

Structural Change in an Open Economy

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May 28, 2012¹

¹The views expressed here are those of the authors and are not necessarily reflective of views of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

Structural Change

Share of employment (16 advanced nations)

Sector	1870	1960	1987
Agriculture	0.49	0.17	0.06
Services	0.24	0.44	0.63
Manufacturing	0.27	0.39	0.30

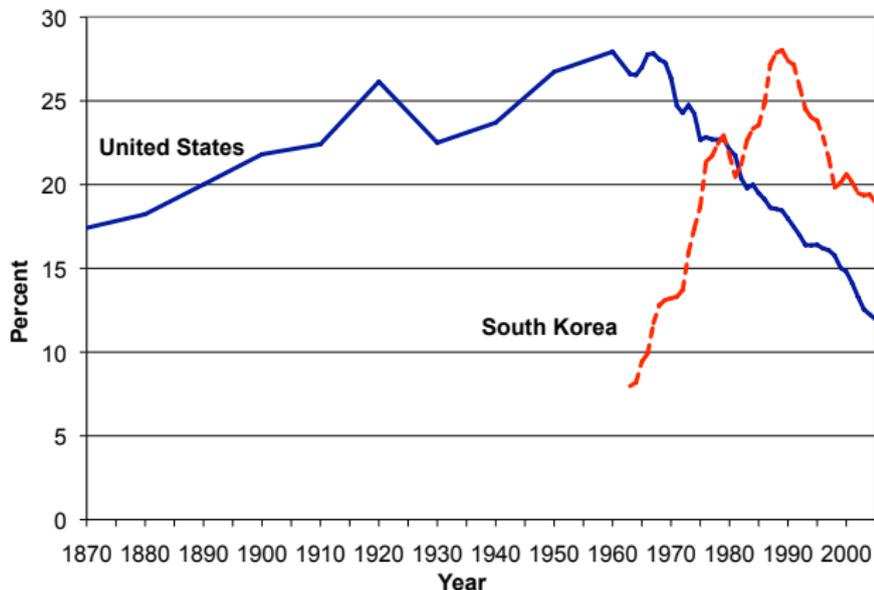
Source: Maddison (1991)

- Agriculture share **declines** over time.
- Services share **rises** over time.
- Manufacturing share **first rises** and **then declines** over time.

Global integration, Structural Change

- World's economies increasingly interlinked via trade.
 - In past 30-40 years many emerging market countries have globalized
- Manufacturing labor shares are declining in developed nations, and rising (although not permanently) in emerging market countries.
 - Trade with emerging markets has been blamed for declining manufacturing employment in developed countries.
- In most countries, manufacturing has the highest productivity growth.

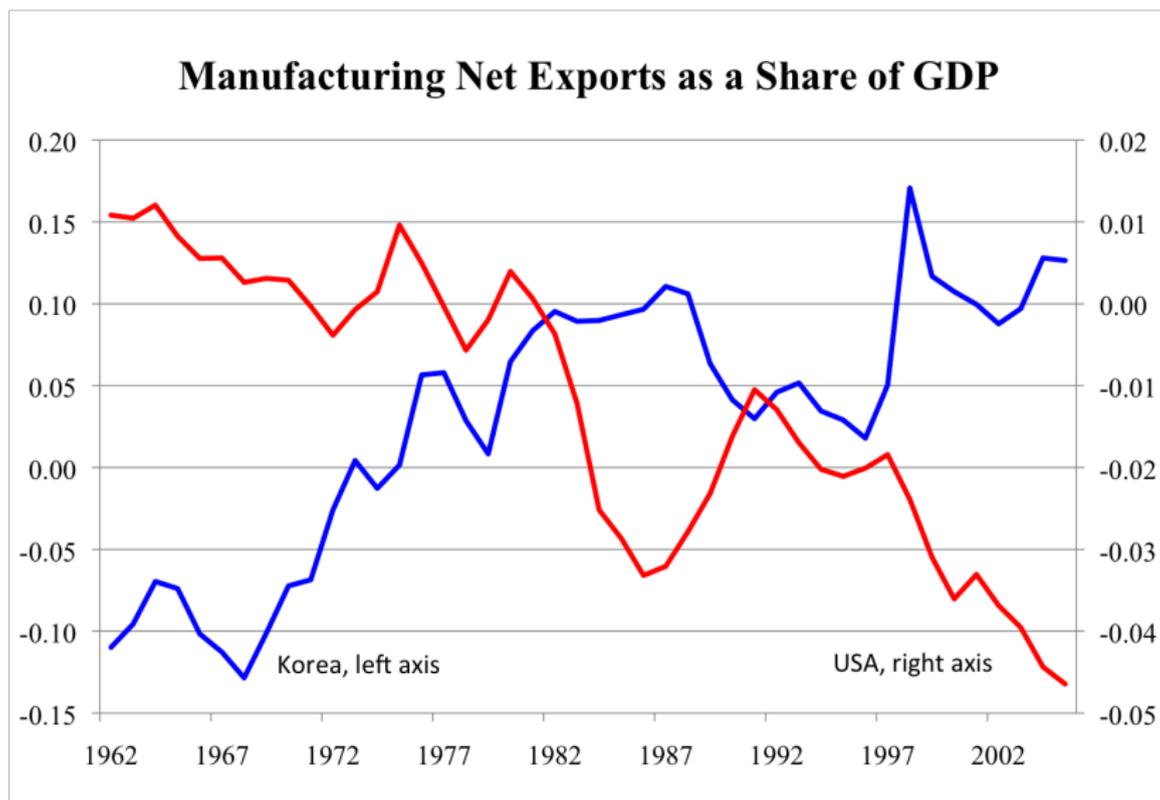
U.S. and South Korea Manufacturing Employment Share



Labor Productivity Growth (1970-2005)

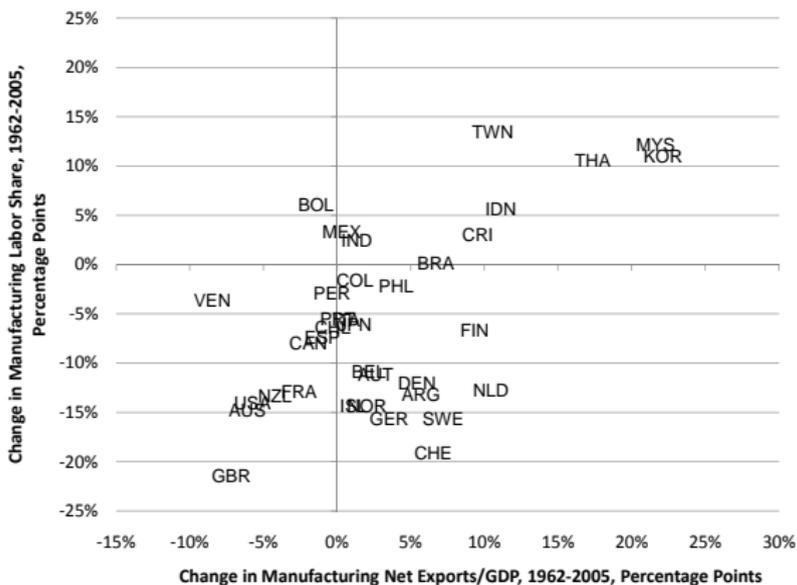
Country	Agriculture	Manufacturing	Services
U.S.	1.5%	3.8%	0.7%
South Korea	4.9%	7.0%	1.7%

South Korea's Manufacturing Net Exports As Share of GDP



Manufacturing Trade and Employment

Figure: Manufacturing Net Exports and Manufacturing Employment



Services Employment and Trade

$$l_{ist} = \beta_0 + \beta_1 trade_{it} + \beta_2 gdppc_{it} + \gamma_i + \epsilon_{it}$$

- i : country; t : period
- l_{ist} : services employment share
- $trade_{it}$: exports+imports as a share of GDP
- $gdppc_{it}$: GDP per capita in 2005 international dollars

Table: Trade and Services Labor Share

	$trade_{it}$	$gdppc_{it}$	β_0	R^2	Obs
Fixed Effect ^a	0.0801 (0.0289)	1.23e-5 (1.12e-6)	0.369 (0.0251)	0.67	379

Key Question

- What is the effect of international trade on the process of structural change?

Our Approach

- We develop a two-country, three-sector model with inter- and intra-sector Ricardian trade

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 - Trade delinks sectoral production and sectoral expenditure:
 - Closed: labor share = expenditure share
 - Open: labor share = expenditure share + net export share

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 - Trade changes relative prices, affecting expenditure shares

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- We demonstrate two ways in which open economy can generate hump pattern in manufacturing employment

Related Research

- Models of structural change:
 - Closed-economy models: Kongsamut, Rebelo and Xie (2001) and [Ngai and Pissarides \(2007\)](#)
 - Open economy models:
 - Matsuyama (2009): an example with Ricardian framework
 - Coleman (2007): model in which large emerging market country integrates with rest of world
- Models of Ricardian trade: [Eaton and Kortum \(2002\)](#)

Two Groups of Theories of Structural Change

- Non-homothetic preferences:
 - Engel (1895)
 - Kongsamut et. al (2001)
- Sector-biased productivity growth:
 - Baumol (1967)
 - Ngai and Pissarides (2007)

Closed economy frameworks

Model Set Up

- Two countries
- Three sectors: agriculture, manufacturing, services
 - Agriculture and manufactured goods are tradable
 - Services are nontradable
- One factor: labor with exogenous supply
 - Mobile across sectors, but immobile across countries
- Productivity growth differs across sectors and countries
- Free trade: based on Ricardian comparative advantage

Technologies

- Services: a single good $Y_{ist} = A_{ist}L_{ist}$
- Agriculture and manufacturing: a continuum of goods

$$y_{imt}(z) = A_{imt}(z)L_{imt}(z) \quad z \in [0, 1]$$

$$y_{iat}(z) = A_{iat}(z)L_{iat}(z) \quad z \in [0, 1]$$

- A is distributed as Fréchet: $F_{igt}(z) = \exp(-T_{igt}z^{-\theta})$
- Goods are combined to yield composite goods for consumption

Prices

- Perfect competition in goods and factor markets

- Service good price: $P_{ist} = \frac{w_{it}}{A_{ist}}$

- Agricultural good price:

$$p_{iat}(z) = \min \left\{ \frac{w_{1t}}{A_{1at}(z)}, \frac{w_{2t}}{A_{2at}(z)} \right\}$$

- Manufacturing good price:

$$p_{imt}(z) = \min \left\{ \frac{w_{1t}}{A_{1mt}(z)}, \frac{w_{2t}}{A_{2mt}(z)} \right\}$$

Preferences

- Tradable sector composite goods: elasticity of substitution η

$$C_{iqt} = \left(\int_0^1 c_{iqt}(z)^{\frac{\eta-1}{\eta}} dz \right)^{\frac{\eta}{\eta-1}}$$

- Intra-temporal utility: elasticity of substitution ϵ

$$C_{it} = \left(\omega_a C_{iat}^{\frac{\epsilon-1}{\epsilon}} + \omega_m C_{imt}^{\frac{\epsilon-1}{\epsilon}} + \omega_s C_{ist}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}$$

- Intertemporal utility: $\sum_{t=0}^{\infty} \beta^t U(C_{it})$

- Budget constraint (period-by-period):

$$P_{it} C_{it} = P_{iat} C_{iat} + P_{imt} C_{imt} + P_{ist} C_{ist} = w_{it} L_{it}$$

Expenditure Shares

- Expenditure share:

$$X_{iqt} = \frac{P_{iqt} C_{iqt}}{w_{it} L_{it}} = \omega_q^\epsilon \left(\frac{P_{iqt}}{P_{it}} \right)^{1-\epsilon}$$

- Aggregate price:

$$P_{it} = \left(\omega_a^\epsilon P_{iat}^{1-\epsilon} + \omega_m^\epsilon P_{imt}^{1-\epsilon} + \omega_s^\epsilon P_{ist}^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}$$

- Sectoral composite good price:

$$P_{iqt} = \left(\int_0^1 p_{iqt}(z)^{\frac{\eta}{\eta-1}} dz \right)^{\frac{\eta-1}{\eta}}$$

Market Clearing Conditions

- Labor markets:

$$L_{it} = L_{ist} + \int_0^1 L_{imt}(z) dz + \int_0^1 L_{iat}(z) dz, \quad i = \{1, 2\}$$

- Services good markets:

$$Y_{ist} = C_{ist}, \quad i = \{1, 2\}$$

- Agriculture goods markets:

$$\sum_{i=1}^2 y_{iat}(z) = \sum_{i=1}^2 c_{iat}(z) \quad \forall z \in [0, 1]$$

- Manufacturing goods markets:

$$\sum_{i=1}^2 y_{imt}(z) = \sum_{i=1}^2 c_{imt}(z) \quad \forall z \in [0, 1]$$

Open-Economy Equilibrium

A *competitive equilibrium* is a sequence of goods and factor prices $\{p_{iat}(z), p_{imt}(z), P_{iat}, P_{imt}, P_{ist}, P_{it}, w_{it}\}_{t=0}^{\infty}$ and allocations $\{l_{iat}(z), l_{imt}(z), L_{iat}, L_{imt}, L_{ist}, y_{iat}(z), y_{imt}(z), Y_{ist}, c_{iat}(z), c_{imt}(z), C_{iat}, C_{imt}, C_{ist}, C_{it}\}_{t=0}^{\infty}$ for $z \in [0, 1]$ and $i = 1, 2$, such that given prices, the allocations solve the firms' maximization problems and the household's maximization problem, and satisfy the market clearing conditions.

Closed Economy Equilibrium

- Sectoral labor share = sectoral expenditure share

$$l_{qt} = \frac{L_{qt}}{L_t} = \frac{w_t L_{qt}}{w_t L_t} = \frac{P_{qt} C_{qt}}{P_t C_t} = X_{qt}$$

- Expenditure share:

$$X_{qt} = \omega_q^\epsilon \left(\frac{P_{qt}}{P_t} \right)^{1-\epsilon}$$

- Prices: $P_{qt} = \frac{w_t}{A_{qt}}$, where $A_{qt} = T_{qt}^{1/\theta} / \gamma$.

Closed Economy Dynamics

$$\begin{aligned}\hat{L}_{qt} = \hat{X}_{qt} &= (1 - \epsilon) \left(\hat{P}_{qt} - (X_{at}\hat{P}_{at} + X_{mt}\hat{P}_{mt} + X_{st}\hat{P}_{st}) \right) \\ &= (\epsilon - 1) \left(\hat{A}_{qt} - (X_{at}\hat{A}_{at} + X_{mt}\hat{A}_{mt} + X_{st}\hat{A}_{st}) \right)\end{aligned}$$

- $\epsilon = 1$: no structural change
- $\epsilon < 1$: labor moves from the highest productivity growth sector to the lowest productivity growth sector
- $\epsilon > 1$: labor moves from the lowest productivity growth sector to the highest productivity growth sector

Key Implications of Closed Economy

- Preferences play a major role in labor allocation across sectors.
- Structural change does not occur if the elasticity of substitution equals one.
- With elasticity of substitution less than one:
 - The high productivity growth sectors experience declining relative prices, expenditure shares and labor shares.
 - Labor moves from the most productive sector to the least productive sector.

Key Ingredients of Open Economy

- Trade based on comparative advantage (Ricardian)
- Assume country 1 has a comparative advantage in manufacturing.

That is, under free trade,

$$\frac{A_{1mt}}{A_{2mt}} > \frac{A_{1at}}{A_{2at}}.$$

- Under free trade, the LOOP holds: $p_{1qt}(z) = p_{2qt}(z)$.
- Tradable composite good prices are equalized across countries: $P_{1qt} = P_{2qt}$.

Open Economy: Prices

- Under Fréchet distribution (and free trade):

$$P_{iqt} = \left[\left(\frac{w_{it}}{A_{iqt}} \right)^{-\theta} + \left(\frac{w_{jt}}{A_{jqt}} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

$$\frac{P_{iqt}}{w_{it}} = \frac{1}{A_{iqt}} \left[1 + \left(\frac{w_{jt}}{w_{it}} \frac{A_{iqt}}{A_{jqt}} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

- Services price: $\frac{P_{ist}}{w_{it}} = \frac{1}{A_{ist}}$

Prices in Open vs. Closed Economy

- $\frac{P_{iat}}{w_{it}}$ and $\frac{P_{imt}}{w_{it}}$ are lower in open economy
- $\frac{P_{ist}}{w_{it}}$ is the same
- $\frac{P_{it}}{w_{it}}$ is lower in open economy
 - Welfare is higher in open economy
- $\frac{P_{ist}}{P_{it}}$ rises, $\frac{P_{1at}}{P_{1t}}$ and $\frac{P_{2mt}}{P_{2t}}$ declines in open economy
- $\frac{P_{1mt}}{P_{1at}}$ is higher in the open economy

Expenditure Shares in Open vs. Closed Economy

- Relative prices and the elasticity of substitution play key role in determining expenditure shares X_{igt} .
- With elasticity less than one, in both countries in open economy,
 - **services** expenditure shares are **higher**;
 - expenditure share of the sector with **comparative disadvantage** is **lower**;
 - expenditure share of the sector with **comparative advantage** is **ambiguous**.

Open Economy: Intra-Sector Trade

In addition to (sectoral) expenditure shares, another share matters: the share of sectoral spending that is on imports:

- Share of country 1's expenditure on sector q goods from country 2 (under free trade):

$$\pi_{12qt} = \frac{(w_{2t}/A_{2qt})^{-\theta}}{(w_{2t}/A_{2qt})^{-\theta} + (w_{1t}/A_{1qt})^{-\theta}} = \frac{1}{1 + \left(\frac{w_{1t}/A_{1qt}}{w_{2t}/A_{2qt}}\right)^{-\theta}}$$

- π_{12qt} rises as w_{2t}/A_{2qt} decreases relative to w_{1t}/A_{1qt}
- The rise is larger with larger θ (a low productivity dispersion)
- Comparative advantage implies $\pi_{12mt} < \pi_{12at}$

Open Economy: Inter-Sector Trade

Putting together these two shares:

- Manufacturing net exports of country 1 as share of its GDP:

$$N_{1mt} = \frac{\pi_{21mt} X_{2mt} w_{2t} L_{2t}}{w_{1t} L_{1t}} - \pi_{12mt} X_{1mt}$$

- Comparative advantage implies $N_{1mt} > 0$ and $N_{1at} < 0$.
- The net export ratio of the sector with comparative advantage is positive in each country.

Open Economy: Labor Allocation

- Services labor share: $l_{ist} = L_{ist}/L_{it} = X_{ist}$
- Manufacturing labor share of country i :

$$l_{imt} = \frac{L_{imt}}{L_{it}} = X_{imt} + N_{imt}$$

- **Direct** contribution of trade: N_{imt}
 - Country 1 has a comparative advantage in manufacturing
 - $N_{1mt} > 0$ and $N_{2mt} < 0$
- **Indirect** contribution of trade: X_{imt}
- Similarly for agriculture labor share

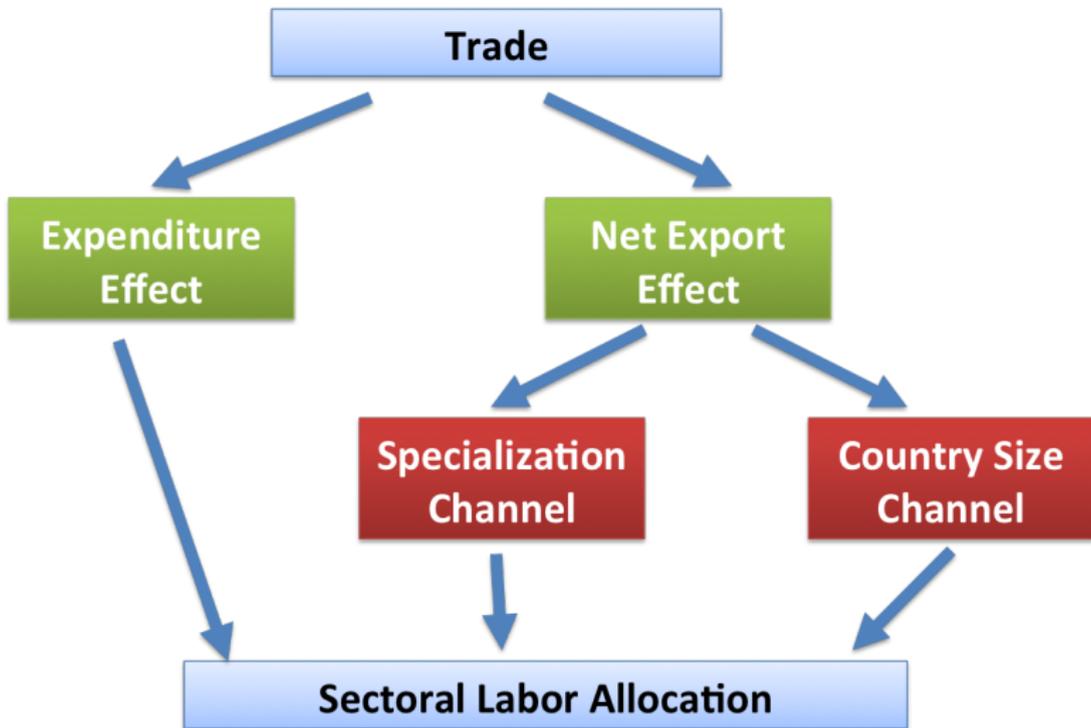
Labor Dynamics

- Growth in manufacturing labor share:

$$\hat{l}_{1mt} = \frac{X_{1mt}}{l_{1mt}} \hat{X}_{1mt} + \frac{N_{1mt}}{l_{1mt}} \hat{N}_{1mt}$$

- First term: **the expenditure effect**
- Second term: **the trade or net export effect**
- Positive growth in manufacturing net export share contributes positively to labor share.
- To focus on trade effect, consider case with elasticity of substitution across sectors = 1; hence, $\hat{X}_{1mt} = 0$

Impact of Trade on Structural Change



Productivity Growth and Hump Pattern in Manufacturing

- Necessary condition for $\hat{N}_{1mt} > 0$: $\hat{A}_{mt} > \hat{A}_{at}$, ($A_{qt} = \frac{A_{1qt}}{A_{2qt}}$)
- Under free trade, manufacturing labor share equation:

$$l_{1mt} = \omega_m \pi_{11m} \left(\frac{w_t L_{1t} + L_{2t}}{w_t L_{1t}} \right)$$

- $\pi_{11m} = \pi_{21m}$: **specialization term**
- Reciprocal of GDP share: **country-size term**
- As manufacturing productivity grows, specialization term contributes positively to manufacturing labor share, while country-size term contributes negatively.
 - Each country buys more of its manufactured goods from country 1 (e.g., South Korea).
 - If $\hat{A}_{at} > 0$, country 1 relative wage grows, country 2 (e.g., United States) purchasing power falls. Country 1 needs less labor to meet country 2 demand.

Productivity Growth and Hump Pattern in Manufacturing

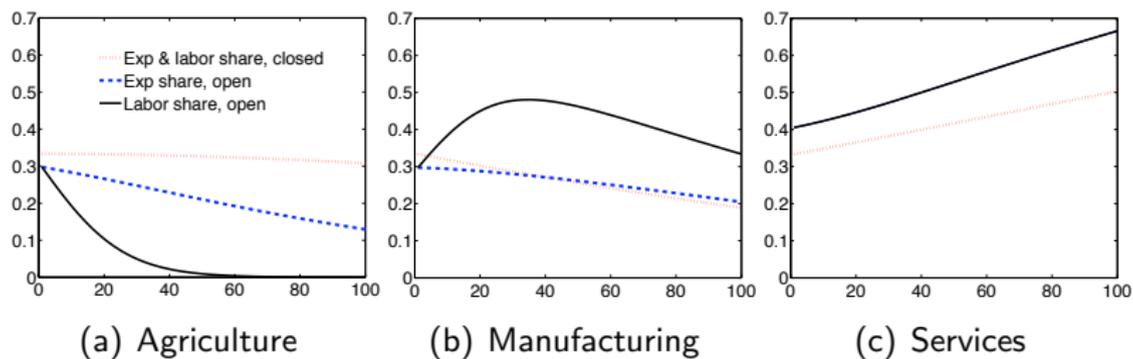
- Initially, specialization term is dominant.
- Eventually, country-size term dominates.
 - Once manufacturing becomes close to completely specialized, employment growth from specialization effect becomes small.
 - In limiting case, country 2 buys all its manufactured goods from country 1, but country 2 has zero mass, so the global economy is effectively just country 1.
 - Country 1 employment share declines until it equals expenditure share.

Structural Change in Open Economy: Example 1

Preferences		
$\epsilon = 0.5$	$\sigma^* = 1.0$	
$\omega_a = 1/3$	$\omega_m = 1/3$	$\omega_s = 1/3$
Labor Endowment		
$L_{10} = 1$	$L_{20} = 10$	$\hat{L}_{1t} = \hat{L}_{2t} = 1.0$
Sectoral Productivities		
$\theta = 4.0$		
$A_{1a0} = 1.0$	$A_{1m0} = 1.0$	$A_{1s0} = 1.0$
$A_{2a0} = A_{1a0}(L_{20}/L_{10})^{1/\theta}$	$A_{2m0} = A_{1m0}(L_{20}/L_{10})^{1/\theta}$	$A_{2s0} = A_{1s0}(L_{20}/L_{10})^{1/\theta}$
$\hat{A}_{1at} = 1.01$	$\hat{A}_{1mt} = 1.02$	$\hat{A}_{1st} = 1.0$
$\hat{A}_{2at} = 1.02$	$\hat{A}_{2mt} = 1.01$	$\hat{A}_{2st} = 1.0$

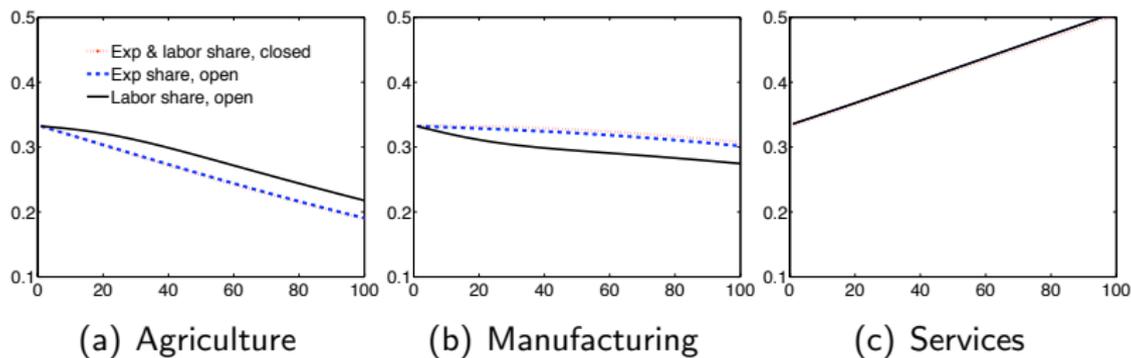
Structural Change in Country 1

Figure: Employment Shares, Closed and Open



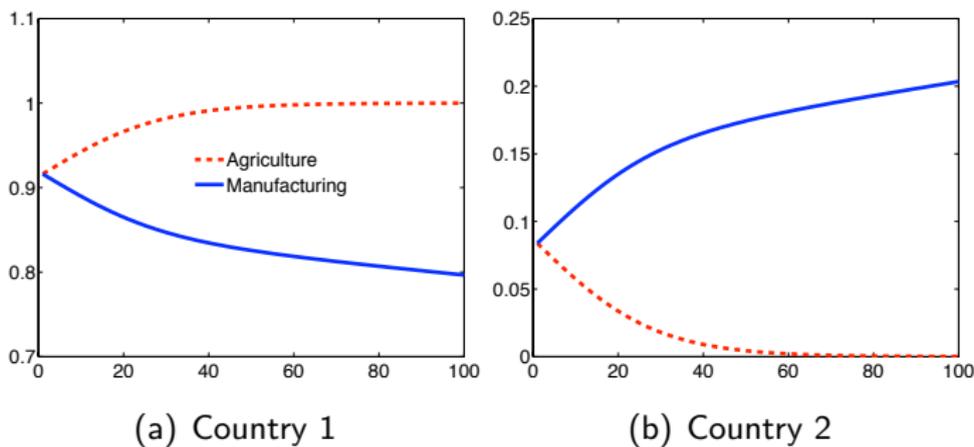
Structural Change in Country 2

Figure: Employment Shares, Closed and Open



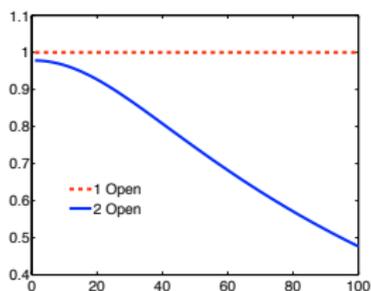
Import Shares

Figure: Import Shares

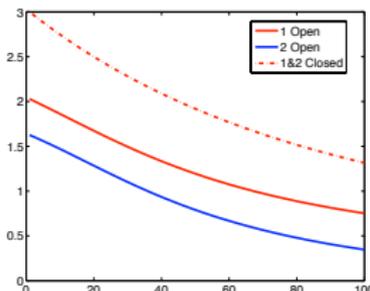


Wages, Prices, and Welfare

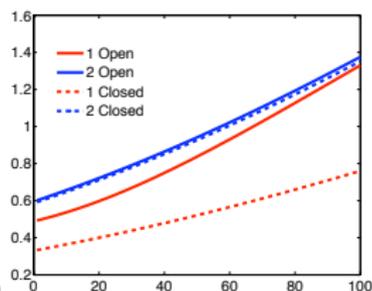
Figure: Wages, Prices, and Welfare



(a) Wages



(b) Prices



(c) Welfare

Structural Change and Trade Costs

- Introduce iceberg trade costs

- Prices:

$$P_{iqt} = \left[(w_{it}/A_{iqt})^{-\theta} + (\tau_{qt} w_{jt}/A_{jqt})^{-\theta} \right]^{-\frac{1}{\theta}}$$

- Import shares:

$$\pi_{ijqt} = \frac{(\tau_{qt} w_{jt}/A_{jqt})^{-\theta}}{(\tau_{qt} w_{jt}/A_{jqt})^{-\theta} + (w_{it}/A_{iqt})^{-\theta}}.$$

- Decline in τ_{qt} affects P_{iqt} and π_{ijqt} like increase in A_{jqt}
- Decline in trade costs can also generate structural change, even in absence of biased sectoral productivity growth

Trade Costs and Hump Pattern in Manufacturing

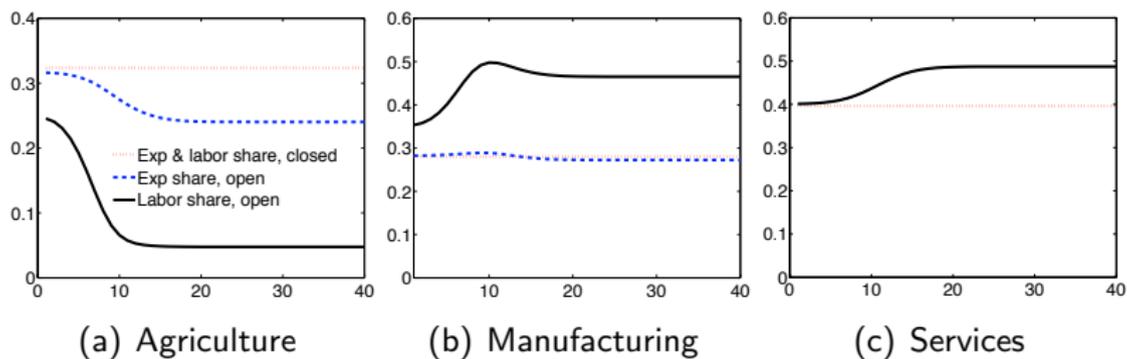
- Suppose country 1 has comparative advantage in manufacturing and is small relative to country 2.
 - Productivity levels are constant over time
- As trade costs decline, specialization increases (manufacturing net export surplus grows) and country 1 relative wage rises
- Initially, specialization effect dominates country-size effect, so manufacturing labor share in country 1 rises
- Eventually, country 1 labor used to satisfy country 2 manufacturing demand declines, so manufacturing labor share in country 1 falls

Structural Change in Open Economy: Example 2

Preferences		
$\epsilon = 0.5$	$\sigma^* = 1.0$	
$\omega_a = 1/3$	$\omega_m = 1/3$	$\omega_s = 1/3$
Labor Endowment		
$L_{10} = 1$	$L_{20} = 10$	$\hat{L}_{1t} = \hat{L}_{2t} = 1.0$
Sectoral Productivities		
$\theta = 4.0$		
$A_{1a0} = 1.5$	$A_{1m0} = 2.0$	$A_{1s0} = 1.0$
$A_{2a0} = 2.0(L_{20}/L_{10})^{1/\theta}$	$A_{2m0} = 1.5(L_{20}/L_{10})^{1/\theta}$	$A_{2s0} = 1.0(L_{20}/L_{10})^{1/\theta}$
$\hat{A}_{1at} = 1.0$	$\hat{A}_{1mt} = 1.0$	$\hat{A}_{1st} = 1.0$
$\hat{A}_{2at} = 1.0$	$\hat{A}_{2mt} = 1.0$	$\hat{A}_{2st} = 1.0$
Trade Costs		
$\tau_{q0} = 2.5$	$\tau_{qt} - 1$ declines at 3% per period	

Structural Change in Country 1

Figure: Employment Shares, Closed and Open



Conclusion

- International trade provides environment in which sectoral output and sectoral expenditure need not be equal
- With neoclassical trade, comparative advantage interacts with global sectoral demand to determine patterns of expenditure, trade, production, and employment
- We study structural change in an open economy with model that highlights these themes
- Model yields rich insights and can potentially better explain patterns in data
- Extending model to include non-homothetic preferences, intermediate goods, and trade costs does not alter the main implications
- Companion project: quantitative assessment

Accounting: the U.S.

Year	I_{mt}	X_{mt}	N_{mt}	$X_{mt} + N_{mt}$
1970	25.6%	27.9%	-1.1%	26.8%
2000	14.5%	21.6%	-4.8%	16.8%
Change	-11.1%	-6.3%	-3.7%	-10.0%

- The direct trade effect accounts for **one third** of the decline in US manufacturing labor share.

Accounting: the U.K.

Year	I_{mt}	X_{mt}	N_{mt}	$X_{mt} + N_{mt}$
1970	34.6%	31.0%	2.4%	33.4%
2000	16.8%	22.9%	-7.8%	15.1%
Change	-17.8%	-8.1%	-10.2%	-18.3%

- The direct trade effect accounts for **more than one half** of the decline in British manufacturing labor share.

Manufacturing Labor Share and Income

