Regional Specialization:
from the geography of industries to the geography of jobs

Antoine Gervais
Université de Sherbrooke

James R. Markusen
University of Colorado, Boulder

Anthony J. Venables
The Productivity Institute, University of Manchester, Monash University

We build on many earlier articles, intersect or overlap with many more.

- Rise and fall of different industries
- Changing demand for different skills and occupations
- Rise / fall / stagnation of different regions
- Regional agglomeration of occupations
- Geographic fragmentation of production processes

So much to acknowledge, will try to clarify our value added, new twists.

Purpose of paper broadly stated.

- Empirics: analyze trends in
  - industry / occupation concentration
  - regional specialization in industries / occupations
  - broadly consistent with literature, updates findings.

- Motivated by the findings, construct a new theoretical approach that mimics the data.

- Draw out regional/national implications:
  - sectors / occupations concentrate / disperse.
  - region size (urbanization).
  - production reallocation across sectors.
  - welfare.

- Draw out international implications:
  - composition of trade with ROW,
  - trade balance in urban goods with ROW.

Empirical Analysis (Antoine)

Sectors => industries   functions => occupations   regions => states

- Fragmentation costs, focus of theory to follow, not directly observed

  Available proxies do not provide either state- or sector-level variation.

- Empirics follow specialization and concentration over time.

  Industry - occupation - state employment using comparable data from the BLS,
  relatively disaggregated data.

- USA Bureau of Labor Statistics - employment in industries, occupations

  Quarterly Census of Employment and Wage dataset (QCEW)
  Occupational Employment Statistics (OES).

  Employment by six-digit (NAICS) industries for each state 1990-2019 (626 industries)

  From the OES, function-by-state data, employment by six-digit Standard Occupational Classification (SOC) occupations by US states for 2000-2019. (704 occupations)

Sector concentration indices for sectors (s) and functions (f)

$$G_s = \sum_r (m_{sr} - m_r)^2$$

$$m_{sr} = L_{sr} / \sum_r L_{sr}$$

region r share of sector s national employment

$$m_r = L_r / \sum_r L_r$$

region r share of national employment

$$G_f = \sum_r (m_{fr} - m_r)^2$$

$$m_{fr} = L_{fr} / \sum_r L_{fr}$$

region r share of function f national employment

$$m_r = L_r / \sum_r L_r$$

region r share of national employment

Regional specialization indices for sectors (s) and function (f)

$$D_r^{sector} = \sum_s (q_{rs} - q_s)^2$$

$$q_{rs} = L_{sr} / \sum_s L_{sr}$$

sector s share of region r total employment

$$q_s = L_s / \sum_s L_s$$

sector s share of national employment

$$D_r^{function} = \sum_f (q_{rf} - q_f)^2$$

$$q_{rf} = L_{fr} / \sum_f L_{fr}$$

function f share of region r total employment

$$q_f = L_f / \sum_f L_f$$

function f share of national employment

Ellison-Glaeser (1997) indices for sector and occupation concentration and regional specialization

corrected from the simple ones above by including information on firm-size distribution

Issue wrt sector and function concentration indices

Decreasing concentration could be due to the shift in employment from more concentrated to less concentrated industries (manufacturing to services?)

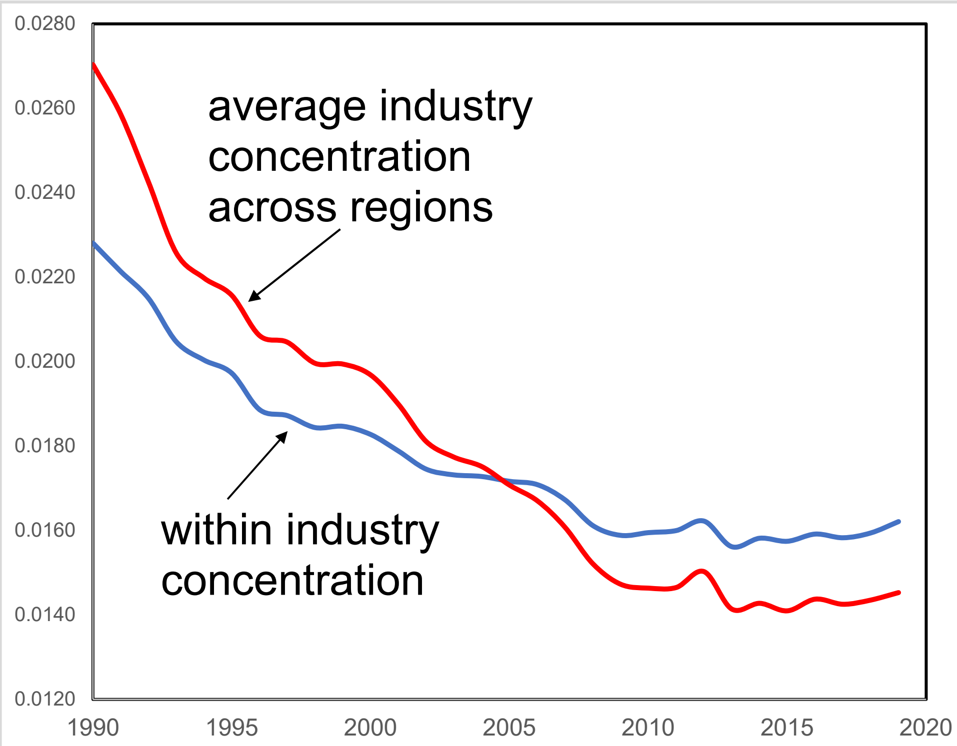
Model is about within-industry shifts. Decompose EG to get within industry shifts.

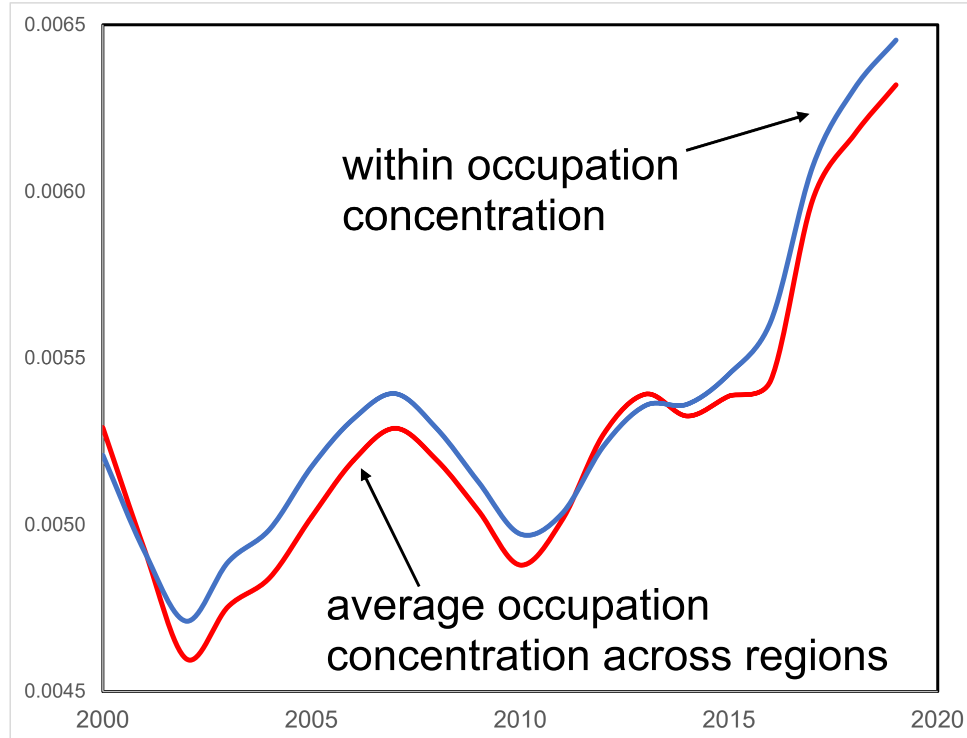
$$EG_\tau^{Sector} = \sum_s m_{s\tau} EG_{s\tau} = \sum_s m_s EG_{s\tau} + \sum_s (m_{s\tau} - m_s) EG_{s\tau}$$

$m_{s\tau}$ = sector s's share of national employment in year tau
m_s = mean of $m_{s\tau}$ over time.

First term in the second equality: holds employment share constant at the sample mean: within industry changes in concentration.

Second term in the second equality: remainder of time series changes.

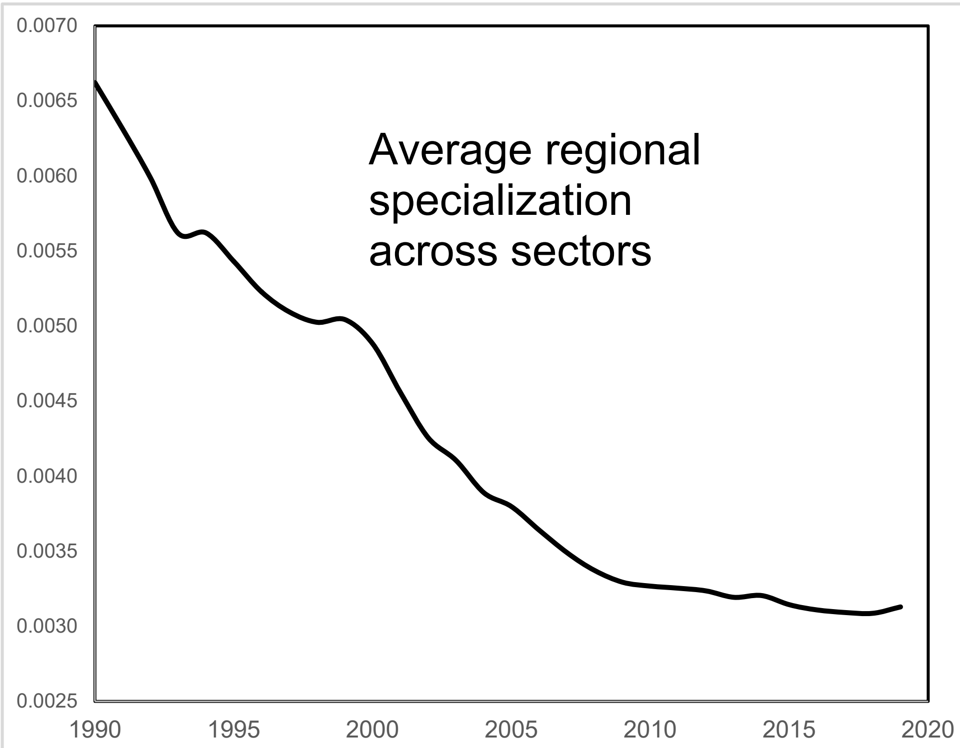


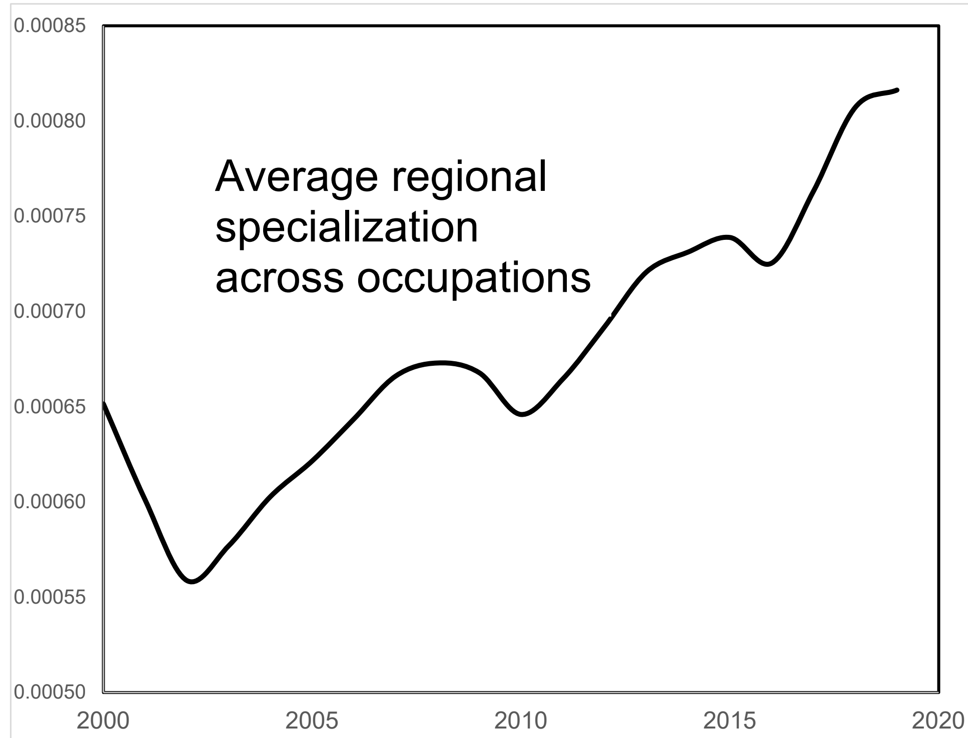


Concentration indices for industries (1990-2019) and occupations (2000-2019)

Blue lines are the focus of the model to follow: within a sector employment becomes more geographically dispersed

Red lines include movement of aggregate employment from more concentrated to less concentrated sectors, from less concentrated to more concentrated occupations





Specialization indices for regions: for industries (1990-2019) and occupations (2000-2019)

Within a region employment becomes more dispersed across sectors

Within a region employment becomes more concentrated across occupations

Model motivated by empirics, tries to capture results:

new economic geography, offshoring and production fragmentation
urban economics, international trade theory

- Regional comparative advantage based on functional (occupational) productivity, sectors differ in function intensity.
- Lower costs of geographically separating activities exploits regions' functional comparative advantage though fragmentation.
- Consistent with empirics: as fragmentation costs fall, regions become more specialized across functions and less specialized in sectors.
- Results derived for regional, national, and international variables.

MODEL

- Two regions within a country produce urban goods/services, referred to as sectors (industries) trade with ROW

- Hinterland with labor, ag good, costless migration to/between regions.

  Congestion, commuting raises production costs in larger region

- Two functions (occupations), such as blue/white collar activities

- Sectors differ in function intensities. Perfect competition, constant returns to scale (refer to industries, no firm-level analysis).

- For a given sector: functions in same (integration) or different cities (fragmentation), Cost to fragmentation - key parameter

- Regions have comparative advantage in functions, not sectors

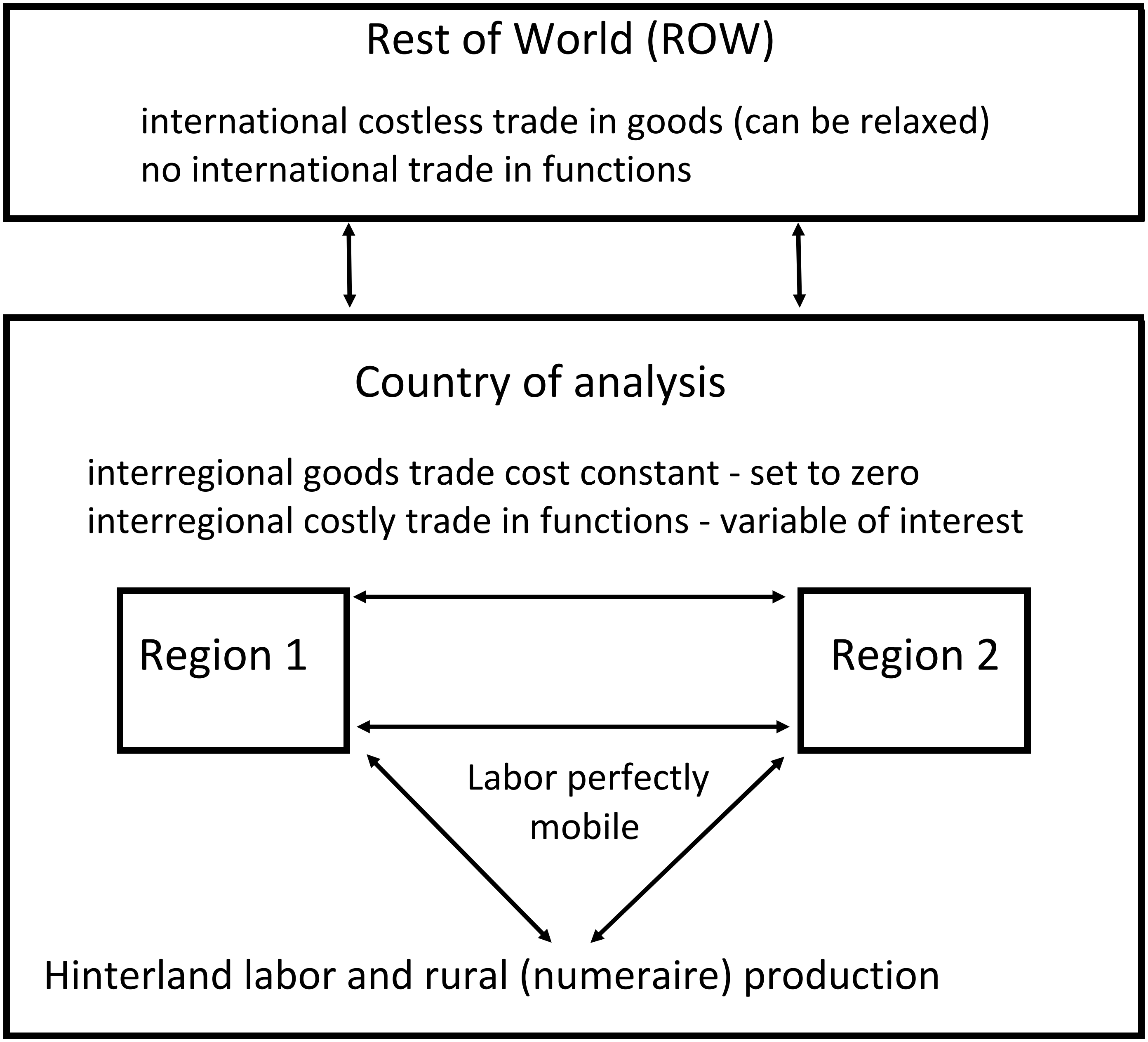
    Ricardian comparative advantage
    external economies to local agglomeration of a function

- Many sectors, labor the only factor of production

- Homogeneous workers have no comparative advantage between functions, but are more productive in one region doing a specific function

- Sector function intensities combine with region function comparative advantage to determine:

    Which sectors are integrated and in which regions
    Which sectors are fragmented


Rest of World (ROW)
international costless trade in goods (can be relaxed)
no international trade in functions
Country of analysis
interregional goods trade cost constant - set to zero
interregional costly trade in functions - variable of interest
Region 1
Region 2
Labor perfectly mobile
Hinterland labor and rural (numeraire) production

Sector index	s (continuum in partial-equilibrium section): $s \in (0,1)$
City index	1, 2
Function index	A, B

$a(s),\ b(s)$	function A or B intensity of sector s amount of function A or B needed to produce one unit of good s
$\lambda_{A1},\ \lambda_{B1},\ \lambda_{A2},\ \lambda_{B2}$	comparative (dis)advantage of cities in functions amount of labor need in city1 to produce one unit of function A, etc. Ricardian-exog, spillovers-endog
$p(s),\ w_1,\ w_2,\ t$	price of sector s, wage in city i, fragmentation cost

Principal assumptions (symmetric cases)

$a(s) = 1 - b(s),\ a'(s) < 0$	low s index = A function intensive
$\lambda_{A1} = \lambda_{B2} < \lambda_{A2} = \lambda_{B1}$	city 1: comparative advantage in A

Partial-equilibrium analytical solutions: one firm in each sector produces one unit of output

$$\pi_1(s) = p(s) - w_1(a(s)\lambda_{A1} + b(s)\lambda_{B1})$$

$$\pi_2(s) = p(s) - w_2(a(s)\lambda_{A2} + b(s)\lambda_{B2})$$

$$\pi_F(s) = p(s) - w_1 a(s)\lambda_{A1} - w_2 b(s)\lambda_{B2} - t(w_1 + w_2)/2$$

Consider symmetric case: $w_1 = w_2, \quad \lambda_{A2} - \lambda_{A1} = \lambda_{B1} - \lambda_{B2} = \Delta\lambda > 0$

$b(s)\Delta\lambda < t$	integrate in 1, low s sector
$t \le b(s)\Delta\lambda, \quad (1 - b(s))\Delta\lambda \le t$	fragment, middle s sector
$(1 - b(s))\Delta\lambda < t$	integrate in 2, high s sector

Intuition: fragmentation profitable when using balance of A and B small saving from fragmentation when only use a little bit of A or B

Spillovers: external economies of scale to a function/city combination. Outputs of function i in city j are

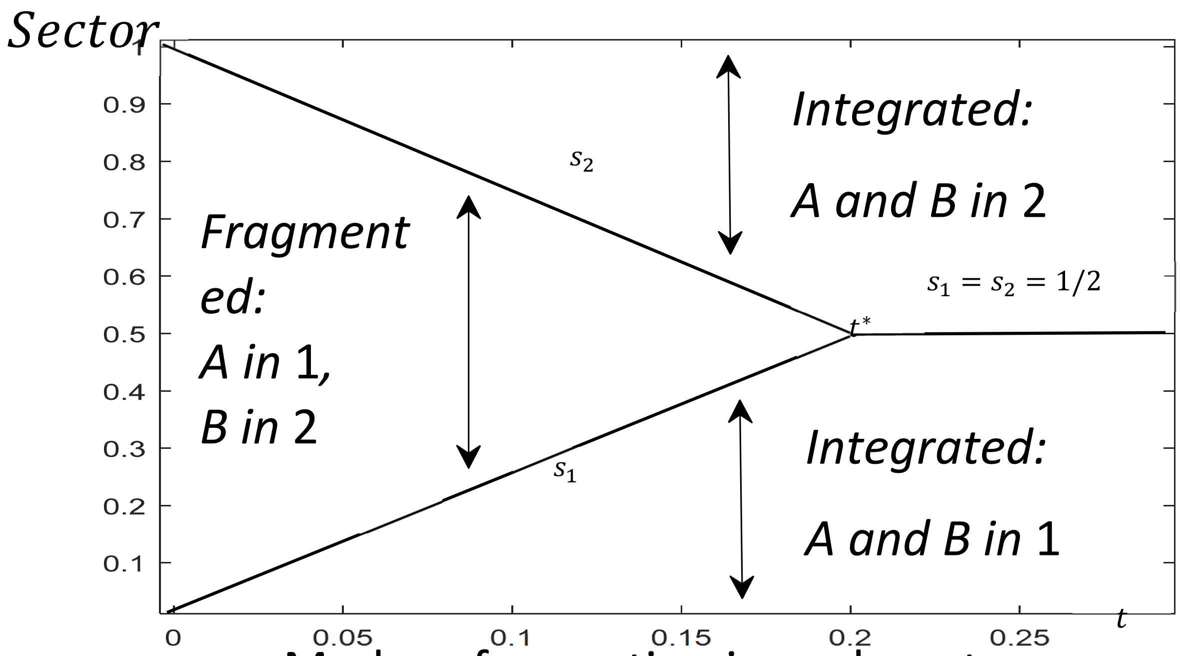
$$X_{A1} = \int_0^{s_2} a(s)ds \qquad X_{B1} = \int_0^{s_1} b(s)ds$$

$$X_{A2} = \int_{s_2}^{1} a(s)ds \qquad X_{B2} = \int_{s_1}^{1} b(s)ds$$

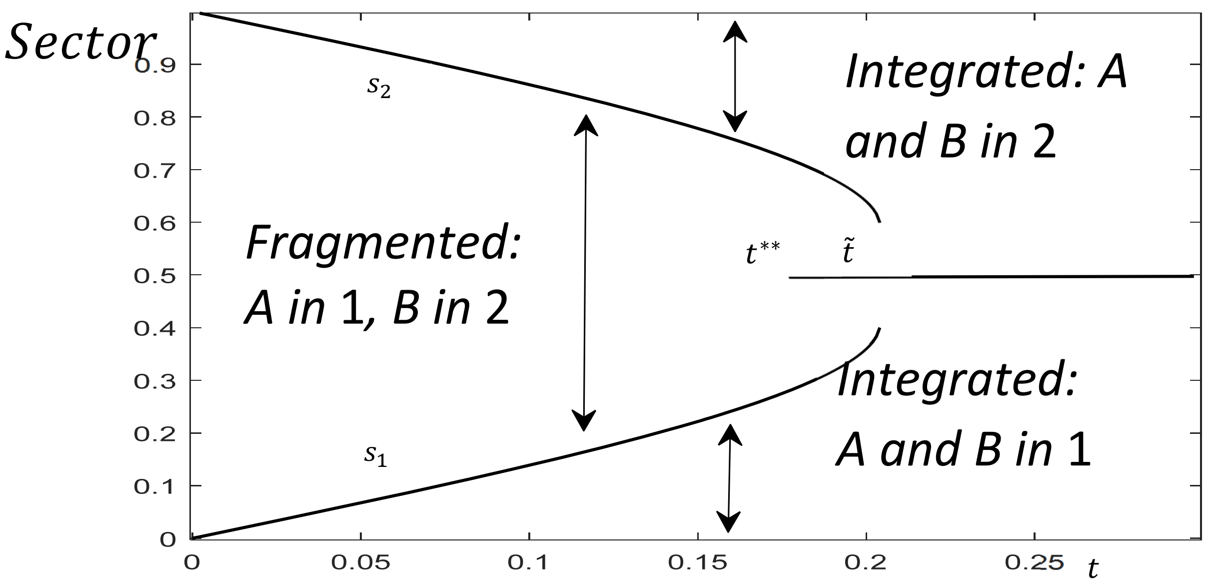
Unit labor inputs needed to produce on unit of a function are:

$$\lambda_{A1} = \Lambda_{A1} - \sigma_A X_{A1} \qquad \lambda_{A2} = \Lambda_{A2} - \sigma_A X_{A2}$$

$$\lambda_{B1} = \Lambda_{AB1} - \sigma_B X_{B1} \qquad \lambda_{B2} = \Lambda_{B2} - \sigma_B X_{B2}$$



Modes of operation in each sector *s*.



Modes in each sector s: with increasing returns.

General-equilibrium model

- sector (industry) output levels are endogenous.
- goods/services prices endogenous, foreign goods prices fixed.
- endogenous labor supply from hinterland, “producer (city) wages”, or equivalently, city populations can differ.
- outside world produces a ces substitute good for each domestic s, Cobb-Douglas demand across the s sectors (“urban” sectors). Armington between domestic and ROW versions.
- quasi-linear preferences between agriculture and composite urban goods. Agricultural good balances trade.

Variables

L_1, L_2	labor demand or employment in city i
w_1, w_2	wages in city i
$X_{A1}, X_{A2}, X_{B1}, X_{B2}$	output of function k = (A,B) in city j
$\lambda_{A1}, \lambda_{A2}, \lambda_{B1}, \lambda_{B2}$	labor requirements in function k in city j
$Q_d(s)$	total output of sector s (all firm types)
$Q_{df}(s)$	domestic demand for foreign goods
$n_1(s), n_2(s), n_F(s)$	sector s output of type 1, 2, F
$p(s)$	price of (domestic) sector s

Non-linear complementarity problem (MCP), discrete number of s sectors (51 industries here).

318 weak inequalities, each with an associated non-negative variable.

First, the supply-demand relationships for labor demand in the two regions, $\perp$ denotes complementarity between the inequality and a variable.

$$L_1 \geq \sum_s n_1(s)(a(s)\lambda_{A1} + b(s)\lambda_{B1}) + n_F(s)a(s)\lambda_{A1} + n_F(s)t/2 \quad \perp \quad L_1$$

$$L_2 \geq \sum_s n_2(s)(a(s)\lambda_{A2} + b(s)\lambda_{B2}) + n_F(s)b(s)\lambda_{B2} + n_F(s)t/2 \quad \perp \quad L_2$$

Second, wages (w_0 hinterland wage, c commuting cost, K number of cities)

$$(w_1 - w_0)K/c \geq L_1 \qquad \perp \quad w_1$$

$$(w_2 - w_0)K/c \geq L_2 \qquad \perp \quad w_2$$

Third, output levels of the two functions in the two cities

$$X_{A1} \geq \sum_s a(s)(n_1(s) + n_F(s)) \quad \perp \quad X_{A1}$$

$$X_{A2} \geq \sum_s a(s)n_2(s) \quad \perp \quad X_{A2}$$

$$X_{B1} \geq \sum_s b(s)n_1(s) \quad \perp \quad X_{B1}$$

$$X_{B2} \geq \sum_s b(s)(n_2(s) + n_F(s)) \quad \perp \quad X_{B2}$$

Fourth, the labor input coefficients (inverse productivity)

$$\lambda_{A1} \geq \Lambda_{A1} - \sigma_A X_{A1} \quad \perp \quad \lambda_{A1}$$
$$\lambda_{A2} \geq \Lambda_{A2} - \sigma_A X_{A2} \quad \perp \quad \lambda_{A2}$$
$$\lambda_{B1} \geq \Lambda_{B1} - \sigma_B X_{B1} \quad \perp \quad \lambda_{B1}$$
$$\lambda_{B2} \geq \Lambda_{B2} - \sigma_B X_{B2} \quad \perp \quad \lambda_{B2}$$

The total output of each sectors (n_i) is complementary to a zero-profit condition, that unit cost is greater than or equal to price.

We use a simple formulation of the fragmentation cost: $t(w_1 + w_2)/2$.

$$w_1(a(s)\lambda_{A1} + b(s)\lambda_{B1}) \geq p(s) \qquad \perp \quad n_1(s)$$

$$w_2(a(s)\lambda_{A2} + b(s)\lambda_{B2}) \geq p(s) \qquad \perp \quad n_2(s)$$

$$w_1 a(s)\lambda_{A1} + w_2 b(s)\lambda_{B2} + t(w_1 + w_2)/2 \geq p(s) \qquad \perp \quad n_F(s)$$

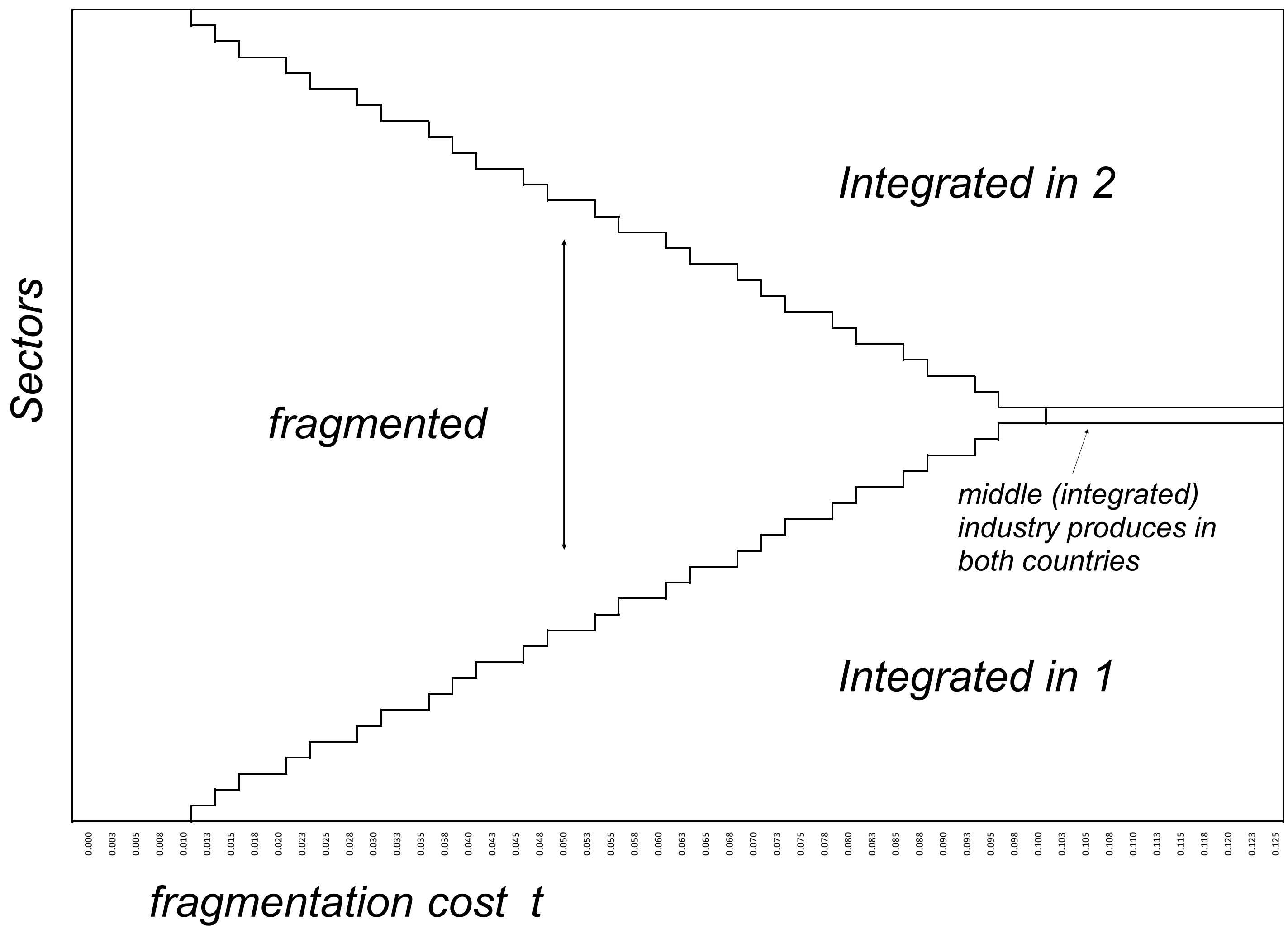
Total output of sector *s* is given by the sum the outputs across firm types.

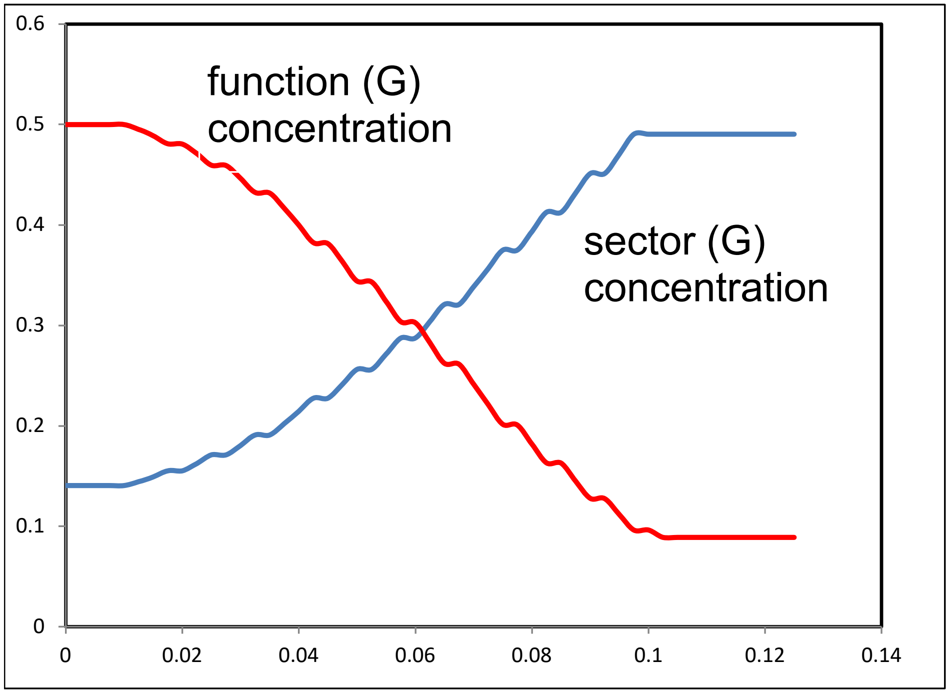
$$Q_d(s) \geq n_1(s) + n_2(s) + n_z(s) \qquad \perp \quad Q_d(s)$$

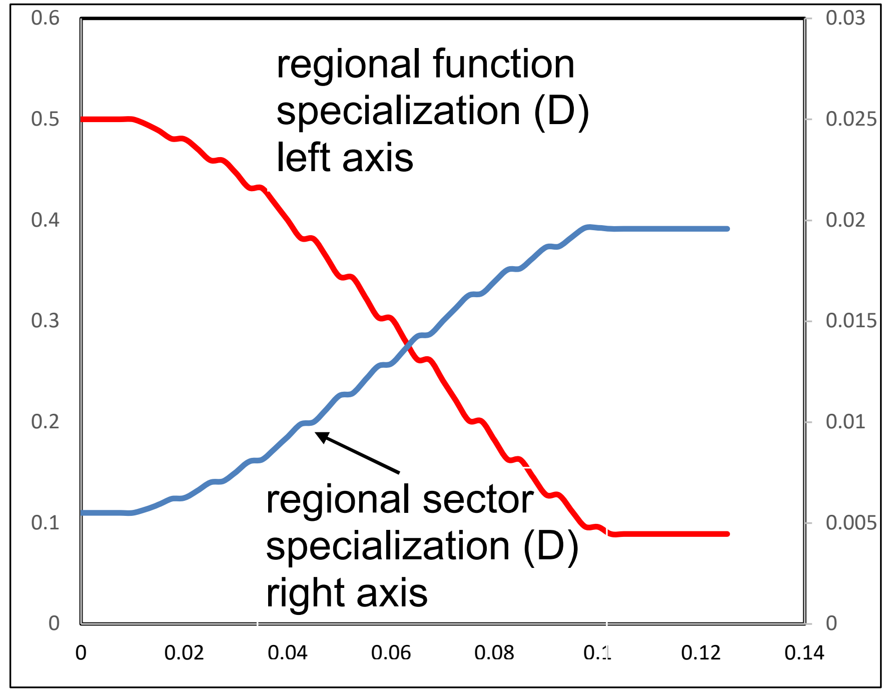
Skip demand side for brevity.

Figure A1: Symmetric Ricardian Case

Ricardian comparative advantage, free entry, no spillovers



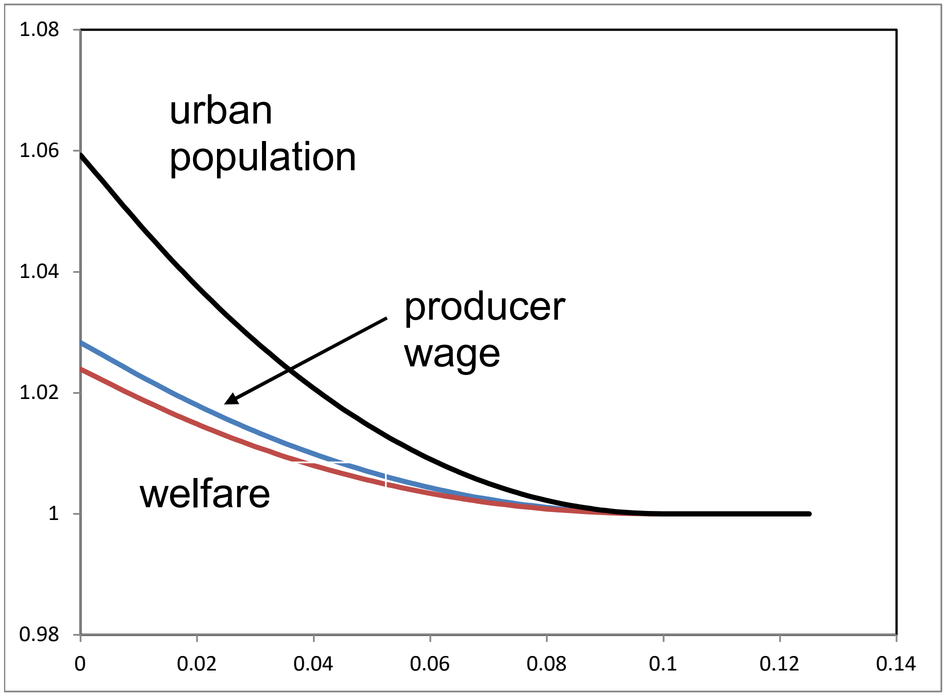


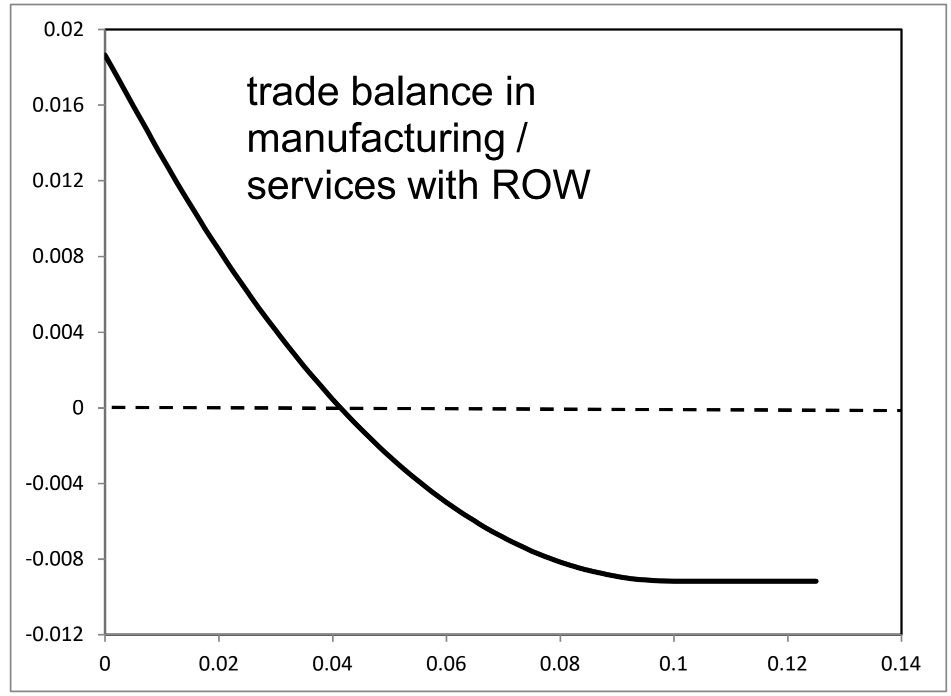


Symmetric Ricardian Case fragmentation cost t on horizontal axes

falling t — raises function concentration across regions, lowers it in sectors

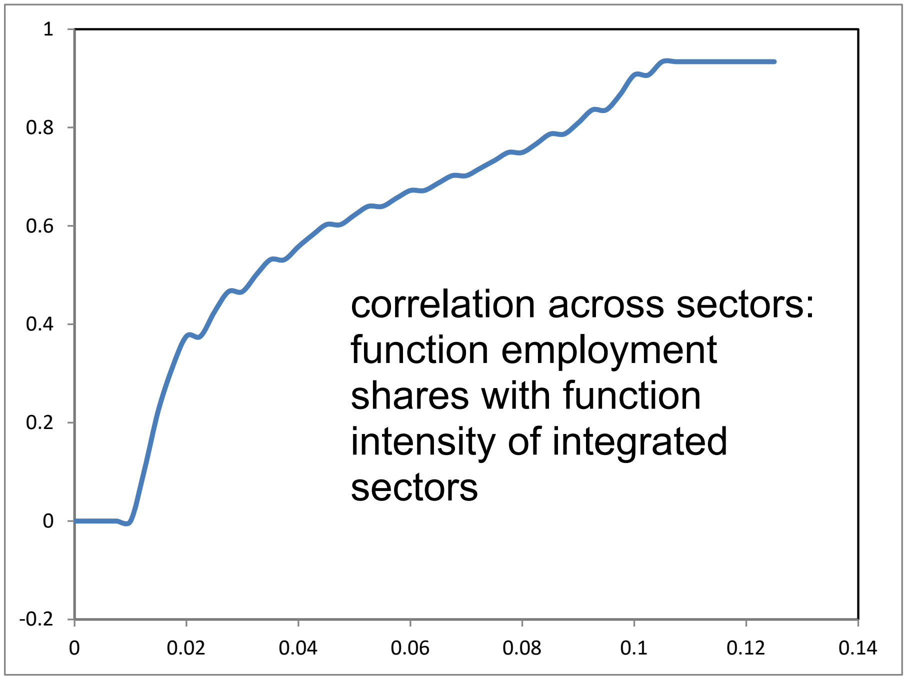
raises regional specialization cross functions, lower it across sectors

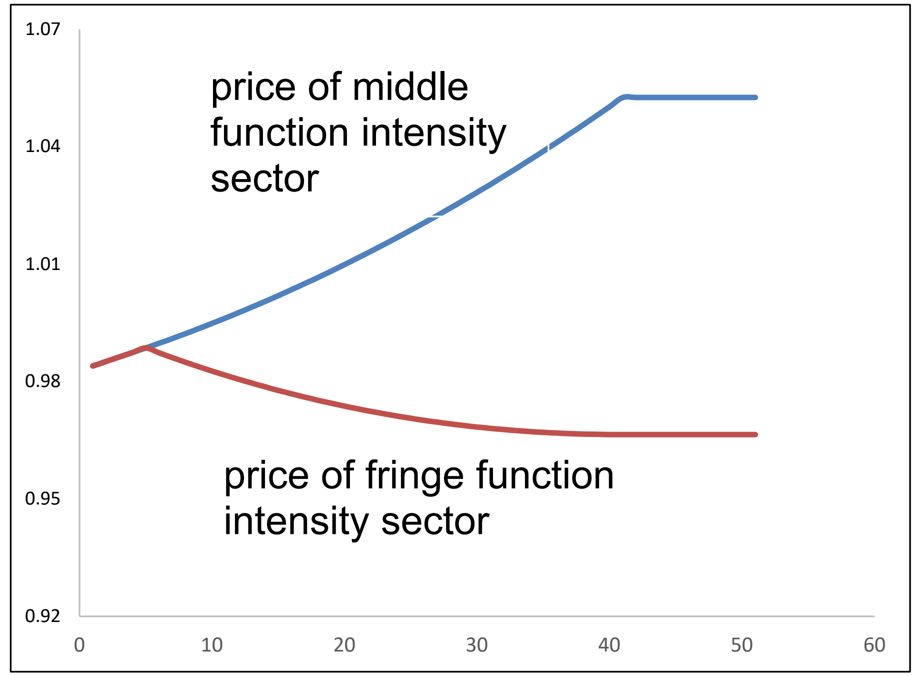




Symmetric Ricardian Case fragmentation cost t on horizontal axes

falling t
- raises total "urban" population, urban/rural wage differential
- alters national trade with ROW, raising net exports of urban goods, lowering that of hinterland good

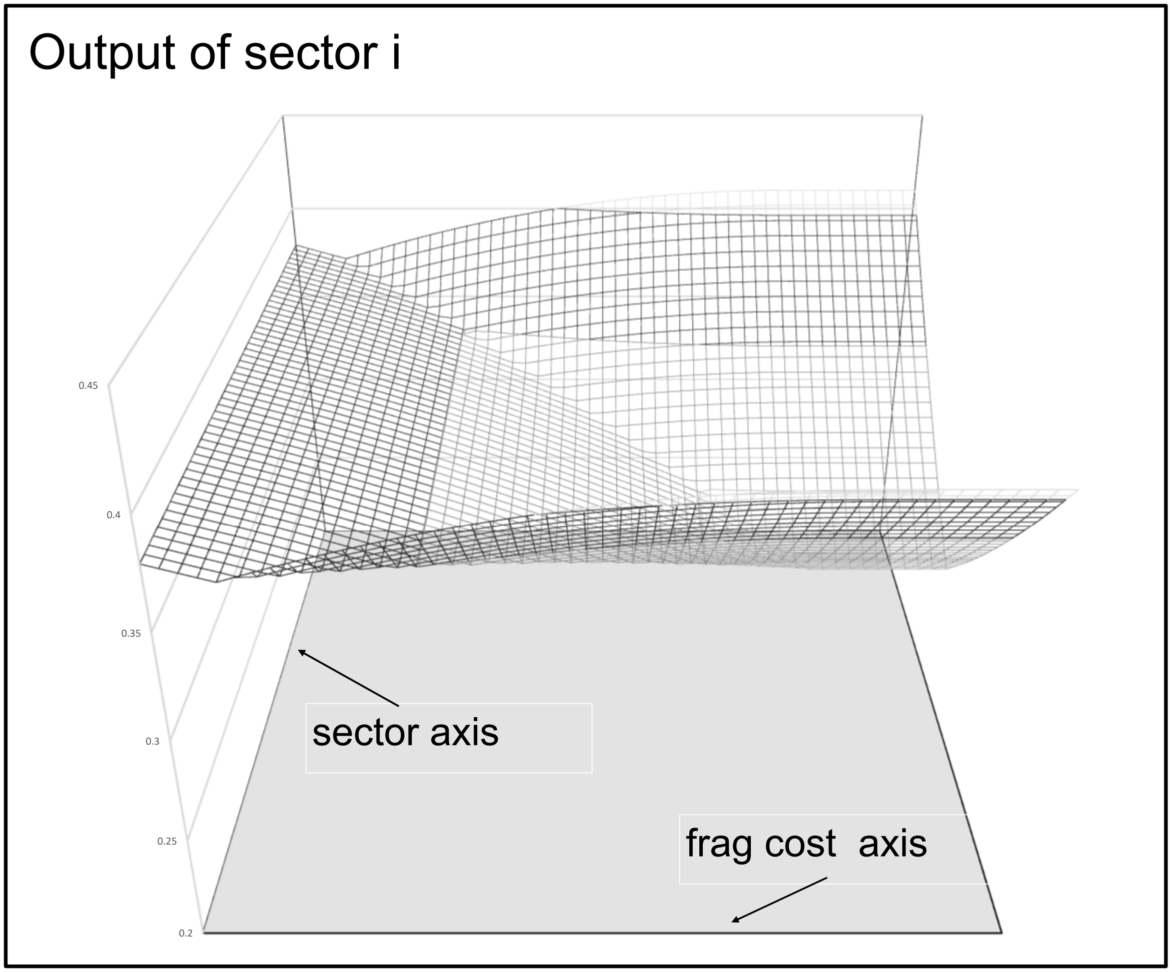




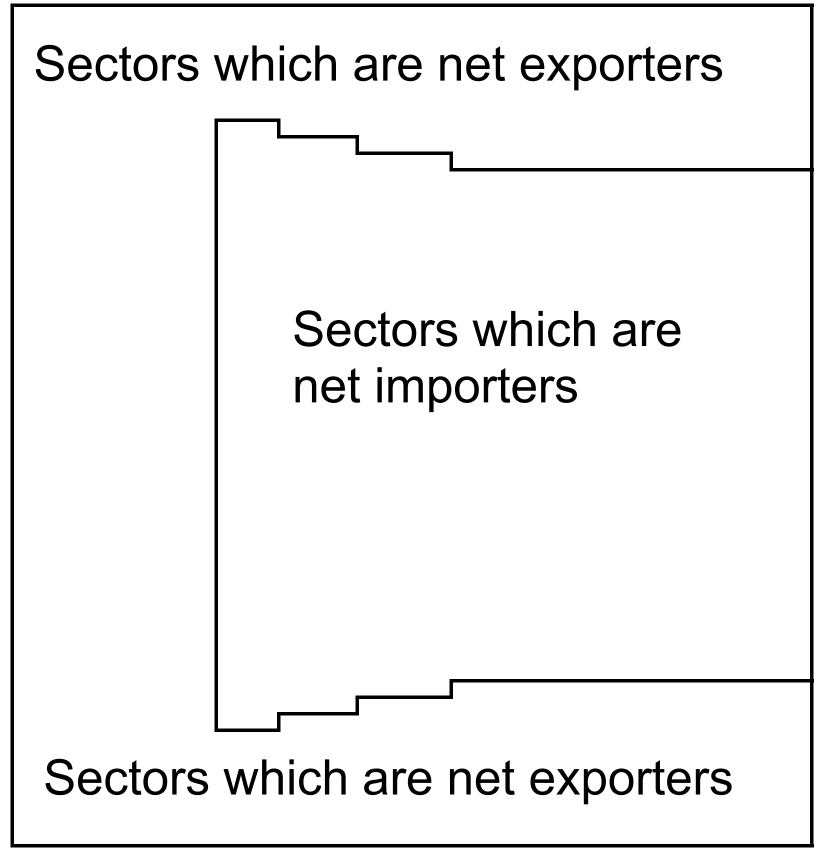
Symmetric Ricardian Case fragmentation cost t on horizontal axes

falling t

- weakens the H-O presumption: each region gains employment in its comparative disadvantage sectors, loses employment in its comparative advantage sectors
- alters the pattern of national comparative advantage from "fringe" sectors to middle function-intensity sectors



Fragmentation cost t on horizontal axis
Sectors on depth axis



Fragmentation cost t on horizontal axis
Sectors on vertical axis

Falling t changes the sectoral composition of national output toward middle function intensity sectors

Falling t changes the middle function intensity sectors from net importers to net exporter

Conclusions:

- Empirics examines concentration and specialization over time.
  - concentration of occupations increases, falls for industries.
  - regional specialization in occupations increases, falls for industries.

- Theoretical model with comparative advantage based region-function specific productivity. Sectors differ in function intensities.

- Falling costs of geographically separating functions mimics behavior of concentration/specialization indices over time.

- Fragmentation analogous to productivity improvement:
  - sectors using a balance of functions (middle intensity) benefit
  - urbanization increases, welfare increases
  - urban / rural wage difference increases

- External trade with ROW changes
  - middle intensity sectors shift from being net importers to become exporters
  - at zero frag costs, no comparative advantage across sectors
  - overall trade balance in urban goods/services shifts from deficit to surplus

- A taste of results: external economies / spillovers case, asymmetric cases, non-monotonic convergence, etc.

A uniform trade liberalization with ROW has

no effect on the pattern of fragmented / integrated industries (Ricardian)

increases fragmentation in the spillovers case (for constant t).

In an asymmetric Ricaridan case (one region has absolute advantage), falling t leads to convergence in region size.

In an asymmetric spillovers case (in one function only), falling t at first leads to region size divergence, then (incomplete) convergence.