Technology and costs in international competitiveness: toward a microfounded evolutionary interpretation

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The international competitiveness: a technology gap perspective

- Trade flows are primarily driven by sector-specific absolute advantages, in turn stemming from technological asymmetries between countries
- Partial disequilibrium framework allows to disentagle technological factors from cost factors as determinants of trade flows:

$$X_{ij} = f(T_{ij}, C_{ij})$$

- Evidence at country and sector-country level:
  - Technology - as proxied by patents, R&D, investments - is relevant in explaining export shares
  - The role of costs is much less clear-cut

(Background paper: Dosi, G., Grazzi, M., and Moschella, D., Technology and costs in international competitiveness: From countries and sectors to firms. *Research Policy*, 44(10), 1795-1814, 2015.)

The international competitiveness: the underlying firm-level dynamics

- Wide and persistent intra-industry heterogeneity in:
  - ex-ante choice of input mix (Dosi and Grazzi, 2006).
  - ex-post performance (Bartelsman and Doms, 2000).
  - partecipation on the export market (Bernard et al., 2012) and innovation activity (Basile, 2001; Caldera, 2010).
- In "new-new" trade theories rooted in Melitz (2003), firm heterogeneity is captured by some efficiency parameter
- What is the distinct role of technological and cost competition in explaing trade at firm-level, within each sector and at different time horizons?
  - Sectors differ in terms of technologies, patterns of innovation, competition mechanisms
  - Firms' capabilities are sticky, while cost are less so

Our contribution

- We offer an overview of the empirics at country and sector-country level, from Soete (1981) to Laursen and Meliciani (2010)
- Employing several sources of Italian firm level data, we address the distinct effects of technological and cost variables on firm's exports
  - Sector-specific estimates
  - Separating the short- and the long-run effects
- We do this on the grounds of a novel heuristic evolutionary model of selection and trade based on a generalized Polya urn process

Main results of the empirical analysis

- We find that technological variables (patents and investments) dominate over cost variables (labour costs)
- Results are reinforced when separating the short- and the long-run effects and still hold when employing Community Innovation Survey data
- We also provide evidence that exports of innovative firms decrease less in response to a real exchange rate appreciation (contribute to the emerging literature on quality sorting and trade)

Table : Country- and sector-level studies

Authors	Years-Contry-Sec	Methodology	Main results
Soete (1981, 1987)	1963-77 - 20 - 40	cross-sectional estim. of 4 equations in 1977	Patents (+)
Fagerberg (1988)	1961-83 - 15 - all econ	2SLS estimation of a six equations model	R&D-Patents (+), Investments (+), Costs ()
Dosi et al. (1990)	1963-77 - 20 - 40	cross-sectional analysis	Investments (+), Patents (+), Costs ()
Greenhalgh (1990)	1954-81 - 1, UK - 31	error correction model	#Innovations (+), Prices ()
Amendola et al. (1993)	1967-87 - 16 - all manuf	autoregressive-distributed lag model	Patents (+), Investments (+), Costs ()
Magnier and Toujas-Bernate (1994)	1975-87 - 5 - 20	error correction model	R&D (+), Investments (+), Prices (-)
Amable and Verspagen (1995)	1970-91 - 5 - 18	error correction model	Patents (+), Investments (+), Costs (-)
Landesmann and Pfaffermayr (1997)	1973-87 - 7 - 2	almost ideal demand system	R&D (+), Costs (-)
Wakelin (1998b)	1988 - 9 - 22	OLS estimation of pooled & sect. data	R&D (+), Patents (+), Investments (), Costs(-)
Carlin et al. (2001)	1970-92 - 14 - 12	distributed lag model	Patents (), R&D (), Investments (+), Costs (-)
Laursen and Meliciani (2000, 2002)	1973-91 - 9 - 19	dynamic model	R&D linkages (+), Costs (-)
Laursen and Meliciani (2010)	1981-03 - 14 - 16	dynamic model	ICT knowledge flows (+), Costs (-)

Note. The Main results column reports whether a variable has, on average, a positive and relevant effect (+), a negative and relevant effect (-), or is not significant ().

Table : Firm-level studies

Authors	Country	Data source	Structure	Firms
Wakelin (1998a)	UK	SPRU innov. survey	cross-section	320
Sterlacchini (1999)	Italy	field study	cross-section	143
Basile (2001)	Italy	Mediocredito surveys	panel	6000
Roper and Love (2002)	Germ. & UK	product development survey(PDS)	cross-section	1087(UK) 1190(Germ.)
Barrios et al. (2003)	Spain	ESEE survey	panel	around 2000
Beise-Zee and Rammer (2006)	Germ.	CIS	cross-section	4786
Lachenmaier and Wöß mann (2006)	Germ.	IFO innovation survey	cross-section	981
Aw et al. (2007)	Taiwan	Statistical Bureau's census and R&D survey	panel	between 518 and 1311
Castellani and Zanfei (2007)	Italy	CIS2 and ELIOS	cross-section	785
Álvarez et al. (2009)	Spain	survey in four industries	cross section	134
Harris and Li (2009)	UK	CIS3 and Annual Respondents Database	cross-section	3303
Caldera (2010)	Spain	ESEE survey	13-years panel	around 1900
Cassiman et al. (2010)	Spain	ESEE survey	8-years panel	around 1000
Damijan et al. (2010)	Slovenia	CIS1, CIS2, CIS3 and firm accounting data	panel	9148
Van Beveren and Vandenbussche (2010)	Belgium	2 CIS surveys	cross-section	189
Eickelpasch and Vogel (2011)	Germ.	German business services statistics	3-years panel	53876
Ganotakis and Love (2011)	UK	survey of new technology based firms (NTBFs)	cross-section	412
Becker and Egger (2013)	Germ.	IFO innovation and Business surveys	3-years panel	1212

An evolutionary model of selection and trade

The model is based on the sequential stochastic allocation of a finite number of export opportunities, X, among a population of N heterogeneous firms. How it works:

- An urn containing NS balls, i.e. S balls for each of the N firms
  - S is the initial size of the firm, assumed to be equal for all firms.
- An competitiveness matrix M (NxN): each entry m_{ij} represents the competitiveness of firm i against firm j
- A pair of balls is drawn at random from the urn corresponding to a payoff m_{ij}. If $m_{ij} > 0$, the ball of i is reintroduced along with m_{ij} extra balls of type i, which correspond to new export opportunities. Conversely, if $m_{ij} \leq 0$, the ball is reintroduced but no extra ball is added.

Main results of the model

Results emerging from Monte Carlo simulation under different parametrizations details:

- Only a fraction of firms turn out to export, i.e. firms which have, *on average*, higher fitness (probabilistic sorting)
- The share of exporters depends both on the number of export opportunities per firm, and on the degree of heterogeneity
- Size distributions of firms is right-skewed

Data

- Micro.3
  - Based on the census of Italian firms conducted yearly by ISTAT; contains information on firms with more than 20 employees in all sectors of the economy for the period 1989-2006
- Statistiche del Commercio Estero (COE) Custom data
  - All cross-border transactions at the firm-product-country level, 1998-2006
  - The integrated Micro.3 - COE database represent around 50-60% of the value added generated by all Italian firms in the manufacturing sectors and between 75% and 80% of Italian exports
- Community Innovation Survey (CIS)
  - We employ both the 2000 (CIS3) and 2004 (CIS4) waves. The survey covers all the firms with 250 or more employees and a sample of firms in the range of employment 10-250

Table : Observations by manufacturing sectors, year 2000

	(I)	(II)	(III)	(IV)	(V)
All manufacturing	30,599	100.00	100.00	75.87	100.00
Food, beverages, tobacco	2049	6.70	7.75	74.33	4.80
Textiles, wearing, leather	5379	17.58	13.70	72.91	13.94
Wood	776	2.54	1.49	66.88	0.67
Paper & printing	1709	5.59	5.06	69.28	2.56
Coke & petroleum	108	0.35	0.90	41.67	2.61
Chemicals	1174	3.84	6.67	91.99	10.11
Rubber & plastics	1863	6.09	5.15	86.74	4.68
Other non-metallic	1697	5.55	5.09	64.76	3.34
Basic metals	866	2.83	4.57	82.56	4.99
Fabricated metal	4668	15.26	9.66	63.52	5.27
Machinery	4433	14.49	15.22	87.95	20.70
Computing & electrical	2681	8.76	10.41	74.67	9.93
Transport equipment	1023	3.34	9.57	77.61	11.07
Other manufacturing	2173	7.10	4.74	85.18	5.33

Note. (I) Number of firms; (II) percentage share of firms within each sector; (III) shares of employment; (IV) percentage of exporting firms within each sector; (V) shares of export volumes.

Selection into export markets and levels of exports

$$P(D_{EXP_{it}} = 1) = \Phi(\beta_1 WAGE_{it-1} + \beta_2 PROD_{it-1} + \beta_3 INV_{it-1} + \beta_4 PAT_{it-1} + \beta_5 EMP_{it-1} + d_t + \epsilon_{it}) \quad (1)$$

$$EXP_{it} = \beta_1 WAGE_{it-1} + \beta_2 PROD_{it-1} + \beta_3 INV_{it-1} + \beta_4 PAT_{it-1} + \beta_5 EMP_{it-1} + d_t + \epsilon_{it} \quad (2)$$

$D_{EXP_{it}} = 1$, if a firm exports

EXP_{it}, trade volumes

$WAGE$, average labour costs per employee

$PROD$, labour productivity

INV, investment intensity (w.r.t. value added)

PAT, dummy for patenting firm

EMP, number of employees

$\Rightarrow$ Eq. (1) Probit estimation; Eq. (2) OLS, Heckman selection model

Selection: results

I

	WAGE	PROD	INV	PAT	Obs.	firms
ALL MANUFACTURING	0.034^{***}	0.119^{***}	0.011^{***}	0.115^{***}	181,524	39,761
Coke & petroleum	0.335^{**}	-0.041	-0.014	-0.085	915	158
Chemicals	0.038^{*}	0.014	0.004	0.025	9261	1714
Basic metals	0.105^{***}	0.063^{***}	0.012^{***}	0.163^{***}	7108	1236
Machinery	0.054^{***}	0.070^{***}	0.009^{***}	0.066^{***}	24,312	5010
Computing & electrical	0.095^{***}	0.150^{***}	0.041^{***}	0.114^{***}	15,294	3624
Transport equipment	0.169^{***}	0.051^{***}	0.012^{***}	0.140^{***}	5725	1244

Note. Probit estimation. Marginal effects computed at means (discrete change from 0 to 1 for patent dummy) with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

▸ robust standard errors

Selection: results

II

	WAGE	PROD	INV	PAT	Obs.	firms
Food, beverages, tobacco	−0.007	0.132***	0.009**	0.144***	14,136	2941
Textiles, wearing, leather	−0.052***	0.253***	−0.017***	0.053	32,356	8030
Wood	0.044	0.204***	0.010	0.206***	4854	1028
Paper & printing	−0.274***	0.131***	0.023***	0.122*	10,635	2268
Rubber & plastics	0.107***	0.068***	0.009***	0.007	9846	2074
Other non-metallic	0.283***	−0.106***	−0.008*	0.285***	12,685	2532
Fabricated metal	0.067**	0.218***	0.034***	0.216***	21,541	5011
Other manufacturing	0.001	0.075***	0.001	0.094***	12,856	2891

Note. Probit estimation. Marginal effects computed at means (discrete change from 0 to 1 for patent dummy) with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Levels of exports: results

I

	WAGE	PROD	INV	PAT	Obs.	firms
ALL MANUFACTURING	−0.002	0.920***	0.086***	0.551***	138,241	31,255
Chemicals	0.199	0.801***	0.307***	0.161	8153	1578
Basic metals	0.114	1.023***	0.080***	0.099	5743	1064
Machinery	0.094	0.918***	0.039***	0.413***	21,544	4531
Computing & electrical	−0.279*	0.842***	0.193***	0.540***	12,056	2796
Transport equipment	0.320	0.922***	0.150***	0.941***	4680	1041

Note. Pooled OLS estimation with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

robust standard errors | heckman selection model

Levels of exports: results

II

	WAGE	PROD	INV	PAT	Obs.	firms
Food, beverages, tobacco	0.333*	0.876***	0.152***	1.057***	9931	2310
Textiles, wearing, leather	−0.046	1.182***	−0.066***	0.614***	23,326	5778
Wood	−0.332	0.486**	0.025	1.825***	3226	743
Paper & printing	−1.438***	1.004***	0.217***	1.365***	7249	1719
Rubber & plastics	0.948***	0.922***	0.074***	0.381***	8492	1848
Other non-metallic	1.655***	−0.238	−0.041	0.762***	8178	1755
Fabricated metal	−0.009	1.135***	0.120***	0.706***	14,647	3531
Other manufacturing	−0.740***	1.214***	0.066***	0.545***	10,562	2471

Note. Pooled OLS estimation with robust standard errors clustered at the firm level in parentheses. Coefficient of *EMP* omitted. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

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Short-run *vs.* long-run

- We adapt the empirical framework of Amendola et al. (1993) to firm-level data and consider an autoregressive distributed lag model

$$\begin{aligned} EXP_{it} = &\sum_{l=1}^{K} \eta_l EXP_{it-l} + \sum_{l=1}^{L} \alpha_l WAGE_{it-l} + \sum_{l=1}^{L} \beta_l PROD_{it-l} + \sum_{l=1}^{L} \gamma_l INV_{it-l} \\ &+ \sum_{l=1}^{L} \delta_l PAT_{it-l} + \sum_{l=1}^{L} \phi_l EMP_{it-l} + d_t + \epsilon_{it} \end{aligned} \tag{3}$$

  with $K = 1$ and $L = 3$
- In order to identify the short-run coefficients, we employ a "twostep system GMM" estimator, to control both for unobserved heterogeneity and for the potential endogeneity of cost and technology variables
- We use less distant lags (typically at $t-2$ and $t-3$) to instrument, in the first difference equation, both the lagged value of the dependent variable (EXP_{it-1}) and the variables that we take as endogeneous, that is wage, productivity, investment intensity, and patents
- Long-run coefficients are calculated from the short-run:

$$x_{long-run} = \frac{\sum_{l=1}^{3} x_l}{1 - \eta_1} \tag{4}$$

  where $x \in \{\alpha, \beta, \gamma, \delta\}$

Short-run *vs.* long-run: results

- Labour costs display some negative and significant effects in the short-run. However, this effect vanishes in the long-run
- Technology variables show quite a different pattern:
  - Investment intensity turns out to have a positive and significant effect both in the short-run and in the long-run
  - The effects of patents show up mostly in the long-run
- Summing up, the most general finding concerns the long-term competitive effect of innovation both in its disembodied form, as captured by patents, and embodied into investments. Conversely, changes in wages appear to display only short-run effects, which are reabsorbed in the longer term. In this respect, results are rather consistent with the aggregate evidence

ADL model for levels of exports: long-run coefficients

I

	WAGE	PROD	INV	PAT	Obs.	firms	AR(2)
ALL MANUFACTURING	−3.468*	3.841***	0.983***	0.869***	60,669	15,738	0.198
	(1.866)	(0.867)	(0.338)	(0.278)			
Chemicals	0.078	1.683*	0.855***	0.188	3825	879	0.421
	(1.977)	(0.887)	(0.292)	(1.127)			
Basic metals	−0.917	0.526	0.337	−0.394	2755	620	0.520
	(2.445)	(0.947)	(0.381)	(1.476)			
Machinery	4.646	1.953	0.856*	1.137**	9736	2422	0.093
	(3.041)	(1.871)	(0.466)	(0.581)			
Computing & electrical	−1.387	1.071*	0.444**	1.418***	5076	1316	0.753
	(0.981)	(0.555)	(0.195)	(0.524)			
Transport equipment	−3.155	1.898	0.095	1.042	2039	524	0.643
	(2.446)	(1.284)	(0.330)	(1.084)			

Note. Twostep system GMM estimation. Long-run coefficients calculated as from formula (4). Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

ADL model for levels of exports: long-run coefficients

II

	WAGE	PROD	INV	PAT	Obs.	firms	AR(2)
Food, beverages, tobacco	1.456	0.907	−0.176	−1.763	4275	1103	0.998
	(1.721)	(0.992)	(0.325)	(2.112)			
Textiles, wearing, leather	−2.142	2.788***	0.326	0.511	9677	2664	0.246
	(1.568)	(0.671)	(0.198)	(0.557)			
Wood	−0.459	0.868	0.445	3.052**	1428	369	0.503
	(1.757)	(1.309)	(0.486)	(1.338)			
Paper & printing	−2.943	2.067**	0.592*	3.667**	3167	876	0.408
	(1.984)	(1.040)	(0.323)	(1.433)			
Rubber & plastics	−0.967	1.451	0.683*	−0.280	3897	1004	0.334
	(2.646)	(1.255)	(0.363)	(1.021)			
Other non-metallic	0.375	0.431	−0.079	2.338**	3796	937	0.006
	(1.800)	(1.048)	(0.373)	(1.159)			
Fabricated metal	−2.371	1.905	0.455	−0.410	6315	1727	0.042
	(3.215)	(1.855)	(0.587)	(1.599)			
Other manufacturing	−4.689*	4.415***	0.144	0.270	4464	1240	0.798
	(2.470)	(1.260)	(0.301)	(1.034)			

Note. Twostep system GMM estimation. Long-run coefficients calculated as from formula (4). Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Innovation premia

$$X_i = \alpha INN_i + \beta sector_i + \epsilon_i \quad (5)$$

where *INN* is one of the two measures of innovation, product or process and X is either an export dummy or the (log) of trade volumes

	CIS3		CIS4	
	(1)	(2)	(3)	(4)
Panel A: Product innovation premia				
Exporting firms	14.8	10.9	13.2	9.4
Levels of exports	116.4	55.0	115.2	51.5
Panel B: Process innovation premia				
Exporting firms	10.0	6.4	11.7	8.3
Levels of exports	80.4	23.1	84.2	25.0

Note. The table reports innovation premia, in percentage, estimated from equation 5. Columns (2) and (4) control for total employment. All differences are significant at the 1% level.

Selection into export markets and levels of exports

$$P(D_{EXP_i} = 1) = \Phi(\alpha WAGE_i + \beta PROD_i + \gamma INPCS_i + \delta INNTYPE_i + \phi EMP_i + \epsilon_i) \quad (6)$$

$$EXP_i = \alpha WAGE_i + \beta PROD_i + \gamma INPCS_i + \delta INNTYPE_i + \phi EMP_i + \epsilon_i \quad (7)$$

$INNTYPE_i$:

- INPDT,INPCS,BOTH: only product innovation, only process innovation, both
- INPCS, INPDT_FIRM, INPDT_MKT, BOTH_FIRM, BOTH_MKT: only process innovation, only product new for the firm, only product new for the market, both process and product new for the firm, both process and product new for the market

Selection, CIS3 and CIS4: results

	CIS3		CIS4	
	(1)	(2)	(3)	(4)
WAGE	−0.046	−0.045	−0.005	−0.005
	(0.028)	(0.028)	(0.031)	(0.031)
PROD	0.142***	0.141***	0.120***	0.119***
	(0.021)	(0.021)	(0.019)	(0.019)
INPDT	0.092***		0.092***	
	(0.011)		(0.011)	
INPCS	0.025*	0.025*	0.050***	0.049***
	(0.014)	(0.014)	(0.012)	(0.011)
BOTH	0.077***		0.093***	
	(0.011)		(0.011)	
INPDT_FIRM		0.071***		0.091***
		(0.019)		(0.014)
INPDT_MKT		0.094***		0.085***
		(0.011)		(0.013)
BOTH_FIRM		0.043**		0.053***
		(0.019)		(0.016)
BOTH_MKT		0.081***		0.105***
		(0.011)		(0.011)
N	4521	4521	3609	3609
pseudo R^2	0.183	0.184	0.172	0.174

Note. Probit estimation of equation (6). Marginal effects calculated at the mean for continuous variables; discrete change from 0 to 1 for dummy variables. Robust standard error in parenthesis. Coefficient on EMP omitted. Sector dummies included.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Levels of exports, CIS3 and CIS4: results

	CIS3		CIS4	
	(1)	(2)	(3)	(4)
WAGE	−0.629**	−0.628**	0.255	0.255
	(0.266)	(0.266)	(0.258)	(0.259)
PROD	1.297***	1.297***	1.053***	1.053***
	(0.146)	(0.146)	(0.137)	(0.137)
INPDT	0.458***		0.270**	
	(0.096)		(0.126)	
INPCS	−0.020	−0.020	0.072	0.073
	(0.116)	(0.116)	(0.111)	(0.111)
BOTH	0.292***		0.341***	
	(0.083)		(0.095)	
INPDT_FIRM		0.544***		0.264
		(0.149)		(0.213)
INPDT_MKT		0.436***		0.274**
		(0.107)		(0.139)
BOTH_FIRM		0.118		0.322**
		(0.169)		(0.145)
BOTH_MKT		0.325***		0.350***
		(0.085)		(0.104)
N	3699	3699	3014	3014
R^2	0.413	0.413	0.418	0.418

Note. OLS estimation of equation (7). Robust standard error in parenthesis. Coefficient on EMP omitted. Sector dummies included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Exchange rates and firm's exports to product-country destinations, by different type of firms

$$\Delta \ln X_{fpct} = c + \alpha D_{ft}^{\text{BOTH}} + \beta \Delta \ln RER_{ct} + \gamma \Delta \ln RER_{ct} * D_{ft}^{BOTH} + d_j + \varepsilon_{fpct} \quad (8)$$

- $\Delta \ln X_{fpct}$, change (log difference) in firm-level product-country export value, quantity or unit value
- D_{ft}^{BOTH}, dummy for firms that introduced product and process innovations in CIS3 and CIS4
- $\Delta \ln RER_{ct}$, change in the log of the real bilateral exchange rate of the Italian currency
- $\Delta \ln RER_{ct} * D_{ft}^{BOTH}$, their interaction
- d_j, set of of fixed effects

Exchange rates and firm's exports to product-country destinations, by different type of firms: results

	Annual Differences					
	ln X_{fcpt} (1)	ln X_{fcpt} (2)	ln $Quantity_{fcpt}$ (3)	ln $Quantity_{fcpt}$ (4)	ln $UnitValue_{fcpt}$ (5)	ln $UnitValue_{fcpt}$ (6)
D_{ft}^{BOTH}	0.005		0.007		-0.002	
	(0.009)		(0.009)		(0.005)	
$\Delta \ln RER_{ct}$	-0.327***	-0.360***	-0.308***	-0.344***	-0.018	-0.015
	(0.104)	(0.112)	(0.115)	(0.122)	(0.021)	(0.020)
$\Delta \ln RER_{ct} * D_{ft}^{BOTH}$	0.117**	0.149**	0.115*	0.155**	0.002	-0.005
	(0.053)	(0.062)	(0.064)	(0.075)	(0.029)	(0.030)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	No	Yes	No	Yes	No
Firm-Product FE	No	Yes	No	Yes	No	Yes
N	329,697	329,697	329,697	329,697	329,697	329,697
adj. R^2	0.005	0.007	0.002	0.003	0.000	0.030

Note. Table reports results of regressions at the firm product country level, using data on exports, quantity and unit value between 2000 and 2007. The dependent and independent variables are defined as annual differences. BOTH is a dummy for firms that introduced both product and process innovations in CIS3 and CIS4. Robust standard errors clustered at country-year level in parenthesis. Year dummies included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Further research questions

- Explore the statistical properties of the polya urn model of selection and trade, along the lines of Bottazzi and Secchi (2006); also, bring it to the product-country level (see Armenter and Koren, 2014)
- What about employment? Some recent evidence shows that both process innovation and import penetration may have negative effects on employment (David et al., 2015)

Thank You!

Simulation landscapes

Table : Parameters and share of exporters in different landscapes

	Landscape 1	Landscape 2	Landscape 3	Landscape 4
PARAMETERS				
Number of firms (N)	1,000	1,000	1,000	1,000
Initial number of balls per firm (S)	10	10	10	10
Number of export opportunities (X)	10,000	20,000	10,000	20,000
Fitness distribution (F)	$lnN(4, 0.25)$	$lnN(4, 0.25)$	$lnN(4, 0.5)$	$lnN(4, 0.5)$
OUTPUT				
Share of exporters	0.23	0.29	0.11	0.12
	(0.02)	(0.03)	(0.02)	(0.03)

Note. The top panel of the table reports the parameters value of the model in four different simulation cases (landscapes). The bottom panel displays the mean and the standard deviation (in parentheses) of the share of exporters that come out from 20 simulation runs for each of the four different landscapes.

Figure : Export opportunities and share of exporters. Mean and standard error bars. Fitness distribution: $lnN(4, 0.5)$

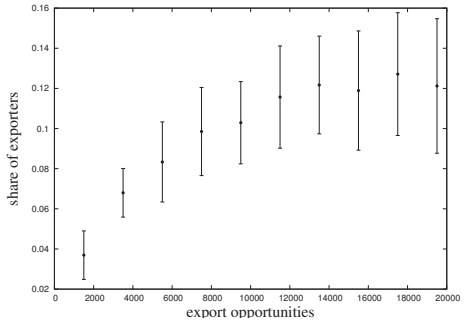
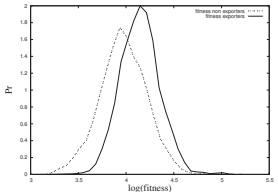
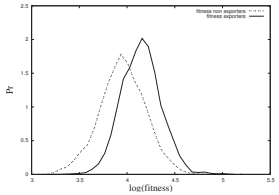


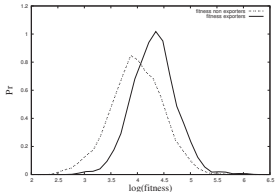
Figure : Fitness distribution of exporters and non exporters. Pooled observations across 20 simulation runs.



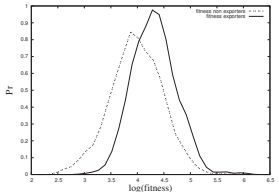
(a) Fitness distribution: $lnN(4, 0.25)$; $X = 10,000$



(b) Fitness distribution: $lnN(4, 0.25)$; $X = 20,000$

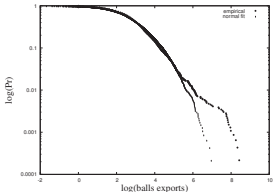


(c) Fitness distribution: $lnN(4, 0.5)$; $X = 10,000$

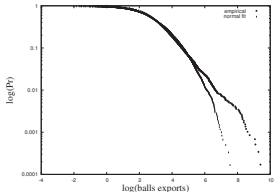


(d) Fitness distribution: $lnN(4, 0.5)$; $X = 20,000$

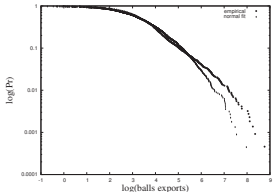
Figure : Exporters size cumulative distribution. Pooled observations across 20 simulation runs.



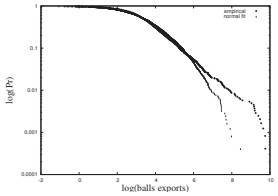
(a) Fitness distribution: $lnN(4, 0.25)$; $X = 10,000$



(b) Fitness distribution: $lnN(4, 0.25)$; $X = 20,000$



(c) Fitness distribution: $lnN(4, 0.5)$; $X = 10,000$



(d) Fitness distribution: $lnN(4, 0.5)$; $X = 20,000$

STAN OECD: countries and industries

- Austria, Belgium, Canada, Germany, Denmark, Spain, Finland, France, UK, Italy, Japan, Netherlands, Norway, Sweden, USA.

Sectors	NACE Rev. 1.1
Food, beverages, tobacco	15-16
Textiles, wearing, leather	17-19
Wood	20
Paper and printing	21-22
Coke & petroleum	23
Chemicals	24
Rubber and plastics	25
Non-metallic (mineral products)	26
Basic metals	27
Fabricated metal (products)	28
Machinery	29
Computing & electrical (machinery)	30-33
Transport equipment	34-35
Other Manufacturing	36-37

Costs, productivity, and technology: equation

$$\begin{aligned} XMS_{ijt} =& \beta_{1j} PAT_{ijt} + \beta_{2j} POP_{it} + \beta_{3j} INV_{ijt} \\ &+ \beta_{4j} PROD_{ijt} + \beta_{5j} WAGE_{ijt} + \epsilon_{ijt} \end{aligned} \tag{9}$$

i for countries, j for sectors, t for time

XMS, export market share

PAT, patents

POP, population

INV, investment intensity (w.r.t. value added)

$PROD$, labour productivity

$WAGE$, average labour costs per employee

Costs, productivity, and technology: results

I

	WAGE	PROD	INV	PAT	Obs.	R^2
ALL MANUFACTURING	0.155**	0.347***	0.698***	0.270***	3161	0.68
Coke & petroleum	0.062	−0.095	0.369***	0.384***	200	0.49
Chemicals	1.594***	0.078	0.069	0.130**	223	0.78
Basic metals	0.795***	0.834***	0.241**	0.163***	190	0.76
Machinery	−0.346	0.317	0.427***	0.341***	240	0.88
Computing & electrical	−0.190	0.006	0.258***	0.424***	240	0.92
Transport equipment	0.578***	1.326***	0.453***	−0.046	251	0.91

Note. Pooled OLS. Coefficient on *POP* omitted. Sector-year dummies (in the aggregate regression) and year dummies (in the sectoral regressions) included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

standard errors

Costs, productivity, and technology: results

II

	WAGE	PROD	INV	PAT	Obs.	R^2
Food, beverages, tobacco	0.445	0.833**	0.924***	0.208**	249	0.36
Textiles, wearing, leather	−0.326	1.517***	1.288***	0.016	227	0.77
Wood	0.284	2.217***	1.172***	0.426***	221	0.67
Paper & printing	−1.649***	1.415***	−0.068	0.290***	226	0.78
Rubber & plastics	−0.323	0.459	0.702***	0.238***	223	0.78
Other non-metallic	−0.534**	0.469*	0.893***	0.021	251	0.79
Fabricated metal	−0.341	−0.307	0.732***	0.314***	190	0.87
Other manufacturing	−0.129	0.510**	0.875***	0.045	230	0.76

Note. Pooled OLS. Coefficient on *POP* omitted. Sector-year dummies (in the aggregate regression) and year dummies (in the sectoral regressions) included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

standard errors

Costs, productivity, and technology: results with s.e.

I

	WAGE	PROD	INV	PAT	Obs.	R^2
ALL MANUFACTURING	0.155^{**}	0.347^{***}	0.698^{***}	0.270^{***}	3161	0.68
	(0.075)	(0.046)	(0.031)	(0.015)		
Coke & petroleum	0.062	-0.095	0.369^{***}	0.384^{***}	200	0.49
	(0.206)	(0.095)	(0.104)	(0.052)		
Chemicals	1.594^{***}	0.078	0.069	0.130^{**}	223	0.78
	(0.252)	(0.171)	(0.133)	(0.060)		
Basic metals	0.795^{***}	0.834^{***}	0.241^{**}	0.163^{***}	190	0.76
	(0.270)	(0.134)	(0.097)	(0.048)		
Machinery	-0.346	0.317	0.427^{***}	0.341^{***}	240	0.88
	(0.212)	(0.213)	(0.072)	(0.046)		
Computing & electrical	-0.190	0.006	0.258^{***}	0.424^{***}	240	0.92
	(0.179)	(0.077)	(0.073)	(0.029)		
Transport equipment	0.578^{***}	1.326^{***}	0.453^{***}	-0.046	251	0.91
	(0.213)	(0.122)	(0.069)	(0.041)		

Note. Pooled OLS. Coefficient on *POP* omitted. Sector-year dummies (in the aggregate regression) and year dummies (in the sectoral regressions) included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Costs, productivity, and technology: results with s.e.

II

	WAGE	PROD	INV	PAT	Obs.	R^2
Food, beverages, tobacco	0.445	0.833**	0.924***	0.208**	249	0.36
	(0.501)	(0.362)	(0.246)	(0.088)		
Textiles, wearing, leather	−0.326	1.517***	1.288***	0.016	227	0.77
	(0.316)	(0.377)	(0.120)	(0.063)		
Wood	0.284	2.217***	1.172***	0.426***	221	0.67
	(0.283)	(0.210)	(0.121)	(0.050)		
Paper & printing	−1.649***	1.415***	−0.068	0.290***	226	0.78
	(0.213)	(0.164)	(0.085)	(0.025)		
Rubber & plastics	−0.323	0.459	0.702***	0.238***	223	0.78
	(0.323)	(0.323)	(0.136)	(0.067)		
Other non-metallic	−0.534**	0.469*	0.893***	0.021	251	0.79
	(0.257)	(0.244)	(0.115)	(0.048)		
Fabricated metal	−0.341	−0.307	0.732***	0.314***	190	0.87
	(0.224)	(0.266)	(0.097)	(0.041)		
Other manufacturing	−0.129	0.510**	0.875***	0.045	230	0.76
	(0.273)	(0.212)	(0.122)	(0.072)		

Note. Pooled OLS. Coefficient on *POP* omitted. Sector-year dummies (in the aggregate regression) and year dummies (in the sectoral regressions) included. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Selection: results with s.e.

I

	WAGE	PROD	INV	PAT	Obs.	firms
ALL MANUFACTURING	0.034***	0.119***	0.011***	0.115***	181524	39761
	(0.008)	(0.005)	(0.001)	(0.007)		
Coke & petroleum	0.335**	−0.041	−0.014	−0.085	915	158
	(0.149)	(0.073)	(0.015)	(0.056)		
Chemicals	0.038*	0.014	0.004	0.025	9261	1714
	(0.021)	(0.012)	(0.003)	(0.016)		
Basic metals	0.105***	0.063***	0.012***	0.163***	7108	1236
	(0.039)	(0.019)	(0.004)	(0.010)		
Machinery	0.054***	0.070***	0.009***	0.066***	24312	5010
	(0.014)	(0.008)	(0.002)	(0.007)		
Computing & electrical	0.095***	0.150***	0.041***	0.114***	15294	3624
	(0.023)	(0.015)	(0.003)	(0.014)		
Transport equipment	0.169***	0.051***	0.012***	0.140***	5725	1244
	(0.042)	(0.020)	(0.004)	(0.015)		

Note. Probit estimation. Marginal effects computed at means (discrete change from 0 to 1 for patent dummy) with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Selection: results with s.e.

II

	WAGE	PROD	INV	PAT	Obs.	firms
Food, beverages, tobacco	−0.007	0.132***	0.009**	0.144***	14136	2941
	(0.030)	(0.016)	(0.004)	(0.044)		
Textiles, wearing, leather	−0.052***	0.253***	−0.017***	0.053	32356	8030
	(0.020)	(0.013)	(0.003)	(0.070)		
Wood	0.044	0.204***	0.010	0.206***	4854	1028
	(0.062)	(0.038)	(0.007)	(0.061)		
Paper & printing	−0.274***	0.131***	0.023***	0.122*	10635	2268
	(0.038)	(0.023)	(0.004)	(0.066)		
Rubber & plastics	0.107***	0.068***	0.009***	0.007	9846	2074
	(0.023)	(0.013)	(0.003)	(0.022)		
Other non-metallic	0.283***	−0.106***	−0.008*	0.285***	12685	2532
	(0.043)	(0.023)	(0.004)	(0.030)		
Fabricated metal	0.067**	0.218***	0.034***	0.216***	21541	5011
	(0.029)	(0.019)	(0.003)	(0.024)		
Other manufacturing	0.001	0.075***	0.001	0.094***	12856	2891
	(0.024)	(0.014)	(0.003)	(0.024)		

Note. Probit estimation. Marginal effects computed at means (discrete change from 0 to 1 for patent dummy) with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Levels of exports: results with s.e.

I

	WAGE	PROD	INV	PAT	Obs.	firms
ALL MANUFACTURING	−0.002	0.920***	0.086***	0.551***	138241	31255
	(0.053)	(0.029)	(0.006)	(0.041)		
Chemicals	0.199	0.801***	0.307***	0.161	8153	1578
	(0.210)	(0.106)	(0.029)	(0.143)		
Basic metals	0.114	1.023***	0.080***	0.099	5743	1064
	(0.303)	(0.124)	(0.029)	(0.343)		
Machinery	0.094	0.918***	0.039***	0.413***	21544	4531
	(0.108)	(0.064)	(0.012)	(0.056)		
Computing & electrical	−0.279*	0.842***	0.193***	0.540***	12056	2796
	(0.152)	(0.093)	(0.022)	(0.112)		
Transport equipment	0.320	0.922***	0.150***	0.941***	4680	1041
	(0.349)	(0.169)	(0.034)	(0.173)		

Note. Pooled OLS estimation with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Levels of exports: results with s.e.

II

	WAGE	PROD	INV	PAT	Obs.	firms
Food, beverages, tobacco	0.333*	0.876***	0.152***	1.057***	9931	2310
	(0.184)	(0.089)	(0.026)	(0.401)		
Textiles, wearing, leather	−0.046	1.182***	−0.066***	0.614***	23326	5778
	(0.117)	(0.060)	(0.014)	(0.141)		
Wood	−0.332	0.486**	0.025	1.825***	3226	743
	(0.387)	(0.233)	(0.042)	(0.253)		
Paper & printing	−1.438***	1.004***	0.217***	1.365***	7249	1719
	(0.263)	(0.143)	(0.027)	(0.347)		
Rubber & plastics	0.948***	0.922***	0.074***	0.381***	8492	1848
	(0.205)	(0.110)	(0.024)	(0.110)		
Other non-metallic	1.655***	−0.238	−0.041	0.762***	8178	1755
	(0.255)	(0.149)	(0.027)	(0.226)		
Fabricated metal	−0.009	1.135***	0.120***	0.706***	14647	3531
	(0.160)	(0.098)	(0.017)	(0.121)		
Other manufacturing	−0.740***	1.214***	0.066***	0.545***	10562	2471
	(0.182)	(0.111)	(0.023)	(0.158)		

Note. Pooled OLS estimation with robust standard errors clustered at the firm level in parentheses. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Levels of exports: Heckman selection model

I

	WAGE	PROD	INV	PAT	Obs.	firms
ALL MANUFACTURING	−0.049	0.758***	0.072***	0.499***	181,524	39,761
	(0.048)	(0.027)	(0.006)	(0.038)		
Chemicals	0.153	0.764***	0.291***	0.118	9261	1714
	(0.196)	(0.098)	(0.026)	(0.137)		
Basic metals	−0.071	0.943***	0.073**	−0.031	7108	1236
	(0.283)	(0.117)	(0.029)	(0.326)		
Machinery	0.014	0.795***	0.028**	0.336***	24,312	5010
	(0.101)	(0.060)	(0.012)	(0.053)		
Computing & electrical	−0.351**	0.673***	0.142***	0.462***	15,294	3624
	(0.142)	(0.087)	(0.021)	(0.107)		
Transport equipment	0.111	0.796***	0.126***	0.777***	5725	1244
	(0.308)	(0.151)	(0.031)	(0.168)		

Note. Maximum likelihood estimation of Heckman selection model with robust standard errors clustered at the firm level in parentheses. The excluded selection variable is the firm's export status at time $t-1$. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Levels of exports: Heckman selection model

II

	WAGE	PROD	INV	PAT	Obs.	firms
Food, beverages, tobacco	0.256	0.690***	0.143***	1.026**	14,136	2941
	(0.167)	(0.084)	(0.025)	(0.415)		
Textiles, wearing, leather	−0.054	0.909***	−0.039***	0.668***	32,356	8030
	(0.107)	(0.058)	(0.013)	(0.145)		
Wood	−0.362	0.205	0.009	1.828***	4854	1028
	(0.350)	(0.216)	(0.039)	(0.206)		
Paper & printing	−0.853***	0.777***	0.165***	1.310***	10,635	2268
	(0.243)	(0.130)	(0.025)	(0.295)		
Rubber & plastics	0.733***	0.800***	0.062***	0.404***	9846	2074
	(0.190)	(0.102)	(0.023)	(0.100)		
Other non-metallic	1.210***	−0.057	−0.018	0.567***	12,685	2532
	(0.228)	(0.134)	(0.025)	(0.207)		
Fabricated metal	−0.094	0.885***	0.072***	0.596***	21541	5011
	(0.147)	(0.091)	(0.016)	(0.115)		
Other manufacturing	−0.706***	1.055***	0.057***	0.508***	12,856	2891
	(0.170)	(0.107)	(0.022)	(0.144)		

Note. Maximum likelihood estimation of Heckman selection model with robust standard errors clustered at the firm level in parentheses. The excluded selection variable is the firm's export status at time $t-1$. Coefficient on *EMP* omitted. Sector-year dummies are included in the first regression (All manufacturing) and year dummies in the sectoral regressions.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.