Lecture 6

Economic Integration and Agglomeration in a Middle Product Economy

Reference:

Peng, Shin-Kun, J.-F. Thisse, and Ping Wang, 2006, "Economic Integration and Agglomeration in a Middle Product Economy," *Journal of Economic Theory* *131, 1-25. (Leading Article)*

1. Introduction

1.1 Trade in General Equilibrium

- Ricardian: McKenzie (1954), Jones (1961)
- Heckscher-Ohlin: McKenzie (1955), Jones (1965,*JPE*)
- Specific Factors: Jones (1971), Samuelson (1971)
- **Middle Products**:
  - Sanyal and Jones (1982,*AER*): "the bulk of international trade consists of the exchange of intermediate products, raw materials, and goods which require further local processing before reaching the final consumer" (p.16)
  - Yi (2003,*JPE*): "vertical specialization [integration] has grown about 30 percent and accounts for about one-third of the growth in trade in the last 20-30 years" (p.55)

1.2. Trade and Growth

Theory: positive

- International specialization

  Stokey (1991, *RES*), Yi (2003, *JPE*)

- Variety enhancement

  Romer (1990, *JPE*), Grossman-Helpman (1992)

- Reverse engineering

  Revera-Bartiz-Romer (1991,*QJE*), Wan (2002)

- Technology transfer/adoption & R&D spillovers

  Krugman (1979,*JIE*), Chen-Shimomura (1998, *IER*)

- Learning from exporting

  Bond-Jones-Wang (2003, *IER*)

- **Empirics**: ambiguous relation
- Levin and Renelt (1992, AER)
- Frankel and Romer (1999, AER)

1.3. Agglomeration

- Trade and agglomeration:

  with final goods trade, strong variety bias and low transport (or trade) cost make regional agglomeration sustainable (Krugman, 1991, *JPE*)

  -**Negative Relation (Core-Periphery)**

  Krugman and Venables,(1995, *QJE*)

  Venables (1996, *IER*)

  Venables and Thisse (2001, *JPubE*)

  Ottaviano-Tabuchi-Thisse (2002, *IER*)

– **Non-monotonic relation**

Fujita and Krugman, (1995, *RSUE*)

Tabuchi, (1999, *JUE*)

– **Positive relation**

Helpman (1998)

1.4. Agglomeration and growth

Theory: **positive relation**

Palivos-Wang (1996, *RSUE*)

Black-Henderson (1999, *JPE*)

Martin (1999, JPubE)

Martin and Ottaviano (2001, *IER*)

Rossi-Hansberg-Wright (2003)

Empirics: ambiguous relation (Berliant-Wang 2004)

Urban Dynamics and Growth: Advances in Urban Economics**,** *Ch. 17*, Edited by Roberta Capello and Peter Nijkamp, Elsevier Science Publishers, B.V. North-Holland.

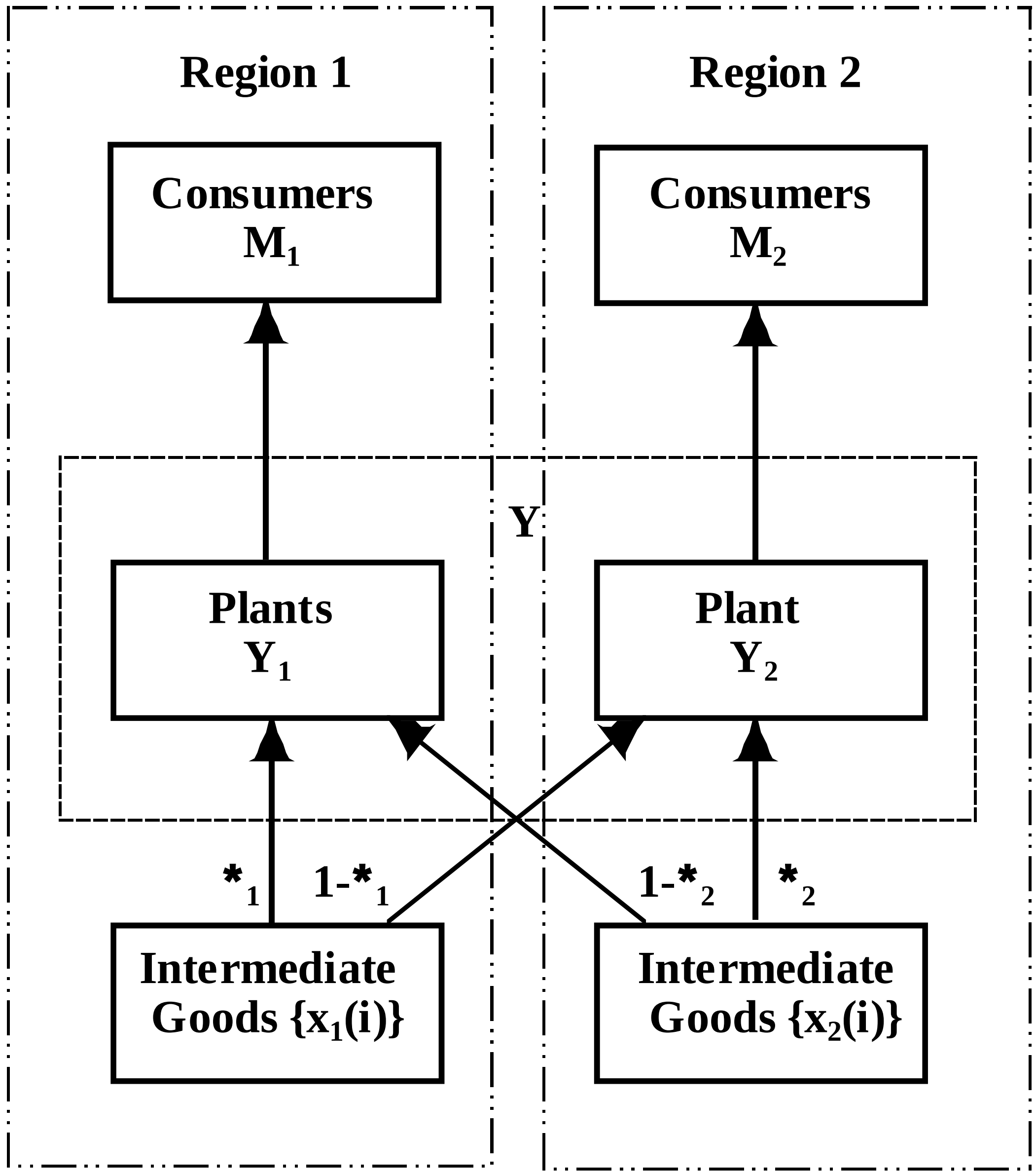
1.5. Open Issues

- Are employment agglomeration and output growth always positively related in a vertically integrated economy?
- Is intermediate goods trade always beneficial to economic growth?
- Does trade in middle products necessarily widen skilled-unskilled wage differential when skilled labor is mobile?

  (Leamer-Wood vs. Lawrence-Slaughter)

2. The Basic Structure

- Two regions (i=1,2), two sectors (intermediate/final)
- Final good:
  - homogenous and non-traded, used for consumption/investment
  - each firm with 2 plants, one in each region
  - using labor/intermediate goods as inputs
  - perfectly competitive
- Intermediate goods:
  - differentiated varieties (N_i) and traded (Ventura 1997; Yi 2003)
  - Using final good as input (capital)
  - shipping one unit interregionally needs $\tau > 0$ units of numéraire
  - intraregional shipping is at no cost
  - monopolistically competitive
- Two types of labor:
  - skilled: mobile, mass = L, designing final production process
  - Unskilled: immobile, mass = 1, manufacturing final production


Region 1
Region 2
Consumers M_1
Consumers M_2
Y
Plants Y_1
Plant Y_2
$*_1$
$1-*_1$
$1-*_2$
$*_2$
Intermediate Goods $\{x_1(i)\}$
Intermediate Goods $\{x_2(i)\}$

2.1.The Intermediate Sector

- Variety $v \in D_1 \equiv [0, N_1]$ in region 1
- Variety $v \in D_2 \equiv [N_1, N]$ in region 2
- Though intermediate goods production is decentralized, skilled workers are hired by the final sector to design intermediate product line:
  - unit skilled labor requirement $\varphi > 0$
  - $N_i = (1/\varphi)\lambda_i L$, i=1,2, with $\lambda_1 + \lambda_2 = 1$
  - each variety is supplied by a single firm
  - $N_1 + N_2 = N$

- Delivered price of variety *v* produced in region *i* and transported to region *j*:

$$p_{ii}(v) = p_i(v) \quad \text{and} \quad p_{ij}(v) = p_i(v) + \tau \quad (j \neq i)$$

- Production cost: each unit of variety *v* requires η >0 units of the numéraire
- Ouput: x(*v*,t)
- Profit:

$$\pi_i(v,t) = \max_{x(v)} \left[p_i(v,t) - r(t)\eta\right] x(v,t)$$

- Value of firm:

$$\Pi(v,t) = \int_t^{\infty} \pi(v,\mu) e^{-\int_t^{\mu}[r(s)-1]ds} d\mu$$

- Middle-product allocation (completely integrated if δ=1/2):

	$v \in D_1$	$v \in D_2$	Demand
1	$\delta_1(v)x(v)$	$(1-\delta_2(v))x(v)$	$x_1^d(v)$
2	$(1-\delta_1(v))x(v)$	$\delta_2(v)x(v)$	$x_2^d(v)$
Supply	$x(v)$	$x(v)$	

- Intermediate goods demand

$$x_1^d(v) = \begin{cases} \delta_1(v)x(v) & \text{if } v \in D_1 \\ (1-\delta_2(v))x(v) & \text{if } v \in D_2 \end{cases}$$

$$x_2^d(v) = \begin{cases} (1-\delta_1(v))x(v) & \text{if } v \in D_1 \\ \delta_2(v)x(v) & \text{if } v \in D_2 \end{cases}$$

- Production cost:

$$K_i \equiv \eta \left[\int_{D_i} x(v)dv \right]$$

2.2.The Final Sector

- Plant output in region i: upon employing the total amount of unskilled labor locally available (mass one),

$$Y_i = \int_0^N \left[\alpha - (\frac{\beta - \gamma}{2}) x_i^d(v)\right] x_i^d(v) dv - \frac{\gamma}{2} \left[\int_0^N x_i^d(v) dv\right]^2$$

  - α = intensity of intermediate goods production
  - $\beta > \gamma$ => the level of production is higher when the production process is more sophisticated
  - for a given value of β, $\gamma > (<) 0$ => intermediate good inputs are Pareto substitutes (complements)
- Total outputs: $Y = Y_1 + Y_2$

- Profit:

$$\begin{aligned} P &= Y - \int_{D_1} [p_1(v) + \tau(1 - \delta_1(v))]\, x(v) dv \\ &\quad - \int_{D_2} [p_2(v) + \tau(1 - \delta_2(v))]\, x(v) dv \\ &\quad - 2W_U - W_S L \end{aligned}$$

- Optimization:

$$v(t) = \max_{\{x(i), \delta_1(i), \delta_2(i)\}} P[x(i), \delta_1(i), \delta_2(i)]$$

- Value of firm:

$$V(t) = \int_t^{\infty} v(\mu) e^{-\int_t^{\mu} [r(s) - 1] ds} d\mu$$

2.3. Consumers

- Mass of region i residents: $M_i = 1 + \lambda_i L = 1 + \varphi N_i$
- Population changes: $$m_i \equiv \frac{\dot{M}_i}{M_i} = \left(\frac{\lambda_i L}{M_i}\right)\frac{\dot{\lambda}_i}{\lambda_i}$$
- Transformation: $$z_i \equiv \frac{Z_i}{M_i} \qquad k_i \equiv \frac{K_i}{M_i} \qquad y_i \equiv \frac{Y_i}{M_i}$$
- Optimization: (locational choice $\max_i U_i$)

$$U_i = \max_{\{z_i(t)\}} \int_0^\infty \frac{[z_i(t)]^{1-\sigma^{-1}} - 1}{1-\sigma^{-1}} e^{-\rho t} dt \qquad (\sigma > 1)$$

s.t.

$$\dot{k}_i = y_i - z_i - (m_i + d_i)k_i - \frac{1}{M_i}\int_{D_i} [(1-r)\eta + \tau(1-\delta_i(v))]\, x(v)dv$$

3. Equilibrium

- **Definition 1:** A **dynamic competitive equilibrium** (**DCE**) is a tuple of paths of quantities $\{z_i, k_i, y_i, x_i, \delta_i, N_i, M_i\}$ and a tuple of paths of prices $\{p_i, W_u, W_S\}$ such that:
  - ***final good and intermediate goods producers optimize***
  - ***zero profit condition for the final good market prevails***
  - ***the intermediate goods and the final good markets both clear***
  - ***the locational equilibrium condition for skilled workers holds***
  - ***population identities hold***
  - ***consumers optimize***

- By Walras' law, the zero profit conditions of the intermediate goods sector are automatically satisfied

3.1. The Final Sector

- FOC w.r.t. x(v):

$$\tilde{p}_i(v) = \alpha - (\beta - \gamma)\Delta_i(v)x(v) - \gamma \int_{D_i} \Psi_i(v,w)\Delta_i(w)x(w)dw$$

where interregional substitution multiplier and average trading price are given by:

$$\Psi_i(v,w) \equiv \left[(1-\delta_i(w)) + \delta_i(v)\left(2\delta_i(w) - 1\right)\right] / \Delta_i(w)$$

$$\tilde{p}_i(v) \equiv [\Gamma(i)p_1(v) + (1-\Gamma(i))p_2(v)] + \tau\left\{1 - [\Gamma(i)\delta_1(v) + (1-\Gamma(i))\delta_2(v)]\right\}$$

$$\Delta_i(v) \equiv (\delta_i(v))^2 + (1-\delta_i(v))^2$$

$$\Delta_i(w)x(w) - \Delta_i(v)x(v) = \frac{-1}{\beta - \gamma}[\tilde{p}_i(w) - \tilde{p}_i(v)]$$

- Intermediate goods demand:

$$x(v) = a_i(v) - b_i(v)\widetilde{p}_i(v) + c_i(v)\int_{D_i} \Psi_i(v,w)\left[\widetilde{p}_i(w) - \widetilde{p}_i(v)\right] dw$$

where

$$b_i(v) \equiv \left\{\Delta_i(v)\left[\beta + (\textstyle\int_{D_i} \Psi_i(v,w)dw - 1)\gamma\right]\right\}^{-1}$$

$$a_i(v) \equiv \alpha b_i(v) \text{ and } c_i(v) \equiv (\gamma/\beta - \gamma)b_i(v)$$

- FOC w.r.t. δ_i(v):

$$(\beta-\gamma)[2\delta_i(v)-1]x(v)+\gamma\int_{D_i}[2\delta_i(w)-1]x(w)dw = \tau x(v)$$

- Intermediate goods distribution and vertical integration:

$$\delta_i^* = \frac{1}{2}\left[1 + \frac{\tau}{\beta + \gamma\left(N_i - 1\right)}\right] \equiv \delta_i(N_i)$$

- **Proposition 1:** (***vertical integration***)
  - *The lower the interregional transport cost or the higher the variety bias is, the less the local varieties will be used by the final producers established in the corresponding region (**more vertical integration**);*
  - *when varieties are substitutes (complement), a higher mass of local varieties induces more (less) vertical integration.*

- Average pricing under symmetry:

$$\tilde{p}_i(v) = p_i(v) + \tau(1 - \delta_i(v)) = p_i + \tau(1 - \delta_i)$$

- Intermediate goods demand under symmetry:

$$x_i = \frac{\alpha - p_i - \tau(1 - \delta_i)}{[\beta + \gamma(N_i - 1)][\delta_i^2 + (1 - \delta_i)^2]}$$

$$= a_i - b_i[p_i + \tau(1 - \delta_i)]$$

$$\frac{\partial x_i}{\partial \tau} = -\frac{2\tau^2\{2\tau(1-\delta_i)^2 + (2\delta_i - 1)^2[2(\alpha - p_i) - \tau]\}}{\{[\beta + \gamma(N_i - 1)]^2 + \tau^2\}^2(2\delta_i - 1)^3} < 0.$$

- $$\frac{\partial \boldsymbol{x_i}}{\partial \boldsymbol{\delta_i}} = \tau \boldsymbol{b_i}(1 - 2\boldsymbol{x_i}) \le (>) 0. \quad \textbf{iff} \quad x_i \ge (<) \frac{1}{2}.$$

- **Proposition 2:** *Variety demand*
  - *decreases in τ*
  - *increases (decreases) with its share in the intermediate good usage by local plants when its input is smaller (larger) than ½ (**size matters**).*

- Skilled wage: $\boldsymbol{W_S} = \frac{1}{\boldsymbol{L}}\left\{\boldsymbol{Y} - \sum_{\boldsymbol{i}=1}^{2} \boldsymbol{N_i}\tilde{\boldsymbol{p}}_{\boldsymbol{i}}\boldsymbol{x_i} - 2\overline{\boldsymbol{W}}_{\boldsymbol{U}}\right\}$

3.2. The Intermediate Sector

- FOC: with respect to *x(v)*

$$p_i(v) - r\eta - \beta\Delta_i(v)x(v) = 0$$

- Intermediate good supply:

$$x_i = \frac{p_i - r\eta}{\beta[\delta_i^2 + (1-\delta_i)^2]} \equiv x_i(N_i, p_i)$$

$$= b_i[\beta + \gamma(N_i - 1)](p_i - r\eta)/\beta$$

- **Proposition 3:** (**variety effect**)
  - *The higher the common price is, the more the supply of each local variety*;
  - *When varieties are substitutes (complement), a larger mass of local varieties increases (decreases) the supply of each variety.*

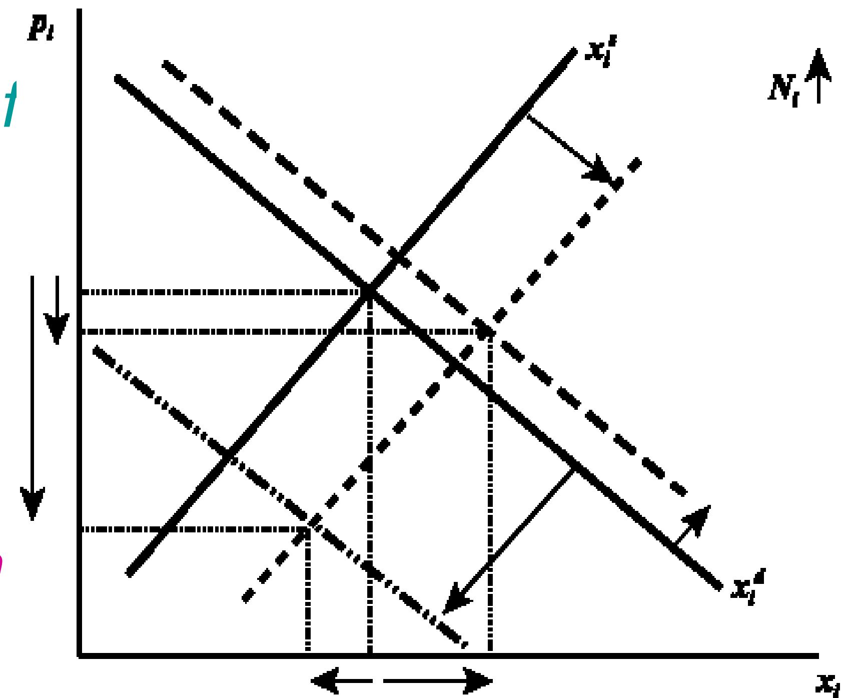
- Equilibrium variety prices:

$$p_i^* = \frac{r\eta\tau + \beta(2\delta_i - 1)[\alpha - \tau(1 - \delta_i)]}{\tau + \beta(2\delta_i - 1)} \equiv p_i(N_i)$$

- Equilibrium variety quantities:

$$x_i^* = \frac{(2\delta_i - 1)[\alpha - \tau(1 - \delta_i) - r\eta]}{[\delta_i^2 + (1 - \delta_i)^2][\tau + \beta(2\delta_i - 1)]} \equiv x_i(N_i)$$

- **Proposition 4:** *Assuming $\alpha + \tau/2 > r\eta$, a larger mass of local varieties lowers the intermediate goods prices but has an ambiguous effect on the equilibrium quantities ((+) interregional redistribution effect* vs. *(-) price effect)*



3.3.Consumption, Capital Accumulation and Locational Choice

- Keynes-Ramsey equation:

$$\frac{\dot{z}_i}{z_i} = \sigma \left\{ \frac{\delta_i}{\eta} \left[\alpha - \frac{\tau \delta_i k_i (1 + \phi N_i)}{\eta (2\delta_i - 1) N_i} \right] - (\rho + m_i + d_i) \right\}$$

- **Lemma 1:** *Assuming α + τ/2 > r η and β - γ > φ γ N², there exis$\overline{N}$ an > 0 a$\overline{k}$d a > 0 such that for all $N_i \in (0, \overline{N})$ and $k_i \in (0, \overline{k})$, y_i increases with N_i and k_i* (**strong dynamic efficiency**).
- Locational equilibrium condition: locational choice => no-arbitrage between regions, i.e.,

$$U_1(N_1) = U_2(N - N_1)$$

4. Steady-State Equilibrium

- **Definition 2:** *A **steady-state equilibrium** (**SSE**) is a dynamic competitive equilibrium {z_i, k_i, y_i, x_i, δ_i, N_i, M_i, p_i, W_S} such that all quantities reach zero growth and m_i=0 (for i=1,2).*

- Two fundamental relationships ($\frac{\dot{k}_i}{k_i} = \frac{\dot{z}_i}{z_i} = m_i = 0$):

$$k_i(N_i) = \frac{\eta}{\tau} \frac{2\delta_i - 1}{\delta_i} \frac{N_i}{1 + \phi N_i} \left[\alpha - \frac{\eta}{\delta_i}(\rho + d_i) \right]$$

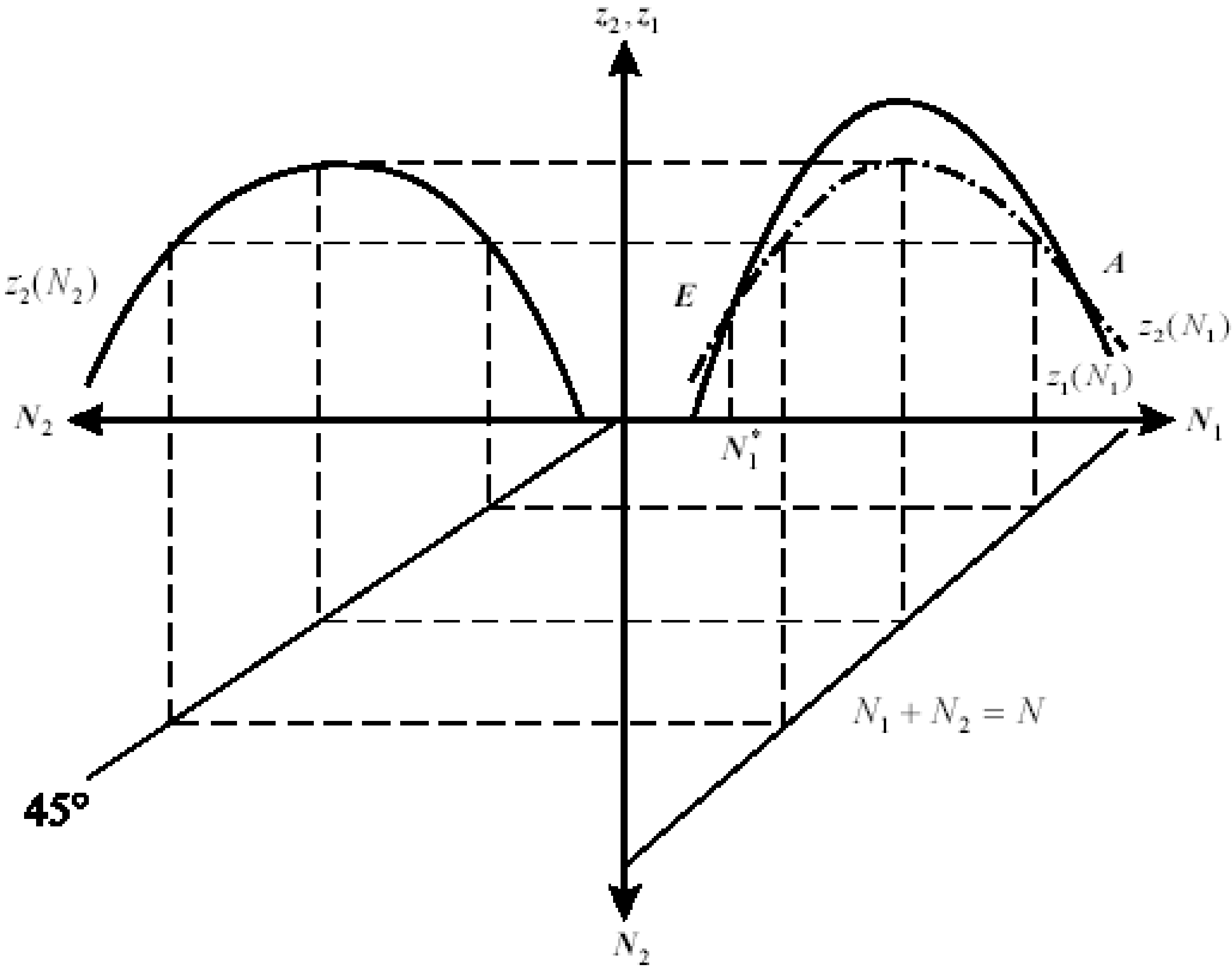
$$z_i(N_i) = y_i - d_i k_i - \frac{N_i x_i \left[(1 - r)\eta + \tau[(1 - \delta_i)] \right]}{1 + \phi N_i}$$

- **Lemma 2:** *Assuming* $\alpha + \tau/2 > r\eta$*, there exists* $\widetilde{N} > 0$ *such that for all* $N_i \in (0, \widetilde{N})$, $\frac{\partial k_i}{\partial N_i} > 0$ *and for all* $N_i \in (\widetilde{N}, N)$, $\frac{\partial k_i}{\partial N_i} < 0$.

- **Lemma 3:** *Assuming* $\alpha + \tau/2 > r\eta$ *and* $\beta - \gamma > \varphi\gamma N^2$*, there exists an* $\widehat{N} > 0$ *such that for* $N_i \in (0, \widehat{N})$, $\frac{\partial z_i}{\partial N_i} > 0$ *and for all* $N_i \in (\widehat{N}, N)$, $\frac{\partial z_i}{\partial N_i} < 0$.

- Lifetime utility: $$U_i = \frac{[z_i(N_i)]^{1-\sigma^{-1}}}{\left(\sigma^{-1} - 1\right)\rho}$$

  locational equilibrium condition => $z_1(N_1) = z_2(N_2)$



z_2, z_1
$z_2(N_2)$
E
A
$z_2(N_1)$
$z_1(N_1)$
N_2
N_1
N_1^*
$N_1 + N_2 = N$
45°
N_2

5. Comparative Static Analysis

- Basic Assumptions:

$\alpha + \tau/2 > r\,\eta$

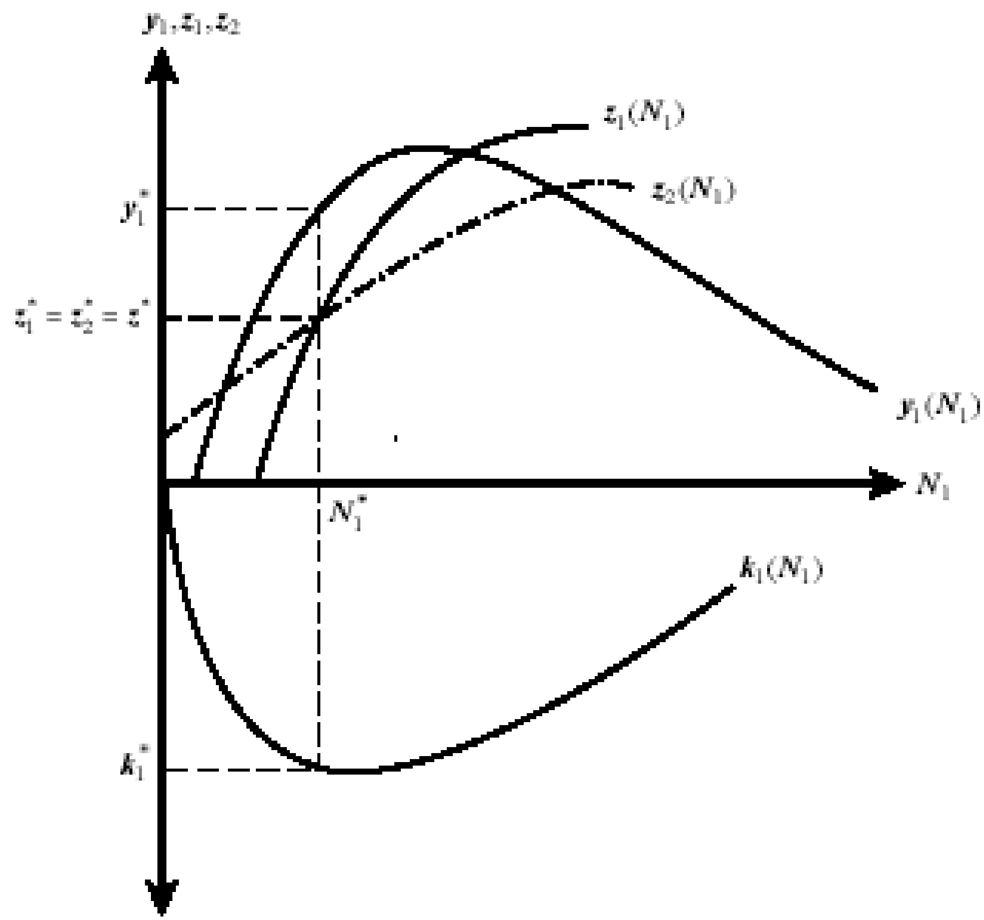
$\beta - \gamma > \varphi\,\gamma N^2,$

$\beta - \gamma > 1 + \tau$

$k_i \in (0, \overline{k})$

$0 < N_1 < \min\{\overline{N}, \widetilde{N}, \widehat{N}\}$

- Recursive system



Wage gap: $W_S - \overline{W_U}$

- **Trade liberalization**: τ decrease
- δ_i decrease, $\Rightarrow$ more vertical integration (proposition 1)
- x_i decrease, (proposition 2)
- p_i Increase, (proposition 4)
- N_i decrease, (proposition 5)
- Sum $\Rightarrow$ The effect on $W_S - \overline{W_U}$ is **ambiguous**
- **(**Leamer 1993, Wood 1994, Lawrence *et al*. 1993**)** ⇔ **(Magrini 2004)**

$$W_S - \overline{W_U} = \frac{1}{L}\{Y - \sum_{i=1}^{2} N_i p_i x_i - (2+L)\overline{W_U}\}$$

6. Conclusions: Main Findings

- ⇒ When **region 1 is a large economy** and region 2 is a small economy, a **decrease** in the inter-regional transport cost **induces** skilled labor mobility, promotes vertical integration, **discourages** employment agglomeration in the large economy, but has **ambiguous** effect on capital accumulation and regional output growth.

- ⇒ A more **efficient design** of the final good production process that occurs only in region 1 results in **higher employment agglomeration, capital accumulation and regional output growth**.

- ⇒ **Growth** and **employment agglomeration** need **not** be positively related in vertically integrated economies.

- ⇒ Middle-product trade need **not** widen the wage gap, due the opposing effects of productivity (+) vs. interregional redistribution (-).

Extensions

- Different utility levels and capital shares for mobile and immobile workers
- Endogenous growth via human capital accumulation or capital-dependent final good production technology
- Tradable final goods
- Optimal tariff in a vertically integrated economy
- Effectiveness of inter-regional transfer, tax and investment subsidy policies for alleviating the social inefficiency resulting from monopolistic competition and agglomeration externality

Thank you