Linking Factor Intensities and Income Elasticities:
A key toward explaining empirical puzzles in Trade?

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Motivation

- Most models assume either 1 or 0 income elasticity
- \+ Large emphasis on supply side and trade costs

- Here: *identical* but non-homothetic preferences

- Markusen (2010) shows that several trade puzzles can be explained:
  - Missing trade (Trefler 95)
  - Home bias
  - Role of income in gravity equations
  - \+ (Larger markups in rich countries)
  - Increase in skill premium

Main ideas

- **Key hypotheses**:

(A1) Correlation between income elasticity and skill (or capital) intensity.

(A2) Rich countries are skill abundant

- *Explaining "missing trade"* (need A1 + A2):
  - Rich countries prefer goods that are skill intensive

  $\Rightarrow$ Rich countries prefer trading with rich countries

- *Explaining the increase in income inequalities* (need A1):
  - As productivity increases, income increases,
  - More demand for skill-intensive goods, more demand for skilled labor

  $\Rightarrow$ Larger skill premium

This paper

- Exploits cross-sector variations
  - *Disclaimer:* Not a paper on quality
- Model combining non-homothetic preferences and gravity
- Estimates income elasticity and correlation with skill intensity
  - Gravity equations to disentangle demand- from supply-side effects
- Simulates counterfactuals to illustrate:
  - The role of non-homotheticity in trade
  - Effect on skill premium

Main Results

- Large correlation between income elasticity and skill intensity ($> 40\%$)
- Can potentially explain approx $1/3^{rd}$ of "missing trade puzzle"
- Generate an important role of per capita income for:
  - Trade / GDP ratios
  - Trading partners
  - Composition of trade
- Can explain a significant part of rising wage inequalities, especially in *developing countries*

Literature

- Theory:
  - Markusen (2010): survey
  - Markusen (1986), Hunter and Markusen (1989): early work
- HO and missing trade puzzle:
  - Cassing and Nishioka (2009)
  - Hertel and Reimer (2010)
- Non-homotheticity and gravity:
  - Fieler (2010)
- Markups and gravity
  - Simonovska (2010)

And lots of great papers on quality

Outline of the presentation

Part 1: zero trade cost

Part 2: trade costs and gravity

Demand systems

We'll compare three sets of demand systems:

1. **Stone-Geary** ("LES") preferences

   $\Rightarrow$ Expenditure shares depend on 1/income

2. **AIDS** (Similar results for ADAIDS)

   $\Rightarrow$ Expenditure shares depend on log(income)

3. **CRIE**: "Constant Relative Income Elasticities" – as in Fieler (2010)

$$U = \sum_k \alpha_k q_k^{\frac{\sigma_k - 1}{\sigma_k}}$$

(with $\sigma_k > 1$)

CRIE preferences

- **Income elasticity**:

$$\frac{e_n}{x_{nk}} \frac{\partial x_{nk}}{\partial e_n} = \frac{\sigma_k}{\sum_{k'} \sigma_{k'} sh_{nk'}}$$

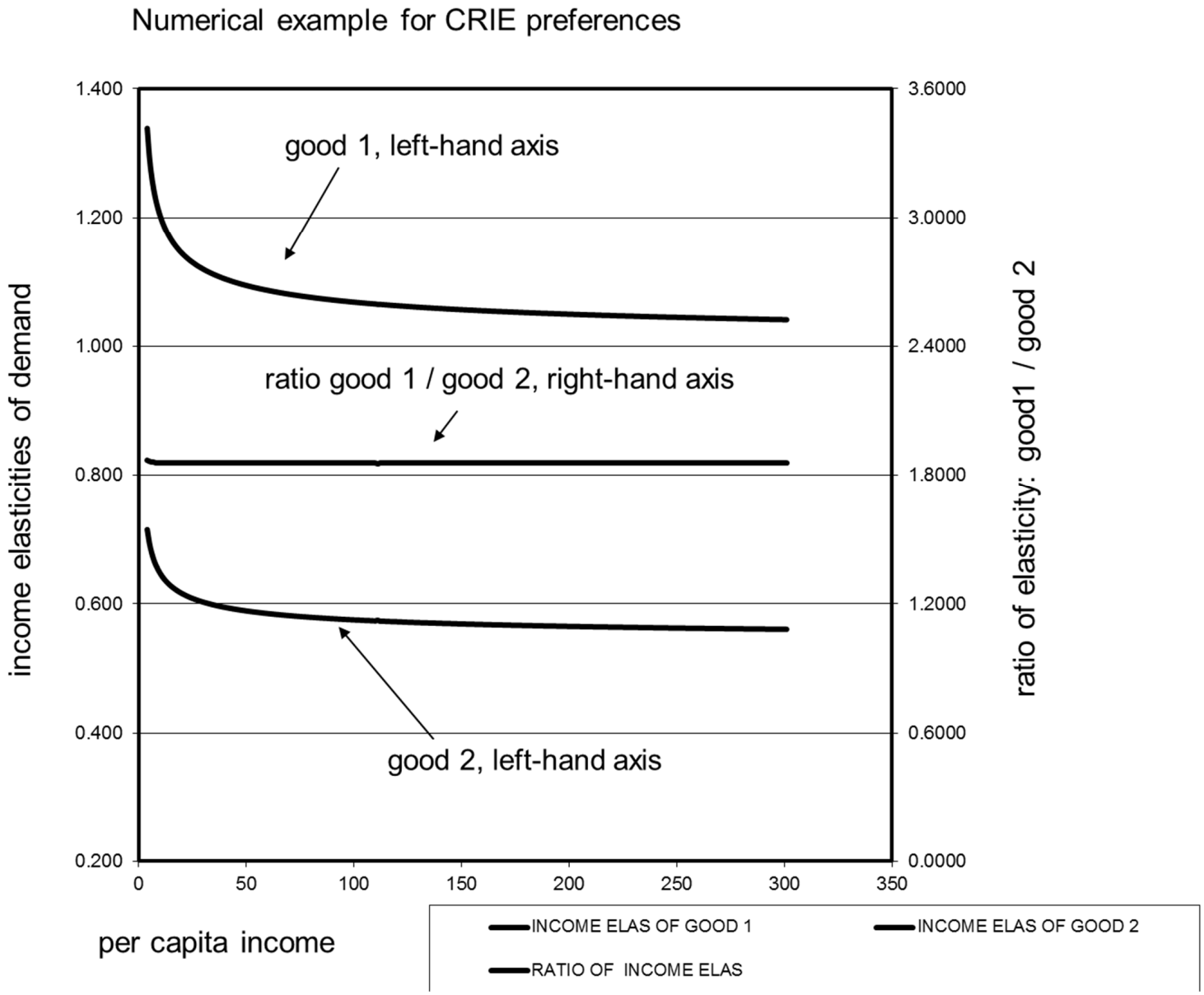
$sh_{nk'}$: expenditure share in country n for sector k'

- **Individual expenditures**:

$$x_{nk} = (\lambda_n)^{-\sigma_k} \alpha_{2,k} (p_k)^{1-\sigma_k}$$

λ_n: Lagriangian associated with the budget constraint.

Income elasticity and CRIE preferences



GTAP 7 Data

- Coverage:
  - 94 countries
  - 56 sectors (manufacturing and services)
  - 5 factors (skilled, unskilled, capital, land, other natural resources)
- Harmonized data
  - Production
  - Expenditure
  - Trade
  - Input-Output Tables

Estimation

- Individual expenditures: $x_{nk} = (\lambda_n)^{-\sigma_k} \alpha_{2,k} (p_k)^{1-\sigma_k}$

- **Estimation**: constrained NLLS with sector fixed effects (η_k)

$$\log x_{nk} = -\sigma_k \log \lambda_n + \eta_k + \varepsilon_{nk}$$

Under the constraint: $\sum_k \exp\left(-\sigma_k \log \lambda_n + \eta_k\right) = e_n$

e_n: observed expenditure per capita

Results

- Large differences in income elasticities
- High correlation with skill intensity
  - Not that much with capital intensity (Hertel and Reimer, 2010)

CREI income elasticities – Extreme values

GTAP code	Sector name	Sigma	Std error	Inc. elasticity
pdr	Paddy rice	0.056	0.158	0.042
pcr	Processed rice	0.109	0.136	0.081
gro	Cereal grains nec	0.203	0.154	0.151
c_b	Sugar cane, sugar beet	0.420	0.297	0.311
oap	Animal products nec	0.552	0.112	0.410
frs	Forestry	0.586	0.110	0.435
ctl	Bovine cattle, sheep and goats, horses	0.587	0.142	0.436
fsh	Fishing	0.605	0.114	0.449
sgr	Sugar	0.773	0.082	0.574
vol	Vegetable oils and fats	0.795	0.081	0.590
rmk	Raw milk	1.533	0.239	1.138
ppp	Paper products, publishing	1.550	0.103	1.151
omn	Minerals nec	1.670	0.226	1.240
pfb	Plant-based fibers	1.716	0.207	1.274
ofi	Financial services nec	1.722	0.117	1.279
obs	Business services nec	1.841	0.106	1.367
coa	Coal	1.872	0.403	1.390
isr	Insurance	1.918	0.129	1.424
gdt	Gas manufacture, distribution	2.635	0.283	1.957
gas	Gas	2.858	0.424	2.122

Notes: Boostrap standard errors for sigma; sigma normalized to one for textiles.

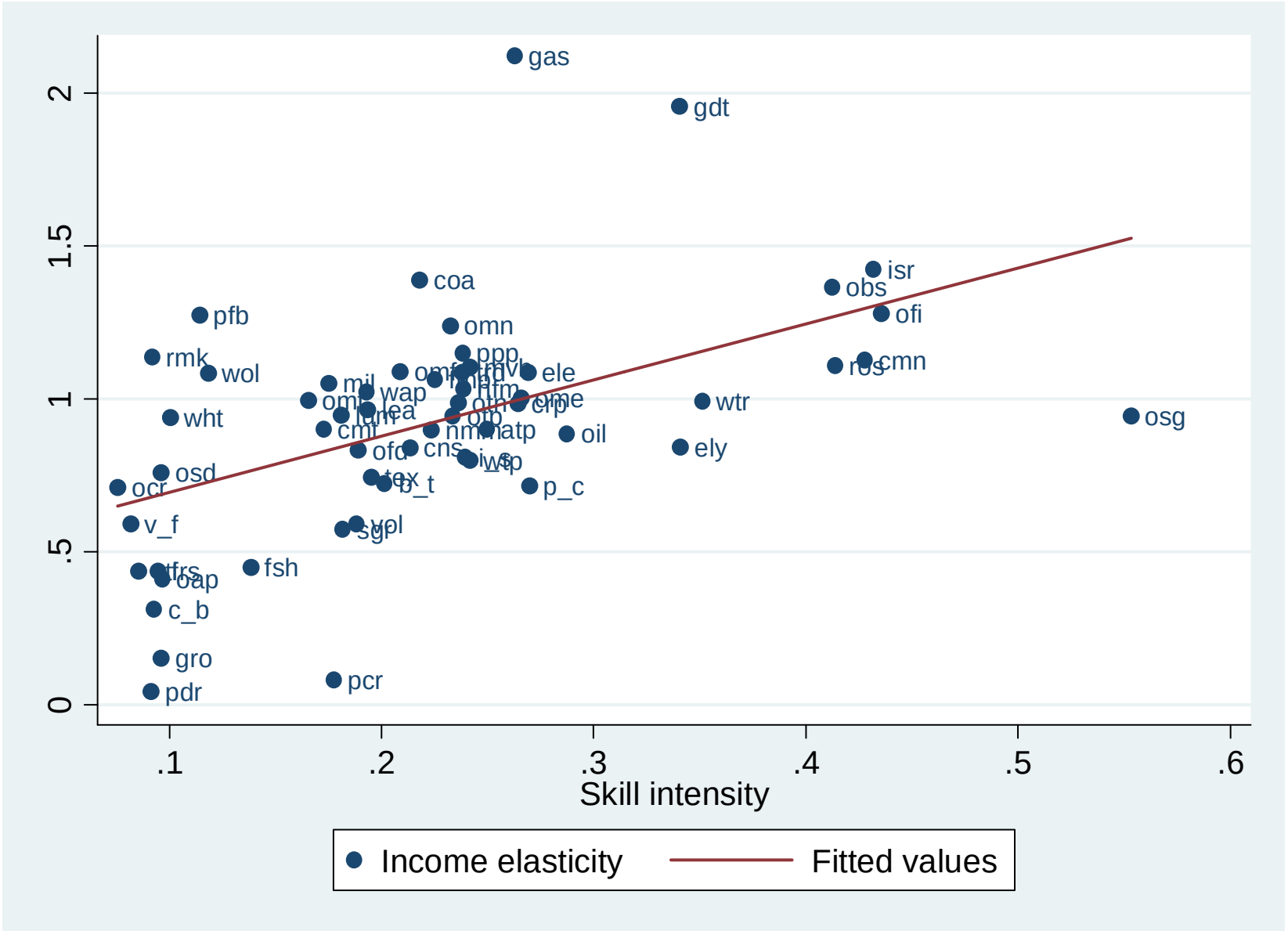
Income elasticity depending on skill intensity

Table 2: Income elasticity and skill intensity

	(1)	(2)	(3)	(4)	(5)	(6)
Specification	LES	LES	AIDS	AIDS	CRIE	CRIE
Skill intensity	0.516**	0.355**	0.631**	0.450**	0.512**	0.478**
	(4.00)	(2.93)	(5.77)	(4.44)	(3.84)	(3.25)
K intensity		0.135		0.115		0.172
		(1.06)		(1.01)		(1.01)
Net. Rces. int.		-0.267*		-0.338**		0.091
		(-2.46)		(-3.41)		(0.44)
Observations	56	56	56	56	56	56
R-squared	0.27	0.32	0.4	0.49	0.26	0.3

Beta coefficients; robust t-statistics into parentheses; * significant at 5%; ** significant at 1%

Income elasticity depending on skill intensity



HOV and missing trade

- HOV assumes homothetic preferences: $sh_{ik} = sh_{wk}$
  (consumption shares for sector k are the same in all countries i)

- If $\frac{sh_{ik}}{sh_{wk}}$ is correlated with $\frac{Y_{ik}}{s_i Y_{wk}}$ (production in sector k relative to share of country i in total world production):

$\Rightarrow$ Less predicted trade

- Correlation between supply and demand side:
  - + 77.4%: Data
  - + 36.7%: fitted LES
  - + 33.9%: fitted AIDS
  - + 36.1%: fitted CRIE
  - + 0%: with homothetic preferences

Road map

Part 1: zero trade cost

Part 2: trade costs and gravity

Trade costs and gravity

- Trade costs: potential explanation for observed correlation between demand and supply
- Gravity equations to differentiate **supply** from **demand** side effects.
- Simulations and counter-factuals to illustrate the role of non-homotheticity:
  - Using within-sector gravity equations and estimated trade costs
  - and estimated demand parameters

Focus on CRIE preferences

Why CRIE?

- Model heavily drawn from Fieler (2010):
  - Fieler only tests the model on aggregate data.
  - Can relax important assumptions on supply side and trade costs
- AIDS: not derived from actual preferences
- Combining gravity across sectors with LES preferences
  Tractable with heterogenous firms and Pareto distributions but yields constant consumption share across sectors

Assumptions

- **Preferences:** $U = \sum_k \alpha_k Q_k^{\frac{\sigma_k - 1}{\sigma_k}}$

  where Q_k is a CES aggregate: $Q_k = \left(\int_{j_k=0}^{1} q(j_k)^{\frac{1-\tilde{\sigma}_k}{\tilde{\sigma}_k}} dj_k \right)^{\frac{\tilde{\sigma}_k}{\tilde{\sigma}_k - 1}}$

- **Production**:

  Productivity in each variety drawn from Frechet (parameters θ_k, z_{ik})

$\Rightarrow$ z_{ik} allows for any comparative advantage of country i in sector k

- **Trade costs:**

$$\begin{aligned}\log d_{nik} = & \delta_{Dist,k} . \log Dist_{ni} - \delta_{Contig,k} . Contiguity_{ni} - \delta_{Lang,k} . ComLang_{ni} \\ & - \delta_{Colony,k} . ColonialLink_{ni} - \delta_{HomeBias,k} . I_{n=i}\end{aligned}$$

Equilibrium conditions

Demand:	$X_{nk} = L_n(\lambda_n)^{-\sigma_k}\alpha_{6,k}(\Phi_{nk})^{\frac{\sigma_k-1}{\theta_k}}$
Budget constraint:	$L_n e_n = \sum_k X_{nk}$
Trade:	$X_{nik} = \frac{S_{ik}(d_{nik})^{-\theta_k}}{\Phi_{nk}} X_{nk}$
with:	$\Phi_{nk} = \sum_i S_{ik}(d_{nik})^{-\theta_k}$
Productivity:	$S_{ik} = \left(z_{ik} \prod_f (w_{fi})^{-\beta_{fk}}\right)^{\theta_k}$
Factor market clearing	...
Income	= Factor reward / population

2-step Estimation

- 1st step: Estimating **gravity equations** by sector (Poisson QMLE)

$\Rightarrow$ Estimate exporter FE and trade costs coeffs to obtain $\widehat{\Phi}_{nk}$
(as in Fally, Paillacar and Terra, 2010)

$$\widehat{\Phi}_{nk} = \sum_i \widehat{S_{ik}} \cdot \widehat{d_{nik}^{-\theta_k}}$$

- 2nd step: Use $\widehat{\Phi}_{nk}$ in **demand equation** to control for supply side:
  1) control for any pattern in comparative advantage
  2) ...weighted by trade costs

NLLS estimation with non-linear constraint (budget constraint):

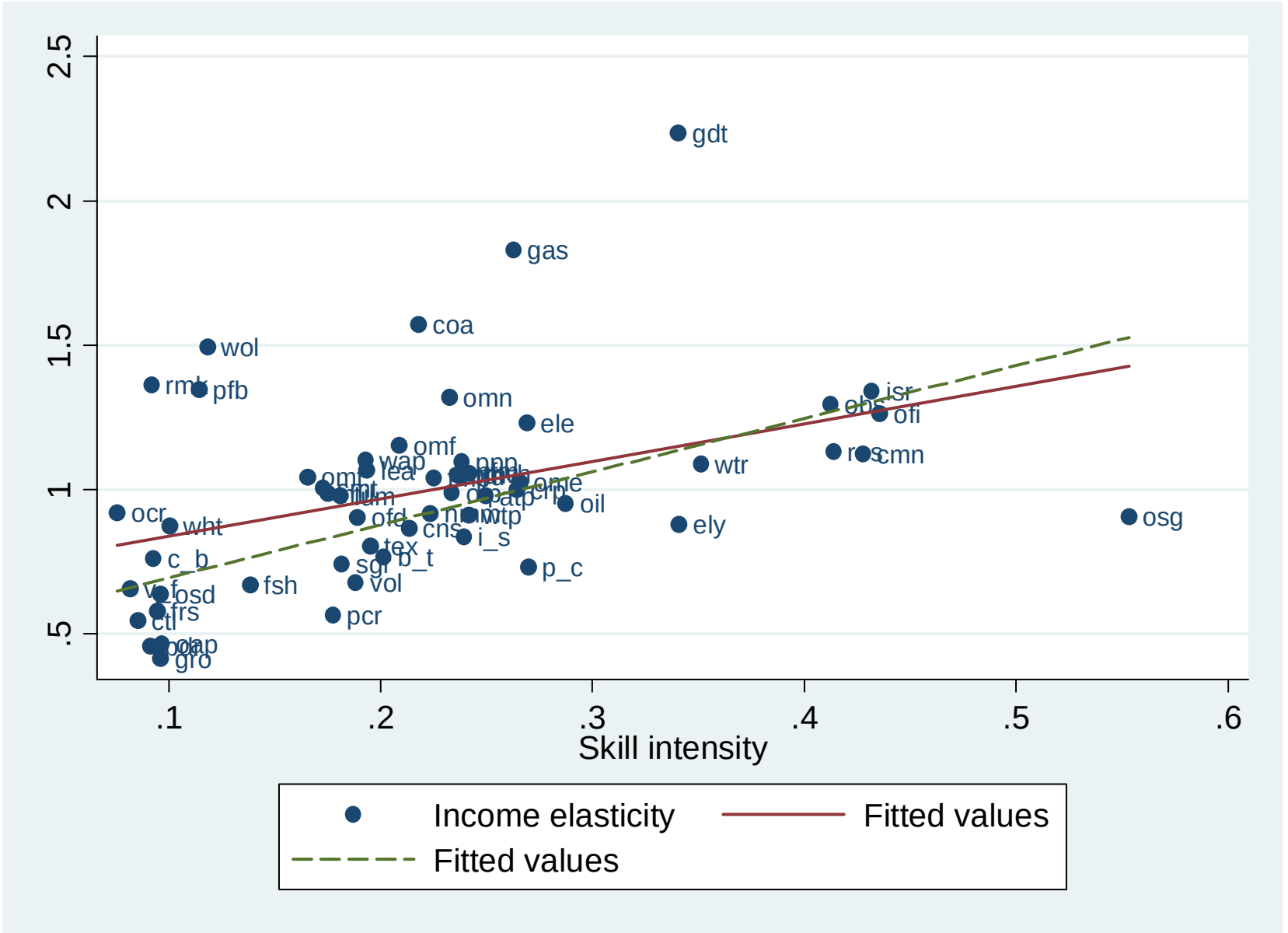
$$\log x_{nk} = -\sigma_k . \log \lambda_n + \log \alpha_{6,k} + \frac{(\sigma_k - 1)}{\theta_k} . \log \widehat{\Phi}_{nk} + \varepsilon_{nk}$$

Corrected income elasticity and skilll intensity

Table 2: Income elasticity and skill intensity

Specification	Correlation	t-statistic
Zero trade cost	0.512	(3.84)
Theta not specified	0.421	(3.45)
Theta constant	0.427	(3.03)
Theta = 4	0.417	(2.86)
Theta = 8	0.423	(2.95)

Income elasticity and skilll intensity (theta = 4)



Income elasticity and distance coefficient

No significant correlation

$\Rightarrow$ The correlation between income elast. and skill intensity is the key

Table 4: Income elasticity and distance coeff

Specification	Correlation	t-statistic
Zero trade cost	-0.023	(-0.08)
Theta not specified	0.059	(0.35)
Theta constant	-0.033	(-0.12)
Theta = 4	-0.079	(-0.30)
Theta = 8	-0.058	(-0.21)

Simulations

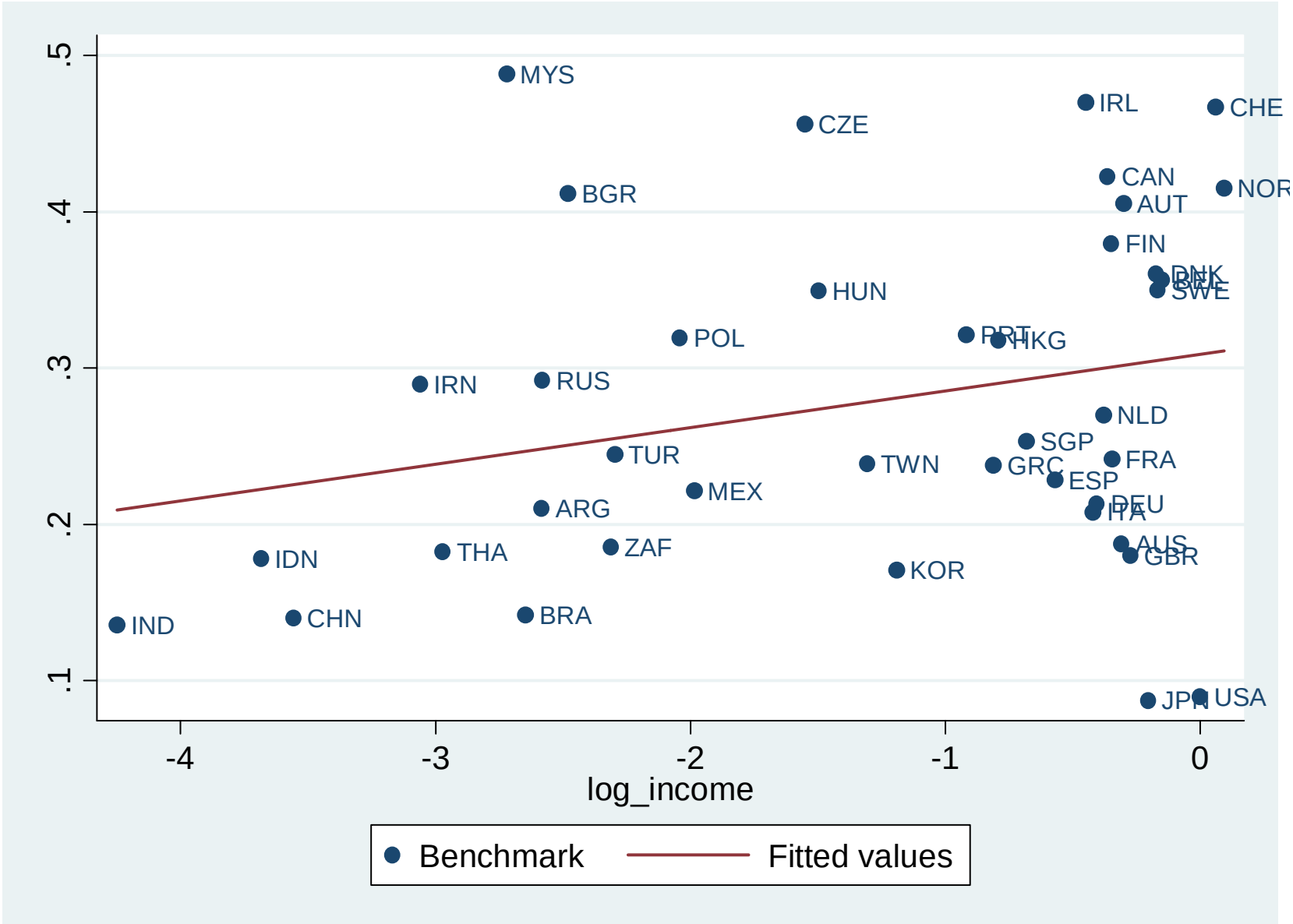
- Use estimated coefficients from demand and gravity equations
  - Restricted to the 40 largest countries... (for the moment)
- Compare homothetic vs. non-homothetic preferences
  - Homothetic case: reestimating demand equation with the same sigma across all sectors
- Counter-factual: effect of increasing productivity on skill premium?
  - Simulating a 10% increase in productivity in all countries
  - Neutral effect in the homothetic case

Trade/GDP ratio

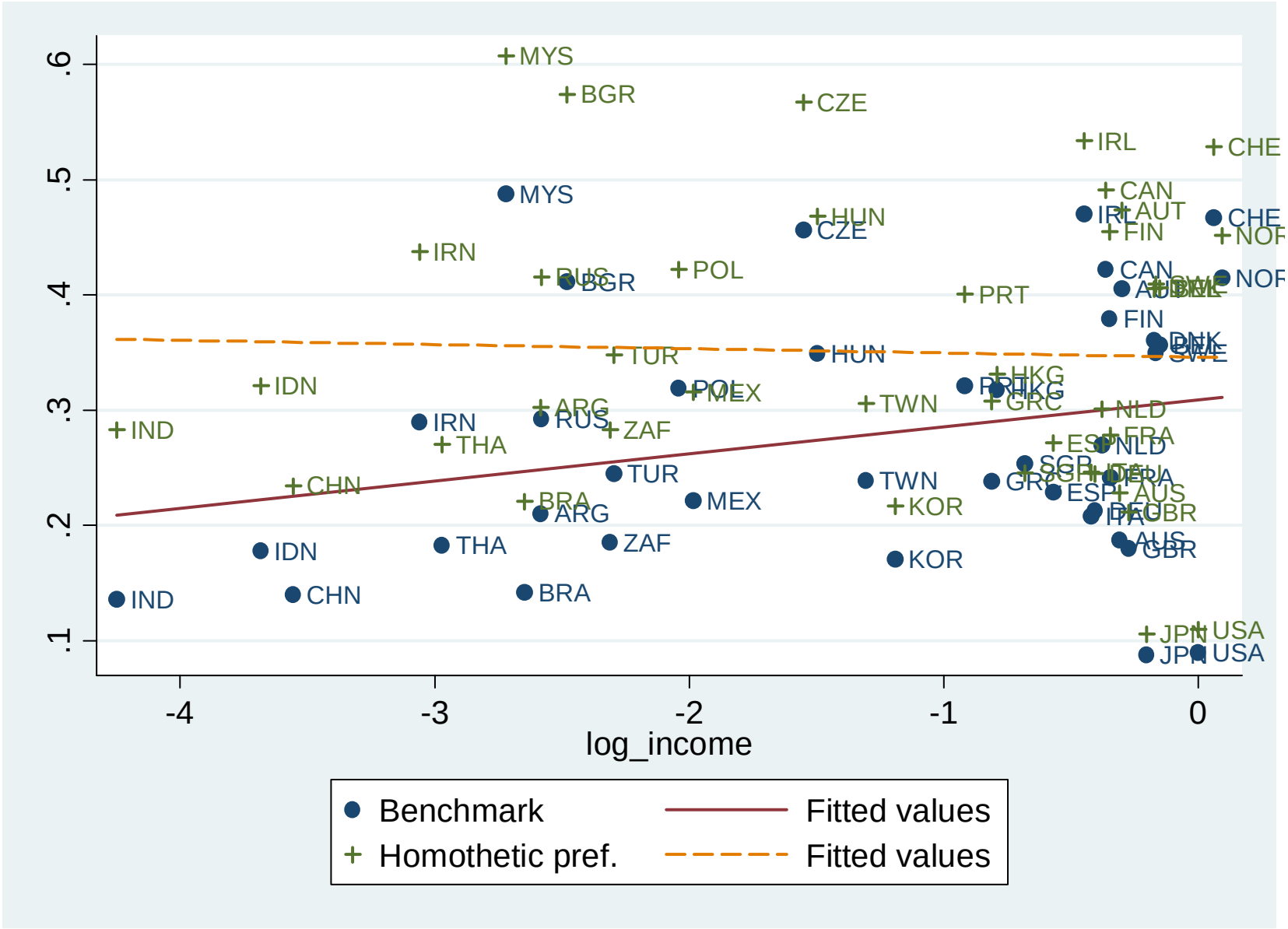
Table 5: Aggregate trade/output ratio

Statistic	Data	Benchmark	Homotheticity
mean across countries	0.209	0.278	0.351
median	0.130	0.186	0.258
p25	0.191	0.249	0.319
p75	0.257	0.359	0.445

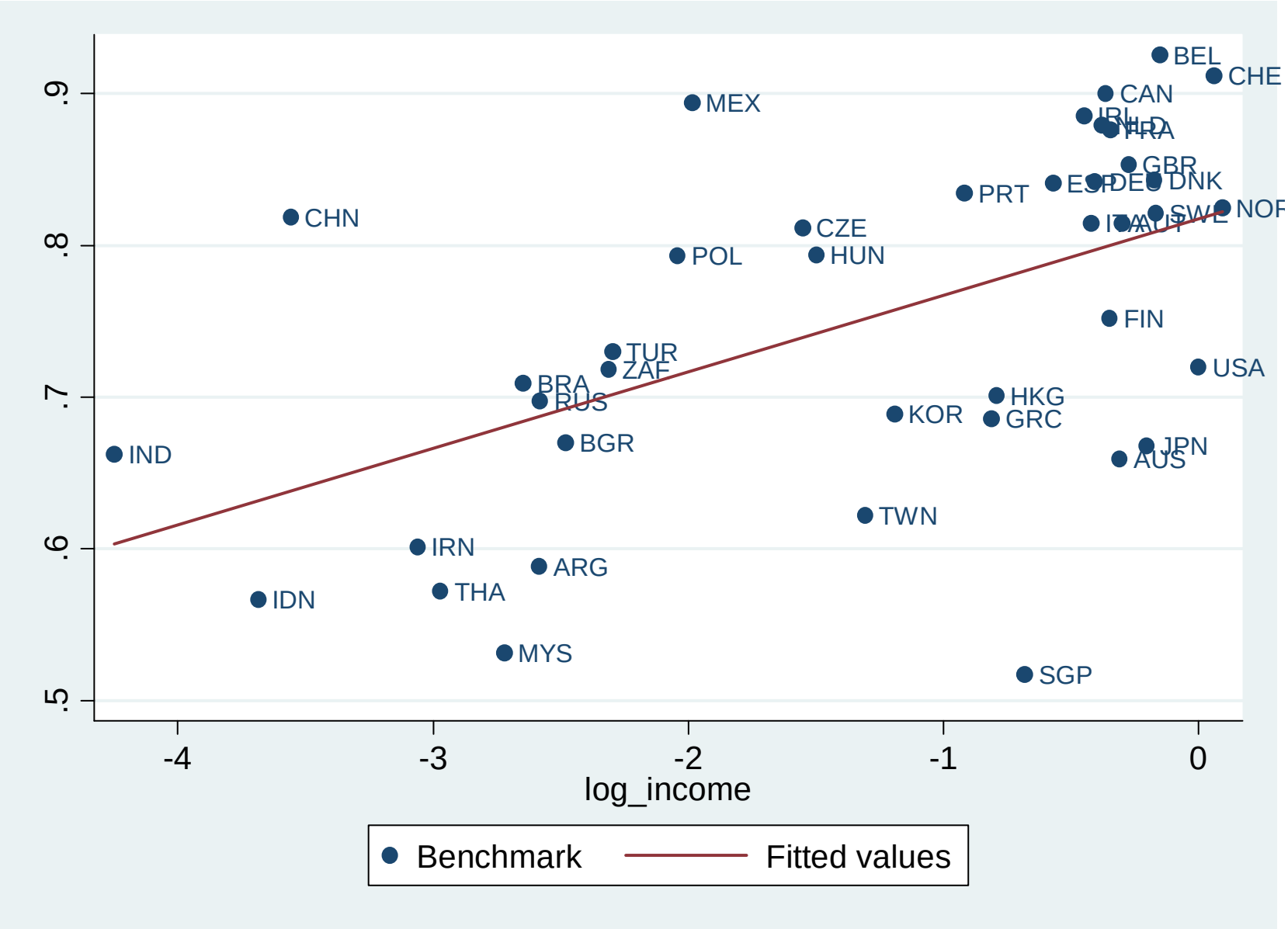
Benchmark: Trade/GDP and per capita income



Comparison: Trade/GDP and per capita income



Benchmark: Share of trade with rich partners



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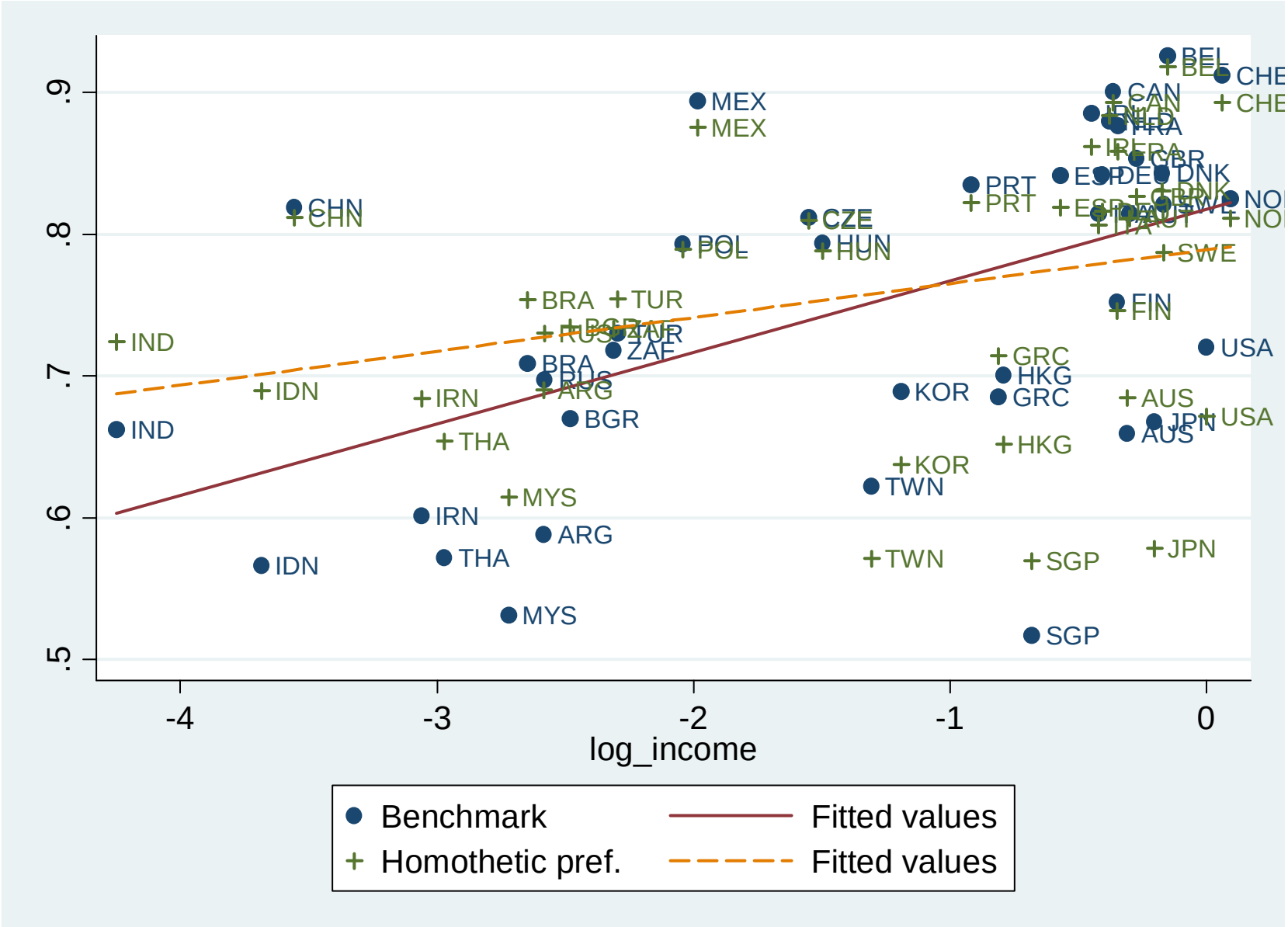
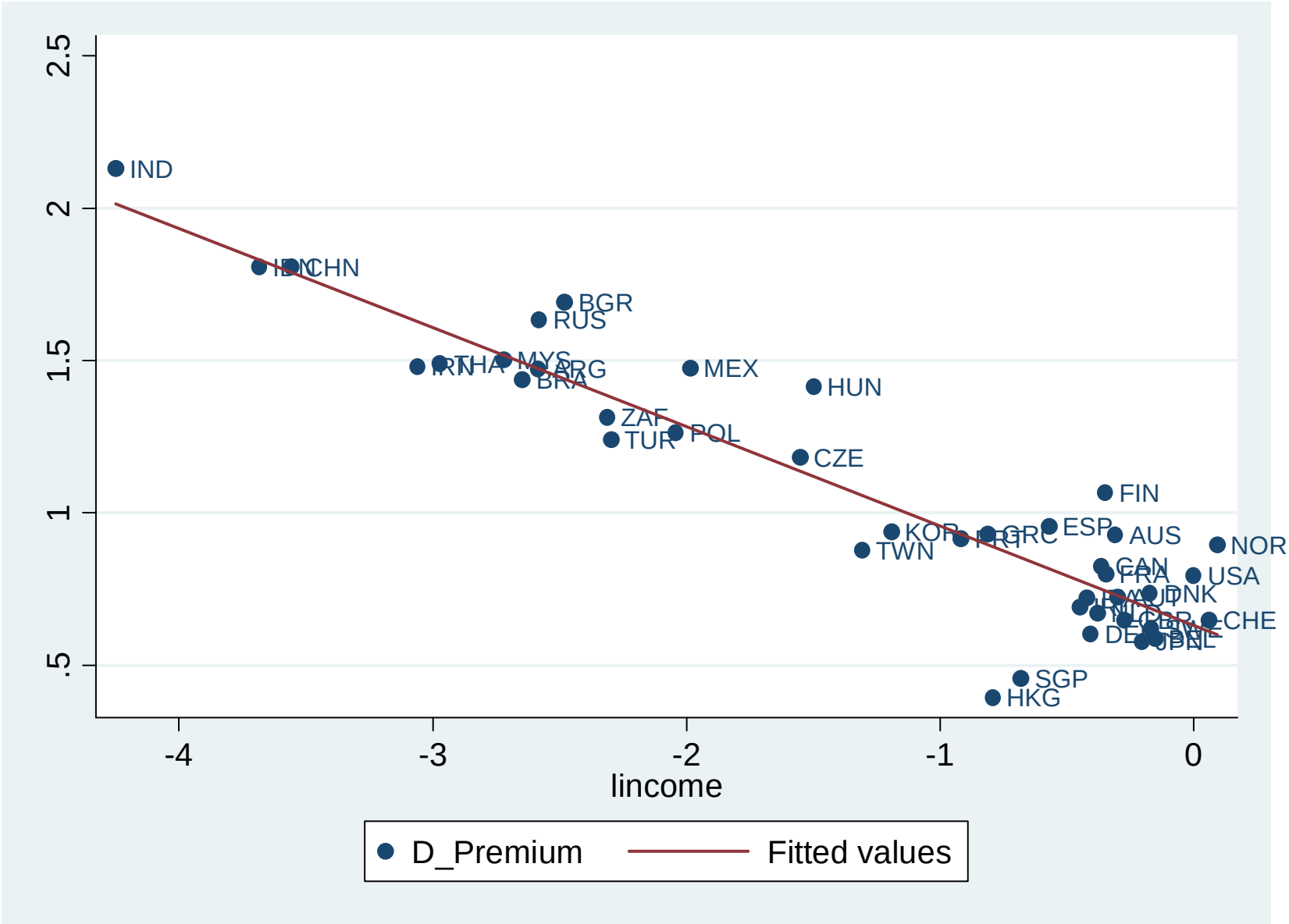


Increase in skill premium after 10% productivity increase



Magnitudes

- China:
  - ◇ With a 10% growth rate
  - \+ Holding skilled labor supply constant
  - ⇒ Skill premium increases by **20% every decade**
- US:
  - ◇ With a 2% growth rate
  - \+ Holding skilled labor supply constant
  - ⇒ Skill premium increase by **2% every decade**
  - ⇒ Explains $\approx 1/10^{th}$ of increase in skill premium for the US (close to what outsourcing can explain?)

Conclusion

- Large correlation between income elasticity and skill intensity ($> 40\%$)
- Can potentially explain significant part of:
  - "Missing trade puzzle"
  - Trade / GDP ratios
  - Trading partners
  - Composition of trade
  - Rising skill premium
    ... especially in *developing countries*
- Sector-level data can already explain a lot

$\Rightarrow$ Even stronger results allowing for within-sector heterogeneity?

On our To-Do list:

- Incorporate intermediate goods
  - Should magnify our results
  - Better match the data
- Using ICP price data
- One-stage estimation
- Simulation with more countries
- Explain why skill intensity is correlated with income elasticity

$\Rightarrow$ A directed-technological-change explanation?