Does Skill Abundance Still Matter?

The Evolution of Comparative Advantage in the 21st Century

Shin Kikuchi, MIT

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Skill Abundance and Comparative Advantage

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  - Developed (Skill-Abundant) Countries—Specialize in Skill-Intensive Sectors
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  - Keys for Patterns of Development (Ventura 1997)
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- **This paper:** What about the 21st century?

At a Glance: Skill Abundance and Comparative Advantage

Revealed Comparative Advantage (RCA) in Skill Intensive Sectors:
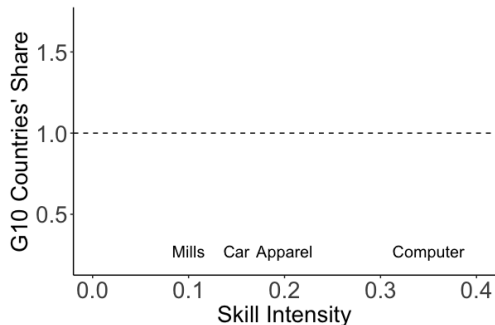
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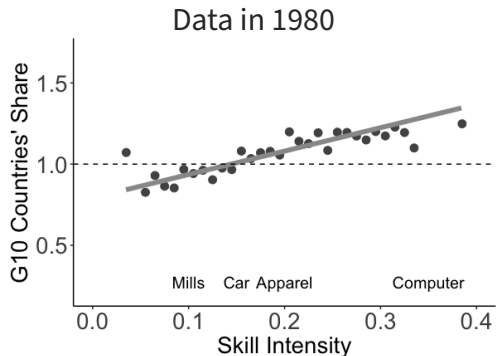G10's share of global exports in a sector divided by G10's share of total global exports

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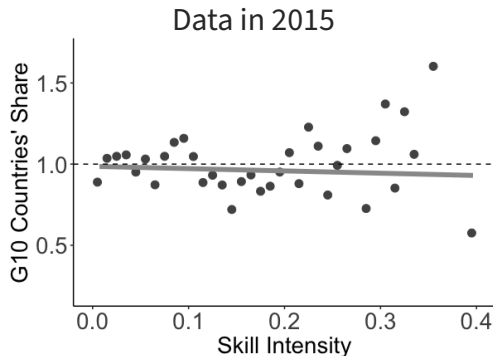G10's share of global exports in a sector divided by G10's share of total global exports

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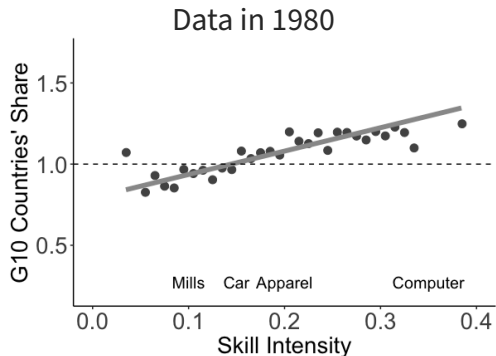G10's share of global exports in a sector divided by G10's share of total global exports

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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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- **Conditional on automation, HO-like predictions still survive**

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  - Shifts of manufacturing from South to North
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  - Shifts of manufacturing from South to North
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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: $\ln \text{Export}_{i,j,s} = - \underbrace{\theta}_{\text{Trade Elas.}} \underbrace{\ln c_{i,s}}_{\text{Unit Cost}} + \underbrace{\eta_{i,j} + \eta_{j,s}}_{\text{FEs}}$

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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

Do Skill-Abundant Countries Export More Skill-Intensive Goods?

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

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- $\text{Exports}_{i,j,s,t}$: Bilateral trade flow i to j in s, from UN Comtrade
- $\text{Skill Intensity}_{s,t}$: $\alpha^H_{s,t}$ Share of skilled labor pay. in value-added, from NBER-CES
- $\text{Skill Abundance}_{i,t}$: $\ln(H_{i,t}/L_{i,t})$ College to Non-College ratio in i, from Barro-Lee

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- $\eta_{i,j,t}$: Exporter-Importer FEs: control distances, productivity level diffs,...
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Expect $\beta_t > 0$: Skill-abundant countries export skill-intensive goods more

Skill Abundance Used to be Important before 2000

$$X_{i,j,s,t} = \exp\left(\beta_t \left[\alpha_{s,t}^H \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$
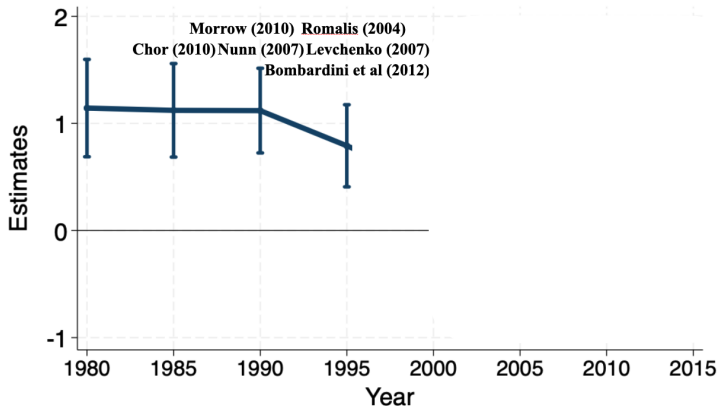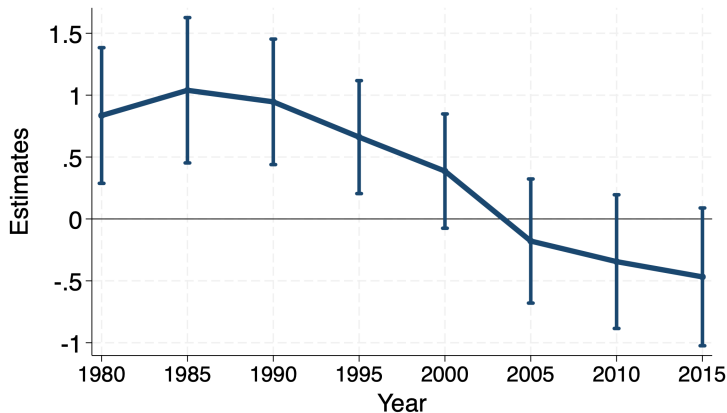
Skill Abundance ≠ CA in Skill-Intensive Sectors after 2000

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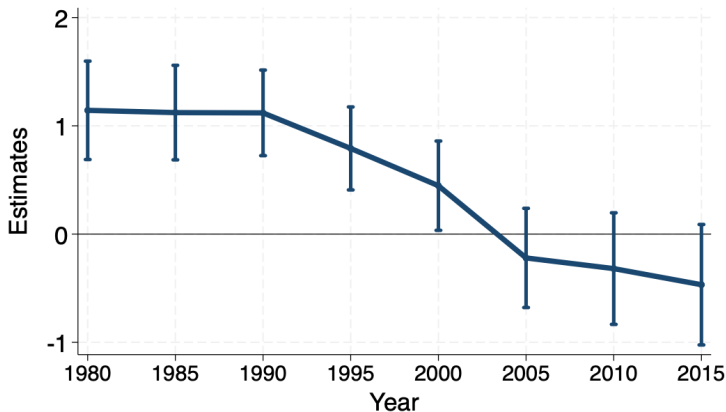
The Change Comes from Export Patterns

$$X_{i,j,s,t} = \exp\left(\beta_t \left[\alpha_{s,1980}^{H} \times \ln\left(\frac{H_{i,1980}}{L_{i,1980}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t}\right) + u_{i,j,s,t}$$
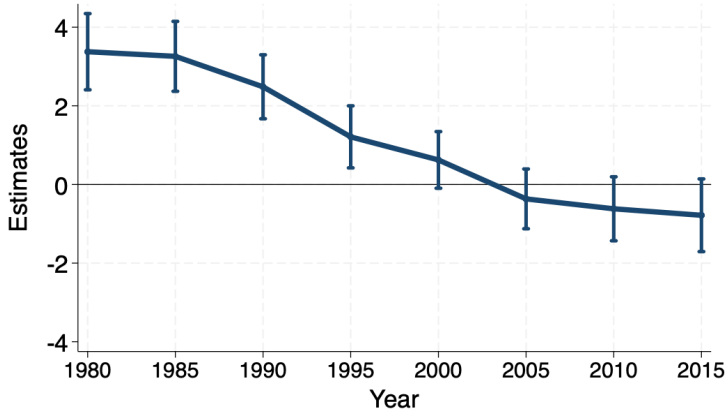
NOT Driven by Attenuating Skill Measurement

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

Robustness Checks

- Other sources of comparative advantage? ▸ Capital ▸ Institution
- Driven by small countries? ▸ Weighted
- Some exporter-sector unobserved het., or IRS? ▸ Pool years and FEs
- Different skill measures? ▸ High School ▸ Predicted by Demographics
- Total exports, instead of bilateral exports (Romalis 2004, Nunn 2007,...) ▸ go
- Different measures of sectoral factor intensity (Chor 2010)
    - $\ln(H_s/L_s)$, instead of $\alpha_s^H (\equiv$ Skilled Payroll Share to Value-Added) ▸ go
- Country-level changes in RCA ▸ Germany ▸ India

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

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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

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
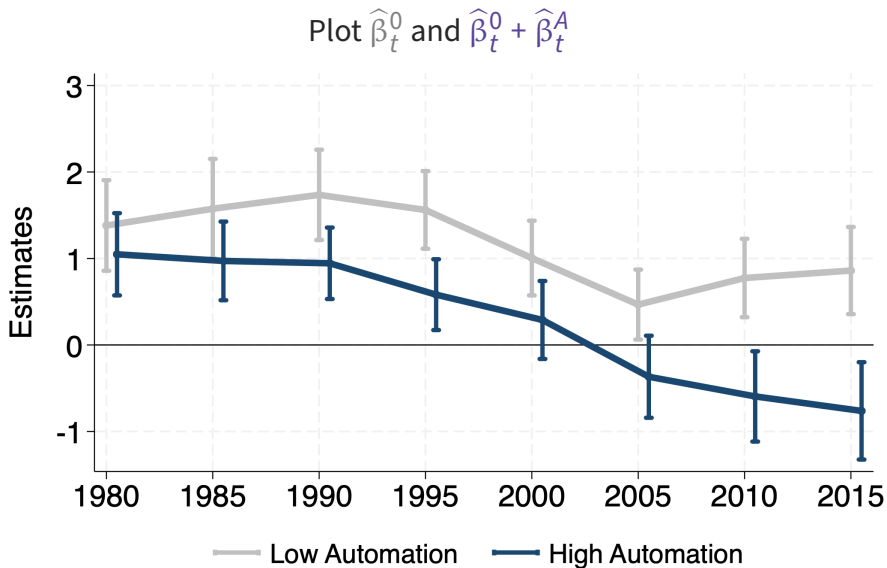
No Heterogeneous Effects from Offshoring

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

Legend: Low Offshoring — High Offshoring

Same Results from Continuous Measures

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

	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

Decreases among High Automation Groups

Fitted values for groups with automation of 10th, 50th, and 90th percentiles
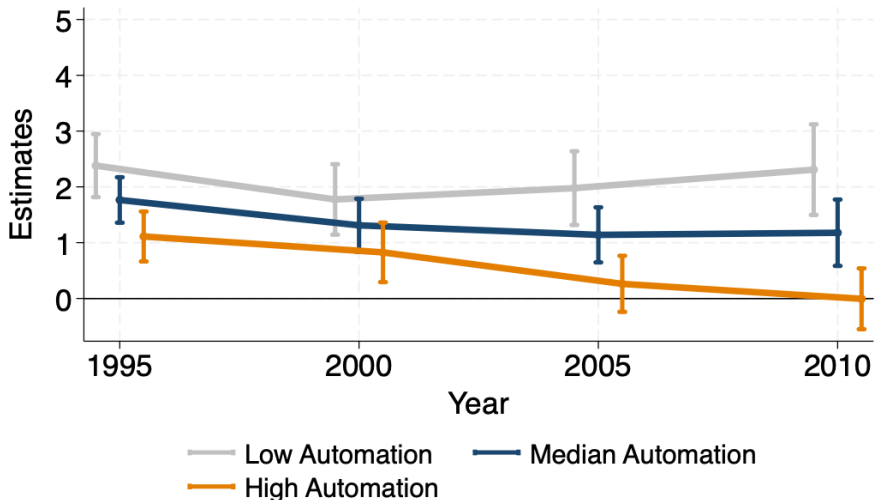
No Clear Heterogeneity by Offshoring

Fitted values for groups with offshoring of 10th, 50th, and 90th percentiles
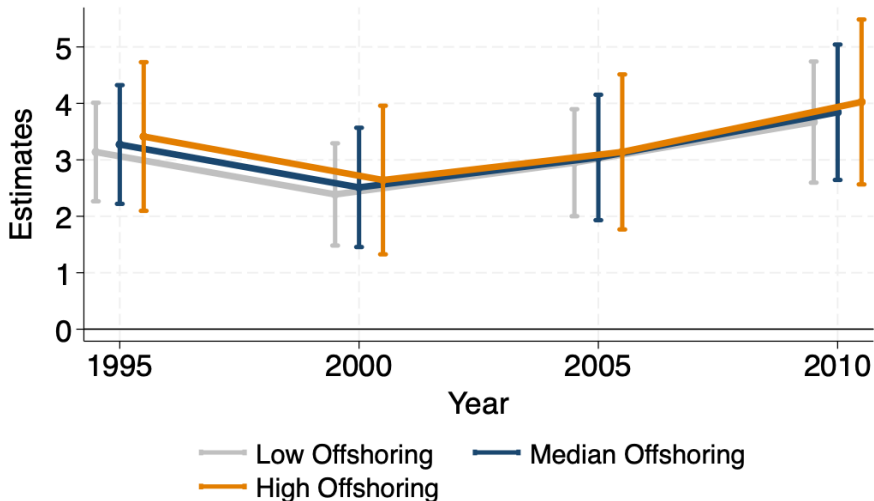
Controlling China Shock does not Change Results

Add China's RCA (revealed comparative advantage) as a control

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x China's RCA				

Takeaway: **China shocks strengthen Heckscher-Ohlin**

Controlling China Shock does not Change Results

Add China's RCA (revealed comparative advantage) as a control

	1995	2010	1995	2010
Skill Intensity x Abundance	1.26	-0.33	2.43	3.51
	(0.23)	(0.28)	(0.45)	(0.46)
x Automation (log robot stock)			-0.15	-0.31
			(0.05)	(0.05)
x Offshoring Share (×100)			0.03	0.11
			(0.05)	(0.06)
x China's RCA			0.20	0.34
			(0.12)	(0.13)

Takeaway: **China shocks strengthen Heckscher-Ohlin**

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 in the paper based on the task model
    - ⋆ *Endogenous* adoption of automation/offshoring in Appendix
- 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 $\{H_i, L_i\}_{i \in \mathcal{I}}$, an equilibrium is a set of wages $\{w_i^H, w_i^L\}_{i \in \mathcal{I}}$

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

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

- Goods and Labor Markets Clear

- Trade is balanced

QUANTIFICATION

Quantitative Analysis: Hat Algebra

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

Quantitative Analysis: Hat Algebra

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- Calibration: 40 countries, 18 sectors (WIOD, 1995-2008)

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  - $\Gamma^M_{i,s,t}$ (automation, constructed)

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

Quantitative Analysis: Hat Algebra

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

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

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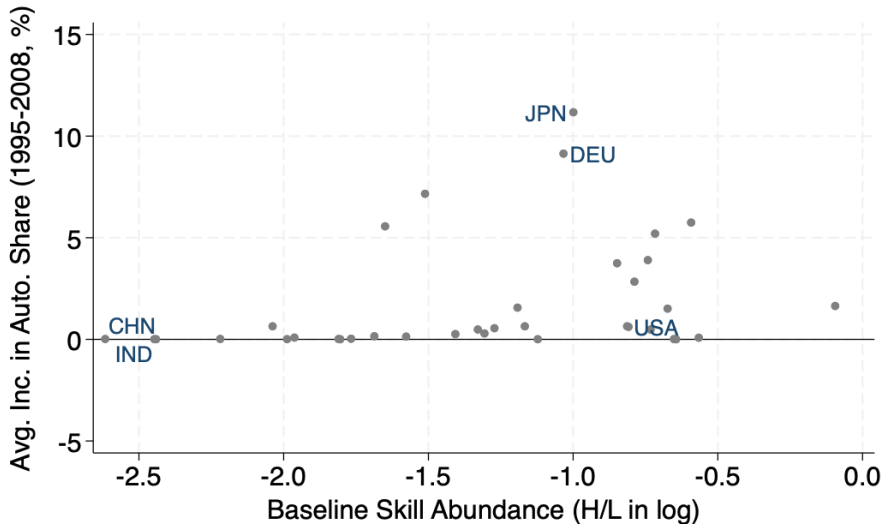
Shock: Offshoring is More Equally Distributed
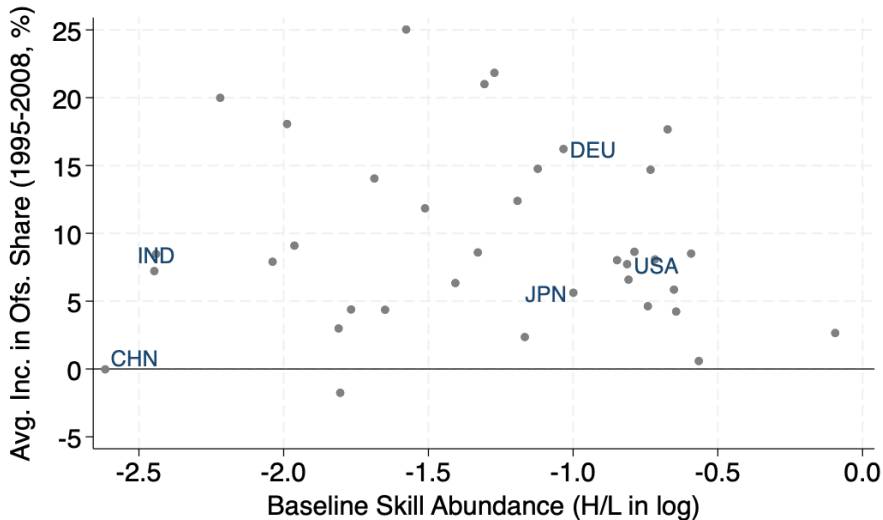
RESULTS: CHANGES IN COMPARATIVE ADVANTAGE

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

- Question: How much can $\Gamma^M_{i,s,t}$ and $\Gamma^{XF}_{i,s,t}$ 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

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

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

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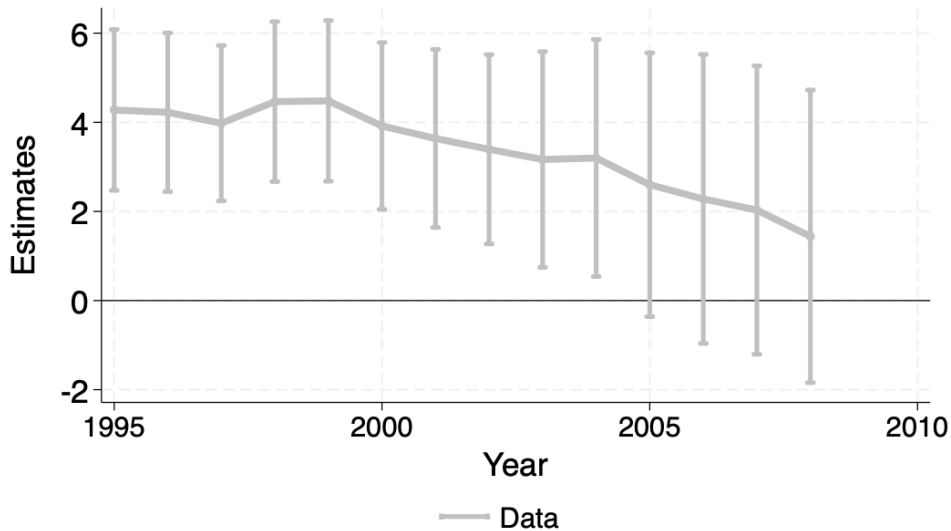
Automation, Not Offshoring, Causes the Decline
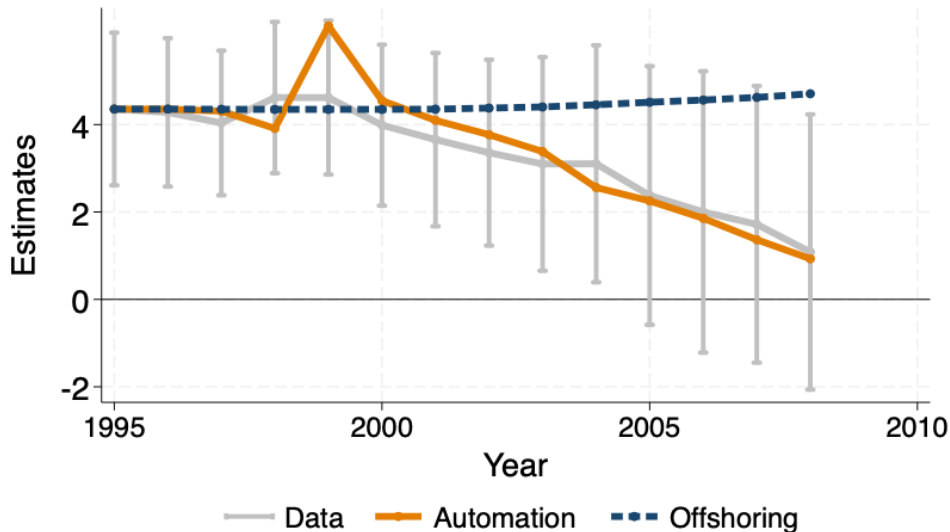
Why Automation?

- Sizes of automation & offshoring similar

- Why automation, not offshoring, matter?

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- One observation: Automation happens disproportionately in $L-$ scarce countries

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- Why automation, not offshoring, matter?

- One observation: Automation happens disproportionately in $L-$ scarce countries

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

Equal Automation Cannot Explain the Decline
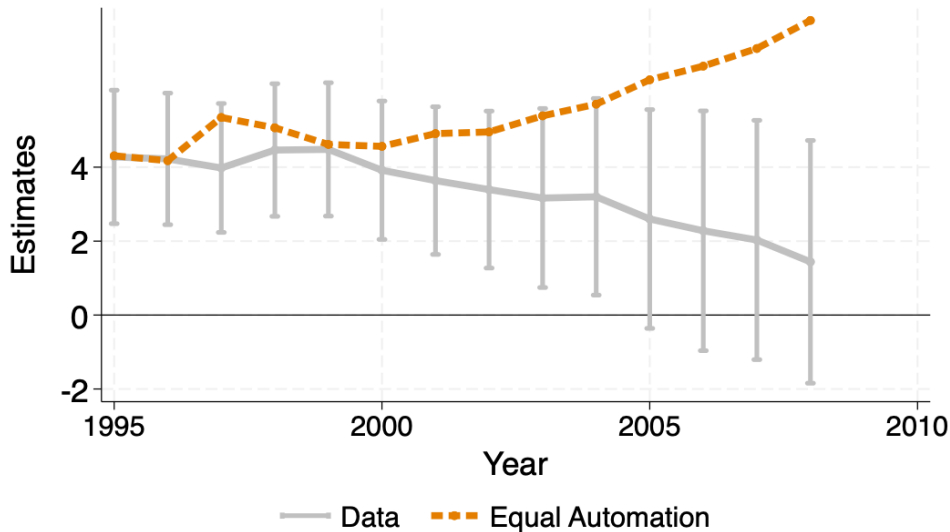
RESULTS: MACRO IMPLICATIONS OF AUTOMATION

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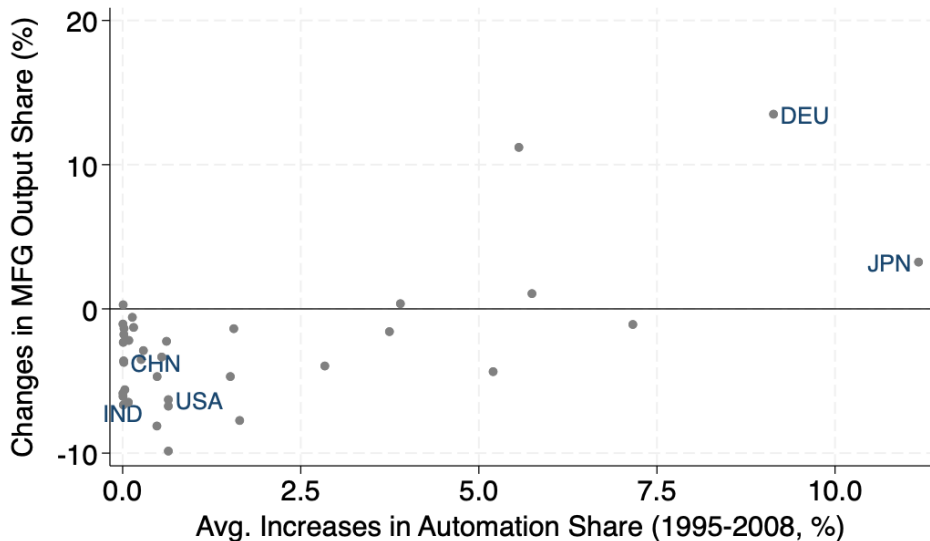
Skill Premia Increases Only in High-Automation Countries
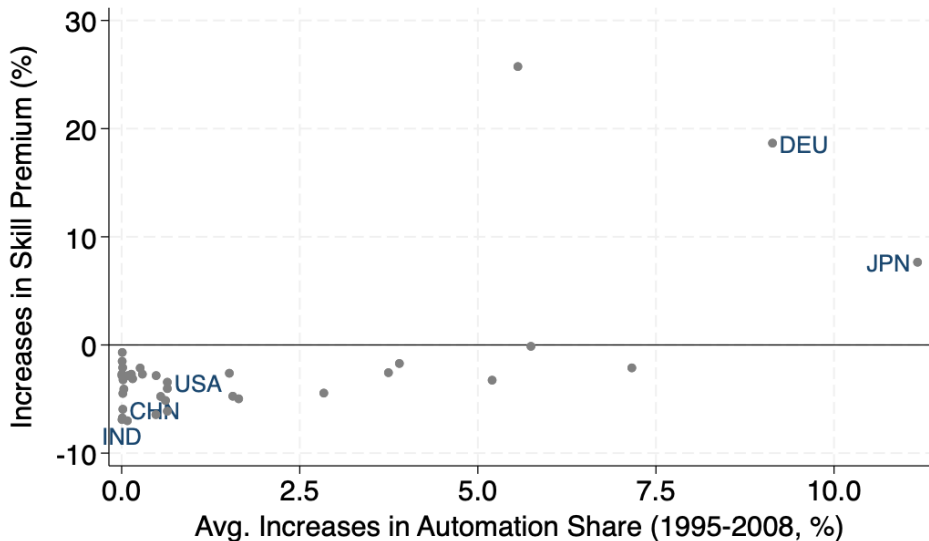
Welfare Increases Everywhere
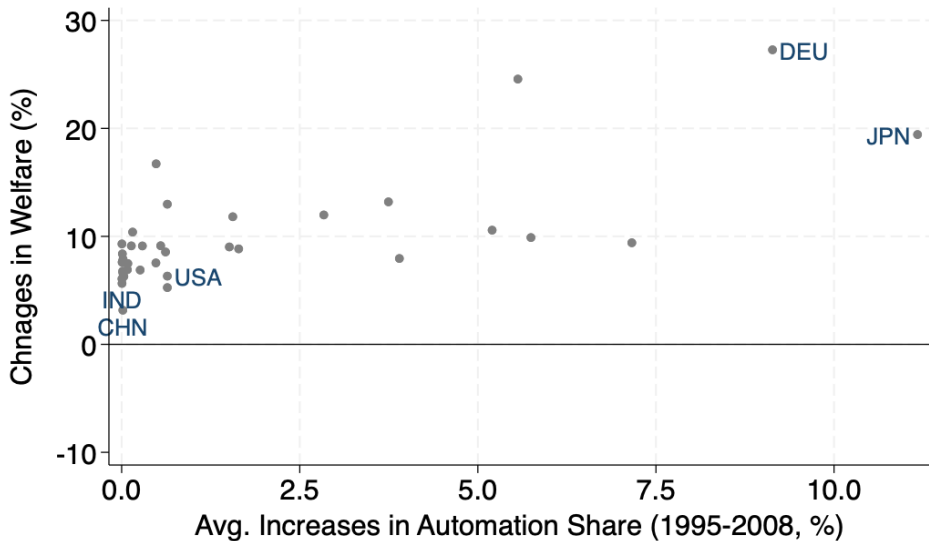
RESULTS: MACRO IMPLICATIONS OF OFFSHORING

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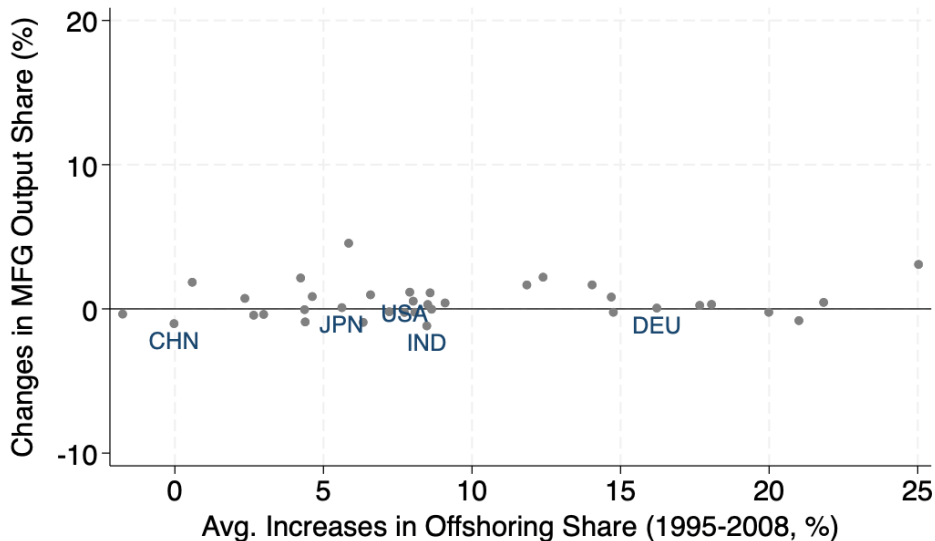
Skill Premia Increases Everywhere, but Less
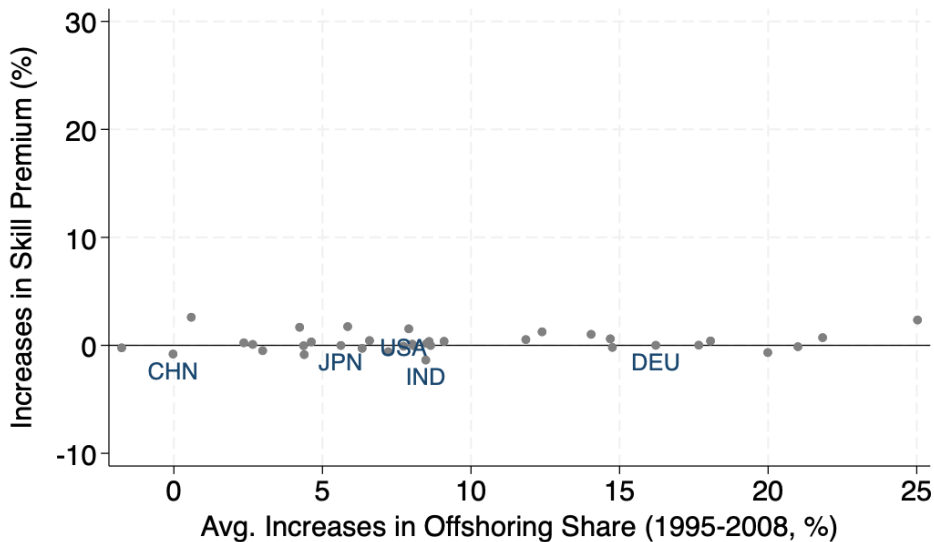
Welfare Increases Everywhere, but Less
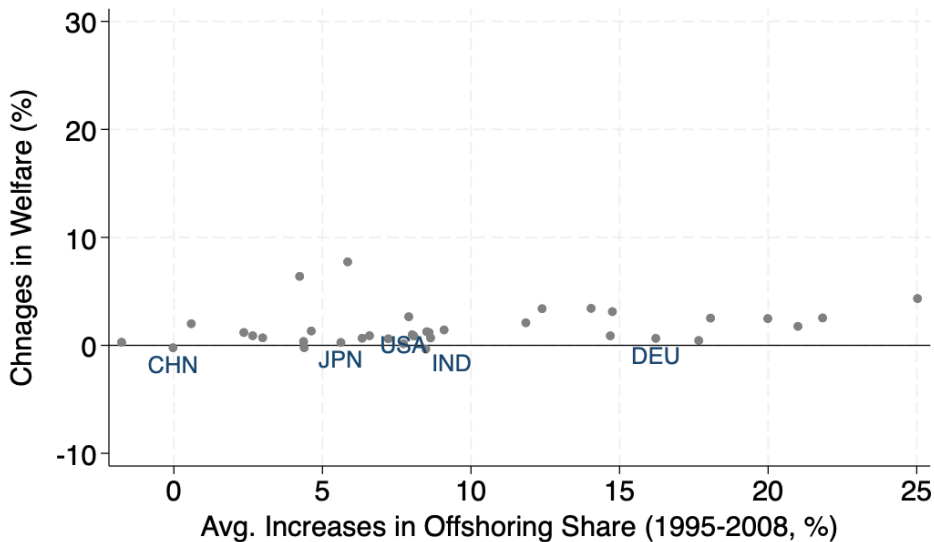
Automation, Globalization, and Inequality

- 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

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- Roles of Trade?
  - Now, set the trade elasticity $\theta = 1$, instead of $\theta = 4$
  - This kills sectoral reallocation via expenditure switch across countries

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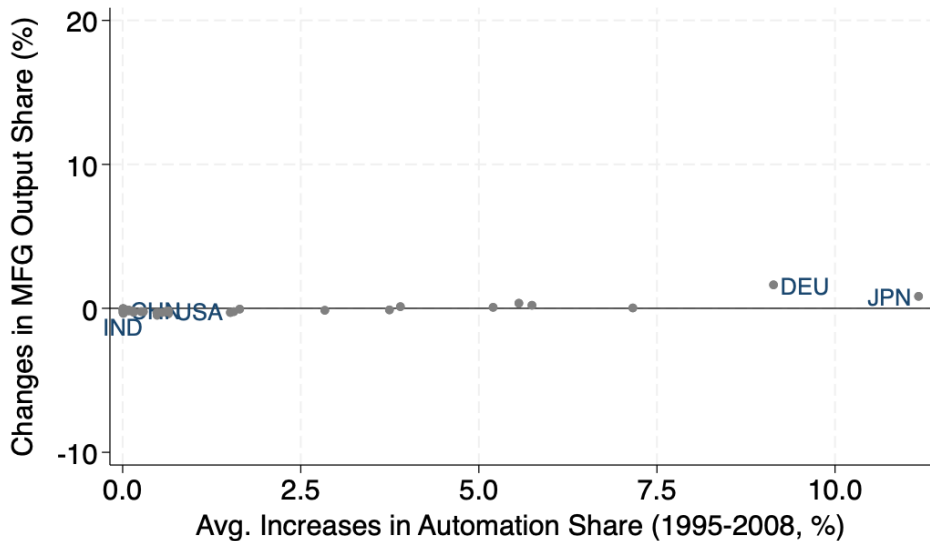
θ = 1: Skill Premia Increases Everywhere
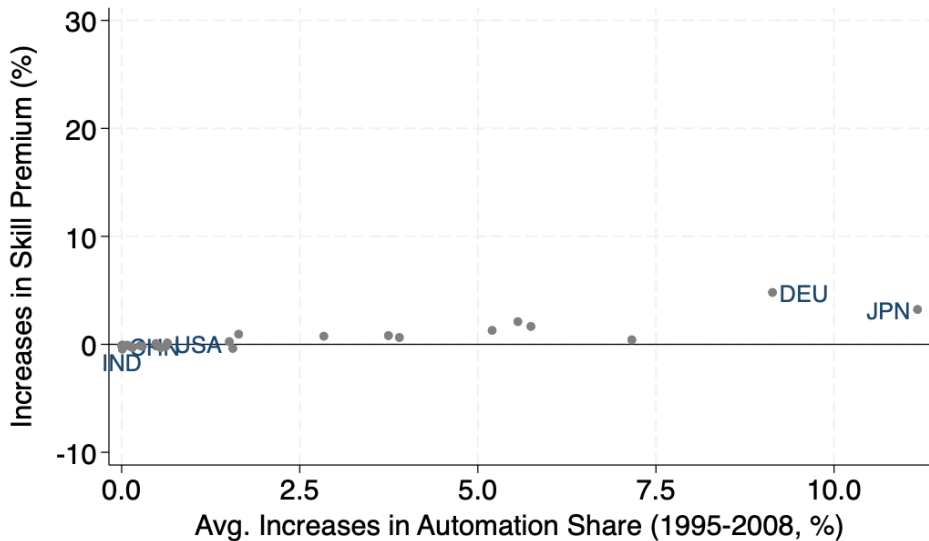
θ = 1: Welfare Increases Everywhere, but Less
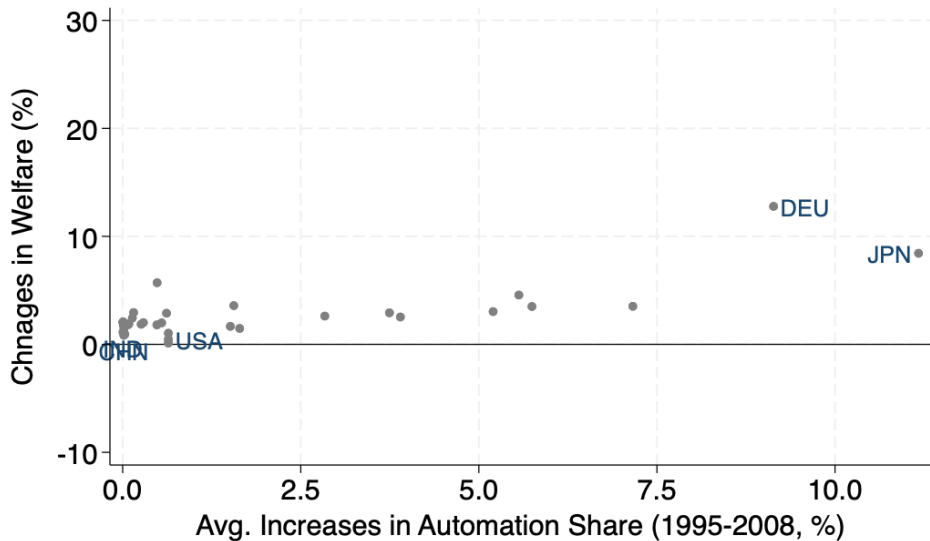
CONCLUSION

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- Automation relocates Global MFG from South to North

  - Inequality within/across countries increases

Conclusion

- Have patterns of comparative advantage changed in the 21st Century?

  - **It did.** Skill abundance no longer matters for comparative advantage

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- **Next (with some work-in-progress):**

  - Policy? e.g.) Robot Tax in an Open Economy *imports* China Shocks

  - Other Applications? e.g.) Clean-dirty Tech v.s. Oil-Rich countries

  - Political Economy? e.g.) Automation helps Decoupling?

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
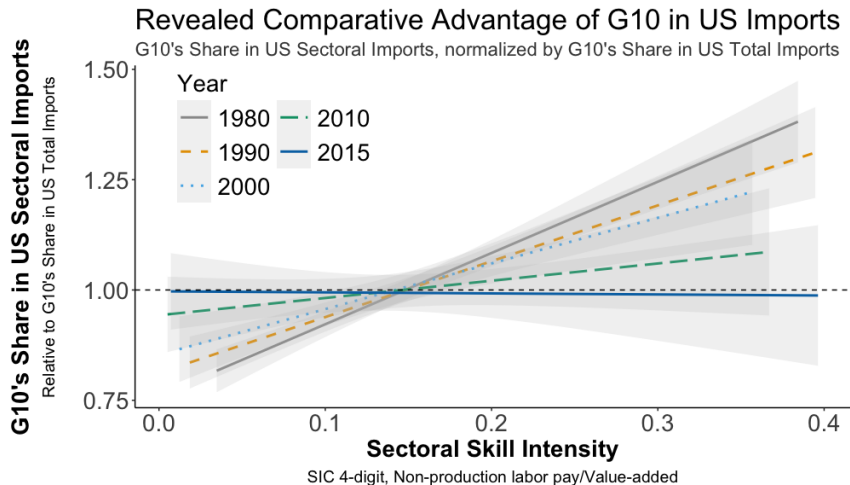
Dropping China Does Not Change the Result

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
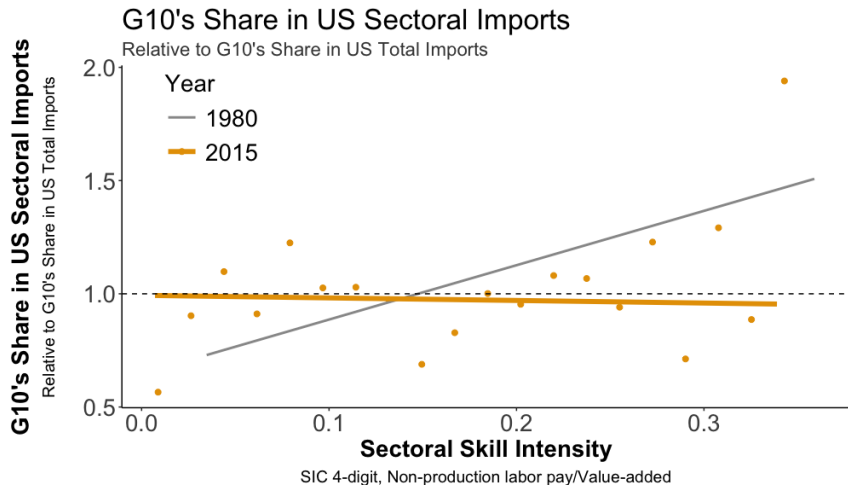
Dropping Japan Does Not Change the Result (if any, cleaner)

G10's Share in US Sectoral Imports

Relative to G10's Share in US Total Imports

Sectoral Skill Intensity

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

Year — 1980 — 2015

Germany

Changes in German Revealed Comparative Advantage: 1980-2015
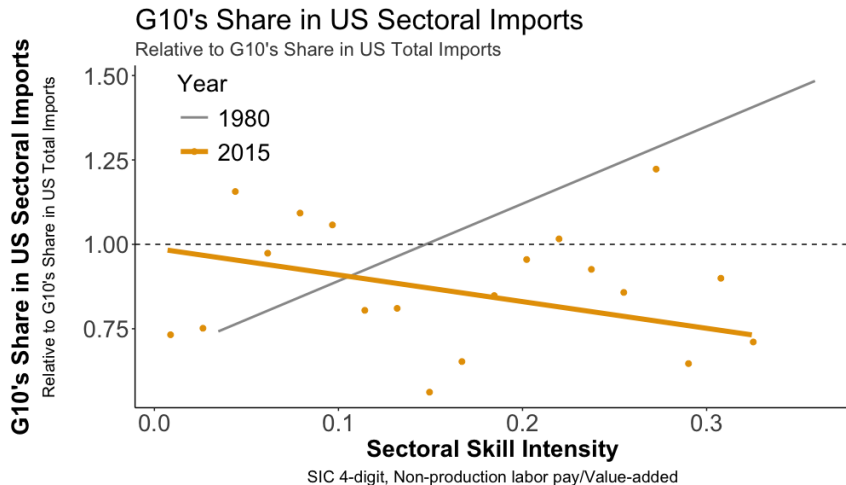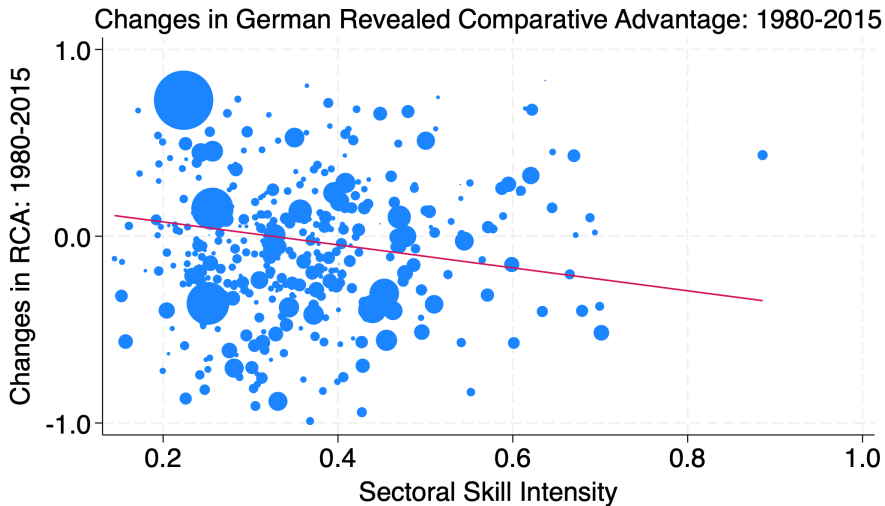
Germany (Low-Automation) › back

Changes in German Revealed Comparative Advantage: 1980-2015

Changes in India's Revealed Comparative Advantage: 1980-2015
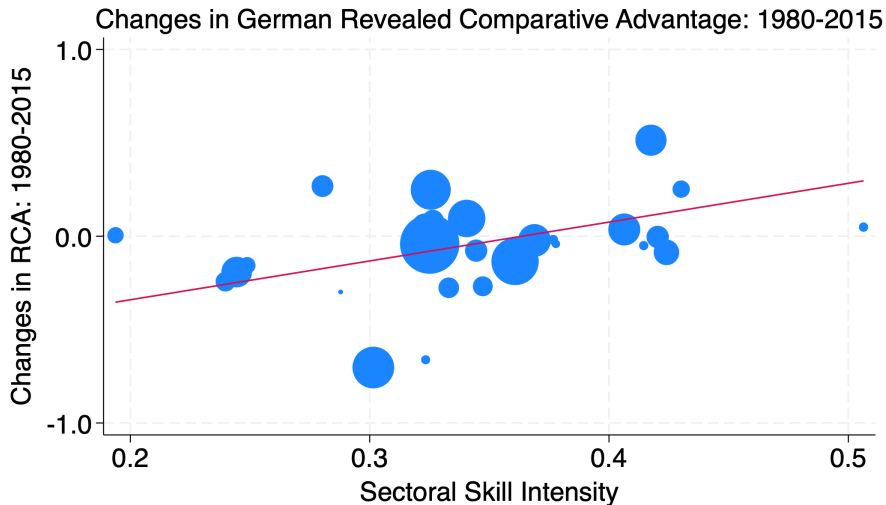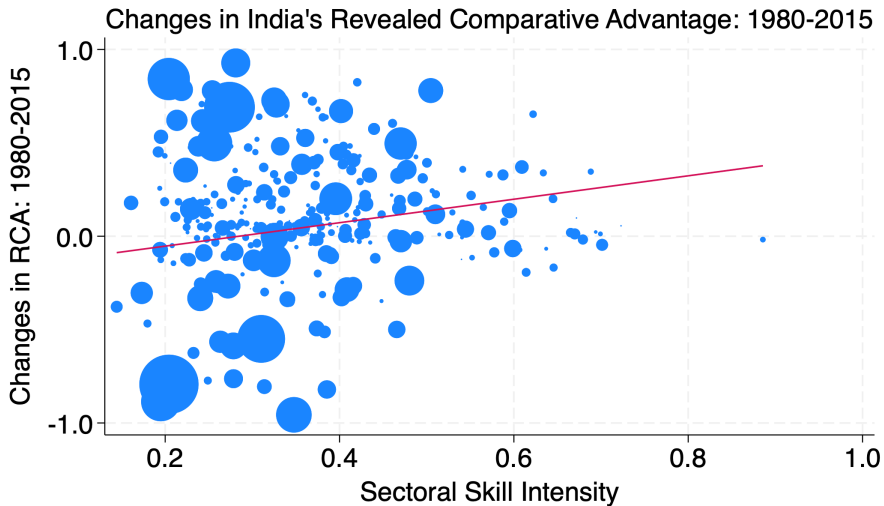
Relative Skilled Wages Decreasing in Skill Endowment
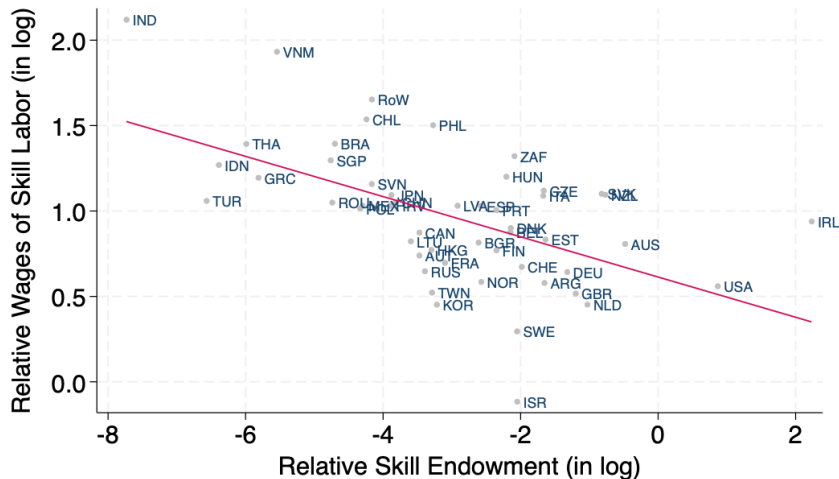
Note: Data from GTAP, 2004

Unskilled Wages Increasing in Skill Endowment
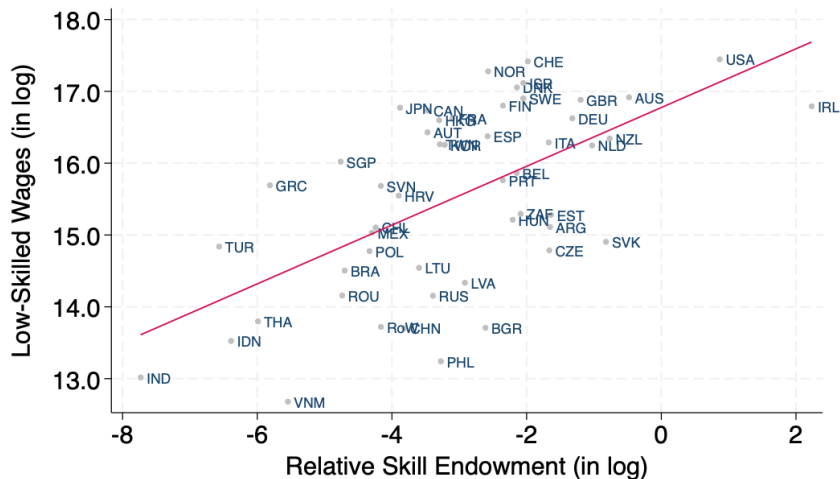
Note: Data from GTAP, 2004

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

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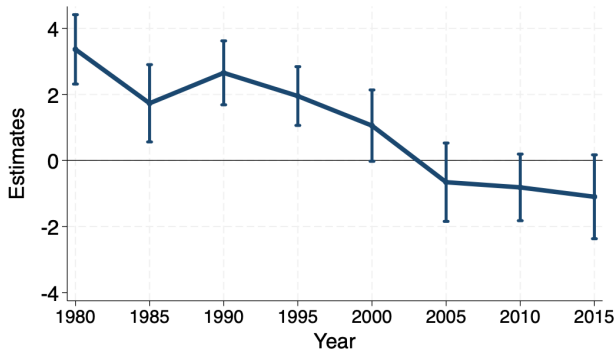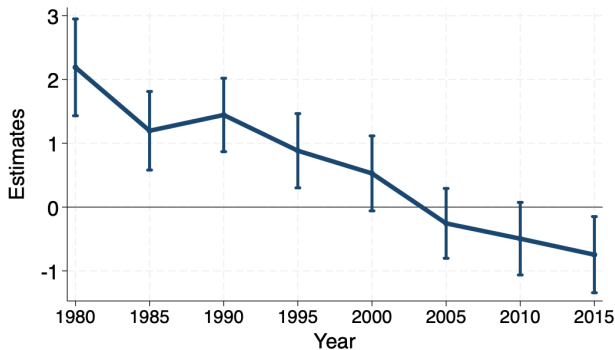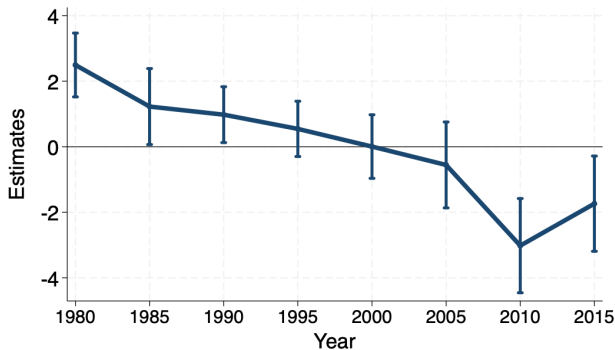
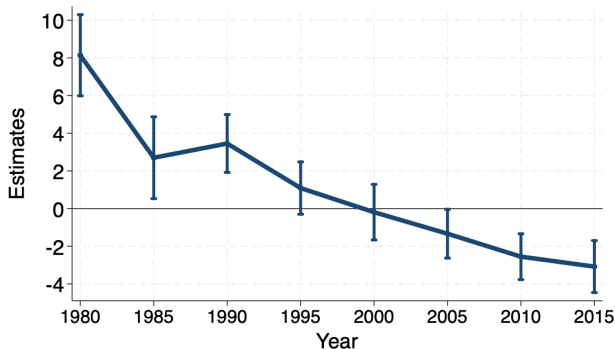# Controlling Capital Intensity and Institutions

$$X_{i,j,s,t} = \exp\left(\beta_t \left[\alpha^H_{s,t} \times \ln\left(\frac{H_{i,t}}{L_{i,t}}\right)\right] + \sum_{f\in\{K,l\}} \beta^F_t \left[\alpha^F_{s,t} \times \ln\left(\frac{F_{i,t}}{L_{i,t}}\right)\right] + \eta_{i,j,t} + \eta_{j,s,t} + u_{i,j,s,t}\right)$$
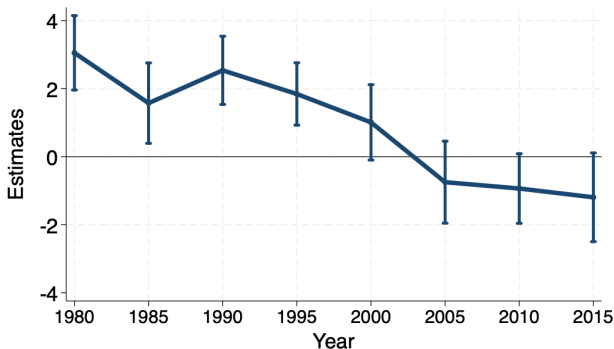
Weighted by Country Export
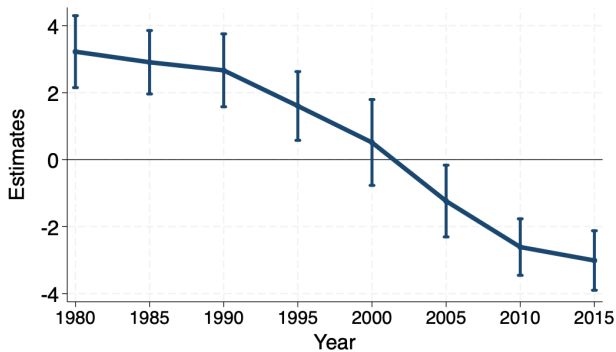
Pool and control Origin-Sector FEs

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

High-school Graduates as Skilled

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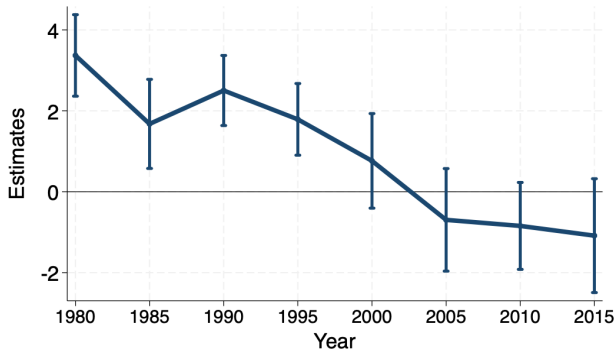
Instrument Skill Endowment by Cohort IV

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

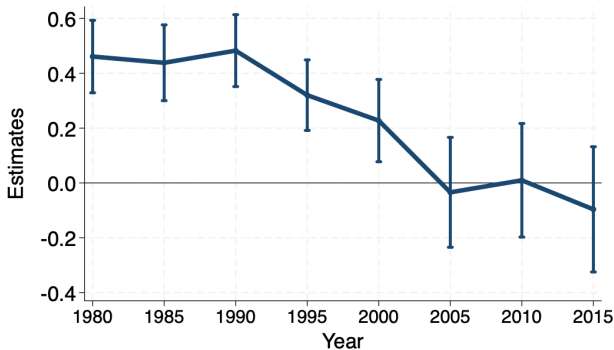# Romalis (2004): Total Export ▸ back

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

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

# 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
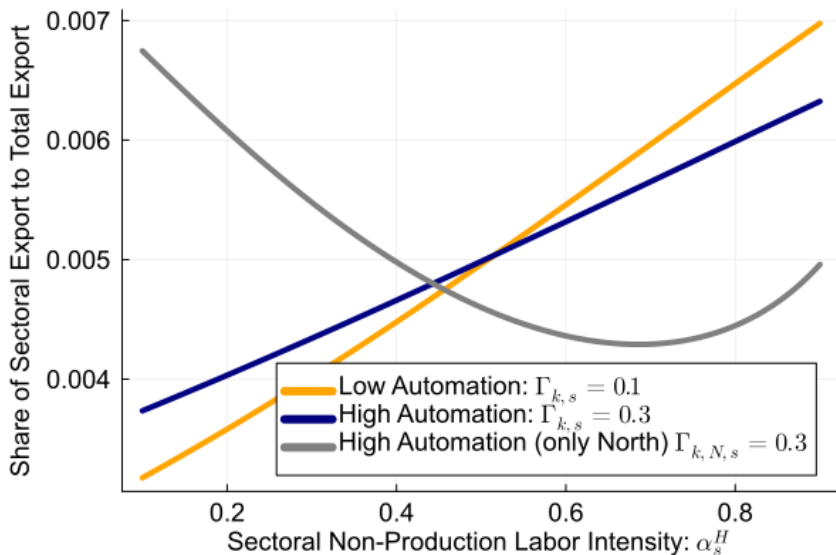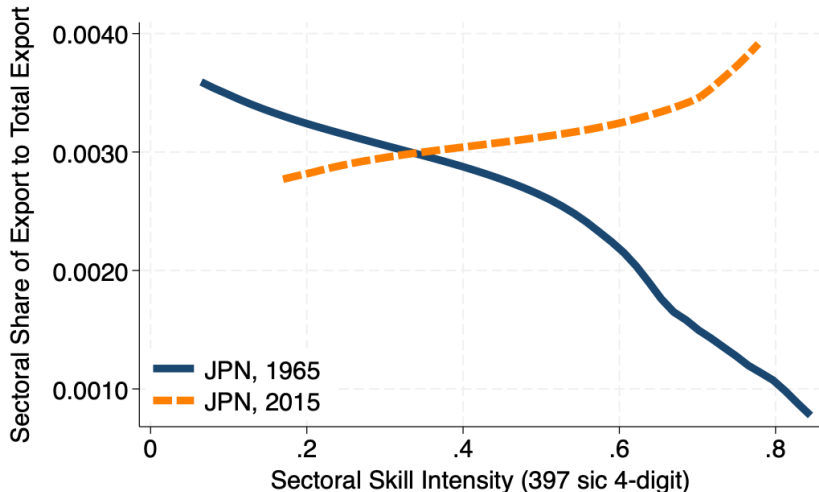
North Specialize in Skill-Intensive Sectors
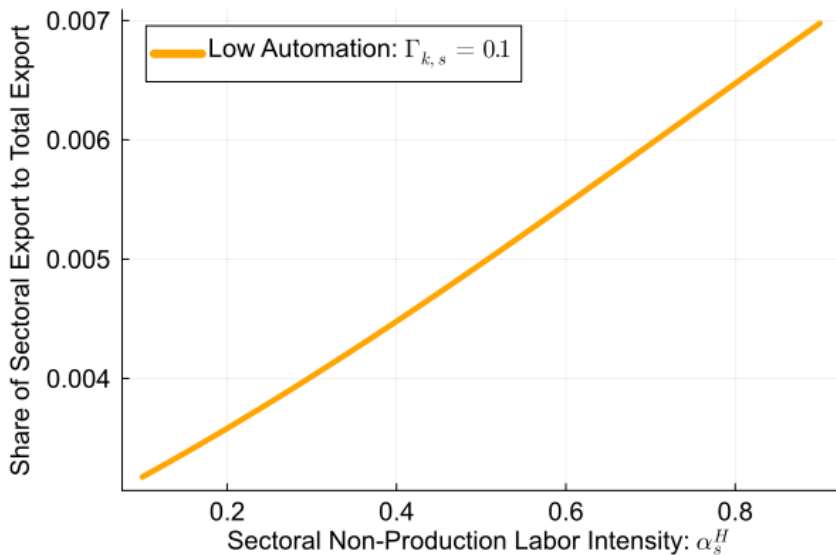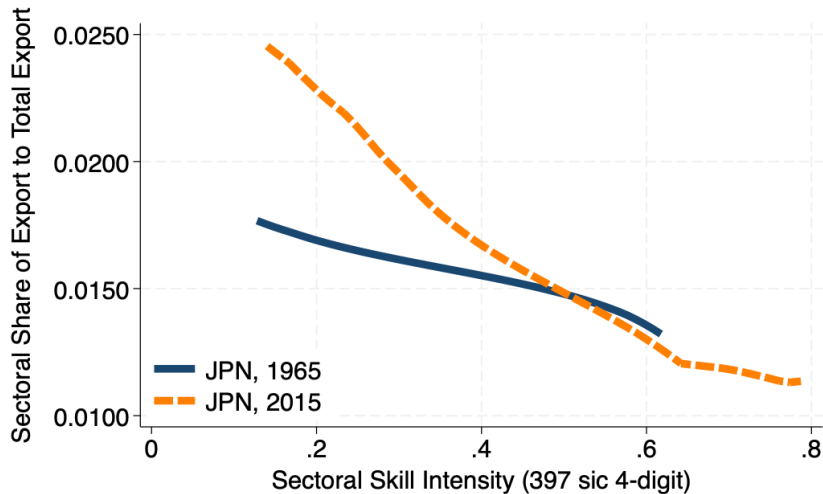
Automation Makes Skills Less Important
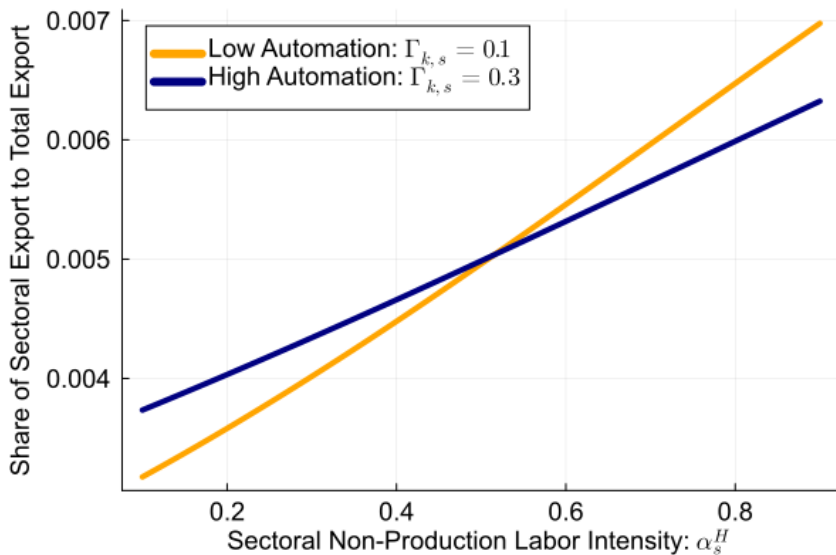
If Only North Automates, Sign Flips

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.

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

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.