Trade-induced structural change and the skill premium

Javier Cravino and Sebastian Sotelo
University of Michigan

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How does trade affect structural change and the skill premium?

- Policy concerns in developed countries:
  - Manufacturing jobs moving overseas
  - Competition from developing countries lowering unskilled wages
- Predictions of standard trade theory (Heckscher–Ohlin):
  - Exporting sectors grow
  - Skill premium increases in skill-abundant countries, decreases elsewhere
- This paper: Propose and quantify an alternative mechanism
  - Manufacturing trade reduces relative price of manufactures *in all countries*
  - Share of manufacturing in value added declines *in all countries*
  - Rewards to factors used intensively in manufacturing decline

What we do: Data

Document 3 differences across broad sectors:

1. Trade integration between 1995-2007
   - Share of expenditures in domestic goods declined in agriculture, mining, manufacturing
   - Share of expenditures in domestic services constant in service sectors

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   - Agriculture, mining and manufacturing are unskilled labor intensive
   - Some services (construction, retail) are unskilled labor intensive
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   - Some services (construction, retail) are unskilled labor intensive
   - Other services (FIRE, health) are skilled labor intensive
3. Use of capital and intermediate inputs
   - Low-skilled intensive sectors (highly traded and not) use more inputs from good producing sectors

What we do: Model

- Multi-country, multi-sector Ricardian model of trade
  - Heterogeneous workers
  - 3 sectors differ in factor and inputs intensities and tradability
  - Allow for trade imbalances across sectors
  - Low substitutability across sectors

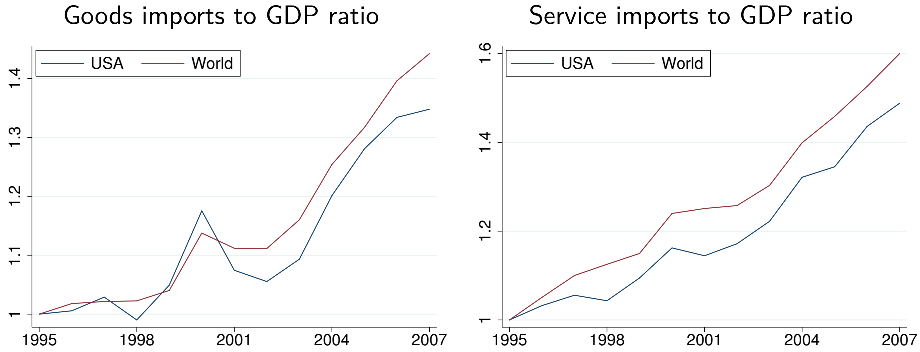
- 2 counterfactual exercises
  1. Changes in trade costs between 1995-2007
  2. Sufficient statistics approach: changes in trade patterns

- Results (C1)
  - Manufacturing share decline in average country 8% model vs 21% data
  - S-P increases in most countries (2.1% on average, up to 10% for some developing countries)

Literature

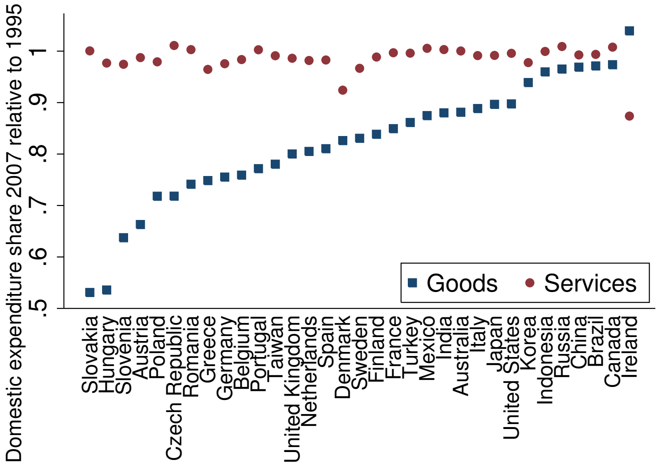
- Trade and skill premium:
  - Theory and empirics on H-O: Summary in Goldberg and Pavcnik [2007]
  - Quantitative models other mechanisms: Burstein, Cravino and Vogel [2013]; Parro [2013]; Burstein and Vogel [2015]; Lee [2016]
- Trade and structural change: Matsuyama [2009]; Uy, Yi and Zhang [2013]; ; Fajgelbaum and Redding [2014]; Kehoe, Ruhl and Steinberg [forthcoming]
- Skill-biased structural change: Buera, Kaboski and Rogerson [2015]

Observation 1: Fast growth in goods and services trade...



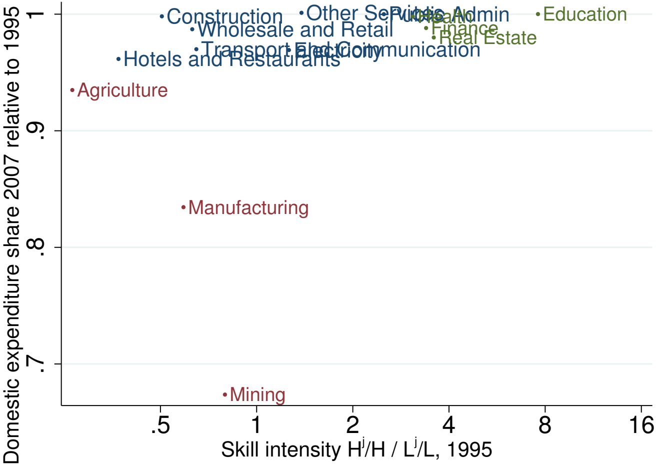
- Goods: Agriculture + Manufacturing + Mining. Source: WIOD.

Observation 1: ...but share of expenditures on domestic services roughly constant



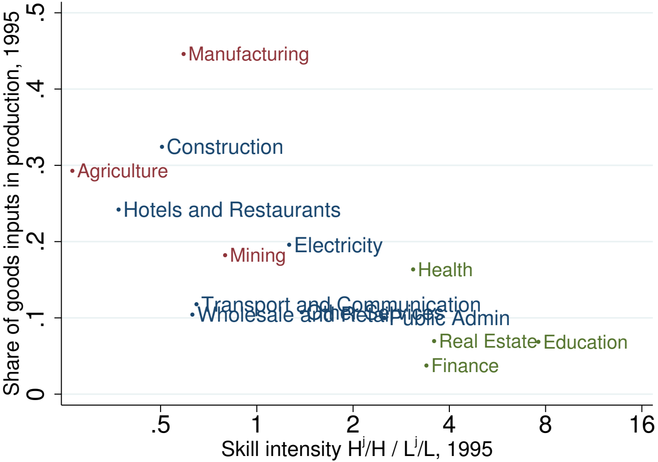
- Domestic expenditure share: $\pi_t^j \equiv 1 - Imports_t^j / \left(Output_t^j + Imports_t^j - Exports_t^j \right)$
- Y-axis: $\pi_{2007}^j / \pi_{1995}^j$;

Observation 2: Decline in domestic expenditure shares in unskilled-labor intensive sectors



- World average. *H*: college graduates. Source: WIOD SEA

Observation 3: Unskilled-labor intensive sectors use more inputs from manufacturing, agriculture and mining



- World average. Input shares from WIOD.

Model

- $i = 1, ..., I$ countries, $j = 1, ..., 3$ sectors
- Production uses
  - skilled labor H_i, unskilled labor, L_i
  - intermediate inputs from each sector X_i^j
- Labor endowments are fixed
- Factors and goods markets perfectly competitive
- Iceberg trade costs

Preferences

- Utility of the representative household in country i

$$C_i = \left[\sum_j \bar{\phi}_i^{j\,\frac{1}{\rho}} \left[C_i^j \right]^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

- Budget constraint

$$s_i H_i + w_i L_i = \sum_j P_i^j C_i^j + NX_i$$

- $NX_i < 0$ country is running a deficit

Technologies: Sectorial output

- Sector j combines tradeable intermediate goods

$$Y_i^j = \left[\int_0^1 q_i^j(\omega)^{\frac{\eta_i - 1}{\eta_i}} \, d\omega \right]^{\frac{\eta_i}{\eta_i - 1}}$$

- Final goods are non-tradeable

$$Y_i^j = C_i^j + X_i^j$$

Technologies: Intermediate goods

- Technology for intermediate goods

$$q_i^j(\omega) \;\; = \;\; A_i^j z_i^j(\omega)\, m_i^j(\omega)^{1-\beta_i^j}\, e_i^j(\omega)^{\beta_i^j}$$

- Sectoral productivity A_i^j; idiosyncratic productivity: $z_i^j(\omega)$
  - $z_i^j(\omega) = u^{-\theta^j},\; u \sim exp(1)$
- Labor bundle

$$e_i^j(\omega) \;\; \equiv \;\; \left[\left[\bar{\mu}_i^j\right]^{\frac{1}{\gamma}} l_i^j(\omega)^{\frac{\gamma-1}{\gamma}} + \left[1-\bar{\mu}_i^j\right]^{\frac{1}{\gamma}} h_i^j(\omega)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}$$

- Intermediate inputs bundle

$$m_i^j(\omega) \;\; \equiv \;\; \left[\sum_{l=1}^{J}\left[\bar{\alpha}_i^{lj}\right]^{\frac{1}{\rho}} x_i^{lj}(\omega)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

Equilibrium

- Unit cost of producer (ω) in sector j

$$c_{in}^j(\omega) = \frac{\bar{\beta}_i^j \left[p_{v,i}^j\right]^{\beta_i^j} \left[p_{b,i}^j\right]^{1-\beta_i^j} \tau_{in}^j}{A_i^j z_i^j(\omega)}$$

- Prices

$$p_n^j(\omega) = min_i \left\{ c_{in}^j(\omega) \right\}$$

- Trade shares

$$\pi_{in}^j = \frac{\left[\tau_{in}^j c_i^j / A_i^j\right]^{-1/\theta^j}}{\sum_s \left[\tau_{si}^j c_s^j / A_s^j\right]^{-1/\theta^j}}$$

- Price indexes

$$P_i^j = \Xi_i^j \left[c_i^j / A_i^j\right] \pi_{ii}^{j\,\theta^j}$$

Sectoral value-added shares and the skill premium

- Log-change in skill premium

$$\tilde{s}_i - \tilde{w}_i \quad = \quad \frac{1}{\bar{\gamma}}\left[\tilde{L}_i - \tilde{H}_i\right] + \frac{1}{\bar{\gamma}}\sum_j \left[\frac{H_i^j}{H_i} - \frac{L_i^j}{L_i}\right]\tilde{v}_i^j$$

  - v_i^j is share of sector j in value added
  - $\bar{\gamma}_i \equiv \gamma \sum_j \frac{\mu_i^j}{\mu_i}\frac{H_i^j}{H_i} + \left[1 - \sum_j \frac{\mu_i^j}{\mu_i}\frac{H_i^j}{H_i}\right] > 0$

- $\frac{s_i}{w_i}$ decreasing in v_i^j if $\frac{L_i^j}{L_i} > \frac{H_i^j}{H_i}$

Relative prices and revenue shares

Special case: same β_i, α_i, ϕ_i across sectors.

- Log-change in value-added shares:

$$\tilde{v}_i^j = [1-\rho]\left[\tilde{P}_i^j - \sum_j v_i^j \tilde{P}_i^j\right] + \frac{\tilde{\lambda}_i^j}{r_i^j} - \sum_j v_i^j \frac{\tilde{\lambda}_i^j}{r_i^j},$$

  $\lambda_i^j = 1 + NX_i^j / R_i$: ratio of sectorial net exports to revenues. r_i^j: share of sector j in revenues

- v_i^j increases in λ_i^j
- v_i^j increasing in P_i^j if $\rho < 1$
  - P_i^j determined in equilibrium

Result

Proposition: Given parameters, a country skill premium can be calculated using only

1. Domestic expenditure shares π_{ii}^{j}'s
2. Sectoral net exports to revenues ratios $1 + NX_i^j / R_i \equiv \lambda_i^j$'s
3. Domestic endowments and technologies H_i, L_i A_i^j

- Implication: π_{ii}^{j}'s and λ_i^j's are sufficient statistics for all international forces affecting revenue shares and the skill premium Equilibrium Characterization

Trade and the skill premium

- Log-change in skill premium

$$\tilde{s}_i - \tilde{w}_i = \frac{1}{\Gamma_i}\left[\tilde{L}_i - \tilde{H}_i\right] + \sum_j \xi^j_{i,\pi}\left[\tilde{\pi}^j_{ii} - \tilde{A}^j_i\right] + \sum_j \xi^j_{i,\lambda}\tilde{\lambda}^j_i$$

- Special case: β_i, α_i, ϕ_i constant across sectors
  - $\Gamma_i \equiv \chi_i \gamma + [1-\chi_i]\rho > 0$
  - $\xi^j_{i,\pi} = \frac{\theta^j[1-\rho]}{\Gamma_i}\left[\frac{H^j_i}{H_i} - \frac{L^j_i}{L_i}\right] < 0$ if $\rho < 1$ & $\frac{H^j_i}{H_i} < \frac{L^j_i}{L_i}$
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Taking the model to the data

- Allow for many industries within each sector

$$Y_i^j = \prod_{k \in K^j} Y_i^j(k)^{\sigma_i^j(k)}$$

- Identical production function across industries within sector
  - Industries only differ in $\theta^j(k)$, $\sigma_i^j(k)$
  - but $\mu_i^j(k) = \mu_i^j$

Parameterization

- 3 sectors:
  - $j = G$ (manufacturing, agriculture, mining)
  - $j = F$ (FIRE, health, education)
  - $j = S$ (other services)
- Sectorial labor intensities $[\frac{H_i^j}{H_i}, \frac{L_i^j}{L_i}]$ aggregate labor shares μ_i from WIOD SEA
- Sectorial input intensities $[\beta_i^j, \alpha_i^{jl}]$ from WIOD
- $\hat{\pi}_{ii}^j$ and $\hat{\lambda}_i^j$ from WIOD
- Elasticities constant across countries:
  - Goods across sectors: $\rho = 0.2$, match prices and expenditure shares More
  - Workers within sectors: $\gamma = 1.51$, match Katz-Murphy [1992]
  - Trade elasticities θ^j from Caliendo-Parro [2015]

Data summary

- Sample: 33 countries, 1995-2007

Data summary: Average country

	$\hat{\pi}_{ii}^{j}$	$\frac{H_i^j}{H_i} - \frac{L_i^j}{L_i}$	β_i^j	$\alpha_i^{G,j}$
S	0.98	-0.09	0.55	0.37
G	0.82	-0.23	0.38	0.67
F	0.98	0.32	0.68	0.23

Counterfactual 1

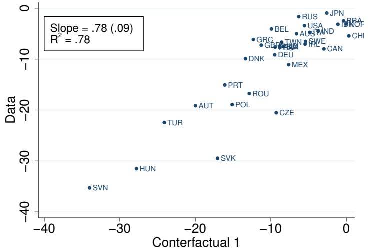
- Changes in trade costs between 1995-2007, fixing other fundamentals
- Estimate trade costs following Head and Reis (2001)

$$\hat{\tau}^j_{ni}\hat{\tau}^j_{in} = \left[\frac{\hat{\pi}^j_{in}\hat{\pi}^j_{ni}}{\hat{\pi}^j_{nn}\hat{\pi}^j_{ii}}\right]^{-\theta^j}$$

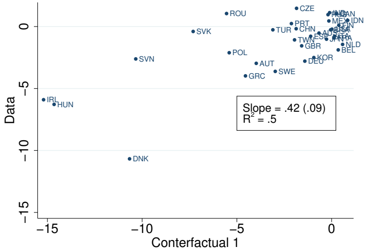
- Compute counterfactual changes in equilibrium following hat algebra apprach in Dekle, Eaton and Kortum (2008)
  - No need or calibrate initial productivity or trade costs levels

C1: Changes in domestic expenditure trade shares - π_{ii}^{j}

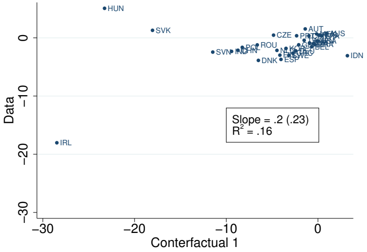
Goods



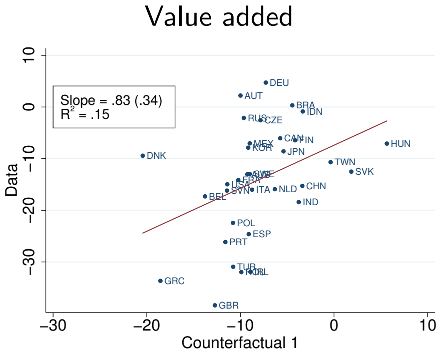
Unskilled-labor intensive services

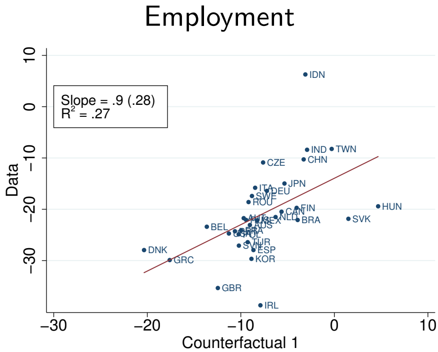


Skilled-labor intensive services



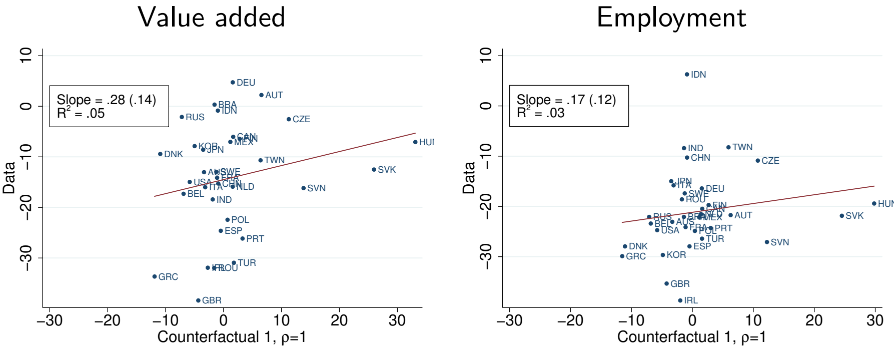
C1: Changes in value-added and employment share of the goods sector





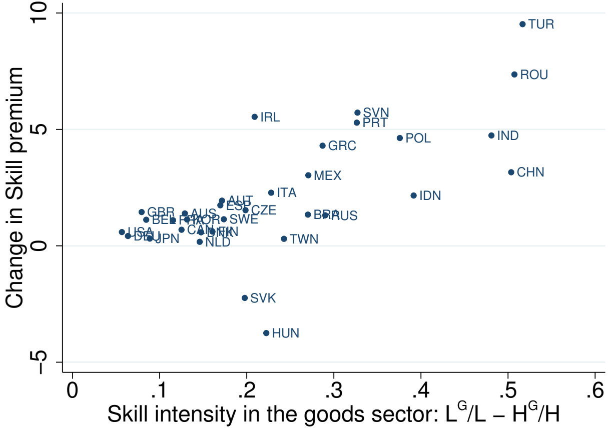
- Average change: $\simeq -8$ percent in C1 vs. $\simeq -20$ percent in data

C1: No price effects ($\rho = 1$)



- Average decline: $\simeq 0$ percent vs. $\simeq -8$ percent in C1

C1: Changes in skill premium



Counterfactual 2

Sufficient statistic approach: Take observed changes in π_{ii}^{j} and λ_{i}^{j} between 1980/1995-2007 as given

- How would sectorial shares and real wages change?
- From previous result:
  - We can conduct exercise without solving for multi-country general equilibrium
  - Only need data for domestic country

Counterfactual 2: Interpretation

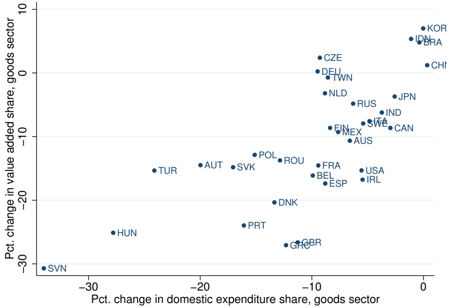
- Between t and t' change in primitives $\left[\tilde{A}_i^j, \tilde{H}_i, \tilde{L}_i, \tilde{\tau}_{in}^j, \tilde{NX}_i\right]_{i,n}^j \Rightarrow$ resulting change skill premium: $\tilde{s}_i - \tilde{w}_i$
- Counterfactual autarkic economy, same factor shares and elasticities but $\tau_{in} = \infty$ for $n \neq i$, $NX_i = 0$. Same changes in primitives $\left[\tilde{A}_i^j, \tilde{H}_i, \tilde{L}_i\right]_i^j \Rightarrow$ resulting change skill premium: $\tilde{s}_i^A - \tilde{w}_i^A$
- To a first order approximation:

$$[\tilde{s}_i - \tilde{w}_i] - \left[\tilde{s}_i^A - \tilde{w}_i^A\right] = \sum_j \xi_{i,\pi}^j \tilde{\pi}_{ii}^j + \sum_j \xi_{i,\lambda}^j \tilde{\lambda}_i^j$$

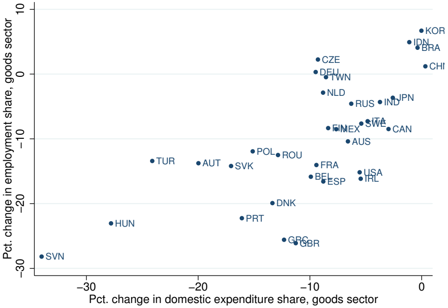
- Exercise answers: What are the additional effects of changes in primitives on the skill premium in an open economy relative to a closed economy?

C2: Changes in share of the good sector in value added and employment

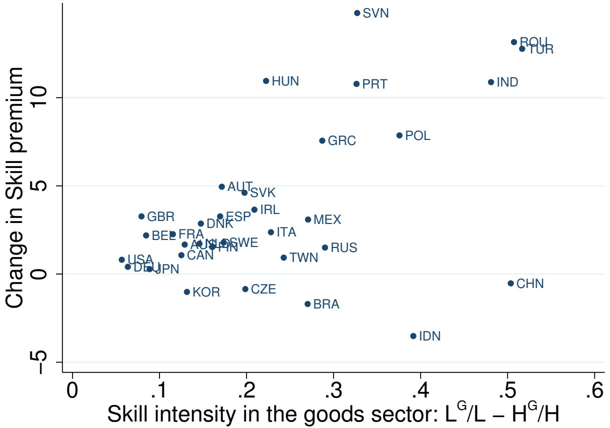
Value Added



Employment



C2: Changes in skill premium



- Skill premium increases in most countries

C2: Earlier periods

Country	Period	Percent change in: π_{ii}^G	v_{ii}^G	s_i/w_i
USA	77-07	-10.8	-20.1	3.1
UK	79-07	-20.1	-23.9	6.6
Canada	81-07	-22.2	-15.6	4.4
Italy	85-07	-7.8	-0.8	2.0
Japan	80-07	-2.6	1.4	-0.1
Netherlands	81-07	-34.5	-20.2	6.6

The skill premium and the factor content of trade

- Payments to skilled labor:

$$w_i L_i = \sum_j \mu_i^j \beta_i^j R_i^j = \sum_j \mu_i^j \beta_i^j Y_i^j + w_i FCT_i^L$$

where $FCT_i^L \equiv \frac{1}{w_i} \sum_j \mu_i^j \beta_i^j \left[R_i^j - Y_i^j \right]$

The skill premium and the factor content of trade

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where $FCT_i^L \equiv \frac{1}{w_i} \sum_j \mu_i^j \beta_i^j \left[R_i^j - Y_i^j \right]$

- Then

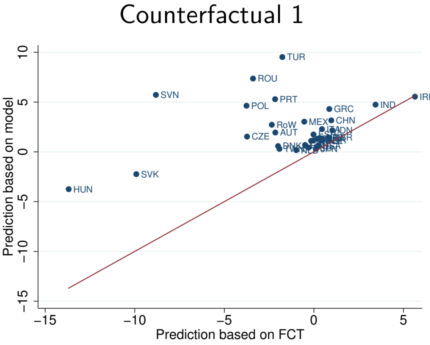
$$w_i = \frac{\sum_j \mu_i^j \beta_i^j Y_i^j}{L_i - FCT_i^L}.$$

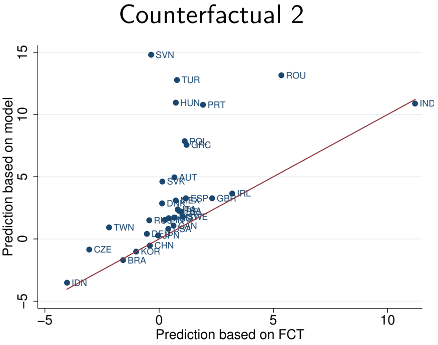
- The skill premium can be written as

$$\frac{s_i}{w_i} = \frac{L_i - FCT_i^L}{H_i - FCT_i^H} \times \frac{\sum_j \left(1 - \mu_i^j\right) \beta_i^j Y_i^j}{\sum_j \mu_i^j \beta_i^j Y_i^j}.$$

- If $Y_i^j = \alpha_i^j Y_i$ and $\mu_i^j = \bar{\mu}_i^j$ all we need is change in FCT (Deardorff-Staiger 1988, Burstein-Vogel 2011)

The skill premium prediction based on FCT



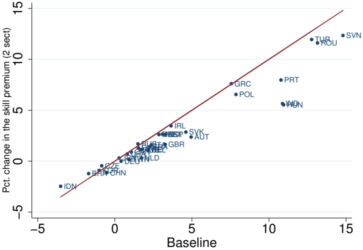


Alternative parameterizations

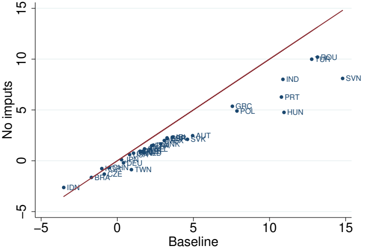
1. Two sector model:
   - Aggregate all services into one sector
2. No Intermediate inputs
   - $\beta_i^j = 1$
3. Non-Homothetic preferences to allow for income effects (Comin et al., 2015; Hanoch, 1975):
   - $1 = \sum_j \bar{\phi}_i^{j\,\frac{1}{\rho}} C_i^{\frac{\varepsilon_j - \rho}{\rho}} \left[C_i^j \right]^{\frac{\rho - 1}{\rho}}$

Change in skill premium C2 : Alternative parameterizations

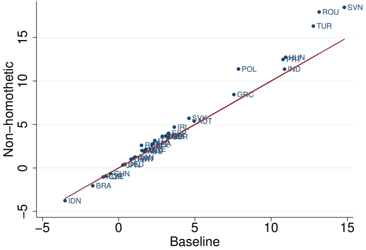
Two sector



No intermediate inputs



Non-Homothetic



Taking stock

1. Data: Low skilled intensive sectors are more tradeable or use more intermediate inputs (or both)

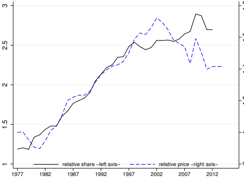
2. New mechanism linking trade to the skill premium
    - Trade lowers prices and value added in unskilled-labor intensive sectors in all countries
    - Rewards for factor used intensively in these sector decline
    - Quantitative calculations country by country

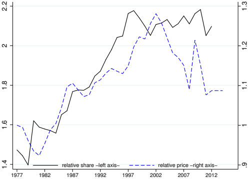
3. Channel quantitatively important for various developing and developed countries

Relative prices vs. Relative shares

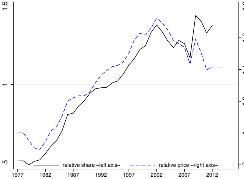
High skilled services vs goods *Low skilled services vs goods*

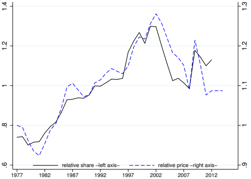
Consumption Bundle





Input bundle used in the low-skilled service sector

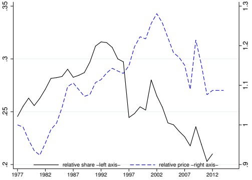




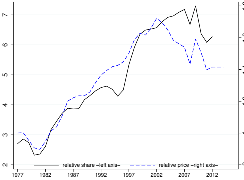
Relative prices vs. Relative shares II

High skilled services vs goods *Low skilled services vs goods*

Input bundle used in the goods sector



Input bundle used in the low-skilled service sector



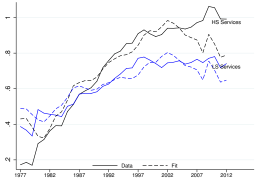
Estimation Results

$$
\begin{aligned}
log\left(\frac{P_i^j C_i^j}{P_i^{j'} C_i^{j'}}\right) &= log\left(\frac{\bar{\phi}_i^j}{\bar{\phi}_i^{j'}}\right) + (1-\rho)\, log\left(\frac{P_i^j}{P_i^{j'}}\right) + \left(\varepsilon_j - \varepsilon_{j'}\right) logC_i. \\
log\left(\frac{P_i^l x_i^{lj}}{P_i^{l'} x_i^{lj}}\right) &= log\left(\frac{\bar{\alpha}_i^{lj}}{\bar{\alpha}_i^{l'j}}\right) + (1-\rho)\, log\left(\frac{P_i^l}{P_i^{l'}}\right).
\end{aligned}
$$

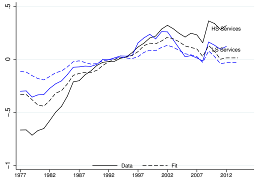
	Bundle				Joint
	Consumption	Unskilled	Skilled	Goods	
$1-\rho$	0.451**	0.987***	0.938***	1.085***	1.004***
	(0.142)	(0.138)	(0.132)	(0.171)	(0.056)

Estimation Fit

Consumption Bundle

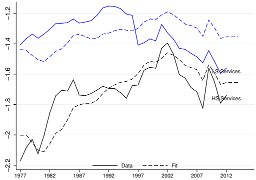


Unskilled-labor intensive services input bundle



Back

Goods input bundle



Skilled-labor intensive services input bundle