

Environmental Regulations and Integration in Global Markets

Using a New Environmental Performance Index

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Seminario Internacional Cadenas Globales
de Valor en América Latina y Europa

23.01.2024

Overview

- 1 Motivation
- 2 Literature review
- 3 Data and methods
- 4 Results
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Motivation



Theoretical expectations

Aggregated approach

- **Pollution Haven Effect:** environmental regulations affect the comparative advantage of dirty goods, reducing their exports and increasing their imports (Hanna 2010, Coppland & Taylor 2004, 1995)
- **Pollution Haven Hypothesis:** a stronger version of the PHE, where regulatory stringency impacts allocation decisions of dirty industries (Coppland & Taylor 2004, 1995)

Disaggregated approach

- **Conventional view:** strict regulations increases costs and have a negative effect on firm trade (D'Agostino 2015, Ambec et al. 2013, Jaffe & Palmer 1997)
- **Porter Hypothesis:** well-designed regulations motivate firms to innovate, increasing their productivity and international competitiveness (Porter & van der Linde 1995)

Impact on firm-level trade flows

- **Shi & Xu (2018)** found that the stricter environmental regulations of the 11th Five-Year Plan reduced the probability to export and the volume exported by Chinese industries
- **Zhang et al. (2020)** identified that stricter wastewater discharge standards implemented in Jiangsu decreased the export likelihood and intensity of local firms
- **Cherniwchan & Najjar (2021)** found that stricter standards in Canada decreased the probability to export and increased the likelihood of firms to stop exporting altogether
- **Zhang et al. (2022)** used the Cleaner Production Audit in China to assess the impact on firm's exports and found a negative effect on exported volume, albeit heterogeneous

Research question

How does the environmental performance of firms impact their participation in global value chains?

Main contributions

- Novel measure of environmental performance at the firm-level
- Empirical framework based on a two-part IV analysis
- Evidence between countries on both export and import trade flows

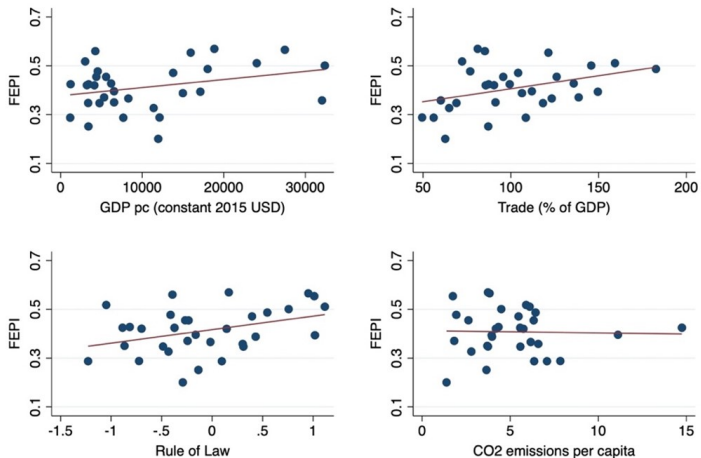
Firm Environmental Performance Index (FEPI)

- **Data source:** World Bank Enterprise Surveys (2018-2020), enabled by the Green Economy Module. Firms are asked about which measures they adopted in the past three years to reduce environmental impact
- **Dataset:** 15,922 firms from 32 European, Central Asian, Middle Eastern, and North African countries
- **Method:** sum of each adopted environmental measure weighted by its relative importance in reducing negative impacts in a given industry

$$FEPI_{ijk} = \sum_{k=1}^{10} M_{ijk} w_{jk}$$

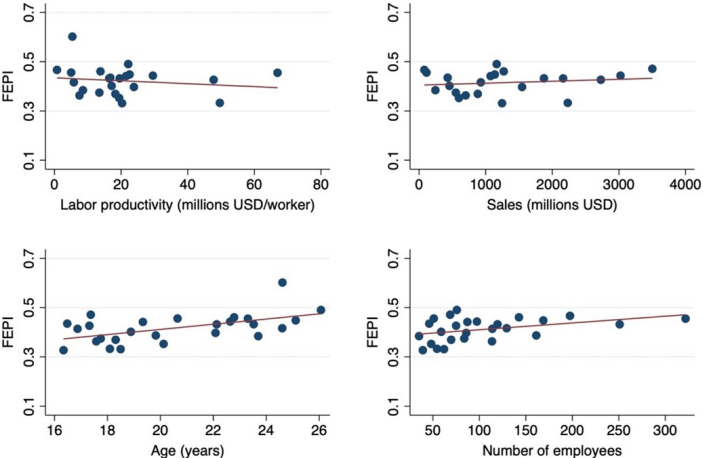
Data and methods

Figure 1: Correlations between FEPI and country-level averages



Data and methods

Figure 2: Correlations between FEPI and industry-level averages



GVC participation and intensity

- **Data source:** World Bank Enterprise Surveys (2018-2020), as it presents data on the sources of revenue (domestic or export) and the origin of inputs (national or imported)
- **Definitions:** there are multiple possibilities according to the literature (Reddy 2020, Del Prete et al. 2017.) In this paper we follow:
 - **Weak definition:** firms export AND import
 - **Strong definition:** firms export, import, AND holds an international certification

Empirical framework

- **Method:** two-part instrumental variable approach
- 1st part: IV probit to estimate the probability of participation

$$\begin{aligned} Pr \left(GVC \text{ participation}_{ijk} = 1 \right) &= \varphi(\beta_0 + \beta_1 FEPI_{ijk} + \beta_2 EnvStandards_{ijk} \\ &\quad + \beta_3 LaborProductivity_{ijk} + \beta_4 Employees_{ijk} \\ &\quad + \beta_5 Age_{ijk} + \beta_6 Foreign_{ijk} + \kappa_j + \iota_k + \varepsilon_{ijk}) \end{aligned}$$

- 2nd part: FRME to estimate the intensity of participation

$$\begin{aligned} Pr \left(GVC \text{ int}_{ijk} \mid GVC \text{ part}_{ijk} = 1 \right) &= \omega(\beta_0 + \beta_1 FEPI_{ijk} + \beta_2 EnvStandards_{ijk} \\ &\quad + \beta_3 LaborProductivity_{ijk} + \beta_4 Employees_{ijk} \\ &\quad + \beta_5 Age_{ijk} + \beta_6 Foreign_{ijk} + \kappa_j + \iota_k + \varepsilon_{ijk}) \end{aligned}$$

Identification strategy

- **Instruments:** interactions between a country-level variable that denotes environmental stringency, and a firm-level variable that captures the environmental awareness

$$EU_k \times MonitorIntensity_{ijk}$$

$$RegulatoryQuality_k \times EnvObjectives_{ijk}$$

Table 1: First-stage results IV probit and FRME

Dependent variables	FEPI		
	(1)	(2)	(3)
EU * Monitoring intensity	0.149*** (0.00516)		0.126*** (0.00556)
Regulatory quality * Env. Objective		0.177*** (0.00843)	0.132*** (0.00833)
Env. standards	0.195*** (0.00677)	0.190*** (0.00689)	0.175*** (0.00720)
Ln labor productivity	0.0193*** (0.00172)	0.0195*** (0.00189)	0.0184*** (0.00177)
Ln Employees	0.0453*** (0.00181)	0.0460*** (0.00184)	0.0427*** (0.00181)
Ln Age	0.000354 (0.00323)	0.000894 (0.00332)	-0.000068 (0.00331)
Foreign	0.002 (0.00864)	-0.00295 (0.00878)	-0.00338 (0.00885)
Constant	0.0437 (0.0315)	0.0178 (0.0329)	0.0536 (0.0329)
R-squared	0.273	0.264	0.285
Observations	16,181	16,147	16,130
Number of repetitions	998	1000	998
Number of countries	32	32	32
Cragg-Donald Wald F-statistic	676.21	487.032	477.982
Stock-Yogo critical values	16.38	16.38	19.93

All regressions contain country and industry dummies. Standard errors are robust and reported in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The Stock-Yogo critical values refer to the weak ID test for 10% maximal IV size.

Table 2: Second-stage results IV probit and FRME (strong definition)

Dependent variables (strong definition)	EU * Monitoring intensity		Strong Reg * Env. Objective		Both	
	(1)	(2)	(3)	(4)	(5)	(6)
	GVC participation	GVC intensity	GVC participation	GVC intensity	GVC participation	GVC intensity
FEPI	0.196*** (0.0294)	0.037 (0.0583)	0.184*** (0.0340)	0.0372 (0.0778)	0.193*** (0.0252)	0.0348 (0.0504)
Environmental standards	0.00878 (0.00843)	-0.0167 (0.0180)	0.0117 (0.00933)	-0.0164 (0.0215)	0.00917 (0.00768)	-0.0166 (0.0168)
Ln labor productivity	0.0103*** (0.00188)	0.00339 (0.00527)	0.0104*** (0.00194)	0.0033 (0.00514)	0.0101*** (0.00177)	0.00327 (0.00505)
Ln Employees	0.0329*** (0.00226)	0.0125** (0.00537)	0.0338*** (0.00242)	0.0127** (0.00599)	0.0329*** (0.00204)	0.0127** (0.00518)
Ln Age	0.0152*** (0.00306)	-0.00377 (0.00786)	0.0147*** (0.00304)	-0.00422 (0.00826)	0.0149*** (0.00307)	-0.00407 (0.00809)
Foreign	0.0409*** (0.00635)	0.0935*** (0.0130)	0.0410*** (0.00631)	0.0937*** (0.0133)	0.0411*** (0.00634)	0.0936*** (0.0133)
Observations	16,018	1,733	15,984	1,726	15,970	1,725
Number of replications	852	745	868	736	859	733
Number of countries	32	32	32	32	32	32
Overid. test (p-value)					0.664	0.000

The reported coefficients are marginal effects at mean values of the independent variables. The dependent variables of probability and intensity of GVC participation follow the strong definition. All regressions contain country and industry dummies. Standard errors are reported in parentheses (***) $p < 0.01$, (**) $p < 0.05$, (*) $p < 0.1$). They are bootstrapped to address heterogeneity and the number of replications is depicted above. The overidentification tests used are the Amemiya-Lee-Newey for the IV Probit and the J-test for the FRM with endogenous variable regressions.

Table 3: Marginal effects of FEPI according to subsamples (both IV)

Independent variable: FEPI	Weak definition		Strong definition	
	(1) GVC participation	(2) GVC intensity	(3) GVC participation	(4) GVC intensity
Total sample	0.272*** (0.0364)	-0.00119 (0.0419)	0.193*** (0.0252)	0.0348 (0.0504)
Sectors				
Manufacturing	0.367*** (0.0587)	0.0509 (0.0476)	0.245*** (0.0440)	0.0532 (0.0622)
Services	0.152*** (0.0428)	-0.233*** (0.0856)	0.126*** (0.0213)	-0.0678 (0.136)
OECD's industry classification				
Medium-high	0.561*** (0.122)	0.0693 (0.0783)	0.349*** (0.0890)	0.122 (0.0870)
Medium	0.703*** (0.204)	-0.111 (0.175)	0.345** (0.135)	-0.496** (0.219)
Medium-low	0.301*** (0.0671)	0.0707 (0.0656)	0.203*** (0.0505)	0.128* (0.0730)
Low	0.148*** (0.0502)	-0.170** (0.0861)	0.118*** (0.0248)	0.0203 (0.134)
Country regions				
Eastern Europe	0.308*** (0.0436)	0.0255 (0.0425)	0.224*** (0.0298)	0.042 (0.0512)
Central Asia	0.179 (0.186)	-0.132 (0.537)	0.251** (0.124)	0.631 (1.195)
Middle East and North Africa	0.352*** (0.133)	-0.377*** (0.144)	0.232*** (0.0814)	-0.317 (0.214)

The reported coefficients are marginal effects at mean values of the independent variables. All regressions contain country and industry dummies. Standard errors are robust and reported in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Marginal effects for importers vs. exporters only (both IV)

	Importers		Exporters	
	(1)	(2)	(3)	(4)
	GVC participation	GVC intensity	GVC participation	GVC intensity
FEPI	-0.089 (0.0645)	-0.105* (0.0619)	0.120*** (0.0336)	0.244*** (0.0946)
Environmental standards	0.0393** (0.0192)	-0.018 (0.0179)	0.00478 (0.0103)	0.00273 (0.0342)
Ln labor productivity	0.0172*** (0.00353)	0.0171*** (0.00335)	0.00519** (0.00219)	0.000705 (0.00678)
Ln Employees	0.00194 (0.00483)	-0.0177*** (0.00436)	0.0283*** (0.00242)	-0.0153* (0.00812)
Ln Age	-0.00557 (0.00585)	-0.0068 (0.00558)	0.00568 (0.00358)	-0.0327** (0.0129)
Foreign	0.111*** (0.0211)	0.129*** (0.0183)	0.0284*** (0.00986)	0.0884*** (0.0329)
Second stage statistics				
Observations	12,062	5,833	12,380	1,180
Number of countries	991	861	696	719
Number of replications	32	32	32	32
Overid. test (p-value)	0.017	0.598	0.066	0.014
First stage statistics				
Cragg-Donald Wald F statistic	337.516	162.892	341.765	57.274
Stock-Yogo critical values	19.93	19.93	19.93	19.93

The reported coefficients are marginal effects at mean values of the independent variables. The dependent variables of probability and intensity of GVC participation follow the broad definition. All regressions contain country and industry dummies. Standard errors are reported in parentheses (*** p < 0.01, ** p < 0.05, * p < 0.1). They are bootstrapped to address heterogeneity and the number of replications is depicted above. The overidentification tests used are the Amemiya-Lee-Newey for the IV Probit and the J-test for the FRM with endogenous variable regressions.

Robustness checks

The main results are robust to:

- Alternative definitions of GVC participation:
 - **Weak 10%:** two-way traders, at least 10% of total sales/inputs
 - **Strong 10%:** two-way traders, at least 10% of total sales/inputs, AND has an international certification
- The inclusion of an alternative instrument:

$$RoL_k \times EnvStandards_{ijk}$$

Conclusion

- Firm environmental performance **increases the probability** of participation in GVC
 - A one-standard deviation increase in FEPI increases the probability of participation by **6.4 p.p.**
 - The effect is observed in all regions and sectors, but it is stronger for exporters, higher technology levels, and in developed countries
- Overall, there is **no effect on the intensity** of GVC participation
 - A negative effect is observed exceptionally for importers only, firms with lower technology levels, and in the MENA region

Thank you!

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Firm-level controls:

- **Environmental standards:** customers require environmental standards
- **Labour productivity (ln):** total sales per employee
- **Employees (ln):** number of workers
- **Age:** years active
- **Foreign:** firms that are foreign-owned

Table A1: Descriptive statistics

Variables	Obs.	Mean	SD	Min	Max
Dependent variables					
GVC participation (weak)	15,922	0.22	0.41	0	1
GVC participation (strong)	15,855	0.11	0.31	0	1
GVC participation (weak 10%)	15,922	0.18	0.39	0	1
GVC participation (strong 10%)	15,869	0.09	0.29	0	1
GVC participation (importers)	12,064	0.48	0.50	0	1
GVC participation (exporters)	12,382	0.10	0.29	0	1
GVC intensity (weak)	15,922	0.11	0.25	0	1
GVC intensity (strong)	15,855	0.05	0.18	0	1
GVC intensity (weak 10%)	15,922	0.10	0.24	0	1
GVC intensity (strong 10%)	15,869	0.05	0.17	0	1
GVC intensity (importers)	12,064	0.27	0.36	0	1
GVC intensity (exporters)	12,382	0.04	0.16	0	1
Firm-level variables					
FEPI	15,922	0.39	0.33	0	1
Environmental standards	15,922	0.14	0.35	0	1
Ln Labor Productivity	15,922	13.15	2.65	3.79	26.09
Ln Employees	15,922	3.31	1.35	0	9.90
Ln Age	15,922	2.71	0.77	0	5.32
Foreign	15,922	0.08	0.27	0	1
Instrumental variables					
EU * Monitoring intensity	15,922	0.21	0.52	0	3
Regulatory quality * Env. objective	15,922	0.10	0.31	0	1
Strong RoL * Env. Standards	15,922	0.043	0.203	0	1

Table A2: Descriptive statistics of questions used in the FEPI's composition

Which of the following measures were adopted over the last three years?	Freq.	Percent	Which Measure Has Contributed the Most to Reducing Environmental Impacts?	Freq.	Percent	Cum.
Improvements to lighting system	7,653	48.75	Don't know (spontaneous)	248	2.57	2.57
Machinery and equipment upgrades	7,134	45.45	None of the above (spontaneous)	655	6.78	9.35
Heating and cooling improvements	5,855	37.3	Heating and cooling improvements	1,369	14.17	23.52
Waste minimization/ management and recycling	5,796	36.92	More climate-friendly energy generation on site	341	3.53	27.05
Energy management	5,217	33.24	Machinery and equipment upgrades	2,152	22.28	49.33
Upgrade of vehicles	5,154	32.83	Energy management	889	9.2	58.53
Water management	3,717	23.68	Waste minimization/management and recycling	1,612	16.69	75.22
Air pollution control measures	2,591	16.51	Air pollution control measures	270	2.8	78.01
Other pollution control measures	2,208	14.07	Water management	158	1.64	79.65
More climate-friendly energy generation on site	2,107	13.42	Upgrade of vehicles	742	7.68	87.33
None	3,883	24.74	Improvements to lighting system	1,047	10.84	98.17
			Other pollution control measures	177	1.83	100
			Total	9,660	100	

Table A3: FEPI statistics across countries

	Obs.	Mean	SD	Min	Max
Per country					
Greece	558	0.57	0.29	0	1
Malta	217	0.57	0.25	0	1
Kosovo	153	0.56	0.29	0	1
Latvia	304	0.55	0.30	0	1
Uzbekistan	1,064	0.52	0.33	0	1
Slovenia	364	0.51	0.32	0	1
Cyprus	203	0.50	0.29	0	1
Slovak Republic	416	0.49	0.31	0	1
Albania	356	0.48	0.32	0	1
Croatia	334	0.47	0.30	0	1
Mongolia	357	0.45	0.26	0	1
Bosnia and Herzegovina	282	0.45	0.32	0	1
Belarus	546	0.43	0.34	0	1
Kyrgyz Republic	310	0.42	0.35	0	1
Moldova	349	0.42	0.33	0	1
Ukraine	1,138	0.42	0.32	0	1
Jordan	322	0.42	0.38	0	1
Serbia	289	0.40	0.31	0	1
Lithuania	341	0.39	0.32	0	1
Poland	624	0.39	0.30	0	1
North Macedonia	299	0.37	0.33	0	1
Bulgaria	637	0.37	0.33	0	1
Italy	693	0.36	0.38	0	1
Lebanon	489	0.35	0.29	0	1
West Bank and Gaza	311	0.35	0.30	0	1
Georgia	495	0.35	0.30	0	1
Kazakhstan	1,069	0.33	0.31	0	1
Russian Federation	1,140	0.29	0.30	0	1
Tajikistan	227	0.29	0.31	0	1
Montenegro	124	0.29	0.31	0	0.97
Morocco	437	0.25	0.29	0	1
Turkey	1,474	0.20	0.26	0	1

Table A4: FEPI statistics across industries

	Obs.	Mean	SD	Min	Max
Industry					
Refined petroleum product	18	0.60	0.29	0	1
Paper	120	0.49	0.29	0	1
Plastics & rubber	462	0.47	0.33	0	1
Tobacco	6	0.47	0.45	0	1
Electronics	191	0.46	0.31	0	1
Wood	262	0.46	0.33	0	1
Transport machines	69	0.46	0.34	0	1
Chemicals	249	0.45	0.33	0	1
Food	2,111	0.44	0.34	0	1
Leather	103	0.44	0.35	0	1
Hotel and restaurants	708	0.44	0.33	0	1
Precision instruments	80	0.43	0.32	0	1
Basic metals	139	0.43	0.34	0	1
Nonmetallic mineral products	772	0.43	0.34	0	1
Machinery and equipment	697	0.42	0.35	0	1
Recycling	102	0.41	0.35	0	1
Furniture	401	0.40	0.32	0	1
Fabricated metal products	1,108	0.40	0.33	0	1
Textiles	532	0.39	0.34	0	1
Publishing, printing, and Recorded media	231	0.38	0.33	0	1
Transport	555	0.37	0.32	0	1
Construction	1,294	0.37	0.33	0	1
Garments	927	0.36	0.33	0	1
Services of motor vehicles	353	0.35	0.32	0	1
Wholesale	1,251	0.33	0.30	0	1
Retail	2,865	0.33	0.30	0	1
IT	316	0.33	0.30	0	1
Per sector					
Manufacturing	8,611	0.42	0.33	0	1
Services	7,311	0.35	0.31	0	1

Table A5: Marginal effects for more restrictive measures of GVC participation (both IV)

	Weak 10% definition		Strong 10% definition	
	(1)	(2)	(3)	(4)
	GVC participation	GVC intensity	GVC participation	GVC intensity
FEPI	0.227*** (0.0343)	0.00855 (0.0458)	0.168*** (0.0227)	0.0298 (0.0529)
Environmental standards	0.0214** (0.0104)	-0.0128 (0.0139)	0.00796 (0.00704)	-0.0117 (0.0177)
Ln labor productivity	0.00378 (0.00241)	-0.00208 (0.00381)	0.00744*** (0.00164)	0.00576 (0.00516)
Ln Employees	0.0301*** (0.00267)	0.0177*** (0.00407)	0.0270*** (0.00196)	0.0172*** (0.00547)
Ln Age	0.00709* (0.00390)	-0.0195*** (0.00613)	0.0141*** (0.00293)	-0.00831 (0.00881)
Foreign	0.119*** (0.00855)	0.0882*** (0.0106)	0.0406*** (0.00563)	0.0807*** (0.0132)
Second stage statistics				
Observations	15,940	2,937	15,993	1,472
Number of countries	967	960	680	584
Number of replications	32	32	32	32
Overid. test (p-value)	0.774	0.000	0.904	0.000
First stage statistics				
Cragg-Donald Wald F statistic	476.892	102.903	477.519	68.726
Stock-Yogo critical values	19.93	19.93	19.93	19.93

The reported coefficients are marginal effects at mean values of the independent variables. The dependent variables of probability and intensity of GVC participation follow the broad definition. All regressions contain country and industry dummies. Standard errors are reported in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). They are bootstrapped to address heterogeneity and the number of replications is depicted above. The overidentification tests used are the Amemiya-Lee-Newey for the IV Probit and the J-test for the FRM with endogenous variable regressions.

Table A6: First-stage results of adding alternative IV (strong definition)

Dependent variables	Strong definition			
	(1)	(2)	(3)	(4)
RoL strong * Env. standards	0.222*** (0.0110)	0.132*** (0.0111)	0.139*** (0.0117)	0.0807*** (0.0121)
EU * Monitoring intensity		0.159*** (0.00531)		0.134*** (0.00568)
Regulatory quality * Env. Objective			(0.00879)	0.203*** (0.00865)
Ln labor productivity	0.0227*** (0.00187)	0.0195*** (0.00180)	0.0206*** (0.00182)	0.0195*** (0.00175)
Ln Employees	0.0560*** (0.00188)	0.0460*** (0.00183)	0.0506*** (0.00187)	0.0473*** (0.00190)
Ln Age	0.00375 (0.00324)	0.000894 (0.00329)	0.00224 (0.00333)	0.000979 (0.00330)
Foreign	0.0125 (0.00895)	-0.00295 (0.00865)	0.00362 (0.00882)	0.00358 (0.00878)
Constant	-0.0169 (0.0353)	0.0178 (0.0327)	0.00697 (0.0332)	0.0408 (0.0318)
Rsquared	0.206	0.264	0.234	0.256
Observations	16201	16147	16147	16130
Number of repetitions	1000	1000	1000	999
Number of Countries	32	32	32	32
Cragg-Donald Wald F statistic	330.607	521.635	462.951	477.987
Stock-Yogo critical values	16.38	19.93	19.93	22.3

All regressions contain country and industry dummies. Standard errors are robust and reported in parentheses (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The Stock-Yogo critical values refer to the weak ID test for 10% maximal IV size.

Table A7: Second-stage results of adding alternative IV (strong definition)

Dependent variables	RoL * Env. standards		EU * Monitoring int. RoL * Env. standards		Reg quality * Objective RoL * Env. standards		EU * Monitoring int. Reg quality * Objective RoL * Env. standards	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GVC participation	GVC intensity	GVC participation	GVC intensity	GVC participation	GVC intensity	GVC participation	GVC intensity
FEPI	0.250*** (0.0364)	0.105 (0.0692)	0.218*** (0.0241)	0.0400 (0.0424)	0.216*** (0.0235)	0.0407 (0.0487)	0.211*** (0.0192)	0.0258 (0.0377)
Ln labor productivity	0.00941*** (0.00204)	0.00172 (0.00509)	0.0100*** (0.00195)	0.00302 (0.00481)	0.00987*** (0.00186)	0.00293 (0.00499)	0.00990*** (0.00181)	0.00324 (0.00505)
Ln Employees	0.0307*** (0.00278)	0.00710 (0.00625)	0.0322*** (0.00216)	0.0111** (0.00502)	0.0325*** (0.00221)	0.0113** (0.00541)	0.0325*** (0.00207)	0.0123** (0.00485)
Ln Age	0.0155*** (0.00322)	-0.00410 (0.00838)	0.0157*** (0.00319)	-0.00385 (0.00795)	0.0152*** (0.00307)	-0.00437 (0.00824)	0.0153*** (0.00309)	-0.00417 (0.00803)
Foreign	0.0406*** (0.00658)	0.0912*** (0.0132)	0.0412*** (0.00629)	0.0922*** (0.0132)	0.0411*** (0.00639)	0.0924*** (0.0133)	0.0413*** (0.00636)	0.0926*** (0.0130)
Observations	16,035	1,735	16,018	1,733	15,984	1,726	15,970	1,725
Number of repetitions	863	725	860	756	868	736	865	731
Number of Countries	32	32	32	32	32	32	32	32
Overid. test (p-value)			0.201	0.000	0.167	0.000	0.305	0.000

The reported coefficients are marginal effects at mean values of the independent variables. The dependent variables of probability and intensity of GVC participation follow the strong definition. All regressions contain country and industry dummies. Standard errors are reported in parentheses (***) $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). They are bootstrapped to address heterogeneity and the number of replications is depicted above. The overidentification tests used are the Amemiya-Lee-Newey for the IV Probit and the J-test for the FRM with endogenous variable regressions.