Comparative Advantage and Agglomeration of Economic Activity

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1 Motivation

- **comparative advantage & increasing returns → pillars of trade & location theory**
  - David Ricardo (1819): countries benefit from trade when being different: technologies
  - Johann Heinrich von Thünen (1826): analysis of land rent pioneers location theory: cities cannot be understood without reference to increasing returns to scale

- **fields develop separately** for a long time: **integration** through the new trade theory, the new economic geography and micro-foundations of urban agglomeration economies

  → **focus is on increasing returns, only** [Krugman 1993; 2009; Fujita and Mori 2005]

  - new trade theory is reaction to trade of similar productions between similar countries
  - adding factor mobility or input-output linkages lead to the new economic geography
  - urban economics develops micro-foundations [Duranton and Puga 2004]

- but: **"world economy is more classical than when the revolution began"**

  "the old trade theory has regained relevance" [Krugman 2009 Nobel Prize]

  - dramatic rise of trade between advanced economies & low-wage economies: China [Krugman 2008; Autor et al 2012, Autor et al. 2014]

  - development of Ricardian multi-country multi-product model of costly trade reflects this shift [Eaton & Kortum 2002; Costinot & Rodriguez-Claré 2014]

  - no robust evidence of such a shift for geography

    some evidence for US that importance of increasing returns may be waning (regional specialization in manufacturing): could be statistical artefact; importance of increasing returns in many countries (e.g. European Union) well-documented [Handbook of Urban and Regional Economics 2004]

→ **both comparative advantage and increasing returns drive world economy today**

Dramatic rise of trade between advanced economies & much poorer low-wage economies

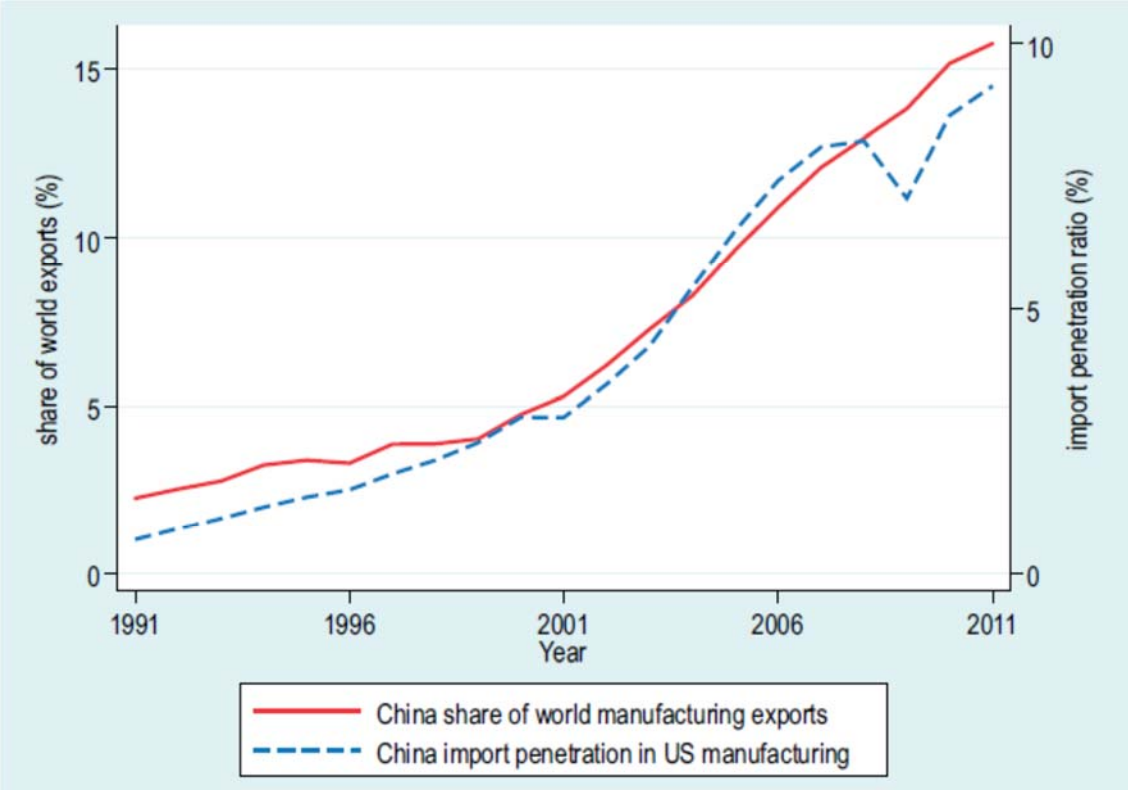
Table 2. Average Hourly Compensation in the Top Ten U.S. Trading Partners, 1975, 1990, and 2005

Year	*Top ten trading partners (largest first)*	*Average hourly compensation (percent of U.S. average)*[a]
1975	Canada, Japan, Germany, United Kingdom, Mexico, France, Italy, Brazil, the Netherlands, Belgium	76
1990	Canada, Japan, Mexico, Germany, United Kingdom, Taiwan, South Korea, France, Italy, China	81[b]
2005	Canada, Mexico, China, Japan, Germany, United Kingdom, South Korea, Taiwan, France, Malaysia	65[c]

Sources: Bureau of Labor Statistics (2006); *Statistical Abstract of the United States.*
a. Averages are weighted by the countries' shares in total U.S. trade.
b. China's hourly compensation is assumed to be 1 percent of the U.S. level.
c. Malaysia's hourly compensation is estimated from United Nations data.

Source: Krugman 2008 Trade and Wages, Reconsidered, Brookings Papers on Economic Activity

The rise of China: China's Share of World Manufacturing Exports & China's Import Penetration in U.S. Manufacturing, 1991–2011



The China share of world manufacturing exports is the ratio of China's total manufacturing exports to world total manufacturing exports as reported in World Development Indicators (http://data.worldbank.org/). The China import penetration ratio is U.S. manufacturing imports from China divided by U.S. domestic absorption in manufacturing (shipments plus imports minus exports).

Source: Autor/Dorn/Hanson/Song 2014, Trade Adjustment: Worker-Level Evidence, Quarterly Journal of Economics

Purpose of this paper

- **study interplay of comparative advantage & increasing returns for trade & location**
  - **incorporation of comparative advantage** in production of final goods & services as in Dornbusch/Fischer/Samuelson (1977); parameterization due to Eaton & Kortum (2002)
  - **incorporation of increasing returns (irs):** final outputs are produced with labor and tradable intermediate goods & services produced by monopolistically competitive firms
    → Ethier's (1982) formalization of Marshall's input-output linkages
- **three key contributions**
  - study three **secular changes** in the economic environment
  - **highlight different effect of two types of trade costs**
  - contribute framework for the modelling of **city systems**

Study secular changes in economic environment → key model parameters

- **'first great unbundling'** (Baldwin 2006)

  associated with rapid fall of transport costs: allowed spatial separation of factories and consumers through trade of final goods & services

- **'second great unbundling'** (Baldwin 2006)

  innovations in information & communication technologies radically reduced costs to trade intermediate goods & services ("tasks") which spatially unpacked offices and services themselves; originally, these were purely localized ("subsidiary trades grow up in the neighborhood", Marshall 1890)

- flattening of distribution of technologies across countries & regions: **"kaleidoscopic comparative advantage"** (Bhagwati 1995; Baumol et al. 1989; Levchenko/Zhang 2015)

Highlight different effect of two types of trade costs

- interaction of comparative advantage and increasing returns has more subtle consequences for the location effects of a fall in trade costs than in new trade and new economic geography

- increasing trade freeness of goods produced in the intermediate goods sector acts in favor of agglomeration as in the new economic geography

- increasing trade freeness of final outputs works in the inverse direction of dispersion

→ **it is the decrease in the trade cost of intermediates rather than final outputs that fosters agglomeration of workers and firms !**

Contribute framework for modelling city systems

- research on the formation of cities and city systems builds on Henderson (1974)
- fundamental trade-off between agglomeration economies crowding economies (urban costs)
- drawback of canonical model: each location/city is specialized in a single sector/industry; reason: sector-specific and non-tradable intermediates; final outputs traded at no cost
- literature which relaxes these two assumptions is thin [Duranton & Puga 2001; 2014]
- our model features both trade costs for final outputs and costly trade of intermediates

→ **diversity of production across locations ("cities") results under partial agglomeration due to comparative advantage; this generalizes with housing/urban extensions**

Related Literature

- **modern Ricardian trade modelling**. Dornbusch, Fischer & Samuelson (1977), Eaton & Kortum (2002), new quantitative models of trade (see Costinot & Rodriguez-Clare 2013), Matsuyama (2013), Stephen Redding (2012)

- **new trade and NEG-models with vertical linkages.** Ethier (1982), Helpman & Krugman (1985); Van Marrewijk et al (1997); Baldwin et al (2003)

- **NEG-analysis and comparative advantage.** Ricci (1999), Venables (1999), Forslid and Wooton (2003), Amiti (2005), Epifani (2005).

- **offshoring literature.** Baldwin (2006), Blinder (2009), Bhagwati and Blinder (2009)

Outline

1 Motivation

2 The model

3 Trade

4 Geography

5 Secular shifts: The interplay of comparative advantage and increasing returns

6 Conclusion

2 The Model

Dornbusch/Fischer/Samuelson (1977): 2 locations (home, foreign), continuum of final goods & services produced under constant returns and perfect competition; labor is only factor

→ we amend this model in three ways

- production of final goods & services makes use labor **and** a symmetric CES-composite of (tradable) **intermediate goods & services** produced under increasing returns and monopolistic competition (Ethier 1982 AER, Matsuyama 2013 Econometrica)

- comparative advantage is **parameterized as in Eaton & Kortum** (2002 Econometrica)

- allow for labor mobility to study the **geography case**: spatial equilibrium

Preferences

- Cobb-Douglas: defined over consumption $c(z)$ of final goods and services $z\epsilon[0,1]$

$$U\{c(z)\} = \exp\left[\int_0^1 \ln c(z)\, dz\right]$$

associated perfect price index:

$$P = \exp\left[\int_0^1 \ln p(z)\, dz\right]$$

$p(z)$ is consumer price of z, may comprise iceberg trade costs $\tau \geq 1$ for imported goods

- perfect competition: producer prices of final goods reflect unit costs

Production of final goods Cobb-Douglas, using labor and CES-composite of intermediates

- constant returns unit cost function, identical cost shares $0 \leq \beta \leq 1$ for all z

$$\kappa(z) = a(z) w^{1-\beta} P_s^{\beta} \quad , \qquad P_S = \left[\int_0^n p_s{}^{1-\sigma} ds + \int_0^{n^*} (\tau_s p_s^*)^{1-\sigma} ds \right]^{\frac{1}{1-\sigma}}$$

w wage

P_s price index of intermediate goods and services (CES price index)

p_s , p_s^* mill prices of intermediate goods and services produced in home and foreign

$\tau_s \geq 1$ iceberg trade costs for imported intermediates

$\sigma > 1$ constant elasticity of substitution between any two intermediates

n , n^* mass of intermediates produced in home, foreign → endogenous

$a(z)$, $a^*(z)$ technology parameter which varies across final goods of home and foreign

Technology distribution across final goods

- comparative advantage as in Dornbusch/Fischer/Samuelson (1977)

  exogenous technology (inverse productivity) parameters $a(z), a^*(z)$

  outputs are ranked in descending order of $A(z) \equiv a^*(z)/a(z)$

- **parameterization** as in Eaton & Kortum (2002) → productivities drawn from Fréchet distr.

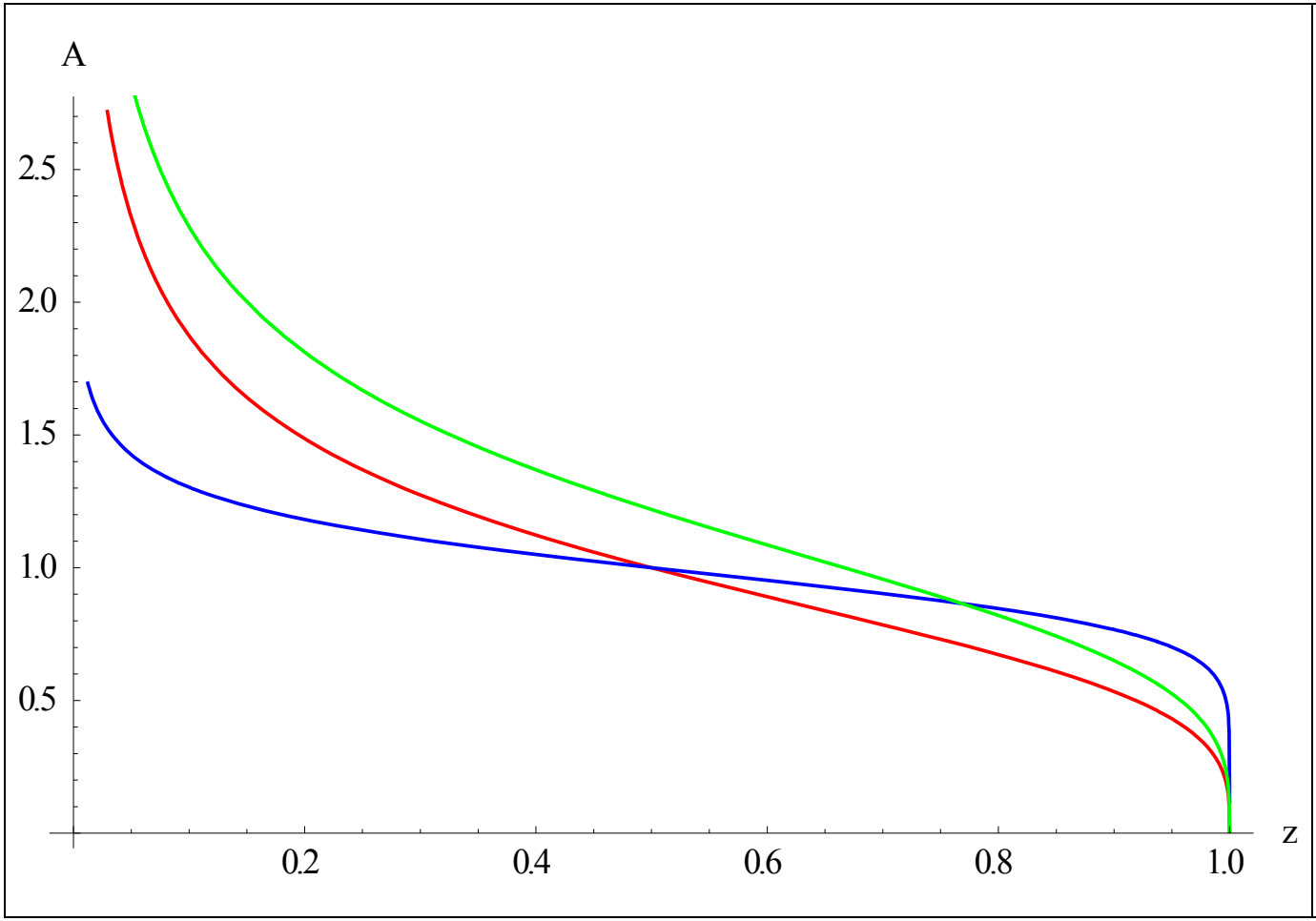
  two-country case: $$A(z) \equiv \frac{a^*(z)}{a(z)} = \left[\frac{T}{T^*}\frac{(1-z)}{z}\right]^{\frac{1}{\theta}}$$

  $\theta > 1$ is inverse measure of the variability of productivities: **comparative advantage**

  $T > 0$ measures home's (absolute) level of technology.

Parameterization of technology

$$A(z) \equiv a^*(z)/a(z) = [T(1-z)/T^*z]^{\frac{1}{\theta}}$$



- red: $\theta = 3.5; T = 1; T^* = 1$
- blue: $\theta = 8.3; T = 1; T^* = 1$
- green: $\theta = 3.5; T = 2; T^* = 1$

Intermediate goods and services s

- produced by single firm under increasing returns and monopolistic competition
- labor input: $l_s = f + mq_s$, → total costs: $w(f + mq_s)$; where: $q_s = q_d + \tau_s q_d^*$
- profit-maximizing producer prices: $p_s = \frac{\sigma}{\sigma-1} wm$
- long-run zero-profits: $\pi_s = (p_s - wm)q_s - wf = 0$ → $q_s = \frac{f(\sigma-1)}{m}$

→ **unit costs, final output z**: $\kappa(z) = \left(\frac{\sigma}{\sigma-1} m\right)^{\beta} a(z)\, w^{1-\beta} \left[nw^{1-\sigma} + n^*(\tau_s\, w^*)^{1-\sigma}\right]^{-\gamma}$

where $\gamma \equiv \beta/(\sigma - 1)$ = agglomeration economies

unit costs fall as n and $n^* \uparrow$ (gains from variety); and when more of the intermediates are local

$\Delta n = -\Delta n^*$ (trade cost savings) → Marshall-Ethier agglomeration force

3 Trade

labor forces L and L^* (immobile across locations)

- **equilibrium system:** 5 equations in $\omega \equiv w/w^*$, $\bar{z}$, $\bar{z^*}$, n and n^*
  - two cutoff-conditions: consumers buy final goods & services from minimum cost source

    $\kappa(\bar{z}) = \tau_f \, \kappa^*(\bar{z})$ home produces $z \in [0, \bar{z}]$ and imports $z \in [\bar{z}, 1]$

    $\kappa^*(\bar{z^*}) = \tau_f \, \kappa(\bar{z^*})$ foreign; produces $z \in [\bar{z^*}, 1]$ and imports $z \in [0, \bar{z^*}]$

  - trade balance: $(1 - \bar{z}) \, wL + n^* \, \tau_s \, p_s^* \, q_{d^*} = \bar{z^*} \, w^* L^* + n \, \tau_s \, p_s \, q_d^*$

  - mass of intermediates in home and foreign: reflects cost share of intermediates in final output, labor market clearing and zero-profit in the sector of intermediates

    $$n = \frac{L}{\sigma f} - \frac{(1-\beta)}{\sigma f}\left(\bar{z}L + \frac{1}{\omega}\bar{z^*}L^*\right) \quad ; \quad n^* = \frac{L^*}{\sigma f} - \frac{(1-\beta)}{\sigma f}\left[(1-\bar{z})\omega L + (1-\bar{z^*})L^*\right]$$

- **analysis in 2 steps:** baseline case: non-tradable intermediates; then tradable intermediates

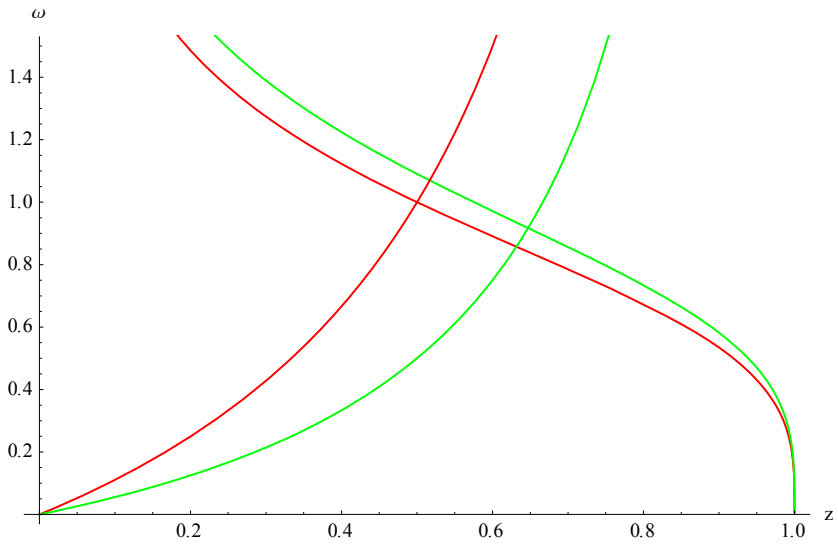
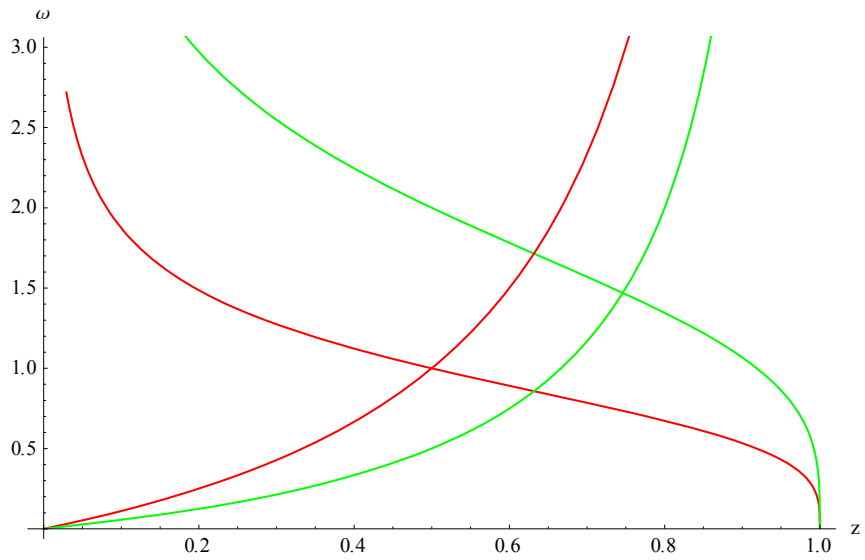
The baseline case: non-tradable localized intermediates

- Marshall's world: $\phi_s = 0$ → yields considerable simplification
- **simple solvable case:** $\phi_f = 1$ → no trade costs for final goods and services
  - only one threshold $\tilde{z}$ where $\kappa(\tilde{z}) = \kappa^*(\tilde{z})$ and $A(\tilde{z}) = \left[\frac{T(1-\tilde{z})}{T^*\tilde{z}}\right]^{\frac{1}{\theta}} = \left(\frac{w}{w^*}\right)\left(\frac{L}{L^*}\right)^{-\gamma}$
  - trade balance (labor market clearing) condition simplifies to $\omega = \frac{\tilde{z}}{1-\tilde{z}}\frac{L^*}{L}$
  - solution: $\omega = \left(\frac{T}{T^*}\right)^{\frac{1}{\theta+1}}\left(\frac{L}{L^*}\right)^{\frac{\gamma\theta-1}{\theta+1}}$; $\tilde{z} = 1\Big/\left[1+\left(\frac{T^*}{T}\right)^{\frac{1}{\theta+1}}\left(\frac{L^*}{L}\right)^{\frac{\gamma\theta+\theta}{\theta+1}}\right]$ where $\gamma \equiv \frac{\beta}{\sigma-1}$

→ interplay between comparative advantage & increasing returns is most easily characterized

Trade equilibrium: Solvable case I

$$A(\tilde{z}) = \left[\frac{T(1-\tilde{z})}{T^*\tilde{z}}\right]^{\frac{1}{\theta}} = \omega\left(\frac{L}{L^*}\right)^{-\gamma};\ \omega = \frac{\tilde{z}}{1-\tilde{z}}\frac{L^*}{L}$$

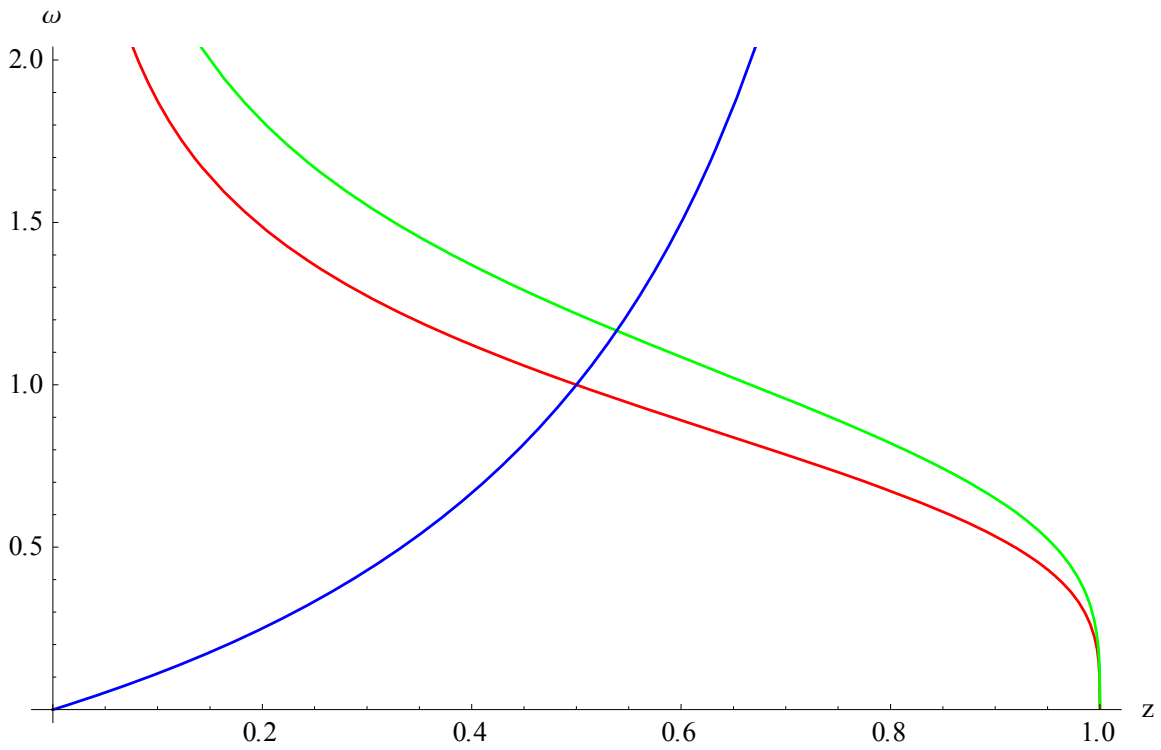
Case $\gamma < 1/\theta$ large location has lower wage $(T = T^*)$ **red:** $L = L^*$ (symmetry); **green:** $L > L^*$	**Case** $\gamma > 1/\theta$ large location has higher wage $(T = T^*)$ **red:** $L = L^*$ (symmetry); **green:** $L > L^*$
	

upward sloping curve = relative wage which balances trade (clears labor markets)

downward sloping curve = hypothetical relative wage which equalizes unit costs (after clearing market for producer services): steeper curve exhibits stronger comparative advantage (θ is smaller)

Trade equilibrium: baseline case II $A(\tilde{z}) = \left[\frac{T(1-\tilde{z})}{T^*\tilde{z}}\right]^{\frac{1}{\theta}} = \omega\left(\frac{L}{L^*}\right)^{-\gamma}$; $\omega = \frac{\tilde{z}}{1-\tilde{z}}\frac{L^*}{L}$ (blue)

Case $T > T^*$ and $L = L^*$;	technically more versed location has higher wage, ceteris paribus
red: $T = T^*$ (symmetry);	**green:** $T > T^*$



- **general case:** $\phi_s = 0$ and $0 \leq \phi_f \leq 1$ → trade costs for final goods & services
  - no closed-form solution for the wage ratio and the two cutoffs
  - existence and uniqueness of equilibrium is easily shown, however
  - results from solvable case largely carry over (subject to some minor qualifications)
  - effect of a change (increase) in the level of trade freeness ϕ_f
    - $\bar{z}$ falls and $\bar{z}^*$ increases: both economies import a greater range of final outputs
    - effect on wage ratio is positive, if initially $1 - \bar{z}^* > \bar{z}$, i.e. when initially, the range of foreign production exceeds the range of home production of final outputs

Tradable intermediates $1 \geq \phi_s \geq 0$

- assume ex-ante symmetry: $\lambda = 1/2$ and $T = T^*$
- multiple equilibria, when intermediates produced under increasing returns become tradable
  - → symmetric equilibrium: both locations have same ranges of final outputs and intermediates
  - → two symmetric equilibria where all intermediates are produced in one of the two locations
- of these equilibria, only the symmetric equilibrium is stable
- effect of an increase in home's relative labor endowment on the wage ratio depends on the balance of agglomeration forces and comparative advantage large as in solvable baseline case
- relative improvement of home's technologies $T/T^* \uparrow$: wage ratio $\omega \equiv w/w^*$ rises, P/P^* falls, V/V^* rises

4 Geography: Mobile workers

Long-run spatial equilibrium

- no first-nature differences ($T = T^*$) $\rightarrow$ $A(z) \equiv a^*(z)/a(z) = [(1-z)/z]^{\frac{1}{\theta}}$

- initial labor endowments are identical in the two locations; workers are mobile in the long-run; no mobility costs; workers are attracted to the location which offers the highest indirect utility

$$\frac{V}{V^*} = \frac{w/P}{w^*/P^*} = \omega \frac{P^*}{P}$$

- symmetry, $\lambda = 1/2$, is spatial equilibrium by construction, however not necessarily stable

Analysis of symmetry breaking

- the condition for symmetry breaking can be written as

$$g(\beta, \theta, \phi_s, \phi_f, \sigma) \equiv \phi_s \, h(\beta, \theta, \phi_f, \sigma) + j(\beta, \theta, \phi_f, \sigma) < 0$$

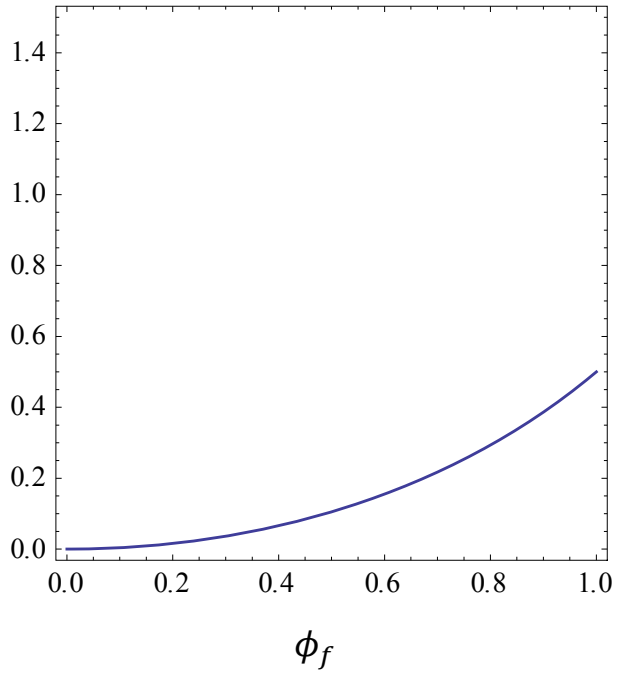
Notice: $h(\cdot)$ and $j(\cdot)$ are independent of $\phi_s \rightarrow g(\cdot)$ is linear in ϕ_s

- analysis of key forces of agglomeration and dispersion is (again) usefully split in two parts:
  - Marshall's world of localized non-tradable intermediates: $\phi_s = 0$
  - intermediates tradable, at a cost $0 < \phi_s \leq 0$

The baseline case: non-tradable intermediates $\phi_s = 0$

- symmetry breaking condition becomes: $\beta/(\sigma-1) > 2/\left[(2\theta+1)\phi_f{}^{-\theta} - 1\right]$.
- if, in addition, $\phi_f = 1$, symmetry breaking condition becomes: $\beta/(\sigma-1) > 1/\theta$

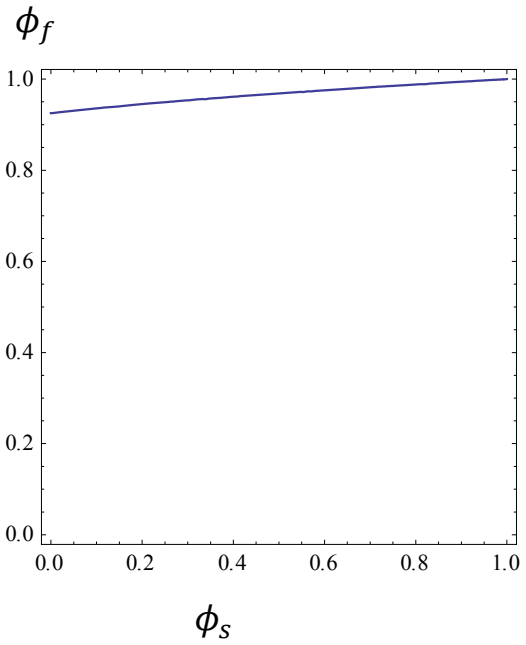
$\gamma \equiv \beta/(\sigma-1)$



- agglomeration above the blue line, symmetry below the blue line
- increasing γ induces/fosters agglomeration
- increasing θ shifts the curve down to the right: agglomeration is more likely
- increasing ϕ_f fosters dispersion: agglomeration plays out more strongly!

Tradable intermediates $0 < \phi_s \leq 0$

- numerical analysis is necessary to disentangle the forces determining symmetry breaking



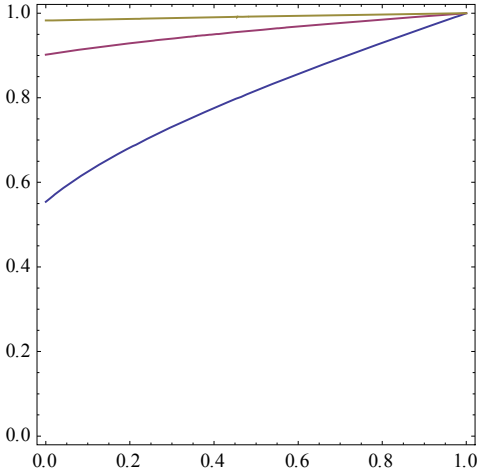
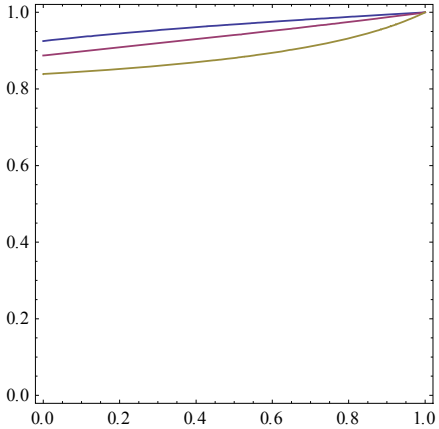
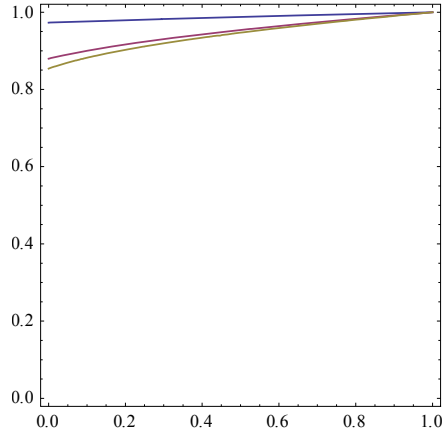
- $\beta = 0.525$ German and Japanese data,
- $\theta = 5.8$ Eaton & Kortum (2002) etc
- $\sigma = 8$ Head and Mayer (2004)

- positive relationship between ϕ_s and ϕ_f
- agglomeration below the blue line, symmetry above the blue line; first partial then full agglomeration

Key finding: increasing trade freeness of final outputs fosters symmetry

increasing trade freeness of intermediates fosters agglomeration

Robustness analysis: Symmetry breaking

a Comparative advantage θ	b Cost share of intermediates β	c Elasticity of substitution σ
		
The symmetry breaking condition shifts up as θ is increased from 1.5 (blue) to 5 (red) to 10 (yellow)	The symmetry breaking condition shifts up as β is increased from 0.1 (yellow) to 0.3 (red) to 0.525 (blue)	The symmetry breaking condition shifts up as σ is lowered from 25 (yellow) to 15 (red) to 5 (blue)

- positive relationship between ϕ_s and ϕ_f is robust !
- increasing θ, increasing β, reducing σ fosters agglomeration as in baseline case

5 Secular Shifts: Interplay of comparative advantage and increasing returns

Three secular changes

- **'first great unbundling'** → $\phi_f \uparrow$
- **'second great unbundling'** → $\phi_s \uparrow$
- flattening of comparative advantage ("**kaleidoscopic**") → $\theta \uparrow$

Notice: no evidence for secular changes in

- cost share of intermediates β [e.g. Becker & Mündler 2015]
- elasticity of substitution σ

Implications for international trade

- reductions in costs of shipping final goods and services (first unbundling) $\phi_f \uparrow$

  → specialization increases ($\bar{z}$ falls, $\bar{z}^*$ rises) and more trade of final goods and services

- reductions in transport, information and communication costs (second unbundling), $\phi_s \uparrow$

  → this reinforces the growth of world trade

- participation of labor-rich countries in world trade (China, India, ….): foreign labor force ↑: their production & export ranges ↑; this is more pronounced, the flatter is comp. adv. (high θ)

- interplay of comparative advantage & increasing returns is important for $\omega \equiv w/w^*$
  - larger economy benefits from agglomeration economies: dampens/reverses fall in ω
  - flatter comparative advantage: (negative) effect on $\omega \equiv w/w^*$ is dampened
  - foreign technology catch-up: their production & export range (finals) ↑; the positive effect on their relative wage is dampened if comparative advantage gets weaker (high θ)

Implications for geography

- effect of trade cost reductions is much more nuanced than implied by new trade and NEG

- second unbundling $\phi_s \uparrow$ works in favor of agglomeration, first unbundling $\phi_f \uparrow$ fosters the dispersive force of comparative advantage and fosters dispersion

  → evolution of the determinants of these trade costs is empirical issue

  → if progress in information and communication technologies is faster than in traditional transport technologies then the second unbundling may be more important (services)

- the flattening of comparative advantage works in favour of agglomeration

6 Conclusion

- world economy reflects comparative advantage and increasing returns shoulder by shoulder (comparative advantage is back)

- analysis of the interplay between comparative advantage and increasing returns within a simple unified Ricardo-Marshall framework - or, rather, Eaton-Kortum-Ethier-framework

- three payoffs
  - allows us to study three **secular changes** in economic environment
  - allows us to **highlight different effect of two types of trade costs**
  - we contribute a framework for the modelling of **city systems**

- tractability of the model should make it a useful tool for policy analysis and empirical work and allow further generalizations (e.g. to many regions)