

Per Capita Income and the Demand for Skills

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Motivation - increasing skill premium

Income inequality, especially between skilled and unskilled workers, has increased considerably over the past three decades.

Many factors potentially at play:

- International trade: trade liberalization has led to high levels of imports of unskilled labor-intensive goods.
 - But, rising skill premium also observed in developing countries.
Counter-factual predictions on skilled/unskilled ratios in production
- Labor: rising skill premium due to skill-bias technical change.
 - But, little formal proof of this. Difficulty explaining shifts in consumption and occupational demand.
- At same time, university wage premium rises even though university-educated share of workforce rises.

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Our mechanism

Observation: Changing composition of final consumption over time

- fall in expenditure shares for food, durables
- rising expenditure shares for services, non-durables

High income elasticity goods and services $\Leftrightarrow$ skilled-labor intensive

- Autor and Dorn (American Economic Review 2013)
- Autor, Dorn, and Hanson (Economic Journal 2015)
- Buera and Kaboski (American Economic Review 2012)
- Caron, Fally, and Markusen (Quarterly Journal of Economics 2014)
- Johnson and Keane (Journal of Labor Economics 2013).
- Glitz and Wissmann (CESifo working paper 2017)
- Kuhn, Schularick and Steins (CEPR discussion paper 2017)
- Dauth, Findeisen, Suedekum (American Economic Review 2017)

Increasing income (for whatever reason) shifts demand to skill-intensive goods and services. $\Rightarrow$ shifts aggregate labor demand away from unskilled labor and toward skilled labor.

Our mechanism

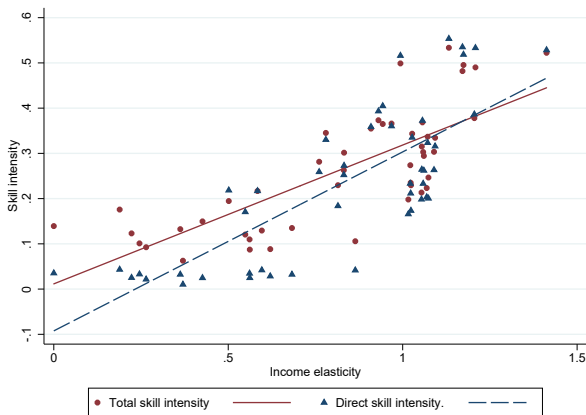


Figure: Correlation between income elasticity and skill intensity. Total skill intensity includes indirect demand for labor, direct does not. The standard deviation in total intensities is 0.13; the standard deviation in direct intensities is 0.17. The coefficient of correlation between income elasticity and total skill intensity is 0.773 with a robust standard error of 0.085 (p-value < 0.01, n = 49).

Methodology

Objective: illustrate how income growth and reductions in trade costs affect the skill premium when preferences are non-homothetic.

Methodology: Multi-regional, multi-sectoral general equilibrium model with non-homothetic preferences.

Steps:

- 1 describe a model of production, trade and consumption in general equilibrium.
- 2 estimate the preference, trade cost and technology parameters of the model. We take a cross-sectional approach which allows us to identify the role of income in explaining shifts in consumption.
- 3 simulate various counterfactual equilibria to quantify the impact of productivity growth and trade cost reductions on the skill premium.

Notes:

- Our simulations focus on the demand side but capture feedbacks from supply and trade.
- We show that non-homothetic preferences push the model's predictions closer to observed estimates of the skill premium.
- But cannot empirically evaluate the contributions relative to the alternative theories of the skill premium.

Data, Model and Estimation

Data

Global Trade Analysis Project (GTAP) dataset (versions 5 and 8)

Coverage:

- Cross-section based on 1997 / 2007
- 57 sectors
- 109 countries

Harmonized data:

- Production (Input-Output tables)
- Consumption (household, public and investment)
- Bilateral trade
- **2 labor types (skilled and unskilled)**

Model and estimation strategy

Framework: [▶ More](#)

- General equilibrium model based on Caron, Fally and Markusen (2014) *“International trade puzzles: a solution linking production and preferences”*.
- **Production and trade:** multi-sectoral extension of Eaton and Kortum (2002) as in Costinot et al. (2012) generates gravity within each sector
- **Non-homothetic demand system:** “Constant relative income elasticity” (CRIE) demand system similar to Fielser (2012) and Non-homothetic CES preferences (Comin et al 2017).
- Model solved by formulating equilibrium conditions in terms of changes relative to the baseline observed equilibrium as in Dekle et al. 2007. Solved by the non-linear PATH solver.

Model overview - Preferences and demand (1)

“Constant relative income elasticity” (CRIE) preferences

Utility:

$$U = \sum_k \alpha_{1,k} Q_k^{\frac{\sigma_k - 1}{\sigma_k}}$$

where Q_k is a CES aggregate:

$$Q_k = \left(\int_{j_k=0}^1 q(j_k)^{\frac{\xi_k - 1}{\xi_k}} dj_k \right)^{\frac{\xi_k}{\xi_k - 1}}$$

- Each industry k composed of a continuum of product varieties indexed by $j_k \in [0, 1]$.
- Preferences are identical across countries, but non-homothetic if σ_k varies across industries.
- These preferences are used in Hanoch (1975), Chao and Manne (1982), Fielier (2012) and Caron, Fally and Markusen (2014).

Model overview - Preferences and demand (2)

CES price index of goods from industry k in country n :

$$P_{nk} = \left(\int_0^1 p_{nk}(j_k)^{1-\xi_k} dj_k \right)^{\frac{1}{1-\xi_k}}$$

Per capita consumption:

$$P_{nk} Q_{nk} = d_{nk} = \lambda_n^{-\sigma_k} \alpha_{2,k} (P_{nk})^{1-\sigma_k}$$

- $\alpha_{2,k} = (\alpha_{1,k} \frac{\sigma_k - 1}{\sigma_k})^{\sigma_k}$
- λ_n is the Lagrangian multiplier associated with the budget constraint
- There is no analytical expression for λ_n .

Income elasticity of demand:

$$\eta_{nk} = \sigma_k \cdot \frac{\sum_{k'} d_{nk'}}{\sum_{k'} \sigma_{k'} d_{nk'}}$$

- The ratio of income elasticities between goods i and j is given by σ_i/σ_j and is constant.

Model overview - Supply and trade

The unit cost of supplying variety j_k to country n from country i :

$$p_{nik}(j_k) = \frac{\tau_{nik}}{Z_{ik}(j_k)} \prod_f (w_{fi})^{\beta_{ikf}} \prod_h (P_{hi})^{\gamma_{ikh}}$$

- P_{ih} is the price index of goods h in country i .
- $\sum_f \beta_{ikf} + \sum_h \gamma_{ikh} = 1$.
- Perfect competition for the supply of each variety j_k .
- $Z_{ik}(j_k)$ is a random variable with a Frechet distribution (Eaton and Kortum, 2002) with a cumulative distribution $F_{ik}(z) = \exp[-(z/Z_{ik})^{-\theta_k}]$.
- Setting generates gravity equations in each sector.
- Productivity parameter Z_{ik} can vary across exporters and sectors, **allowing for any pattern of Ricardian comparative advantage at the sector level**.
- Trade costs τ_{nik} can vary by sector, allowing for differences in trade costs across sectors.

Model overview

Unit cost:	$S_{ik} = z_{ik}^{\theta_k} \left(\prod_f (w_{fi})^{\beta_{ifk}} \right)^{-\theta_k} \left(\prod_h (P_{ih})^{\gamma_{ikh}} \right)^{-\theta_k}$
Bilateral trade flows:	$X_{nik} = \frac{S_{ik}(\tau_{nik})^{-\theta_k}}{\Phi_{nk}} X_{nk}$
Phi:	$\Phi_{nk} = \sum_i S_{ik}(\tau_{nik})^{-\theta_k}$
Price index:	$P_{nk} = \alpha_{3,k}(\Phi_{nk})^{-\frac{1}{\theta_k}}$
Final demand:	$D_{nk} = L_n(\lambda_n)^{-\sigma_k} \alpha_{2,k}(P_{nk})^{1-\sigma_k}$
Budget constraint:	$L_n r_n = \sum_k D_{nk}$
Absorption:	$X_{nk} = D_{nk} + \sum_{i,h} \gamma_{nhk} X_{inh}$
Factor market clearing:	$F_{fi} w_{fi} = \sum_{n,k} \beta_{ifk} X_{nik}$
Budget balance:	$L_i r_i = \sum_f F_{fi} w_{fi}$

Estimation strategy

Estimation strategy: [► More](#)

- Identification of income elasticity of demand parameters by **controlling for estimated supply-side differences in comparative advantage and trade costs.**

Estimation strategy

Unit cost: $S_{ik} = z_{ik}^{\theta_k} \left(\prod_f (w_{fi})^{\beta_{ifk}} \right)^{-\theta_k} \left(\prod_h (P_{ih})^{\gamma_{ikh}} \right)^{-\theta_k}$

Bilateral trade:

$$X_{nik} = \frac{S_{ik}(\tau_{nik})^{-\theta_k}}{\Phi_{nk}} X_{nk}$$

1 - Estimate gravity equations by sector (Poisson-PML)

$$\log X_{nik} = \underbrace{\log S_{ik}}_{FX_{ik}} + \underbrace{\log(\Phi_{nk}^{-1} X_{nk})}_{FM_{nk}} - \underbrace{\beta_{Dist,k} \log Dist_{ni} + \dots + \beta_{HomeBias,k} \cdot I_{n=i}}_{\text{Proxies for trade costs, } \tau_{nik}} + \varepsilon_{nik}$$

Phi:

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2 - Re-construct $\hat{\Phi}_{nk} = \sum_i \hat{S}_{ik}(\hat{d}_{nik})$

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3 - Estimate σ_k controlling for $\hat{\Phi}_{nk}$ under budget constraint (constrained NLLS)

Final demand:

$$D_{nk} = L_n(\lambda_n)^{-\sigma_k} \alpha_{4,k}(\hat{\Phi}_{nk})$$

$$\log d_{nk} = \log \alpha_k + -\sigma_k \cdot \log \lambda_n + (\sigma_k - 1) \cdot \frac{\log \hat{\Phi}_{nk}}{\hat{\theta}} + \varepsilon_{nk}$$

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How do income growth and trade liberalization influence the demand for skilled labor when preferences are non-homothetic?

Simulating changes in the skill premium

COUNTERFACTUAL: historical 1995-2010 rates of growth in income and trade liberalization

- Income: changes in real per capita GDP targeted through uniform z_i (TFP)
- Trade: changes in export/GDP ratios targeted through exporter-specific border effects $\hat{\beta}_{border,ik}$

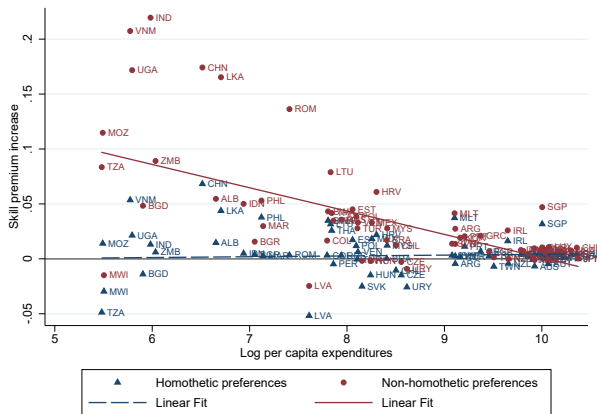
VARIABLE OF INTEREST: change in the skill premium $\widehat{\left(\frac{w_{nH}}{w_{nL}}\right)}$

- simulated in **general equilibrium**, to include supply-side (production, trade) response on relative prices.
- A **partial equilibrium approximation** for this elasticity is:

$$\log \left(\widehat{\frac{w_{nH}}{w_{nL}}} \right) \approx \frac{1}{\tilde{\rho}_n} \log \hat{z} \sum_k (sh_{nk}^H - sh_{nk}^L) \eta_{nk}$$

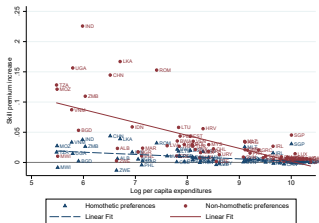
where $sh_{nk}^H \equiv \frac{\beta_{nkH} Y_{nk}}{\sum_{k'} \beta_{nkH'} Y_{nk'}}$ is the share of sector k in the total skill labor employment in country n (and sh_{nk}^L refers to the share of unskilled workers in sector k), and η_{nk} is the income elasticity in sector k , country

Simulation results

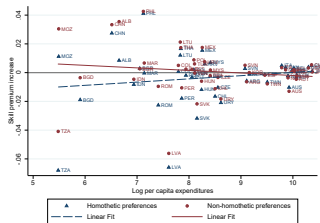


Decomposition

- **Growth counterfactual:** re-simulate the changes in the skill premium caused by productivity growth, but not changes in trade costs
- **Trade counterfactual:** re-simulate the changes in the skill premium caused by changes in trade costs, but not productivity



(a) Growth counterfactual



(b) Trade counterfactual

Figure: Decomposition into the growth and trade channels. Simulated general equilibrium changes in the skill premium caused by 1995 to 2010 changes in real per capita income (a) and openness to trade (b). For clarity, Figure b only displays countries which experienced a reduction in trade costs.

Growth counterfactual (1)

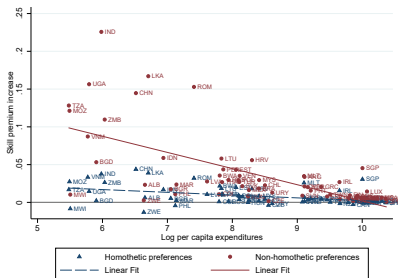


Figure: Simulated general equilibrium changes in the skill premium caused by 1995 to 2010 changes in real per capita income.

- Estimates large in the developing world, (f.ex. 14.5% increase in China, 22.6% in India, 8.7% in Vietnam and in the 10-18% range for African countries).
- 9.6% on average for countries classified as low-income, and 2.4% for countries middle-income and above.

Growth counterfactual (1)

Why is the effect on the skill premium larger for low- and middle-income countries?

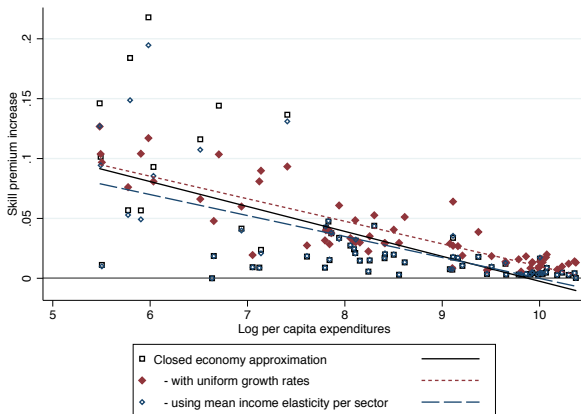


Figure: Growth channel. Closed-economy approximations. Effect of heterogenous growth rates and effect of cross-country variations in income elasticity within sectors.

Trade counterfactual (1)

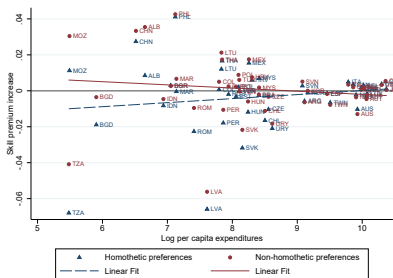
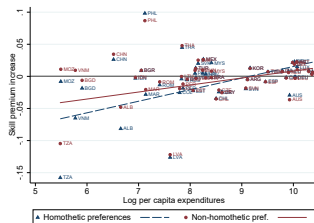


Figure: Simulated general equilibrium changes in the skill premium caused by 1995 to 2010 changes in and openness to trade.

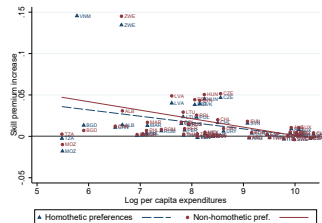
Different channels here:

- Like productivity, trade raises incomes.
- The sector-level correlation between income elasticity and skill intensity implies a country-level correlation between relative specialization in consumption and relative specialization in production.
- $\Rightarrow$ lower predicted net factor content of trade.
- $\Rightarrow$ weaker link between trade and relative wages (weakening of

Trade counterfactual decomposition



(a) First term: Difference in direct effect

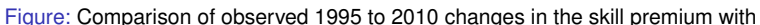


(b) Second term: Difference in final demand effects

Table: The effect of trade on the skill premium (in %): decomposition of the difference between non-homothetic and homothetic preferences. Average over countries which experienced a reduction in trade costs.

Channel:	Country groups (per capita income)		
	low income	middle income	high income
Direct	4.10	0.10	-0.22
Demand	1.77	0.30	0.13
IQ	0.08	0.08	-0.05

- WIOD (World input-output database) contains wage data and allows computation of 1995-2010 changes in skill premium for 40 countries (but few low-income countries).
- Historical changes vary in sign and magnitude; correlation with log per capita income is -0.28.
- Observed changes in the skill premium are caused by a number of confounding and possibly interacting mechanisms $\Rightarrow$ we limit ourselves to a simple correlation exercise



Robustness checks

- The effects of productivity and trade are linked to the elasticity of substitution between skilled and unskilled labor $\Rightarrow$ For values between 1.4 and 1.7 GE estimates are very close to inversely proportional to $\tilde{\rho}$

Results are qualitatively and quantitatively robust to:

- Differences in the θ_k parameter (elast of trade to trade costs).
- The use of “implicitly-additive” preferences (as in Comin et al, 2016 and Matsuyama, 2019) (integrated into our general equilibrium model.) CRIE preferences are separable and impose a strong link between price elasticities and income elasticities in consumption.
- The use of country-specific measures of input requirements (incl. skill and unskill inputs); correlation of income elasticity with skill intensity is strong in most countries (not just on average)
- Using the more recent GTAP8 dataset based on 2007.

Summary

- Growing income inequality is a defining feature of our time.
- Many reasons identified and studied by the literature.
- Our contribution: quantitative assessment of a simple yet overlooked mechanisms
 - $\Rightarrow$ when allowing for non-homothetic preferences, growth in income increasingly shifts consumption patterns towards goods and services that require relatively more skilled labor in their production.
 - $\Rightarrow$ effects of trade on the skill premium with NH preferences.
- These are working alongside other forces, with which they are not incompatible.
 - skill-biased technical change (Borstein and Vogel, 2017)
 - other sources of structural transformation (Cravino and Sotelo, 2018)
- Future research: integrate and contrast alternative mechanisms in a unified framework.