Comparative advantage in routine production

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Our starting point

- We want to understand why countries at a similar level of development and with similar factor endowments specialize in different types of goods.
- We want to understand why countries with similar endowments appear to adjust very differently to the ongoing process of globalization and technological change.

Our approach:

→ A key feature of both processes (trade integration & technological change) is that they bring about labor reallocation.
→ We know that labor reallocation is costly, our hypothesis is that the extent of barriers to worker mobility may be country-specific.
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Main findings

Theory:
1. Comparative advantage predictions for countries that are identical in every respect, except for their ability to smooth labor reallocation
2. Microfoundations for differential smoothing are in preparation

Empirics:
1. Characterizing industries by routine-intensity and countries by substitution elasticity passes ‘sniff test’
2. Countries differ starkly in the routine-intensity of their net exports
3. Culture or institutional differences are able to predict specialization
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Implications:
1. Institutional characteristics that facilitate transitions in the labor market may be a source of comparative advantage
2. Workers benefit relatively more from technological change and trade integration in countries with flexible labor markets
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Roadmap

1. Literature review
2. The model
   - Production function
     - Parameter assumptions
     - CES properties
   - Comparative advantage predictions
3. Microfounding country-level differences in substitutability (ongoing)
4. Evidence on the pattern of trade
   - Uncover country ranking in terms of routine-intensity of exports
   - Relate country ranking to country characteristics (‘endowments’)
Heckscher-Ohlin framework: importance of endowments

- Sectors differ in factor intensities (which are universal)
- Countries differ in endowments (which are fixed)
- Different relative autarky prices provide incentive for trade
  - Country endowed with a lot of $X$ specializes in $X$-intensive good

Most important sources of comparative advantage may be man-made
- Porter (1990): Country with strong universities specializes in knowledge-intensive goods
- Nunn (2007): Country with strong rule of law specializes in contract-intensive goods (which use a lot of differentiated inputs)
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1. Literature Review

**Labor market perspective: importance of $K$-$L$ substitution**

- **Labor literature on job polarization & technical change:**
  - Technological change (innovation) leads to labor displacement from routine tasks (Autor, Levy, Murnane, 2003; Acemoglu & Autor, 2013)
  - Strong employment protection laws discourage firms from investing in high-risk, high-return projects (Bartelsman, Gauthier, De Wind, 2016)
  - Dynamic: labor has comparative advantage in new tasks → opposite effects of automation and innovation (Acemoglu & Restrepo, 2016)

- **Related applications:**
  - Macro: high $K$-$L$ substitutability becomes more valuable once countries have accumulated more $K$ → leads to higher GDP per capita (Klump et al., 2000)
  - Trade: strength of financial institutions leads to investment in higher-risk, higher-return projects (Bonfiglioli et al., 2016)
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The structure of production

- We borrow two-tiered production function from the labor literature
- Production technology of final goods is Cobb-Douglas
  \[ Y_g = z A_g^{1-\beta} M_g^\beta \]
- Abstract tasks are carried out by non-routine labor \( A_g = L_g^a \)
- Routine tasks are produced with CES production function
  \[ M_g = Z \left[ \alpha (K_g)^\mu + (1 - \alpha) (L_g^m)^\mu \right]^{1/\mu} \]
- Standard assumptions:
  - Routine-intensity \( \beta \) is sector, but not country-specific \( \rightarrow \beta_g \)
  - \( \mu \in [0, 1] \), such that elasticity of substitution \( \sigma = (1 - \mu)^{-1} > 1 \)
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- Novel assumptions:
  - Countries have the same efficiency \( (z, Z) \) and endowments \( (K/L) \).
  - \( K-L \) substitutability \( \sigma \) is country, but not sector-specific \( \rightarrow \sigma_{i} \).
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Two-tiered production function

- Assumptions of sector-specific $\beta_g$ and country-specific $\sigma_i$ lead to

$$Y_{igt} = z' \left( L^a_{igt} \right)^{1-\beta_g} \left( (1 - \alpha)(L^m_{igt})^{\mu_i} + \alpha(K_{igt})^{\mu_i} \right)^{\beta_g} \mu_i$$

- Verify whether there is empirical support for these assumptions

- Using EU-KLEMS data

  - For 20 countries, 33 sectors, 25 years
  - Assume high-skill workforce is $L^a$ ($L^m = L - L^a$)
  - Calculate $\frac{L^a}{L^a + L^m}$ and $\ln(\frac{K}{L^m})$
  - Estimate $\beta_{ig}$ and $\mu_{ig}$ exploiting only time-series variation

- ANOVA analysis provides support that

  - Country FE have most explanatory power for variation in $\ln(\frac{K}{L^m})$ & $\mu_{ig}$
  - Sector FE have most explanatory power for variation in $\frac{L^a}{L^a + L^m}$ & $\beta_{ig}$
## ANOVA

<table>
<thead>
<tr>
<th>Dep. Var.</th>
<th>Sector</th>
<th>Country</th>
<th>Year</th>
<th>Sector</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{L^a}{L^a + L^m})</td>
<td>9.98</td>
<td>5.41</td>
<td>2.84</td>
<td>62.03</td>
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<tr>
<td>(54.2%)</td>
<td>(28.5%)</td>
<td>(0.00)</td>
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<tr>
<td>(\ln\left(\frac{K}{L^m}\right))</td>
<td>3843</td>
<td>466</td>
<td>789</td>
<td>1118</td>
<td>114.73</td>
<td>320.63</td>
</tr>
<tr>
<td>(12.1%)</td>
<td>(20.5%)</td>
<td>(29.1%)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
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</tbody>
</table>

### (b) Estimated parameters

| \(\beta_{ig}\) | 25.52 | 5.30 | 2.67 | 6.03 | 5.01 |
| (20.8%) | (10.5%) | (0.00) | (0.00) |
| \(\sigma_{ig}\) | 1636 | 191 | 217 | 1.03 | 1.93 |
| (11.7%) | (13.3%) | (0.43) | (0.01) |
Properties of CES function

- Cannot easily predict comparative advantage from comparative statics of \( \frac{\partial (Y_1/Y_2)}{\partial \sigma} \) or \( \frac{\partial (p_1/p_2)}{\partial \sigma} \)

- CES is defined as production function with the following property:

\[
\sigma = \frac{d \ln(K/L)}{d \ln(F_k/F_l)}
\]

- It can be re-written as second-order differential equation in \( F(K, L) \); solution contains two integration constants

- The elasticity of substitution is implicitly defined as a point elasticity, related to one particular point on one particular isoquant

- Requiring a CES to go through one particular point, say \( \{Y_0, K_0, L_0, w_0/r_0\} \), pins down the integration constants

- Comparative statics need to incorporate that \( \frac{\partial Z}{\partial \sigma} \neq 0 \) and \( \frac{\partial \alpha}{\partial \sigma} \neq 0 \)
Work with normalized CES

- Klump, McAdam, Willman (2012):

\[(a) \quad Y = Y_0 \left[ (1 - s_0) \left( \frac{K}{K_0} \right)^\mu + s_0 \left( \frac{L^m}{L_0^m} \right)^\mu \right]^{\frac{1}{\mu}} \quad \text{with} \quad s_0 = \frac{w_0 L_0^m}{Y_0} \]

(b) or substitute \( \alpha'(\mu) = \frac{k^{1-\mu}}{k^{1-\mu} + \omega} \) and \( Z'(\mu) = \ldots \)
Labor allocation to routine and abstract tasks

- Solving the model \((L_1^m, L_2^m, L_1^a, L_2^a, K_1, K_2)\)
  - Upper tier problem: optimal factor use in final good production
  - Lower tier problem: optimal factor use in routine input production
  - Cost minimization in routine production and capital market clearing delivers total amount of routine output
  - Cost minimization in routine production and labor market clearing delivers total amount of labor available for abstract tasks
  - Optimal factor use in final good production and labor market clearing delivers second expression for total amount of routine output

- Solution for relative wage \(\omega_i(\mu; L, K, \alpha, c) = (w_i/r_i)\) is the positive real root of polynomial of degree \(\sigma_i\) (assuming \(\sigma_i\) integer)

\[
F_i(\omega_i; \cdot) = \frac{L}{K} (\omega_i)^{\sigma_i} - c (\omega_i)^{\sigma_i-1} - (1 + c) \left(\frac{1 - \alpha}{\alpha}\right)^{\sigma_i} = 0
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Response to capital deepening leads to comp. advantage

- We are interested in comparative statics: how variation in $\sigma$ impacts labor reallocation across tasks when capital stock increases.
- To make a sound comparison, we normalize the CES function:
  - benchmark point at which factor allocation invariant to $\sigma$;
  - enables us to focus on structural effect of higher substitutability.
- $\sigma$ is inherently a parameter that governs adjustment/dynamics:
  - Capital deepening could create opportunities for trade between ex-ante identical countries;
  - Capital deepening could tilt comparative advantage (CA) in a certain direction, regardless of the initial CA.
Comparative advantage predictions

- Study capital deepening relatively to the point of normalization:
  - to clear $K$ market, relative wage $ω^*_i$ has to increase
  - is especially the case in the low-$σ$ country
  - makes labor relatively expensive in the low-$σ$ country
  - makes routine output relatively expensive in the high-$σ$ country

- HO-type predictions for the pattern of trade
  - each country exports the final good that uses more intensively the factor in which the country is more abundant
  - high-$σ$ country has become relatively non-routine labor abundant
  - high-$σ$ country specializes in the non-routine intensive good

- Factor price equalization
  - relative price of labor and of routine output are equalized
  - through further divergence in capital intensity of routine production
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Intuition from labor adjustment

- Consider 2 countries identical in all respects except for $\sigma$
- They start from the same point of production (no trade initially)
- Add some extra $K$ to both countries’ endowment
- Extra $K$ can only be deployed in the production of routine tasks, freeing up labor to be redeployed producing abstract tasks: $\Delta L^a = -\Delta L^m > 0$
- $\Delta L^a$ is absorbed by shifting output towards the non-routine-intensive sector
- This adjustment goes furthest in the high-$\sigma$ country: relative to the low-$\sigma$ country its price for the non-routine-intensive good falls (increases less)

$\Rightarrow$ the low-$\sigma$ country will be a net exporter of the routine-intensive good
Possible mechanisms to micro-found (low) $\sigma$

Recall $\sigma = \frac{d \ln(K/L)}{d \ln(F_k/F_l)}$

- Simplest mechanism: Variation in severance pay incurred by the firm
- Labor market rigidities—e.g. mobility costs, rigid work practices, search costs—drive a wedge between average and marginal wages and reduce adjustments to shocks
- Legal obligation to retrain workers after termination to split burden of educating workers who transition from $L^m$ to $L^a$ between the firm and society at large (financed by taxes)
- In countries with low bargaining power for labor, workers can appropriate less of the returns to ($K$-biased) innovations and firms will choose more risky projects (as they can adjust $K/L$ to take advantage of innovations)
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We follow the 2-step approach of Costinot (2009):

**Step 1:** Retrieve pattern of specialization, i.e. ranking of countries in terms of routine versus non-routine intensity of (net) exports

**Step 2:** Explain country rankings using country characteristics that proxy for $\sigma$ (institutional, cultural, organizational, labor-market features,...)

- Could do it in 1 step: regress exports on ‘sector$_g \times \sigma_i$-proxy’
  - Useful to gauge quantitative importance of this channel relative to other HO-inspired channels from the literature
Reduced form evidence in two-step analysis

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Step 1: retrieve routine intensity of exports

- Estimate on two separate samples
  - 43 largest exporters $i$ and all importers $j$ (small countries are grouped)
  - Within EU trade

- Key explanatory variable: industry ranking w.r.t. routine intensity $r_g$
  - 140 US census industries, 77 in manufacturing
  - Correlated positively with skill intensity, but not identical ($\rho = -0.62$)
  - Matched to HS 4-digit trade data and aggregated to industry

- We run the following regression:

$$\ln EXP_{gij} = \tau_{ij} + \tau_{gj} + \gamma_i r_g + \epsilon_{gij}$$

- Estimated separately for 1995, 2005, 2015 to see whether patterns are stable (using 2-year average exports to smooth outliers)
- $\tau_{ij}$ captures bilateral barriers and exporter characteristics
- $\tau_{gj}$ captures variation in import barriers and preferences

- CA pattern is given by ranking of exporter fixed effects: $\gamma_i$
(a) Countries with negative correlation -- specializing in non-routine intensive industries

(b) Countries with positive correlation -- specializing in routine intensive industries

(Slight convergence or weakening of routineness-based comparative advantage)
Within EU ranking by routineness ($\gamma_i$)

(Large differences, but shrinking over time)
Step 2: connect pattern of CA to country characteristics

Which institutional or cultural dimensions explain the cross-country variation in the routine-intensity of exports?

We test the following dimensions ($l_i$)

1. Quality of institutions: ‘Rule of law’
2. Quality of the workforce: ‘Ability to perform’ (Costinot, 2009)
3. Cultural traits: LT orientation; $1/\text{uncertainty avoidance}$ (Hofstede, ’80)
4. Lack of frictions in other domain: ‘Internal migration’ ($\text{mobility}$)
5. Labor market regulations: strictness of employment protection (OECD)

We run the following regression:

$$\ln \hat{\gamma}_i = \delta_0 + \delta_1 l_i + \epsilon_i$$

Recall that $\hat{\gamma}_i$ increases in routine-intensity of exports: expect $\delta_1 < 0$
Country characteristics that explain $\hat{\gamma}_i$ in full sample

<table>
<thead>
<tr>
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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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<td><strong>log(GDP/capita)</strong></td>
<td>-0.619***</td>
<td>-0.168</td>
<td>-0.482***</td>
<td>-0.553***</td>
<td>-0.372*</td>
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<tr>
<td></td>
<td>(2.7)</td>
<td>(0.8)</td>
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<td><strong>Rule of law</strong></td>
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<td></td>
<td>(0.1)</td>
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<tr>
<td><strong>Quality of workforce</strong></td>
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<td>-0.538***</td>
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<td><strong>Observations</strong></td>
<td>43</td>
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<tr>
<td><strong>Adjusted R²</strong></td>
<td>0.34</td>
<td>0.44</td>
<td>0.44</td>
<td>0.30</td>
<td>0.15</td>
</tr>
</tbody>
</table>

- Coefficients are standardized $\beta$ coeff. that measure effects in SE, t-stats in brackets
- Without GDP/capita control, coefficient on ‘Rule of law’ is -0.512***
- Results similar in 1995/2015; using 1/SE as weights; controlling for Rule of law
Country characteristics that explain $\hat{\gamma}_i$ within EU

<table>
<thead>
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<td>log(GDP/capita)</td>
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<td>Internal migration</td>
<td></td>
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<td>-0.365</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.6)</td>
<td></td>
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</tr>
<tr>
<td>Strictness of EPL</td>
<td></td>
<td></td>
<td></td>
<td>0.607***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3.4)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>27</td>
<td>16</td>
<td>26</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.43</td>
<td>0.19</td>
<td>0.43</td>
<td>0.18</td>
<td>0.45</td>
</tr>
</tbody>
</table>

- Coefficients are standardized $\beta$ coeff. that measure effects in SE, t-stats in brackets
- Without GDP/capita control, all coefficients become (strongly) significant
- Except for ‘Strictness of EPL’ most magnitudes are similar to full sample results
What do we learn?

- We learn that institutions which facilitate labor reallocation across tasks may be a source of comparative advantage
  1. Countries that adjust more smoothly to technological change (e.g. better $K$) specialize in production of non-routine-intensive goods
  2. Workers in such countries benefit more from opening up to trade

- Way forward: connect $\sigma$ to the magnitude of adjustment costs
  1. Current approach is reduced form: countries differ in $K-L$ substitutability, but this is a feature of the production function
  2. Microfoundation of $\sigma$: worker- or employer-side friction that reduces the sensitivity of $K/L$ ratio to changes in $w/r$
  3. If this changes the incentives for automation or $K$ accumulation, the mechanism would be re-enforcing
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