Deindustrialization and Industry Polarization[1]

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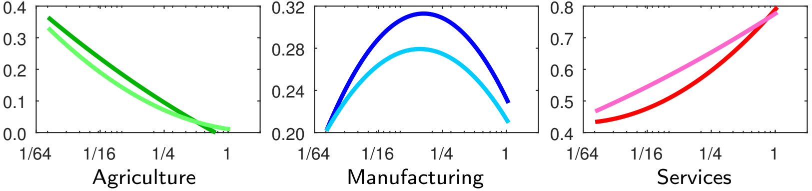
[1] The views expressed here are those of the authors and are not necessarily reflective of views of the Federal Reserve Banks of Chicago and Dallas, and the Federal Reserve System.

Facts: Deindustrialization

For each period pd $\in$ {pre-90, post-90}:

$$va^j_{n,t} = \alpha^j_n + \sum_{pd} \left(\beta^j_{0,pd} + \beta^j_{1,pd} y_{n,t} + \beta^j_{2,pd} y^2_{n,t} \right) \mathbb{1}_{t=pd} + \epsilon^j_{n,t},$$

Predicted sector value added shares: pre-90 vs post-90



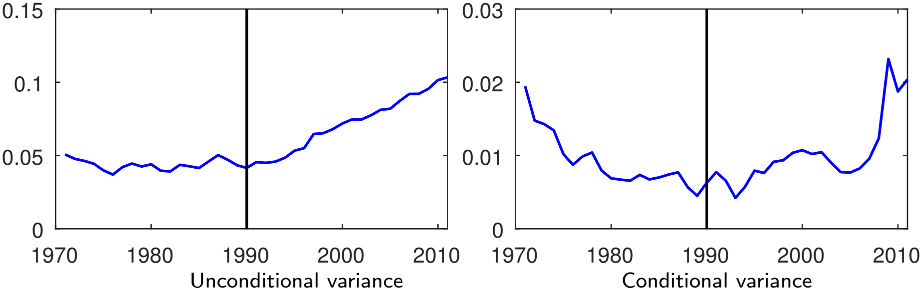
Note: Lines in the darker (lighter) color are for the pre-90 (post-90) period.

- Manufacturing curve shifts down over time (Rodrik, 2016) with the peak declining 3.4 percentage points (pp)
- Between $\frac{1}{16}$ and $\frac{1}{4}$ of U.S. per capita GDP, services curve shifts up 6-7 pp.

▸ Estimates

Facts: Industry Polarization (New)

Figure: Cross-country Variance of Manufacturing Value Added Shares



Notes: Unconditional variance reports the log-variance of the manufacturing VA share across countries in each year. Conditional variance reports the mean squared difference between the log observed VA share and the log predicted VA share from regression (26) across countries in each year.

- Unconditional and conditional variances increase post-1990
- In services, unconditional and conditional variances decreasing over time

Research Question

What are the drivers of deindustrialization and industry polarization over time?

- Answers to this question are vastly important in policy discussions.
  - Historically, industrialization separates countries into the rich or the poor.
  - Even today, manufacturing is believed to be the driver of growth.
  - Abundant industrial policies aim to (re)build up the manufacturing sector.
- Candidates are international trade and sector-biased productivity growth.

What We Do

- Build and calibrate a dynamic trade model of structural change
  - Main drivers are shocks to sector productivity and trade costs
  - Income, relative price, and comparative advantage channels operate
  - Calibrated model delivers deindustrialization and industry polarization
- Quantify effects of trade integration vs. sector-biased productivity growth
  - Sector-biased productivity growth alone: important for deindustrialization, but not for polarization
  - Trade integration alone: important for polarization, but not for deindustrialization
  - Interaction of two is important for global structural change and deindustrialization
- Develop story for deindustrialization and industry polarization
  - Relative price of manufacturing to services plays key role

Related Literature

- Deindustrialization
  - Empirical: Rodrik (2016); Haraguchi, Cheng, and Smeets (2017); Felipe, Mehta, and Rhee (2019)
  - Models: Huneeus and Rogerson (2020); Fujiwara and Matsuyama (2022)
- Open economy models of structural change
  - Matsuyama (2009, 2019); Sposi (2012); Uy, Yi, and Zhang (2013); Sposi, Yi, and Zhang (2018); Swiecki (2017); Betts, Giri, and Verma (2017); Teignier (2018); Cravino and Sotelo (2019); Lewis, Monarch, Sposi and Zhang (2020)
- Input-output and structural change
  - Sinha (2019); Sposi (2019)
- Investment and structural change
  - Kehoe, Ruhl, and Steinberg (2018); Herrendorf, Rogerson, and Valentinyi (2020); García-Santana, Pijoan-Mas, and Villacorta (2021)
- Multi-country trade models with capital accumulation
  - Eaton, Kortum, Neimann, and Romalis (2016); Alvarez (2017); Ravikumar, Santacreu, and Sposi (2019); Anderson, Larch, and Yotov (2020); Mix (2021)

Model

Overview

- Multi-country, three-sector (agriculture, manufacturing, and services) dynamic model with Ricardian trade
  - Each sector has a continuum of tradable varieties
  - Comparative advantage determines which country makes which variety for purchase by another country
  - Varieties combined to make composite sectoral good $\rightarrow$ consumption, investment, intermediate inputs
- Representative household in each country owns capital and labor and faces consumption-investment trade-off under perfect foresight
  - Employ non-homothetic constant elasticity of substitution (CES) preferences
- Main driving forces include sectoral productivity shocks and sectoral (bilateral) changes to international costs of trade
  - Also, three aggregate driving forces affecting national labor supply, investment, and trade imbalances

Calibration

Data Sources

- 28 countries plus ROW, 1971–2011
  - Australia, Austria, Belgium-Luxembourg, Brazil, Canada, China, Cyprus, Denmark, Spain, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Mexico, Netherlands, Portugal, South Korea, Sweden, Turkey, Taiwan, United Kingdom, United States, Rest-of-World
- Three broad sectors (ISIC v4):
  - Agriculture: Agriculture, forestry and fishing (A)
  - Manufacturing: Mining and quarrying (B); Manufacturing (C); Electricity, gas, steam and air conditioning supply (D); Water supply, sewerage, waste management and remediation activities (E)
  - Services: the remaining sectors from F to S
- Data sources: WIOD, EU-KLEMS, GGDC 10-sector Database, Historical Statistics Database, IMF DOTS, UN Comtrade, Penn World Tables, BEA

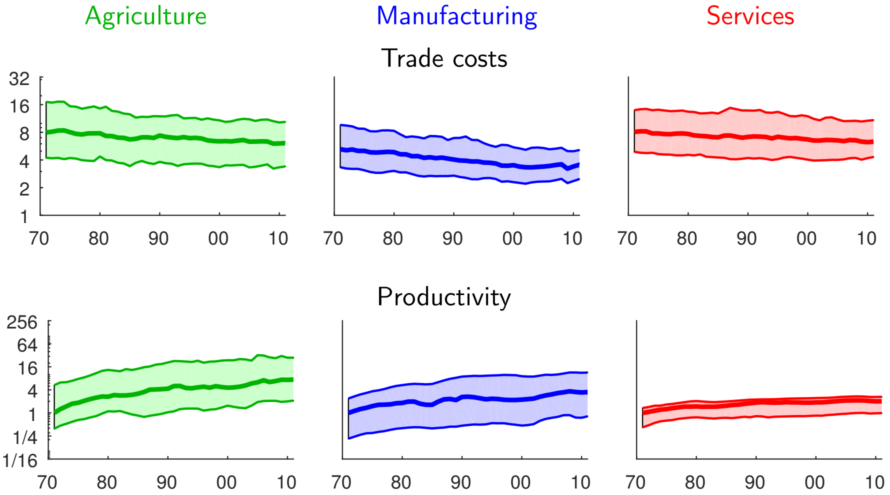
Calibration

Time Invariant Parameters

Income elasticities	ε^a	0.45	(0.41, 0.48)
	ε^s	1.34	(1.27, 1.43)
Price elasticities	σ_c	0.06	(0.01, 0.12)
	σ_x	0.29	(0.16, 0.40)
	σ_e^a	0.48	(0.43, 0.53)
	σ_e^m	0.06	(0.01, 0.13)
	σ_e^s	0.01	(0.01, 0.01)
Value added shares in output	ν^a	0.57	(0.42, 0.78)
	ν^m	0.36	(0.27, 0.43)
	ν^s	0.61	(0.48, 0.73)
Discount factor	β	0.96	
Capital share in value added	α	0.33	
Capital depreciation rate	δ	0.06	
Adjustment cost elasticity	λ	0.75	
Trade elasticity	θ^j	4	

Calibration Results

Sectoral Fundamental Productivity and Trade Costs



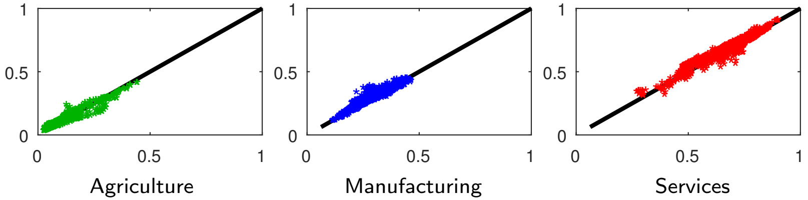
Notes: 25^{th}, 50^{th}, and 75^{th} percentiles. Median productivity normalized to 1 in 1971.

- Services trade costs decline, and services productivity rises, relatively slowly

Calibration

Sectoral Value Added Shares

Model (y-axis) vs. Data (x-axis)



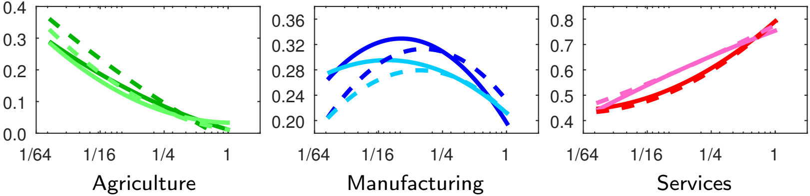
- The model reproduces sectoral value added shares relatively well.

▸ Consumption shares ▸ Investment shares ▸ Input shares

Calibration

Sectoral Value Added Shares

Predicted sector value added shares: pre-90 vs post-90



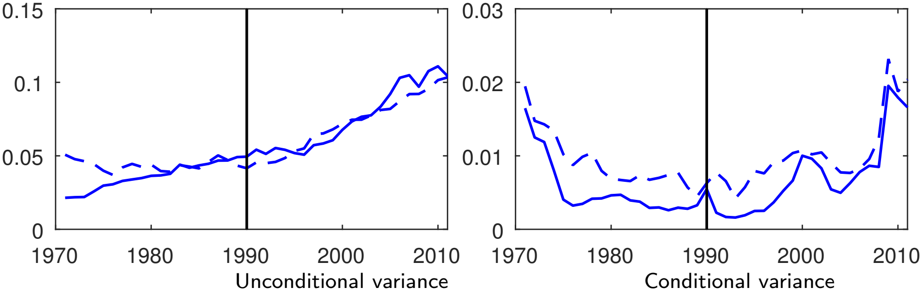
Note: Dashed lines: data; Solid lines model; Dark lines: pre-1990; light lines: post-1990

- Model successfully accounts for:
  - Decline in manufacturing peak
  - "Servicification" (increase of 5-6 pp for range of $\frac{1}{16}$ and $\frac{1}{4}$ of U.S. per capita GDP)

Calibration

Industry Polarization: Baseline Model and Data

Figure: Industry Polarization: Baseline Model and Data



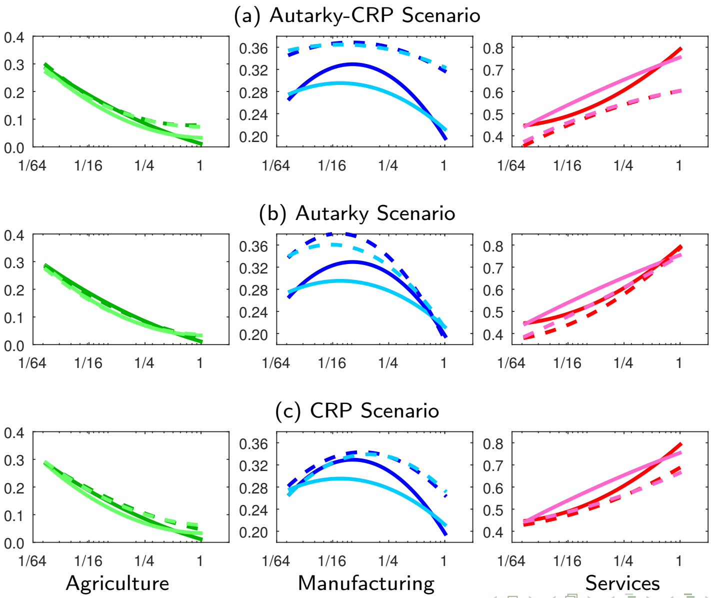
Notes: Dashed lines - data; Solid lines - model. Unconditional variance reports the log-variance of the manufacturing VA share. Conditional variance reports the mean squared difference between the log VA share and the log predicted VA share using regression (26) across countries in each year.

- Model successfully accounts for increased dispersion in industry value-added (as well as decreased dispersion in services value-added)

Counterfactual analysis

- Autarky counterfactual
  - Trade costs set prohibitively high in every sector-country pair: $d^j_{n,i,t} = \infty, n \neq i$
- Constant relative productivity (CRP) counterfactual
  - Each sector's productivity grows at same rate: $\frac{A^j_{n,t+1}}{A^j_{n,t}} = 1 + g_{n,t}$
- Autarky-CRP counterfactual
  - Trade costs set prohibitively high in every sector-country pair: $d^j_{n,i,t} = \infty, n \neq i$
  - Each sector's productivity grows at same rate: $\frac{A^j_{n,t+1}}{A^j_{n,t}} = 1 + g_{n,t}$

Counterfactual: Predicted VA Shares



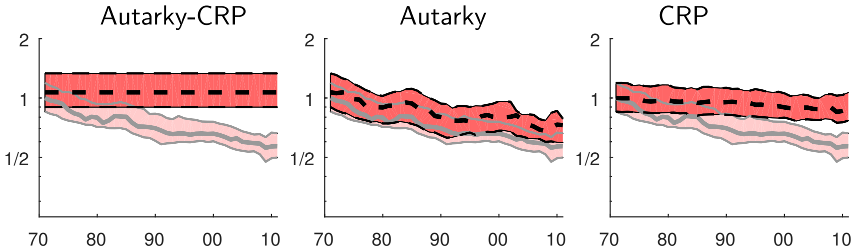
Implications for Deindustrialization

Peak Manufacturing Value Added Share

	Data	Baseline	Autarky-CRP	Autarky	CRP
Pre-90	0.313	0.329	0.369	0.381	0.343
Post-90	0.279	0.295	0.365	0.361	0.339
Change	−0.034	−0.034	−0.004	−0.020	−0.004

- Sector-biased productivity growth alone explains about 60% of the decline.
- Interaction of SBPG and trade integration accounts for about 40% of the decline
- Similar results hold for increase in services value-added share

Relative Price of Manufacturing to Services



Notes: 25^{th}, 50^{th}, and 75^{th} percentiles. Each series relative to the baseline median in 1971.

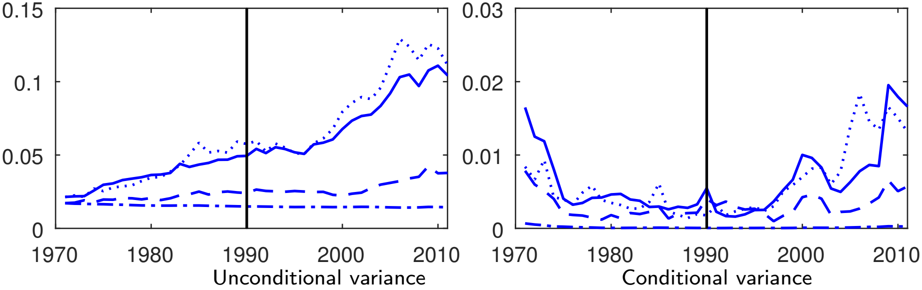
- Sector-biased productivity growth lowers relative price of manufactured goods over time.
- Interaction effect: Trade openness increases contact with countries experiencing sector-biased productivity growth and amplifies relative price changes.

Story for Deindustrialization

- Sector-biased TFP growth and trade integration over decades has led to low relative price of manufactured goods
- With elasticities of substitution < 1, spending has shifted away from manufactured goods – global market for manufactured goods smaller than in earlier decades
- Hence, while earlier industrializers faced relatively high prices and demand for manufactured goods – larger share of resources freed up from agriculture went to manufacturing ...
- Later industrializers are facing relatively low prices and demand for manufactured goods – larger share of resources freed up from agriculture going directly to services

Implications for Industry Polarization

Figure: Predicted Industry Polarization – Baseline and Counterfactuals



Notes: Unconditional variance reports the log-variance of the manufacturing VA share. Conditional variance reports the mean squared difference between the log simulated VA share and the log predicted share. Top panel: Solid lines – baseline model; Dotted lines – CRP scenario; dashed lines – autarky scenario; dotted-dashed lines – autarky-CRP scenario.

Contributions

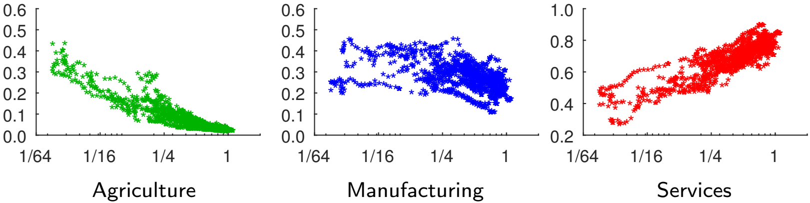
- Build and calibrate model of structural change, and conduct counterfactual exercises, to explain deindustrialization and industry polarization over time
  - Our story for deindustrialization: Sector-biased productivity growth, in conjunction with trade integration, lowers manufacturing relative prices over time, which lowers spending shares on manufactured goods
    - ⋆ Early industrializers faced relatively high manufacturing price; later industrializers faced relatively low manufacturing price.
    - ⋆ Relatively low manufacturing price led to smaller shift into manufacturing, and larger shift into services, compared to past
  - Our story for industry polarization: Trade integration leads to specialization, and then increases dispersion of manufacturing value-added shares
- Policy Implications
  - Important for policy makers to sort out effects of their policies from global forces
  - Returns to public investment in services sector productivity higher now than previously

Thank you

Structural Change

- Well-known: As countries grow, the value-added share declines in agriculture, rises in services, and first rises and then declines in manufacturing.

Sector value added shares vs income per capita

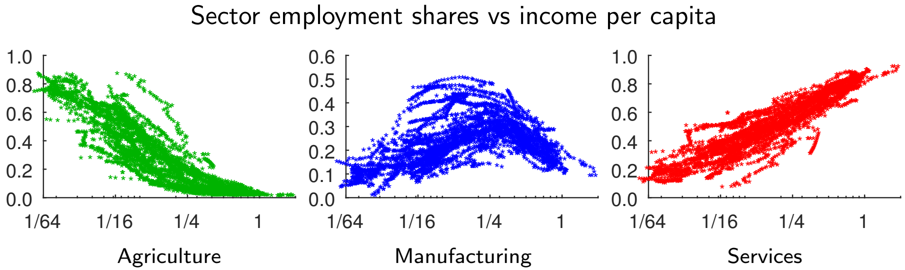


Notes: Real income per capita is at PPP prices, relative to United States in 2011. The data is a balanced panel covering 28 countries from 1971–2011.

- Less-known: whether and how does this relationship change over time?

Employment shares

Facts: Structural Change



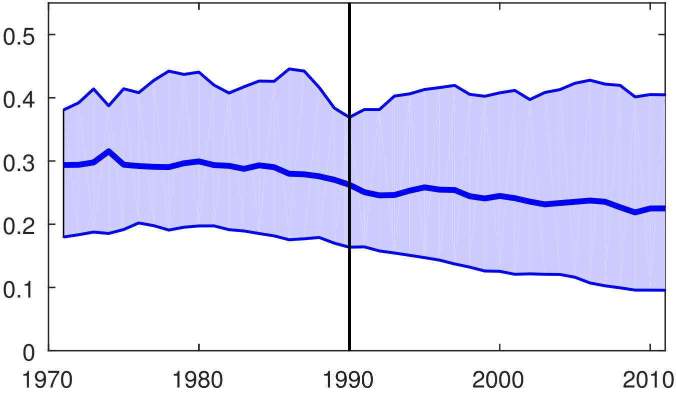
Notes: Real income per capita is at PPP prices, relative to United States in 2011. The data is an unbalanced panel covering 40 countries from 1900–2011.

- As countries grow, employment share of:
  - Agriculture declines,
  - Manufacturing follows a hump pattern,
  - Services increases.

Return

Facts: Industry Polarization (New)

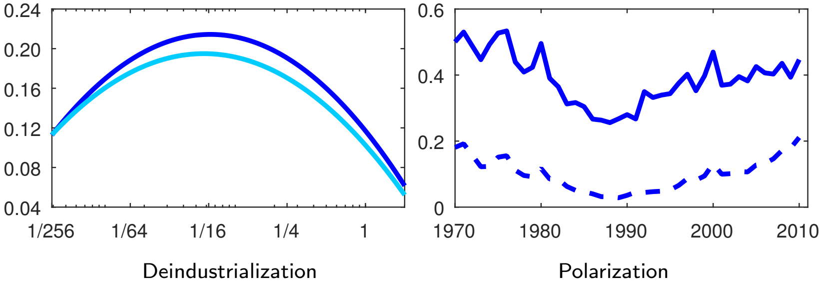
Figure: Distribution of Manufacturing Value Added Shares



Notes: The solid line denotes the median value across countries in each year, while the upper and lower bands correspond to the 99th and 1st percentiles, respectively.

Facts: Deindustrialization and Industry Polarization

Figure: Robustness with 95 countries over 1970–2010



Source: Felipe, Mehta, and Rhee (2019); Authors' calculations.

Return to deindustrialization | Return to polarization

Facts: Deindustrialization

Estimates

For each period pd $\in \{$pre-90, post-90$\}$:

$$va^j_{n,t} = \alpha^j_n + \sum_{pd} \left(\beta^j_{0,pd} + \beta^j_{1,pd} y_{n,t} + \beta^j_{2,pd} y^2_{n,t} \right) \mathbb{1}_{t=pd} + \epsilon^j_{n,t},$$

	Pre-1990		Post-1990			R^2
	β_1	β_2	β_0	β_1	β_2	
Agriculture	−0.076 (0.007)	−0.022 (0.005)	−0.018 (0.004)	−0.006 (0.002)	0.015 (0.002)	0.94
Manufacturing	−0.090 (0.009)	−0.071 (0.007)	0.007 (0.006)	−0.025 (0.002)	−0.019 (0.002)	0.83
Services	0.166 (0.010)	0.093 (0.007)	0.011 (0.006)	0.019 (0.002)	0.004 (0.003)	0.94

Note: The F statistic rejects the null hypothesis that βs are the same across the two periods at the 99 percent level.

Return

Model

Household Preferences

- More familiar representation

$$1 = \sum_{j \in \mathcal{J}} u^{\frac{\varepsilon^j (1-\sigma^c)}{\sigma}} \left(c^j\right)^{\frac{\sigma-1}{\sigma^c}}$$

$$\Leftrightarrow$$

$$u = \left(\sum_{j \in \mathcal{J}} u^{\frac{(\varepsilon^j - 1)(1-\sigma)}{\sigma}} \left(c^j\right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

  - Collapses to homothetic CES when $\varepsilon^j = 1$

Return

Model

Household Preferences

- Lifetime utility:

$$W_n = \sum_{t=1}^{\infty} \beta^{t-1} \psi_{n,t} L_{n,t} \ln\left(\frac{C_{n,t}}{L_{n,t}}\right)$$

- Intratemporal utility: non-homothetic CES as in CLM (2020)

$$1 = \sum_{j \in \{a,m,s\}} \omega_{c,n}^{j} \left(\frac{C_{n,t}}{L_{n,t}}\right)^{\frac{(1-\sigma_c)}{\sigma_c}\varepsilon^j} \left(\frac{c_{n,t}^{j}}{L_{n,t}}\right)^{\frac{\sigma_c - 1}{\sigma_c}}$$

  - Income elasticities: $\varepsilon^a < \varepsilon^m = 1 < \varepsilon^s$
  - Price elasticity: $0 < \sigma_c < 1$

▸ Example

Model

Household Constraints

- Household budget constraint:

$$\underbrace{\sum_{j\in\{a,m,s\}} p^j_{n,t} c^j_{n,t}}_{P^c_{n,t} C_{n,t}} + \underbrace{\sum_{j\in\{a,m,s\}} p^j_{n,t} x^j_{n,t}}_{P^x_{n,t} X_{n,t}} = (R_{n,t} K_{n,t} + W_{n,t} L_{n,t}) - NX_{n,t},$$

  - $NX_{n,t} = \phi_{n,t}(R_{n,t} K_{n,t} + W_{n,t} L_{n,t}) - L_{n,t} T^P_t$, as in Caliendo et al. (2017)

- Capital accumulation constraint:

$$K_{n,t+1} = (1-\delta) K_{n,t} + (X_{n,t})^{\lambda} (\delta K_{n,t})^{1-\lambda},$$

$$X_{n,t} = \left(\sum_{j\in\{a,m,s\}} \omega^j_{x,n} (x^j_{n,t})^{\frac{\sigma_x - 1}{\sigma_x}} \right)^{\frac{\sigma_x}{\sigma_x - 1}}$$

  - Price elasticity: σ_x

Model

Household FOCs

- Sectoral consumption share:

$$\frac{p^j_{n,t} c^j_{n,t}}{P^c_{n,t} C_{n,t}} = (\omega^j_{c,n})^{\sigma_c} \left(\frac{p^j_{n,t}}{P^c_{n,t}}\right)^{1-\sigma_c} \left(\frac{C_{n,t}}{L_{n,t}}\right)^{(\varepsilon^j - 1)(1-\sigma_c)}$$

- Sectoral investment share:

$$\frac{p^j_{n,t} x^j_{n,t}}{P^x_{n,t} X_{n,t}} = (\omega^j_{x,n})^{\sigma_x} \left(\frac{p^j_{n,t}}{P^x_{n,t}}\right)^{1-\sigma_x}$$

- Consumption-investment tradeoff (Euler equation):

$$\frac{C_{n,t+1}/L_{n,t+1}}{C_{n,t}/L_{n,t}} = \beta \left(\frac{\psi_{n,t+1}}{\psi_{n,t}}\right) \left(\frac{\frac{R_{n,t+1}}{P^x_{n,t+1}} - \Phi_2\left(K_{n,t+2}, K_{n,t+1}\right)}{\Phi_1\left(K_{n,t+1}, K_{n,t}\right)}\right) \left(\frac{P^x_{n,t+1}/P^c_{n,t+1}}{P^x_{n,t}/P^c_{n,t}}\right)$$

Model

Production

- Production of tradable variety $v \in [0,1]$:

$$y^j_{n,t}(v) = a(v)\left(A^j_{n,t} k^j_{n,t}(v)^{\alpha} \ell^j_{n,t}(v)^{1-\alpha}\right)^{\nu^j_n} e^j_{n,t}(v)^{1-\nu^j_n}$$

  - Inputs from all sectors are bundled in a CES fashion with price elasticity σ^j_e.
  - Time-varying, sector-specific, value-added productivity: $A^j_{n,t}$
  - Variety-specific productivity drawn from Frèchet: $F^j(a) = exp(-a^{-\theta^j})$

- Sector composite good used in consumption, investment and intermediates:

$$q^j_{n,t} = \left(\int_0^1 q^j_{n,t}(v)^{\frac{\eta-1}{\eta}} dv\right)^{\frac{\eta}{\eta-1}} = c^j_{n,t} + x^j_{n,t} + \sum_{k\in\{a,m,s\}} e^{k,j}_{n,t}$$

Model

Trade: Eaton-Kortum (2002), Uy-Yi-Zhang (2013)

- Import of variety by country n from country i in sector j is subject to time-varying iceberg costs: $d^j_{n,i,t} \geq 1$

- Trade, determined by Ricardian comparative advantage, directly affects sectoral reallocations:

$$\pi^j_{n,i,t} = \frac{\left((A^j_{i,t})^{-\nu^j_i} u^j_{i,t} d^j_{n,i,t}\right)^{-\theta^j}}{\sum_{i'=1}^{N} \left((A^j_{i',t})^{-\nu^j_{i'}} u^j_{i',t} d^j_{n,i',t}\right)^{-\theta^j}}$$

$$u^j_{i,t} \propto (R_{i,t})^{\alpha\nu^j_i} (W_{i,t})^{(1-\alpha)\nu^j_i} \left(p^{e,j}_{i,t}\right)^{1-\nu^j_i}$$

- Trade, impacting prices and income, indirectly affects sectoral reallocation:

$$p^j_{n,t} \propto \left(\sum_{i=1}^{N} \left((A^j_{i,t})^{-\nu^j_i} u^j_{i,t} d^j_{n,i}\right)^{-\theta^j}\right)^{-\frac{1}{\theta^j}}$$

Model

Equilibrium

The model economy is summarized by time invariant parameters (β, ε^j, σ_c, σ_x, σ_e^j, θ, δ, λ, η, α, ν_n^j, $\omega_{c,n}^j$, $\omega_{x,n}^j$, $\omega_{e,n}^{j,k}$), time varying exogenous processes of sectoral productivities and trade costs $\{A_{n,t}^j, d_{n,i,t}^j\}$, the initial capital $\{K_{n,1}\}$, processes of labor supply $\{L_{n,t}\}$, trade imbalances $\{\phi_{n,t}\}$, and discount factors $\{\psi_{n,t}\}$.

Definition

A competitive equilibrium of this model consists sequences of allocations $\{C_{n,t}$, $X_{n,t}$, $K_{n,t}$, $c_{n,t}^j$, $x_{n,t}^j$, $k_{n,t}^j$, $l_{n,t}^j$, $e_{n,t}^j$, $e_{n,t}^{j,k}$, $\pi_{n,i,t}^j\}$ and prices $\{P_{n,t}^c$, $P_{n,t}^x$, $p_{n,t}^{e,j}$, $p_{n,t}^j$, $R_{n,t}$, $W_{n,t}\}$ that satisfy the following conditions: (1) the representative household maximizes utility taking prices as given, (2) firms maximize profits taking prices as given, (3) each country purchases each variety from the least costly country, and (4) markets clear.

Calibration

Key Elasticities: Constrained NLS for Preference Parameters

- FOC (objective)

$$\ln\left(\frac{p^j_{n,t}c^j_{n,t}}{p^m_{n,t}c^m_{n,t}}\right) = \sigma_c \ln\left(\frac{\omega^j_{c,n}}{\omega^m_{c,n}}\right) + (1-\sigma_c)\ln\left(\frac{p^j_{n,t}}{p^m_{n,t}}\right) + (1-\sigma_c)(\varepsilon^j - 1)\ln\left(\frac{C_{n,t}}{L_{n,t}}\right) + \epsilon^j_{c,n,t} \tag{1}$$

s.t. $\sigma_c > 0, \sum_j \omega^j_{c,n} = 1$

- Utility (consumption, $C_{n,t}$) not observable, use expenditure function:

$$\underbrace{P^c_{n,t}C_{n,t}}_{\text{total expenditure}} = L_{n,t}\left(\sum_{j\in\{a,m,s\}}(\omega^j_{c,n})^{\sigma_c}\left(\frac{C_{n,t}}{L_{n,t}}\right)^{(1-\sigma_c)\varepsilon^j}(p^j_{n,t})^{1-\sigma_c}\right)^{\frac{1}{1-\sigma_c}} \tag{2}$$

- Guess $\{\sigma^c, \varepsilon^j, \omega^j_{c,n}\}$, recover $C_{n,t}$ from (2), then estimate $\{\sigma^c, \varepsilon^j, \omega^j_{c,n}\}$ using (1). Iterate to find fixed point.

Calibration

Key elasticities: Constrained OLS for Investment and IO

- For investment:

$$\ln\left(\frac{p^j_{n,t}x^j_{n,t}}{p^m_{n,t}x^m_{n,t}}\right) = \sigma_x \ln\left(\frac{\omega^j_{x,n}}{\omega^m_{x,n}}\right) + (1-\sigma_x)\ln\left(\frac{p^j_{n,t}}{p^m_{n,t}}\right) + \epsilon^j_{x,n,t}$$

$$\text{s.t. } \sigma_x > 0, \sum_j \omega^j_{x,n} = 1$$

for $j = a$ and s.

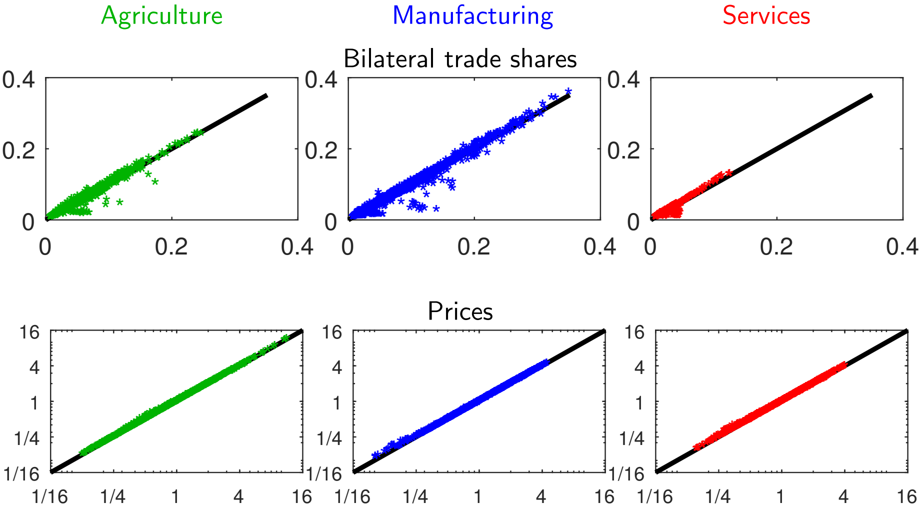
Calibration

Time Varying Driving Forces

$$\begin{pmatrix} A^j_{n,t} \\ d^j_{n,i,t} \\ \psi_{n,t} \\ \phi_{n,t} \\ L_{n,t} \end{pmatrix} \leftrightarrow \begin{pmatrix} \text{sector prices} \\ \text{sector bilateral trade flows} \\ \text{aggregate investment rate} \\ \text{aggregate trade imbalance} \\ \text{aggregate employment} \end{pmatrix}$$

Calibration Results

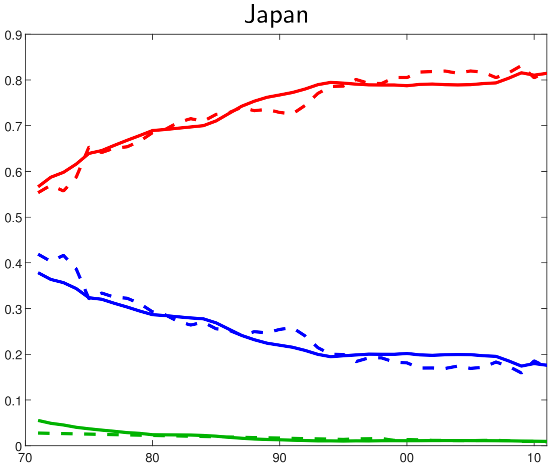
Targeted Moments



Notes: Vertical axis - model, horizontal axis - data.

Calibration

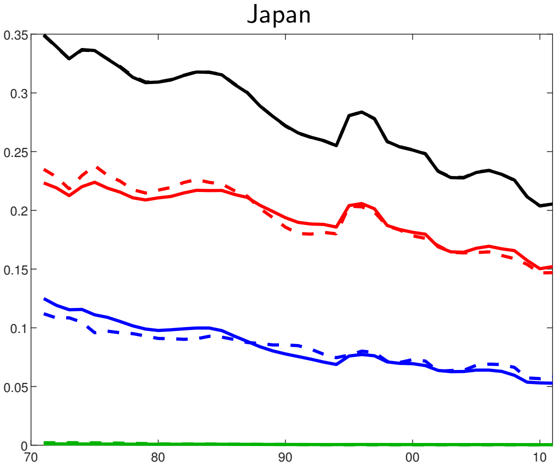
Sectoral consumption spending shares in Japan



- **Notes: Dashed line: data; Solid line: model; Green: agriculture; Blue: manufacturing; Red: services**

Calibration

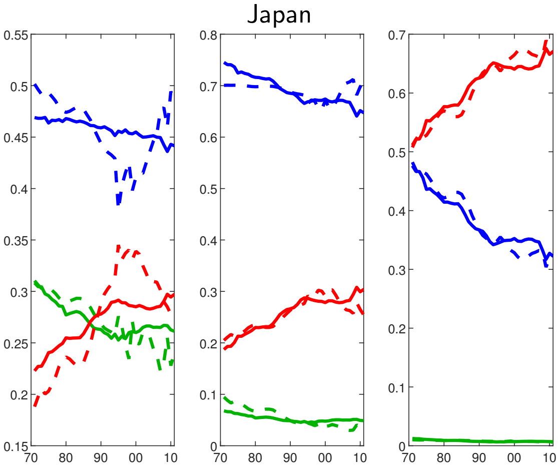
Sectoral investment spending, shares of GDP, in Japan



- **Notes: Dashed line: data; Solid line: model; Green: agriculture; Blue: manufacturing; Red: services**

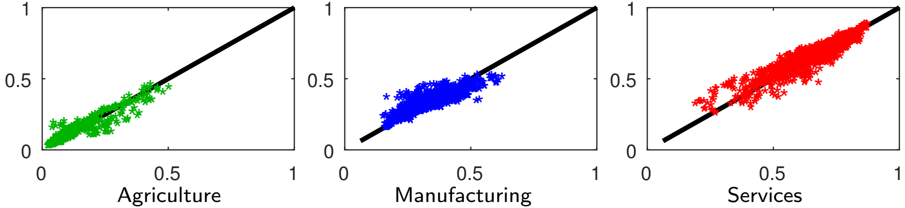
Calibration

Sectoral intermediate input spending shares for Ag, Man, and Serv, in Japan



- **Notes: Dashed line: data; Solid line: model; Green: agriculture; Blue: manufacturing; Red: services**

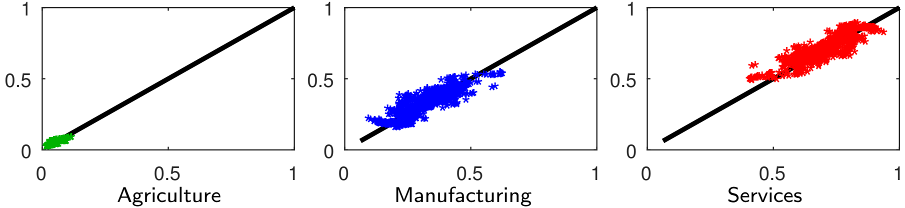
Sectoral Consumption Shares



Note: Model - y-axis; data - x-axis.

▸ Return

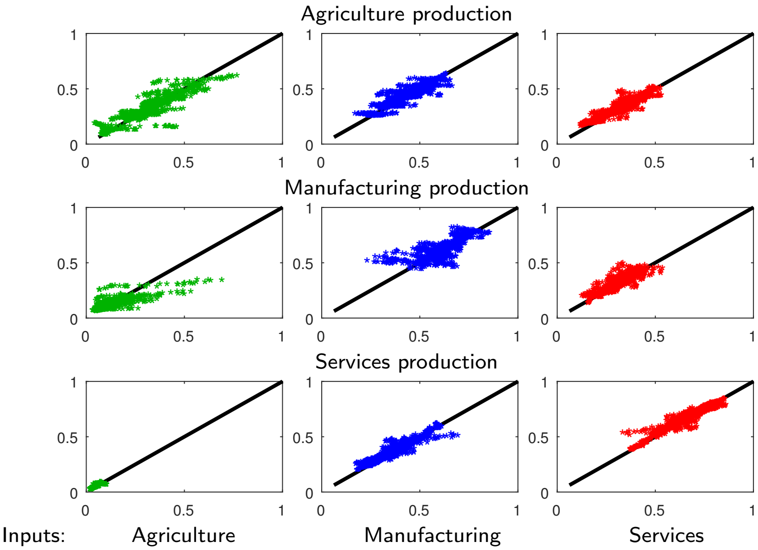
Sectoral Investment Shares



Note: Model - y-axis; data - x-axis.

▸ Return

Sectoral Input Shares

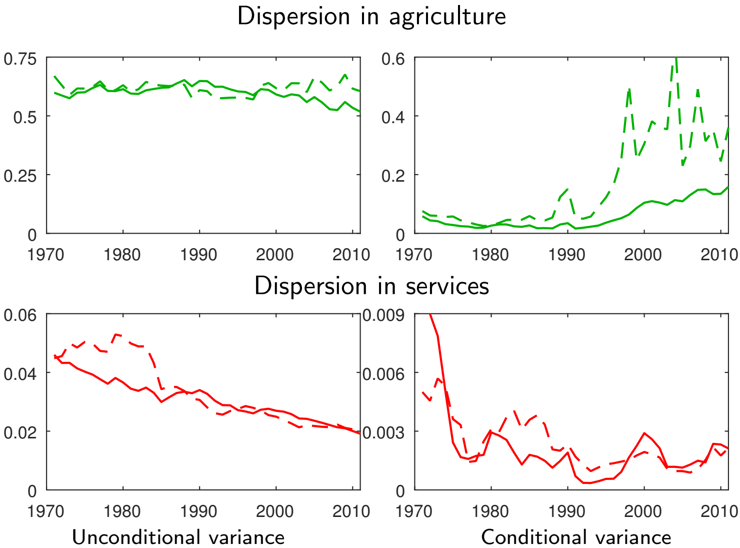


Note: Model - y-axis; data - x-axis.

Return

Calibration

Cross-country Variance in sectoral VA shares



Return

Implications for Industry Polarization

Variance of Manufacturing Value Added Share

	Data	Baseline	Autarky-CRP	Autarky	CRP
Unconditional					
Pre-90	0.043	0.039	0.015	0.024	0.038
Post-90	0.074	0.077	0.014	0.029	0.085
Change	0.031	0.038	−0.001	0.005	0.047
Conditional					
Pre-90	0.0091	0.0054	0.0002	0.0028	0.0041
Post-90	0.0103	0.0072	0.0001	0.0033	0.0082
Change	0.0012	0.0018	−0.0001	0.0005	0.0041

- Trade integration alone leads to substantial industry polarization, and sector-biased productivity alone contributes little to industry polarization.
- Sector-biased productivity growth *in conjunction with trade integration* partially offsets effect of trade integration alone.

Story for Industry Polarization

- Trade integration over decades has led to increased specialization
- Those countries with comparative advantage in manufacturing have had high shares of manufacturing value-added, but ...
- Those countries without comparative advantage in manufactured goods have relied increasingly on imports – their manufacturing value-added shares have declined

Empirical Evidence for Model Mechanisms

Independent variables	(1)	(2)	(3)
Fixed effect, pre-1990	0.020	0.011	0.017
	(0.007)	(0.007)	(0.006)
Income per capita, pre-1990	−0.090	−0.118	−0.056
	(0.009)	(0.010)	(0.011)
Income per capita squared, pre-1990	−0.025	−0.033	−0.020
	(0.002)	(0.003)	(0.003)
Income per capita, post-1990	−0.071	−0.088	−0.046
	(0.007)	(0.008)	(0.008)
Income per capita squared, post-1990	−0.019	−0.023	−0.016
	(0.002)	(0.002)	(0.002)
Population		0.121	0.121
		(0.022)	(0.021)
Population squared		−0.014	−0.011
		(0.002)	(0.002)
Relative price, manufacturing to services			**0.109**
			(0.010)
Country fixed effects	Y	Y	Y
Adjusted R^2	0.83	0.84	0.85

Notes: The left hand side variable is the manufacturing value added share, and all right-hand side variables are in logarithms.

Final Demand and Input-Output Channels

$$\begin{bmatrix} va^a \\ va^m \\ va^s \end{bmatrix} = \begin{bmatrix} 1-\xi^{a,a} & -\xi^{m,a} & -\xi^{s,a} \\ -\xi^{a,m} & 1-\xi^{m,m} & -\xi^{s,m} \\ -\xi^{a,s} & -\xi^{m,s} & 1-\xi^{s,s} \end{bmatrix}^{-1} \begin{bmatrix} \nu^a & 0 & 0 \\ 0 & \nu^m & 0 \\ 0 & 0 & \nu^s \end{bmatrix} \begin{bmatrix} \rho_c\zeta_c^a + \rho_x\zeta_x^a + \rho_n\zeta_n^a \\ \rho_c\zeta_c^m + \rho_x\zeta_x^m + \rho_n\zeta_n^m \\ \rho_c\zeta_c^s + \rho_x\zeta_x^s + \rho_n\zeta_n^s \end{bmatrix},$$

- Sector value added shares determined by IO matrix and final demand vector
- Allow one channel to vary as in the model and hold all other channels constant at 1995 values

	Peak Manufacturing Share			Unconditional variance		
	Pre-1990	Post-1990	Change	Pre-1990	Post-1990	Change
All channels	0.329	0.295	−0.034	0.039	0.077	0.038
Sectoral cons shares	0.317	0.299	−0.018	0.037	0.059	0.022
Sectoral inv shares	0.270	0.269	−0.001	0.046	0.048	0.002
Sectoral IO shares	0.295	0.286	−0.009	0.043	0.051	0.008
Aggregate inv rate	0.265	0.264	−0.001	0.050	0.047	−0.003

▸ Leontief inverse

Channels for Structural Change

$$\begin{bmatrix} va^a \\ va^m \\ va^s \end{bmatrix} = \begin{bmatrix} 1-\xi^{a,a} & -\xi^{m,a} & -\xi^{s,a} \\ -\xi^{a,m} & 1-\xi^{m,m} & -\xi^{s,m} \\ -\xi^{a,s} & -\xi^{m,s} & 1-\xi^{s,s} \end{bmatrix}^{-1} \begin{bmatrix} \nu^a & 0 & 0 \\ 0 & \nu^m & 0 \\ 0 & 0 & \nu^s \end{bmatrix} \begin{bmatrix} \rho_c\zeta_c^a + \rho_x\zeta_x^a + \rho_n\zeta_n^a \\ \rho_c\zeta_c^m + \rho_x\zeta_x^m + \rho_n\zeta_n^m \\ \rho_c\zeta_c^s + \rho_x\zeta_x^s + \rho_n\zeta_n^s \end{bmatrix},$$

- IO matrix is analogous to "Leontief inverse" matrix

$$\xi^{j,k} = (1-\nu^j)\left(\frac{IO^{j,k}}{\sum_{k'\in\{a,m,s\}} IO^{j,k'}}\right)\left(\frac{\nu^k}{\nu^j}\right)$$

- Final demand split between sector shares and component shares

$$\rho_c = \frac{P^c C}{P^c C + P^x X + N}$$

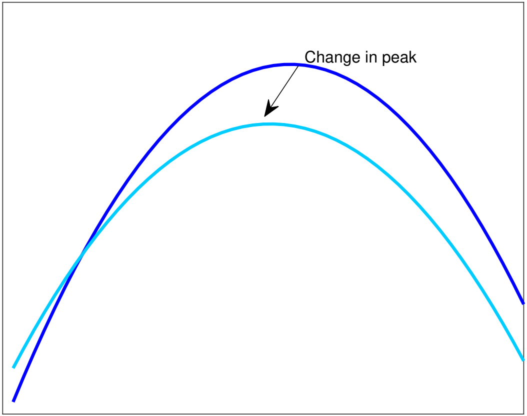
$$\zeta_c^j = \frac{p^j c^j}{P^c C}$$

Return

Counterfactual

Visualization of quantifying the change in peak

Change in peak manufacturing value added share



Return