Structural Change in an Open Economy

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

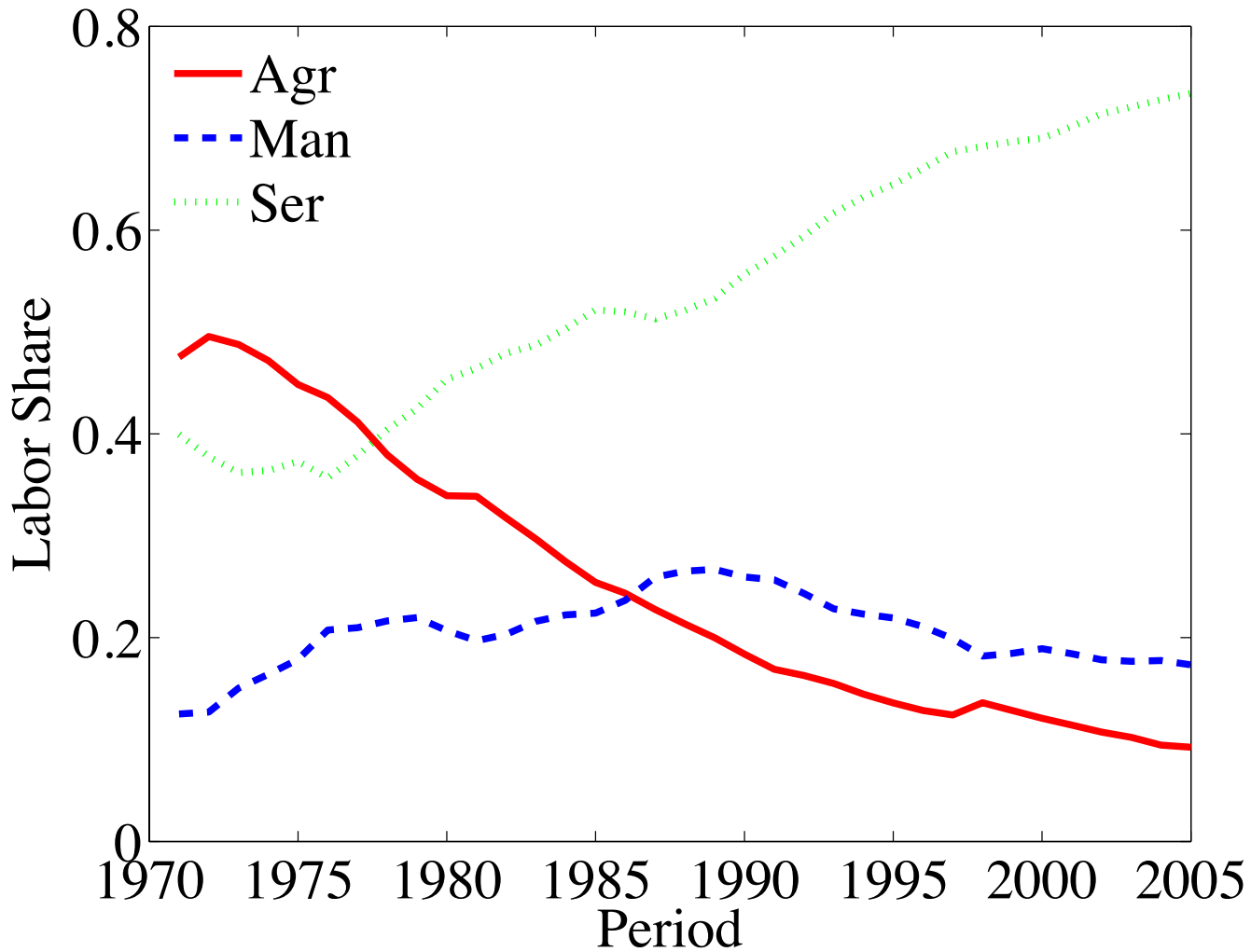
Structural Change in the Advanced Nations

Share of Employment (16 advanced nations)

Sector	1870	1960	1987
Agriculture	0.49	0.17	0.06
Services	0.24	0.44	0.63
Industry	0.27	0.39	0.30
Source: Maddison (1991)			

- Agriculture labor share declines, and services labor share rises
- Manufacturing labor share displays a hump-shaped pattern

South Korea's Structural Change



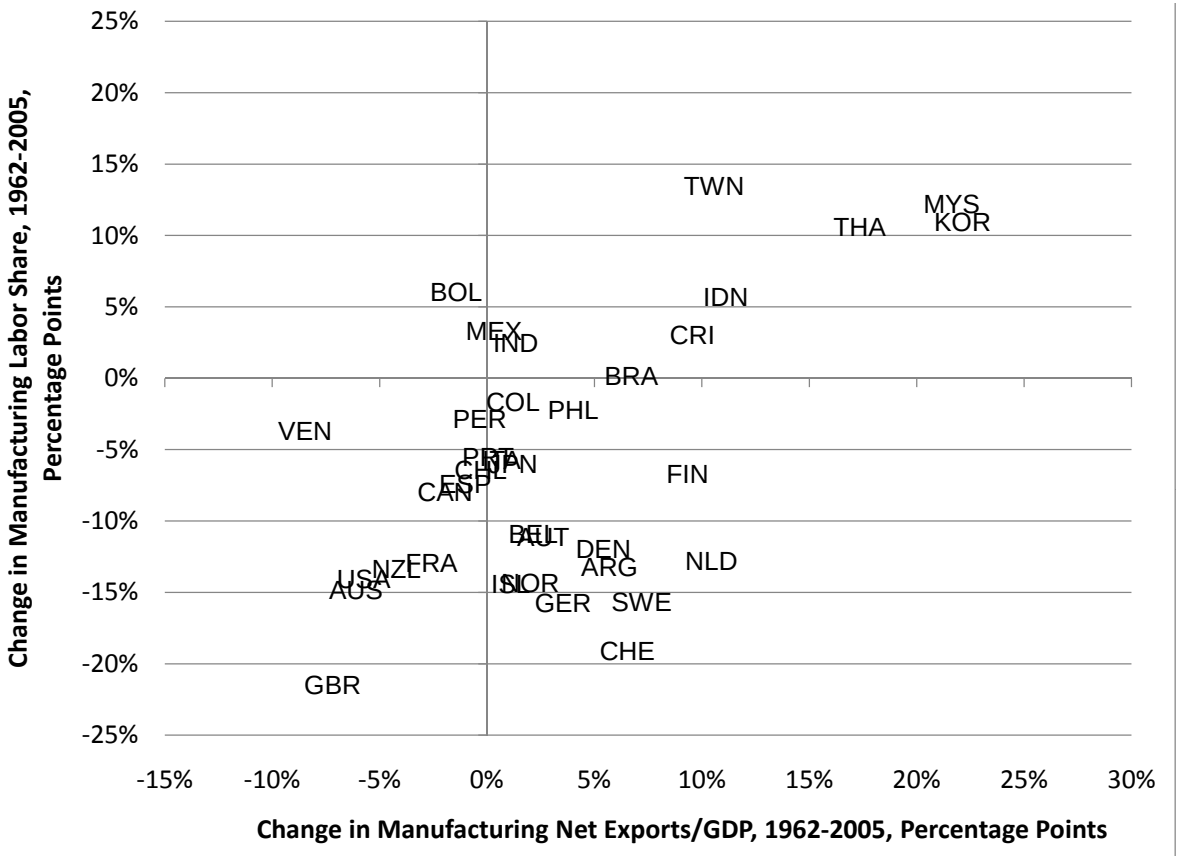
Data source: EU KLEMS database

Trade Openness and Structural Change

- Structural change is ongoing in developed and emerging market countries
- Increased global trade has increased links between developed and emerging market countries
- Link between globalization and structural change?
  - Autor, Dorn, and Hanson (2012) attribute about 1/4 of decline in U.S. manufacturing employment to trade with China
  - Theoretically, increased trade openness leads to sectoral labor reallocation, potentially contributing to structural change

Manufacturing Trade and Employment

Figure: Manufacturing Net Exports and Manufacturing Employment



Dominant Frameworks for Modeling Structural Change

- Non-unitary income elasticity of demand

  Engel (1895), Kongsamut, Rebelo and Xie (2001)

- Non-unitary substitution elasticity and sector-biased technical change

  Baumol (1967), Ngai and Pissarides (2007)

- Common feature: closed economy frameworks

Goal and What We Do

Study the role of international trade in structural change both analytically and quantitatively

- Develop two-country, three-sector model with:
  - Non-unitary sectoral income elasticities (Engel's law)
  - Non-unitary sectoral substitution elasticities in conjunction with asymmetric productivity growth across sectors (Baumol effect)
  - Ricardian trade (Eaton and Kortum)
  - Intermediate goods
- Develop intuition for how openness to trade can lead to and propagate structural change
- Conduct quantitative analysis calibrated to South Korea and the Rest of the World between 1971 and 2005

Related Literature

- Three-sector (closed economy) models of structural change:
  - Echevarria (1997), Kongsamut, Rebelo, and Xie (2001), Ngai and Pissarides (2007), Rogerson (2008), Restuccia, Yang, and Zhu (2008), Foellmi and Zweimuller (2008), Buera and Kaboski (2009, 2012), Duarte and Restuccia (2010), Verma (2012), and Herrendorf, Rogerson, and Valentinyi (2012)
- Early open economy models of structural change:
  - Matsuyama (1992) and Echevarria (1995)
- Multi-sector models of Ricardian (Eaton-Kortum type) trade:
  - Shikher (2012), Levchenko and Zhang (2012), Caliendo and Parro (2011)
- Quantitative research with open economy models:
  - Coleman (2007), Galor and Mountford (2008), Stefanski (2012), Ungor (2012), Swiecki (2012)
  - Sposi (2012) and Teignier-Bacque (2012)

Set up

- Two countries
  - Representative household in each country
- Three sectors: agriculture, manufacturing, services
  - Agriculture and manufactured consist of a continuum of tradable goods
  - Services are nontradable
- One factor of production: labor
  - Mobile across sectors, but immobile across countries
- Productivity levels and growth differ across sectors and countries
- Trade: based on Ricardian comparative advantage
- Perfect competition in all markets

Technologies

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

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

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

  - A is distributed as Fréchet: $F_{iqt}(A) = \exp(-T_{iqt} A^{-\theta})$
    - Mean A_{iq} is linear in $T_{iq}^{1/\theta}$; dispersion is linear in $1/\theta$
  - Goods are combined via CES aggregator to yield composite goods for consumption

Preferences

- Cobb-Douglas period utility:

$$U(C_{ia}, C_{im}, C_{is}) = (C_{ia})^{\omega_a}(C_{im})^{\omega_m}(C_{is})^{\omega_s}$$

  - Elasticities of substitution and income: 1

- Budget constraint (period-by-period):

$$P_{ia}C_{ia} + P_{im}C_{im} + P_{is}C_{is} = w_i L_i$$

Expenditure Shares

- Sectoral expenditure share:

$$X_{iqt} = \frac{P_{iqt} C_{iqt}}{w_{it} L_{it}} = \omega_q$$

- Note: in closed economy, sectoral labor share = sectoral expenditure share:

$$l_{iqt} = \frac{L_{imt}}{L_{it}} = X_{iqt} = \omega_q$$

  - In closed economy version of simple model, regardless of sectoral productivity growth patterns, there is no structural change.

Trade Shares

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

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

  - π_{21mt} is fraction of country 2's expenditure on manufactured goods that consists of imports of country 1's manufactured goods.

- If country 1 has a comparative advantage in manufacturing, then $N_{1mt} > 0$ and $N_{1at} < 0$.

Labor Shares

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

$$l_{imt} = X_{imt} + N_{imt} = \omega_m + N_{imt}$$

  - If country 1 has a comparative advantage in manufacturing, $N_{1mt} > 0$ and $N_{2mt} < 0$

- Similarly for agriculture labor share

Labor Share Dynamics

- Growth in manufacturing labor share:

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

- Positive growth in manufacturing net export share contributes positively to labor share.

Two Scenarios for Manufacturing Labor Share Hump-Shape

Assume country 1 is relatively small and has comparative advantage in manufacturing

- Scenario 1: Sufficiently rapid declines in barriers to manufacturing trade over time
  - As comparative advantage is increasingly revealed, net export channel becomes more prominent; l_{1m} rises. Country 1 supplies an increasing share of global demand for manufactured goods
  - Over time, relative wage in country 1 rises, reducing relative purchasing power of country 2, and ultimately leading to less labor needed to satisfy foreign demand.
  - Eventually, relative wage effect dominates, and manufacturing labor share peaks and then declines.
- Scenario 2: Sufficiently rapid relative manufacturing productivity growth over time

Summary of Simple Model

- Open economy provides additional channel(s) by which structural change can occur.
- Example of structural change in dynamic open economy:
  - Increasing specialization over time leads to increased use of labor to satisfy foreign demand in comparative advantage sector.
  - Rising relative wages leads to decreased use of labor to satisfy foreign demand in comparative advantage sector
  - Under certain conditions, the former effect is always dominant initially, and the latter effect is always dominant later.

Additional Features in Calibrated Model

- Stone-Geary non-homothetic preferences with non-unitary elasticity of substitution:

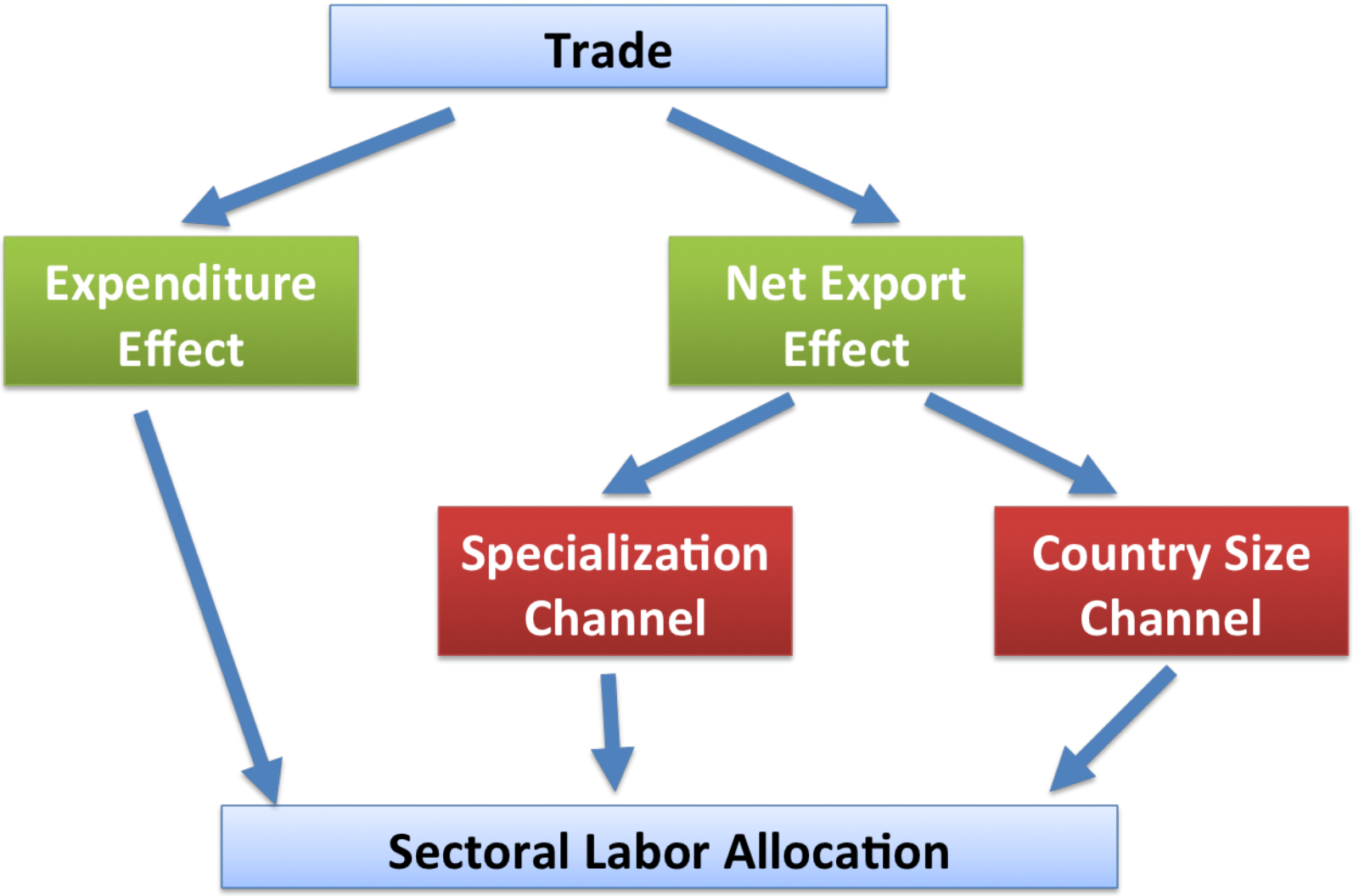
$$\left[\omega_a(C_{ia}-\bar{C}_a)^{\frac{\epsilon-1}{\epsilon}}+\omega_m(C_{im}-\bar{C}_m)^{\frac{\epsilon-1}{\epsilon}}+\omega_s(C_{is}-\bar{C}_s)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}$$

- Intermediate goods

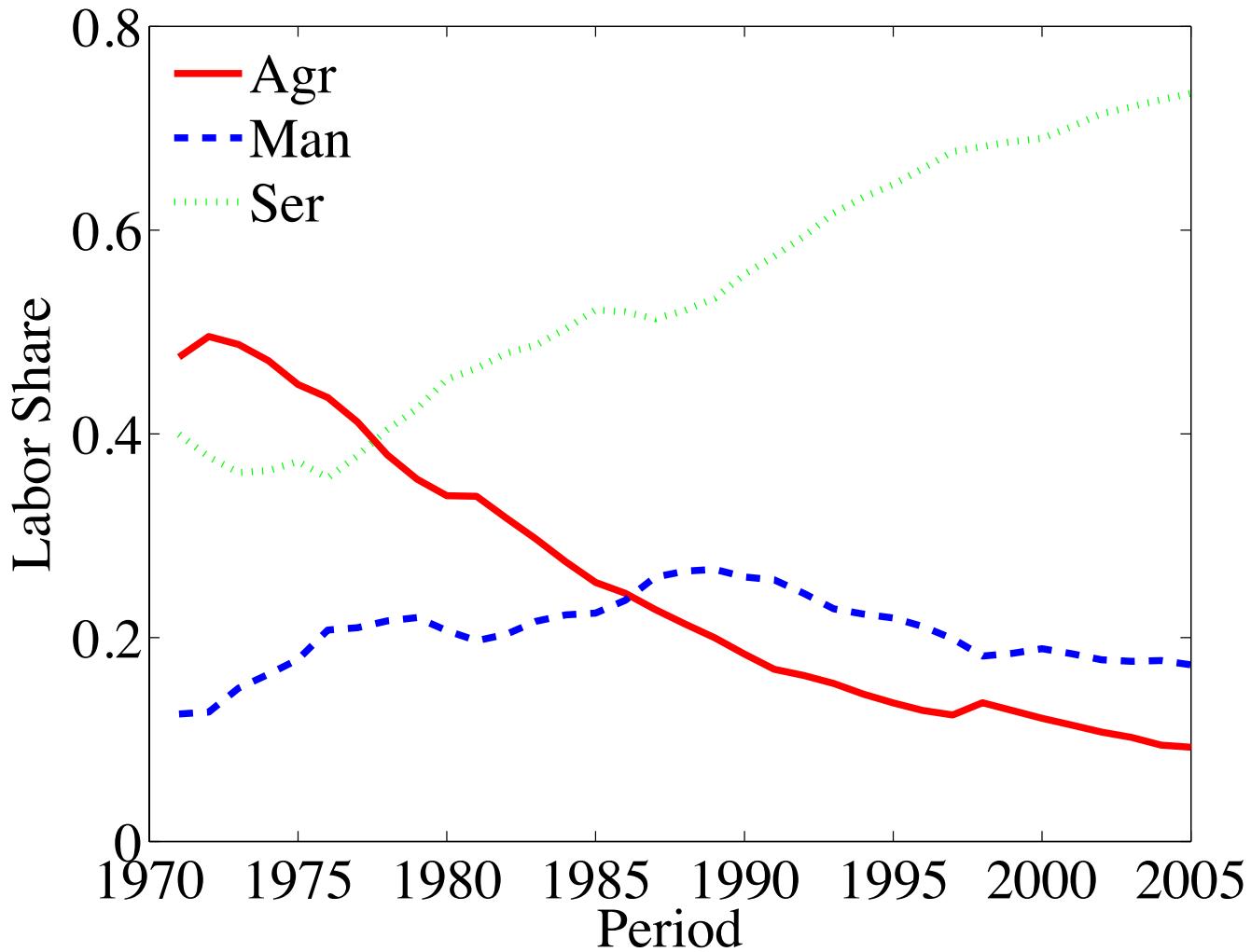
$$\text{Output:}\quad Q_{ik}(z)=A_{ik}(z)L_{ik}(z)^{\lambda_k}\left[\Pi_{n=a,m,s}M_{ikn}^{\gamma_{kn}}(z)\right]^{1-\lambda_k}$$

  - $L_{ik}(z)$: labor inputs
  - $M_{ikn}(z)$: sector-n composites as intermediates in sector k

Impact of Trade on Structural Change



Explaining South Korea's Structural Change



Data source: EU KLEMS database

Calibration of Time-Invariant Parameters

- Korea and ROW consisting of Korea's major trading partners
- $\theta = 4.0$: Simonovska & Waugh (2012)
- $\{\lambda_k, \gamma_{nk}\}$: Korea's sectoral input-output tables
- $\{\omega_k, \bar{C}_k, \epsilon\}$: Korea's real & nominal sectoral expenditure data

Parameter Values

Preference Parameters

ϵ	ω_a	ω_m	ω_s	$\bar{C}_a$	$\bar{C}_m$	$\bar{C}_s$	η
0.751	0.131	0.214	0.655	696.0	0.0	0.0	4.0

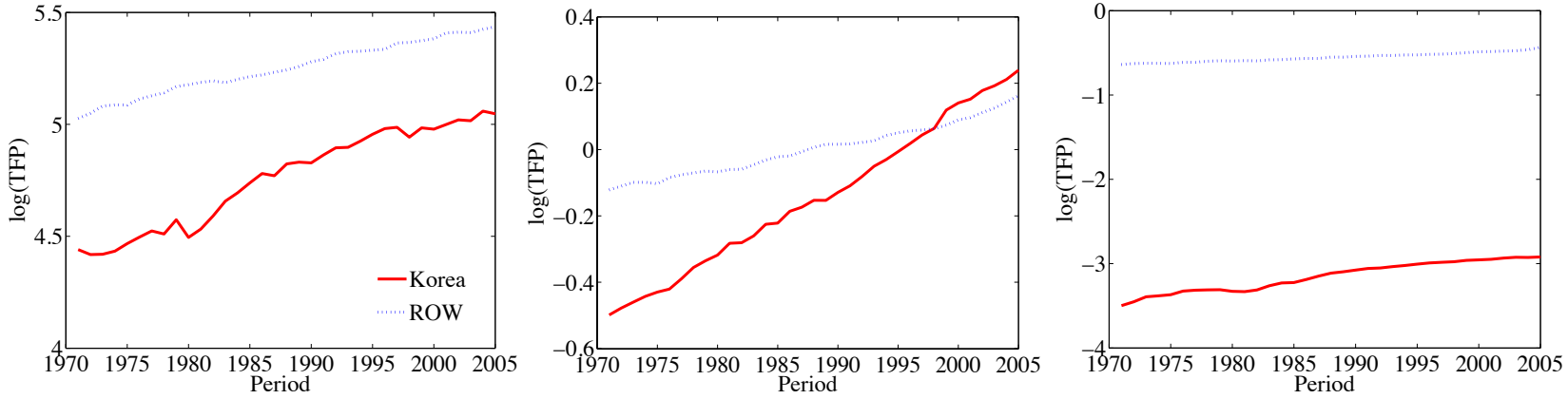
Production Parameters

λ_j	$\gamma_{\text{row, column}}$				θ
		Agr	Man	Ser	
0.456	Agr	0.665	0.165	0.171	4.0
0.275	Man	0.118	0.699	0.183	
0.576	Ser	0.073	0.396	0.530	

Calibration of Time-Varying Exogenous Processes

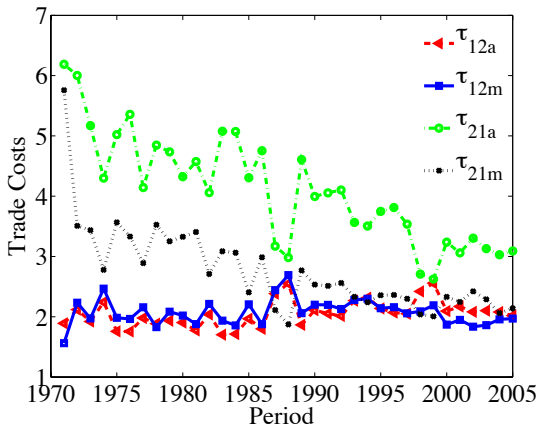
- Labor supply: total employment in Korea and ROW
- TFP and trade cost shocks:
  - Initial period: three sectoral productivities and two trade costs in each country to match four sectoral labor shares, two sectoral export shares and two sectoral import shares, Korea's relative per capita income, and Korea's agricultural subsistence expenditure as a share of total expenditure
  - TFP in subsequent periods: compute TFP growth rates from the data
  - Trade costs in subsequent periods: set to match sectoral import and export shares

TFP Shocks

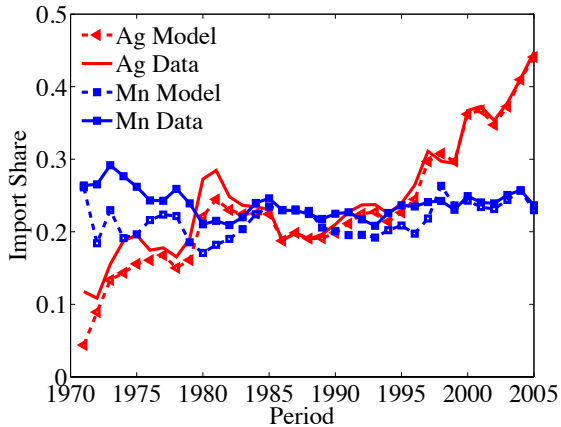


(a) Agriculture (b) Manufacturing (c) Services

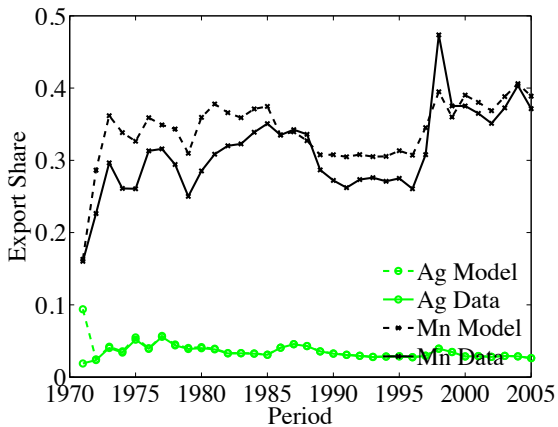
Trade Costs and Trade Shares



(d) Trade Costs

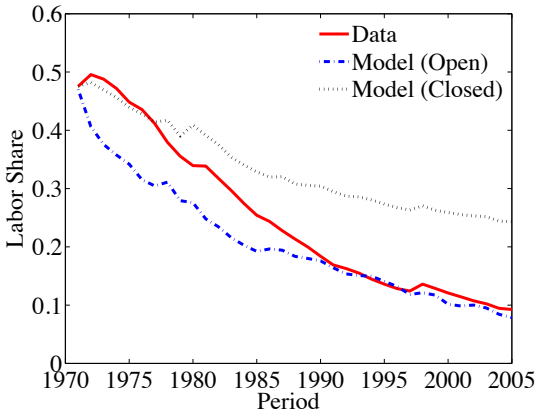


(e) Korean Import Shares

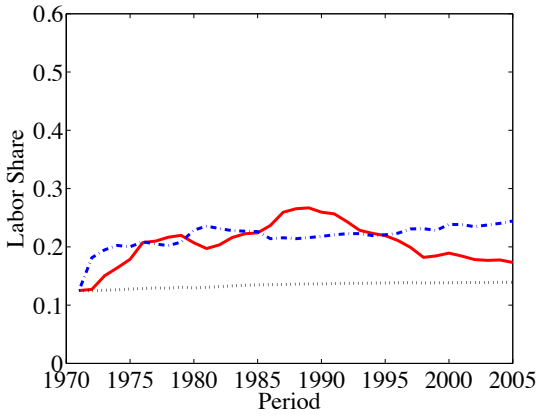


(f) Korean Export Shares

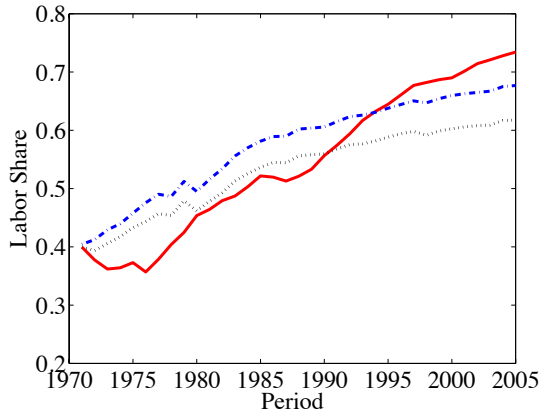
Korea's Structural Change: Benchmark



(g) Agriculture

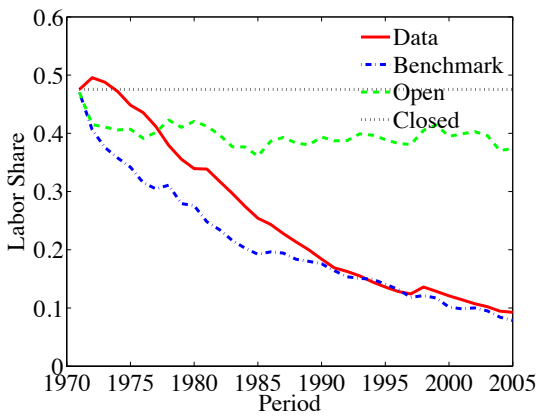


(h) Manufacturing

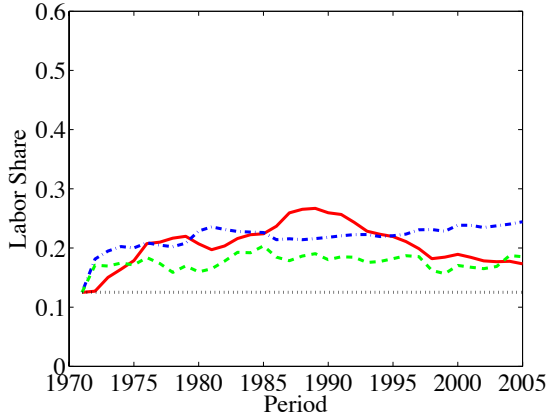


(i) Services

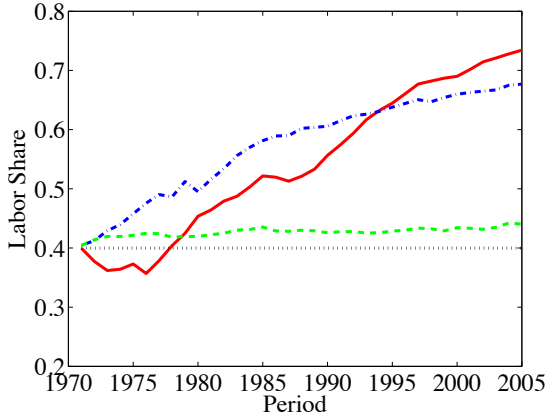
Korean Structural Change: Constant TFPs



(j) Agriculture

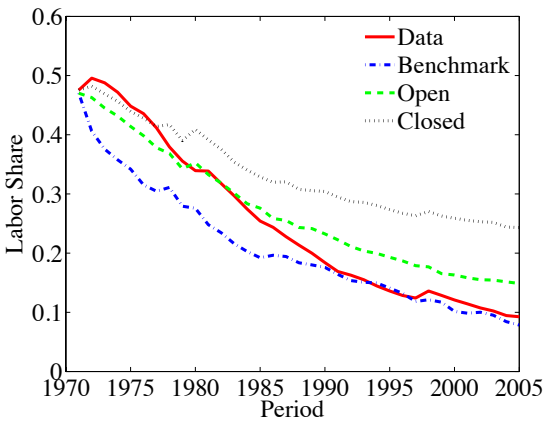


(k) Manufacturing

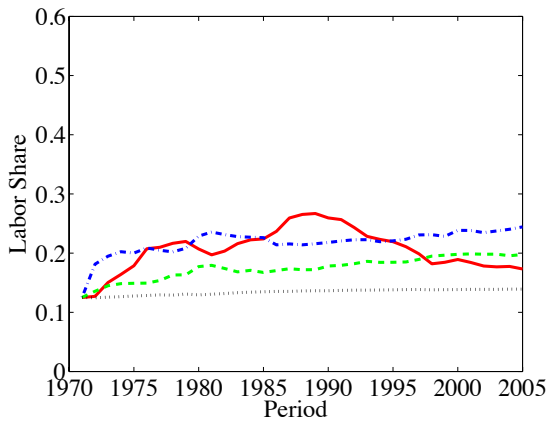


(l) Services

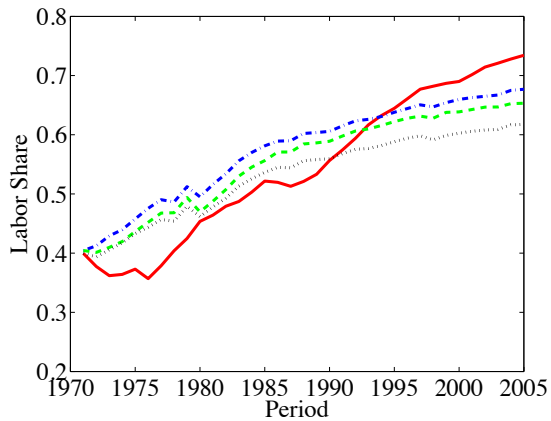
Korean Structural Change: Constant Trade Costs



(m) Agriculture

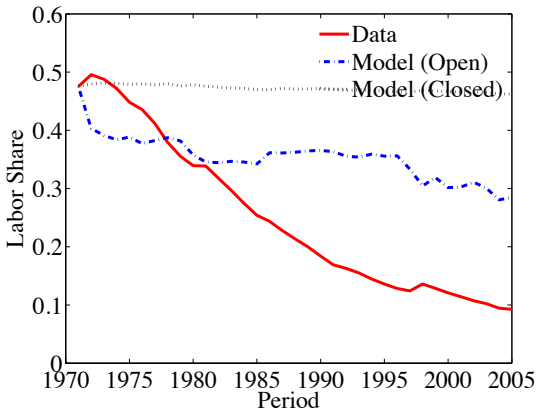


(n) Manufacturing

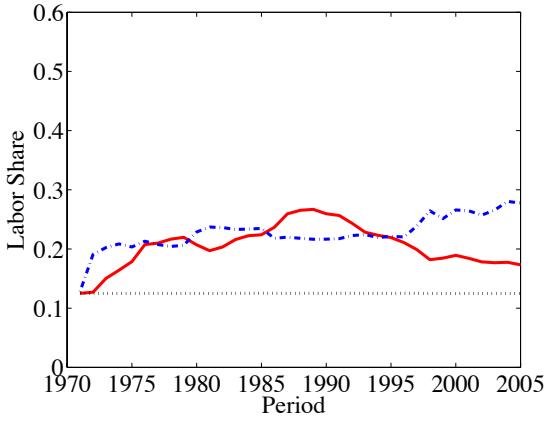


(o) Services

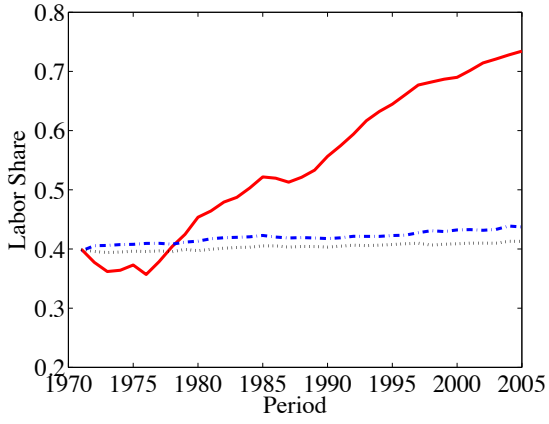
Korean Structural Change: Homothetic Preferences



(p) Agriculture



(q) Manufacturing



(r) Services

Summary

Main contribution of paper is quantitative analysis of role of international trade in S. Korea's structural change between 1971 and 2005.

- Benchmark model accounts for virtually all of evolution of agriculture and services labor shares, and rising part of manufacturing hump.
- Root mean square error (RMSE) of closed economy model is 60 percent higher than in benchmark model.
- Counterfactural exercises show that:
  - Productivity shocks important for all three sectors — with shocks exerting a stronger effect in open economy
  - Trade cost shocks important for agriculture and manufacturing
  - Non-homothetic preferences important for services and agriculture

Future Work

- Extend model to allow for tradable services
- Extend quantitative analysis to include China. Conjecture: including China will allow model to explain declining portion of Korea's manufacturing hump pattern.

Policy Implications

- To the extent S. Korea's policies on trade, investment, and productivity led to more trade, increased investment, and higher productivity, they contributed to Korea's structural change.
  - Recall that a key feature of structural change in many countries is that manufacturing eventually declines
- Our model implies that lower tariffs, taxes, and subsidies improve welfare.
  - See, for example, Lee (1996), for evidence that tariffs and subsidies lowered productivity growth in Korea's manufacturing industries.
  - Richer modeling frameworks might imply a role for non-zero tariffs and subsidies.

APPENDIX

Prices

- The cost of an input bundle: $v_{ik} = w_i^{\lambda_k} \left(\Pi_{n=a,m,s} \left(P_{in}\right)^{\gamma_{kn}}\right)^{1-\lambda_k}$
- Tradable good price: $p_{ik}(z) = \min\{p_{i1k}(z), p_{i2k}(z)\}$
  - Individual prices: $p_{ijk}(z) = \tau_{ijk} v_{jk} / A_{jk}(z)$
  - τ_{ijk}: trade costs of shipping sector-k goods from country j to i
- Sectoral price: $P_{ik} = \left(\int_0^1 p_{ik}(z)^{\frac{\eta}{\eta-1}} dz\right)^{\frac{\eta-1}{\eta}}$
  - $\Phi_{ik} = T_{1k} \left(v_{1k}\tau_{i1k}\right)^{-\theta} + T_{2k} \left(v_{2k}\tau_{i2k}\right)^{-\theta}$
  - $P_{ik} = \Gamma \left(\Phi_{ik}\right)^{-\frac{1}{\theta}}$

Trade Shares

- π_{jik}: share of country j's expenditure on sector-k goods coming from country i

$$\pi_{jik} = \frac{T_{ik}\left(v_{ik}\tau_{jik}\right)^{-\theta}}{\Phi_{jk}} = \frac{T_{ik}\left(v_{ik}\tau_{jik}\right)^{-\theta}}{T_{ik}\left(v_{ik}\tau_{jik}\right)^{-\theta} + T_{jk}\left(v_{jk}\tau_{jjk}\right)^{-\theta}}$$

- Trade shares π_{jik} rise under
  - a higher average productivity in country i
  - a lower unit cost of input bundles in country i
  - a lower trade cost from country i to j

Market Clearing Conditions

- Labor markets:

$$L_i = L_{is} + L_{im} + L_{ia}$$

- Goods markets:

$$Q_{ik} = C_{ik} + \sum_{n=a,m} (1-\lambda_n)\gamma_{nk} \sum_{j=1,2} \frac{\pi_{jin} P_{jn} Q_{jn}}{P_{ik}} + (1-\lambda_s)\gamma_{sk} \frac{P_{is} Q_{is}}{P_{ik}}$$

  - Allow for trade in intermediates
  - Capture two-way input-output linkages across sectors

Competitive Equilibrium

A competitive equilibrium is a sequence of goods and factor prices $\{P_{ia}, P_{im}, P_{is}, w_i\}_{i=1,2}$, allocations $\{L_{ia}, L_{im}, L_{is}, Q_{ia}, Q_{im}, Q_{is}, C_{ia}, C_{im}, C_{is}\}_{i=1,2}$, and trade shares $\{\pi_{ija}, \pi_{ijm}\}_{i,j=1,2}$, such that

- given prices, the allocations solve the firms' problems
- given prices, the allocations solve the households' problems
- the markets clear

Highlight The Role of Trade

- Shut down nonhomothetic preferences: $\bar{C}_k = 0$
- Shut down the intermediate input channel: $\lambda_k = 1$

Closed Economy (Pissarides and Ngai 2007)

- Prices:

$$P_{1k}^c / w_1^c = 1/A_{1k}$$

- Labor shares (= expenditure shares):

$$\hat{l}_{1kt}^c = \hat{X}_{1kt}^c = (\epsilon - 1)\left(\hat{P}_{1kt}^c - \hat{P}_{1t}^c\right) = (1-\epsilon)(\hat{A}_{1kt} - \hat{A}_{1t})$$

- When $\epsilon = 1$, there is no structural change
- When $\epsilon < 1$, a sector with rising relative productivity has declining relative prices, expenditure and labor shares
  - Labor moves from the most productive sector to the least productive sector

Open Economy: Trade Patterns

- Country 1 has a comparative advantage in manufacturing iff

$$\frac{A_{1m}}{A_{2m}/\tau_{12m}} > \frac{A_{1a}}{A_{2a}/\tau_{12a}}$$

- Trade patterns:

$$\pi_{12m} = \frac{1}{1+(\frac{w_2}{w_1}\frac{A_{1m}}{A_{2m}/\tau_{12m}})^{\theta}} < \frac{1}{1+(\frac{w_2}{w_1}\frac{A_{1a}}{A_{2a}/\tau_{12a}})^{\theta}} = \pi_{12a}$$

  - The comparative advantage sector has a smaller import share
  - The comparative advantage sector has a net export surplus

Open Economy: Prices and Expenditure Shares

- Prices:

$$\frac{P_{1a}}{w_1} = \frac{\pi_{11a}^{1/\theta}}{A_{1a}} \quad < \quad \frac{\pi_{11m}^{1/\theta}}{A_{1m}} = \frac{P_{1m}}{w_1}$$

  - Services relative prices are higher in both countries
  - The comparative disadvantage sector's relative prices are lower

- Expenditure shares with $\epsilon < 1$

  - Services shares are higher in both countries
  - The comparative disadvantage sector's shares are lower

Open Economy: Labor Shares

- Services:

$$l_{1s} = X_{1s}$$

- Tradables: N_{1k} is sectoral net exports as a share of GDP

$$l_{1k} = X_{1k} + N_{1k}$$

  - Net export channel: N_{1k} (positive for the CA sector)
  - Expenditure channel: X_{1k}

Relative Income