Digitalisation of firms and (type of) employment

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Research question:
How does the use of digital technologies within firms influence employment growth and workforce composition?

Who? Private firms in Belgium 2003-2019

Our strength? The dataset

Main findings

ICT investments is a smooth process

Digitalised firms experienced higher employment growth, especially larger firms

The composition of the labour force is changing differently

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What do we know from the literature?

Employment Substitution Effect

Digital technologies replace workers,
leads to job losses and higher unemployment

Focus on industry-level

Key studies: Frey and Osborne (2017),
Brynjolfsson and McAfee (2014),
Acemoglu and Restrepo (2018, 2020),
Graetz and Michaels (2018), Acemoglu et al. (2022)

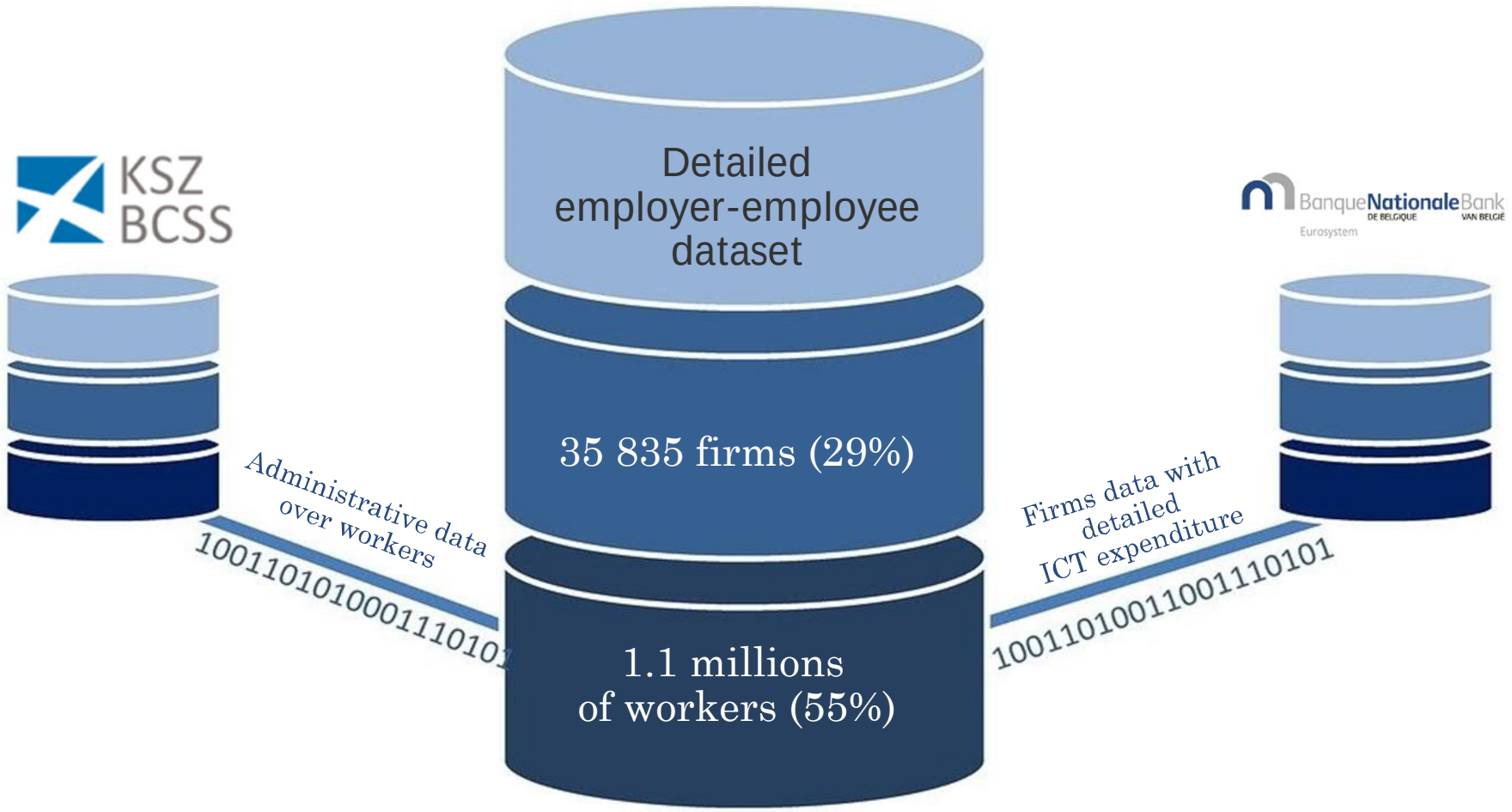
Employment Creation Effect

Digitalisation drives an increase in
total employment

Focus on firm-level

Key studies: Autor (2015), Dutz et al. (2018),
OECD (2019), Stehrer (2019),
Ghodsi et al. (2020), Koch et al. (2021),
Dixon et al. (2021), Aghion et al. (2022),
Miho et al. (2023)

Our sample


KSZ BCSS
Detailed employer-employee dataset
35 835 firms (29%)
1.1 millions of workers (55%)
Administrative data over workers
1001101010001110101
Firms data with detailed ICT expenditure
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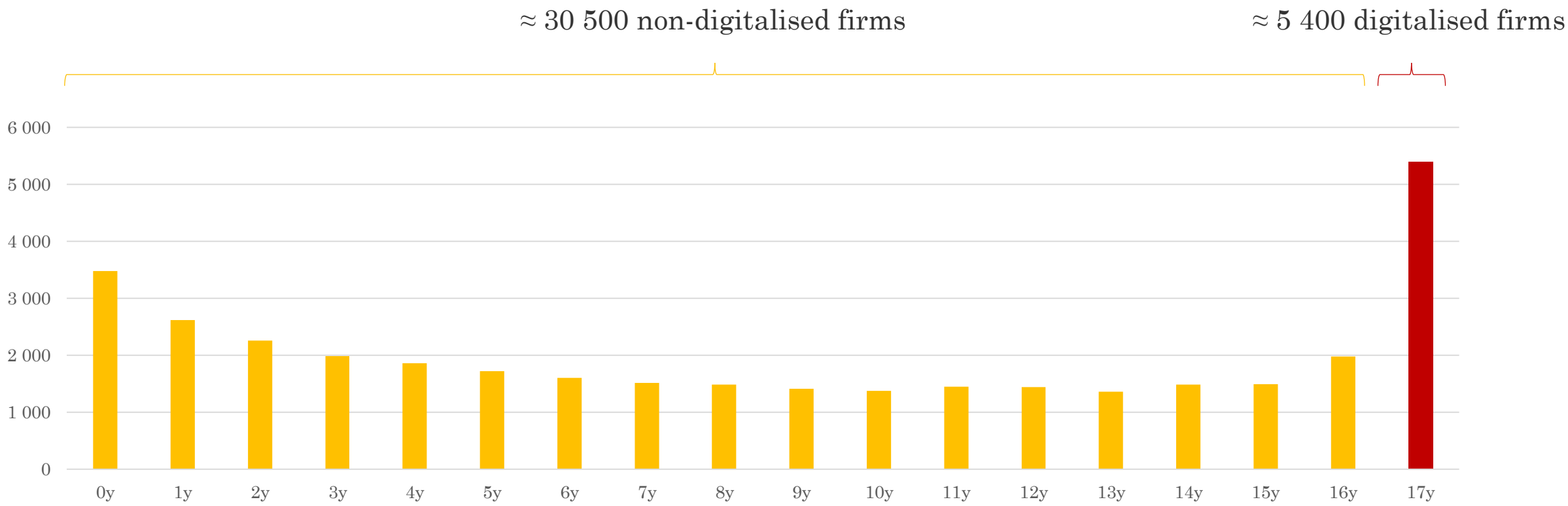
Definition of a digitalised firm

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

$$D_i = 0 \; otherwise$$

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

Firms grouped by number of years they are above the median

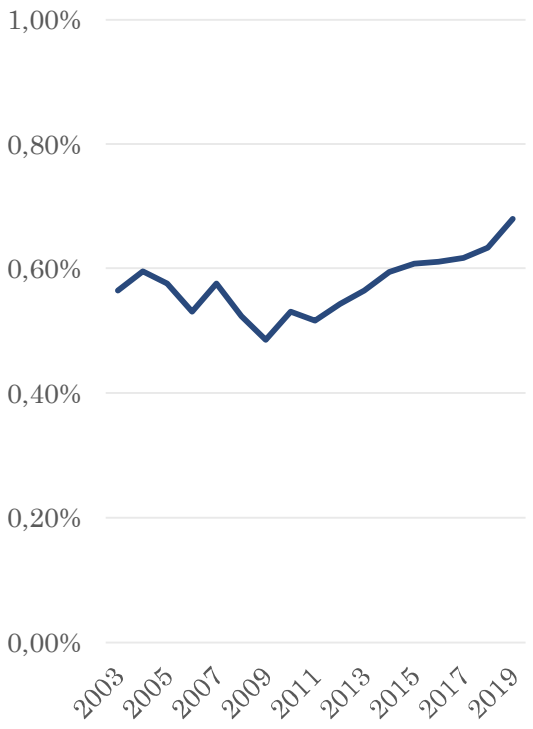


No spikes in ICT expenditure, continuous process

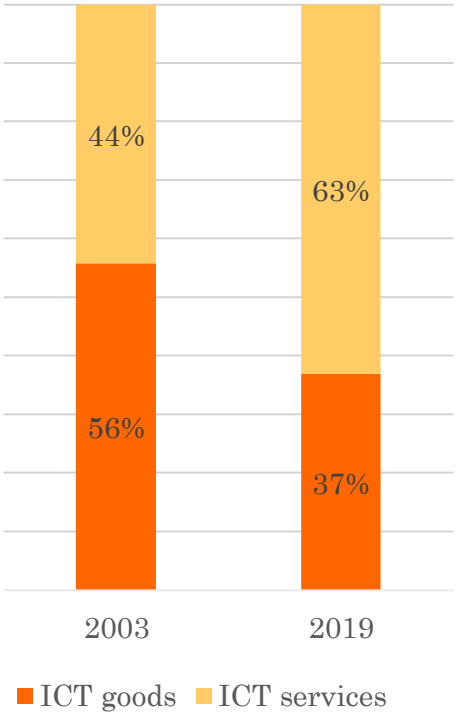
Correlation between firms' ICT share in t and in t-1	0.81
Correlation between the maximum ICT share over the period and	
the average ICT share (excluding the maximum)	0.80
the ICT share the year before the maximum	0.80
the ICT share 2 years before the maximum	0.76
the ICT share 3 years before the maximum	0.73
the ICT share the year after the maximum	0.81
the ICT share 2 years after the maximum	0.76
the ICT share 3 years after the maximum	0.74

Correlation between the minimum ICT share over the period and	
the average ICT share (excluding the minimum)	0.63
the ICT share the year before the minimum	0.59
the ICT share 2 years before the minimum	0.54
the ICT share 3 years before the minimum	0.51
the ICT share the year after the minimum	0.60
the ICT share 2 years after the minimum	0.58
the ICT share 3 years after the minimum	0.56

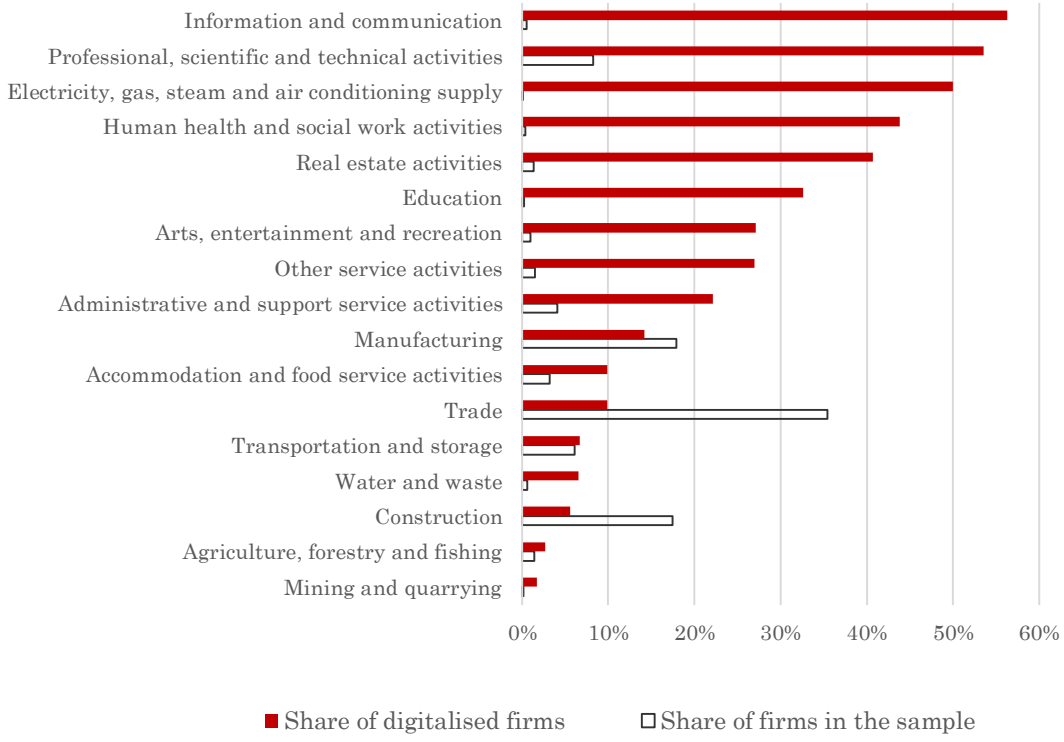
Evolution over time of the median share of ICT expenses



Evolution of the types of ICT expenses



Share of digitalised firms by sectors



Methodology

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

where $E_{i,2019}$ is employment in firm i in 2019, $E_{i,2003}$ is employment in firm i in 2003, D_i is a binary variable taking the value of 1 if the firm is digitalised and 0 otherwise, s_i is a sector dummy, and ε_i is the error term.

Unweighted and weighted estimations

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Baseline estimation

- +19% employment growth
  ⇔ 1.1% increase per year on average

- Raise to 34% when weighting by firm size
  ⇔ 1.8% per year

- Stronger positive relationship between digitalisation and employment among large firms

	(1)	(2)
Digitalisation	0.174***	0.291***
	(0.016)	(0.015)
Initial log of employment	-0.229***	-0.207***
	(0.004)	(0.004)
Constant	0.489***	1.149***
	(0.009)	(0.018)
Sector fixed effect	Yes	Yes
Firm size weights	No	Yes
Nb of observations	35 835	35 835
R^2	0.118	0.224

Note: (robust standard errors), *** p<0.01, ** p<0.05, * p<0.1

Robustness checks

Controlling for previous growth rate (2003-2010)

- Strong significant relationship between digitalisation and employment

Controlling for initial capital and productivity

Splitting the sample into growing and shrinking firms

Changing the period covered

Changing the definition of digitalisation

Robustness checks

Controlling for previous growth rate (2003-2010)

Controlling for initial capital and productivity

- Magnitude of the link slightly reduced but the positive effect persists

Splitting the sample into growing and shrinking firms

Changing the period covered

Changing the definition of digitalisation

Robustness checks

Controlling for previous growth rate (2003-2010)

Controlling for initial capital and productivity

Splitting the sample into growing and shrinking firms

- Stronger effect on shrinking firms: digitalisation associated with stabilisation or slower decrease in employment than non-digitalised firms

Changing the period covered

Changing the definition of digitalisation

Robustness checks

Controlling for previous growth rate (2003-2010)

Controlling for initial capital and productivity

Splitting the sample into growing and shrinking firms

Changing the period covered

- Consistently show a positive relationship between digitalisation and employment
- Effect stronger in earlier periods than in more recent ones

Changing the definition of digitalisation

Robustness checks

Controlling for previous growth rate (2003-2010)

Controlling for initial capital and productivity

Splitting the sample into growing and shrinking firms

Changing the period covered

Changing the definition of digitalisation

- Consistent with baseline
- Stronger effect of ICT goods than ICT services

Heterogeneity analyses

- Workers flows
- Workforce composition
- Sectoral analysis

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Workers dynamics behind the net employment growth

- The following equations are used for our estimations:

$$log \sum_{t=2003}^{2019} N_{it} = \alpha + \beta\, log\left(E_{i,2003}\right) + \gamma D_i + \eta s_i + \varepsilon_i$$

$$log \sum_{t=2003}^{2019} X_{it} = \alpha + \beta\, log\left(E_{i,2003}\right) + \gamma D_i + \eta s_i + \varepsilon_i$$

- Results show greater labour market dynamism among digitalised firms

	Total entries		Total exits	
	(1)	(2)	(3)	(4)
Digitalisation	0.159***	0.095***	0.101***	0.039***
	(0.015)	(0.012)	(0.012)	(0.009)
Initial log of employment	0.757***	0.794***	0.825***	0.837***
	(0.004)	(0.003)	(0.003)	(0.002)
Constant	1.609***	2.222***	1.474***	1.962***
	(0.009)	(0.014)	(0.007)	(0.011)
Sector fixed effect	Yes	Yes	Yes	Yes
Firm size weights	No	Yes	No	Yes
Nb of observations	35 835	35 835	35 835	35 835
R^2	0.590	0.886	0.718	0.929

Note: (robust standard errors), *** p<0.01, ** p<0.05, * p<0.1

Workforce composition : Education level and age

We estimate the following equation for each specific characteristic x

$$\frac{E^x_{i,2019}}{E_{i,2019}} - \frac{E^x_{i,2003}}{E_{i,2003}} = \alpha + \mu\left(\frac{E^x_{i,2003}}{E_{i,2003}}\right) + \beta\, log\, E_{i,2003} + \gamma D_i + \eta s_i + \varepsilon_i$$

How the change in the share of characteristic x in total employment from the beginning to the end of the period is associated with digitalisation

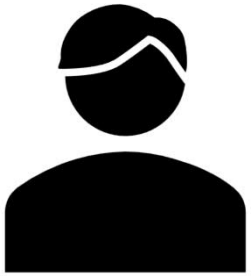
Digitalisation and workers' level of education

	Low-educated		Middle-educated		High-educated	
	(1)	(2)	(3)	(4)	(5)	(6)
Digitalisation	-0.021***	-0.013***	-0.011**	0.003	0.039***	0.011***
	(0.004)	(0.002)	(0.005)	(0.002)	(0.004)	(0.002)
Initial log of employment	0.001	-0.004***	0.002	-0.002***	0.011***	0.008***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Initial share of the respective level of education	-0.780***	-0.678***	-0.738***	-0.633***	-0.635***	-0.492***
	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Constant	0.149***	0.141***	0.336***	0.299***	0.108***	0.087***
	(0.003)	(0.002)	(0.004)	(0.003)	(0.002)	(0.002)
Sector fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm size weights	No	Yes	No	Yes	No	Yes
Nb of observations	35 835	35 835	35 835	35 835	35 835	35 835
R^2	0.477	0.511	0.380	0.352	0.306	0.307

Note: (robust standard errors), *** p<0.01, ** p<0.05, * p<0.1

- Stronger increase in share of highly-educated workers in digitalised firms (+4pp), compensates by both lower share of low (+2pp) and medium-educated workers (+1pp)
- Effect less pronounced in large firms but still statistically significant

Digitalisation and workers' age



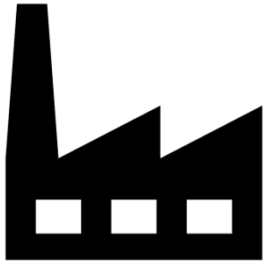
- Descriptive stats: larger share of older workers among firms in general

- This trend is less pronounced among digitalised firms which tend to increase less the share of older workers than non-digitalised firms and instead attract more middle-aged workers

	Young (20-24)		Middle-aged (25-54)		Older (55-64)	
	(1)	(2)	(3)	(4)	(5)	(6)
Digitalisation	0.006**	-0.003***	0.029***	0.014***	-0.034***	-0.010***
	(0.002)	(0.001)	(0.005)	(0.002)	(0.005)	(0.002)
Initial log of employment	-0.001	0.000*	0.025***	0.007***	-0.020***	-0.007***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Initial share of the respective age group	-0.911***	-0.829***	-0.941***	-0.926***	-0.799***	-0.800***
	(0.003)	(0.003)	(0.006)	(0.006)	(0.007)	(0.008)
Constant	0.058***	0.048***	0.593***	0.649***	0.263***	0.202***
	(0.001)	(0.001)	(0.005)	(0.005)	(0.003)	(0.003)
Sector fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm size weights	No	Yes	No	Yes	No	Yes
Nb of observations	35 835	35 835	35 835	35 835	35 835	35 835
R^2	0.702	0.738	0.455	0.496	0.271	0.287

Note: (robust standard errors), *** p<0.01, ** p<0.05, * p<0.1

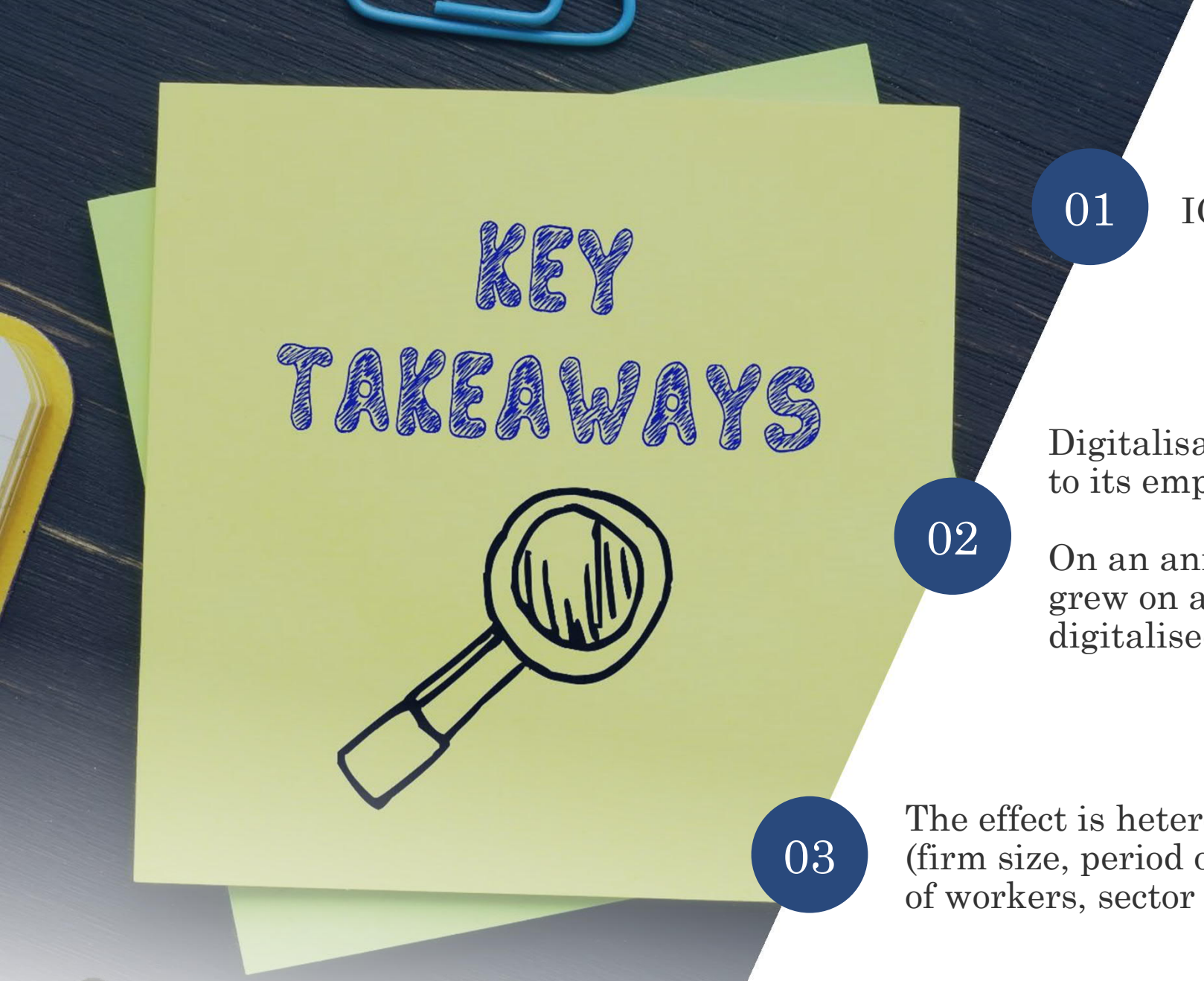
Heterogeneity by sector of activity



	Manufacturing		Services		Construction		Trade		Transport		Professional, scientific and technical activities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Digitalisation	0.193***	0.518***	0.169***	0.192***	0.285***	0.291***	0.069**	-0.232***	0.257***	0.228***	0.184***	-0.087*
	(0.038)	(0.035)	(0.017)	(0.016)	(0.052)	(0.041)	(0.027)	(0.024)	(0.092)	(0.066)	(0.038)	(0.049)
Initial log of employment	-0.214***	-0.238***	-0.233***	-0.196***	-0.245***	-0.168***	-0.222***	-0.080***	-0.256***	-0.185***	-0.206***	-0.229***
	(0.009)	(0.010)	(0.005)	(0.004)	(0.010)	(0.009)	(0.007)	(0.005)	(0.018)	(0.017)	(0.016)	(0.013)
Constant	0.476***	1.085***	0.488***	1.205***	0.448***	0.773***	0.472***	0.734***	0.698***	1.060***	0.457***	1.6097***
	(0.025)	(0.052)	(0.010)	(0.018)	(0.020)	(0.031)	(0.014)	(0.023)	(0.045)	(0.066)	(0.032)	(0.056)
Sector fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm size weights	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Nb of observations	6 415	6 415	28 608	28 608	6 261	6 261	12 696	12 696	2 193	2 193	2 969	2 969
R^2	0.158	0.299	0.103	0.160	0.103	0.119	0.093	0.122	0.091	0.095	0.071	0.145

Note: (robust standard errors), *** p<0.01, ** p<0.05, * p<0.1

- Stronger effect in the manufacturing industry, construction and transport
- Reduction in employment for larger firms in trade and professional, scientific and technical activities



01 ICT investments is a smooth process

02 Digitalisation of a firm is positively related to its employment growth.

On an annual basis, a digitalised firm grew on average 1.1% more than a non-digitalised firm

03 The effect is heterogenous
(firm size, period of time, type of ICT, type of workers, sector of activity)

Discussion

- Need for thoughtful policies: SMEs, upskilling, sector-specific strategies
- Will the next technological advances have the same effect? What about AI?
- What about wages?

Many thanks for your attention!

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Working paper available at www.nbb.be