Comparative advantage in routine production

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FIRES

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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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)
  - Costinot (2009): Country with high-quality workforce specializes in complex goods (which require a lot of training to master many tasks)

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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 $\rightarrow$ 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 $\rightarrow$ 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

$$M_g = Z\left[\alpha\left(K_g\right)^{\mu} + (1-\alpha)\left(L_g^m\right)^{\mu}\right]^{1/\mu}$$

- Standard assumptions:
  - Routine-intensity β is sector, but not country-specific $\rightarrow$ β_g
  - $\mu \in [0,1]$, such that elasticity of substitution $\sigma = (1-\mu)^{-1} > 1$

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  - Countries have the same efficiency (z, Z) and endowments (K/L)
  - K-L substitutability σ is country, but not sector-specific $\rightarrow$ σ_i

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Two-tiered production function

- Assumptions of sector-specific β_g and country-specific σ_i lead to

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

- 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 $\left(\frac{K}{L^m}\right)$
  - Estimate β_{ig} and μ_{ig} exploiting only time-series variation
- ANOVA analysis provides support that
  - Country FE have most explanatory power for variation in ln $\left(\frac{K}{L^m}\right)$ & μ_{ig}
  - Sector FE have most explanatory power for variation in $\frac{L^a}{L^a+L^m}$ & β_{ig}

ANOVA

	Sum of squares				F-statistic (N,1)		
	Dep.Var.	Sector (33)	Country (20)	Year (25)	Sector (33)	Country (20)	Year (25)
(a) Observable variables							
$\frac{\overline{L^a}}{L^a+L^m}$	9.98	5.41	2.84		62.03	53.69	
		(54.2%)	(28.5%)		(0.00)	(0.00)	
$\ln\left(\frac{K}{L^m}\right)$	3843	466	789	1118	114.73	320.63	363.49
		(12.1%)	(20.5%)	(29.1%)	(0.00)	(0.00)	(0.00)
(b) Estimated parameters							
β_{ig}	25.52	5.30	2.67		6.03	5.01	
		(20.8%)	(10.5%)		(0.00)	(0.00)	
σ_{ig}	1636	191	217		1.03	1.93	
(if < 20)		(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) $$Y = Y_0 \left[(1 - s_0) \left(\frac{K}{K_0} \right)^{\mu} + s_0 \left(\frac{L^m}{L_0^m} \right)^{\mu} \right]^{\frac{1}{\mu}} \quad \text{with } s_0 = \frac{w_0 L_0^m}{Y_0}$$

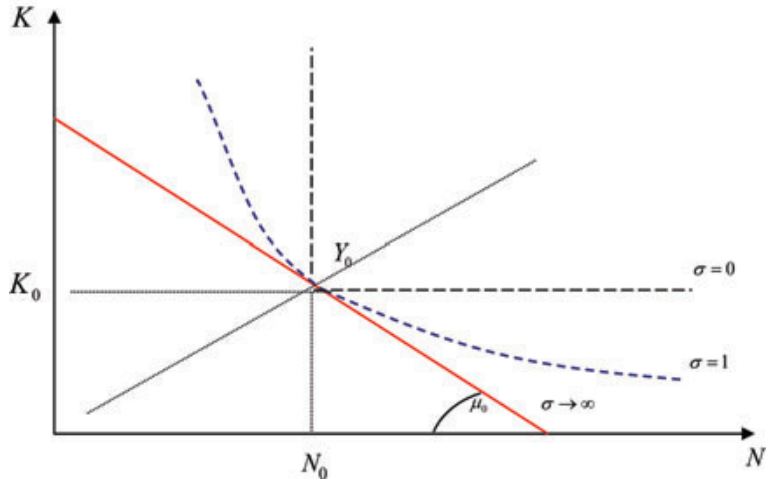

Figure 1. Isoquants of Normalized CES Production Functions.

(b) or substitute $\alpha'(\mu) = \dfrac{k^{1-\mu}}{k^{1-\mu} + \omega}$ 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 σ_i (assuming σ_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 σ 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 σ
  - enables us to focus on structural effect of higher substitutability
- σ 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 σ
- 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: $\Delta L^a = -\Delta L^m > 0$
- ΔL^a is absorbed by shifting output towards the non-routine-intensive sector
- This adjustment goes furthest in the high-σ country: relative to the low-σ country its price for the non-routine-intensive good falls (increases less)

$\Rightarrow$ the low-σ country will be a net exporter of the routine-intensive good

Possible mechanisms to micro-found (low) σ

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

- 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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Reduced form evidence in two-step analysis

- 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 σ (institutional, cultural, organizational, labor-market features,...)

- Could do it in 1 step: regress exports on '$\text{sector}_g \times \sigma_i$-proxy'
  - Useful to gauge quantitative importance of this channel relative to other HO-inspired channels from the literature
  - E.g. Nunn (2007) and Chor (2010)

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Step 1: retrieve routine intensity of exports

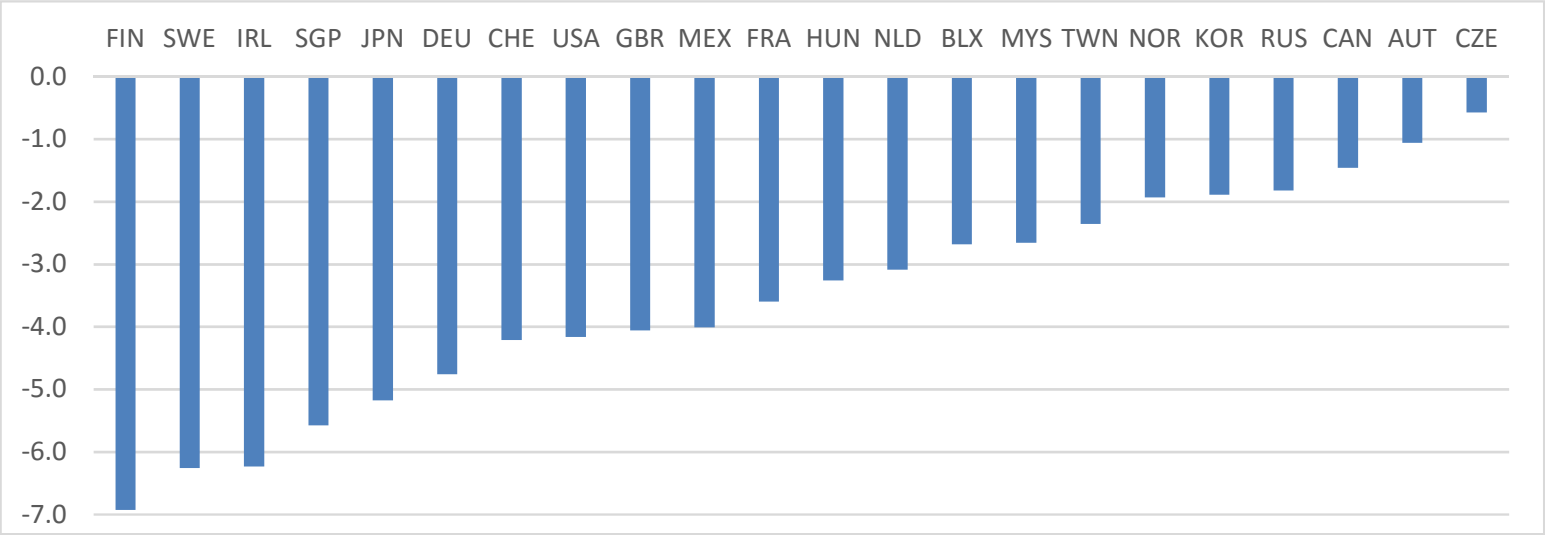
- Estimate on two separate samples
  - 43 largest exporters i and all importers j (small countries are grouped)
  - Within EU trade
- Key explanatory variable: industry ranking w.r.t. routine intensity r_g
  - Using task codifiability ranking of Autor, Levy, Murnane (2003)
  - 140 US census industries, 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:

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

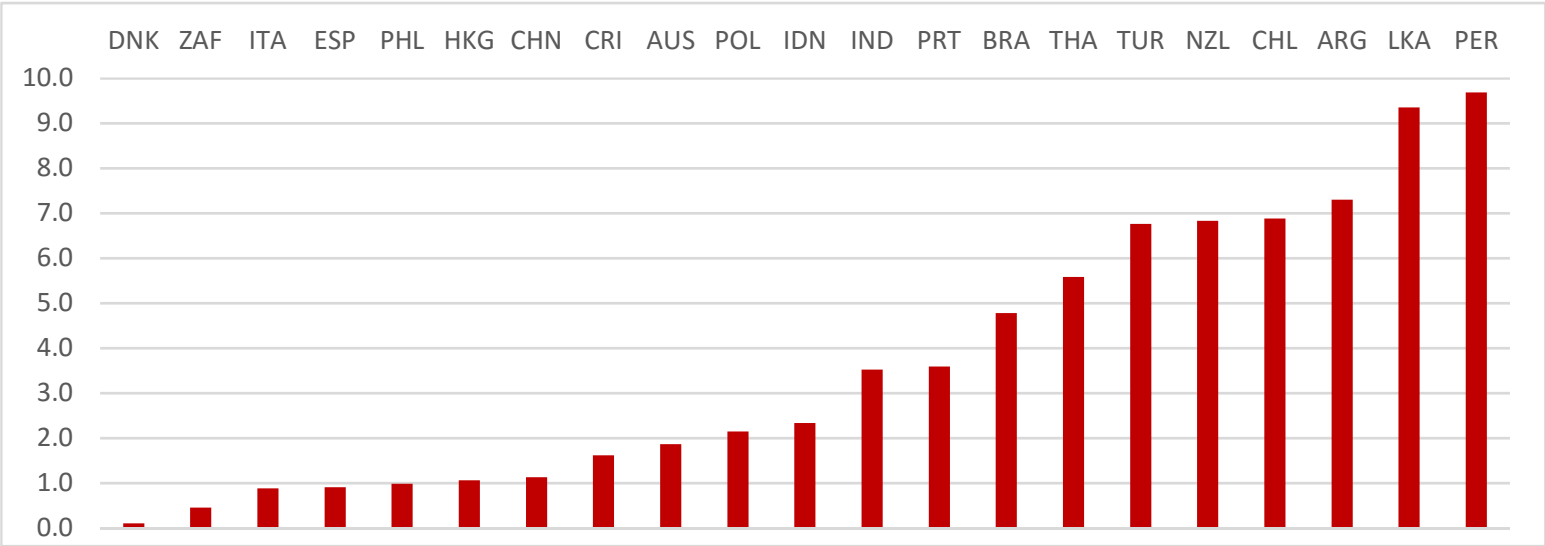
  - ↪ Estimated separately for 1995, 2005, 2015 to see whether patterns are stable (using 2-year average exports to smooth outliers)
  - ↪ τ_{ij} captures bilateral barriers and exporter characteristics
  - ↪ τ_{gj} captures variation in import barriers and preferences
- CA pattern is given by ranking of exporter fixed effects: γ_i

Country ranking in terms of routineness (γ_i) for 2005

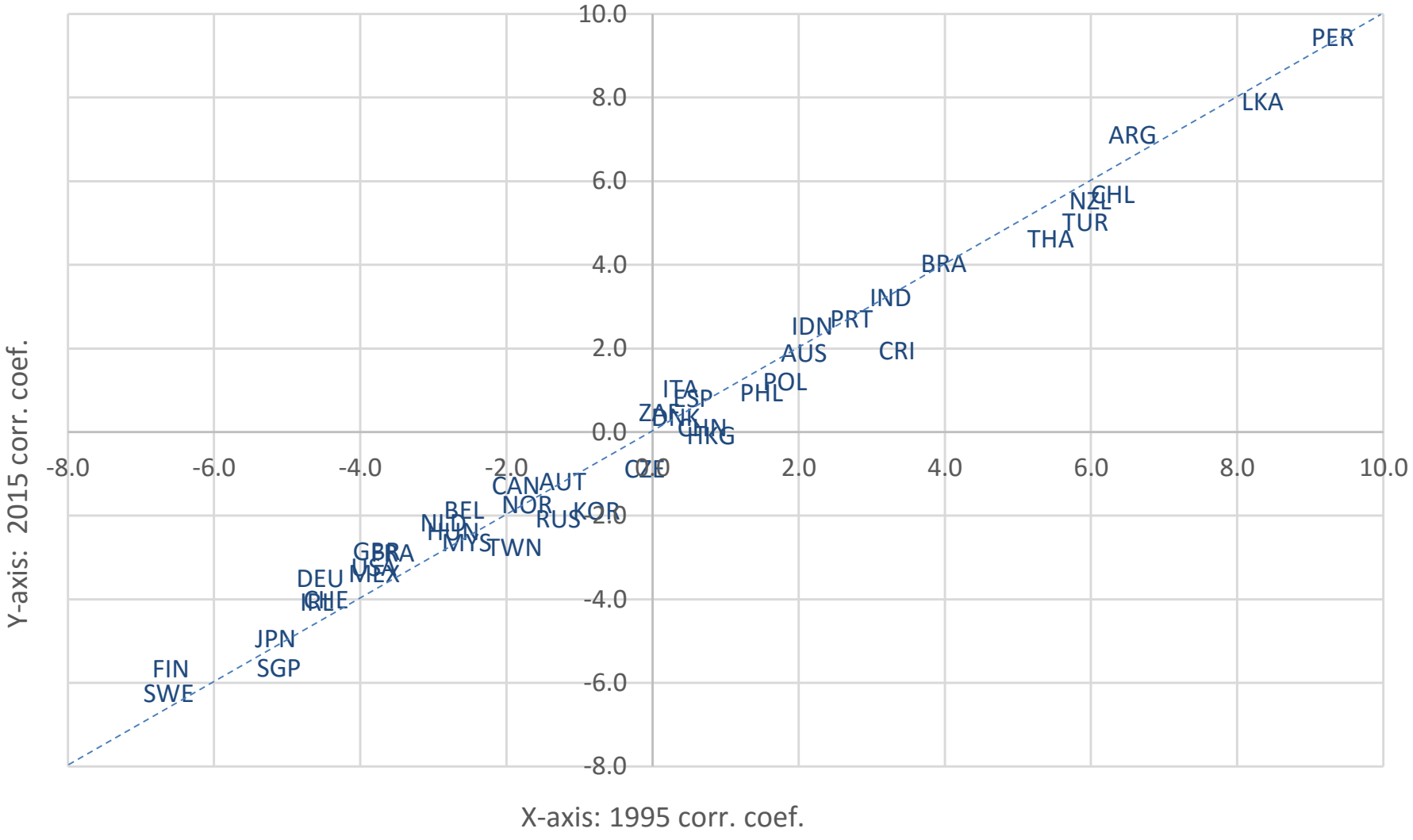
(a) Countries with negative correlation -- specializing in non-routine intensive industries



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

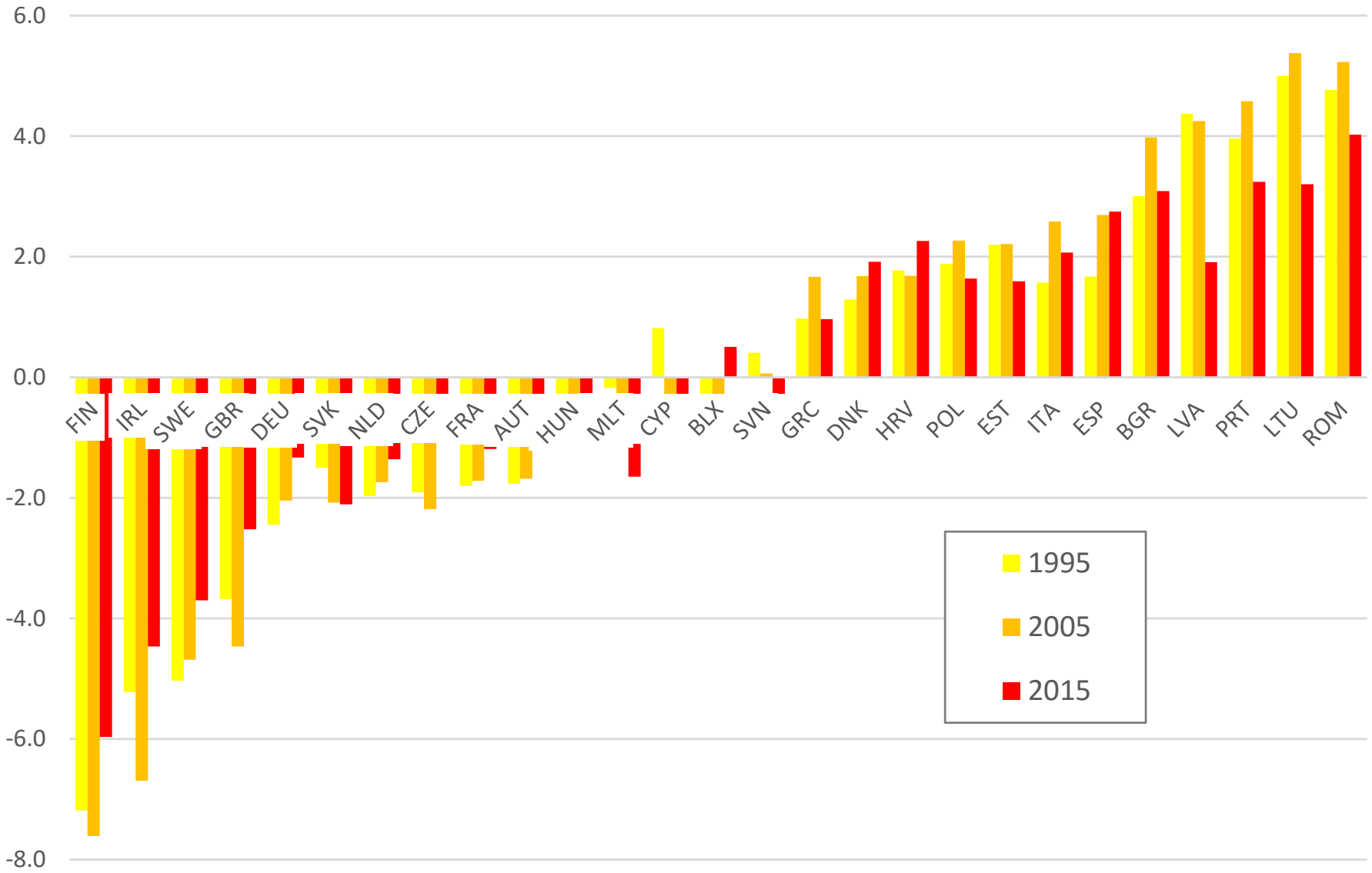


Evolution of routineness ranking (1995 versus 2015)



(Slight convergence or weakening of routiness-based comparative advantage)

Within EU ranking by routineness (γ_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 (I_i)
  1. Quality of institutions: 'Rule of law'
  2. Quality of the workforce: 'Ability to perform' (Costinot, 2009)
  3. Cultural traits: LT orientation; 1/uncertainty avoidance (Hofstede, '80)
  4. Lack of frictions in other domain: 'Internal migration' (mobility)
  5. Labor market regulations: strictness of employment protection (OECD)
- We run the following regression:

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

↪ 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

	(1)	(2)	(3)	(4)	(5)
log(GDP/capita)	-0.619***	-0.168	-0.482***	-0.553***	-0.372*
	(2.7)	(0.8)	(4.0)	(3.3)	(1.7)
Rule of law	0.009				
	(0.1)				
Quality of workforce		-0.538***			
		(2.6)			
Hofstede/culture			-0.375***		
			(3.1)		
Internal migration				-0.195	
				(1.2)	
Strictness of EPL					-0.149
					(0.7)
Observations	43	43	42	26	26
Adjusted R^2	0.34	0.44	0.44	0.30	0.15

- Coefficients are standardized β 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

	(1)	(2)	(3)	(4)	(5)
log(GDP/capita)	-0.330	0.027	-0.632***	-0.264	-0.317*
	(1.1)	(0.1)	(4.1)	(1.2)	(1.8)
Rule of law	-0.384				
	(1.3)				
Quality of workforce		-0.569			
		(1.3)			
Hofstede/culture			-0.190		
			(1.2)		
Internal migration				-0.365	
				(1.6)	
Strictness of EPL					0.607***
					(3.4)
Observations	27	16	26	18	18
Adjusted R^2	0.43	0.19	0.43	0.18	0.45

- Coefficients are standardized β 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 σ 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 σ: 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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