

Links between R&D, innovation and export across European manufacturing firms

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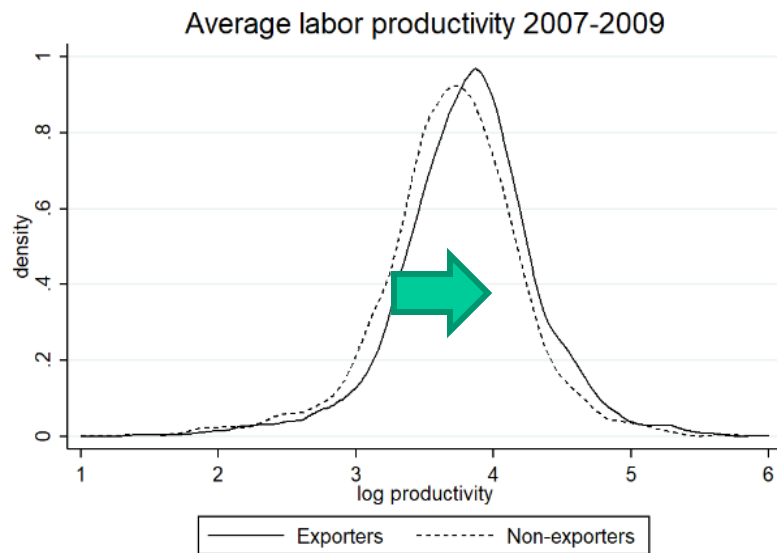
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(♠) Universitat Rovira i Virgili, Reus (Spain)

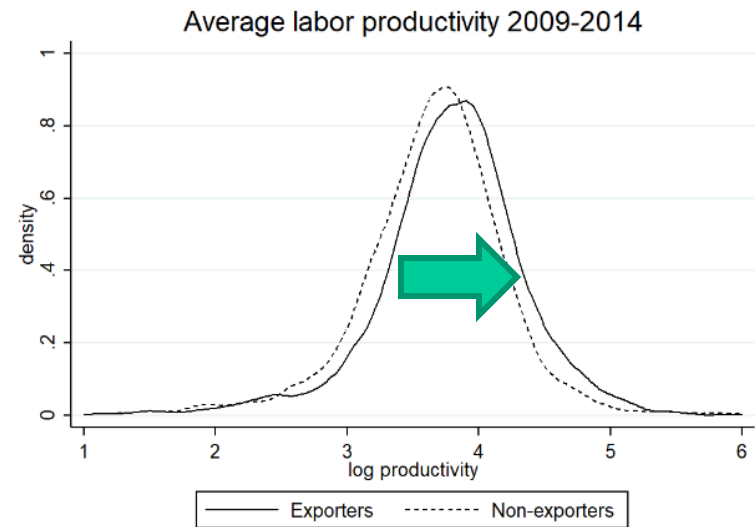
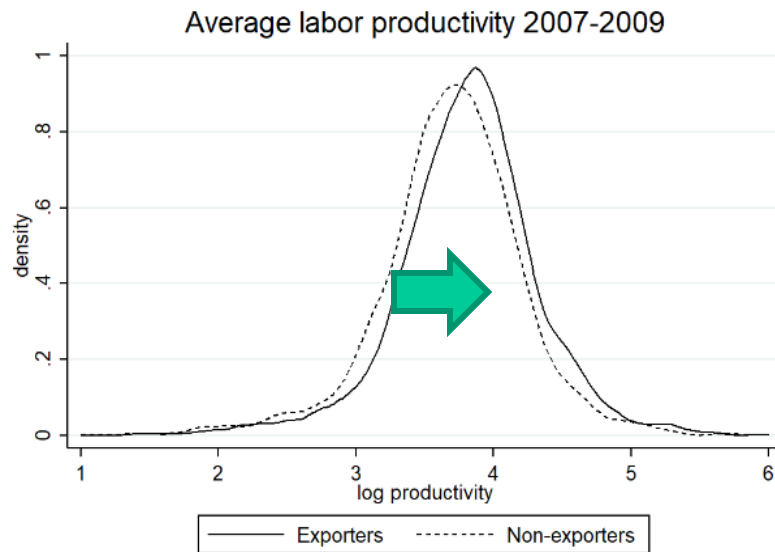
Which is the evidence between export status and productivity?

Kernel densities of the logarithmic value of the labour productivity.
Differences between exporters and non-exporters.



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Approaches to firm heterogeneity between productivity and export:

I. Self-selection hypothesis (Bernard and Jensen, 1995; Melitz, 2003)

$$e_{it} = g(\omega_{it-1}) + \xi_{it}$$

II. Learning-by-exporting hypothesis (De Loecker, 2007, 2010; Wagner, 2007)

$$\omega_{it} = g(\omega_{it-1}, e_{it-1}) + \xi_{it}$$

III. R&D-innovation-productivity-export: the missing link (Aw et al., 2011).

$$\omega_{it} = g(\omega_{it-1}, d_{it-1}, e_{it-1}) + \xi_{it}$$

IV. Extensive (Melitz, 2003) or **intensive margins** (Fernandes et al., 2018)

Links between R&D, innovation, export and productivity

Decision
to invest
in R&D



R&D
intensity



Innovation



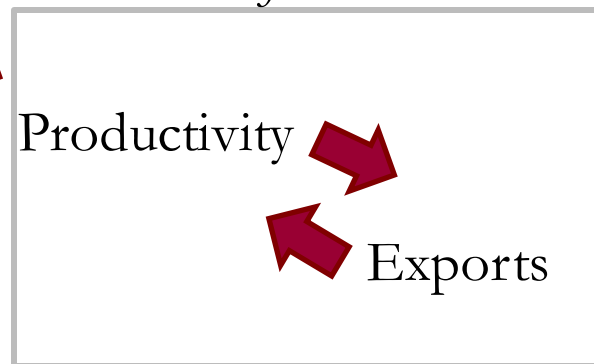
Productivity



Exports

Learning-by-exporting

Self-selection

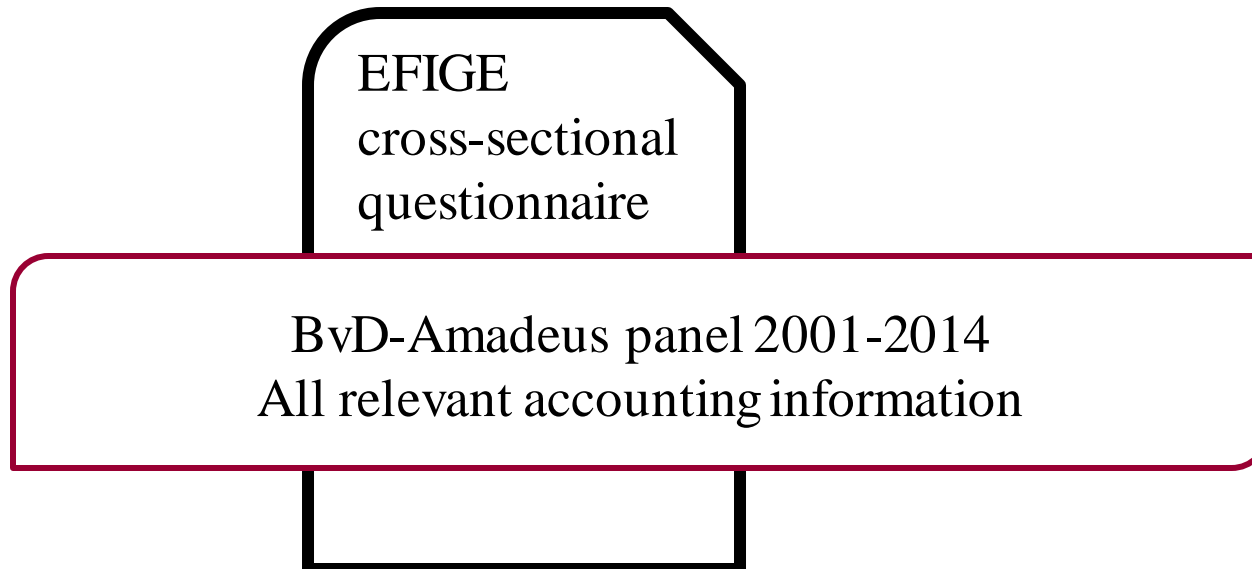


Hypotheses

- By testing the “**self-selection effect**”:
 - H1. More productive firms have a greater capacity to export.
 - H2. Innovative firms present a positive association with their export capacity.
- By testing the “**learning-by-exporting effect**”:
 - H3. Exporting firms have greater subsequent productivity levels.
 - H4. Exporting firms are more prone to undertake R&D and invest more intensively in R&D.
- In order to calibrate the knowledge frontier distance of the **European countries**:
 - H5: The drivers of the SS effect and the impacts of the LBE process on the performance of the exporter firms differ between laggard countries and leader countries.

Looking for useful data:

- EFIGE dataset: a representative sample of almost 15,000 firms from 7 EU countries (GER, FRA, ITA, ESP, UK, AUS, HUN) surveyed on quantitative and qualitative information on ≈ 150 items regarding R&D and innovation, financing, export, etc. in 2007-2009
- BvD-Amadeus: panel data (2001-2014) containing the relevant accounting information for the above firms.



Empirical strategies

- To control for possible selection biases, we apply coarsened exact matching (cem) to our sample (exporters are treated, non-exporters are non-treated).
- Our theoretical arguments are based on an «augmented» CDM approach model (**CDM structural models**) where we test SS and LBE hypothesis (Jienwatcharamongkhon and Tavassoli, 2013; Rehman, 2017)
- Heckman (1)-(2) and GSEM model (3)-(7)

$$Prob(RD_i = 1|X = x_{1i}) = \theta(x_{1i,t}\beta_{11} + SS_i\beta_{12} + LBE_i\beta_{13} + \epsilon_{1i}) \quad (1)$$

$$RDint_i = x_2\beta_{21} + SS_i\beta_{22} + LBE_i\beta_{23} + \epsilon_{2i} \quad (2)$$

$$Prob(Prod_i = 1|X = x_{3i}) = \theta(x_{3i}\beta_{31} + SS_i\beta_{32} + LBE_i\beta_{33} + \epsilon_{3i}) \quad (3)$$

$$Prob(Proc_i = 1|X = x_{4i}) = \theta(x_{4i}\beta_{41} + SS_i\beta_{42} + LBE_i\beta_{43} + \epsilon_{4i}) \quad (4)$$

$$LabProd_{i,2010} = x_{5i}\beta_{51} + LBE_i\beta_{52} + \epsilon_{5i} \quad (5)$$

$$Exp_i = x_{6i}\beta_{61} + SS_i\beta_{62} + \epsilon_{6i} \quad (6)$$

$$LabProd_{i,2009-14} = x_{7i}\beta_{71} + LBE_i\beta_{72} + \epsilon_{7i} \quad (7)$$

Main results

Table 2. Estimated coefficients, Heckman equation and GSEM. Matched sample.

	Heckman equation		GSEM				
	(1) R&D status	(2) R&D intensity	(3) Product Innovation	(4) Process Innovation	(5) Labour prod. 2010	(6) Export intensity	(7) Avg. proc level 09-1
Exporter	0.601*** (0.0355)	0.0581 (0.0805)	0.156*** (0.0382)	0.0595 (0.0382)	0.0315* (0.0164)		-0.0185 (0.0156)
Productivity 2002–07	0.111*** (0.0383)	0.464*** (0.0485)	-0.0574 (0.0387)	0.132*** (0.0384)		3.363*** (0.850)	
R&D intensity			0.0449*** (0.0059)	0.0261*** (0.0044)			
R&D status					0.0371** (0.0180)		0.0840*** (0.0175)
Product Innovation					-0.0807*** (0.0225)		-0.0398* (0.0236)
Process Innovation					0.0446** (0.0183)		0.0043 (0.0211)
Organization Innovation					-0.00468 (0.0191)		0.0136 (0.0216)
Market Innovation					0.0286 (0.0251)		-0.0360* (0.0209)
Innovative sales %							-0.0004 (0.0005)
KL ratio	0.0348* (0.0207)	0.370*** (0.0263)			0.293*** (0.0110)		0.312*** (0.0102)
Workers	0.167*** (0.0184)	-0.0152 (0.0268)	0.230*** (0.0222)	0.193*** (0.0225)	0.0302*** (0.0111)	5.854*** (0.441)	0.0422*** (0.0103)
Physical investments	0.0041*** (0.0011)	0.0165*** (0.0016)	0.0015 (0.0014)	0.0127*** (0.0014)	-0.0008 (0.0006)		0.0002 (0.0007)
Group	0.0237 (0.0409)	-0.0755 (0.0475)	0.0412 (0.0481)	0.0288 (0.0484)	0.0437** (0.0218)	4.211*** (0.981)	4.1×10 ⁻⁵ (0.0201)
Human capital	0.422*** (0.0349)	0.0486 (0.0560)	0.239*** (0.0436)	0.118*** (0.0430)	0.0668*** (0.0198)	2.253*** (0.813)	0.0597*** (0.0175)
Mature firms	0.0741** (0.0325)	-0.102** (0.0400)	0.0979*** (0.0371)	0.0437 (0.0371)	0.0256 (0.0162)	2.698*** (0.708)	0.0342** (0.0150)
Competitors			0.104*** (0.0374)	0.0655* (0.0373)			
Quality certification			0.0123 (0.0372)	0.207*** (0.0369)			
Tax incentives	0.492*** (0.0392)						
Leader countries	-0.0532 (0.0364)	0.0045 (0.0447)	-0.0201 (0.0403)	-0.388*** (0.0410)	0.325*** (0.0179)	-6.09*** (0.710)	0.372*** (0.0159)
Scale-intensive sectors	-0.0773** (0.0372)	-0.119** (0.0471)	0.0257 (0.0417)	0.0364 (0.0416)	-0.0689*** (0.0188)	-0.265 (0.783)	-0.0614** (0.0173)
Specialized-suppliers sectors	0.197*** (0.0477)	-0.0700 (0.0574)	0.130** (0.0604)	-0.166*** (0.0630)	0.0483* (0.0254)	6.449*** (1.292)	0.0737*** (0.0231)
Science-based sectors	0.513*** (0.0880)	0.210** (0.0942)	0.481* (0.247)	-0.536** (0.239)	0.107 (0.104)	-3.647 (3.896)	0.187** (0.0853)
Constant	-2.092*** (0.136)	-1.786*** (0.358)			2.185*** (0.0602)	- (3.305)	2.038*** (0.0542)
R ²	0.1219		0.0775	0.0695	0.3350	0.0931	0.3542
Observations	7,511	3,122	6,140	6,140	6,140	6,140	6,140

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ and from the Heckman equation, Mills ratio -0.104

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More productive firms exhibit more capacity to export.

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Productivity 2002-07	0.111*** (0.0383)	0.464*** (0.0485)	-0.0574 (0.0387)	0.132*** (0.0384)		3.363*** (0.850)	
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Innovative sales %							-0.0004 (0.0005)
KL ratio	0.0348* (0.0207)	0.370*** (0.0263)			0.293*** (0.0110)		0.312*** (0.0102)
Workers	0.167*** (0.0184)	-0.0152 (0.0268)	0.230*** (0.0222)	0.193*** (0.0225)	0.0302*** (0.0111)	5.854*** (0.441)	0.0422*** (0.0103)
Physical investments	0.0041*** (0.0011)	0.0165*** (0.0016)	0.0015 (0.0014)	0.0127*** (0.0014)	-0.0008 (0.0006)		0.0002 (0.0007)
Group	0.0237 (0.0409)	-0.0755 (0.0475)	0.0412 (0.0481)	0.0288 (0.0484)	0.0437** (0.0218)	4.211*** (0.981)	4.1×10 ⁻⁵ (0.0201)
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Constant	-2.092*** (0.136)	-1.786*** (0.358)			2.185*** (0.0602)	-	2.038*** (0.0542)
R ²	0.1219		0.0775	0.0695	0.3350	0.0931	0.3542
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Table 3. Leader vs. laggard countries

	LEADER		LAGGARD	
	Export intensity	Avg. prod. level 09–14	Export intensity	Avg. prod. level 09–14
Exporter		0.0023 (0.0213)		-0.0237 (0.0216)
Productivity 2002–07	8.231*** (1.549)		1.869* (1.010)	
R&D intensity				
R&D status		0.0174 (0.0251)		0.125*** (0.0237)
Product Innovation		-0.0513 (0.0383)		-0.0309 (0.0301)
Process Innovation		-0.0665** (0.0310)		0.0474* (0.0286)
Organization Innovation		0.0374 (0.0320)		-0.0015 (0.0292)
Market Innovation		-0.0021 (0.0303)		-0.0489* (0.0279)
Innovative sales %		7.3×10^{-5} (0.0010)		-0.0009 (0.0006)
KL ratio		0.287*** (0.0154)		0.318*** (0.0133)
Workers	4.357*** (0.527)	0.0462*** (0.0117)	7.464*** (0.714)	0.0391** (0.0181)
Physical investments		0.0018** (0.0008)		-0.0007 (0.0010)
Group	5.445*** (1.279)	-0.0095 (0.0238)	2.453 (1.494)	0.0268 (0.0337)
Human capital	4.506*** (1.369)	0.0143 (0.0256)	1.392 (1.010)	0.0803*** (0.0236)
Mature firms	3.340*** (1.070)	-0.0149 (0.0203)	2.672*** (0.924)	0.0660*** (0.0211)
Scale-intensive sectors	-2.063* (1.212)	-0.0707*** (0.0237)	0.779 (1.022)	-0.0573** (0.0247)
Specialized-suppliers sectors	4.679** (1.866)	0.0745** (0.0324)	8.033*** (1.769)	0.0911*** (0.0335)
Science-based sectors	0.421 (5.882)	0.173 (0.127)	-10.42*** (3.889)	0.210** (0.0957)
Constant	-37.46*** (6.095)	2.558*** (0.0745)	-18.57*** (4.135)	1.987*** (0.0780)
R ²	0.1427	0.2804	0.0799	0.3239
Observations	2412	2412	2728	2728

SS is more intense for firms in leader countries

Main results

Table 3. Leader vs. laggard countries

	LEADER		LAGGARD	
	Export intensity	Avg. prod. level 09–14	Export intensity	Avg. prod. level 09–14
Exporter		0.0023 (0.0213)		-0.0237 (0.0216)
Productivity 2002–07	8.231*** (1.549)		1.869* (1.010)	
R&D intensity				
R&D status		0.0174 (0.0251)		0.125*** (0.0237)
Product Innovation		-0.0513 (0.0383)		-0.0509 (0.0501)
Process Innovation		-0.0665* (0.0310)		0.0474* (0.0286)
Organization Innovation		0.0374 (0.0320)		-0.0015 (0.0292)
Market Innovation		-0.0021 (0.0303)		-0.0489* (0.0279)
Innovative sales %		7.3×10 ⁻⁵ (0.0010)		-0.0009 (0.0006)
KL ratio		0.287*** (0.0154)		0.318*** (0.0133)
Workers	4.357*** (0.527)	0.0462*** (0.0117)	7.464*** (0.714)	0.0391** (0.0181)
Physical investments		0.0018** (0.0008)		-0.0007 (0.0010)
Group	5.445*** (1.270)	0.0095 (0.0238)	2.453 (1.494)	0.0268 (0.0307)
Human capital	4.506*** (1.369)	0.0143 (0.0256)	1.392 (1.010)	0.0803*** (0.0236)
Mature firms	3.340*** (1.070)	-0.0149 (0.0203)	2.672*** (0.924)	0.0660*** (0.0211)
Scale-intensive sectors	-2.063* (1.212)	-0.0707*** (0.0237)	0.779 (1.022)	-0.0573** (0.0247)
Specialized-suppliers sectors	4.679** (1.866)	0.0745** (0.0324)	8.033*** (1.769)	0.0911*** (0.0335)
Science-based sectors	0.421 (5.882)	0.173 (0.127)	-10.42*** (3.889)	0.210** (0.0957)
Constant	-37.46*** (6.095)	2.558*** (0.0745)	-18.57*** (4.135)	1.987*** (0.0780)
R ²	0.1427	0.2804	0.0799	0.3239
Observations	2412	2412	2700	2700

SS is more intense for firms in leader countries

R&D & innovation affect differently to subsequent firm labour productivity

Physical investments and human capital have different impacts

Main results

Table 4. Heckman estimation of the percentage of the R&D intensity, innovative sales and the percentage of exports. Matched sample.

	R&D equation		Innovation equation		Export equation	
	Probability of carrying out R&D	R&D intensity	Probability of innovating	Percentage of innovative sales	Probability of exporting	Percentage of exports over sales
	(1)	(2)	(3)	(4)	(5)	(6)
Productivity 2002–2007	0.111*** (0.0383)	0.464*** (0.0485)	-0.0918** (0.0394)	-0.931 (0.713)	-0.0392 (0.0360)	-0.583 (0.914)
Exporter	0.601*** (0.0355)	0.0581 (0.0805)	0.289*** (0.0380)	2.163** (0.912)		
Workers	0.167*** (0.0184)	-0.0152 (0.0268)	0.134*** (0.0197)	-0.969** (0.378)	0.262*** (0.0175)	4.573** (0.966)
Physical investments	0.0041*** (0.0011)	0.0165*** (0.0016)	0.0058*** (0.0013)	0.0327 (0.0259)	-0.0097*** (0.0011)	-0.0564 (0.0471)
KL ratio	0.0348* (0.0207)	0.370*** (0.0263)	0.0386* (0.0216)	0.882** (0.422)	0.255*** (0.0190)	2.576** (1.000)
Mature firms	0.0741** (0.0325)	-0.102** (0.0400)	0.0073 (0.0347)	-1.937*** (0.682)	0.138*** (0.0307)	-0.586 (0.959)
Group	0.0237 (0.0409)	-0.0755 (0.0475)	-0.0450 (0.0430)	0.464 (0.818)	0.0828** (0.0384)	5.839** (1.052)
Human capital	0.422*** (0.0349)	0.0486 (0.0560)	0.112*** (0.0380)	-0.535 (0.722)	0.278*** (0.0332)	1.991 (1.306)
Leader countries	-0.0532 (0.0364)	0.0045 (0.0447)	-0.259*** (0.0383)	-1.622** (0.755)	-0.146*** (0.0341)	-4.204** (1.054)
Scale-intensive sectors	-0.0773** (0.0372)	-0.119** (0.0471)	-0.0038 (0.0398)	0.724 (0.805)	0.0196 (0.0350)	-0.574 (1.018)
Specialized-suppliers sectors	0.197*** (0.0477)	-0.0700 (0.0574)	0.0158 (0.0507)	0.225 (0.954)	0.396*** (0.0450)	5.753** (1.714)
Science-based sectors	0.513*** (0.0880)	0.210** (0.0942)	0.241*** (0.0902)	0.0141 (1.462)	0.419*** (0.0793)	1.314 (2.271)
Tax incentives	0.492*** (0.0392)		0.303*** (0.0443)		0.130*** (0.0376)	
R&D status			1.233*** (0.0353)			
R&D intensity				0.709*** (0.0405)		
Innovator					0.198*** (0.0308)	
Innovative sales						0.158** (0.0212)
Constant	-2.092*** (0.136)	-1.786*** (0.358)	-0.952*** (0.139)	18.67*** (3.134)	2.141*** (0.128)	2.176 (11.69)
Mills ratio		-0.104 (0.104)		0.915 (1.138)		-1.110 (5.615)
Wald χ^2		721.14		389.75		132.19
Prob($X > \chi^2$)		(0.000)		(0.000)		(0.000)
Selected observations		3,122		4,255		4,286
Non-selected obs.		4,389		3,088		3,878

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Innovative firms present a positive association with their export capacity

- **Our results show that:**
 - Our results remark the **intense and complex links** between, R&D, innovation and firm performance.
 - European firms are subject to a process of **self-selection**.
 - However, the **LBE effect is partially confirmed**.
 - Exporting firms are more prone to engage in R&D activities, and more often have product and process innovation outputs
 - but they do not register an “export premium” in terms of productivity.
 - Export and productivity drivers differ for firms in **leaders and laggards**.
- **Policy implications:**
 - We recommend **European policies to promote innovation and exports according to a country’s innovative capacity**.
 - **Leader countries** should enhance R&D and product innovation so that their firms improve their competitiveness in markets with products of high technological complexity.
 - **Laggard countries** must promote investments in physical capital, skills and process innovations.

Links between R&D, innovation and export across European manufacturing firms

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