Discussion of “Capital Goods Trade and Economic Development”

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## Big Picture

<table>
<thead>
<tr>
<th>Experiment</th>
<th>N</th>
<th>$V[\alpha k]$</th>
<th>$V[(1 - \alpha)l]$</th>
<th>$V[\alpha k + (1 - \alpha)l]$</th>
<th>$V[y]$</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>King-Levine</td>
<td>142</td>
<td>0.26</td>
<td></td>
<td></td>
<td>1.31</td>
<td>0.20</td>
</tr>
<tr>
<td>Hall-Jones</td>
<td>141</td>
<td>0.26</td>
<td>0.028</td>
<td>0.43</td>
<td>1.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Weil</td>
<td>141</td>
<td>0.26</td>
<td>0.043</td>
<td>0.48</td>
<td>1.30</td>
<td>0.37</td>
</tr>
<tr>
<td>Test sample</td>
<td>75</td>
<td>0.11</td>
<td>0.017</td>
<td>0.18</td>
<td>0.53</td>
<td>0.34</td>
</tr>
<tr>
<td>Test correction</td>
<td>75</td>
<td>0.11</td>
<td>0.028</td>
<td>0.22</td>
<td>0.53</td>
<td>0.41</td>
</tr>
<tr>
<td>Imp. Sub. School.</td>
<td>141</td>
<td>0.26</td>
<td>0.150</td>
<td>0.72</td>
<td>1.30</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Source: Caselli (2010)
Trade

- Does trade in capital goods help to eliminate gaps in capital(+TFP)
- Eaton Kortum (2001)
  - Make observations that a handful of advanced countries export capital goods
  - North-South growth model with capital as the key tradable sector (with EK structure)
  - Trade improves relative price of capital, thus real investment rate and output per worker

Challenge: (1) the inferred “trade-based price” - Hsieh and Klenow (2007) makes a related observation that domestic price of capital does not vary strongly across countries of different income levels. (2) No intermediate good sector. Fill in the quantitative implications?
Source: Eaton and Kortum (2001), downward sloping
Waugh 2010

Source: Waugh (2010), fits tradable price (with asym. trade costs)
This Paper

- Trade in capital goods $\rightarrow$ (1) improves capital formation (2) increases aggregate TFP
- Quantitatively important

Ambitious and carefully implemented paper!
Model: Technology

- Two tradable sectors: $K$ capital, $M$ intermediates
- For a continuum of $K$ goods, $v \in [0,1]$, and $M$ goods, $u \in [0,1]$.
  \[
  e(v) = v^{-\theta}[k_e(v)^{\alpha}l_e(v)^{1-\alpha}]^\nu m_e(v)^{1-\nu} \\
  m(u) = u^{-\theta}[k_m(u)^{\alpha}l_m(u)^{1-\alpha}]^\nu m_m(u)^{1-\nu}
  \]
- $v \sim \lambda_e, u \sim \lambda_m$, country specific, $k$ and $m$ are CES aggregate good of $v$ and $u$ respectively.
- Final consumption good producer
  \[
  f = A_f[k_f^{\alpha}l_f^{1-\alpha}]^{\nu_f} m_f^{1-\nu_f}
  \]
- $A_f$ exogenous to the model, country specific
Model: Consumer

- Neo-classical growth framework
- Consumer’s invest/consumption decision is to maximize $x_t$ and $c_t$
  \[
  \sum_t \beta_t \log(c_t), \text{ s.t.}
  \]
  - $k_{t+1} = (1 - \delta)k_t + x_t$
  - $P^t_f c_t + P^t_k x_t = w_t + r_t k_t$
- Impose steady state such that $r = [1/\beta - (1 - \delta)]P_k$ and $x = \delta k$.
- Trade-off: purchase capital goods vs consumption goods.
Equilibrium Objects

For each country, in addition to consumer’s save/consumption ($r \propto P_k$)
  
  - Allocations of factors to each sector (Producer profit maximization)
  
  - Prices $P_f, P_k, P_m$ (CES aggregation)

$$
P_{ki} = \gamma B_k \{ \sum_j [(r_j^{\alpha \nu} w_j^{(1-\alpha)\nu} P_{mj}^{1-\nu}) \tau_{kij}]^{-\frac{1}{\theta}} \lambda_{kj} \}^{-\theta}
$$

$$
P_{mi} = \gamma B_m \{ \sum_j [(r_j^{\alpha \nu} w_j^{(1-\alpha)\nu} P_{mj}^{1-\nu}) \tau_{mij}]^{-\frac{1}{\theta}} \lambda_{mj} \}^{-\theta}
$$

$$
P_{fi} = B_f \frac{[(r_i^{\alpha \nu f} w_i^{(1-\alpha)\nu f} P_{mi}^{1-\nu})]}{A_f}
$$

  - Trade shares (Gravity equation for both $k, m$)

$$
\pi_{ij} = \frac{[(r_j^{\alpha \nu} w_j^{(1-\alpha)\nu} P_{mj}^{1-\nu}) \tau_{ij}]^{-\frac{1}{\theta}} \lambda_j}{\sum_l [(r_l^{\alpha \nu} w_l^{(1-\alpha)\nu} P_{ml}^{1-\nu}) \tau_{il}]^{-\frac{1}{\theta}} \lambda_l}
$$

  - Wages $w$ (Balanced Trade)

  - Can construct equilibrium objects similarly as in Waugh (2010)
Capital Deepening

The key insight from this paper is that

- Income per worker $y_i \propto A f_i (\frac{\lambda_{mi}}{\pi_{mii}}) \frac{\theta (1 - \nu_f)}{\nu} k^\alpha$ (Waugh 2010)

- Trade endogenously affects TFP term $(\frac{\lambda_{mi}}{\pi_{mii}}) \frac{\theta (1 - \nu_f)}{\nu}$

- New for this paper: capital per worker is endogenously determined too

$$k_i \propto (\frac{\lambda_{mi}}{\pi_{mii}})^{\frac{\theta (1 - \nu)}{\nu (1 - \alpha)}} (\frac{\lambda_{ki}}{\pi_{kii}})^{\frac{\theta}{1 - \alpha}}$$

- Trade liberalization would accompany increase in capital investment and lower relative price of capital.
Identification Strategy

Bilateral trade flows play a central role in previous works (i.e. Waugh, EK)

- Parameters $\lambda_i$ (N-1), $\tau_{ij}$ (N(N-1))
- Data $\pi_{ij}$ (N(N-1))
- Under-identified by $N - 1$ data points
- Waugh (2010) shows that restricting parameter spaces $\tau_{ij} = \tau_{i'j} = \tau_j$ explains trade shares pretty well. Now over-identified.

Price data and Income per worker data are not directly targeted, instead used as external validations.

- As a result, fit is obviously not perfect.
Fit

1996 GDP Per Worker: U.S. = 1

Model: U.S. = 1
Identification Strategy: This Paper

Bilateral trade flow + prices + income per worker

- Parameters $\lambda_{ki}, \lambda_{mi}, A_{fi}$ $(3(N-1))$, trade costs $\tau_{ki,j}, \tau_{mi,j}$ $(2N(N-1))$.
- Trade flows $\pi_{ki,j}, \pi_{mi,j}$ $(2N(N-1))$.
- No reduction of parameter space - instead target more data
- Prices $\frac{P_{ki}}{P_{fi}}, \frac{P_{mi}}{P_{fi}}$ $(2(N-1))$ relative to U.S.
- Income per worker $(N-1)$ relative to U.S.

The above system is exactly identified. (1) Given observed price/trade flow: $\tau_{ij}$. (2) Observed relative prices: $\lambda_i$. (3) Income per worker: $A_{fi}$.

- The paper further uses price levels, not clear what role it plays. But that restores over-identification.
- Might be useful to be explicit about estimation procedures.
Figure 2: Income per worker, US=1
• The way to estimate $\theta$ follows Simonovska and Waugh (2014), but is the background assumption consistent?

• The $P_k$ and $P_m$ directly targeted
  • How noisy is the data? Not an expert myself, but “quality” and “sample size” come to mind.
  
  • What if reduce parameter space (i.e. like Waugh 2010) and target only trade shares, can we still get reasonable cross-country pattern of $P_k$?

• Explains variations in cross-country capital formation quite well.
Discussion of Result

• No trade distortions: income per capita 90/10 goes from 22.5 to 10.2.
  • 80% is due to increase in capital per worker

• Total decline very close to Waugh (2010), which goes from 25.7 to 11.4
  • all TFP gains

• In other words, most of the import share response is captured now by capital sector, while limited action from intermediates. Supported by previous developing country liberalization episodes?

• Any deep reason why the fraction of change due to $k$ is so uniformly 80% across countries? One would expect ex-ante country-sector-specific trade barriers, i.e. distortion to sectoral comparative advantage, could affect the relative importance.
Some Evidence: Average

Source: Authors’ analysis based on data described in the text.

Some Evidence: Heterogeneity

**Table 7.** Mean Growth, Investment, and Openness Changes in 24 Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Growth difference</th>
<th>Investment difference</th>
<th>Openness difference</th>
<th>Year of liberalization</th>
<th>Sample period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mauritius</td>
<td>3.62</td>
<td>0.34</td>
<td>35.90</td>
<td>1968</td>
<td>1951–98</td>
</tr>
<tr>
<td>Uruguay</td>
<td>3.08</td>
<td>−1.01</td>
<td>11.22</td>
<td>1990</td>
<td>1951–98</td>
</tr>
<tr>
<td>Chile</td>
<td>2.80</td>
<td>−1.12</td>
<td>26.33</td>
<td>1976</td>
<td>1952–98</td>
</tr>
<tr>
<td>Taiwan</td>
<td>2.29</td>
<td>9.91</td>
<td>55.77</td>
<td>1963</td>
<td>1952–98</td>
</tr>
<tr>
<td>Uganda</td>
<td>2.24</td>
<td>1.63</td>
<td>−6.60</td>
<td>1988</td>
<td>1951–98</td>
</tr>
<tr>
<td>Guinea</td>
<td>1.85</td>
<td>−2.74</td>
<td>7.28</td>
<td>1986</td>
<td>1960–98</td>
</tr>
<tr>
<td>Guyana</td>
<td>1.80</td>
<td>−7.49</td>
<td>84.49</td>
<td>1988</td>
<td>1951–98</td>
</tr>
<tr>
<td>Benin</td>
<td>1.74</td>
<td>1.64</td>
<td>8.72</td>
<td>1990</td>
<td>1960–98</td>
</tr>
<tr>
<td>Mali</td>
<td>1.19</td>
<td>0.86</td>
<td>15.68</td>
<td>1988</td>
<td>1961–98</td>
</tr>
<tr>
<td>Poland</td>
<td>0.83</td>
<td>−4.30</td>
<td>3.35</td>
<td>1990</td>
<td>1971–98</td>
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<tr>
<td>Paraguay</td>
<td>0.42</td>
<td>2.01</td>
<td>49.71</td>
<td>1989</td>
<td>1952–98</td>
</tr>
<tr>
<td>Cyprus</td>
<td>0.34</td>
<td>−4.05</td>
<td>29.13</td>
<td>1960</td>
<td>1951–96</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.18</td>
<td>0.48</td>
<td>5.91</td>
<td>1986</td>
<td>1951–98</td>
</tr>
<tr>
<td>Tunisia</td>
<td>−0.30</td>
<td>−5.58</td>
<td>31.94</td>
<td>1989</td>
<td>1962–98</td>
</tr>
<tr>
<td>Philippines</td>
<td>−0.40</td>
<td>1.03</td>
<td>39.54</td>
<td>1988</td>
<td>1951–98</td>
</tr>
<tr>
<td>Israel</td>
<td>−0.96</td>
<td>−6.10</td>
<td>21.42</td>
<td>1985</td>
<td>1951–98</td>
</tr>
<tr>
<td>Mexico</td>
<td>−2.16</td>
<td>−4.59</td>
<td>17.56</td>
<td>1986</td>
<td>1951–98</td>
</tr>
<tr>
<td>Jordan</td>
<td>−4.28</td>
<td>5.75</td>
<td>40.61</td>
<td>1965</td>
<td>1955–98</td>
</tr>
</tbody>
</table>

*Source: Authors’ analysis based on data described in the text.*

Summary

• Great paper, learned a lot by reading it
• Capital back in picture for trade and growth.
  • Skill Capital Complementarity
  • Innovation