Digitalization and regionalization: Global Value Chains in European industries

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Motivations & background   Data & variables   GVC regionalization & Digitalization   Econometric analysis   Conclusions & Research agenda

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Digital technologies & Trade: recent debate (1)

- Digitalization is deeply affecting production processes, firms, and industry structures, value creation and capture mechanisms (Teece, 2018)
- Main drivers related to digital technologies (Eurofound, 2018): Digitization of processes; Automation of labour; Coordination through platforms
- Implications for trade
  - Digital technologies increase efficiency and lower coordination costs ⇒ further fragmentation of the international production (WTO, 2019)
  - Some digital technologies are more capital-intensive and require complementary investments in infrastructures and skilled labour (World Bank, 2020; Baldwin, 2016) ⇒ incentive to relocate production in advanced countries
  - "Countries with complementary production capabilities tend to integrate in a given area" (He et al., 2024)
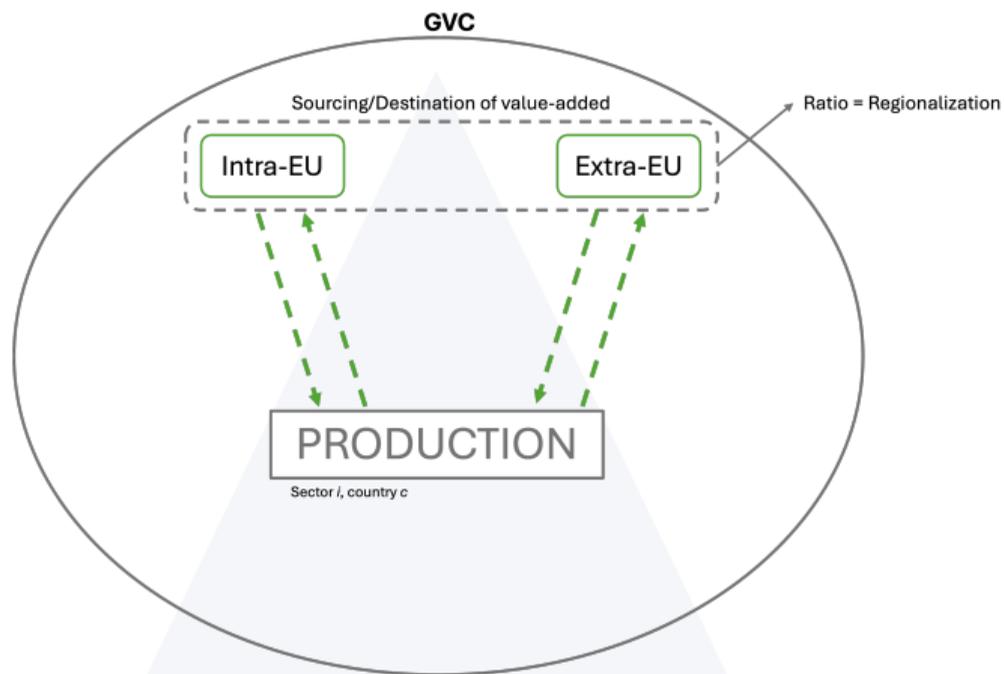
Digital technologies & Trade: recent debate (2)

- "The net effect depends on the impact on coordination costs, monitoring costs, asset specificity, and location specificity" (Autio et al., 2021): centripetal vs. centrifugal forces
- Digital *in situ* technologies: upgrade processes in a given geographic location
  - Affect industry upgrading ⇒ *centripetal*
  - Also: greater efficiency, lower costs, less need to take advantage of costs differentials (Ferrantino and Koten, 2019)
- Digital *communication* technologies: connect geographically dispersed locations
  - i.e., "traditional" ICT technologies: communication systems, platforms, etc.
  - Affect coordination costs (within firm) and transaction costs (between firms) ⇒ *centrifugal*
  - Also: lower entry and operative costs (Antràs, 2020; World Dev. Report, 2020); better coordination of production and transactions (Sturgeon, 2019).
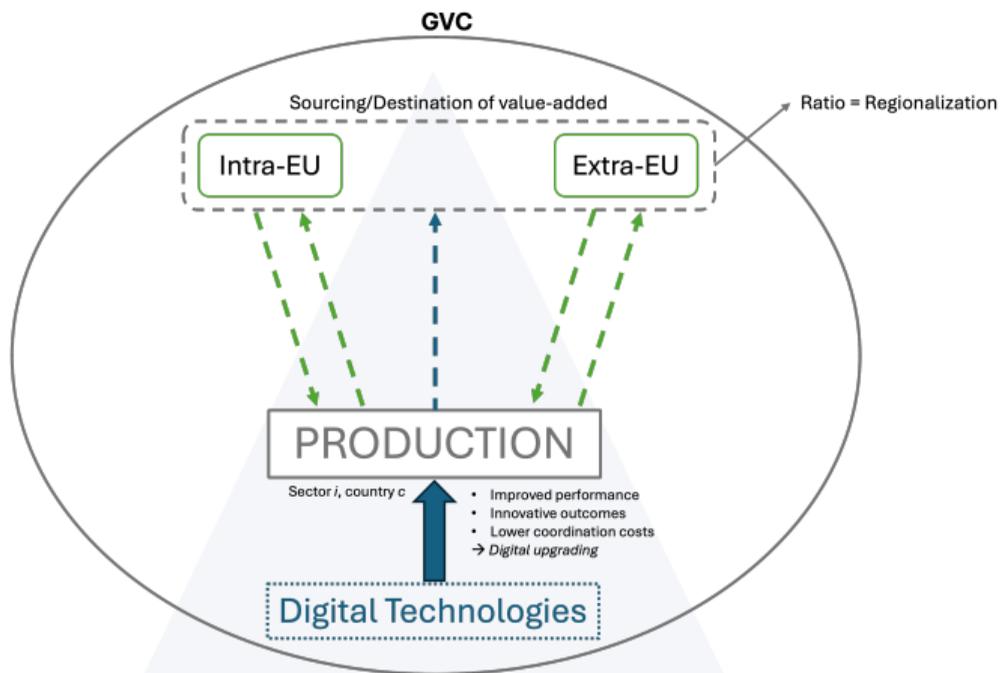
Aim of the paper

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

- Overall effect seems to be, in the end, an empirical matter
- We attempt to combine the evidence on the trade dynamics with a technological explanation
- 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

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Trade & Digital technologies: mechanism

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Trade & Digital technologies: mechanism

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

Panel composition

- Years: 2005-2018
- 9 European countries: Aut, Bel, Cze, Deu, Fra, Gbr, Ita, Nld, Svk
- Industries: Manufacturing (NACE "C") + ICT intensive sectors (NACE "J")
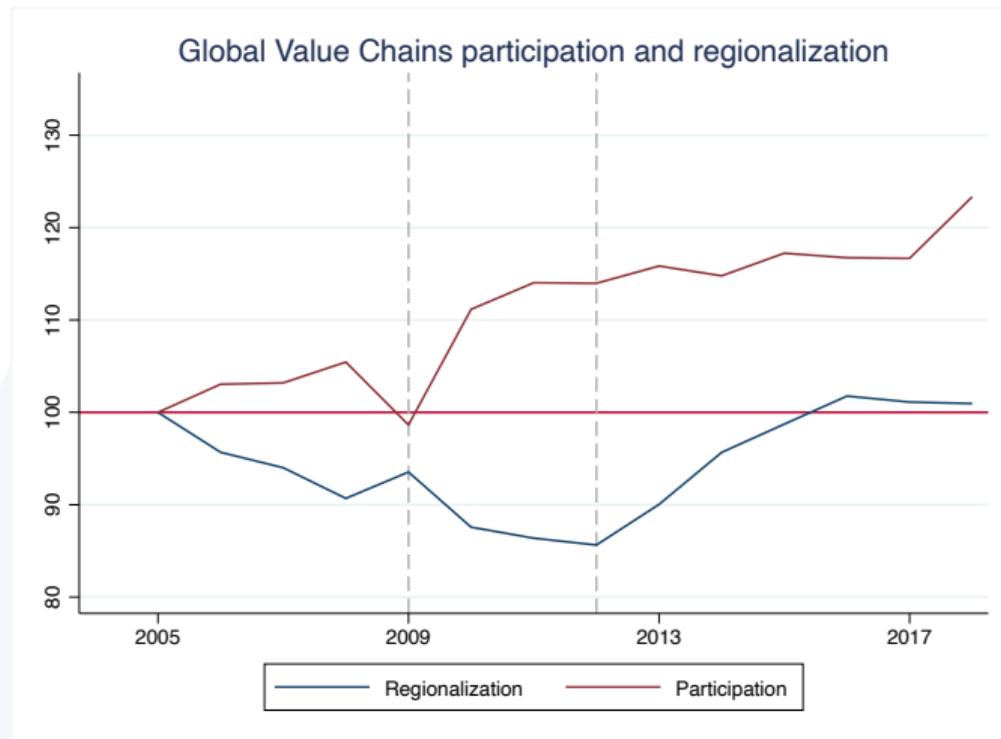
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Regionalization measure

- Indicator: regional-to-global perspective (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

$$Regionalization_{i,c,t}^{GVC} = \frac{IntraEU_{i,c,t}}{ExtraEU_{i,c,t}}$$

Participation and regionalization of GVC

- Participation in GVC falls in 2009 but rapidly recovers, increasing more than 20% until the end of period under study
- In the period 2005-2012, European VA begins to be more "globalized"
- After 2012 crisis, regionalization begin to grow again, reaching the initial levels

  → *Which "regional" flow influenced the dynamics?*

Global Value Chains participation and regionalization

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# GVC value-added by region

- The dynamics is driven by the increase in the extra-EU flows, whose evolution between the two crises determines the de-regionalization, until 2012
- After 2012 crises, extra-EU value-added begin to shrink
- The reduction in extra-EU value-added, together with the increase in intra-EU (started after the 2009 crisis), determines the regionalization

GVC value-added by region
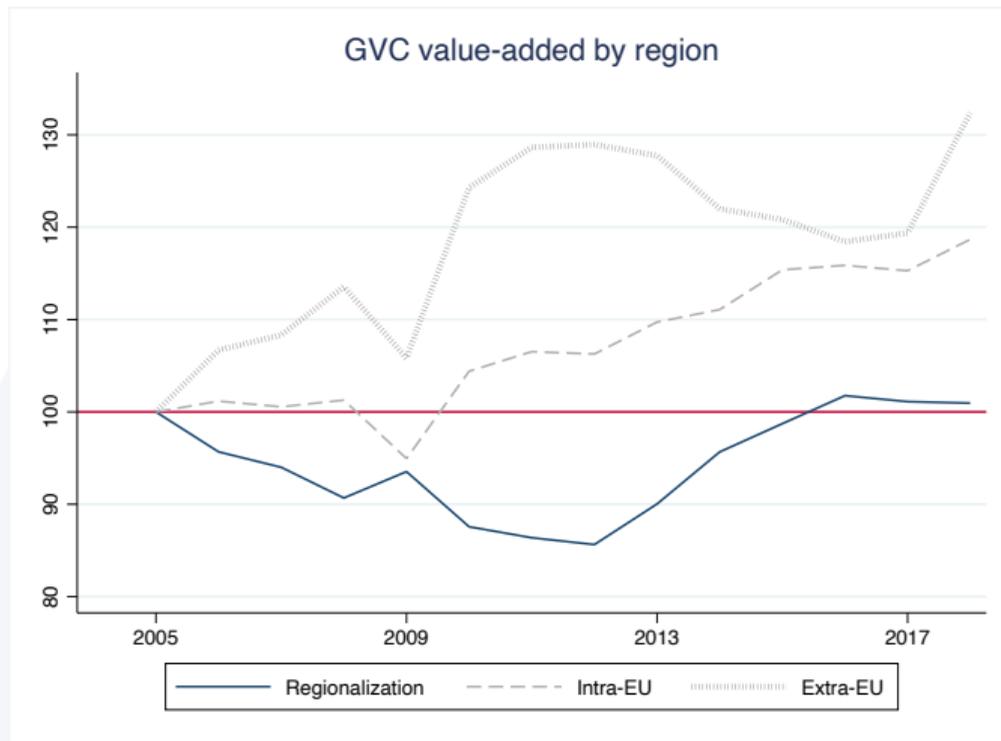
Digital and non-digital capital
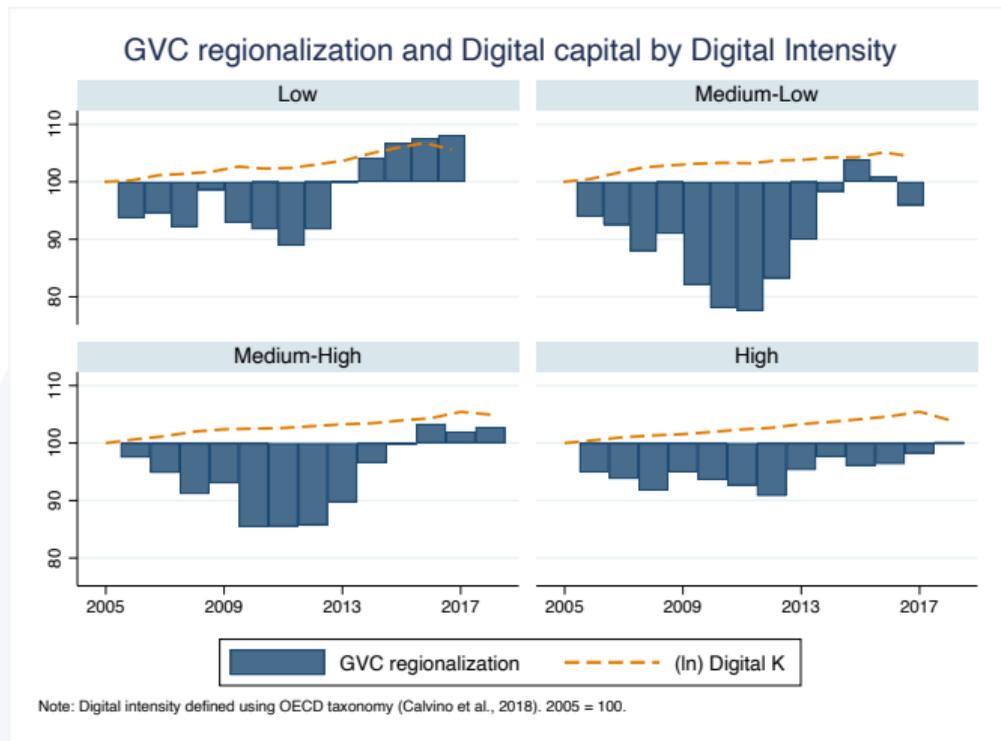
- Starting from 2012: rapid growth of digital capital with respect to oth. K
- Steep increase also **in lower digital intensity** industries (low and medium-low)
- Particularly relevant for low digital industries
  - *pervasiveness* of digital technologies

Digital and Non-digital capital by OECD Digital Intensity

Low — Medium-Low — Medium-High — High

Digital capital — Non-digital capital
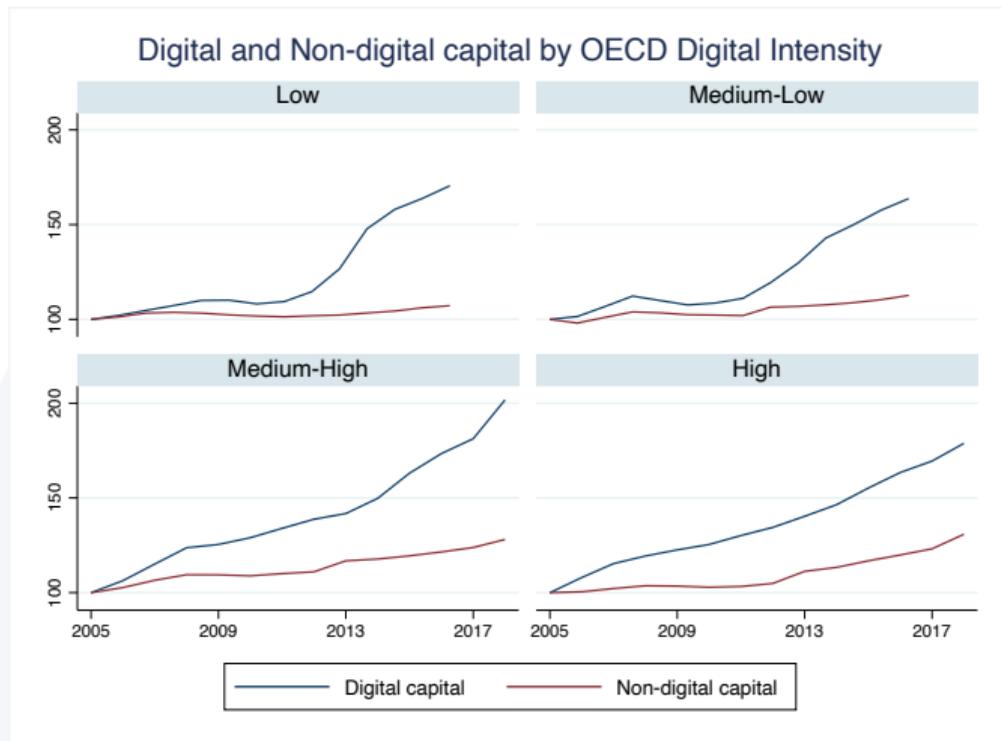
Regionalization by industries' digital intensity

- Stronger "globalization" between 2005 and 2012 in medium digital-intensive sectors
- More pronounced regionalization in low-digital sectors (after 2012)
  - But highest increase in digital capital, which seems to correlate
- Regionalization of high digital-intensive sectors constantly < 100

GVC regionalization and Digital capital by Digital Intensity

Note: Digital intensity defined using OECD taxonomy (Calvino et al., 2018). 2005 = 100.

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Digitalization & regionalization: is there a correlation?

- We can clearly distinguish two phases (both for time-series and for correlation)
- In the first part of the series: negative correlation digital-regionalization
  - ICT may have helped to lower trade barriers ⇒ "globalization"
- In 2012-2018 there is a **positive correlation**

Digital capital weighted by Gross Output (source: EU-KLEMS)
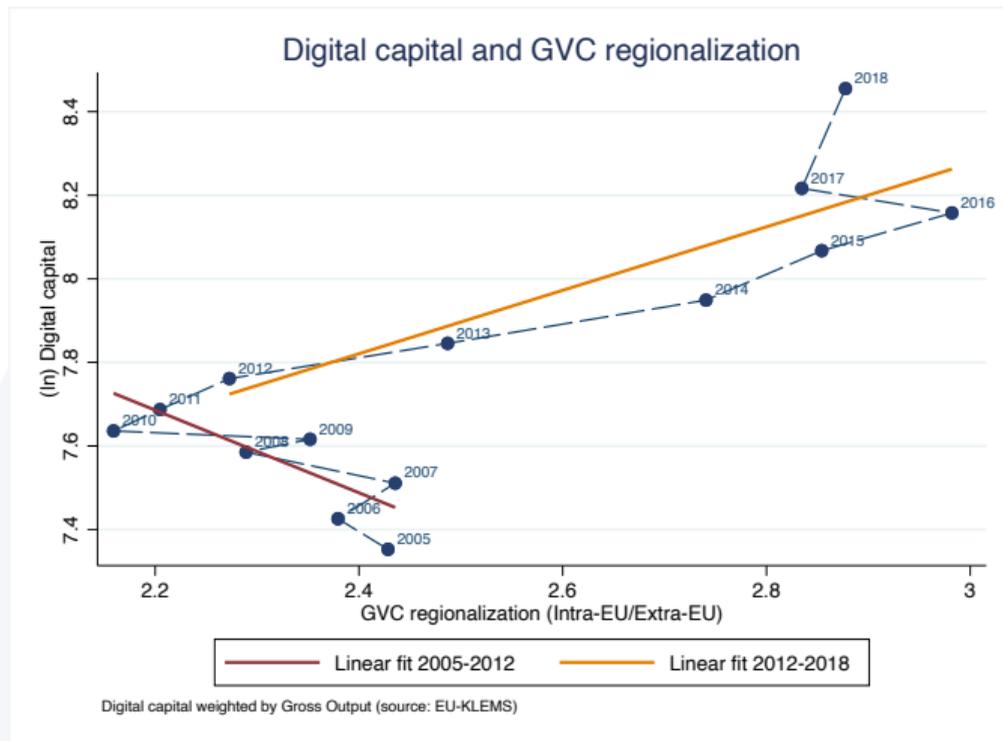
GVC & digitalization: evidence

- GVCs' participation recovered rapidly after 2009 crisis
- Starting from 2005, regionalization (i.e., intra-EU/extra-EU) declined until 2012, and recovered after the crisis
- Steady growth for Intra-EU value-added since 2009, contributing to reach the regionalization level of initial period
  - Along with the decrease of extra-EU value-added after 2012
- Digital technologies are pervasive: relevant growth after 2013 regardless of the industries' digital intensity
- Correlation between diffusion of digital capital in low-digital sectors and increase in regionalization

Econometric analysis

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

$$Regionalization_{i,c,t}^{GVC} = \beta DigitalCapital_{i,c,t-1} + \gamma Controls_{i,c,t-1} + \alpha_{i,c} + \varepsilon_{i,c,t}$$

- Common factors may affect both regionalization and digitalization
- Higher regionalization in EU due to political and economic integration
- Endogeneity concerns (potential reverse causality)

Econometric strategy (1/3)
Identification

- 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: two Bartik IVs based on OECD data
  - No. of applications by priority date
    - (log of) Number of ICT-related patents (Inaba and Squicciarini, 2017)
    - (log of) Number of AI-related patents (Baruffaldi et al., 2020)

- Rationale: number of world patents = existing technological opportunities
  - Use of digital goods (embedded in patents) "mediated" by the digital capital at the country-sector level

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Econometric strategy (2/3)
Bartik IV

1st IV: ICT-related patents $\rightarrow Btk1_{i,c,t} = \dfrac{KDT_{i,c,t-1}}{KDT_{c,t-1}} \times logPAT_t^{ICT}$

2nd IV: AI-related patents $\rightarrow Btk2_{i,c,t} = \dfrac{KDT_{i,c,t-1}}{KDT_{c,t-1}} \times logPAT_t^{AI}$

- KDT: Digital capital (ICT + Software & Database), share at country level

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Econometric strategy (3/3)
Identified model

$$y_{i,c,t} = \beta \widehat{lnKDT}_{i,c,t-1} + \gamma X_{i,c,t-1} + \alpha_{i,c} + y09_t + y12_t + \varepsilon_{i,c,t}$$

- y = (1) GVC participation; GVC regionalization ratio; (2) Ratios' components: (log of) Intra- and (log of) Extra-EU value-added
- Btk1 (ICT-related) and Btk2 (AI-related) as IVs in 2SLS
- Individual (country-sector) fixed effects
- Year dummies for major time disruption (i.e., 2009, and 2012)
- Controls: Non-digital capital; employment; value-added
- All variables lagged by 1 year

Results (1/2)

Table: Participation and regionalization

	(ln) GVC participation		GVC regionalization	
	FE	2SLS	FE	2SLS
	(1)	(2)	(3)	(4)
(ln) Digital capital, t-1	0.095***	0.110***	0.032	0.173***
Oth. controls	✓	✓	✓	✓
Obs.	1,736	1,603	1,736	1,603
R2	0.179	0.183	0.058	0.062
Kleibergen-Paap F		48.301		48.301

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

Digitalization: (1) enhances GVC participation, and (2) contributes to regionalization if we consider the IVs

Results (2/2)

Table: 2SLS - GVC Intra- vs. Extra-EU value-added

	(ln) GVC Region.	(ln) Intra-EU	(ln) Extra-EU
	(1)	(2)	(3)
(ln) Digital capital, t-1	0.113***	0.444***	0.331***
Oth. controls	✓	✓	✓
Obs.	1,603	1,603	1,603
R2 (within)	0.049	0.307	0.309
Kleibergen-Paap F	48.301	48.301	48.301

2SLS estimations. Oth. Controls include: (ln) non-digital capital, (ln) employment, (ln) value-added, dummies for 2009 and for 2012. Bartik IVs based on ICT- and AI-related world stock of patents (OECD). Country-sector fixed effects always included. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

- Both trade flows grow with digital, but with different paces
- Intra-EU flows grow more with respect to extra-regional

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Conclusions

Digitalization

- Contributed to the growth of GVC participation, in the period 2005-2018
- Impacts positively GVC regionalization
- Digital capital positively affects both value-added components of regionalization index
  - i.e., no "de-globalization" evidence associated to digitalization
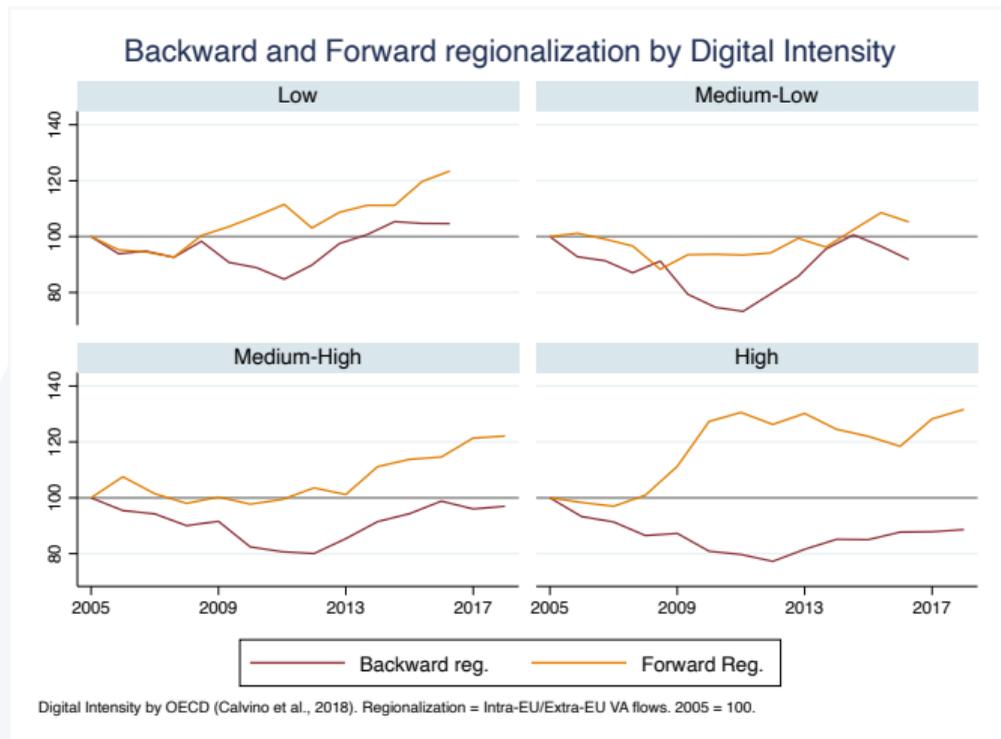- But with different magnitude: growth of Intra-EU larger than Extra-EU

→ Digitalization boosts the growth of intra-regional flows

- Is it due to higher complementarity of production processes?
- Which kind of GVC participation (i.e., backward or forward) is affecting the results?
- Which mechanism is in place?

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Research agenda

Digitalization effect on

- Backward p. → Foreign VA in domestic X → Input sourcing
- Forward p. → Domestic VA in foreign X → Output destination

- High digitalized sectors lead the regionalization of **forward VA**
- Higher the digital intensity ⇒ larger VA re-processed by other European industries

Backward and Forward regionalization by Digital Intensity

Digital Intensity by OECD (Calvino et al., 2018). Regionalization = Intra-EU/Extra-EU VA flows. 2005 = 100.

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Thanks for your attention! ☺

We look forward to your comments and suggestions.

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