Does Skill Abundance Still Matter?

The Evolution of Comparative Advantage in the 21st Century

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        * Keys for Patterns of Development (e.g., East Asian Miracles)
        * Implications for Globalization, Technology, and Inequality

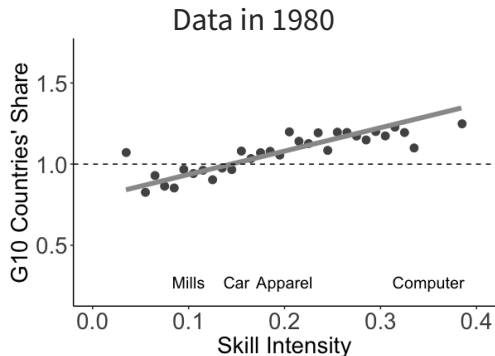# At a Glance: Skill Abundance and Comparative Advantage

Revealed Comparative Advantage (RCA) in Skill Intensive Sectors:

G10's share of global exports in a sector divided by G10's share of total global exports

At a Glance: Skill Abundance and Comparative Advantage

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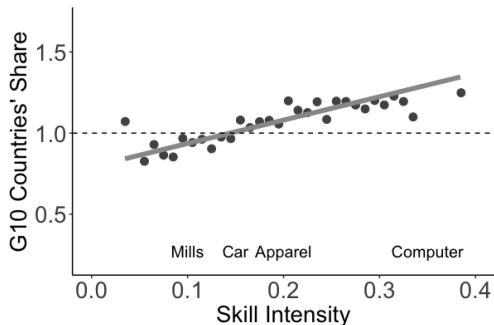G10's share of global exports in a sector divided by G10's share of total global exports

Data in 1980

$$\text{G10's RCA}_s \equiv \frac{\dfrac{\text{G10 Export}_s}{\text{G10 Export}}}{\dfrac{\text{World Export}_s}{\text{World Export}}}$$

Skill Intensity: Non-production Workers' Payroll divided by Value-Added, from NBER-CES Data

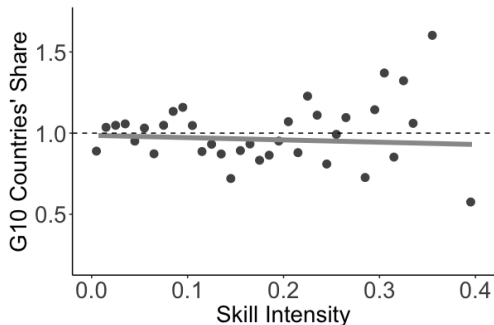# At a Glance: Skill Abundance and Comparative Advantage

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Research Questions

- Does skill abundance *systematically* no longer matter for comparative advantage?

- What forces can empirically and quantitatively explain the pattern?
    - Potential hypotheses: Automation, Offshoring

- What are the macro implications?
    - Manufacturing shares, Skill premia, Welfare

Preview (1/2) New Facts on Comparative Advantage

- Follow the literature's state-of-the-art specification
  - Based on a multi-sector Eaton-Kortum model (Chor 2010, Costinot et al 2012)

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- **Vanishing Importance of Skill Abundance in Comparative Advantage**
- **Heterogeneous declines** across groups of countries & sectors
  - More declines among groups of countries & sectors with more automation
  - No such heterogeneity from offshoring

Preview (2/2) Causes are Automation, Not Offshoring

- Theory: A multi-sector Eaton-Kortum model with automation & offshoring
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- Implications of Offshoring
  - No big shift in manufacturing as a whole
  - Smaller changes in skill premia & welfare

Key Contributions

1. Sources of Comparative Advantage:
   - Ricardian: MacDougall (1951), Stern (1962), Balassa (1963), Golub and Hsieh (2000), Nunn (2007), Levchenko (2007), Manova (2008), Costinot (2009), Costinot et al (2012)
   - HO: Leamer (1980, 1984), Bowen et al (1987), Trefler (1993, 1995), Harrigan (1997), Davis & Weinstein (2001), Schott (2001), Romalis (2004), Morrow (2010), Chor (2010)
   - Mean Reversion: Levchenko & Zhang (2016), Hanson et al (2016)

   → **New Facts: Skill Abundance Matter in 1980s, Not Anymore post-2000.**

2. Consequences of Technology and Globalization on Inequality:

Key Contributions

1. Sources of Comparative Advantage:

2. Consequences of Technology and Globalization on Inequality:
   - Technology: Katz & Murphy (1992), Feenstra & Hanson (1999), Acemoglu (2002), Autor et al (2003), Acemoglu & Autor (2011), Autor & Dorn (2013), Acemoglu & Restrepo (2018,2022), Webb (2020), Loebbing (2021)
   - Offshoring: Lawrence & Slaughter (1993), Berman et al (1994), Feenstra & Hanson (1997, 1999, 2001), Becker & Muendler (2014), Hummels et al (2014), Alfaro-Urena et al (2021)
   - Interaction of Tech and Trade: Xu (2001), Acemoglu (2002), Thoenig & Verdier (2003), Burstein et al (2013), Parro (2013), Burstein & Vogel (2017), Morrow & Trefler (2022)

   → **Automation Changes Comparative Advantage and Big Effects on Inequality**

FACTS: DOES SKILL ABUNDANCE STILL MATTER?

Revealing Comparative Advantage: Refresher

- Multi-sector Eaton-Kortum Model (Chor (2010), Costinot et al (2012))

  Exporter i, Importer j, Sector s: $\quad \ln \text{Export}_{i,j,s} = - \underbrace{\theta}_{\text{Trade Elas.}} \underbrace{\ln c_{i,s}}_{\text{Unit Cost}} + \underbrace{\eta_{i,j} + \eta_{j,s}}_{\text{FEs}}$

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- Unit cost (α_s^H: Skill Intensity = the share of skilled labor payroll in value-added)

  $$c_{i,s} = (w_i^H)^{\alpha_s^H}(w_i^L)^{1-\alpha_s^H} \quad \rightarrow \quad \ln c_{i,s} = \alpha_s^H \times \ln(w_i^H/w_i^L) + \ln w_i^L$$

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- If relative wage is some (log-linear) function of Skill Abundance$_i$,

  $$\ln \text{Exports}_{i,j,s} = \beta \left[\text{Skill Intensity}_s \times \text{Skill Abundance}_i \right] + \eta_{i,j} + \eta_{j,s} + \varepsilon_{i,j,s}$$

- Canonical specification to reveal the source of comparative advantage

Skill Abundance as a Source of Comparative Advantage

Higher Exports in Skill-Intensive Goods from Skill-Abundant Countries?

$$\ln \text{Exports}_{i,j,s,t} = \beta_t \left[\text{Skill Intensity}_{s,t} \times \text{Skill Abundance}_{i,t} \right] + \eta_{i,j,t} + \eta_{j,s,t} + \varepsilon_{i,j,s,t},$$

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- Expect $\beta_t > 0$: Skill-abundant countries export skill-intensive goods more
- $\text{Exports}_{i,j,s,t}$: Bilateral trade flow i to j in s, from UN Comtrade
- $\text{Skill Intensity}_{s,t}$: Share of skilled labor pay. in value added, from NBER-CES
- $\text{Skill Abundance}_{i,t}$: Ratio of College- to Non-college-educated in i, from Barro-Lee
- $\eta_{i,j,t}$: Exporter-Importer FEs: control distances, productivity level diffs,...
- $\eta_{j,s,t}$: Importer-Sector FEs: control tariffs, expenditure shares,...

Skill Abundance Used to be Important before 2000
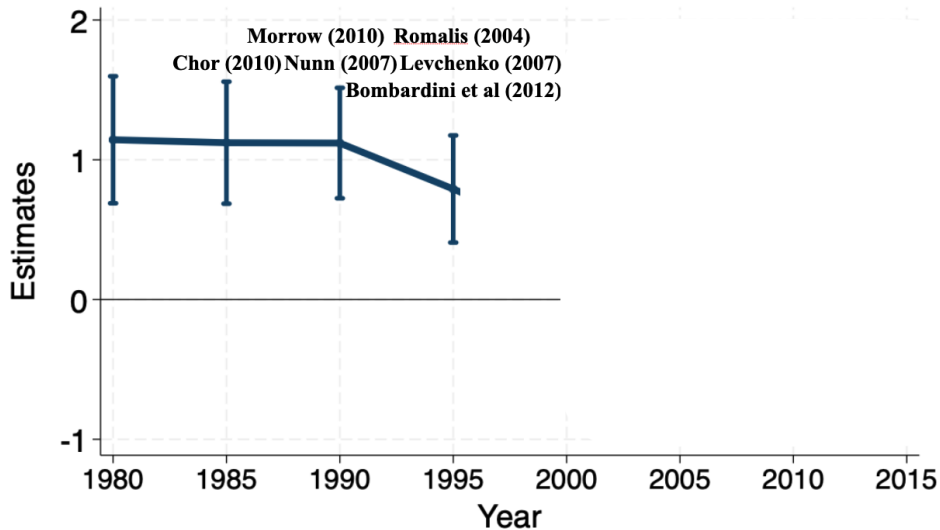
Skill Abundance $\neq$ CA in Skill-Intensive Sectors after 2000
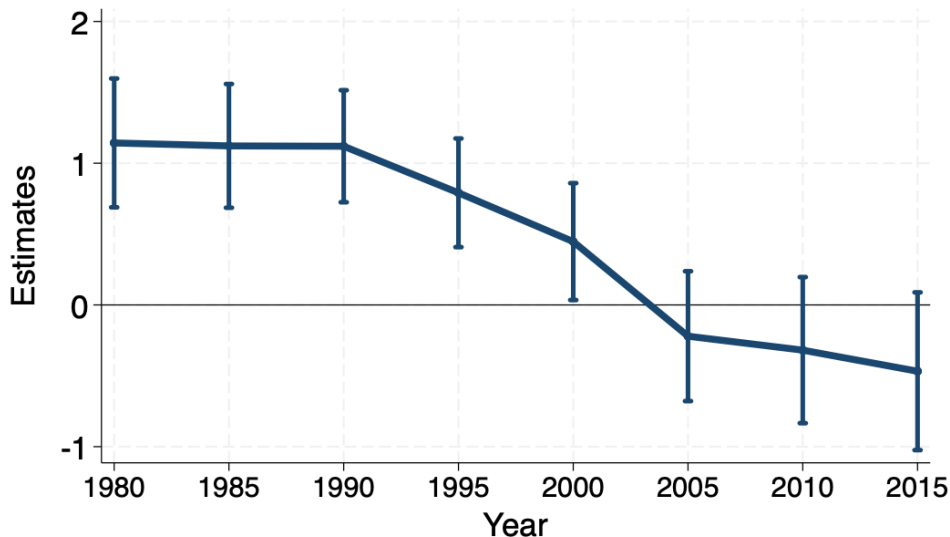
Robustness (1) Other Papers' Specifications

1. Total exports, instead of bilateral exports (Romalis 2004, Nunn 2007,...)

2. Different measures of sectoral factor intensity (Chor 2010)
   - $\ln(H_s/L_s)$, instead of α_s^H ($\equiv$ Skilled Payroll Share to Value-Added)

Using Total Exports Does Not Change Results
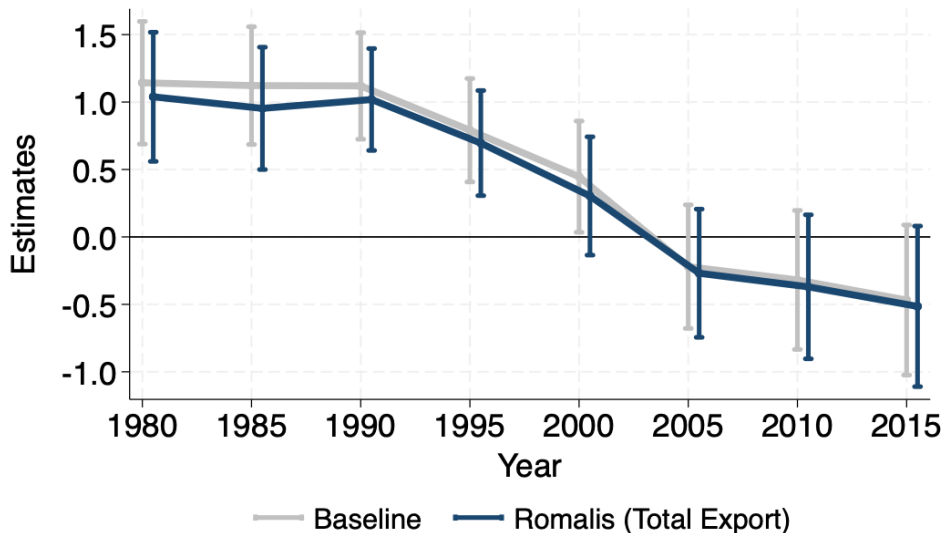
Using Different Intensity Measures Does Not Change Trends
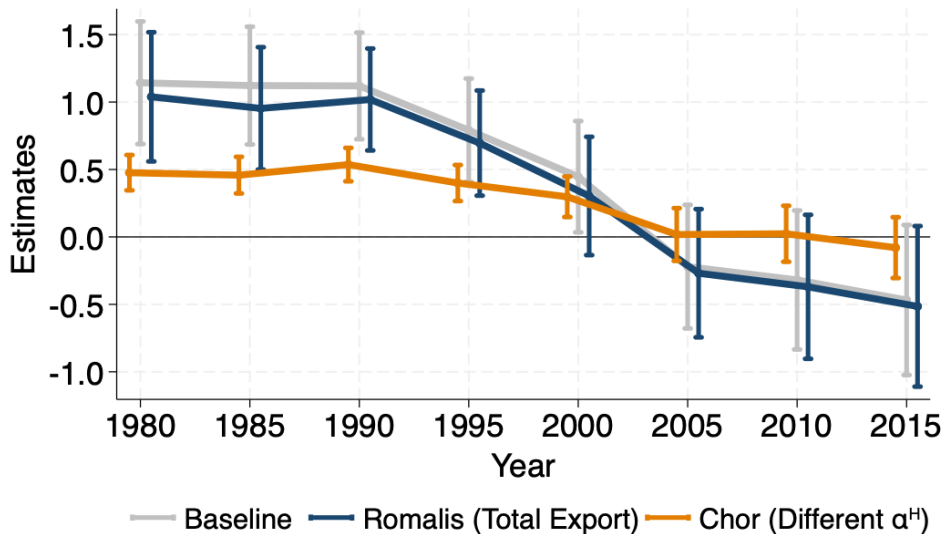
Robustness (2)

- Other sources of comparative advantage? ‣ Capital ‣ Institution
- Driven by small countries? ‣ Weighted
- Some exporter-sector unobserved het., or IRS? ‣ Pool years and FEs
- "Endogenous" skill abundance? ‣ Use 1980 Value
- "Endogenous" skill intensity *in the US*? ‣ Use 1980 Value
  - "Endogenous" interaction? ‣ Use 1980 Values for Both
  - but, 1980's measure becomes less relevant by construction? ‣ Use 2015 Value
- Different skill measures? ‣ High School ‣ Predicted by Demographics

SOME POTENTIAL HYPOTHESES: AUTOMATION AND OFFSHORING

Potential Hypotheses: Automation and Offshoring

- What can make domestic skill abundance less relevant for CA after the 1990s?

# Potential Hypotheses: Automation and Offshoring

- What can make domestic skill abundance less relevant for CA after the 1990s?

- Two mega-trends, replacing low-skill labor
  - Automation: Replace low-skill labor with machines
  - Offshoring: Replace low-skill labor with foreign inputs

Potential Hypotheses: Automation and Offshoring

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• This section: Explore heterogeneous effects across countries and sectors
  – Caution: Just descriptive analysis for potential hypotheses
  – Causal interpretation using the model later

Potential Hypotheses: Automation and Offshoring
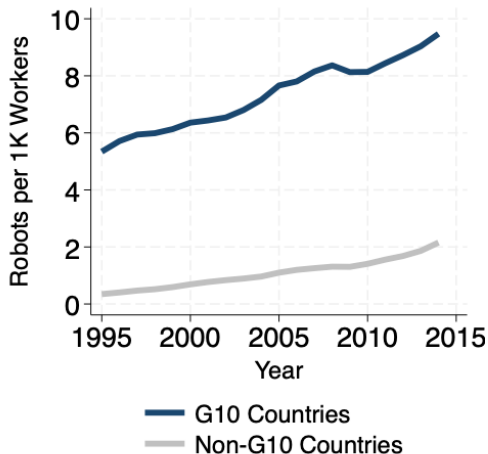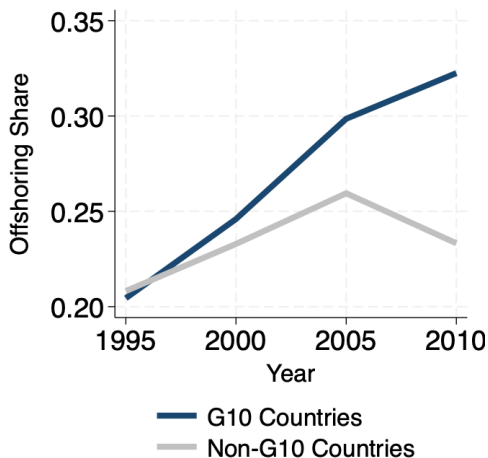
Specification for Heterogeneous Effects

$$X_{i,j,s,t} = \exp\left[\underbrace{\beta_t^0\left(1 + \beta_t^A HA_{i,s}\right)}_{=\beta_t} \cdot \left(\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right) + \eta_{i,j,t} + \eta_{j,s,t}\right] + \varepsilon_{i,j,s,t}$$

- $HA_{i,s}$: High-automation dummy (below/above the median robot adoption)
- Expect β_t^A to be decreasing over time
- Same for offshoring: replace $HA_{i,s}$ with $HO_{i,s}$ based on offshoring share

Skills Abundance Matters in Low-Automation Country/Sector

Plot $\widehat{\beta}_t^0$ and $\widehat{\beta}_t^0 + \widehat{\beta}_t^A$

Legend: Low Automation, High Automation
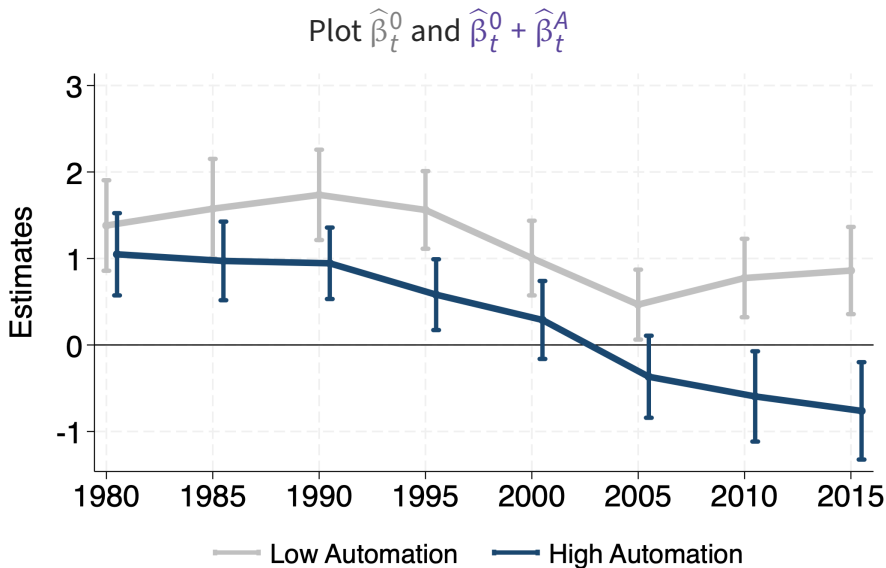
No Heterogeneous Effects from Offshoring
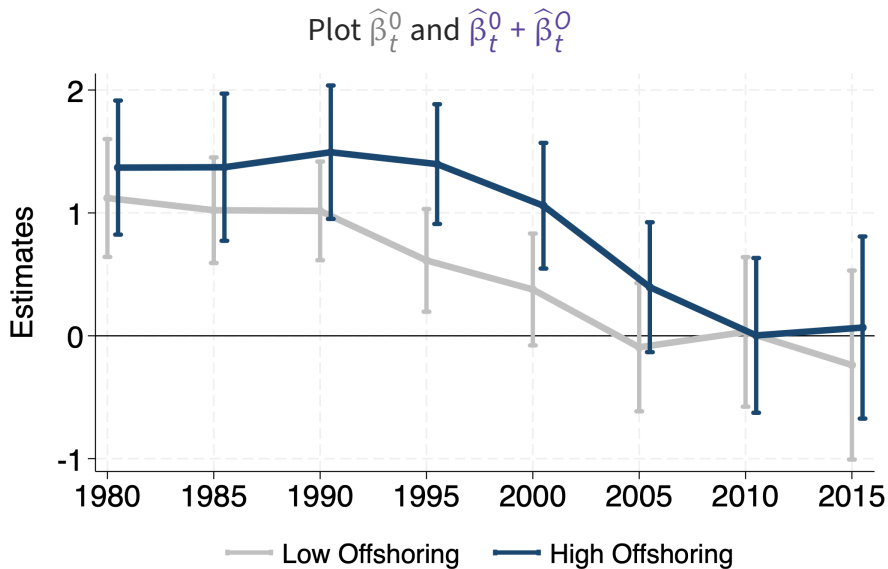
Plot $\widehat{\beta}_t^0$ and $\widehat{\beta}_t^0 + \widehat{\beta}_t^O$

— Low Offshoring — High Offshoring

Same Results from Continuous Measures

$$X_{i,j,s,t} = \exp\left[\beta_t^0 \left(1 + \beta_t^A \text{Auto}_{i,s} + \beta_t^O \text{Ofs}_{i,s}\right) \cdot \left(\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right) + \eta_{i,j,t} + \eta_{j,s,t}\right] + \varepsilon_{i,j,s,t},$$

	1995	2010	1995	2010
Skill Intensity x Abundance	1.26	-0.33		
	(0.23)	(0.28)		
x Automation (log robot stock)				
x Offshoring Share (×100)				

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	1995	2010	1995	2010
Skill Intensity x Abundance	1.26	-0.33	3.00	3.49
	(0.23)	(0.28)	(0.41)	(0.57)
x Automation (log robot stock)			-0.19	-0.35
			(0.05)	(0.06)
x Offshoring Share (×100)			0.04	0.05
			(0.05)	(0.07)

Note: Automation measure: 12.2 for German cars, 2.3 for Indian textiles

Summary of Empirical Facts

Summary

- **Skill abundance become less important in comparative advantage** over time

- Less important with higher **Automation**

- **Offshoring** has surprisingly, small effects

MODEL: TRADE WITH AUTOMATION AND OFFSHORING

Overview

- Multi-sector Eaton-Kortum Model with Input-Output Linkages

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- Primary factors:
  - Labor: $H_{i,s}$ (high-skilled), $L_{i,s}$ (low-skilled)

Overview

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- **New: Unit Cost function with Automation and Offshoring**

- Primary factors:
    - Labor: $H_{i,s}$ (high-skilled), $L_{i,s}$ (low-skilled)

- Additional Production factors (produced using outputs)
    - Automation Capital: $M_{i,s}$
    - Intermediate: $XD_{i,s}$ (domestic), $XF_{i,s}$ (foreign)
        - ⋆ including non-automation capital (buildings, land)

Standard Multi-Sector Eaton Kortum Model

- Country i, j, Sector s

- Trade share (gravity equation) is given by

$$\pi_{i,j,s}^{F} = \frac{(c_{i,s} \cdot \tau_{i,j,s})^{-\theta}}{\sum_{l}^{\mathcal{J}}(c_{l,s} \cdot \tau_{l,j,s})^{-\theta}}$$

  – Trade share: $\pi_{i,j,s}^{F} \equiv X_{i,j,s} / \sum_{l} X_{l,j,s}$
  – Unit cost: $c_{i,s}$; Trade cost: $\tau_{i,j,s}$; Trade elasticity $\theta > 0$

Unit Cost Function with Automation and Offshoring Shock

Unit production cost:

$$c_{i,s} = \Lambda_s \cdot (w_i^H)^{\alpha_s^H} \cdot \left[\left(\frac{w_{i,s}^M}{\Gamma_{i,s}^M} \right)^{\Gamma_{i,s}^M} \cdot \left(\frac{w_i^L}{\Gamma_{i,s}^L} \right)^{\Gamma_{i,s}^L} \cdot \left(\frac{w_{i,s}^{XD}}{\Gamma_{i,s}^{XD}} \right)^{\Gamma_{i,s}^{XD}} \cdot \left(\frac{w_{i,s}^{XF}}{\Gamma_{i,s}^{XF}} \right)^{\Gamma_{i,s}^{XF}} \right]^{1-\alpha_s^H}$$

- Production task can be completed by one of the factors
  - machine M, low-skilled labor L, domestic inputs XD, foreign inputs XF
  - $\Gamma_{i,s}^F$: task shares within production-task for factor $F \in \{M, L, XD, XF\}$
  - Micro-foundation: task model (Acemoglu & Restrepo)
- Machines and intermediates are produced using final goods

Goods & Labor Market Clearing

Goods Market Clearing (Output $Y_{i,s}$, sectoral exp. share $\mu_{i,s}$, IO coef. α)

$$Y_{i,s} = \underbrace{\sum_j \pi^F_{ij,s}\mu_{j,s}(w^L_j L_j + w^H_j H_j)}_{\text{Final Consumption in } j} + \underbrace{\sum_j \sum_r \pi^M_{ij,r}\alpha^M_{j,sr}(1-\alpha^H_r)\Gamma^M_{j,r}Y_{j,r}}_{\text{Machine in } j-r}$$

$$+ \underbrace{\sum_r \alpha^X_{i,sr}(1-\alpha^H_r)\Gamma^{XD}_{i,r}Y_{i,r}}_{\text{Domestic Intermediates in } i-r} + \underbrace{\sum_j \sum_r \pi^X_{ij,r}\alpha^X_{j,sr}(1-\alpha^H_r)\Gamma^{XF}_{j,r}Y_{j,r}}_{\text{Foreign Intermediates in } j(\neq i)-r}$$

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Labor Market Clearing

$$w^L_i L_i = \sum_s (1-\alpha^H_s)\Gamma^L_{i,s}Y_{i,s}$$

$$w^H_i H_i = \sum_s \alpha^H_s Y_{i,s}$$

Equilibrium Conditions

Given factor endowments $\{H_i, L_i\}_{i \in \mathcal{J}}$, an equilibrium is a set of wages $\{w_i^H, w_i^L\}_{i \in \mathcal{J}}$

- Consumers maximize utility by choosing from which countries to buy
  $\rightarrow$ trade share $\pi_{i,j,s}$, as a function of unit cost $\{c_{i,s}\}_{i \in \mathcal{J}, s \in \mathcal{S}}$

- Unit cost, $c_{i,s}$, as a function of $\{w_i^H, w_i^L\}_{i \in \mathcal{J}}$
  - $\{w_{i,s}^M, w_{i,s}^{XD}, w_{i,s}^{XF}\}$ are functions of $\{w_i^H, w_i^L\}_{i \in \in \mathcal{J}}$ with IO coef.

- Goods and Labor Markets Clear

- Trade is balanced

QUANTIFICATION

Quantitative Analysis

- Two Exercises:
  1. Can changes in $\Gamma^M_{i,s,t}$ (automation) and $\Gamma^{XF}_{i,s,t}$ (offshoring) explain $\widehat{\beta}_t$?
  2. Using the same model, what are the macro implications?

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- Calibration: Data for 40 countries, 18 sectors (WIOD+GTAP, 1995-2008)

    – $\Gamma_{i,s,t}^{M} \equiv \frac{p_{i,s,t}^{M} M_{i,s,t}}{\text{Total Cost}_{i,s,t}}$ (automation, constructed)

$$p_{i,s,t}^{M} M_{i,s,t} = \underbrace{p_{i,s,t0}^{K} K_{i,s,t0}}_{\text{Capital Income}} \cdot \underbrace{\frac{p_{US,s,t0}^{M} M_{US,s,t0}}{p_{US,s,t0}^{K} K_{US,s,t0}}}_{\text{Machine-Capital Ratio}} \cdot \underbrace{\frac{p_{i,s,t}^{R} R_{i,s,t}}{p_{i,s,t0}^{R} R_{i,s,t0}}}_{\text{Increases in Robots}} \cdot$$

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    – $\Gamma_{i,s,t}^{XF}$ (offshoring, just data), fixing $\Gamma_{i,s,t}^{XD}$ (domestic intermediate share)

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  1. Can changes in $\Gamma^M_{i,s,t}$ (automation) and $\Gamma^{XF}_{i,s,t}$ (offshoring) explain $\widehat{\beta}_t$?
  2. Using the same model, what are the macro implications?

- Calibration: Data for 40 countries, 18 sectors (WIOD+GTAP, 1995-2008)

  - $\Gamma^M_{i,s,t} \equiv \dfrac{p^M_{i,s,t} M_{i,s,t}}{\text{Total Cost}_{i,s,t}}$ (automation, constructed)

$$
p^M_{i,s,t} M_{i,s,t} = \underbrace{p^K_{i,s,t0} K_{i,s,t0}}_{\text{Capital Income}} \cdot \underbrace{\dfrac{p^M_{US,s,t0} M_{US,s,t0}}{p^K_{US,s,t0} K_{US,s,t0}}}_{\text{Machine-Capital Ratio}} \cdot \underbrace{\dfrac{p^R_{i,s,t} R_{i,s,t}}{p^R_{i,s,t0} R_{i,s,t0}}}_{\text{Increases in Robots}} \cdot
$$

  - $\Gamma^{XF}_{i,s,t}$ (offshoring, just data), fixing $\Gamma^{XD}_{i,s,t}$ (domestic intermediate share)
  - Adjust $\Gamma^L_{i,s,t}$ (low-skilled labor share) to make $\sum_{F=L,M,XD,XF} \Gamma^F_{i,s,t} = 1$

More Automation in Skill-Abundant Countries
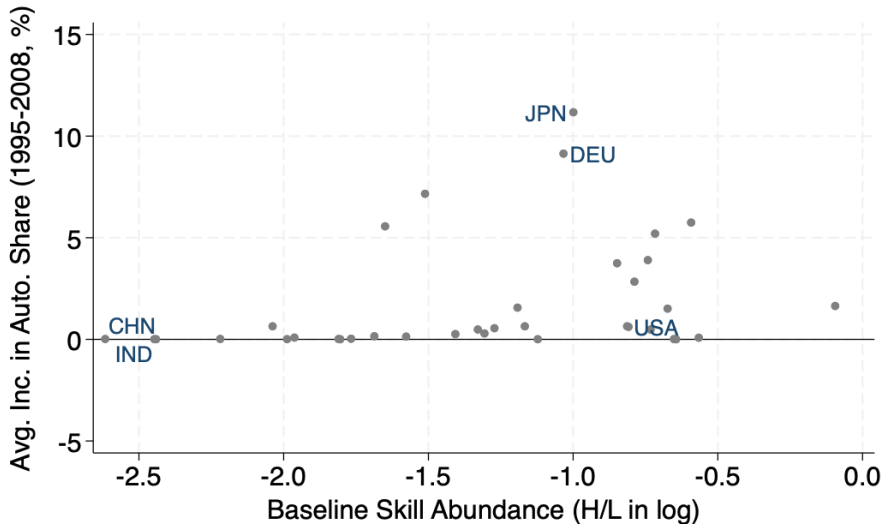
Offshoring is More Equally Distributed
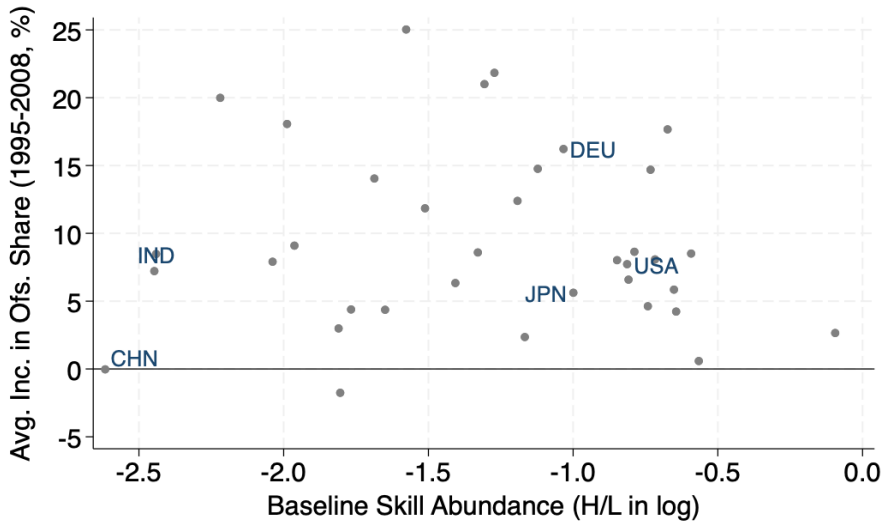
CHANGES IN COMPARATIVE ADVANTAGE

1. Automation and Offshoring on Changes in $\widehat{\beta}$

- Question: How much can $\Gamma_{i,s,t}^{M}$ and $\Gamma_{i,s,t}^{XF}$ explain the path of $\widehat{\beta}_t$?
- Calibrate the model to 1995, and hat algebra
- Run the same regression as in data but for counterfactual economies

$$\ln(X_{i,j,s,t})' = \beta_t \left[\alpha_{s,t_0}^{H} \times \ln \left(\frac{H_{i,t_0}}{L_{i,t_0}} \right) \right] + \eta_{i,j,t} + \eta_{j,s,t} + \varepsilon_{i,j,s,t}.$$

- Counterfactual trade flow: $(X_{i,j,s,t})'$
  - Data (World Input-Output Database)
  - Case 1. Only Automation: Change $\Gamma_{i,s,t}^{M}$
  - Case 2. Only Offshoring: Change $\Gamma_{i,s,t}^{XF}$

In Data, $\widehat{\beta}_t$ decreases
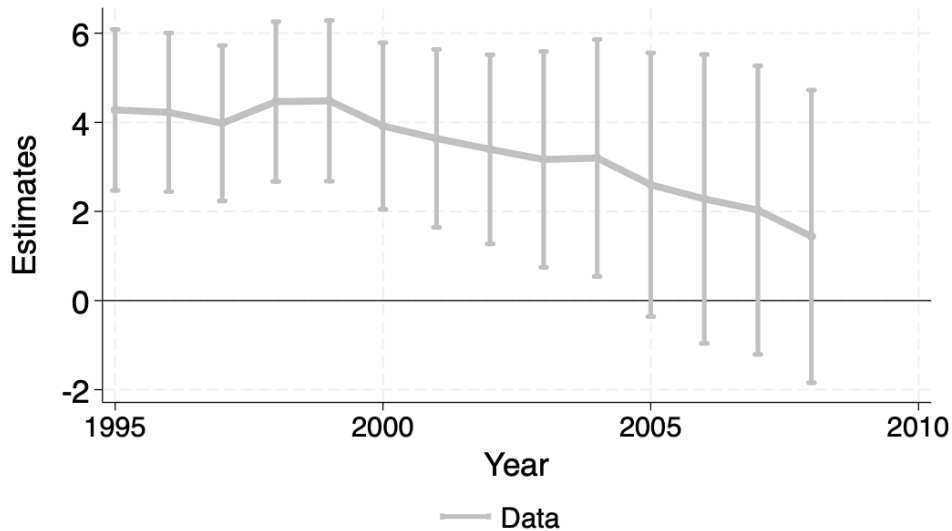
Automation, Not Offshoring, Causes the Decline
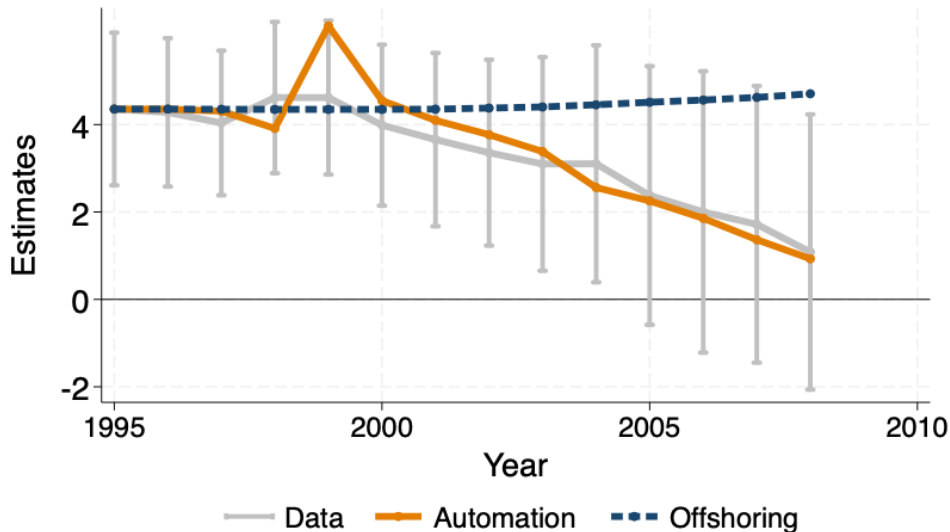
Why Automation?

- Sizes of automation & offshoring similar
  - If any, offshoring is larger

- Why automation, not offshoring, matter?

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- Experiment: Suppose all the countries increase automation equally...

Equal Automation Cannot Explain the Decline
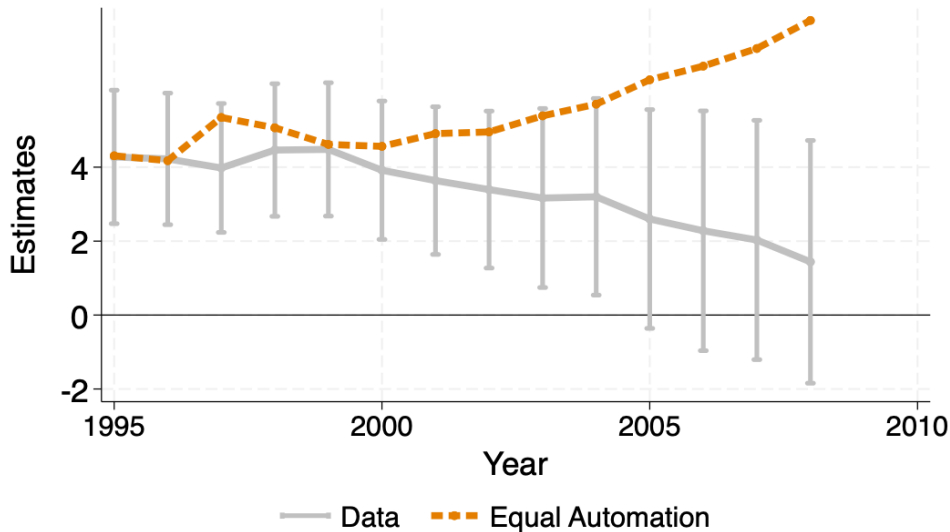
MACRO IMPLICATIONS OF AUTOMATION

Manufacturing Shifts to High-Automation Countries
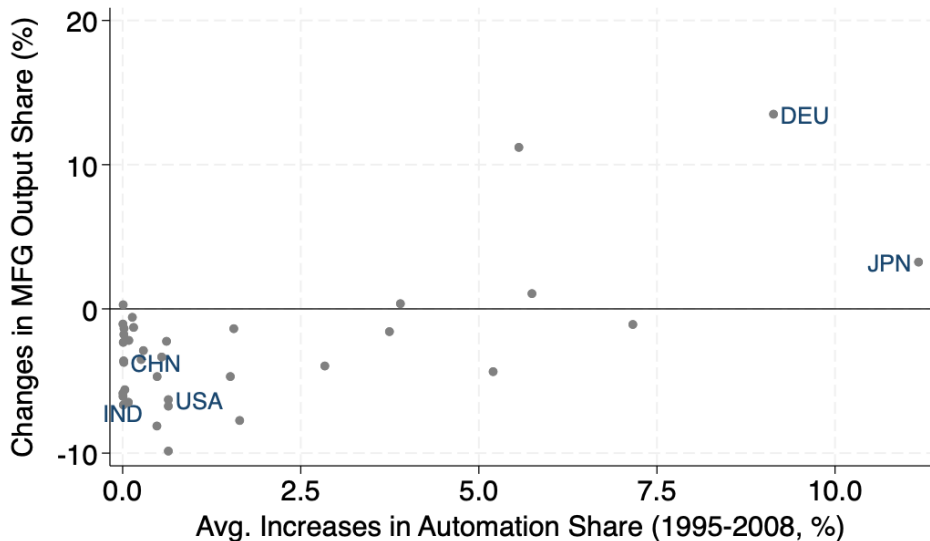
Skill Premia Increases Only in High-Automation Countries
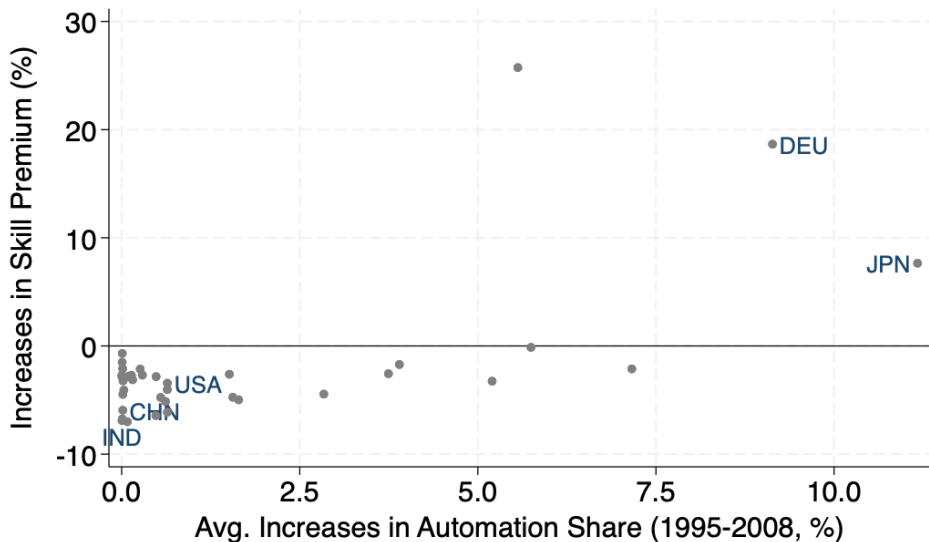
Welfare Increases Everywhere
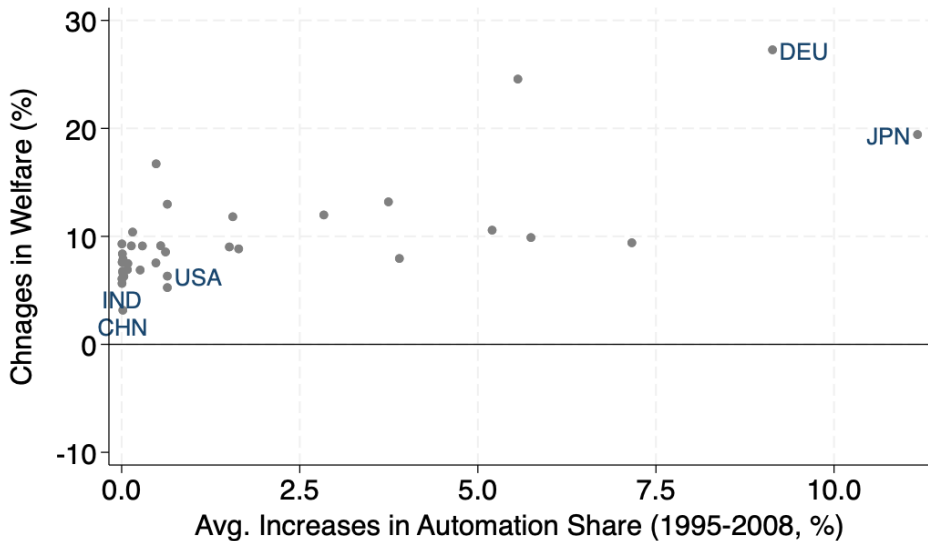
MACRO IMPLICATIONS OF OFFSHORING

Manufacturing Shifts Less
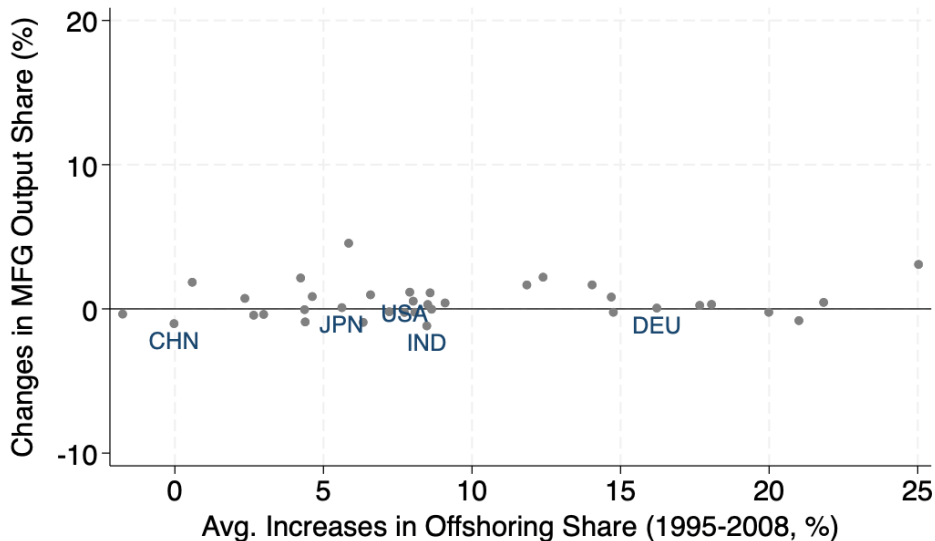
Skill Premia Increases Everywhere, but Less
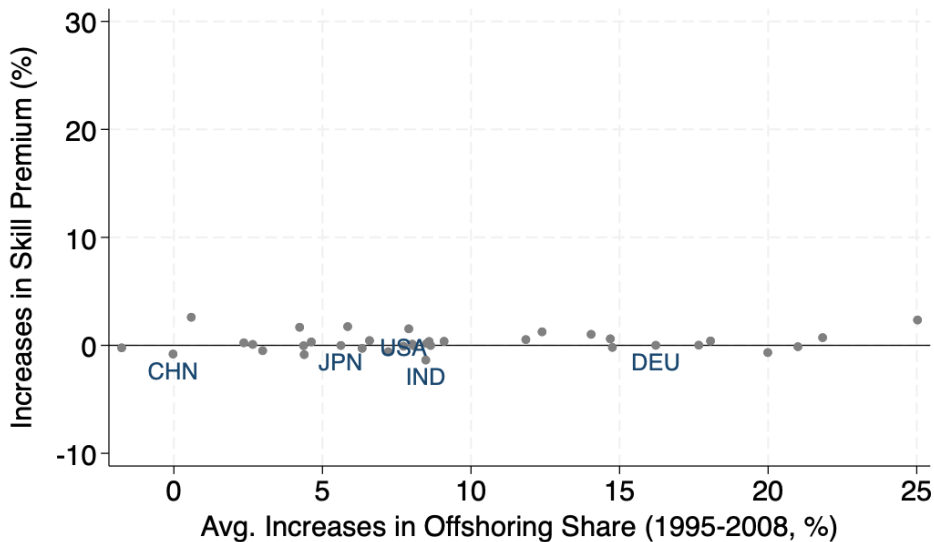
Welfare Increases Everywhere, but Less
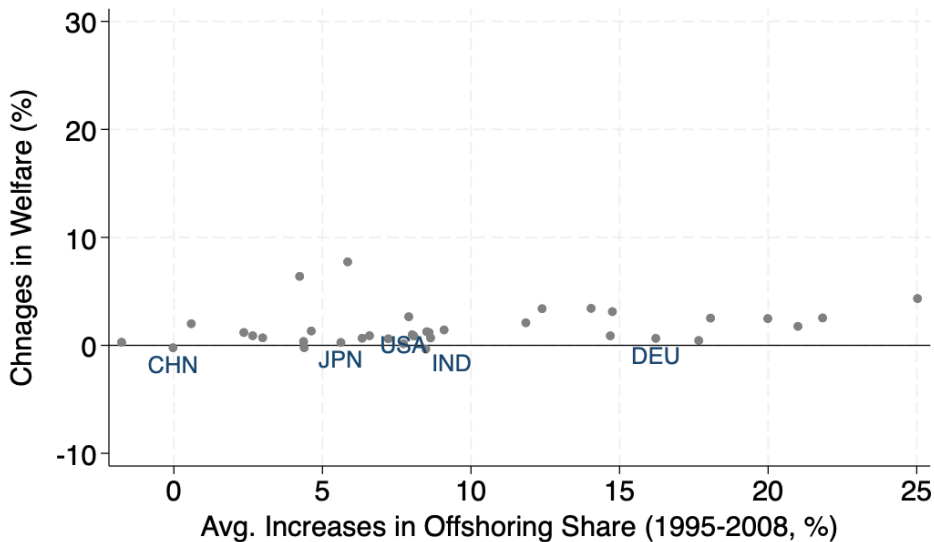
The Relationship between Automation, Globalization, and Inequality

- Automation $\rightarrow$ shifts MFG to High-Automation countries

- Demand for H increases in High-Automation countries

- Demand for L increases in Low-Automation countries
    - Move to Service sectors, which are more L–intensive

The Relationship between Automation, Globalization, and Inequality

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- Roles of Trade?

- Now, set the trade elasticity $\theta = 1$, instead of $\theta = 4$

θ = 1: Lower Elas. Makes MFG Shifts Less
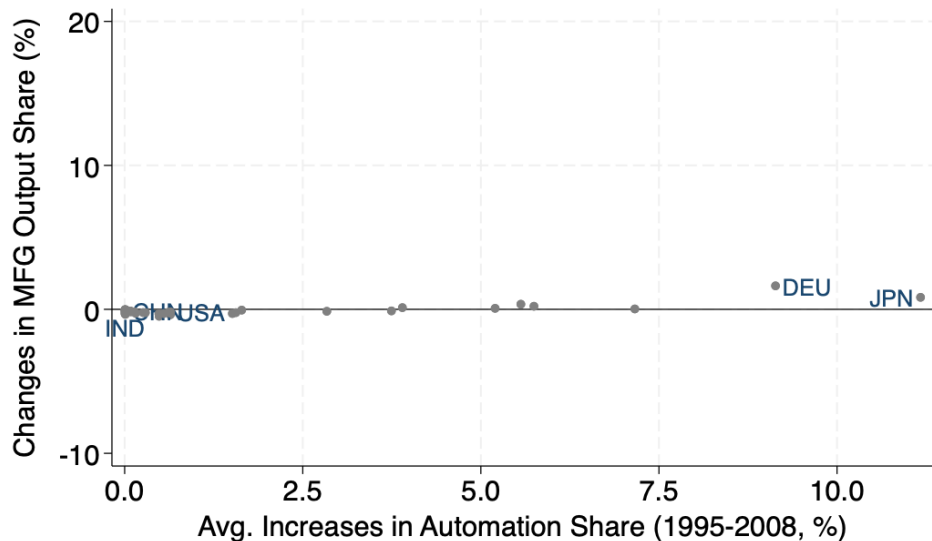
θ = 1: Skill Premia Increases Everywhere
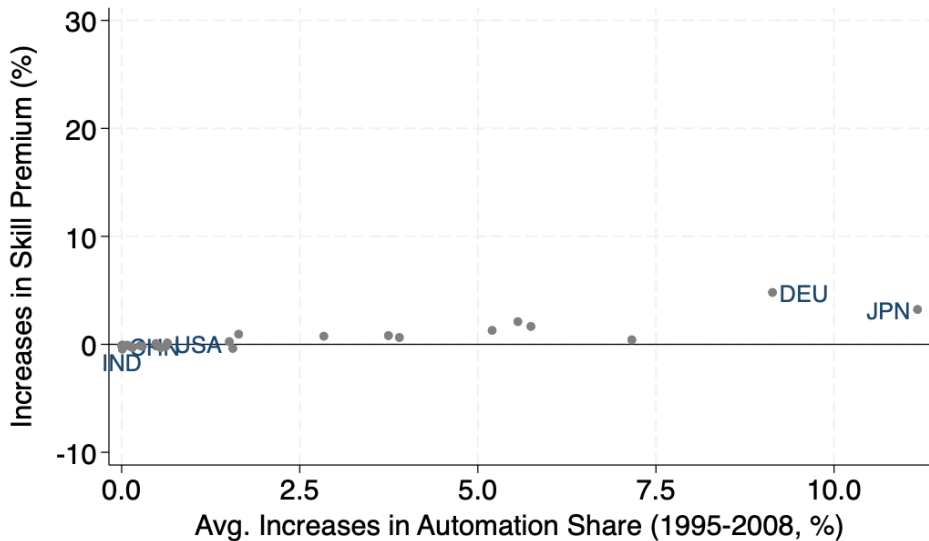
θ = 1: Welfare Increases Everywhere, but Less
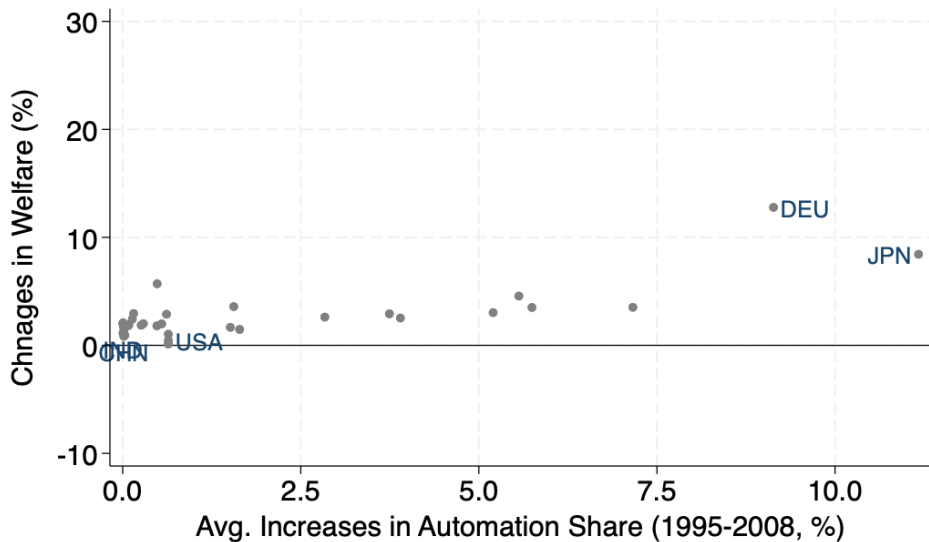
Conclusion

- Have patterns of comparative advantage changed or not?

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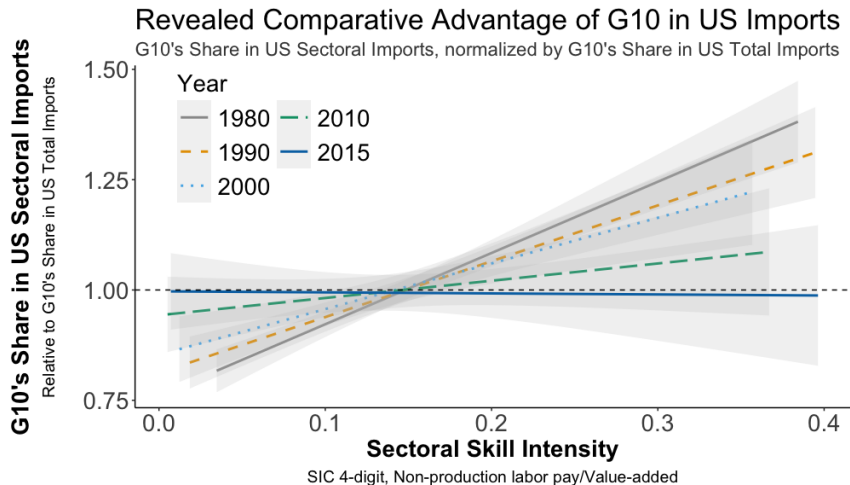 - **It did.** Skill abundance no longer matters for CA

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- **NEXT:** Policy implications? Clean-dirty tech v.s. oil-rich countries?

APPENDIX

FACTS

It's Not Just 1980 vs 2015. It's the Trend!

Revealed Comparative Advantage of G10 in US Imports

G10's Share in US Sectoral Imports, normalized by G10's Share in US Total Imports

G10's Share in US Sectoral Imports
Relative to G10's Share in US Total Imports

Sectoral Skill Intensity

SIC 4-digit, Non-production labor pay/Value-added

Year
- 1980
- 1990
- 2000
- 2010
- 2015

Dropping China Does Not Change the Result

G10's Share in US Sectoral Imports
Relative to G10's Share in US Total Imports

G10's Share in US Sectoral Imports
Relative to G10's Share in US Total Imports

Year
— 1980
— 2015

Sectoral Skill Intensity
SIC 4-digit, Non-production labor pay/Value-added
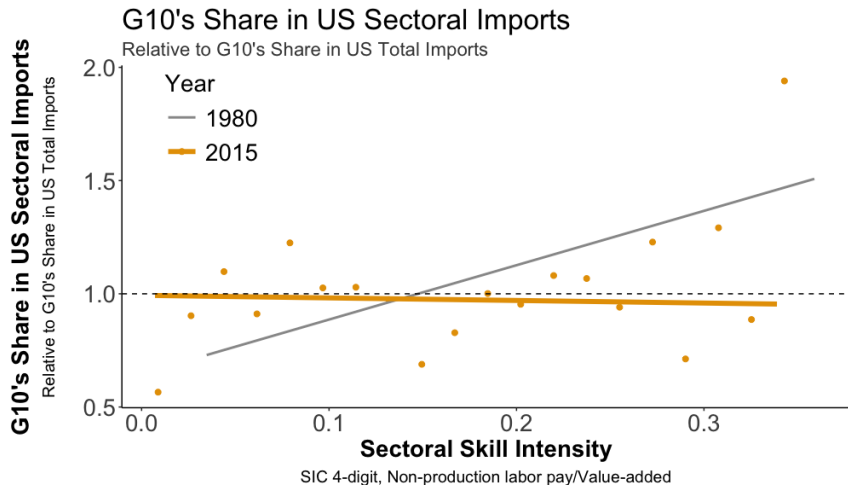
Dropping Japan Does Not Change the Result (if any, cleaner)

G10's Share in US Sectoral Imports
Relative to G10's Share in US Total Imports

Year
— 1980
— 2015

Y-axis: G10's Share in US Sectoral Imports / Relative to G10's Share in US Total Imports

X-axis: Sectoral Skill Intensity

SIC 4-digit, Non-production labor pay/Value-added
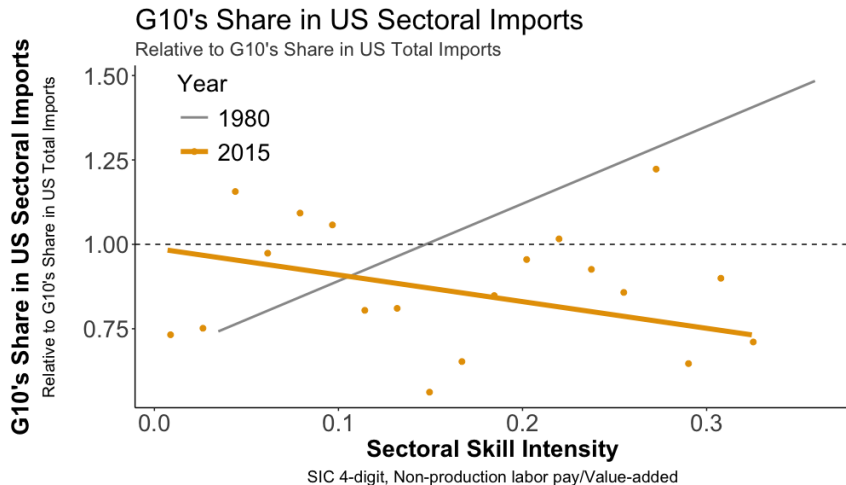
Relative Skilled Wages and Skill Endowment
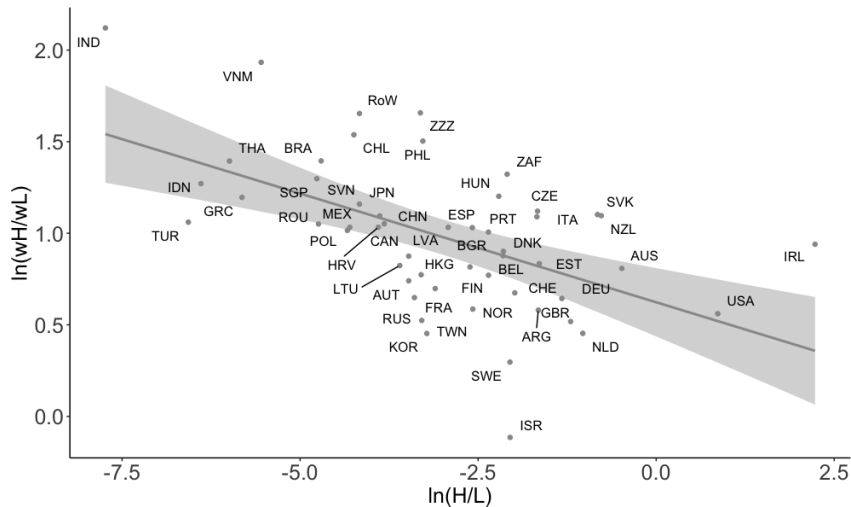
Note: Data from GTAP, 2004

Levels of Unskilled Wages and Skill Endowment
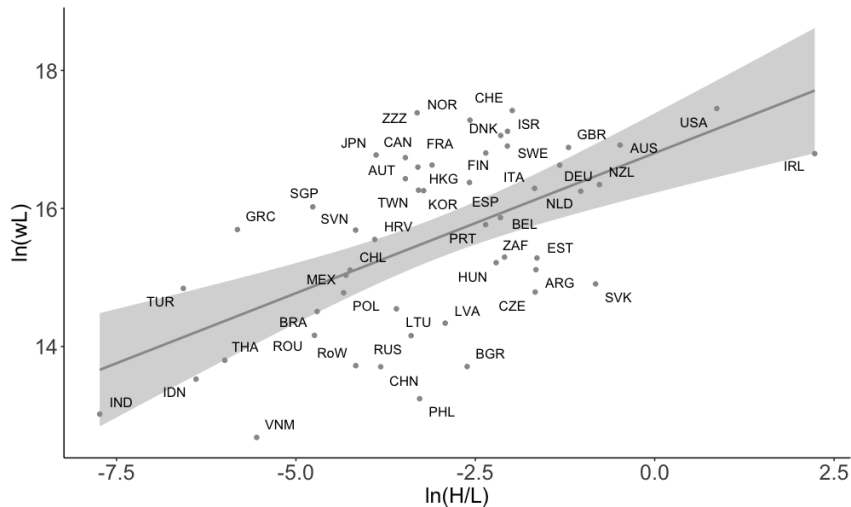
Note: Data from GTAP, 2004

REGRESSION

Simplified Structural Interpretation

- Gravity Equation + Unit Production Cost

$$X_{i,j,s} = \left((c_{i,s}\tau_{i,j}\tau_{j,s})\right)^{1-\sigma} \cdot (P_{j,s})^{\sigma-1} X_{j,s}, \quad \ln X_{i,j,s} = (1-\sigma)\cdot\ln c_{i,s} + \mu_{i,j} + \mu_{j,s}$$

$$c_{i,s} = (w_i^H)^{\alpha_s^H}(w_i^L)^{1-\alpha_s^H}, \quad \ln c_{i,s} = \underbrace{\frac{d\ln(w^H/w^L)}{d\ln(H/L)}}_{\equiv \epsilon^w: \text{ Rel. Wage Elas.}<0} \cdot \alpha_s^H \cdot \ln\left(\frac{H_i}{L_i}\right) + \ln w_i^L$$

- Regression

$$\ln X_{i,j,s} = (1-\sigma)\epsilon^w\left[\alpha_s^H \times \ln\left(\frac{H_i}{L_i}\right)\right] + \mu_{i,j} + \mu_{j,s} + \ln w_i^L$$

ROBUSTNESS

Controlling Capital Intensity

$$X_{i,j,s,t} = \exp\left(\beta_t \left[\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right) \right] + \beta_t^K \left[\alpha_{s,t}^K \times \ln\left(\frac{K_{i,t}}{L_{i,t}}\right) \right] + \eta_{i,j,t} + \eta_{j,s,t} \right) + u_{i,j,s,t}$$
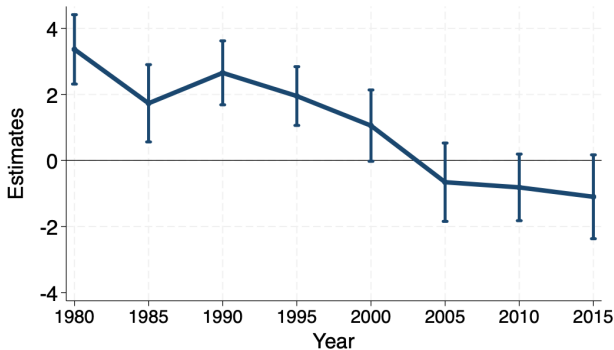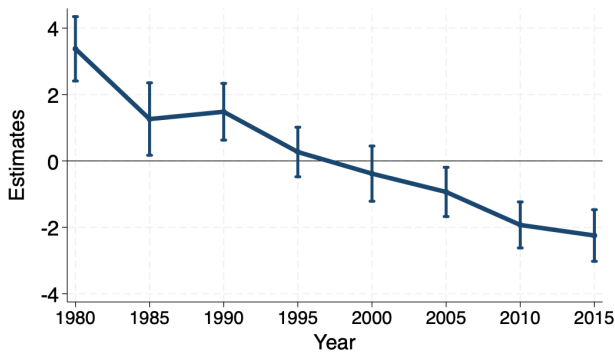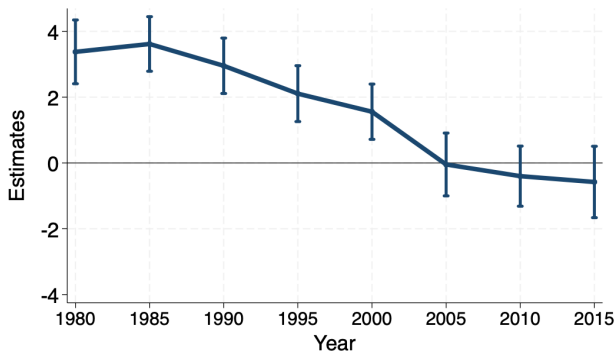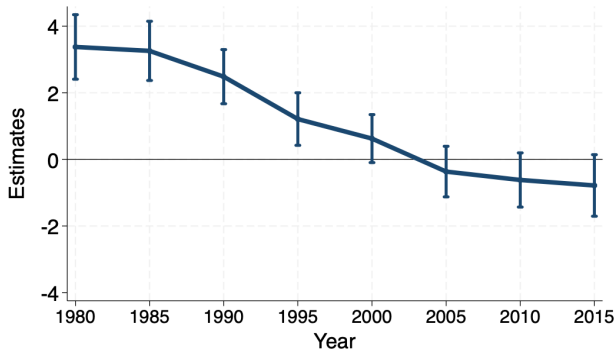
Controlling Capital Intensity and Institutions

$$X_{i,j,s,t} = \exp\left(\beta_t\left[\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \sum_{f\in\{K,l\}}\beta_t^F\left[\alpha_{s,t}^F \times \ln\left(\frac{F_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$
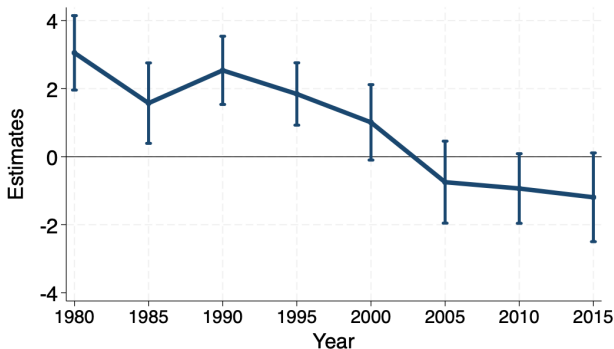
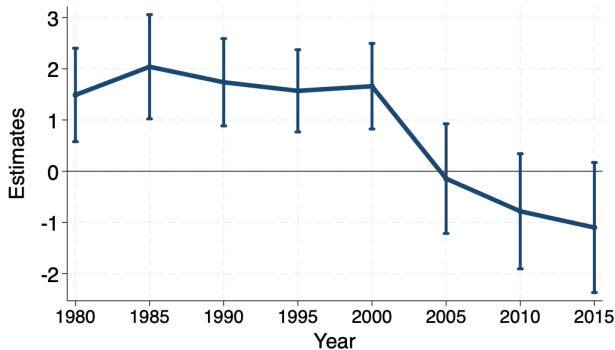# Weighted by Country Export
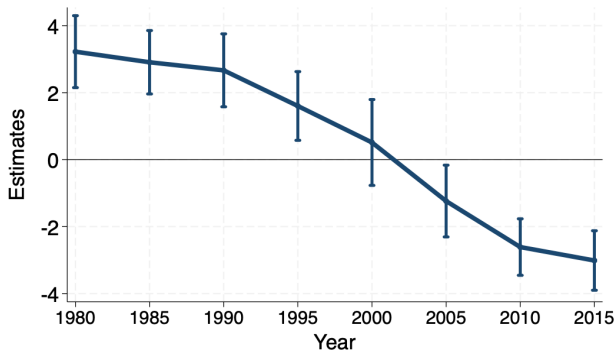
$$X_{i,j,s,t} = \exp\left(\beta_t\left[\alpha^H_{s,t} \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,s} + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$
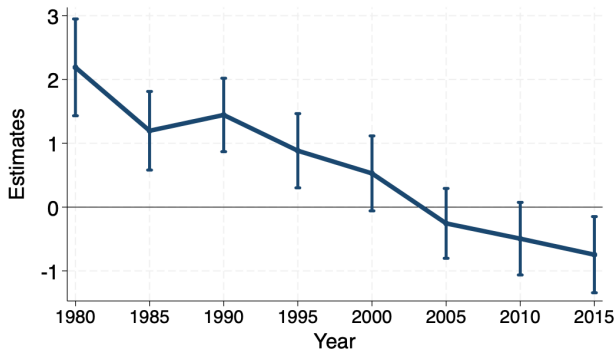
Use 1980's Factor Endowment

$$X_{i,j,s,t} = \exp\left(\beta_t\left[\alpha_{s,t}^H \times \ln\left(\frac{H_{i,1980}}{L_{i,1980}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$

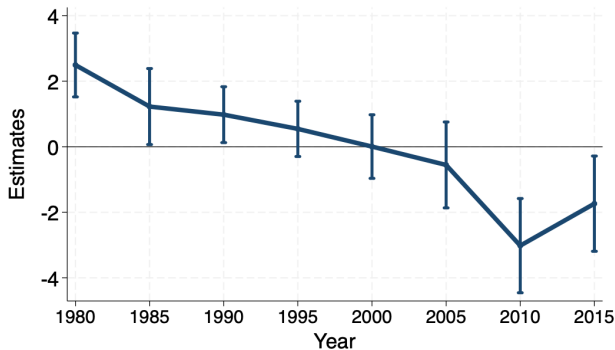$$X_{i,j,s,t} = \exp\left(\beta_t \left[\alpha_{s,1980}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$

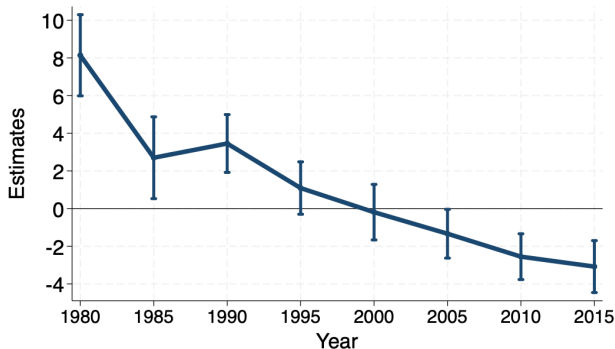# Use 1980's Factor Endowment and Intensity

$$X_{i,j,s,t} = \exp\left(\beta_t \left[\alpha_{s,1980}^H \times \ln\left(\frac{H_{i,1980}}{L_{i,1980}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$

Use 2015's Factor Intensity ‣ back

$$X_{i,j,s,t} = \exp\left(\beta_t\left[\alpha_{s,2015}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$
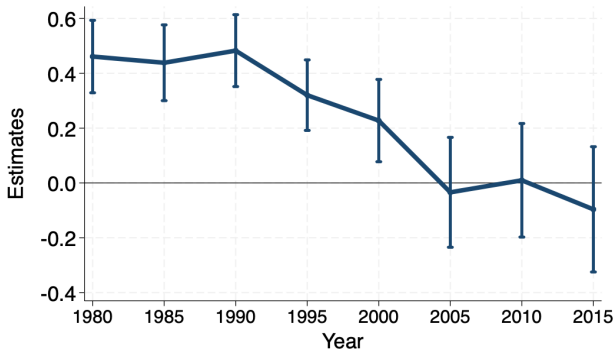
High-school Graduates as Skilled

$$X_{i,j,s,t} = \exp\left(\beta_t\left[\alpha_{s,t}^H \times \ln\left(\frac{HS_{i,t}}{NHS_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$

Instrument Skill Endowment by Cohort IV

$$X_{i,j,s,t} = \exp\left(\beta_t\left[\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$

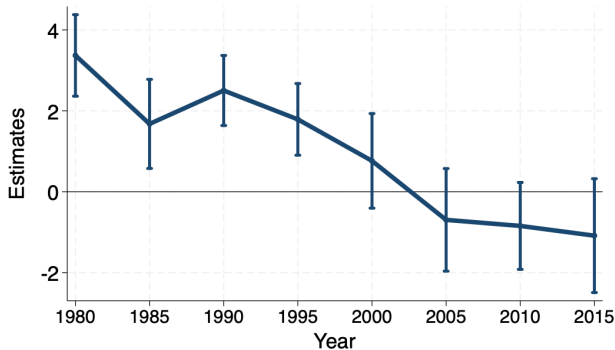$$X_{i,j,s,t} = \exp\left(\beta_t\left[\ln\left(\frac{H_{s,t}}{L_{s,t}}\right) \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$

Romalis (2004): Total Export ‣ back

$$X_{i,s,t} = \exp\left(\beta_t \left[\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,t} + \eta_{s,t}\right) + u_{i,s,t}$$

# TWO COUNTRY ILLUSTRATION: AUTOMATION

Two Country Illustration: Automation

- North (40% are H) and South (25% are H)
- Actual factor intensity across 397 SIC sectors
- Set $\alpha_s^G = \alpha_s^M = 0$ (focus on value-added)
- Exogenous changes in factor intensity common across sectors & countries
    - Automation: Increase $\Gamma_{i,s}^K = 0.1$ to 0.3
- Show export share of each sector in North against α_s^H – Slope is β^H
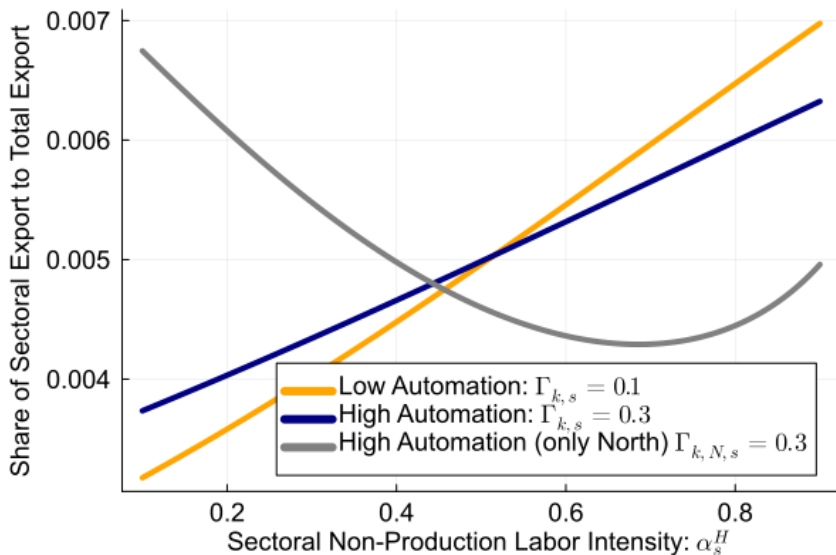
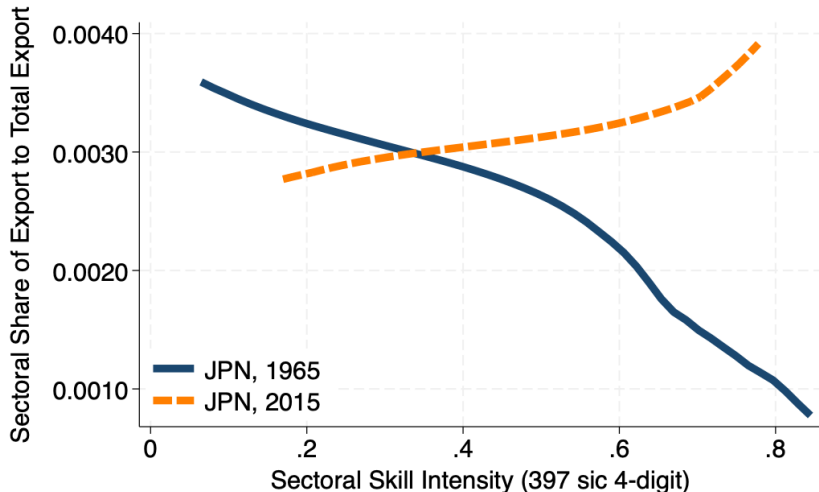# North Specialize in Skill-Intensive Sectors
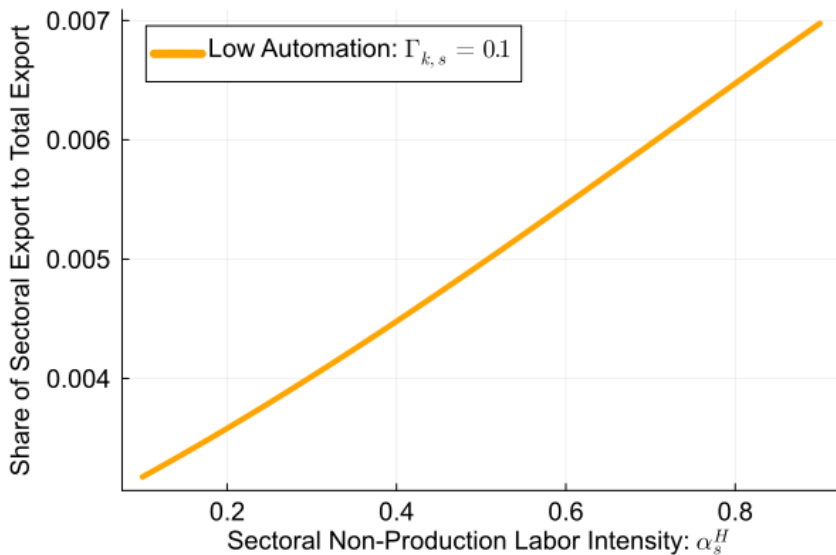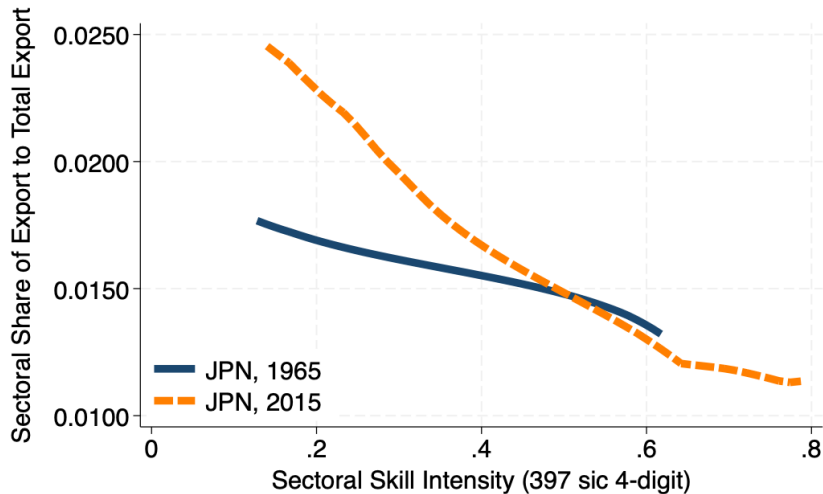
Automation Makes Skills Less Important
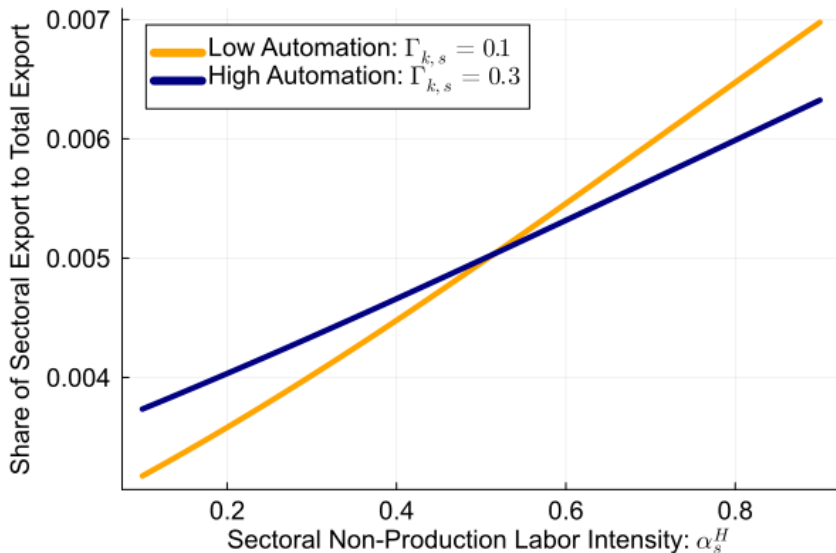
If Only North Automates, Sign Flips

Example: Within Low-Automation Sectors, Japan Specializes in Skill Intensive Industries

Example: Within High-Automation Sectors, Japan Specializes in Low-Skill Intensive Industries

CALIBRATION

Calibration

Description	Parameter	Values	Source
Panel A: Time-Invariant Parameters			
Trade Elas.	θ	4	Standard
Expenditure Share	$\mu_{i,s}$	Data	WIOT
Panel B: Time-Variant Parameters			
Factor Endowment	H_{it}, L_{it}	Data	WIOT
Factor Share	$\alpha_{i,s,t}^{H}, \Gamma_{i,s,t}^{F}$	Data	WIOT

TOY MODEL: TASK AND COMPARATIVE ADVANTAGE

Model

- Small open economy with two sectors ($s = 1, 2$)
- Demand

$$q_s = (c_s)^{1-\sigma} \cdot \overline{Q_s}$$

- Production (micro-foundation = task framework)

$$Y_s = \zeta \cdot (H_s)^{\alpha_s} \left((L_s)^{\Gamma} (M_s)^{1-\Gamma} \right)^{1-\alpha_s}, \quad \alpha_1 = 1 - \alpha_2 = \alpha > 1/2$$

  – M_s: machines or foreign factors supplied at a fixed price r
- Factor market clearing

$$\sum_{s=1,2} H_s = H, \quad \sum_{s=1,2} L_s = L$$

Equilibrium

- Wages $\{w^L, w^H\}$ that satisfy

$$w^L L = \Gamma(1-\alpha)(c_1)^{1-\sigma} + \Gamma\alpha(c_2)^{1-\sigma}, \quad w^H H = \alpha(c_1)^{1-\sigma} + (1-\alpha)(c_2)^{1-\sigma}$$

- Unit cost

$$c_S = \left(w^H\right)^{\alpha_S} \left((w^L)^\Gamma (r)^{1-\Gamma}\right)^{1-\alpha_S}$$

Comparative Advantage

- A change in factor endowment $\widehat{H} = -\widehat{L}$ (=compare two small countries)

- Up to 1st order, CA in H-intensive sector ($s = 1$)

$$\widehat{c_2} - \widehat{c_1} = \underbrace{-(2\alpha - 1)\widehat{\omega}}_{\text{Skill Premium<0}} \underbrace{-(1 - \Gamma)(2\alpha - 1)\widehat{w^L}}_{\text{Task Displacement}}$$

- Skill premium ($\widehat{\omega} \equiv \widehat{w^H} - \widehat{w^L}$) and wages

$$\widehat{\omega} = \underbrace{-2\widehat{H}}_{\text{Labor Supply}} + \underbrace{(2\alpha - 1)(\sigma - 1)\left(\widehat{c_2} - \widehat{c_1}\right)}_{\text{GE Effect}}, \quad \widehat{w^L} = \frac{(\sigma - 1)(2\alpha - 1) - 1}{2 + (1 - \Gamma)(\sigma - 1)(2\alpha - 1)}\widehat{\omega}$$

Comparative Advantage if $\Gamma = 1$

Proposition 1: Rybczynski (1955)

An increase in skilled labor $\widehat{H} > 0$ strengthens comparative advantage in a skill-intensive sector.

$$\widehat{c}_2 - \widehat{c}_1 = \frac{2(2\alpha - 1)}{1 + (2\alpha - 1)^2(\sigma - 1)}\widehat{H}$$

Comparative Advantage if $\Gamma < 1$

Proposition 2: Acemoglu-Restrepo meets Rybczynski

An increase in skilled labor $\widehat{H} > 0$ strengthens comparative advantage in a skill-intensive sector. However, the elasticity is lower when labor share Γ is lower.

$$\widehat{c_2} - \widehat{c_1} = \frac{2(2\alpha - 1)}{\frac{1}{\eta(\Gamma)} + (2\alpha - 1)^2(\sigma - 1)} \widehat{H} \tag{1}$$

where $\eta(\Gamma) = 1 - \frac{1 - (\sigma - 1)(2\alpha - 1)}{\frac{2}{1 - \Gamma} + (\sigma - 1)(2\alpha - 1)} \in (0, 1)$ is increasing in Γ.