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

Justin Caron, Thibault Fally, Jim Markusen
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
  ⇒ 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
  ⇒ 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 1/3rd 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

- **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
   ⇒ Expenditure shares depend on $1/\text{income}$

2. **AIDS** (Similar results for ADAIDS)
   ⇒ Expenditure shares depend on $\log(\text{income})$

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:**

\[
\frac{e_n}{x_{nk}} \frac{\partial x_{nk}}{\partial e_n} = \frac{\sigma_k}{\sum_k \sigma_k s_{hk'}}
\]

\( s_{hk'} \): expenditure share in country \( n \) for sector \( k' \)

- **Individual expenditures:**

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

\( \lambda_n \): Lagriangian associated with the budget constraint.
Income elasticity and CRIE preferences

Numerical example for CRIE preferences

- **good 1, left-hand axis**
- **ratio good 1 / good 2, right-hand axis**
- **good 2, left-hand axis**

<table>
<thead>
<tr>
<th>per capita income</th>
<th>income elasticities of demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>INCOME ELAS OF GOOD 1</td>
</tr>
<tr>
<td>50</td>
<td>INCOME ELAS OF GOOD 2</td>
</tr>
<tr>
<td>100</td>
<td>RATIO OF INCOME ELAS</td>
</tr>
</tbody>
</table>
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 \((\eta_k)\)

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

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

\( e_n \): 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

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

Notes: Bootstrap standard errors for sigma; sigma normalized to one for textiles.
Table 2: Income elasticity and skill intensity

<table>
<thead>
<tr>
<th>Specification</th>
<th>(1) LES</th>
<th>(2) LES</th>
<th>(3) AIDS</th>
<th>(4) AIDS</th>
<th>(5) CRIE</th>
<th>(6) CRIE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill intensity</td>
<td>0.516**</td>
<td>0.355**</td>
<td>0.631**</td>
<td>0.450**</td>
<td>0.512**</td>
<td>0.478**</td>
</tr>
<tr>
<td>K intensity</td>
<td>0.135</td>
<td>0.115</td>
<td>0.172</td>
<td>0.115</td>
<td>0.172</td>
<td>0.172</td>
</tr>
<tr>
<td>Net. Rces. int.</td>
<td>-0.267*</td>
<td>-0.338**</td>
<td>0.091</td>
<td>-0.338**</td>
<td>0.091</td>
<td>0.091</td>
</tr>
</tbody>
</table>

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

![Graph showing the relationship between skill intensity and income elasticity, with fitted values indicated by a red line.]
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):

  ⇒ 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 heterogeneous firms and Pareto distributions but yields constant consumption share across sectors
Assumptions

▶ Preferences: \( U = \sum_k \alpha_k Q_k^{\sigma_k^{-1}} \)

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 \( \theta_k, z_{ik} \))

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

▶ Trade costs:

\[ \log d_{nik} = \delta_{Dist,k} \cdot \log Dist_{ni} - \delta_{Contig,k} \cdot Contiguity_{ni} - \delta_{Lang,k} \cdot ComLang_{ni} \]
\[ - \delta_{Colony,k} \cdot ColonialLink_{ni} - \delta_{HomeBias,k} \cdot I_n=i \]
Equilibrium conditions

Demand: \( X_{nk} = L_n(\lambda_n)^{-\sigma_k}\alpha_{6,k}(\Phi_{nk})^{\sigma_k-1/\theta_k} \)

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: \( S_{ik} = (z_{ik} \prod_f (w_{fi})^{-\beta_{fk}})^{\theta_k} \)

Factor market clearing ... 

Income = Factor reward / population
2-step Estimation

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

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

\[
\hat{\Phi}_{nk} = \sum_i \hat{S}_{ik} \cdot \hat{d}_{nik} \cdot \hat{\theta}_k 
\]

▶ 2nd step: Use \( \hat{\Phi}_{nk} \) 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):

\[
\log x_{nk} = -\sigma_k \cdot \log \lambda_n + \log \alpha_{6,k} + \frac{(\sigma_k - 1)}{\theta_k} \cdot \log \hat{\Phi}_{nk} + \varepsilon_{nk}
\]
Corrected income elasticity and skill intensity

**Table 2: Income elasticity and skill intensity**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Correlation</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero trade cost</td>
<td>0.512</td>
<td>(3.84)</td>
</tr>
<tr>
<td>Theta not specified</td>
<td>0.421</td>
<td>(3.45)</td>
</tr>
<tr>
<td>Theta constant</td>
<td>0.427</td>
<td>(3.03)</td>
</tr>
<tr>
<td>Theta = 4</td>
<td>0.417</td>
<td>(2.86)</td>
</tr>
<tr>
<td>Theta = 8</td>
<td>0.423</td>
<td>(2.95)</td>
</tr>
</tbody>
</table>
Income elasticity and skill intensity (theta = 4)
Income elasticity and distance coefficient

No significant correlation
⇒ The correlation between income elast. and skill intensity is the key

Table 4: Income elasticity and distance coeff

<table>
<thead>
<tr>
<th>Specification</th>
<th>Correlation</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero trade cost</td>
<td>-0.023</td>
<td>(-0.08)</td>
</tr>
<tr>
<td>Theta not specified</td>
<td>0.059</td>
<td>(0.35)</td>
</tr>
<tr>
<td>Theta constant</td>
<td>-0.033</td>
<td>(-0.12)</td>
</tr>
<tr>
<td>Theta = 4</td>
<td>-0.079</td>
<td>(-0.30)</td>
</tr>
<tr>
<td>Theta = 8</td>
<td>-0.058</td>
<td>(-0.21)</td>
</tr>
</tbody>
</table>
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
### Table 5: Aggregate trade/output ratio

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Data</th>
<th>Benchmark</th>
<th>Homotheticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean across countries</td>
<td>0.209</td>
<td>0.278</td>
<td>0.351</td>
</tr>
<tr>
<td>median</td>
<td>0.130</td>
<td>0.186</td>
<td>0.258</td>
</tr>
<tr>
<td>p25</td>
<td>0.191</td>
<td>0.249</td>
<td>0.319</td>
</tr>
<tr>
<td>p75</td>
<td>0.257</td>
<td>0.359</td>
<td>0.445</td>
</tr>
</tbody>
</table>
Benchmark: Trade/GDP and per capita income

![Graph showing benchmark fitted values for various countries like Argentina (ARG), Australia (AUS), Austria (AUT), Belgium (BEL), Bulgaria (BGR), Brazil (BRA), Canada (CAN), and others, plotted on a log-income scale. The graph includes fitted values indicated by a red line.]
Comparison: Trade/GDP and per capita income

The graph compares Trade/GDP and per capita income for various countries, showing fitted values and homothetic preferences.
Benchmark: Share of trade with rich partners
Comparison: Share of trade with rich partners

![Graph showing the relationship between log_income and the share of trade with rich partners for various countries. The graph includes markers for Benchmark, Fitted values, and Homothetic pref. with corresponding fitted values.](image-url)
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

⇒ 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
  ⇒ A directed-technological-change explanation?