Digitalization and regionalization of Global Value Chains in European industries

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Roundtable on The Digital Economy Amid Rising International Tensions

ROMA TRE UNIVERSITÀ DEGLI STUDI

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In a nutshell

Aim To study the effect of digitalization on the regionalization of GVCs

- Empirical analysis on a subsample of EU countries in 2005-2018
- Attempt to give a technological explanation to trade dynamics

Main results

- Digitalization increases GVCs' regionalization
  (+10% digital K associated with a +6.7% regionalization)
  - But no de-globalization effect
- Digitalization affects regional GVC VA flows with different intensity

Digital technologies & Trade: background

Technological change

- Digitalization is deeply affecting production processes, firms, and industry structures, value creation and capture mechanisms (Teece, 2018)
- Main drivers: digitization of processes; automation of labour; coordination through platforms (Eurofound, 2018)

Recent debate in trade

- Resilience, rationalization, regionalization, digitalization of supply chains and GVC (Antràs, 2020; Brun et al., 2019)

IB perspective: centripetal vs. centrifugal forces (Autio et al., 2021)

- Digital *in situ* technologies: upgrade processes in a given geographic location; less need to take advantage of costs differentials (Ferrantino and Koten, 2019)
- Digital *communication* technologies: connect geographically dispersed locations; lower entry and operative costs (Antràs, 2020; World Dev. Report, 2020); affect coordination costs (within firm) and transaction costs (between firms) (Sturgeon, 2019).

Review of main effects of digital technologies

Digital technology	Main effect	Main references	Expected sign on regionalization
Computers & ICT	Reducing communication costs	Baldwin (2016)	-
	Improving productivity	Biagi (2013); Draca et al. (2009)	+
	Lowers coordination costs	Fort (2017)	-
	Lower geographical distances facilitating knowledge transfer within firms	Forman and van Zeebroeck (2019)	-
Big data	Product innovation; higher likelihood of market success for new products	Niebel et al. (2019)	+
	Supports higher decision-making quality	Awan et al. (2021)	+/-
Robotics & automation	Positive impacts on employment; increase among workers with different kinds of routine-related tasks	Domini et al. (2019)	+
	Negative effects on employment and wages in US commuting zones	Acemoglu and Restrepo (2019)	-
	Increase in intermediate inputs from foreign suppliers	Cilekoglu et al. (2024)	-
Additive manuf.	Reduction in costs of production	Freund et al. (2022)	+
	Complementarity with labor, no labor-saving effects	Felice et al. (2021)	+/-
	Potential reduction of labor input; higher customization of products	Laplume et al. (2016)	+
AI	Facilitate in creating new products; positively affects productivity; favors high-skilled labor demand	Yang (2022)	+
	Some AI tasks are complementary to human tasks	Mondolo (2021)	+
	Higher innovation performance; increase in sales for world-first product innovation; contribution in cost savings	Rammer et al. (2022)	+

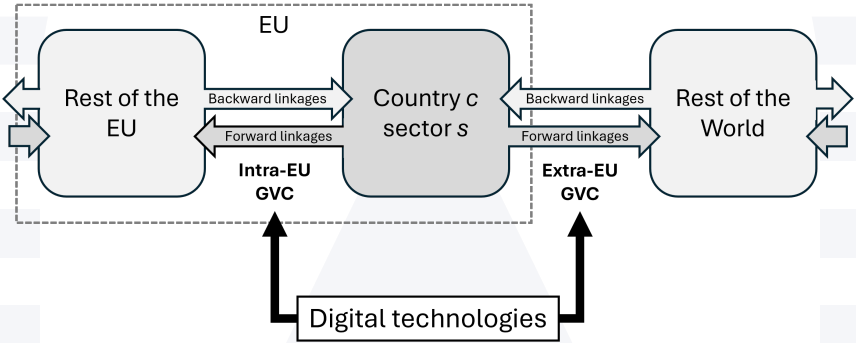
Aim of the paper

Two opposite forces are in place: some technologies pushing toward further fragmentation and some others toward relocation

- Overall effect seems to be, in the end, an empirical matter
- Focus on European countries, then we define
  - **Regional trade: Intra-EU flows** (all countries belonging to the EU)
  - Extra-regional trade: Extra-EU flows (i.e., rest of the world)

- **Aim of the paper**
  To provide empirical evidence on the interaction between the diffusion of digital technologies and the impacts in terms of VA trade deriving from their adoption in the European industries

Digital technologies & Trade: framework



Data

Main variables

Multiple sources

- Regionalization: VA trade flows by regions → **OECD-TiVA**
- Digitalization: ICT + Software & Database capital stock → **EU-KLEMS**
  - Volume, 2015 ref. prices

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Panel composition

- Years: 2005-2018
- 9 European countries: Aut, Bel, Cze, Deu, Fra, Gbr, Ita, Nld, Svk
- Manufacturing sectors: NACE C

▸ Sample selection

Data

Regionalization measure

- Indicator: regional-to-global perspective (Los et al., 2015; Bontadini et al., 2022)
- Value-added taken into account: FVA + DVA in gross exports
- We distinguish each VA flow in:
  - Intra-EU value-added (i.e., *regional*)
  - Extra-EU value-added (i.e., *extra-regional* ⇒ rest of the world)
  - We compute the ratio between intra- and extra-VA ⇒ index of relative importance

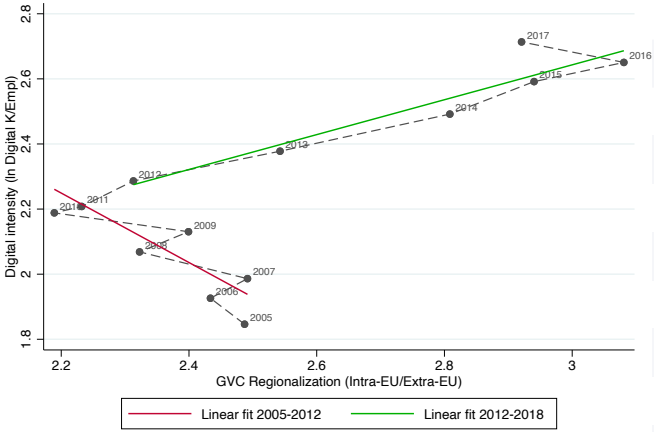
$$GVC\_Regio_{cst} = \frac{GVC\_Intra_{cst}}{GVC\_Extra_{cst}}$$

Digitalization & regionalization: is there a correlation?

- Rapid diffusion of digital capital even in low digital intensive sectors
  - L/ML sectors: more than +50% in 12 years ▸ Graph
- Two phases clearly visible (different sign in corr.)
- 2005-2012: negative correlation digital-regionalization
  - ICT may have helped to lower trade barriers ⇒ globalization
- In 2012-2017 there is a **positive correlation**

▸ Figure: GVC regionalization

Figure: Digital capital and GVC regionalization



Digital K per empl. weighted by Gross Output (source: EU-KLEMS).

Econometric analysis

Our aim is to analyze: Digital Technologies $\longrightarrow$ GVC Regionalization

$$y_{cst} = \alpha + \beta ln\_Kq\_Digital_{cs,t-1} + \gamma Controls_{cs,t-1} + f.e. + \varepsilon_{cst}$$

Econometric analysis

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$$y_{cst} = \alpha + \beta ln\_Kq\_Digital_{cs,t-1} + \gamma Controls_{cs,t-1} + f.e. + \varepsilon_{cst}$$

- Common factors may affect both regionalization and digitalization
  - EU political and economic integration; reverse causality concerns
- Bartik IV approach (Bartik, 1991; Goldsmith-Pinkham et al., 2020)
  - Introduction of an exogenous variation in the data
  - Helps to consider the evolution of the quality of digital goods
- Exogenous variations: (log of) number of ICT- and AI-related patents (worldwide)
  - OECD classifications: Inaba & Squicciarini (2017); Baruffaldi et al. (2020)
- Rationale: number of world patents = existing technological opportunities

Econometric strategy (1/2)

Identification: Bartik IV

main IV: ICT-related patents $\rightarrow IV_{cst} = \frac{Kq\_Digital_{cs,2005}}{Kq\_Digital_{c,2005}} \times ln\_Patent_t^{ICT}$

- $Kq\_Digital$: Digital capital (ICT + Software & Database), share at country level

Robustness:

alt. IV1: AI-related patents $\rightarrow IVrob1_{cst} = \frac{Kq\_Digital_{cs,2005}}{Kq\_Digital_{c,2005}} \times ln\_Patent_t^{AI}$

alt. IV2: Innovative property $\rightarrow IVrob2_{cst} = \frac{Kq\_InnProp_{cs,2005}}{Kq\_InnProp_{c,2005}} \times ln\_Patent_t^{ICT}$

alt. IV3: AI pat. & inn. prop. $\rightarrow IVrob3_{cst} = \frac{Kq\_InnProp_{cs,2005}}{Kq\_InnProp_{c,2005}} \times ln\_Patent_t^{AI}$

- K in Innovative Property: R&D, Oth. IP products, Design, and New financial products

▸ Descriptive statistics ▸ Exogeneity ▸ No. of ICT and AI patents

Econometric strategy (2/2)

Identified model

$$y_{cst} = alpha + \beta \widehat{ln\_Kq\_Digital}_{cs,t-1} + \gamma Controls_{cs,t-1} + f.e. + \varepsilon_{cst}$$

- y = GVC participation; GVC regionalization ratio; Intra- and Extra-EU value-added
- OLS and 2SLS with main IV (ICT patents), clustered s.e.
- Controls: Non-digital capital; employment; value-added; year dummies for major time disruption (i.e., 2009, and 2012); individual (country-sector) fixed effects
- All variables lagged by 1 year
- Robustness check: Bartik based on alternative shifts and shares (AI patents, inn. prop.)

Main results

Table: 2SLS-IV model

	(ln) GVC		Regionalization	
	Particip.	Region.	(ln) Intra	(ln) Extra
	(1)	(2)	(3)	(4)
(ln) Digital capital, t-1	0.149*	0.669***	0.823***	0.154
Oth. controls	✓	✓	✓	✓
Obs.	1,398	1,398	1,398	1,398
R2	0.488	0.005	0.316	0.187
Underid. test (Chi-sq)	85.16			
Weak id. test (F)	84.77			

Oth. Controls include: (ln) non-digital capital, (ln) employment, (ln) sectoral value-added, dummies for 2009 and 2012. Bartik IVs based on ICT-related world stock of patents (OECD). Country-sector fixed effects always included. SE clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneous impacts of digitalization

1. by Sectoral digital intensity ▸ Results
   - Sample split by OECD digital-intensity sectoral taxonomy (Calvino et al., 2018)
   - A +10% digital K increases regional. by 8.2% (6.3%) in low (high) digital sectors
   - Intra-EU GVC flows drive the results

2. by Backward and Forward perspectives ▸ Results
   - Backw. = foreign VA in exports; Forw. = own domestic VA in other's exports
   - A +10% digital K increases regionalization by 6.6% backward and 6% forward
   - Intra-EU GVC flows again drive the results

Conclusions

Impact of digitalization on trade in value-added in European industries:

- Is positive on GVC regionalization, in the period 2005-2018
- Digital capital affects with a differentiated magnitude the value-added components
  - No significative effect on extra-EU flows, positive on intra-EU
  - i.e., **no de-globalization** evidence associated to digitalization
- Results apply to both low and high digital-intensive sectors
- Increases regionalization both for backward and forward linkages

Main takeaway

Positive impact but with heterogeneous effects:
digitalization is associated with GVC participation
but also seems to imply stronger Intra-EU GVC linkages, i.e. regionalization

Thanks for your attention! ☺

We look forward to your comments and suggestions.

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Sample selection (1)

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Relevance of countries in the sample for trade in value-added

Countries' content of Foreign and Domestic Value-Added in gross exports as a share of total EU-28 value.

	Foreign Value-Added			Domestic Value-Added		
	Mean	SD	Median	Mean	SD	Median
Total sample	0.200	0.191	0.150	0.082	0.102	0.039
Out of sample	0.174	0.240	0.119	0.099	0.243	0.023
Included	0.334	0.222	0.303	0.155	0.127	0.118

Values of FVA (left panel) and DVA (right panel) to shares computed with respect to the year-by-year total EU-28 value. All NACE market sectors.

Sample selection (2)

	Foreign Value-Added			Domestic Value-Added		
	Mean	SD	Median	Mean	SD	Median
AUT	0.153	0.012	0.148	0.057	0.003	0.056
BEL	0.293	0.045	0.274	0.078	0.007	0.074
CZE	0.150	0.006	0.150	0.034	0.001	0.034
DEU	0.859	0.074	0.823	0.433	0.021	0.428
FRA	0.448	0.075	0.410	0.230	0.022	0.221
GBR	0.316	0.056	0.298	0.241	0.027	0.233
ITA	0.372	0.076	0.339	0.188	0.025	0.174
NLD	0.327	0.031	0.333	0.123	0.009	0.118
SVK	0.086	0.008	0.087	0.016	0.001	0.016
POL	0.155	0.016	0.154	0.060	0.006	0.060
HUN	0.138	0.030	0.129	0.023	0.002	0.023
ESP	0.263	0.042	0.243	0.126	0.006	0.126
GRC	0.049	0.007	0.049	0.020	0.003	0.019

VA dynamics by region

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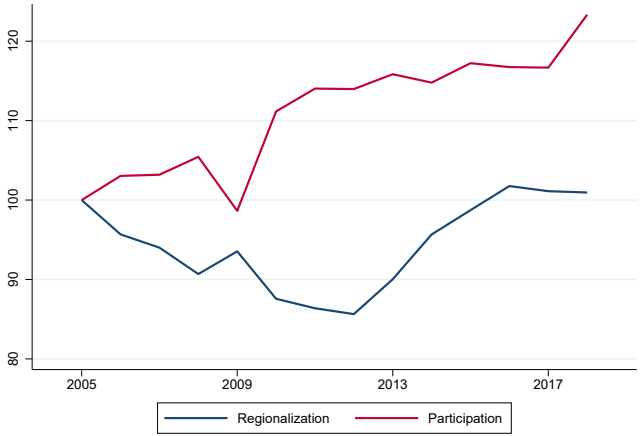
Figure: GVC Participation and Regionalization



Authors' elaboration on OECD-TiVA data. 2005 = 100.

Digital capital diffusion

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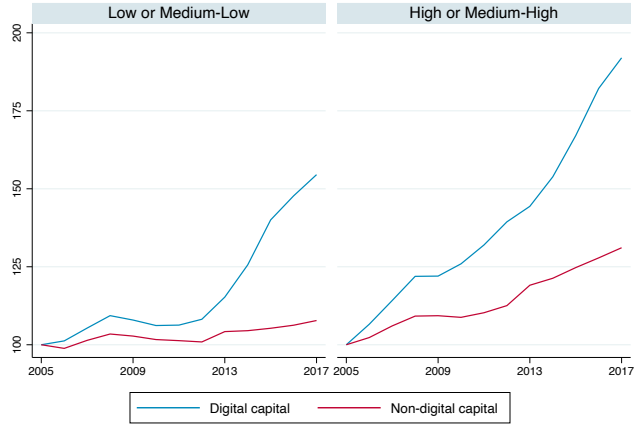
Figure: Capital by sectoral digital intensity



Source: EU-KLEMS. Taxonomy on digital intensive sectors by Calvino et al. (2018). 2005 = 100.

Explanatory variables

Descriptive statistics

Table: Bartik IVs, descriptive statistics

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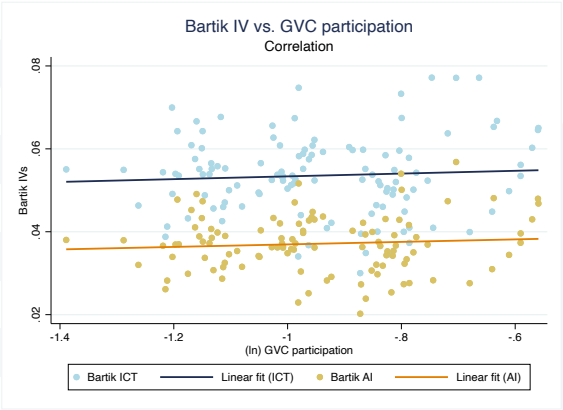
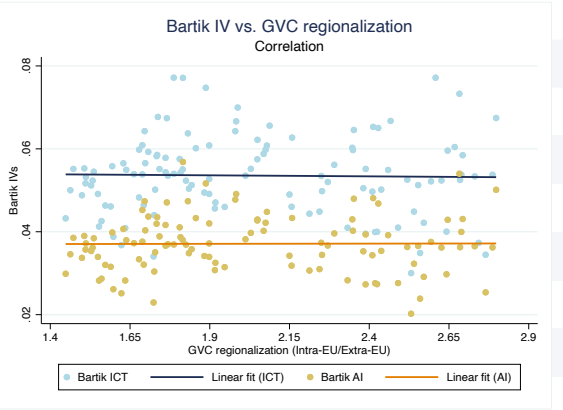
	N	Mean	SD	p25	p50	p75	Min	Max
bartik_ict	1,603	0.052	0.089	0.013	0.022	0.042	0.001	0.759
bartik_ai	1,469	0.036	0.063	0.009	0.015	0.030	0.001	0.524
ln_kdigital	1,588	6.622	1.742	5.423	6.602	7.714	1.917	11.052

Bartik IV (1/2)

Exogeneity





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Bartik IV (2/2)

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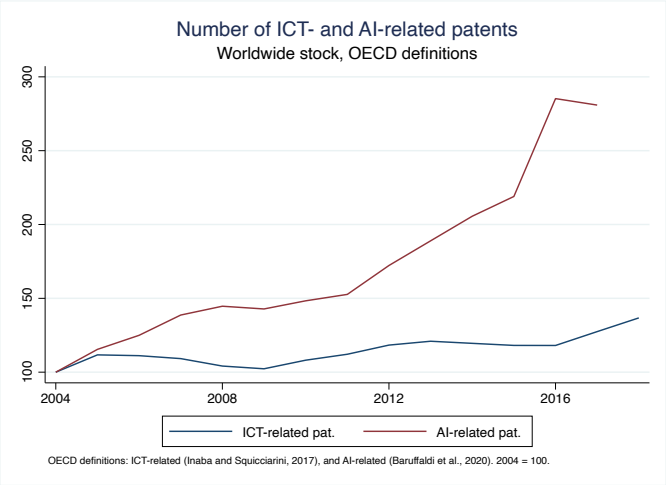
Digital patent stock



Heterogeneity (1): Sectoral Digital Intensity

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Table: 2SLS-IV model

	(ln) GVC				Regionalization			
	Participation		Regionalization		(ln) Intra		(ln) Extra	
	Low	High	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(ln) Digital capital, t-1	0.349**	0.111*	0.822**	0.633***	1.053**	0.663***	0.231	0.030
Oth. controls	✓	✓	✓	✓	✓	✓	✓	✓
Obs.	696	702	696	702	696	702	696	702
R2	0.176	0.533	0.022	0.044	0.323	0.291	0.129	0.307
Underid. test (Chi-sq)	28.36	59.88	28.36	59.88	28.36	59.88	28.36	59.88
Weak id. test (F)	28.10	59.32	28.10	59.32	28.10	59.32	28.10	59.32

Oth. Controls include: (ln) non-digital capital, (ln) employment, (ln) sectoral value-added, dummies for 2009 and for 2012. Bartik IVs based on ICT-related world stock of patents (OECD). Country-sector fixed effects always included. SE clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity (2): Backward and Forward

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Table: 2SLS-IV model

	(ln) GVC				Regionalization			
	Participation		Regionalization		(ln) Intra		(ln) Extra	
	Backw.	Forw.	Backw.	Forw.	Backw.	Forw.	Backw.	Forw.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(ln) Digital capital, t-1	0.125	0.166**	0.661***	0.598***	0.824***	0.726***	0.163	0.128
Oth. controls	✓	✓	✓	✓	✓	✓	✓	✓
Obs.	1,398	1,398	1,398	1,398	1,398	1,398	1,398	1,398
R2	0.479	0.001	0.014	0.025	0.320	0.191	0.162	0.039

Oth. Controls include: (ln) non-digital capital, (ln) employment, (ln) sectoral value-added, dummies for 2009 and for 2012. Bartik IVs based on ICT-related world stock of patents (OECD). Country-sector fixed effects always included. SE clustered at the individual level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.