Global Value Chains as channel of green knowledge in EU regions.

A two-step GMM analysis.

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Motivations

- Paris agreement, Agenda 2030, and the scientific literature fully acknowledge the environmental issues, such as air pollution (Armeanu et al., 2018; Barnes, 2019; Haibo et al., 2019).

- The relation between economic development and environmental issues is nowadays well-known (Dinda, 2004; Georgiev et al., 2014; Fujii et al., 2016).

- Recent studies assess a role to green technologies (Costantini et al., 2017), policies (Eurostat, 2011) and Global Value Chains (Wang et al., 2020), but there is still little understanding on whether this mechanism works also across EU regions.

Literature review
Air pollution (AP)

- In the heated debate on AP, the literature proposes some useful tools, both in terms of technologies (Tomita 2001; OECD 2013; Ibrahim 2014) and industrial structures "adaptation" (Cole 2000; Dinda 2004).

- Green patents represent a positive factor in reducing air pollution (Glachant et al 2013; Costantini et al 2017; Wang et al 2020).

- A recent stream of literature sheds new light on the role of GVCs in coping air pollution, although providing evidence only at the national level (Wang et al 2020).

Literature review
Green Patents

- Green patents reduce AP emissions, no matters if evaluated for sectors (Nameroff et al., 2004), countries (Shen et al., 2020) or the substances emitted (Töbelmann et al., 2020).
- Costantini et al. (2017) assess the key role of green technologies in abating the environmental impact of sectoral pollution, directly and indirectly, through spill-overs (Sarfraz, 2021; Kahn, 2022).
- One of the key findings of Wang et al. (2020) concerns the positive role of green patents in reducing the emissions of NOx and SOx particles.

Literature review
Global Value Chains (GVCs)

- GVCs allow economies to gain tools and experience, exploiting new opportunities (Morrison et al, 2008; Pietrobelli et al, 2011; Fagerberg et al 2018; Jurowetzki et al 2018; Colozza et al, 2021).

- These opportunities may concern also the environment (Glachant et al 2013; De Marchi et al, 2013; De Marchi et al, 2020).

- Overall, a deeper integration in GVCs facilitate the reduction of AP (Poulsen et al 2018; Wang et al 2020).

Global Value Chains and environmental upgrading

- In summary, all these studies find that the higher the value added shared in GVCs, the greater the positive effect on environment (reducing emissions of air pollutants...).
- In this work, as well as in the mentioned contributions, our hypothesis is that intangibles, and with higher value added (Baldwin et al 2014, Gereffi and Fernandez-Stark 2016; Rungi and Del Prete 2017), activities in GVCs may lead economies to reduce pollution.
- In other words, we assume the following relation, graphically represented with an adapted smile-curve (in the next slide).

Global Value Chains and environmental upgrading (1)

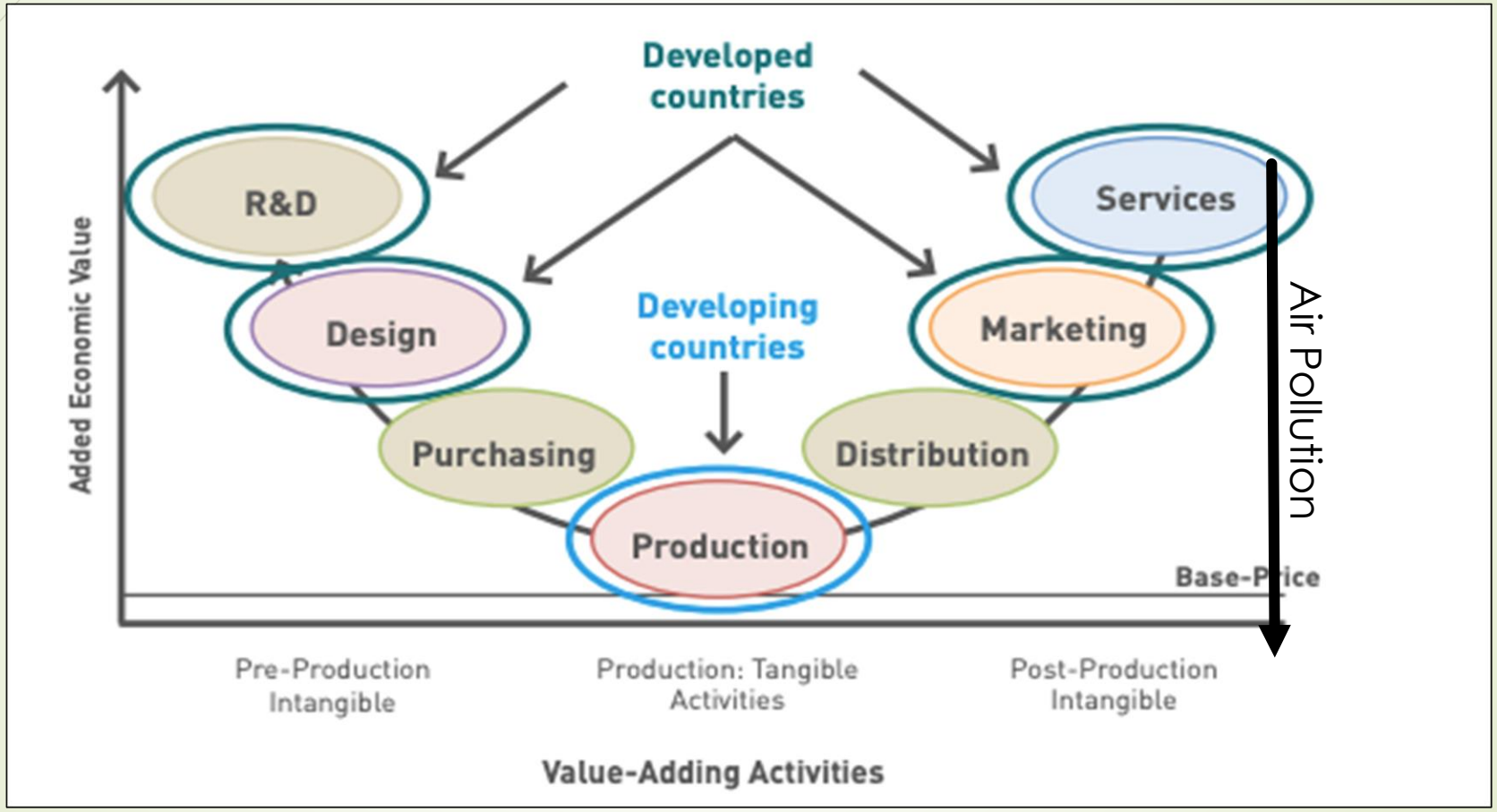


Figure a - Value Added and GVCs participation. Source: Gereffi and Fernandez-Stark (2016), based on Baldwin et al. (2014)

Research questions

Thus, we investigate:

- the effects of GVCs integration and green patents on air pollution of EU regions;
- If these effects differ across regions, and if the "environmental awareness" has a role.

Data and methods

The key-challenges of this work are essentially:

- Creation of air pollutants (NOx and SOx) emission dataset: computed distributing national data on sectoral emissions following the presence of such sectors in nuts-2 regions;

- Construction of GVCs participation indicators: relying on RIOD tables (Thissen et al 2018) and innovative techniques (Borin et al 2020), we calculate the ratio of the value added shared in backward and forward linkages on gross exports;

(...the first dataset on participation in GVCs and air pollution for EU nuts-2 regions!)

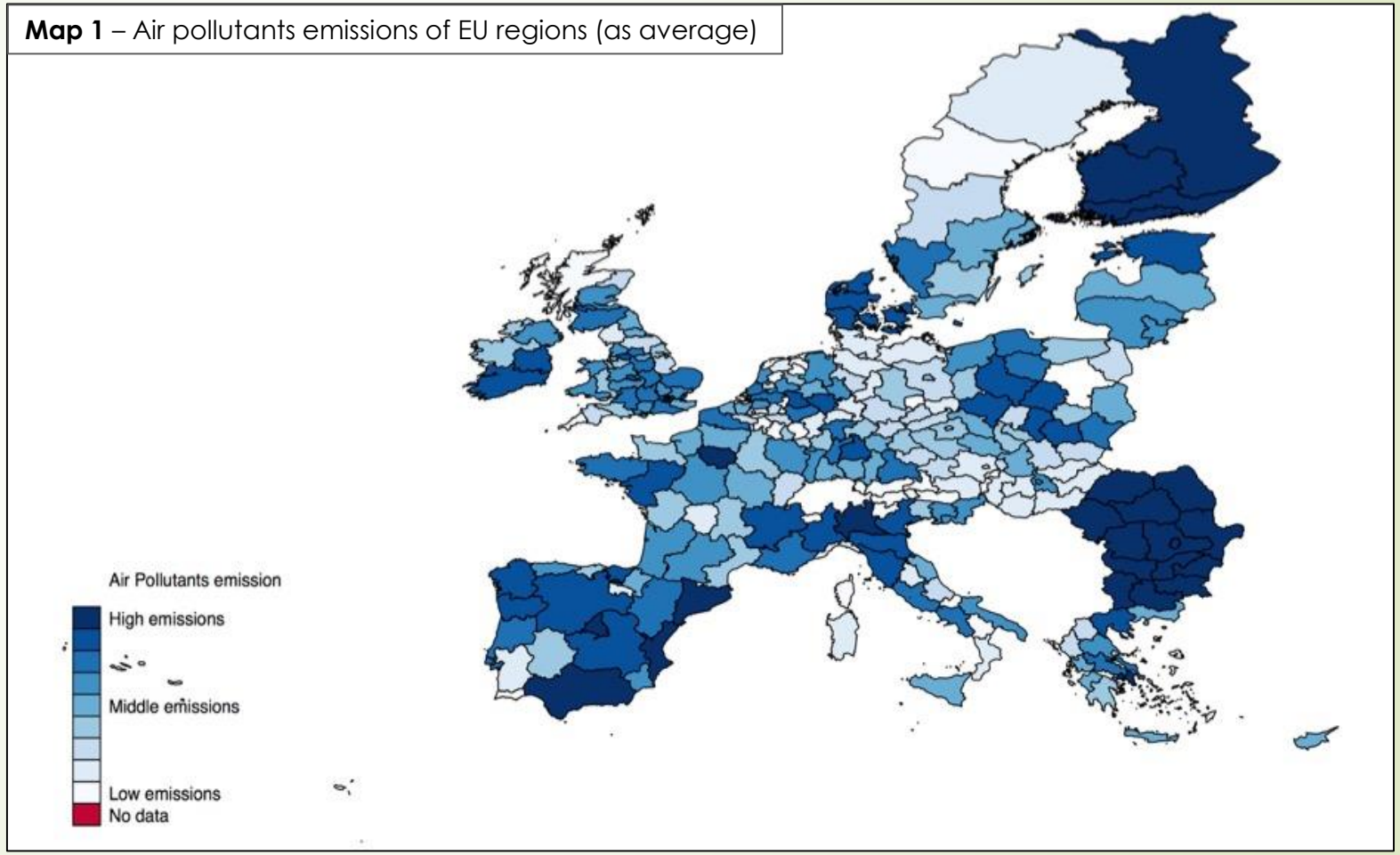
Time span: 2000-2010

Data and methods

Air Pollution

In Map 1, we represent the average of Air Pollutants (AP) emissions of EU regions.

Map 1 – Air pollutants emissions of EU regions (as average)

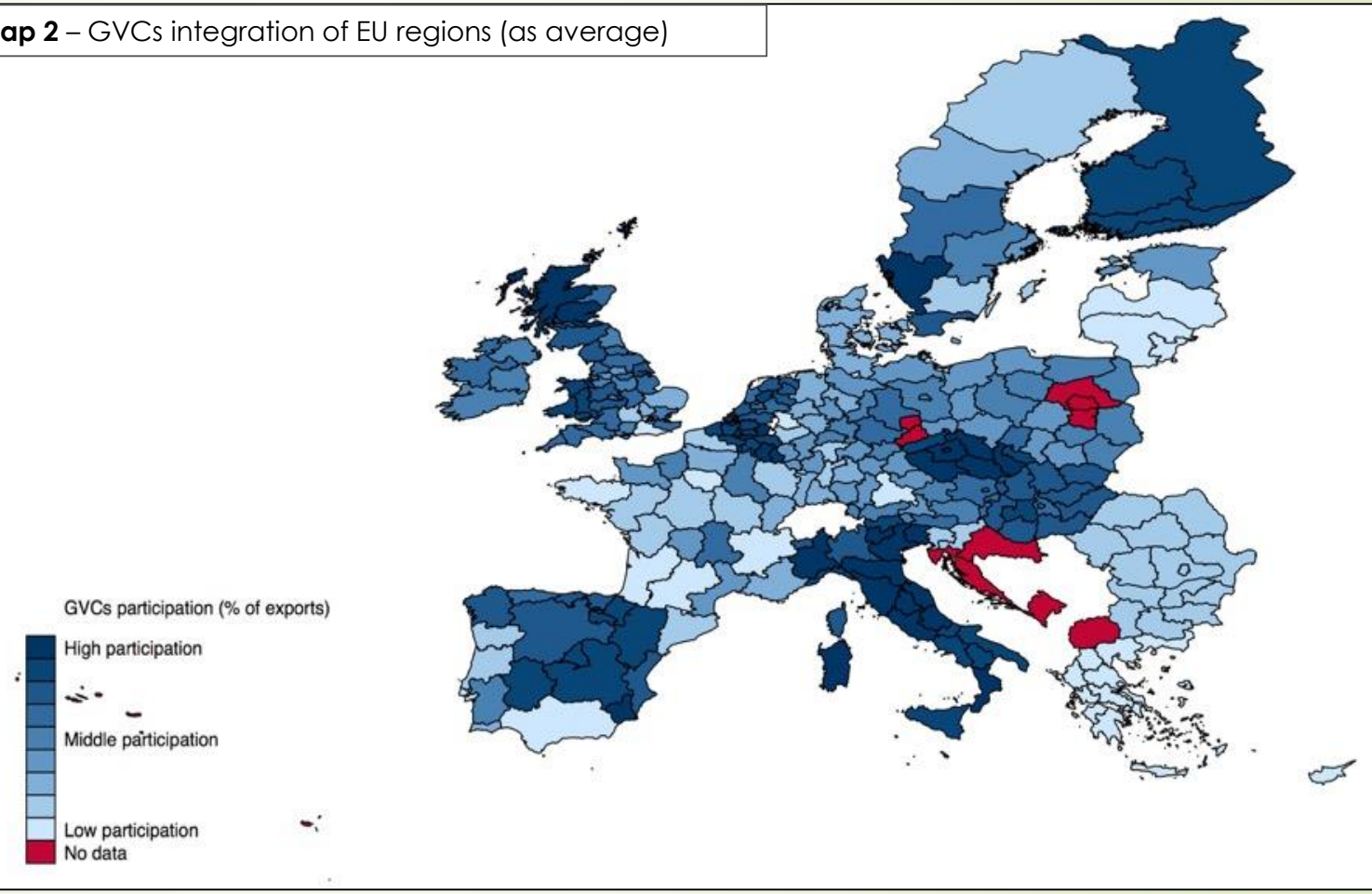


Data and methods

GVCs participation

In Map 2, we represent the average of the GVCs participation index of EU regions.

Map 2 – GVCs integration of EU regions (as average)



Data and methods
Variables of interest

Other variables of interest:

- **Green patents (per capita)**: Haščič et al. (2015) provide the categorization of "green patents", which corresponds to classification y2 of OECD dataset. We calculate the stock of patents following the Perpetual Inventory Method (Braun et al., 2010).
- **Specialization in manufacturing (value added, ISP_c)**: we employ a recent index of specialization (Lo Cascio et al 2017), which corresponds to an improved version of Balassa (1965). Balanced around 0, this index indicates with 1 complete specialization, and -1 complete despecialization.
- **Gross Domestic Product (per capita) and population density**: we extract these variables from Eurostat, as last control variables.

Data and methods

Controls and Environmental awareness

We define the regional awareness on environmental issues using "implicit taxes on energy consumption" (ITEC), extracted from Eurostat. Since that these data are referred to the national level, we consider two groups of regions, splitted in terms of ITEC(/GDP):

- Regions that belong to countries with low environmental awareness (lc), where the ITEC is lower than its average value of 2.4%;
- Regions that belong to countries with high environmental awareness (hc), where the ITEC is higher than its average value of 2.4%;

Data and methods
Models

- We employ a twostep GMM model (Roodman, 2009), testing the following equation 1:

$$(1)\quad APpop_{r,t} = \beta_0 + \beta_1 APpop_{r,t-1} + \beta_2 GVCindex_{r,t-1} + \beta_3 GreenPatentpop_{r,t-1} + \beta_4 ISP\_c_{r,t} + \beta_5 GDPpop_{r,t-1} + \beta_6 Popdensity_{r,t-1} + \varepsilon_r$$

- And we evaluate if this mechanism differ between regions, by splitting them in terms of ITEC.
- Moreover, we use Windmeijer-corrected standard errors (at regional level), to avoid some heteroskedasticity issues.

Results

Table 1	(1)	(2)	(3)
	General	**Low environmental awareness**	**High environmental awareness**
VARIABLES (t-1, mean centered)	*Dependent variable: Air Pollution per capita (NOx + SOx; time span: 2000-2010)*		
Air Pollution per capita	**0.910*** **	**0.883*** **	**0.836*** **
	(0.01062)	(0.01612)	(0.03174)
GVCs index (%, log)	**-0.00591*** **	**-0.00705*** **	**-0.00617*** **
	(0.00184)	(0.00240)	(0.00239)
Green Patents per capita (PIM, log)	**-0.000864*** **	**-0.00226*** **	-0.000141
	(0.00024)	(0.00062)	(0.00029)
ISP Manufacturing	0.000405	0.00269	**-0.00608** **
	(0.00095)	(0.00191)	(0.00258)
GDP per capita (constant values, log)	0.000235	-6.08e-05	0.000718
	(0.00065)	(0.00150)	(0.00091)
Population density (/Km^2, log)	0.000432	0.000600	0.000188
	(0.00057)	(0.00077)	(0.00038)
Constant	-0.00207***	-0.00175***	-0.00216***
	(0.00014)	(0.00034)	(0.00031)
Observations	1,909	919	990
Standard Errors	Robust	Robust	Robust
A.R. 1 p-value	3.51e-10	1.04e-06	2.26e-05
A.R. 2 p-value	0.884	0.973	0.221
Hansen p-value	0.113	0.305	0.603
# of instruments	184	144	184

Robust standard errors in parentheses. Standard errors are clustered at regional level. # of instruments: number of instruments employed in the analysis.
[*** p<0.01, ** p<0.05, * p<0.1]

Interpretations and concluding remarks

Our findings show that in EU regions:

- Air Pollutants emission are mainly related to the existing levels of pollution.
- In all the cases, GVCs participation facilitates the reduction of Air Pollutants emissions, especially when the regions have low environmental awareness.
- On the ground, green patents reduce the Air Pollutants emissions, but higher environmental awareness is able to substitute its role of counteracting these emissions.

Thank you for your attention

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Results

Table 2	(1) General	(2) Backward General	(3) Forward General	(4) General no-env	(5) Backward no-env	(6) Forward no-env	(7) General env	(8) Backward env	(9) Forward env
VARIABLES (t-1, mean centered)	*Dependent variable: Air Pollution per capita (NOx + SOx; time span: 2000-2010)*								
Air Pollution per capita	**0.910*** **	**0.912*** **	**0.924*** **	**0.883*** **	**0.883*** **	**0.878*** **	**0.789*** **	**0.788*** **	**0.840*** **
	(0.01062)	(0.01132)	(0.01247)	(0.01612)	(0.01661)	(0.01788)	(0.03532)	(0.03336)	(0.03223)
GVCs index (%, log)	**-0.00591*** **			**-0.00705*** **			**-0.0111*** **		
	(0.00184)			(0.00240)			(0.00240)		
Backward GVCs index (%, log)		**-0.00653*** **			**-0.00552** **			**-0.0103*** **	
		(0.00153)			(0.00228)			(0.00217)	
Forward GVCs index (%, log)			0.00224			-0.00367			0.00273
			(0.00185)			(0.00303)			(0.00244)
Green Patents per capita (PIM, log)	**-0.000864*** **	**-0.000775*** **	**-0.000881*** **	**-0.00226*** **	**-0.00242*** **	**-0.00254*** **	-0.000383	-1.61e-05	-0.000480
	(0.00024)	(0.00025)	(0.00023)	(0.00062)	(0.00064)	(0.00063)	(0.00042)	(0.00046)	(0.00042)
ISP Manufacturing	0.000405	0.00119	0.000406	0.00269	**0.00368* **	0.00134	**-0.00660** **	**-0.00443* **	**-0.00813*** **
	(0.00095)	(0.00103)	(0.00091)	(0.00191)	(0.00188)	(0.00216)	(0.00275)	(0.00255)	(0.00243)
GDP per capita (constant values, log)	0.000235	-0.000328	0.000511	-6.09e-05	-1.33e-05	0.00115	0.00129	-0.000112	0.00162
	(0.00065)	(0.00068)	(0.00059)	(0.00150)	(0.00155)	(0.00147)	(0.00111)	(0.00124)	(0.00107)
Population density (/Km^2, log)	0.000432	-4.45e-05	-0.000229	0.000600	7.85e-05	0.000609	**-0.000749** **	**-0.000982** **	**-0.000853*** **
	(0.00057)	(0.00059)	(0.00058)	(0.00077)	(0.00074)	(0.00074)	(0.00037)	(0.00043)	(0.00029)
Constant	0.0245***	0.0247***	-0.00555	0.0303***	0.0226***	0.0136	0.0491***	0.0425***	-0.00375
	(0.00727)	(0.00561)	(0.00561)	(0.00946)	(0.00835)	(0.00909)	(0.00972)	(0.00801)	(0.00747)
Observations	1,909	1,909	1,909	919	919	919	990	990	990
Standard Errors	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust
A.R. 1 p-value	3.51e-10	3.43e-10	3.26e-10	1.04e-06	1.04e-06	1.15e-06	2.73e-05	2.37e-05	2.15e-05
A.R. 2 p-value	0.884	0.925	0.831	0.973	0.994	0.934	0.235	0.291	0.173
Hansen p-value	0.113	0.161	0.119	0.305	0.327	0.326	0.190	0.118	0.235
# of instruments	184	184	184	144	144	144	144	144	144

Robust standard errors in parentheses. Standard errors are clustered at regional level. # of instruments: number of instruments employed in the analysis.
[*** p<0.01, ** p<0.05, * p<0.1]

Interpretations

- The process of environmental upgrading along GVCs is achieved thanks to backward component.
- Backward component represents to what extent economies rely on the share of imported intermediate inputs to produce intermediate or final goods to be exported.