}}^h / \tau$:
  - any firms with $c > c_D^l$ must exit
  - those with $c_X^l < c < c_D^l$ conduct domestic sales
  - those with $c < c_X^l$ exports
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- Intermediate supplies and profits:
  \[
  q_D^l(c) = \frac{\mu^l M}{2 \gamma b^l} \left( c_D^l - c \right) ; q_X^l(c) = \frac{\tau \mu^h M}{2 \gamma b^h} \left( c_X^l - c \right) \\
  \pi_D^l(c) = \frac{\mu^l M}{4 \gamma b^l} \left( c_D^l - c \right)^2 ; \pi_X^l(c) = \frac{\tau^2 \mu^h M}{4 \gamma b^h} \left( c_X^l - c \right)^2
  \]
Skilled Workers

- No intermediate trade ($\tau \to \infty$):
  - intermediate goods aggregator:
    $$D_1^l = \frac{\alpha b^l - c^l_D}{\eta b^l} \left[ \frac{\alpha}{2} + \frac{(k + 1) c^l_D}{2b^l (k + 2)} \right]$$
  - final firm’s profit:
    $$v^l = \frac{\alpha b^l - c^l_D}{2\eta b^l} \left[ \alpha \left( b^l - 1 \right) - \frac{(k + 1) (b^l + 1) c^l_D}{(k + 2) b^l} \right]$$
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  - final firm’s profit:
    \[
    \nu^l = \frac{\alpha b^l - c_D^l}{2\eta b^l} \left[ \alpha \left( b^l - 1 \right) - \frac{(k+1)(b^l+1)c_D^l}{(k+2)b^l} \right]
    \]
- With intermediate trade ($\tau < \infty$) between 2 ex ante identical countries with Pareto firm distribution:
  - price distribution of goods sold by foreign firms matches that of those sold by domestic firms (Melitz-Ottaviano 2008)
  - $D_1^l$ and $\nu^l$ take the same forms as above
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  - Locational choice: $l^* = \arg \max_{l \in \{A,B\}} \{v^l\}$. 
Zero Cutoff Profit

- Matching price distribution across 2 countries => average price can be derived only based upon domestic firms:

\[ \bar{p}^l = \frac{1}{G(c_D^l)} \int_0^{c_D^l} p_D^l(c) dG(c) = \frac{2k + 1}{2k + 2} c_D^l \]

- Zero Cutoff Profit (ZCP):

\[ N_l = \frac{2(k + 1)\gamma}{\eta} \alpha \left[ \ln \left(\frac{L}{M}\right) - \ln \left(\mu^l\right) \right] - c_D^l \]

- Negative relationship between the cutoff \((c_D^l)\) and the number of intermediate firms selling to country \(l\) \((N_l)\): more competition in intermediate goods markets => tougher selection (smaller cutoff).
Free Entry of Intermediate Firms

- Zero expected profit:
  \[
  \kappa = \frac{M}{2\gamma (k+1)(k+2)(c_M)^k} \left[ \frac{\mu^l}{b^l} \left( c_D^l \right)^{k+2} + \frac{\tau^{-k}\mu^h}{b^h} \left( c_D^h \right)^{k+2} \right].
  \]

- Cutoff (interior case \(c_D^l < c_M\)):
  \[
  \left( c_D^l \right)^{k+2} = \theta \frac{b^l}{\mu^l} = \theta \frac{\ln (L/M) - \ln (\mu^l)}{\mu^l}
  \]
  where \(\theta \equiv \frac{2\gamma\kappa(k+1)(k+2)(c_M)^k}{(1+\tau^{-k})M}\) is increasing in \(\tau\) and \(\gamma\).

- Negative relationship between the cutoff \((c_D^l)\) and the size of the final good market \((\mu^l)\): larger final goods market (usually referred to as the market size effect) => tougher selection of intermediate firms (smaller cutoff).

- More unskilled labor force \(L\), higher transport cost \(\tau\) or stronger variety effect \(\gamma\) => easier selection.
Intermediate Good Demand and Supply

- Maximized profit:

\[
\nu^l = \frac{\alpha - (b^l)^{-\frac{k+1}{k+2}} \left( \frac{\theta}{\mu^l} \right)^{\frac{1}{k+2}}}{2\eta} \left[ \alpha (b^l - 1) - \frac{(k+1)(b^l + 1)(b^l)^{-\frac{k+1}{k+2}} \left( \frac{\theta}{\mu^l} \right)^{\frac{1}{k+2}}}{k+2} \right]
\]

where \( b^l \) is decreasing in \( \mu^l \)

- Higher \( \mu^l \) $\Rightarrow$ tougher selection $\Rightarrow$ higher productivity $\Rightarrow$ higher \( \nu^l \), where this gain is increasing in \( \theta \) (and hence trade cost)

- Lower trade cost (lower \( \theta \))
  - lowers MB(agglomeration) of skilled
  - lower cutoff $\Rightarrow$ tougher selection and higher \( \nu^l \) $\Rightarrow$ raise MB(agglomeration).
Labor Market and Locational Equilibrium

- **Labor market equilibrium:**
  - market clearing: $\mu^l M \ell_1^l = L$
  - equilibrium unskilled wage:
    $$
    \omega^l = \frac{\mu^l M}{L} \frac{\alpha \ln (L/M) - \ln (\mu^l) - c_D^l}{\eta b^l} \left[ \frac{\alpha}{2} + \frac{(k + 1) c_D^l}{2 b^l (k + 2)} \right]
    $$

- **Locational equilibrium:**
  - interior distribution: $\nu^l = \nu$ for $l = A, B$, whenever $\mu^l \in (0, 1)$
  - extreme distribution (full agglomeration): $\mu^l = 1$ and $\mu^h = 0$, if $\nu^l > \nu^h$. 
A world equilibrium is a list of quantities \( \{\ell^l_1, q^l_1(j), D^l, Y^l, N^l\} \), prices \( \{p^l(j), w^l, v^l\} \), cutoffs \( \{c^l_D, c^l_X\} \), and population distribution \( \{\mu^l\} \) for \( l = A, B \) and \( j \subseteq [0, N^l] \), such that

1. all final and intermediate firms optimize
2. the zero cutoff profit and free entry conditions are met
3. labor markets clear
4. locational equilibrium holds
5. population identity holds.
Equilibrium Configurations

- Without loss of generality, focus on: $\mu^A \geq \mu^B$
- Define: $\Delta v \equiv v^A - v^B$, $\mu \equiv \mu^A$ (so $\mu^B = 1 - \mu$)
- Types of equilibrium configurations:
  - symmetric configuration (dispersion): $\mu^l = 1/2$
  - agglomeration configuration: $\mu^l > 1/2$ (full agglomeration if $\mu^l = 1$)
- Stability: a world equilibrium is stable if
  - $d\Delta v/d\mu \leq 0$, for $\mu \in [1/2, 1)$
  - (i) $\Delta v > 0$ or (ii) $\Delta v = 0$ and $d\Delta v/d\mu \geq 0$, for $\mu = 1$. 
Existence and Stability

Theorem

1. A symmetric world equilibrium (SWE) always exists, with \( c_D^l < c_M \) for \( l = A, B \)
2. If the SWE is unstable, \( \exists \) an agglomeration world equilibrium (AWE) and almost surely at least one is stable.

- Key: to establish conditions under which the SWE is unstable and hence an AWE will arise
- Thus, we focus on conditions to ensure \( \frac{d\Delta v}{d\mu} \bigg|_{\mu=1/2} > 0 \).
Define: $\beta \equiv \ln \left( \frac{2L}{M} \right)$, $\tilde{\beta} \equiv \frac{1}{4} \left[ (k - 2) + (k^2 + 12k + 20)^{1/2} \right]$, $\Omega(\beta)$ and $\tilde{\theta}(\beta)$ (too ugly to show)

**Theorem**

1. If $\beta < \tilde{\beta}$, $\exists$ an AWE with a sufficiently large $\theta$
2. If $\beta > \tilde{\beta}$ and
   1. if $\Omega(\beta) > 0$, $\exists$ an AWE with intermediate $\theta$ in the neighborhood $I_{\tilde{\theta}(\beta)}$ of $\tilde{\theta}(\beta)$
   2. if $\Omega(\beta) < 0$, the SWE is stable.

- Key: Case 1 and Case 2(a) gives rise to agglomeration
- Under Case 2(b), there may still exist an agglomeration equilibrium.
Three Channels

- Decompose $\frac{d\Delta v}{d\mu} |_{\mu=1/2} = 2 \frac{d\nu^A}{d\mu^A} |_{\mu=1/2}$, where

$$\frac{d\nu^l}{d\mu^l} = \frac{\partial \nu^l}{\partial c^l_D} \left( \frac{\partial c^l_D}{\partial \mu^l} + \frac{\partial c^l_D}{\partial b^l} \frac{\partial b^l}{\partial \mu^l} \right) + \frac{\partial \nu^l}{\partial b^l} \frac{d b^l}{d \mu^l}.$$

1. Direct market size effect on selection $\frac{\partial \nu^l}{\partial c^l_D} \frac{\partial c^l_D}{\partial \mu^l}$: larger market size $\Rightarrow$ lower cutoff $\Rightarrow$ productivity gain and agglomeration (+)

2. Complementarity effect on selection: $\frac{\partial \nu^l}{\partial c^l_D} \frac{\partial c^l_D}{\partial b^l} \frac{\partial b^l}{\partial \mu^l}$: larger market size $\Rightarrow$ lower unskilled labor per firm $\Rightarrow$ lower intermediate demand and cutoff $\Rightarrow$ productivity gain and agglomeration (+)

3. Direct labor force effect $\frac{\partial \nu^l}{\partial b^l} \frac{d b^l}{d \mu^l}$: larger market size $\Rightarrow$ lower unskilled labor per firm $\Rightarrow$ lower final goods production gain and markup $\Rightarrow$ dispersion (-).
Trade and Agglomeration

- Trade liberalization (lower $\tau$):
  - negative direct labor force effect larger
  - impact on the two positive selection effects ambiguous: the importance of these selection effects depends on the unskilled labor force (via $\beta$)

Theorem

For a sufficiently small or sufficiently large unskilled labor force with an initially low trade cost, trade liberalization induces dispersion.

- Intuition: with lower trade cost,
  - sufficiently small unskilled labor force => unimportant selection effects => dominating negative direct labor force effect => dispersion
  - sufficiently large unskilled labor force => dominating selection effects, which are negative with low initial trade cost => dispersion.
Trade and Selection

Theorem

1. When trade liberalization induces agglomeration, it leads to tougher firm selection and raises productivity.
2. When trade liberalization induces dispersion, its effects on firm selection and productivity is ambiguous.

Intuition: with lower trade cost,

- direct effect => lower cutoff and tougher selection
- indirect endogenous entry effects due to complementarity between intermediate inputs (via $b^l$) and locational choice (via $\mu^l$)
  - lower cutoff and tougher selection if it induces agglomeration
  - higher cutoff and easier selection if it induces deglomeration.
Numerical Results I

- Much richer configurations than NEG
- Variety effect matters
- Baseline parameters: $\alpha = 10, \eta = 1, M = 5, L = 12, z_M = 0.01 (c_M = 100), k = 2, \gamma = 0.02, \kappa = 1$

Dispersion  
Agglomeration

![Dispersion Graph](image1)
![Agglomeration Graph](image2)

Figure 1: Case 1 under $\tau = 1.5$

Figure 2: Case 1 under $\tau = 10$
Numerical Results II

- Stronger variety effect ($\gamma \uparrow$) need not induce agglomeration

![Graphs showing the effect of $\gamma$ on $\overline{SV}$ for different cases of $\gamma$.](image-url)
Conclusions

**Main take-aways:**

- Trade liberalization may not induce agglomeration or dispersion of the skilled
  - agglomeration if the unskilled labor force is large and the initial trade cost is high
  - hollow-out of domestic industries possible for countries with initially low trade cost or smaller unskilled labor force (East Asian Tigers)
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Bonuses:

- Trade liberalization may not improve productivity: it enhances productivity via selection if it induces agglomeration
- Strong NEG variety effect need not induce agglomeration.