Proximity as a Source of Comparative Advantage

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Introduction

- Classic Ricardo: specialize in good in which relatively more productive
- Many-good many-country Ricardo [*Costinot*(2009)]: export relatively more in sector in which relatively more productive
- Ranking of relative technology stocks establishes ranking of relative sectoral exports [*CDK*(2012)]
- BUT: increasingly international production unbundling
- Contribution of input cost channel to define comparative advantage?

Ricardo in the data

- What's inside the black box of technology? [*Chor*(2010)]
- Complementarity specific country-sector characteristics
- Welfare analysis: trade in inputs magnifies gains from trade [*EK*(2002), *CP*[2012]]
- BUT: what about role of inputs in determining pattern of trade?
- Country-sector complementarity in different dimension:
  - Cost of inputs matters more in certain sectors
  - Countries can be ranked in terms of proximity to suppliers

What this paper does

- Uses stylized model to spell out mechanism through which inputs may become source of comparative advantage
- Derives theoretically grounded measure of proximity *to suppliers*
- Shows that this proximity characteristic creates wedge in the cost of inputs across countries
- Verifies in data that input cost channel co-determines intersectoral specialization
- Quantifies contribution of the input cost channel relatively to technology

Production function

- Finite number of sectors k
- Within sector: infinite countable number of varieties $\alpha \in A \equiv \{1, ..., \infty\}$
- Variety production function Cobb-Douglas (inputs & labor)

$$\omega_i^k = \nu_i^{1-\zeta^k} P_i^{\zeta^k} \epsilon^k$$

  where ζ^k is 'input intensity' characteristic of sector
- Landed cost given by

$$c_{ij}^k(\alpha) = \frac{\omega_i^k \tau_{ij}^k}{z_i^k(\alpha)}$$

- z drawn from Frechet: $Prob\,[Z > z] = 1 - \exp\left[-\left(z/z_i^k\right)^{-\theta}\right]$

Price indices

- Perfect competition: least cost variety bought

$$p_j^k(\alpha) = \min_i \left[c_{ij}^k(\alpha) \right]$$

- Sectoral price index in the destination across all exporters

$$E\left[p_j^k(\alpha)^{1-\sigma} \right] = (P_j^k)^{1-\sigma} = \Gamma \left[\Phi_j^k \right]^{-(1-\sigma)/\theta}$$

 1. $\Gamma = \Gamma\left[(\theta + 1 - \sigma)/\theta \right]$
 2. $\Phi_j^k = \sum_{i \in I} \left[c_{ij}^k \right]^{-\theta}$
 3. $c_{ij}^k = \omega_i^k \tau_{ij}^k / z_i^k$, with z_i^k fundamental sectoral productivity

- Overall price index (cost of input bundle):

$$P_i = \prod_{k=1}^{K} P_i^{k\,\gamma^k}$$

- Sectoral trade share: $\pi_{ij}^k = \left[c_{ij}^k \right]^{-\theta} / \Phi_j^k$

Proximity characteristic

- Use definition of sectoral price index

$$P_j^k = \kappa \left[\Phi_j^k\right]^{-1/\theta}$$

- To write:

$$P_j^k = \kappa \left[\overline{\Phi}^k\right]^{-1/\theta} \left\{\sum_{n=1}^{N} \tau_{nj}^{\theta} \pi_{nj}^{k}\right\}^{1/\theta}$$

- Use definition of overall price index: $P_j = \prod_{k=1}^{K} \left[P_j^k\right]^{\gamma^k}$
- To write:

$$P_j = \kappa \prod_{k=1}^{K} \left[\overline{\Phi}^k\right]^{-\gamma^k/\theta} \prod_{k=1}^{K} \left\{\sum_{n=1}^{N} \tau_{nj}^{\theta} \pi_{nj}^{k}\right\}^{\gamma^k/\theta}$$

Industry-specific cost component

- Cost of input bundle consists of:
  - world's best practice across sectors
  - destination-specific proximity to suppliers:
    $\rightarrow$ trade costs weighed by probability this supplier is least cost
- Industry-specific cost component ω^k:

$$\omega_j^k = \underbrace{\epsilon^k \kappa^{\zeta^k} \left\{ \prod_{s=1}^{S} \left[\overline{\Phi}^s \right]^{-\gamma^s/\theta} \right\}^{\zeta^k}}_{sector-specific}$$

$$\underbrace{\left[\nu_j^k \right]^{1-\zeta^k} \left\{ \prod_{s=1}^{S} \left[\sum_{n=1}^{N} \tau_{nj}^{\theta} \pi_{nj}^{s} \right]^{\gamma^s/\theta} \right\}^{\zeta^k}}_{exporter-sector-specific}$$

Pattern of RCA

- Relative sectoral exports to market j

$$\ln\left\{X_{ij}^k/X_{i'j}^k\right\} = \theta\left[\ln\frac{z_i^k}{z_{i'}^k} - (1-\zeta^k)\ln\frac{\nu_i^k}{\nu_{i'}^k} - \ln\frac{\tau_{ij}\tau_i^{E,k}}{\tau_{i'j}\tau_{i'}^{E,k}}\right]$$

$$+\theta\left[-\zeta^k\ln\left\{\frac{\prod_{s=1}^S\left[\sum_{n=1}^N\tau_{ni}^\theta\pi_{ni}^s\right]^{\gamma^s/\theta}}{\prod_{s=1}^S\left[\sum_{n=1}^N\tau_{ni'}^\theta\pi_{ni'}^s\right]^{\gamma^s/\theta}}\right\}\right]$$

- Proximity: $\overline{PROX}_i^M = 1/\prod_{s=1}^S\left\{\sum_{n=1}^N\pi_{ni}^s\tau_{ni}^\theta\right\}^{\gamma^s/\theta}$.
- Four exporter-sector cost components: technology, wages, proximity, export costs
- Retrieved in estimation relatively benchmark country and sector: exporter-sector dummy

Estimation: Three-step procedure

- **First step**: retrieve exporter-sector dummies (cross-section)

$$X_{ij,t}^{k} = \exp\left\{fe_{ij,t} + fe_{j,t}^{k} + fe_{i,t}^{k} + \xi_{ij,t}^{k}\right\}$$

- Dummy contains cost components specific to exporter-sector:

$$\widehat{fe}_{i,t}^{k} = \theta \ln(z_{i,t}^{k}) - \theta(1-\zeta^{k}) \ln \nu_{i,t}^{k} - \theta\zeta^{k} \ln(P_{i,t}) - \theta \ln(\tau_{i,t}^{E,k})$$

- **Second step**: estimate model parameters (all years pooled)

$$\widehat{fe}_{i,t}^{k} = \theta\left[\ln \widehat{z}_{i,t}^{k} - (1-\zeta^{k}) \ln \widehat{\nu}_{i,t}^{k}\right] + fe_{t} + \lambda_{it}^{k}$$

$\widehat{z}_{i,t}^{k}$: TFP; $\widehat{\nu}_{i,t}^{k}$: wages (instrumented)

Three-step procedure (contd.)

- Residual of second step $\widehat{\lambda}_{it}^{k}$ contains:
  - index of trade frictions incurred in sourcing inputs (proximity)
  - trade cost paid to get domestic varieties to world markets
- **Third step**: proximity mechanism in residual component?
- Split sample by proximity & form pairwise sectoral residuals
- Interact relative proximity with sectoral input intensity
- Look at sign and significance of β_1 (pooled data)

$$\frac{1}{\widehat{\theta}}\left[\widehat{\lambda}_{i,t}^{k}-\widehat{\lambda}_{i',t}^{k}\right]=\beta_0+\beta_1\ln\left\{\left(\frac{\widehat{\overline{PROX}}_{i,t}^{M}}{\widehat{\overline{PROX}}_{i',t}^{M}}\right)^{\widehat{\zeta}^{k}}\right\}$$

$$+fe_{i,t}-fe_{i',t}+\eta_{ii',t}^{k}$$

Data: 1995-2009

- WIOD: ISIC Rev.3 2-digit sectors
  output, inputs, labor expenditure, workforce, capital expenditure, investment, capital stocks
- COMEXT: CN8 digit data aggregated to 2-digit
  bilateral imports by EU-15 from main partners
- COMTRADE: total imports and exports by sector
- ANBERD: R&D data (nominal expenditure, research personnel)
- Statistical Yearbooks China: R&D data

Technology and wages

- TFP: fit Cobb-Douglas production function

$$\ln(\bar{z}_i^k) = \ln Y_i^k - \beta_{I,i}^k \ln I_i^k - \beta_{H,i}^k \ln H_i^k - \beta_{K,i}^k \ln K_i^k$$

Y, I real output (inputs), H hours worked, K capital use

- Wages
  1. hourly wage ν_i^k reported in WIOD
  2. hourly wage adjusted for worker efficiency

$$\bar{\nu}_i^k = \sum_{edu} \frac{\omega_{edu,i}^k}{\bar{\omega}_{edu,i}^k} \bar{\nu}_{edu,i}^k$$

$edu = \{l, m, h\}$ is skill; ω ($\bar{\omega}$) is cost (hour) share by skill; $\bar{\nu}_{edu,i}^k$ is efficiency-adjusted wage by skill

$$\bar{\nu}_{edu,i}^k = \nu_{edu,i}^k e^{-gS_{edu}}$$

where $g = .06$: return to education; S_{edu}: average nb years schooling

Instruments

- TFP instrumented with R&D
  1. R&D personnel and real capital stocks: $[(I), (II)]$
  2. Deflated R&D expenditure: $[(III), (IV)]$

- Wages instrumented with workforce
  1. Number persons engaged: $[(II), (IV)]$
  2. Efficiency-adjusted workforce: $[(I), (III)]$

$$\overline{L}_i^k = \sum_{edu} \overline{L}_{edu,i}^k$$

where $\overline{L}_{edu,i}^k$ is efficiency adjusted nb workers

$$\overline{L}_{edu,i}^k = L_{edu,i}^k e^{gS_{edu}}$$

- Bottleneck: R&D data
- Drops: Russia, Bulgaria, Brazil, India, Indonesia, Lithuania, Latvia

Sample of countries

Table: Sample of countries: from 42 to 26

ID	Country	Type	ID	Country	Type
AT	Austria	intra-eu15	PL	Poland	ceec
BE	Belgium-Luxembourg	intra-eu15	RO	Romania	ceec
DK	Denmark	intra-eu15	SK	Slovakia	ceec
FI	Finland	intra-eu15	SI	Slovenia	ceec
FR	France	intra-eu15	TR	Turkey	ceec
DE	Germany	intra-eu15	CA	Canada	other devpd
GR	Greece	intra-eu15	JP	Japan	other devpd
IE	Ireland	intra-eu15	KR	Korea	other devpd
IT	Italy	intra-eu15	NO	*Norway*	other devpd
NL	Netherlands	intra-eu15	CH	*Switzerland*	other devpd
PT	Portugal	intra-eu15	US	USA	other devpd
ES	Spain	intra-eu15	BR	*Brazil*	other emerging
SW	Sweden	intra-eu15	CN	China	other emerging
GB	United Kingdom	intra-eu15	IN	*India*	other emerging
BG	*Bulgaria*	ceec	ID	*Indonesia*	other emerging
HR	*Croatia*	ceec	MY	*Malaysia*	other emerging
CZ	Czech Republic	ceec	MX	Mexico	other emerging
EE	Estonia	ceec	RU	*Russia*	other emerging
HU	Hungary	ceec	SG	*Singapore*	other emerging
LV	*Latvia*	ceec	TW	Taiwan	other emerging
LT	*Lithuania*	ceec	TH	*Thailand*	other emerging

- Sample: focus on main EU15 trading partners
- In blue: dropped b/c absent from WIOD database
- In red: R&D bottleneck

Estimated parameters

- Estimated heterogeneity $\widehat{\theta}$ (EK: 8.3; CDK: 6.5; SW: 4.5):
  1. overidentified: 7.28(.51), 6.72(.43)
  2. identified: 7.84(.52), 7.28(.45)
  3. NB: 4.5 in one-sector economy
- Precisely estimated coefficient on hourly wage: $-\theta(1-\zeta_k)$
- Estimated sectoral input intensity $\widehat{\zeta_k}$:
  1. one sector economy: $\zeta_k = \zeta = .69$ (matches data)
  2. Sector-specific: strongly correlated ζ_k in WIOD

Sectoral input intensity

Table: Sectoral factor share of inputs

	DATA	(I)	(II)	(III)	(IV)
17-18	0.68	0.82	0.79	0.79	0.78
19	0.72	0.97	0.88	0.95	0.87
20	0.67	0.64	0.68	0.65	0.68
21-22	0.63	0.61	0.65	0.62	0.66
24	0.69	0.74	0.74	0.75	0.75
25	0.65	0.74	0.74	0.74	0.74
26	0.62	0.70	0.71	0.70	0.71
27-28	0.66	0.78	0.77	0.78	0.78
29	0.64	0.62	0.66	0.62	0.66
30-33	0.66	0.66	0.68	0.66	0.69
34-35	0.76	0.75	0.74	0.76	0.75
36-37	0.65	0.62	0.67	0.63	0.68

- estimated parameters higher in levels
- higher variability in estimated parameters
- strongly correlated with income share of inputs in data

Proximity ranking

- Compute proximity characteristic in each year

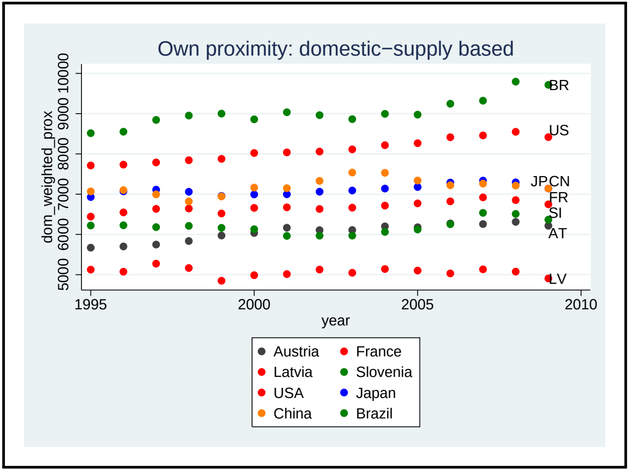
$$\left[\overline{PROX}_{i,t}^{M}\right]^{-1} = \prod_{s=1}^{S}\left\{\sum_{n=1}^{N}\pi_{ni,t}^{s}\tau_{ni}^{\theta}\right\}^{\gamma^s/\theta}$$

  - distance as proxy of bilateral trade frictions
  - observed market shares as weights (incl. domestic)
  - estimated θ, expenditure shares γ^k from data

- Instrument with proximity endowment: unweighted norm of distance vector

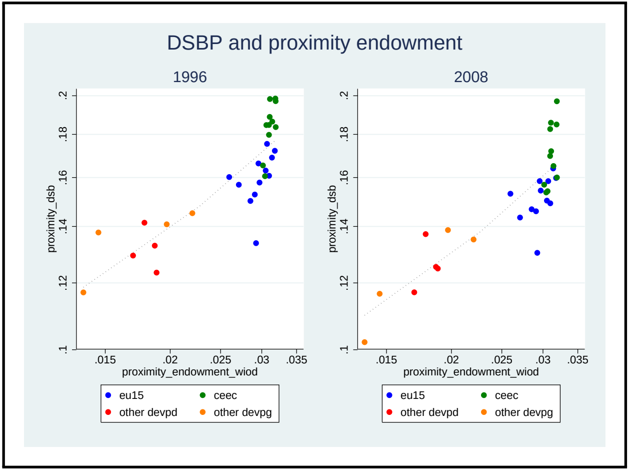
$$\left[PROX_{i}^{M}\right]^{-1} = \left[\sum_{n=1}^{N} dist_{in}^{2}\right]^{0.5}$$

Persistence of proximity characteristic



- plots reciprocal of proximity for subset of countries
- illustrates variability across countries and persistence overtime

Microfounded proximity & proximity endowment



- persistent characteristic
- $> 2/3$ total variance picked up by proximity endowment

Proximity mechanism

- Group countries according to proximity characteristic
- Compute pairwise sectoral residuals rescaled by $\widehat{\theta}$
- Compute relative proximity rescaled by $\widehat{\zeta}^k$
- Focus on intersectoral variation: include exporter-year fixed effects

$$\frac{1}{\widehat{\theta}}\left[\widehat{\lambda}_{i,t}^{k}-\widehat{\lambda}_{i',t}^{k}\right]=\beta_0+\beta_1 \ln\left\{\left(\frac{\widehat{\overline{PROX}}_{i,t}^{M}}{\widehat{\overline{PROX}}_{i',t}^{M}}\right)^{\widehat{\zeta}^k}\right\}$$

$$+fe_{i,t}-fe_{i',t}+\eta_{ii',t}^{k}$$

- Proximity mechanism determines residual ranking of relative sectoral exports if β_1 positive, significant

Results for the full sample

Table: Proximity mechanism in the residual component of RCA rankings

	all (I)	*all* (I)	*all* (IV)	*all* (IV)	*devd* (I)	*devg* (I)
$relprox * inpint$	0.689***	0.375***	1.255***	0.658***	1.288***	0.176**
	(0.064)	(0.093)	(0.100)	(0.152)	(0.101)	(0.078)
recent		0.585***		1.033***		
		(0.126)		(0.200)		
Obs	17748	17748	20097	20097	8883	8865
R^2	0.674	0.674	0.665	0.665	0.541	0.776
Recent FE		YES		YES		

- results robust to instrumenting procedure
- proximity matters more in recent period (2001-2009)

Results by sub-group

Table: Proximity mechanism in residual component of RCA rankings

	(I)	**(II)**	**(III)**	**(IV)**
eu15-to-devpd	1.379***	2.359***	1.344***	2.263***
nb-obs	5541	5541	6399	6399
ceec-to-devpd	1.151***	2.242***	0.890***	1.712***
nb-obs	3342	3342	3894	3894
eu15-to-devpg	0.165	0.356**	0.254**	0.520***
nb-obs	5529	5529	6100	6100
ceec-to-devpg	0.191*	0.623***	0.127	0.489***
nb-obs	3336	3336	3704	3704

Variance decomposition

- Quantify contribution of input cost channel to RCA

- Work with relative exporter-sector dummies
- Split sample by proximity & form pairwise combinations
- Calculate total explained variance by TFP, wages, proximity
- Focus on share uniquely attributable to relative proximity

$$\frac{1}{\widehat{\theta}}\left(\widehat{fe}^{\,k}_{i,t} - \widehat{fe}^{\,k}_{i',t}\right) = \alpha_0 + \alpha_1 \ln\left[\frac{\widehat{z}^{k}_{i,t}}{\widehat{z}^{k}_{i',t}}\right] + \alpha_2 \ln\left\{\left[\frac{\widehat{\nu}^{k}_{i,t}}{\widehat{\nu}^{k}_{i',t}}\right]^{-(1-\widehat{\zeta}^{k})}\right\} +$$

$$\alpha_3 \ln\left\{\left[\frac{\widehat{PROX}^{M}_{i,t}}{\widehat{PROX}^{M}_{i',t}}\right]^{\widehat{\zeta}^{k}}\right\} + fe_{i,t} + fe_{i',t} + \xi^{k}_{ii',t}$$

Unexplained variance attributable to proximity

Table: Fraction of residual variance attributable to proximity

	all (I)	*all* (II)	*all* (III)	*all* (IV)
relprox $*$ *inpint*	2.777*** (0.282)	3.381*** (0.336)	2.583*** (0.255)	3.043*** (0.297)
R^2	**0.178**	**0.200**	**0.181**	**0.196**
Obs	17,748	17,748	20,097	20,097

Table: Coefficient of partial determination (proximity, all years)

	all (I)	*all* (II)	*all* (III)	*all* (IV)
resid $-$ *relprox*	2.601*** (0.305)	3.180*** (0.363)	2.446*** (0.283)	2.907*** (0.330)
R^2	**0.154**	**0.173**	**0.154**	**0.169**
Obs	17,748	17,748	20,097	20,097

Increasing importance overtime

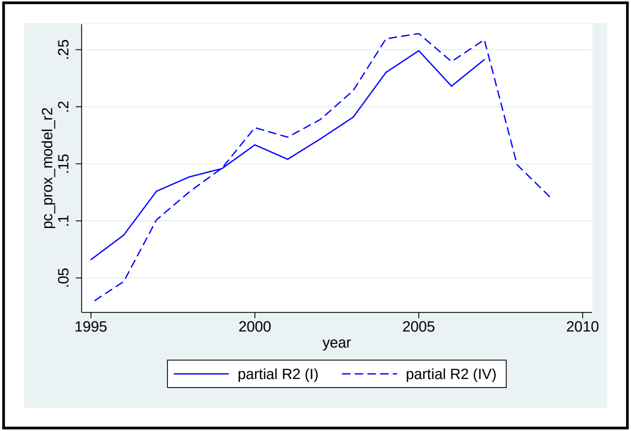


Figure: Coefficient of partial determination (proximity, annual)

Focus on intersectoral variation

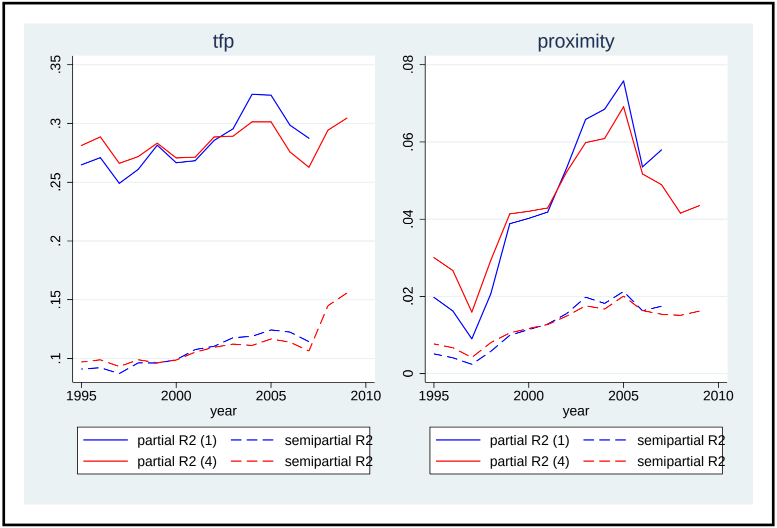
Table: The intersectoral component of RCA rankings

	all (I)	*all* (II)	*all* (III)	*all* (IV)	β-*coef* (I)
tfp	2.143***	2.105***	2.124***	1.994***	2.50
	(0.110)	(0.107)	(0.111)	(0.107)	
wage	1.981***	1.919***	2.291***	2.178***	2.32
	(0.112)	(0.109)	(0.120)	(0.117)	
proximity	1.668***	2.964***	1.642***	2.861***	0.24
	(0.160)	(0.274)	(0.156)	(0.265)	
R^2	0.731	0.731	0.731	0.726	
Obs	17,748	17,748	20,097	20,097	

- Proximity matters at the intersectoral level
- BUT contribution much lower (see standardized coef. col.5)

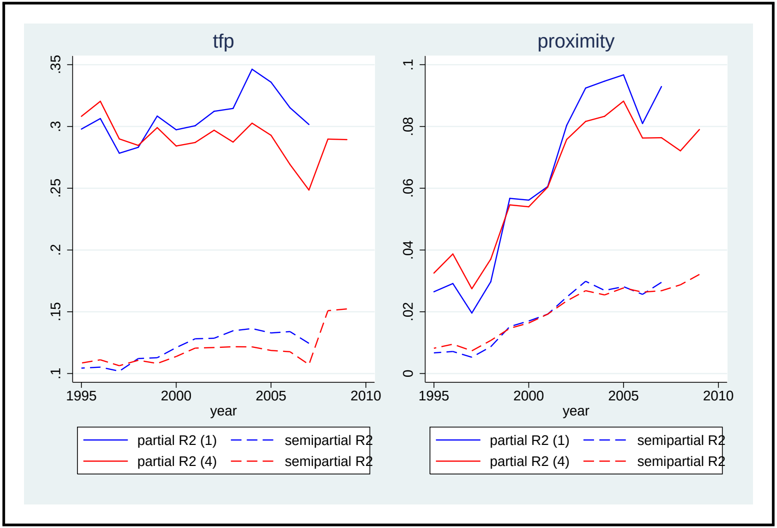
Increasing importance overtime

Figure: Partial and semipartial r^2 in cross section: full sample



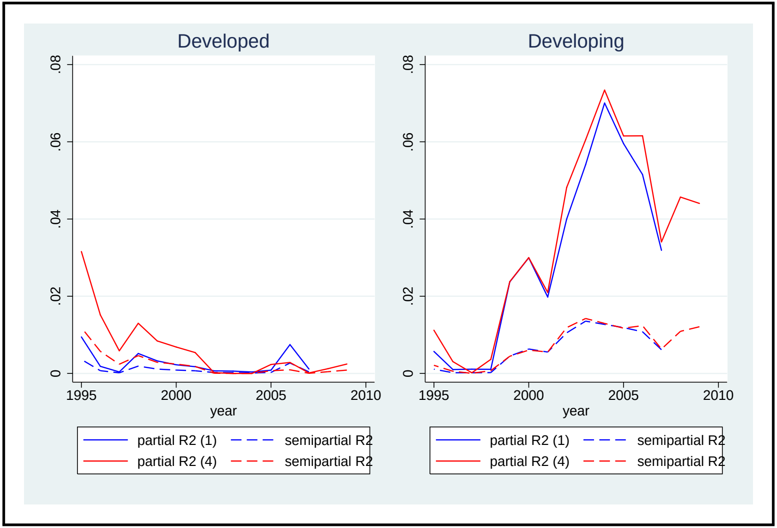
Results by subgroup: EU-15

Figure: Partial and semipartial r^2: EU15



Results by subgroup: CEECs

Figure: Partial and semipartial r^2: proximity (CEECs)



Does proximity constitute a source of comparative advantage?

- Determines wedge in relative cost of the input bundle which matters more in input-intensive sectors
- Input cost channel contributes to shape pattern of RCA across partners whith differ in proximity to suppliers
- This mechanism has growing importance overtime
- BUT: intersectoral specialization still determined by ranking of relative technology stocks

Robustness & Further Work

- Use model structure to compute price indices: do results on the role of proximity stand?
- Use explicit IO structure: do results in this paper establish a lower bound on the importance of the input cost channel?
- Look into persistence: which type (magnitude) of shocks on structure of trade costs (technology stocks) needed to inflect pattern of specialization?