It takes (more than) a moment: Revisiting the link between firm productivity and aggregate exports

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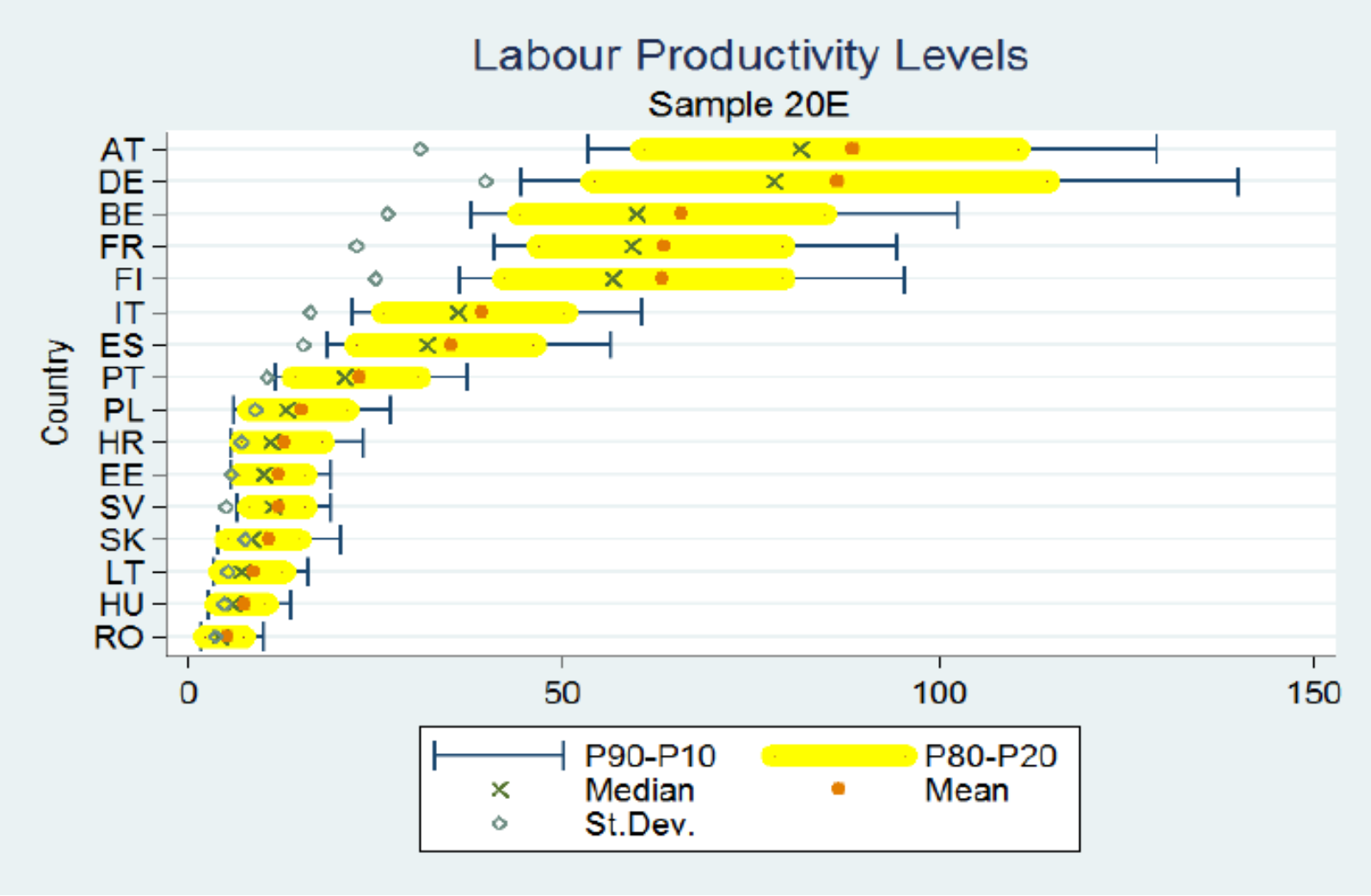
Motivation

- MICRO TO MACRO:
  - ⇒ The aim of this paper is to examine which features of productivity distributions are related to aggregate exports.
  - ⇒ (Ir)resistible prominence of average productivity (first moment) in explaining aggregate export
    - ⇒ policy practice (e.g. competitivness measured by average unit labour costs)
    - ⇒ micro-macro trade literature (standard trade model à la Melitz 2003; comparative advantage in Ricardian framework à la Costinot et al. 2012)
  - ⇒ Contradicting hints
    - ⇒ The distribution of firms' characteristics matters for aggregate outcomes (Gabaix, 2011 and Happy Few Mayer Ottaviano, 2007).
    - ⇒ Recent empirical studies provide evidence of the large heterogeneity of firms' performances (TFP and labour productivity) both within and between countries (CompNet).

Motivation



Source: Our calculation from CompNet.

Presentation outline

- What we do and achieve
- Literature
- Theoretical Framework
- Empirical Analysis
- Policy implications

This paper

What does it do?

Which moments of productivity distributions (mean; dispersion; asimmetry) are related to aggregate exports (exporters' multilateral resistance)? Does standard trade theory stand to the data?

a. Define theoretically the null hypothesis:

   1. Derive a gravity equation of the standard trade model à la Melitz (2003), where aggregate bilateral exports from country *o* to any country *d* only depend on the mean productivity (and number of firms) and not on higher moments of the productivity distribution of its producers

b. Test empirically the null hypothesis

   1. THE COMPETITIVENESS INDEX (Multilateral resistance term). Run gravity regressions and derive origin country/industry fixed effects controlling for importer fixed effects and dyadic characteristics.
   2. RELATE IT TO PRODUCTIVITY DISTRIBUTIONS. Regress these fixed effects on various moments of the country/industry productivity distributions (if higher moments matter too, not only the first moment, the null hypothesis is rejected).

This paper

What does it achieve?

1. The null hypothesis is rejected:
   a. Aggregate exports are highly correlated to the first moment of productivity distributions, but also to measures of dispersion and asymmetry.
   b. Asymmetry is especially robust.

2. These results hold both for labor productivity and a subsample of indicators TFP.
3. The results are robust to different specifications (and standard errors).
4. Revisit policy framework

Literature

- Happy Fews and Granularity.
  - The Happy Few (Clerides Lach and Tybout, 1998, Bernard and Jensen, 1999; Mayer and Ottaviano, 2007): aggregate exports highly concentrated.
  - Granularity (Gabaix, 2011; Di Giovanni & Levchenko, 2013): idiosyncratic shocks to large firms affect aggregate fluctuations.

- New Gravity
  - Structural gravity with heterogeneous firms and Pareto, exporters multilateral resistance terms is only related to exporting country's first moments and number of firms (from Melitz, 2003; Chaney, 2008; Helpman et al.,2008; Head and Mayer, 2014).

- Gains from trade and productivity distributions
  - Pareto to quantify welfare effects of trade by using a parsimonious set of aggregate stats (Arkolakis et al. ,2012; Costinot and Rodriguez-Clare, 2014).
  - Away from Pareto to correctly compute variable bilateral elasticities to trade costs (Bas et al., 2015; Melitz and Redding, 2015).

Theoretical Framework

Aggregate export in generalized trade model with heterogeneous firms

$$X_{od} = \frac{N_o \int_0^{c_{od}} u'(q_{od}(c)) q_{od}(c) dG_o(c)}{\sum_{m=1}^{M} N_m \left[\int_0^{c_{md}} u'(q_{md}(c)) q_{md}(c) dG_m(c)\right]} y_d L_d$$

Aggregate export in standard trade model à la Melitz (2003)

- CES demand system
- Iceberg variable and fixed trade costs
- Pareto distribution

$$X''_{od} = N_o \left(\overline{c}_{oo}\right)^{-k} \left(f_{od}\right)^{1-\frac{k}{\sigma-1}} \left(\tau_{od}\right)^{-k} \frac{y_d L_d \left(\overline{c}_{dd}\right)^{1-\sigma+k} \left(f_{dd}\right)^{\frac{k}{\sigma-1}-1}}{N_d^s \left(\overline{c}_d^s\right)^{1-\sigma}} \quad \textbf{(1)}$$

Exporters' capability (Multilateral resistance)

Only first moments matter

Theoretical Framework

- If we explicit factor prices and productivity assuming technology is Cobb Douglas in labour and capital with shares α and *(1-α)* (see Head and Mayer, 2014), exporters' capabilities is:

$$N_o(\bar{c}_{oo})^{-k} = N_o\left(\alpha^{\alpha}(1-\alpha)^{1-\alpha}\right)^{-k}(w_o^{\alpha}r_o^{1-\alpha})^{-k}(\overline{\varphi_{oo}})^{k}$$

Average productivity

- We assume
  - capital freely mobile within and across sectors (captured by country fixed effect);
  - labour freely mobile only within sectors

Empirical Strategy

We test the implication of the model in two steps.

1. We run gravity regressions to estimate origin country fixed effects for a sample of Eurozone countries. Fixed effects ideally measure the "competitiveness" of the sampled countries.

2. We check whether the variation in the estimated origin country fixed effects is related to various moments of the distribution of firm productivity.

Objective: Test the null hypothesis of the "standard trade model":

- only the first moment of the productivity distribution matter for competitiveness.

Data

Productivity measures: CompNet Database

- The CompNet database is a database of comparable productivity indicators for 17 (variable) EU countries built by members of CompNet using state of the art computation methodologies.
  - All firms 1996-2012
  - > 20 employees 2001-2011 (cross country comparable).

- The data exploits the information contents coming not only from averages, but also from the distribution of firms across several dimensions (e.g. productivity, size, sectors).
  - unweighted average, median, coefficient of variation, 10^{th}, 20^{th}, 80^{th}, and 90^{th} percentiles, and skewness
- Main origin source: Central Banks and NSI micro level databases.

Data

CompNet Database

- *Countries*: Austria, Belgium, Croatia, Estonia, Finland, France, Germany, Hungary, Italy, Lithuania, Poland, Portugal, Romania, Slovakia, Slovenia, Spain.

- *Sectors*: manufacturing sectors at NACE 2-digit rev.2 (with the exclusion of Coke and Petroleum (19) and Tobacco (12))

- *Time period*: 1996-2012/2001-2011 (two overlap the two version of CompNet database).

- Productivity measured as labour productivity (value added per worker) and TFP (Wooldridge with modifications by Galuscak).

- In the second stage, we eliminate observational units that are obtained with less than 10 observations (at least 10 firms by sector, year, and country).

- Unbalanced panel.

Data

Gravity Data

- ***Eurostat Comext:*** export values in (logs) of millions of euros by destination, country, year & sector.
- ***Eurostat***: labor compensation and total employment by sector.
- ***Cepii:*** distance, common border, common language, former colony.
- ***UNCTAD:*** nominal bilateral exchange rate.

Empirical Analysis

First Step

Gravity:

- Unbalanced panel of 472,321 observations
- Baseline: includes all bilateral export flows from *20E* CompNet countries *(o)* to destination countries *(d)* and 22 manufacturing sectors *(s)* from 2001 to 2012 *(t)*.
- We estimate Eq. (1) as follows

$$Log(Export)_{o,d,s,t} = \alpha_{o,s,t} + \beta_{d,s,t} + \gamma_{o,d} + \varepsilon_{o,d,s,t}$$

- $\alpha_{o,s,t}$:origin*year*sector fixed effects -> Competitiveness index
- $\beta_{d,s,t}$: destination * year*sector fixed effects
- $\delta_{o.d}$: dyadic terms (distance, common border, etc…)

Fixed effects $\alpha_{o,s,t}$ measure the competitiveness of the sampled countries as suppliers, netting out importer-specific and country-pair-specific characteristics

Empirical Analysis

First step results

	(1) All	(2) From 2001	(3) From 2001 (Country in sample 20E)
Log(Distance)	-1.219***	-1.235***	-1.214***
	(.0601)	(.064)	(.0761)
Common Border	.5166***	.5775***	.4655***
	(.1476)	(.1527)	(.1546)
Common Language	.7079***	.7123***	.7222***
	(.1005)	(.1006)	(.1315)
Former Colony	.6125***	.5727***	.6496***
	(.1659)	(.1643)	(.1641)
Obs	775764	578965	472321
R^2	.8248	.8185	.8268
Fixed Effects 1	Origin*Sector*Year	Origin*Sector*Year	Origin*Sector*Year
Fixed Effects 2	Destination*Sector*Year	Destination*Sector*Year	Destination*Sector*Year

Empirical Analysis

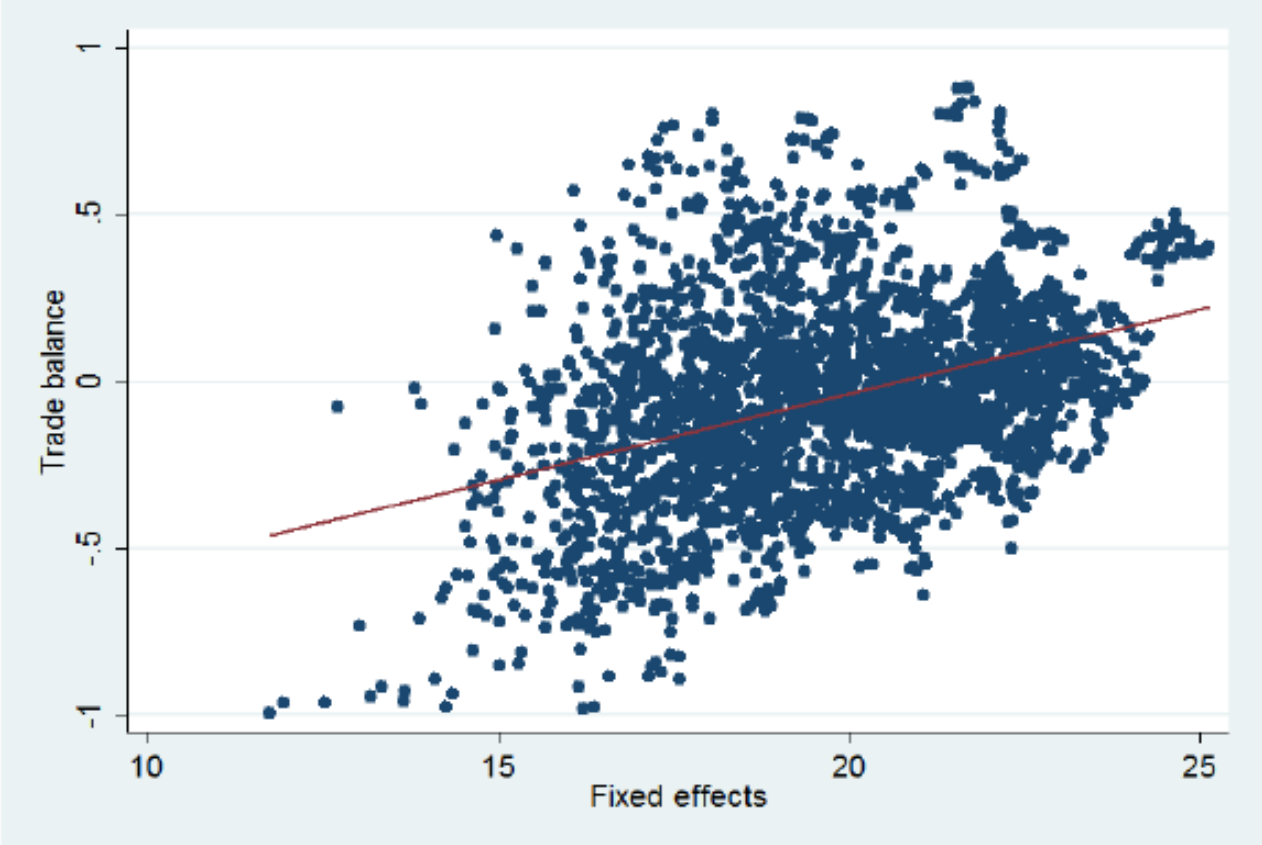
First step: Competitive index, descriptive statistics

Country	Mean	St.Dev	IQR	Obs	Min	Max
Austria	12.642	0.978	0.919	227	9.170	14.575
Belgium	13.132	1.278	1.836	242	9.217	15.327
Croatia	10.070	0.700	0.953	224	7.859	11.457
Estonia	10.285	0.795	0.879	239	7.065	11.775
Finland	12.002	1.247	1.518	250	8.606	14.519
France	13.959	1.298	1.554	252	9.735	15.798
Germany	14.535	1.276	1.698	252	11.088	17.048
Hungary	11.505	1.091	1.495	210	8.160	14.253
Italy	14.161	1.088	0.637	253	10.237	16.612
Lithuania	10.569	0.820	0.804	211	7.661	12.224
Malta	9.671	0.870	1.324	36	8.265	11.042
Poland	12.437	0.974	1.174	176	9.359	14.337
Portugal	12.087	0.691	0.714	147	9.512	13.016
Romania	11.251	0.896	1.119	210	8.519	12.853
Slovakia	11.012	0.934	0.937	229	8.338	13.615
Slovenia	10.976	0.860	1.063	237	8.128	12.601
Spain	13.388	1.023	1.148	252	9.603	14.997
Total	12.159	1.756	2.649	3647	7.065	17.048

- The estimated $\alpha's$ are highly correlated among all the specifications.
- The most advanced European economies, such as Germany or France, show the highest values, while smaller countries (e.g., Estonia or Romania) reports the lower ones.
- Fixed effects are positively correlated with sectoral trade balance (index of correlation equal to 0.30).

Empirical Analysis

First step: Competitiveness index and trade balance



Source: authors elaborations on Eurostat ComExt data. Each dot is defined at country-sector-year level. The Y-axis reports the trade balance defined as $\frac{export-import}{export+import}$. The X-axis reports the fixed effect computed from Eq. 11 (see Table 3, Col.3.). The red line represents the linear interpolation.

Empirical Analysis

Second stage: Asimmetry and Dispersion measures

Asymmetry

For each country-sector-year triple, we measure the asymmetry of distribution using parametric *(Skewness index – third moment*) and non parametric (*Pearson's second skewness coefficient*) asymmetry indices

$$Pears._{o,s,t} = (\frac{mean_{ost} - median_{dst}}{st.dev._{ost}}),$$

and the *skewness index* reported in the CompNet database (third moment).

Dispersion

- The ratio of the 80th to the 20th percentile of the productivity distribution (P80/P20).
- The ratio of the 90th to 10th percentile of the productivity distribution (P90/P10).

Data

Second Stage: Productivity distributions from CompNet Database

	Labour Productivity				
Country	LProd(Mean)	LProd(Asim.)	LProd(Skew.)	LProd(P90/P10)	LProd(P80/P20)
Austria	4.347	0.175	0.907	2.528	1.862
Belgium	4.004	0.220	1.287	2.725	1.908
Croatia	2.328	0.249	1.271	4.154	2.522
Estonia	2.321	0.208	0.976	3.726	2.402
Finland	4.018	0.218	1.234	2.469	1.753
France	4.121	0.217	1.207	2.714	1.910
Germany	4.516	0.200	1.193	3.175	2.108
Hungary	1.784	0.262	1.572	5.848	2.921
Italy	3.582	0.205	1.301	2.840	1.950
Lithuania	2.024	0.269	1.317	5.347	3.113
Poland	2.436	0.252	1.667	4.897	2.767
Portugal	2.978	0.202	1.125	3.278	2.163
Romania	1.497	0.300	1.813	5.814	3.178
Slovakia	2.263	0.273	1.921	5.555	2.954
Slovenia	2.392	0.182	1.045	2.967	1.960
Spain	3.496	0.204	1.127	3.021	2.039
Total	3.102	0.225	1.307	3.739	2.309

Empirical Analysis

Second Step

More than one moment!!!

Following the theoretical model

$$Comp.Ind_{o,s,t} = a_0 + a_1 Asim_{o,s,t-1} + a_2 Dis_{o,s,t-1} + a_3 Mean_{o,s,t-1} + D_o + D_s + D_t + e_{ost}$$

- The dependent variable is the competitiveness index (*Comp.Ind.*), i.e, the fixed effects of gravity.
- First moment: *Mean* is the average productivity level as computed from the CompNet database.
- Higher moments: *Asim ; Disp* measures of asymmetry and dispersion.
- We lag explanatory variables of one year to minimize concerns of reverse causality.
- We include different combinations of fixed effects (country, sector, and year).

Empirical Analysis

Second Step: benchmark labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\text{Log(LProd(Mean))}_{ost-1}$	.0841***	.0804***	.0748***	.0944***	.1056***	.0919***	.0835***	.1021***	.0947***
	(.0232)	(.0231)	(.0223)	(.022)	(.0222)	(.022)	(.0214)	(.0222)	(.0216)
$\text{Log(firms)}_{ost-1}$	.5957***	.595***	.5966***	.5964***	.5772***	.5961***	.597***	.5776***	.58***
	(.0314)	(.031)	(.0303)	(.0314)	(.0319)	(.0312)	(.0304)	(.0317)	(.0308)
Log(wage)_{ost-1}	-.0627***	-.0654***	-.0701***	-.0599***	-.0598***	-.0615***	-.067***	-.0618***	-.0671***
	(.0142)	(.0144)	(.0142)	(.0138)	(.014)	(.0141)	(.0139)	(.0142)	(.014)
$\text{LProd(P90/P10)}_{ost-1}$		.0136*				.0072		.0093	
		(.0079)				(.0082)		(.008)	
$\text{LProd(P80/P20)}_{ost-1}$			.1054***				.0886***		.0983***
			(.0251)				(.0251)		(.0249)
$\text{LProd(Pears.)}_{ost-1}$				.4133***		.3913***	.2887**		
				(.1177)		(.1244)	(.1192)		
$\text{LProd(Skew.)}_{ost-1}$					.0761***			.0728***	.0681***
					(.0191)			(.0195)	(.0185)
Cons.	9.784***	9.77***	9.628***	9.634***	9.661***	9.634***	9.548***	9.657***	9.529***
	(.2088)	(.2092)	(.2087)	(.202)	(.2052)	(.2023)	(.2048)	(.2055)	(.2078)
Obs.	2789	2789	2789	2789	2789	2789	2789	2789	2789
R2	.9293	.9294	.93	.9309	.9298	.9298	.9298	.9302	.9309
Country fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Sector fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Clustering	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year

Empirical Analysis
Second step: quantifying the impact

Increase of one standard deviation in:	%Δ Country Competitiveness
Average Productivity	6.2%
Pears Index	2.5%

Asymmetry has as a positive impact, but relatively smaller than average productivity

Empirical Analysis

Robustness I

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Log(LProd(Mean))}_{ost-1}$	.0963***	.1068***	.0844***	.0949***	.0932***	.1021***	.0814***	.0903***
	(.0242)	(.0244)	(.0234)	(.0236)	(.0239)	(.0239)	(.0234)	(.0234)
$\text{Log(firms)}_{ost-1}$	.6208***	.5973***	.6215***	.601***	.5974***	.5799***	.5982***	.583***
	(.0336)	(.034)	(.0326)	(.0329)	(.0326)	(.0332)	(.0316)	(.032)
Log(wage)_{ost-1}	-.0542***	-.0543***	-.0611***	-.0613***	-.0596***	-.0597***	-.0664***	-.0666***
	(.0143)	(.0146)	(.0144)	(.0145)	(.0143)	(.0145)	(.0144)	(.0145)
$\text{LProd(P80/P20)}_{ost-1}$			.0902***	.1021***			.0875***	.0965***
			(.0256)	(.0254)			(.0271)	(.027)
$\text{LProd(Pears.)}_{ost-1}$	.473***		.345***		.3889***		.2624**	
	(.1193)		(.1206)		(.13)		(.1317)	
$\text{LProd(Skew.)}_{ost-1}$		.0858***		.0775***		.0678***		.0599***
		(.0199)		(.0193)		(.0211)		(.0205)
Cons.	8.097***	8.216***	8.283***	8.294***	11.3***	11.31***	11.2***	11.17***
	(.2748)	(.2776)	(.2166)	(.213)	(.155)	(.1564)	(.1617)	(.1646)
Obs.	2789	2789	2789	2789	2789	2789	2789	2789
R2	.9323	.9324	.9328	.933	.9322	.9322	.9327	.9328
Country X year fixed effects	yes	yes	yes	yes	no	no	no	no
Sector X year fixed effects	no	no	no	no	yes	yes	yes	yes
Sector fixed effects	yes	yes	yes	yes	no	no	no	no
Country fixed effects	no	no	no	no	yes	yes	yes	yes
Clustering	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year	Sector-year

Empirical Analysis

Robustness II

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Alternative clustering				**WLS**		
$\text{Log(LProd(Mean))}_{ost-1}$	.0844***	.0949***	.0814***	.0903***	.087***	.0973***	.0893***	.0974***
	(.0222)	(.0208)	(.02)	(.0194)	(.022)	(.0218)	(.0226)	(.0225)
$\text{Log(firms)}_{ost-1}$	.6215***	.601***	.5982***	.583***	.631***	.6124***	.6114***	.5979***
	(.0234)	(.023)	(.0236)	(.0233)	(.0343)	(.0346)	(.0334)	(.0337)
Log(wage)_{ost-1}	-.0611***	-.0613***	-.0664***	-.0666***	-.055***	-.0553***	-.0601***	-.0603***
	(.0147)	(.0144)	(.0133)	(.0128)	(.0138)	(.0139)	(.0137)	(.0138)
$\text{LProd(P80/P20)}_{ost-1}$	.0902***	.1021***	.0875***	.0965***	.1027***	.1162***	.0999***	.1106***
	(.0213)	(.0196)	(.0206)	(.0194)	(.0277)	(.0271)	(.0291)	(.0286)
$\text{LProd(Pears)}_{ost-1}$	.345***		.2624**		.364***		.283**	
	(.116)		(.1204)		(.1257)		(.1376)	
$\text{LProd(Skew)}_{ost-1}$		.0775***		.0599***		.076***		.0577***
		(.0192)		(.0184)		(.0197)		(.0207)
Cons.	8.283***	8.294***	11.2***	11.17***	7.117***	7.102***	11.03***	10.99***
	(.1772)	(.1704)	(.3227)	(.3171)	(.2511)	(.2531)	(.1575)	(.1598)
Obs.	2789	2789	2789	2789	2770	2770	2770	2770
R^2	.9328	.933	.9327	.9328	.9359	.9361	.9358	.9359
Country X year fixed effects	yes	yes	no	no	yes	yes	no	no
Sector X year fixed effects	no	no	yes	yes	no	no	yes	yes
Sector fixed effects	yes	yes	no	no	yes	yes	no	no
Country fixed effects	no	no	yes	yes	no	no	yes	yes
Clustering	Country-year	Country-year	Country-year	Country-year	Sector-year	Sector-year	Sector-year	Sector-year

Empirical Analysis

Robustness III

Excluded Country	$\text{Log(LProd(Mean))}_{ost-1}$	$\text{Log(firms)}_{ost-1}$	Log(wage)_{ost-1}	$\text{LProd(Pears.)}_{ost-1}$	Obs.	R2
AUT	.0835***	.6282***	-.0514***	.5687***	2629	.9317
BEL	.1054***	.5857***	-.0665***	.3981***	2595	.9335
CRO	.0931***	.5815***	-.0658***	.392***	2709	.9282
EST	.0896***	.5842***	-.0512***	.4943***	2623	.9266
FIN	.1187***	.5756***	-.0562***	.3102**	2589	.9377
FRA	.1059***	.6004***	-.0641***	.3245***	2558	.9323
GER	.0842***	.6082***	-.0594***	.4337***	2558	.9171
HUN	.0843***	.5879***	-.0524***	.3009***	2601	.9308
ITA	.0854***	.572***	-.0751***	.3711***	2642	.9261
LIT	.0897***	.5768***	-.0817***	.4035***	2639	.9274
POL	.0951***	.5892***	-.0598***	.4335***	2697	.9305
PRT	.1206***	.6084***	-.0481***	.4678***	2663	.9317
ROM	.1071***	.6306***	-.0542***	.4242***	2602	.9351
SVK	.0761***	.6044***	-.0661***	.4027***	2586	.9299
SLO	.1051***	.6164***	-.0497***	.4624***	2586	.9291
SPA	.0805***	.5957***	-.0608***	.3866***	2558	.9288

Empirical Analysis

Second Step: robustness TFP

The available data allow us to compute only two cross country comparable statistics on TFP: mean and asymmetry

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Log(TFP(Mean))}_{ost-1}$	.0435**	.0527***	.0427**	.0519***	.0445**	.0535***
	(.0184)	(.0185)	(.0191)	(.0192)	(.0195)	(.0195)
$\text{Log(firms)}_{ost-1}$	.6162***	.6167***	.6202***	.6208***	.619***	.6199***
	(.0343)	(.0339)	(.0356)	(.0352)	(.0357)	(.0354)
Log(wage)_{ost-1}	-.0505***	-.0483***	-.0515***	-.0491***	-.0483***	-.0461***
	(.015)	(.015)	(.0159)	(.0157)	(.0158)	(.0156)
$\text{TFP(Pears.)}_{ost-1}$		.4085***		.3981***		.4124***
		(.111)		(.1178)		(.1253)
Cons.	10.02***	9.87***	10.32***	10.17***	11.66***	11.52***
	(.218)	(.2165)	(.1971)	(.2233)	(.1694)	(.1718)
Obs.	2464	2462	2464	2462	2464	2462
R2	.9327	.9332	.9341	.9346	.9351	.9355
Country fixed effects	yes	yes	no	no	yes	yes
Sector fixed effects	yes	yes	yes	yes	no	no
Country fixed effects	yes	yes	no	no	no	no
Country X year fixed effects	no	no	yes	yes	no	no
Sector X year fixed effects	no	no	no	no	yes	yes
Clustering	sector - year	sector - year	sector - year	sector - year	sector - year	sector - year

Conclusions

- We reject the null hypothesis of the standard trade model that it is average productivity that matters for aggregate exports

- The dispersion and the asymmetry of productivity distributions must be taken into account, along with mean productivity, when explaining aggregate export performance.

- Transition towards higher productivity percentiles should be a central policy objective, besides from aiming at the average productivity of the productive sector.