# Digitalisation of firms and (type of) employment

Discussion

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NBB Conference 2024, Brussels 3 October 2024

# The paper

- Analysis of the association between investment in digitalization and employment (size and composition by educational levels and age)
- Excellent data set
- Main results. In firms that invested more in digitalization (2003-2019):
  - Higher employment growth. Due to higher hiring and despite higher exits.
  - Changes in composition of the workforce
    - Higher share of highly educated workers
    - Shift towards middle-aged workers
- Suggest skill-biased technological progress

# My comments

- Topical issue: New technologies and jobs.
  - Digitalisation vs. Robotics and Artificial Intelligence
- Excellent data set. Many possibilities
- About what is in the paper
  - Definition and measurement of digitalisation
- About what is NOT in the paper (but may be it should be)
  - Other indicators of the impact of digitalisation on firms: productivity, wages
  - Causal effects

# Digitalisation: What kind of technology?

- Digitalisation vs. Robotics and Artificial Intelligence. How to measure investment in digitalisation

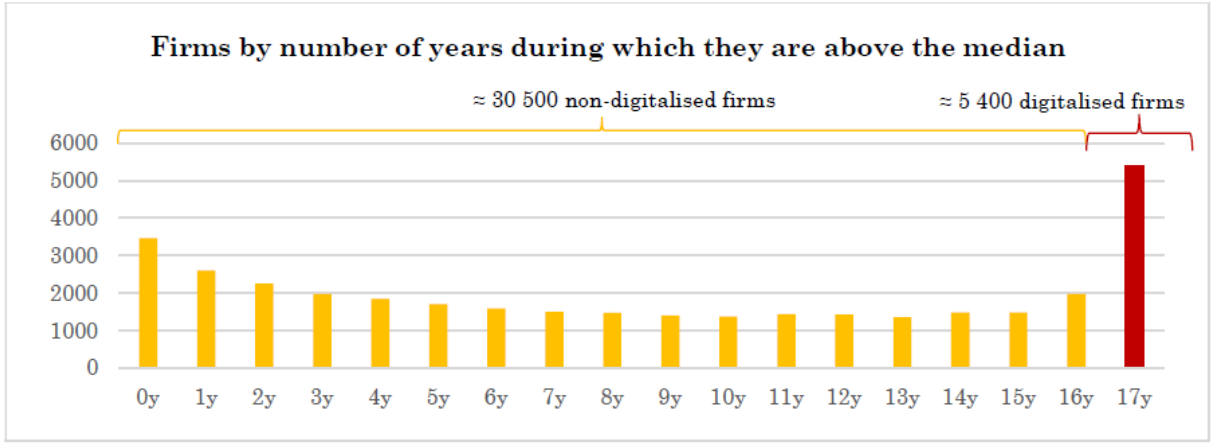
Digitalisation of a firm is defined as follows:

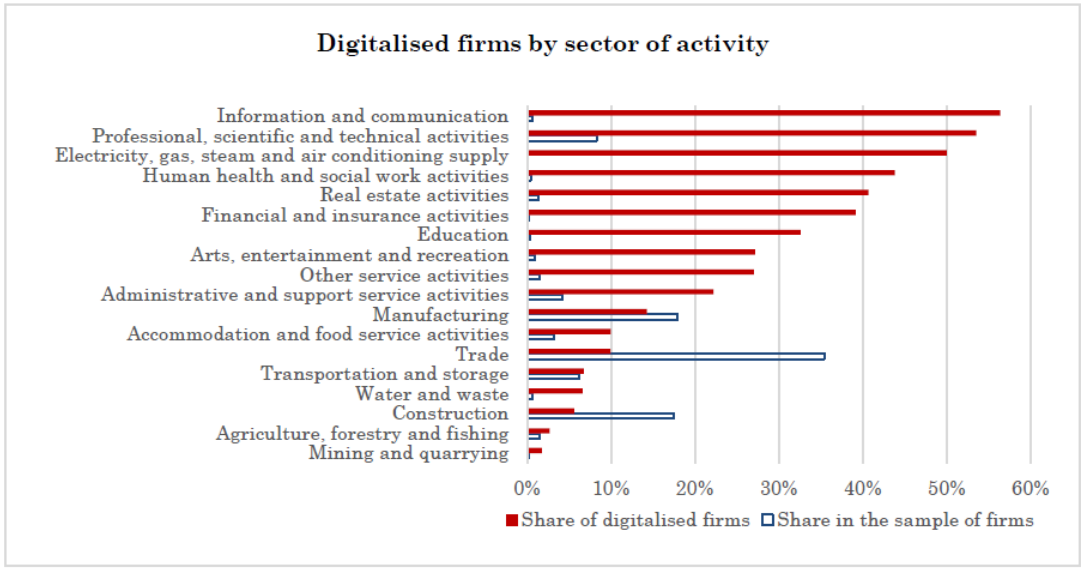
$$D_i = 1 \quad if \quad \forall t \;\; \delta_{i,t} > \tilde{\delta}_t, \;\; t \in \{2003, \ldots, 2019\}$$

$$D_i = 0 \; otherwise \qquad (1)$$

where $\delta_{i,t}$ is the share of digital expenditures of firm $i$ in year $t$ among its total expenditures, and $\tilde{\delta}_t$ is the median share of digital expenditures for all firms in our sample in year $t$.

**Figure 1 – Distribution of digitalised firms**



# Digitalisation: What kind of technology?

- Definition: Too wide? Including too many expenses?
- Long period 2003-2019. Firm mobility across sectors, size groups. Attrition bias?

$$log(E_{i,2019}) - log(E_{i,2003}) = \alpha + \beta\, log(E_{i,2003}) + \gamma D_i + \eta s_i + \varepsilon_i \qquad (2)$$

- Why a discrete measure? Why not a continuous measure of accumulated investment?
- Sectoral analysis and by size of firms and employment trends. More granularity? Counterintuitive results? Wrong definition of the dummy for digitalisation?
- Distinction goods-services. Useful? Larger effects for goods. Were ICT goods/services in 2003 the same as in 2019?
- Effects on workforce composition: More informative when looking at occupations.

# Effects on productivity and wages

- Effects on employment results suggest digitalisation is kind of skill-biased technological progress. Should we look at occupations rather than on education levels?
- Will we see also skill-biased technological progress when looking at productivity?
- Effects on wages/wage share?
- Firm profitability?

# Causal effects

- Warning against interpretation of correlation as causality. However:
  - “Our empirical results indicate firms that adopt digital technologies expand their net employment”.
  - “Insights into how digitalization reshapes workforce demographics over time”

- Towards estimation of causality
  - Panel data? Firms moving from non-digitalisation to digitalisation
  - Propensity score matching: Michael Koch & Ilya Manuylov & Marcel Smolka (EJ 2021). Robots and Firms (in Spain)
  - Bartik instruments (shift-share analysis)?
  - Help from “digitalisation”?

To estimate the causal effect of investment on employment, you'll want to use an instrumental variable (IV) that influences investment but does not directly affect employment except through investment. Here are some potential candidates:

1. **Tax Incentives**: Changes in tax policy that encourage investment can serve as an IV. For example, tax credits for capital investment can drive firms to invest more.
2. **Access to Credit**: Changes in the availability of credit (like shifts in lending standards or interest rates) can impact firms' ability to invest.
3. **Industry-Specific Shocks**: External shocks, such as changes in regulation or sudden demand increases in certain industries, can spur investment in those sectors, which may then lead to increased employment.
4. **Geographic Variation**: Differences in investment incentives across regions (e.g., state or local grants for businesses) can serve as a valid IV if those incentives influence investment levels without directly impacting employment.
5. **Lagged Investment Variables**: Past investment levels might influence current employment, assuming that they are exogenous to current employment levels.

When selecting an IV, ensure it meets the relevance condition (strongly correlated with investment) and the exclusion restriction (affecting employment only through investment). Careful testing and validation are critical to confirm the validity of your chosen IV.

To estimate the causal effects of investment in digital technologies on employment using firm-level data, you can use the **two-stage least squares (2SLS) estimation** method with appropriate instrumental variables (IVs). Here are some potential instruments:

1. **Predetermined Employment Composition**: Use the historical composition of employment within firms as an instrument. This can help isolate the impact of digital technology investments from other factors influencing employment [1].

2. **Industry-Specific Technological Adoption Rates**: Leverage the average rate of digital technology adoption within the industry as an instrument. This assumes that firms in industries with higher adoption rates are more likely to invest in digital technologies [1].

3. **Geographical Proximity to Tech Hubs**: Use the geographical proximity of firms to major technology hubs or innovation centers as an instrument. Firms closer to these hubs are more likely to adopt digital technologies due to easier access to resources and expertise [1].