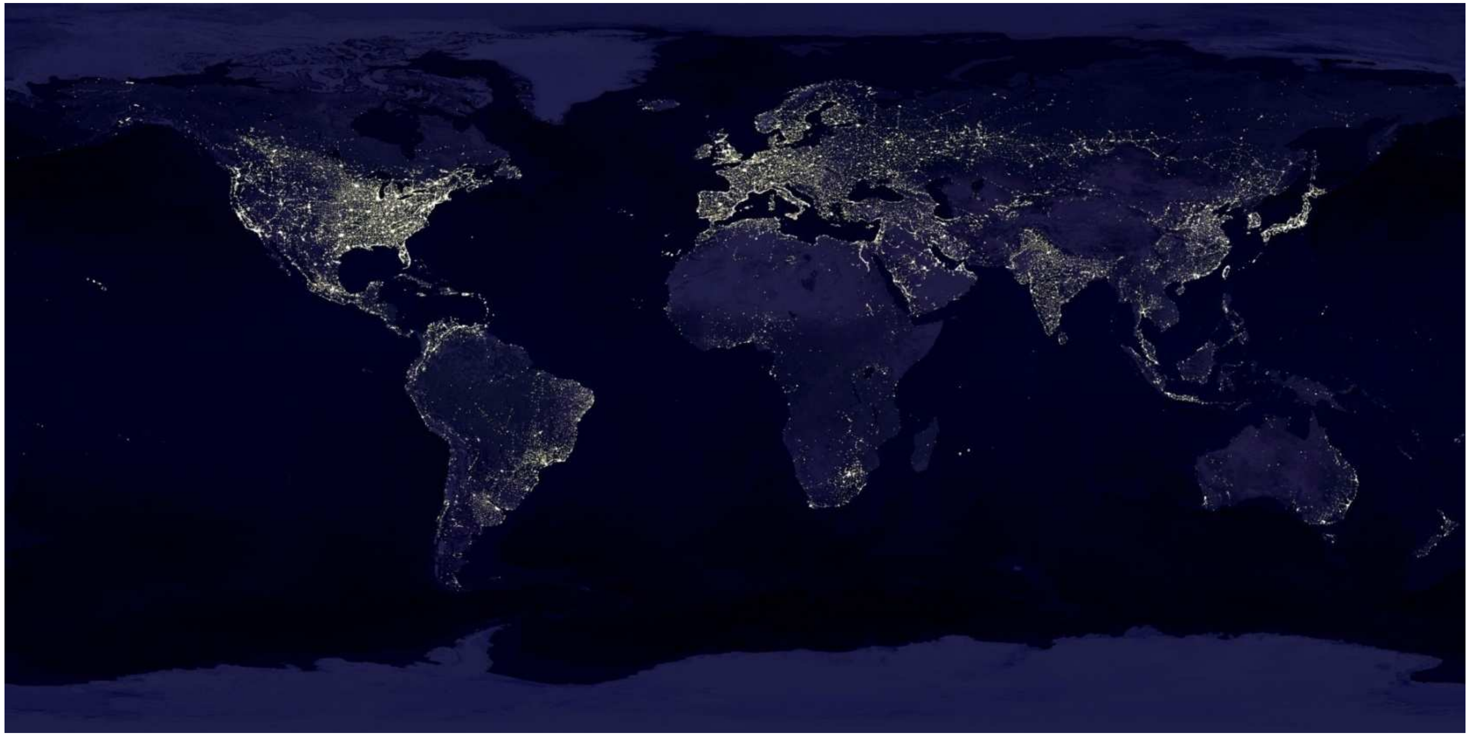
International Economics #4
Location Choice



Overview

1. **Why geography matters**
2. **Spatial economy: the Hotelling model**
3. **The core-periphery model**
4. **Multinational firms: a bird's eye view**

1. Why geography matters

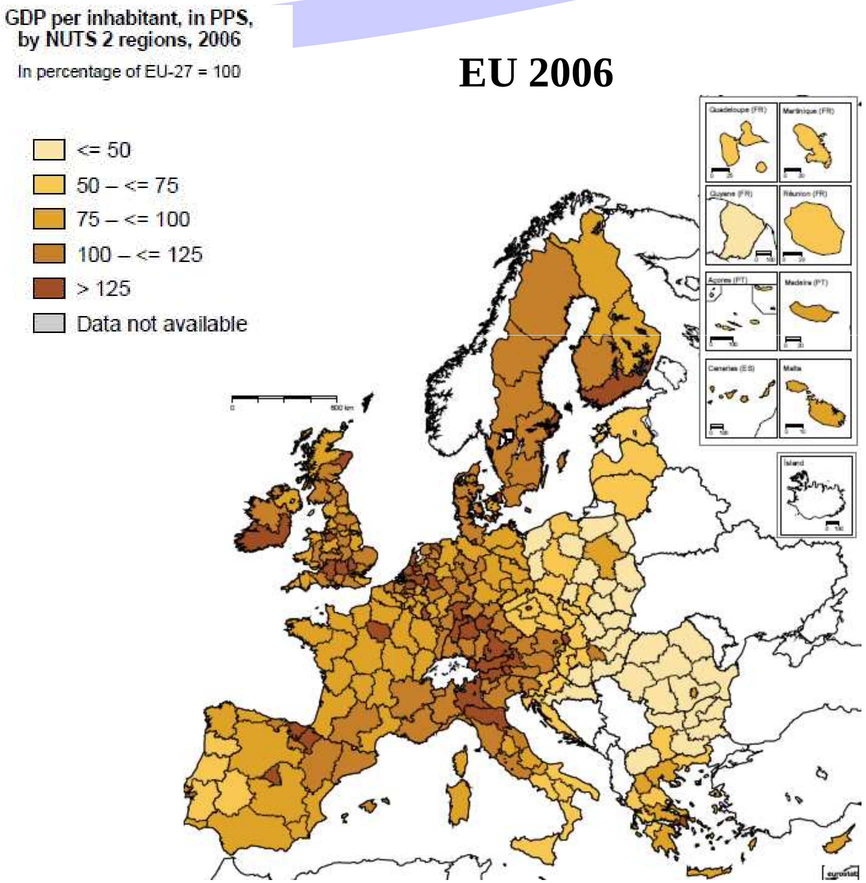
Traditional trade theory does not explain industry location well

- Hotelling's (1929) seminal work on spatial economy
- Neo-classical growth theory: representative agent models, no spatial granularity; convergence of nations
- Ricardo, HOS trade theory: explains trade in goods and services, not factor movements
- Such theories ignore **multiple equilibria** and **circular causality**, all of which can be **instable**
- First-generation endogenous-growth models ('AK' models, e.g. Romer)
  - Based on network or technological externalities
  - Account for local agglomeration (ex.: Silicon Valley) but not for interactions between regions
- Need to account for **pecuniar externalities** through market prices

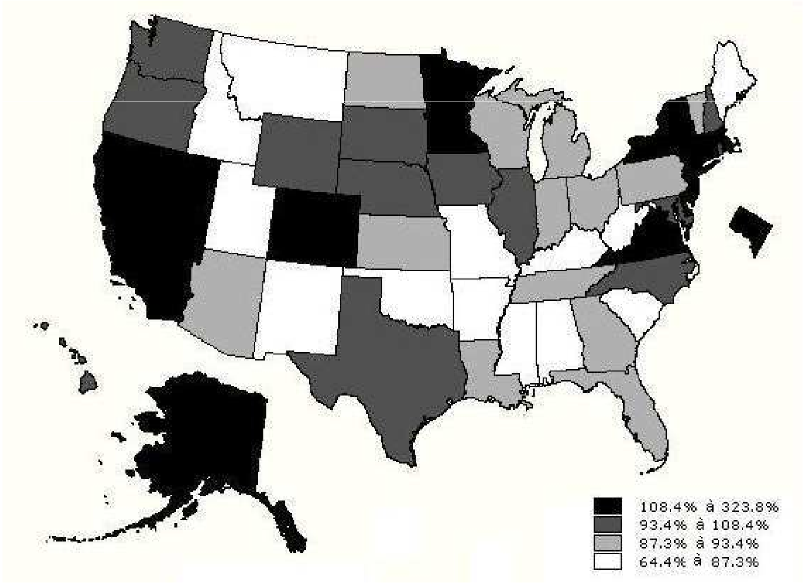
Polarization at work

Regional distribution of GDP-per-person

EU 2006



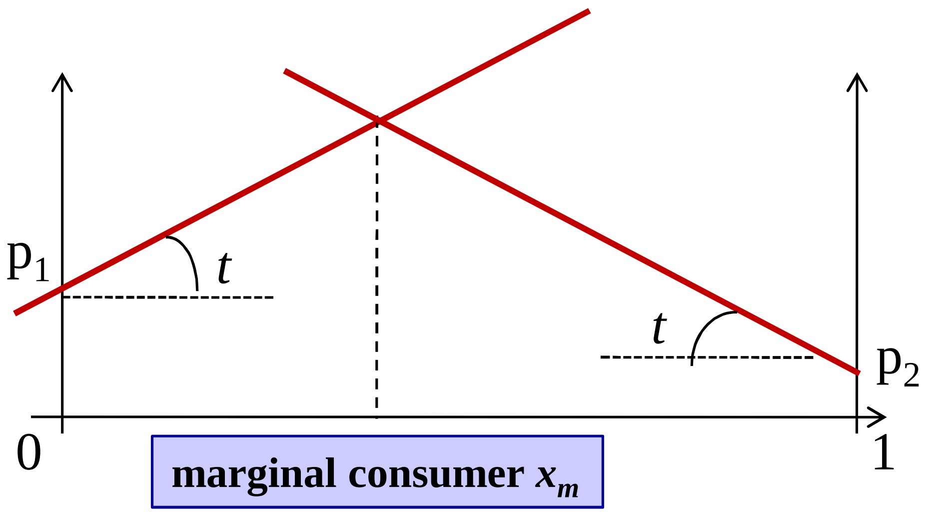
USA 2006



2. Spatial economy: the Hotelling model

Hotelling's location model (1929)

- Firms #1 and #2 compete through prices on a linear market (say, a street)
- Consumers are indexed by location x and bear a proportional transport cost t
- Suppose initially that firms are located in 0 and in 1: then if $|p_2 - p_1| \geq t$, only one firm covers the whole market
- Consumer x purchases from firm #1 if and only if: $p_1 + tx < p_2 + t(1-x)$, thus if and only if: $x < x_m = ½ + (p_2 - p_1)/2t$



Cournot-Nash equilibrium with immobile firms

Firms located in 0 and 1:

- Firm #1 — Profit: $\Pi_1(p_1,p_2) = (p_1-c)(p_2-p_1+t)/2t$
  - Reaction function: $p^*_1(p_2) = ½\,(p_2+t+c)$
- Firm #2 — Profit: $\Pi_2(p_1,p_2) = (p_2-c)(p_1-p_2+t)/2t$
  - Reaction function: $p^*_2(p_1) = ½\,(p_1+t+c)$
- Nash equilibrium: $p^*_1 = p^*_2 = t+c$
- Equilibrium profit: $\Pi*_1 = \Pi*_2 = t/2$

Lower transport costs erode equilibrium profits

Cournot-Nash equilibrium with mobile firms

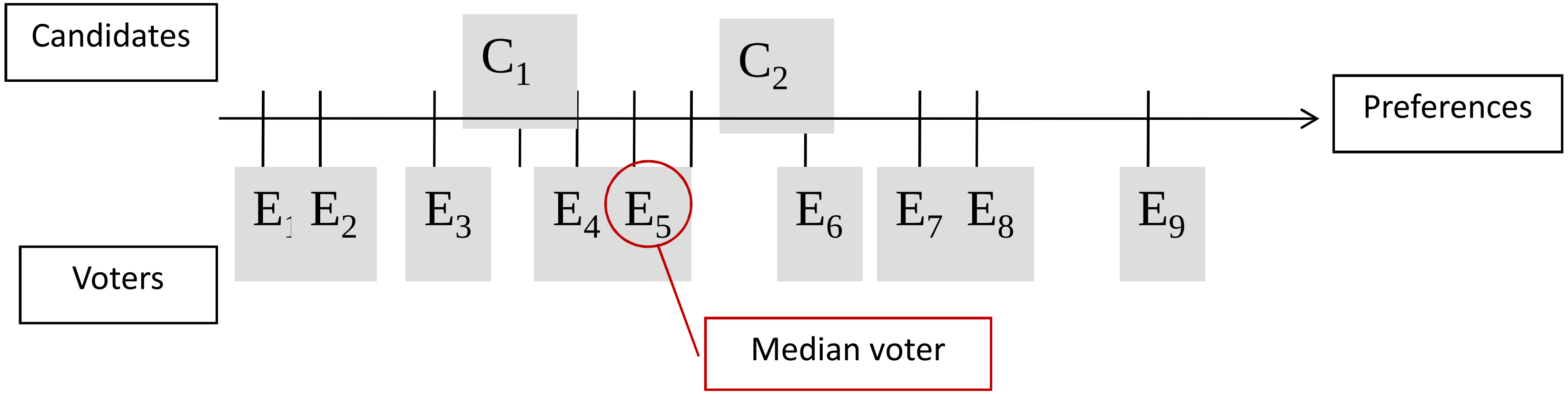
Firmes located in x_1 and x_2; $c=0$ for simplicity

- If $|p_2-p_1| \geq t\ |x_2-x_1|$, a single firm covers the whole market
- Marginal consumer: $x_m = ½(x_2+x_1) + (p_2-p_1)/2t$
- FOC: $p^*_1 = t/3\ (2+x_1+x_2)$

  $p^*_2 = t/3\ (4-x_1-x_2)$
- Equilibrium profit: $\Pi^*_1 = t/2\ (2+x_1+x_2)^2$

  $\Pi^*_2 = t/2\ (4-x_1-x_2)^2$
- Unstable equilibrium. Both firms have an incentive to locate at the centre of the market = ***minimum differentiation principle*** or ***Hotelling's law***

Analogy with 'median-voter' theory



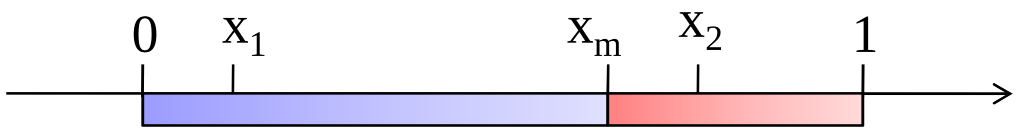
Minimum differentiation principle: in a one-dimensional political space, political parties have an incentive to appeal to the median voter.

Discontinuous equilibria

FOCs are not enough to characterize Nash equilibrium:

- If $x_2<1$, Firm #2 sells to consumers located between x_m and x_2 but also to consumers located between x_2 and 1

  If firm #1 sets p_1 below $p'_1 = p_2^* - t(x_2-x_1)$, then x_m drifts beyond x_2 and all clients buy from Firm #1 (p_1 'undercuts' p_2^*).



  Firm #1 chooses p'_1 rather than p_1^* if $\Pi_1(p'_1) > \Pi_1(p_1^*)$. This is the case if $(x_1+x_2+2)^2 < 4/3\,(2+x_1-2x_2)$. Firm #2's profit then falls to zero and there is no Nash equilibrium

- Conversely, if $x_1>0$, Firm #2 chooses p'_2 rather than p_2^* if $(4-x_1-x_2)^2 < 4/3\,(1+2x_1-x_2)$.

Special case: symmetrical equilibriums ($x_1+x_2 = 1$)

- Maths become simpler: ***price equilibrium is possible if firms are sufficiently far apart*** (namely, if $x_1 \leq ¼$ and $x_2 \geq ¾$)
  - In order to divert all clients of Firm #2, Firm #1 would have to cut its price by such an amount that it would make it unprofitable
- Nash equilibrium is given by: $p^*_1 = p^*_2 = t$

3. The core-periphery model

Source: BBC.

Driving forces

Agglomeration forces

- **Upstream, demand-shifting externalities** *(‘backward linkages’)*

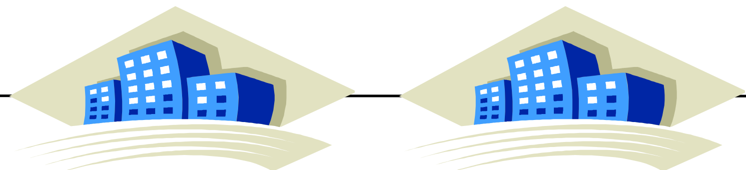
New workers coming in → higher local demand → entry of new firms

- **Downstream, production-shifting externalities** *(‘forward linkages’)*

More product diversity → lower prices → more purchasing power→ new workers coming in

Dispersion forces

- **Pro-competitive effect**
  - New workers coming in → lower wages
  - Entry of new firms → lower prices
- **Congestion costs:** pollution, traffic jams, bottlenecks, scarcer land resources
- **Comparative advantage**

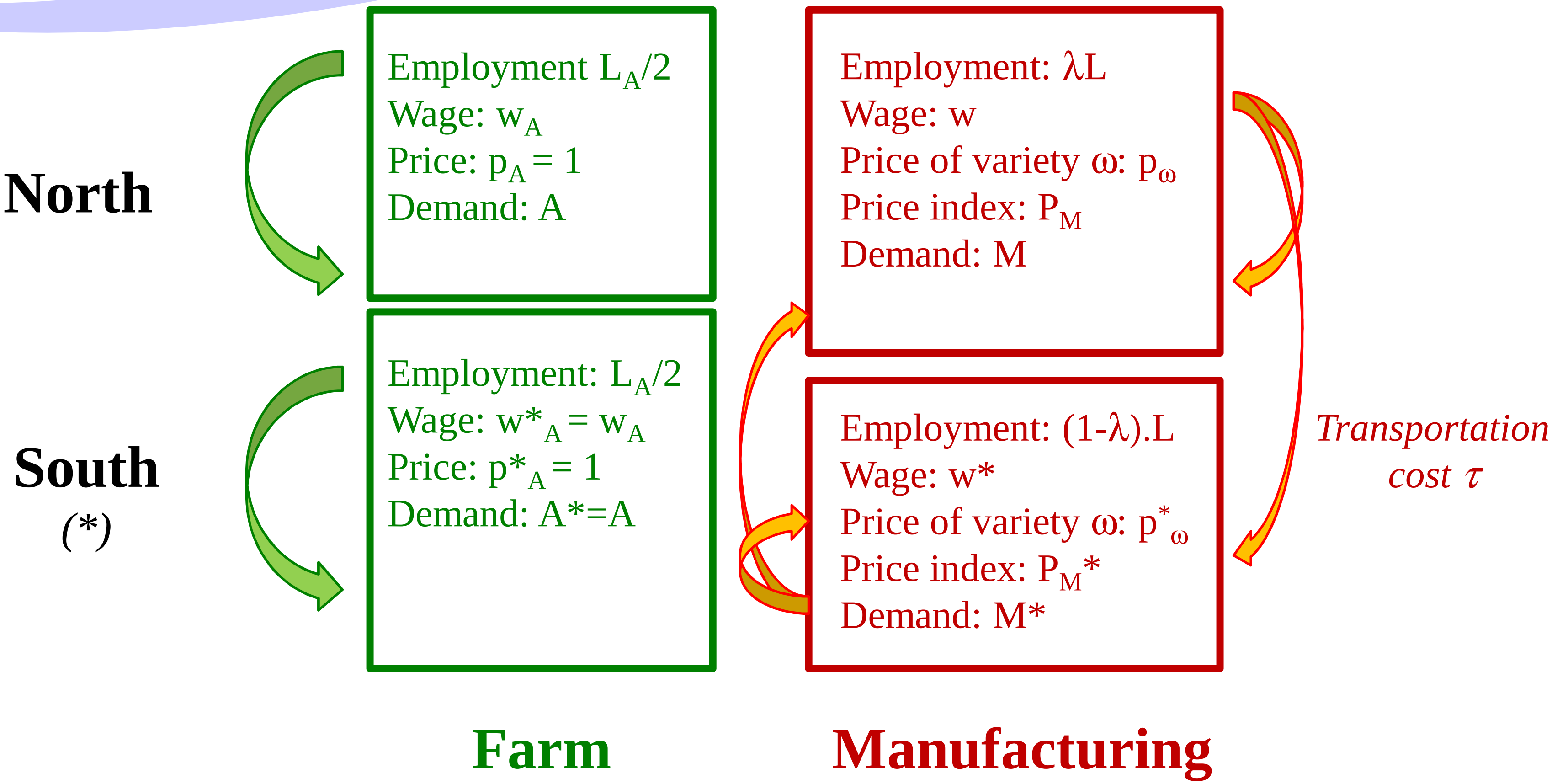


The core-periphery ('CP') model

- Two countries ('North' and 'South') and two goods:
  - ***Non-tradable good*** « A »: variable cost and constant-return to scale farm sector hiring geographically immobile non-skilled workers
  - ***Tradable good*** « M »: manufacturing industry with N firms producing N differentiated goods under monopolistic competition with fixed costs and hiring geographically mobile skilled workers
  - A is used as numéraire in each country
  - 'Iceberg'-type ***transportation cost***: a fraction $1/\tau < 1$ reaches its destination

- L_M: supply of skilled workers, a fraction $\lambda \in [0,1]$ of which is located in North
- L_A: supply of non-skilled workers, equally spread between North and South

Overview of the CP model



Sector M equilibrium (cf. lesson #3)

Fixed cost technology: $l = f + q/\varphi$ **(1)**

Domestic price: $p_\omega = \dfrac{\sigma}{\sigma-1} w/\varphi \qquad p^*_\omega = \dfrac{\sigma}{\sigma-1}\dfrac{w^*}{\varphi}$ **(2)**

Export price: $\tau.p_\omega$ (North-produced goods)

$\tau.p^*_\omega$ (South-produced goods)

Free-entry condition (zero profit) : $q_\omega = (\sigma\text{-}1).\varphi f$ **(3)**

Number of firms: $N = \lambda L/\sigma f$ and $N^* = (1\text{-}\lambda)L/\sigma f$

Remark: firm location goes together with skilled worker location

Definitions: **Aggregate demand**: $M = \left(\int q_\omega^{(\sigma-1)/\sigma} d\omega\right)^{\sigma/(\sigma-1)}$

Price index: $P_M = \left(\int p_\omega^{1-\sigma} d\omega\right)^{\frac{1}{1-\sigma}}$

Short-term equilibrium (skilled workers are immobile)

- Utility maximization : $Max\ U = M^{\mu} A^{1-\mu}$ **(4)**
- Revenue sharing: $M = \mu R/P$ and $A = (1-\mu)R$ *(because $P_A=1$)*

  with: $R = ½\, w_A L_A + \lambda w L$

  (5)
- De même, $M^* = \mu R^*/P^*$ and $A = (1-\mu)R^*$

  with: $R^* = ½\, w_A L_A + (1-\lambda) w^* L$
- Local demand of North-produced variety ω: $\left(\frac{p_\omega}{P}\right)^{-\sigma} \frac{\mu R}{P}$
- Total demand: $q_\omega = \left(\frac{p_\omega}{P}\right)^{-\sigma} \frac{\mu R}{P} + \tau \left(\frac{\tau p_\omega}{P^*}\right)^{-\sigma} \frac{\mu R^*}{P^*}$ **(6)**

Price equations

- Aggregate price index: $P = \left(NP_M^{1-\sigma} + N^*(\tau P_M^*)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$ **(7)**

Remember that: $N = \lambda L/\sigma f$ and $N^* = (1-\lambda)L/\sigma f$ (*free entry*)

and that: $P_M = \frac{\sigma}{\sigma-1}\frac{w}{\varphi}$ $P^*_M = \frac{\sigma}{\sigma-1}\frac{w^*}{\varphi}$ (*profit maximization*)

- Hence the ***price equations***:

$$P = k_1\left(\lambda w^{1-\sigma} + (1-\lambda)(\tau w^*)^{1-\sigma}\right)^{1/(1-\sigma)}$$

$$P^* = k_1\left(\lambda(\tau w)^{1-\sigma} + (1-\lambda)w^{*1-\sigma}\right)^{1/(1-\sigma)}$$

$$k_1 = \frac{1}{\varphi}\frac{\sigma}{\sigma-1}\left(\frac{L}{\sigma f}\right)^{1/(1-\sigma)}$$ **(8)**

Wage equations

- Market clearing for good ω: $(\sigma-1)\varphi f = \left(\frac{p_\omega}{P}\right)^{-\sigma}\frac{\mu R}{P} + \tau\left(\frac{\tau p_\omega}{P^*}\right)^{-\sigma}\frac{\mu R^*}{P^*}$

  Remember that: $p_\omega = \frac{\sigma}{\sigma-1}\frac{w}{\varphi}$

- Hence the ***wage equations***:

$$w = k_2\left(P^{\sigma-1}R + \tau^{1-\sigma}P^{*\sigma-1}R^*\right)^{1/\sigma}$$

$$w^* = k_2\left(\tau^{1-\sigma}P^{\sigma-1}R + P^{*\sigma-1}R^*\right)^{1/\sigma}$$

$$k_2 = \varphi\frac{\sigma-1}{\sigma}\left(\frac{\mu}{(\sigma-1)\varphi f}\right)^{1/\sigma} \qquad \textbf{(9)}$$

The complete system

- Price equations **(8)**

$$P = k_1\left(\lambda w^{1-\sigma} + (1-\lambda)(\tau w^*)^{1-\sigma}\right)^{1/(1-\sigma)}$$

$$P^* = k_1\left(\lambda(\tau w)^{1-\sigma} + (1-\lambda)w^{*1-\sigma}\right)^{1/(1-\sigma)}$$

- Wage equations **(9)**

$$w = k_2\left(P^{\sigma-1}R + \tau^{1-\sigma}P^{*\sigma-1}R^*\right)^{1/\sigma}$$

$$w^* = k_2\left(\tau^{1-\sigma}P^{\sigma-1}R + P^{*\sigma-1}R^*\right)^{1/\sigma}$$

- ➢ Non-linear system in (P,P^*,w,w^*) with λ as a key parameter
- ➢ No closed solution but can be solved numerically, and special solutions can be exhibited.

Spatial equilibrium: definition

- A ***spatial equilibrium*** is a long-term equilibrium, as described by state variable λ, such that ***no single skilled worker has an interest to relocate***. It can be either stable or unstable.
- Criterium is welfare of skilled worker: $\boldsymbol{U = M^{\mu} A^{1-\mu}}$

  with: $M = \mu w/P$ et $A = (1-\mu)w$

  and hence: $U = \mu^{\mu}(1-\mu)^{1-\mu}\, V$ **(10)**

  with: $V = wP^{-\mu}$

- Spatial equilibrium is defined by:

  or (corner solution):

$0 < \lambda < 1$	and	$V(\lambda) = V^*(\lambda)$
$\lambda = 0$	and	$V(0) < V^*(0)$
$\lambda = 1$	and	$V(1) > V^*(1)$

The polarized world (λ=1)

Short-term equilibrium with λ=1 (all manufacturing in North)

- Price equations **(8)** : $P = k_1 w$; $P^* = k_1 \tau w$
- Wage equations **(9)** :

$$w = k_1^{(\sigma-1)/\sigma} k_2 . w^{(\sigma-1)/\sigma} \left(R + R^*\right)^{1/\sigma}$$

$$w^* = k_1^{(\sigma-1)/\sigma} k_2 . w^{(\sigma-1)/\sigma} \left(\tau^{1-\sigma} R + \tau^{\sigma-1} R^*\right)^{1/\sigma}$$

Note that: $k_1^{(\sigma-1)/\sigma} k_2 = \mu^{1/\sigma} L^{-1/\sigma}$

- Revenue: $R = wL + ½ w_A L_A$; $R^* = ½ w_A L_A$

  Noting that skilled workers in the North earn 100% of manufacturing revenue, $wL = \mu(R+R^*)$, makes it possible to compute R and R^*:

$$R = \frac{1}{2}\frac{1+\mu}{1-\mu} w_A L_A \qquad R^* = \frac{1}{2} w_A L_A \qquad \textbf{(11)}$$

- Hence the levels of wages,…

$$w = \frac{\mu}{1-\mu}\frac{w_A L_A}{L}$$

$$w^* = \left(\frac{\mu}{2}\right)^{1/\sigma}\left(\frac{\mu}{1-\mu}\right)^{1-1/\sigma}\left(\tau^{1-\sigma}\frac{1+\mu}{1-\mu}+\tau^{\sigma-1}\right)^{1/\sigma}\frac{w_A L_A}{L} \qquad \textbf{(12)}$$

- …and of welfare:

$$V = wP^{-\mu} = k_1^{-\mu} w^{1-\mu}$$

$$V^* = w^* P^{*-\mu} = k_1^{-\mu}\tau^{-\mu}w^{-\mu}w^*$$

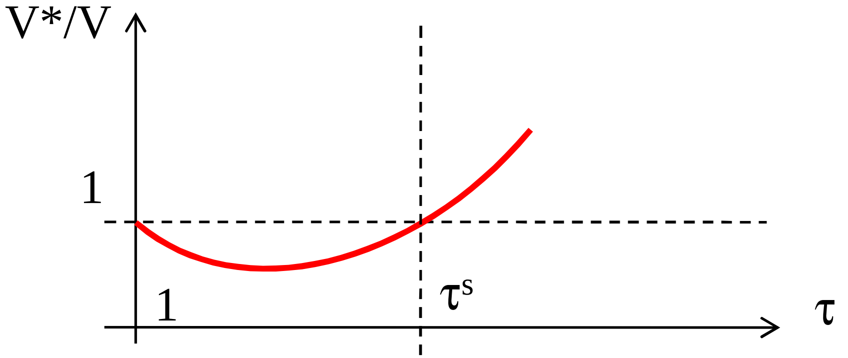
$$V^*/V = \tau^{-\mu}\frac{w^*}{w} = \tau^{-\mu}\left(\frac{2}{1-\mu}\right)^{-1/\sigma}\left(\tau^{1-\sigma}\frac{1+\mu}{1-\mu}+\tau^{\sigma-1}\right)^{1/\sigma}$$

$$V^*/V = \left(\frac{1-\mu}{2}\tau^{-\sigma(\mu-\frac{\sigma-1}{\sigma})}+\frac{1+\mu}{2}\tau^{-\sigma(\mu+\frac{\sigma-1}{\sigma})}\right)^{1/\sigma} \qquad \textbf{(13)}$$

- The North-polarized equilibrium is a spatial equilibrium if and only if:

$$V^*/V = \left(\frac{1-\mu}{2} \tau^{-\sigma(\mu - \frac{\sigma-1}{\sigma})} + \frac{1+\mu}{2} \tau^{-\sigma(\mu + \frac{\sigma-1}{\sigma})} \right)^{1/\sigma} < 1$$

- $V^*/V = 1$ when $\tau = 1$ (no transportation cost). For any other value of τ, answer depends on comparison between μ and $(\sigma-1)/\sigma$:
  - If $\mu > (\sigma-1)/\sigma$, then V*/V decreases with τ: polarization is a spatial equilibrium whatever the level of transportation costs ('black hole' condition)
  - If $\mu < (\sigma-1)/\sigma$, then there exist a unique $\tau^s > 1$ called the ***'support point'*** such that V* = V. Polarization is a spatial equilibrium only if $\tau \leq \tau^s$



- The same reasoning holds for the South-polarized equilibrium

The flat world (λ=½)

- Both countries being identical, it is obvious that V = V* and the symmetrical equilibrium is a spatial equilibrium. But is it ***stable***, *i.e.* do we have:

  $V(1/2+\varepsilon) < V^*(1/2+\varepsilon)$ and $V(1/2-\varepsilon) > V^*(1/2-\varepsilon)$?
- Differentiating the 4 equations, 4 variables system made of price equations **(8)** and wage equations **(9)** around λ = ½, one deduce a linear system in (dP,dP*,dw,dw*), then dV and dV* (see Fujita *et al.*, 1999, chapter 5)
- After tedious (but simple) computation, one shows that:
  - If $\mu \geq (\sigma-1)/\sigma$ ('black hole'), symmetrical equilibrium is always unstable;
  - If $\mu < (\sigma-1)/\sigma$, symmetrical equilibrium is stable if and only if:

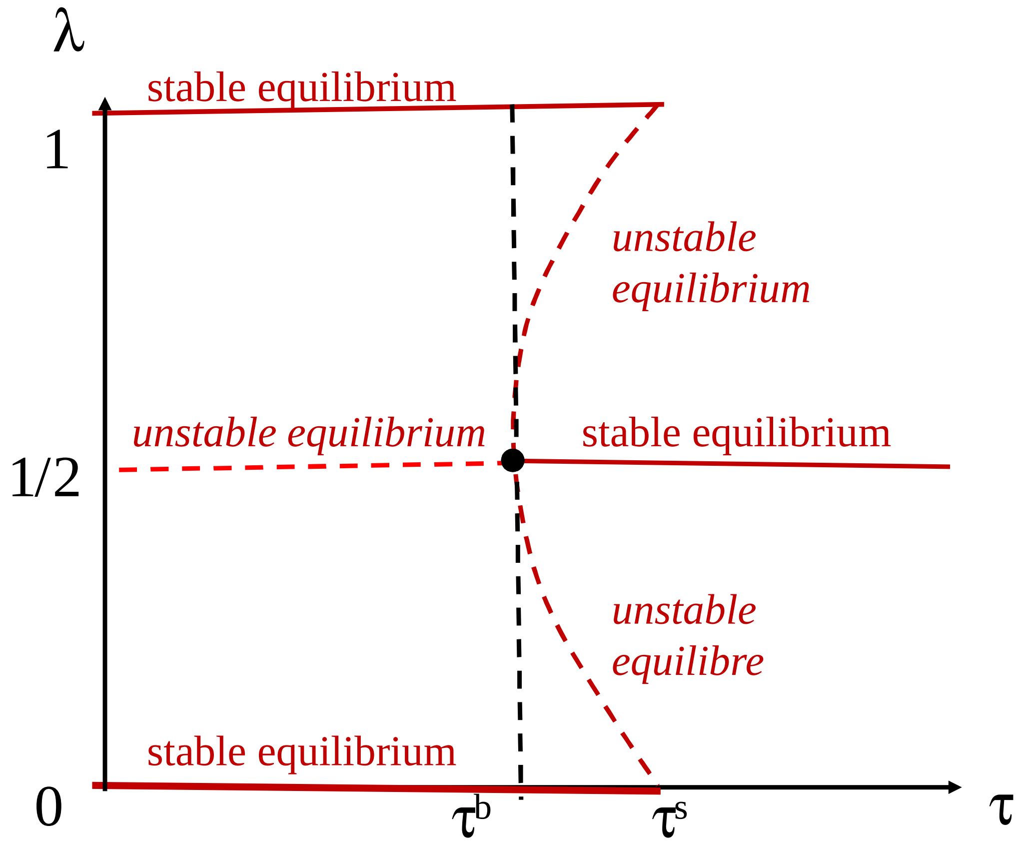
$$\tau \geq \tau^B = \left(\frac{(1+\mu)(\sigma/(\sigma-1)+\mu)}{(1-\mu)(\sigma/(\sigma-1)-\mu)} \right)^{1/(\sigma-1)}$$

τ^B is the ***'break point'*** and $\tau^B < \tau^S$

Spatial equilibria

- If $\mu < (\sigma - 1)/\sigma$, spatial equilibria are:
  - $\lambda = 0$ or 1 if $\tau \leq \tau^S$
  - $\lambda = ½$ if $\tau \geq \tau^B$
- When transportation cost τ is between τ^B and τ^S, there are three stable equilibria: $\lambda = 0$, $\lambda = 1$ (agglomeration), and $\lambda = ½$ (dispersion).
- Furthermore, it can be shown that there are two unstable, intermediary equilibria for $0 < \lambda < ½$ and $½ < \lambda < 1$

Spatial equilibrium and transportation cost: the 'Tomahawk' diagram



Understanding the driving forces

What if λ increases steadily starting from symmetrical equilibrium λ = ½ (workers relocating from South to North)?

- ***Cumulative demand effect ('forward linkage')***
  - Income and wages increase in North (since revenue is consumed locally) and decrease in South [**(5)** and **(9)**], creating additional incentive to migrate
- ***Cumulative supply effect ('backward linkage')***
  - Number of firms increase in North; prices thus decrease [**(3)** and **(7)**] due to higher number of varieties and lower imports, which adds to income and create additional incentive to migrate
- ***Stabilizing, pro-competitive effect***
  - Higher wages are passed to prices

Lessons of the CP model

- When transportation costs go down, there is a ***catastrophic shift*** from symmetric to polarized equilibrium
- ***History matters***: industry location is path-dependent
- ***Agglomeration prevails:***
  - ***when goods are more differentiated***
    - When σ is high (homogenous varieties), $\tau^S \sim \tau^B \sim 1$ and dispersion is always stable. Conversely, when $\sigma \sim 1$ (differentiated varieties), τ^S and τ^B are high and polarization is more likely
  - ***when manufacturing dominates the economy***
    - τ^S and τ^B are increasing functions of μ

Limitations of the CP model

- No closed-form solution
- Disputable assumption of a *marginal need* of skilled workers (in the real world, skilled work is more needed for conception than for production)
- No equilibrium selection mechanism; no expectations
- Model is biased towards polarization
  - One single dispersion force = pro-competitive effect
  - No congestion cost
- Main driver of agglomeration = labor mobility (true in US, not in Europe)

Empirical measurement of transportation costs

- Exports from North to South:

$$M_{NS} = N * \tau \left(\frac{\tau P^*}{P} \right)^{-\sigma} \frac{R}{P} = N * \phi P^{*-\sigma} P^{\sigma-1} R$$

$$\phi = \tau^{1-\sigma}$$

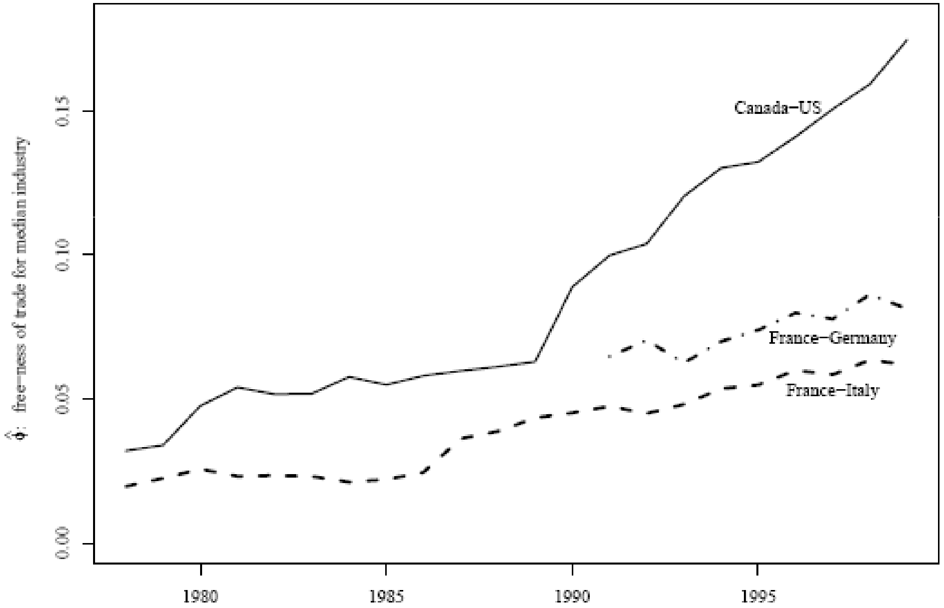
- Consumption in North of North-produced good:

$$M_{NN} = N \left(\frac{\tau P^*}{P} \right)^{-\sigma} \frac{R}{P} = N P^{*-\sigma} P^{\sigma-1} R$$

- Hence a measure of ϕ based on trade flows:

$$\phi^2 = \frac{M_{NS} M_{SN}}{M_{NN} M_{SS}}$$

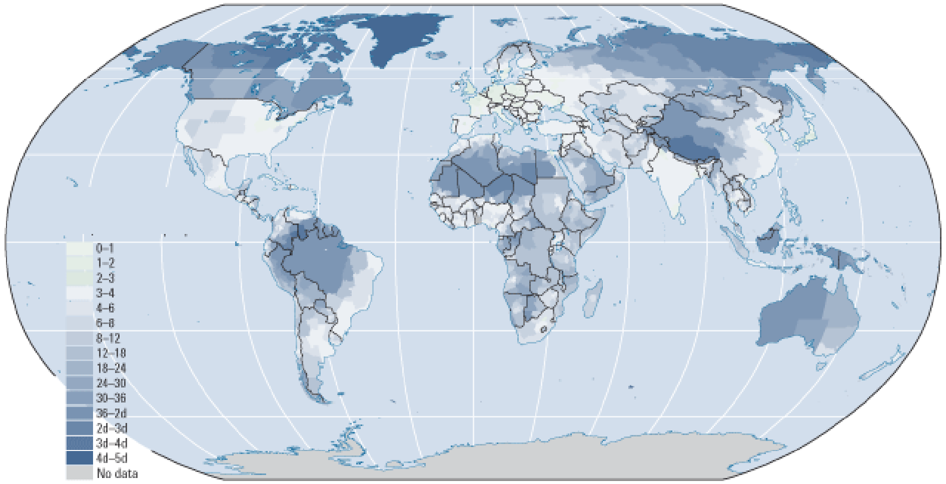
The 'ϕ-ness' of trade



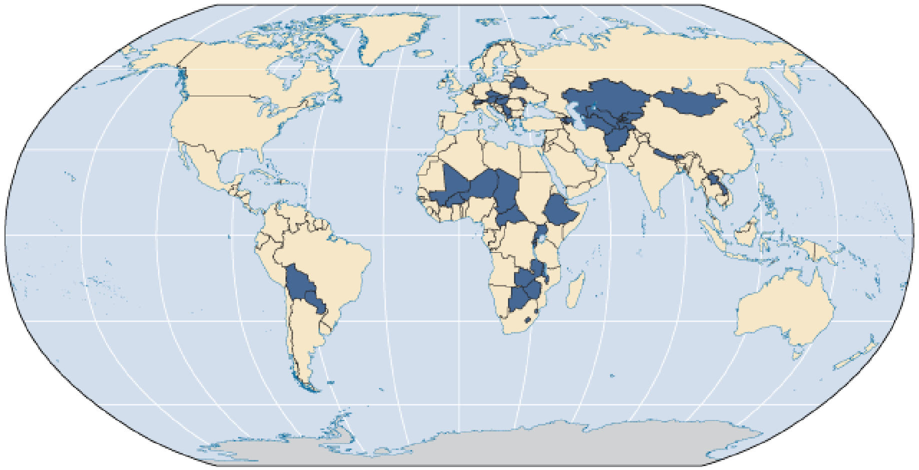
Source: Keith Head and Thierry Mayer, « The Empirics of Agglomeration and Trade », in *Handbook of Regional and Urban Economics*, 2004, vol. 4, Chapter 59, pp. 2609-2669.

Unequal geography

Travel time in hours and days to the nearest city of 50,000 or more people



Forty-three 'landlocked' countries do not have direct access to a coast



Source: World Bank, *World Development Report 2009*.

Lessons for regional policies

- Conflict of objectives between:
  - ***Geographical fairness*** – need for regional policies, budget transfers
  - ***Efficiency*** (welfare-improving concentration) – need for competitiveness clusters
- First rank optimum: do not oppose concentration; compensate loosing regions with lump-sum transfers
- Ambiguous role of transport infrastructures: in CP model, lower transport cost increase concentration; risk of desindustralization of peripheral regions
- IT has a potential to overcome this dilemma by 'making the world flatter', ex: 3-G access in rural areas

Lessons for development policies

- Risk of 'underdevelopment trap' in countries w/o natural resources (*i.e.* landlocked, non commodity-producing countries)
- Remedies:
  - '*Big push'* to coordinate expectations (Krugman, 1991 ; Murphy, Schleifer et Vishny, 1989) = not enough in practice
  - Openness to international markets (EU, Mercosur-like regional custom unions; trade deals such as NAFTA, Cotonou-Lomé; WTO-led multilateral trade rounds)

4. Multinational firms: a bird's eye view

- ***Horizontal FDI (HFDI)***: cross-border relocation of production close to final demand
- ***Vertical FDI (VFDI):*** cross-border fragmentation of production process reflecting international division of labor

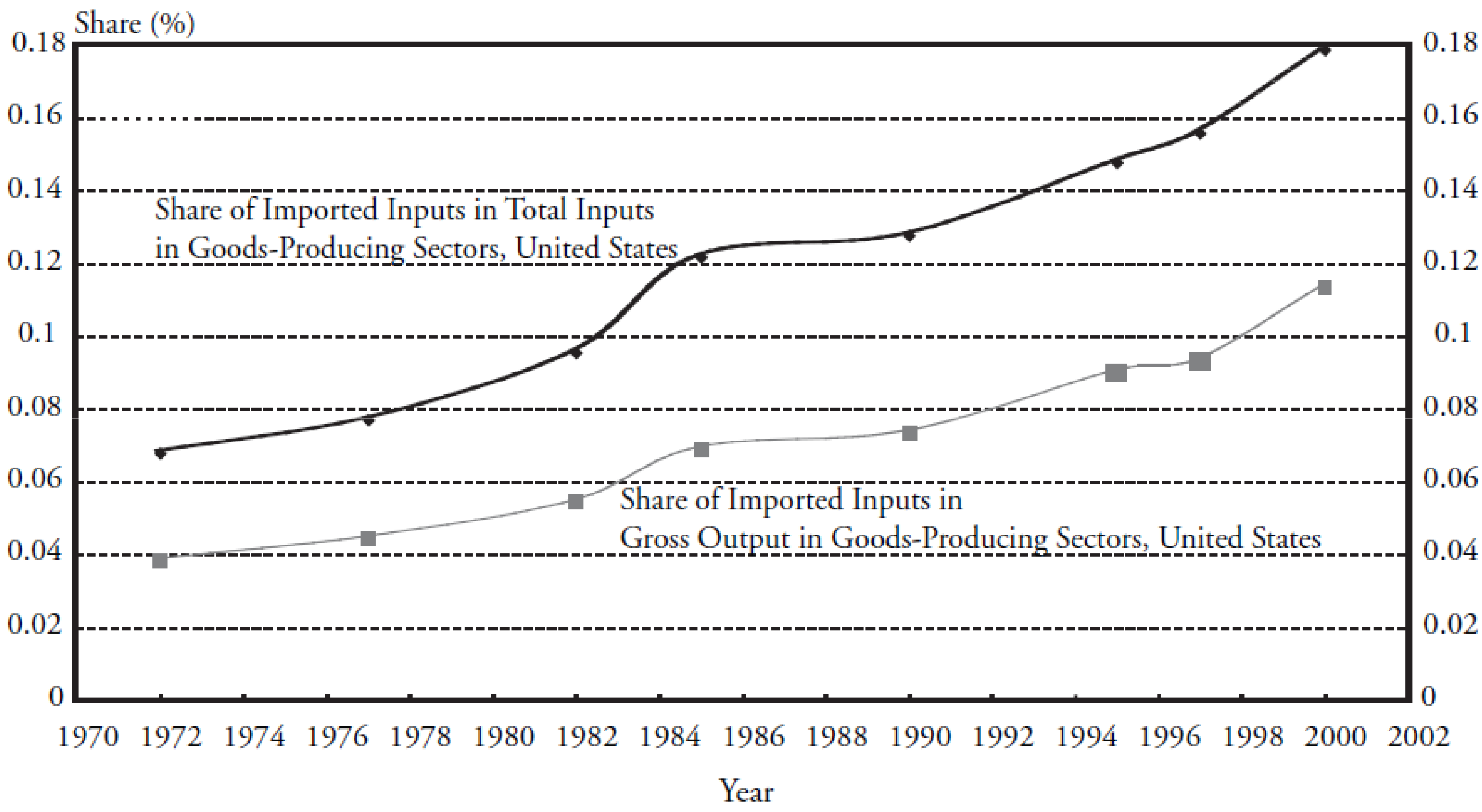
Horizontal FDI and trade: the O-L-I paradigm

- ‘Ownership-Location-Internalization’ paradigm (Dunnning, 1973) explains trade-off between exports and HFDI.
- FDI based on three conditions:
  - ***Firm-specific advantage***
    - Technology, work organization, brand, reputation) exploited within the firm
  - ***Country-specific advantage***
    - Difference in factor endowment, taxation, public infrastructures, market size, institutions (property rights, regulation, graft…)
  - ***Internalization advantage*** (as opposed to arm’s length transaction such as licensing)
    - Depends on industrial organization, information asymmetry, comparison beween external and internal transaction costs – cf. Coase Theorem. Ex: ‘tariff-jumping’ FDI.

FDI and trade: recent developments

- Brainard (AER, 1997)
  - Trade-off between proximity and concentration depends on comparison between transport costs and location costs, and on scale economies within the firm.
- Markusen and Venables (JIE, 2000)
  - Synthesis with HOS model. Case for HFDI when factor endowments differ sharply. Reduction in transportation cost can lead either to VFDI (when upstream activities are labor-intensive) or to HFDI (when downstream activities are labor-intensive).
- Helpman, Mélitz and Yeaple (AER, 2004)
  - Synthesis with Mélitz model (2003) with heterogeneous firms. Only firms with higher productivity can afford to relocate production
- Latest studies attempt at describing complex VFDI strategies (ex: multinational relocating part of supply chain from host-country to third country)

Vertical supply chains (‘task trade’)



Source: Grossman and Rossi-Hansberg (2006).