PRIN PROJECT WORKSHOP

# DIGITAL TECHNOLOGIES AND GLOBAL VALUE CHAINS. EVIDENCE FROM THE ITALIAN INDUSTRY

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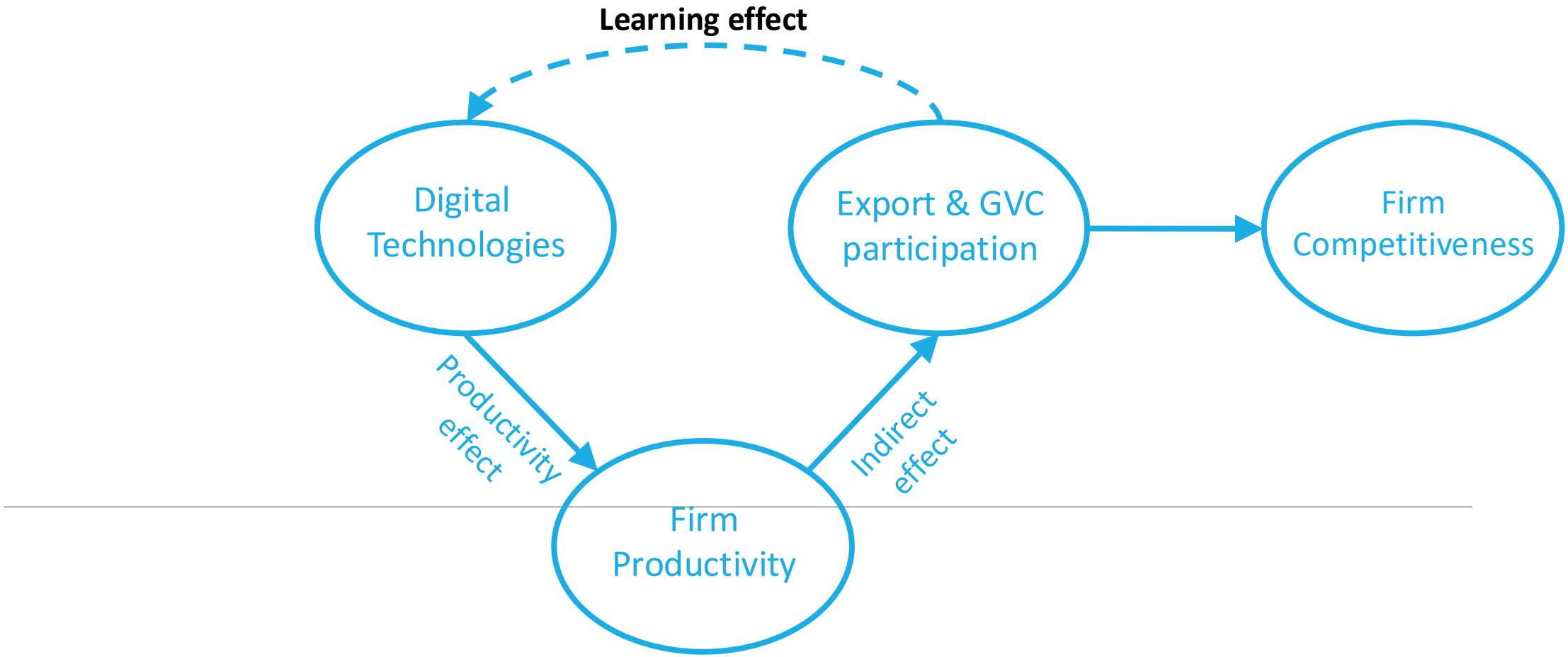
# Can GVCs stimulate DT Adoption?



# Can GVCs stimulate DT adoption? Aims of the paper

- **investigating whether firm participation in GVCs is associated with a higher firm propensity to adopt DT.**
- **what type of GVC governance is the most suitable to stimulate investments in DT**
- **whether the impact of participation in GVCs is heterogenous along firms size**

First research hypothesis

# Participation in GVCs is associated with a larger firms' propensity to adopt DT

Requires updated technologies for complying with standards requested by clients, and keeping prices competitive

Increases the frequency of exchanges, opening up several channels of learning

Imposes higher requirements in terms of technological standards for exchanging high volume of information across inter-firm linkages, and coordinating the activities of various independent actors

(Cardona et al., 2013; Delera et al. 2022; Jean et al., 2010; Jin et al., 2014; OECD; 2015; Ponte et al., 2019; Taglioni and Winkler, 2016; WTO, 2021; World Bank, 2020)

## Second research hypothesis:

# The GVC governance plays a role in DT adoption

**Governance modes: i) arms-length, ii) modular, iii)relational**

"**Relational mode**" (Gereffi et al., 2005; Pietrobelli and Rabellotti, 2011; Ponte et al., 2019)

Firms take part in high value-added stages of production (R&D, design, engineering) through long-lasting and repeated supplier-buyer interaction (Agostino et al., 2020; Brancati et al., 2017)

Relational governance is the one which mostly favors the transmission of knowledge, managerial expertise and technological know-how along the GVC

Repeated interactions and long lasting relationship interactions among firms

Lower transaction costs → reward of digital "specific" investments

## Third research hypothesis:
# Mediating role of firm size

Lower DT adoption by micro and small firms

Poor managerial ability (Schivardi and Schmitz, 2020); liquidity constraint (Hoffmann and Nurski, 2021; Stoneman and Battisti, 2010); low absorption capacity (Cohen and Levinthal, 1990); failure to carry out complementary investments (Brynjolfsson and Milgrom, 2012; Teece, 2010)

The channels, through which GVC involvement may foster firms' investment in DT, may be especially at work in the case of smaller companies for whom **learning channels and knowledge transfers** are expected to have stronger marginal effects .

Participation in a GVC may allow micro and small firms to (partially) bridge the DT adoption gap with larger firms

# Micro-level analysis based on the Italian industry

Ideal testing ground of our research hypotheses for:

- the **low level of digitalization** of the Italian industry (Cirillo et al., 2023; European Commission, 2020; Giunta and Trivieri, 2007; Giunta and Mantuano 2025; Hassan and Ottaviano, 2013; Meliciani and Pini, 2021; Schivardi and Schmitz, 2020; OECD, 2022)
- the **extensive, but uneven, participation** of Italian firms **in GVCs**.
- **stagnant economic growth of the last two decades**

# Data

- We draw on data from the 2017 and 2019 waves of the MET (Monitoring Economy and Territory) survey on the Italian industry – the most extensive survey conducted within a single European country – to obtain our proxies for DT adoption.
- From the same source – and including data from the 2015 wave – we collect the information needed to attain the GVC participation proxies.
- MET also provides firms' balance sheet information (sourced from the BvD-AIDA data-base), which is used to retrieve the control variables entering the econometric model.
- Our sample consists of an unbalanced panel of 24,439 firms, totaling 54,191 observations.

# MEASURES OF GVC PARTICIPATION

**A firm is involved in a GVC if it is:**

**i) an exporter of intermediate goods** (i.e., semi-finished products that are employed by other firms as production inputs);

**ii) a two-way trader,** i.e. fully internationalized firms that **both import and export;**

**iii)** a partially internationalized **firm that either imports or exports, provided that it declares to be involved in significant and long-lasting relationships with foreign counterparts.**

# MEASURES OF DT ADOPTION

**Collaborative and interconnected robots (OPDT) ;**

**3D printers (OPDT);**

**augmented reality (OPDT);**

**experimental simulations and virtual tests (OPDT);**

**nanotechnologies and intelligent materials (OPDT);**

**electronic integration of data and information in the production process (INFDT);**

**electronic information sharing with customers/suppliers in the distribution chain; electronic communication between machinery and products, (INFDT);**

**management of large amounts of data on open systems; clouds (INFDT);**

**collection and analysis of large amounts of data (INFDT);**

**security in network operations and open systems (INFDT).**

# Empirical equation

The baseline equation is:

$$\mathrm{P}(DT_{it} = 1 \big| X_{i(t-1)}) = F(\alpha + \beta GVC_{i(t-1)} + \phi' Z_{i(t-1)} + \gamma_s + \gamma_r + \gamma_t + u_{it})$$

where:

- *DT* is a binary variable coded one if the firm uses or plans to use (one or more of) digital technological applications ;

- GVC is a dummy coded 1 if a firm participates in a GVC and zero otherwise at t-1;

- *Z* is a vector of control variables: SIZE; AGE; CASHFL; LEVERAGE and an indicator of firms' investment in R&D
- $\gamma_s, \gamma_r, \gamma_t$ : industry, regional, time fixed effects

# Empirical equation: OPDT and INFDT

The empirical equation is then estimated by replacing DT with:

- ***OPDT:*** dummy coded 1 if a firm declares to use (or plans to use) at least one operational digital technology (collaborative and interconnected robots; 3D printers; augmented reality; experimental simulations and virtual tests; nanotechnologies and intelligent materials), zero otherwise.

or

- ***INFDT****:* dummy coded 1 if a firm declares to use (or plans to use) at least one informational digital technology (electronic integration of data and information; electronic information sharing; IOT; clouds; big data; cyber security), zero otherwise.

# Addressing endogeneity concerns

- Reverse causality may be an issue if both DT and GVC display a high degree of persistence over time. Indeed, it is possible that investments in DT, by increasing technical efficiency and productivity, enable firms to deal with sunk costs attached to the internationalization process. **To tackle this potential problem, we focus on the *introduction* rather than the *use* of DT, modelling the probability of adopting DT *for the first time* (that is in 2019):**

$$P(Y\_DT_{i2019} = 1|X_{i2017}) = F(\alpha + \beta GVC_{i2017} + \phi Z_{i2017} + \gamma_t + \gamma_r + \gamma_s + u_{it})$$

- **Propensity Score Matching:** conditional on firms' characteristics and sectoral, regional and year dummies; comparing participants and non-participants with a similar probability of participating in GVCs. (Sample selection issue)
- **Lewbel estimator** (2012) based on internal instruments
- **IV strategy** based on external instruments
- **Oster approach (2019)** to evaluating the relevance of unobservable factors (relative to observable factors) in determining the estimated parameters of our GVC proxies

**Results confirm our findings**

## Estimation results: GVC participation and digital technology adoption

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | **DT** | **OPDT** | **INFDT** | **DT** *actual* | **OPDT** *actual* | **INFDT** *actual* |
| GVC | 0.0459*** | 0.0406*** | 0.0409*** | 0.0366*** | 0.0216*** | 0.0353*** |
| | *0.0000* | *0.0000* | *0.0000* | *0.0000* | *0.0020* | *0.0000* |
| Firm characteristics | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Sector dummies | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Region dummies | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Year dummies | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Observations | 11,605 | 11,605 | 11,605 | 11,605 | 11,605 | 11,605 |

Superscripts ***, ** and * denote statistical significance at 1, 5 and 10 percent level, respectively. Standard errors (not reported) are robust to heteroskedasticity and autocorrelation; p-values in italics. To avoid simultaneity bias, all explanatory variables are lagged once. Actual investments are those actually realized (excluding planned investments not yet realized).

# The role of GVC governance mode

To verify hypothesis 2, we replace the *GVC* variable with three dummies based on the question "Do your clients mainly choose you on the basis of?"

"Our price" → ***ARMS***

"Our ability to comply with stringent technical requirements/specifications" → ***MODU***

"Close collaboration for the identification of technological solutions" → ***REL***

## Estimation results: GVC governance and digital technology adoption

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | DT | | OPDT | | INFDT | |
| ARMS | 0.0326 | | 0.0374* | | 0.0260 | |
| | *0.1560* | | *0.0740* | | *0.2550* | |
| MODU | 0.0322** | | 0.0214 | | 0.0305** | |
| | *0.0300* | | *0.1130* | | *0.0380* | |
| REL | 0.0635*** | 0.0635*** | 0.0698*** | 0.0701*** | 0.0615*** | 0.0615*** |
| | *0.0090* | *0.0090* | *0.0010* | *0.0010* | *0.0100* | *0.0100* |
| ARMO | | 0.0323** | | 0.0253** | | 0.0293** |
| | | *0.0170* | | *0.0410* | | *0.0290* |
| Firms' characteristics | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Sector dummies | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Region dummies | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Year dummies | *yes* | *yes* | *yes* | *yes* | *yes* | *yes* |
| Observations | 6,576 | 6,576 | 6,576 | 6,576 | 6,576 | 6,576 |
| REL vs ARMO | | 1.568 | | 4.280 | | 1.724 |
| | | *0.2105* | | *0.0386* | | *0.1892* |

Superscripts ***, ** and * denote statistical significance at 1, 5 and 10 percent level, respectively. Standard errors (not reported) are robust to heteroskedasticity and autocorrelation; p-values in italics. To avoid simultaneity bias, all explanatory variables are lagged once.

# To verify our third hypothesis →**heterogeneity along firms' size classes.**

- we define an ordinal variable **DSIZE**, taking values 1 to 4 for micro, small, medium, and large firms, respectively.
- we retrieve **the predicted probabilities** of DT adoption for **eight groups** of firms, characterized in terms of GVC participation and DSIZE
- We then compute **a "conditional multiplier",** assessing the relative effect of joining a GVC for each size category

**Predicted probabilities of DT adoption: GVC participation, REL and firm size**

| | | 1 | 2 |
|---|---|---|---|
| | | GCV | REL |
| | | DT | DT |
| 0.GVC(REL)-DSIZE1 | 01 | 0.2138*** | 0.2774*** |
| | | *0.0000* | *0.0000* |
| 0.GVC(REL)-DSIZE2 | 02 | 0.2948*** | 0.3521*** |
| | | *0.0000* | *0.0000* |
| 0.GVC(REL)-DSIZE3 | 03 | 0.4095*** | 0.4820*** |
| | | *0.0000* | *0.0000* |
| 0.GVC(REL)-DSIZE4 | 04 | 0.5301*** | 0.4989*** |
| | | *0.0000* | *0.0000* |
| 1.GVC(REL)-DSIZE1 | 11 | 0.2707*** | 0.3637*** |
| | | *0.0000* | *0.0000* |
| 1.GVC(REL)-DSIZE2 | 12 | 0.3656*** | 0.4842*** |
| | | *0.0000* | *0.0000* |
| 1.GVC(REL)-DSIZE3 | 13 | 0.4557*** | 0.4660*** |
| | | *0.0000* | *0.0000* |
| 1.GVC(REL)-DSIZE4 | 14 | 0.5727*** | 0.5788*** |
| | | *0.0000* | *0.0000* |
| | | Conditional multipliers | Conditional multipliers |
| 11/01 | | 1.266 | 1.311 |
| 12/02 | | 1.240 | 1.375 |
| 13/03 | | 1.113 | 0.967 |
| 14/04 | | 1.080 | 1.160 |

Superscripts ***, ** and * denote statistical significance at 1, 5 and 10 percent level, respectively; p-values in italics. Firm characteristics as well as sectoral, regional and year dummies are always included. DSIZE is codified as 1/2/3/4 for micro/small/medium/large firms, respectively

To exemplify, row 1 shows the probability of investing in *DT* for the group (01), which identifies:

- micro firms outside GVCs ($GVC = 0$ and $DSIZE = 1$) in column 1;
- micro firms outside relational GVCs in column 2.

Using predicted probabilities, we compute "conditional multipliers". For instance, in column 1, the conditional multiplier for micro firms (1.266) is the ratio of the fitted probability of investing in DT for firms involved in GVCs (0.2707) to that of those not participating (0.2138).

Conditional multipliers:

- take the highest values for micro and small firms and the lowest for medium-sized and large businesses;
- for *REL* are, in most cases, larger than those of *GVC*.

# Conclusions

H1: GVC participation is positively associated with the propensity of DT adoption

H2: Relational governance plays a significant role in fostering DT adoption

H3: Gain deriving from being in a GVC in terms of propensity to use DT is greater when the size of firms is smaller

↓

Integration in international production networks is a channel to:

- incentivize companies, especially micro and small firms, to invest in advanced DT
- help the diffusion of these new technologies
- facilitate a recovery of aggregate productivity.

# Policy implications

Incentivize lead firms with conditionality (Mazzucato and Rodrick, 2023)

Target industries with relational governance (Florio et al., 2018; Kano, 2018; Sturgeon et al., 2008)

Support small firms, taking into account the micro complementarities between financial resources, human capital, managerial expertise.

# THANK YOU FOR YOUR ATTENTION

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