The impact of ICTs and digitalization on productivity and labor share: Evidence from French firms

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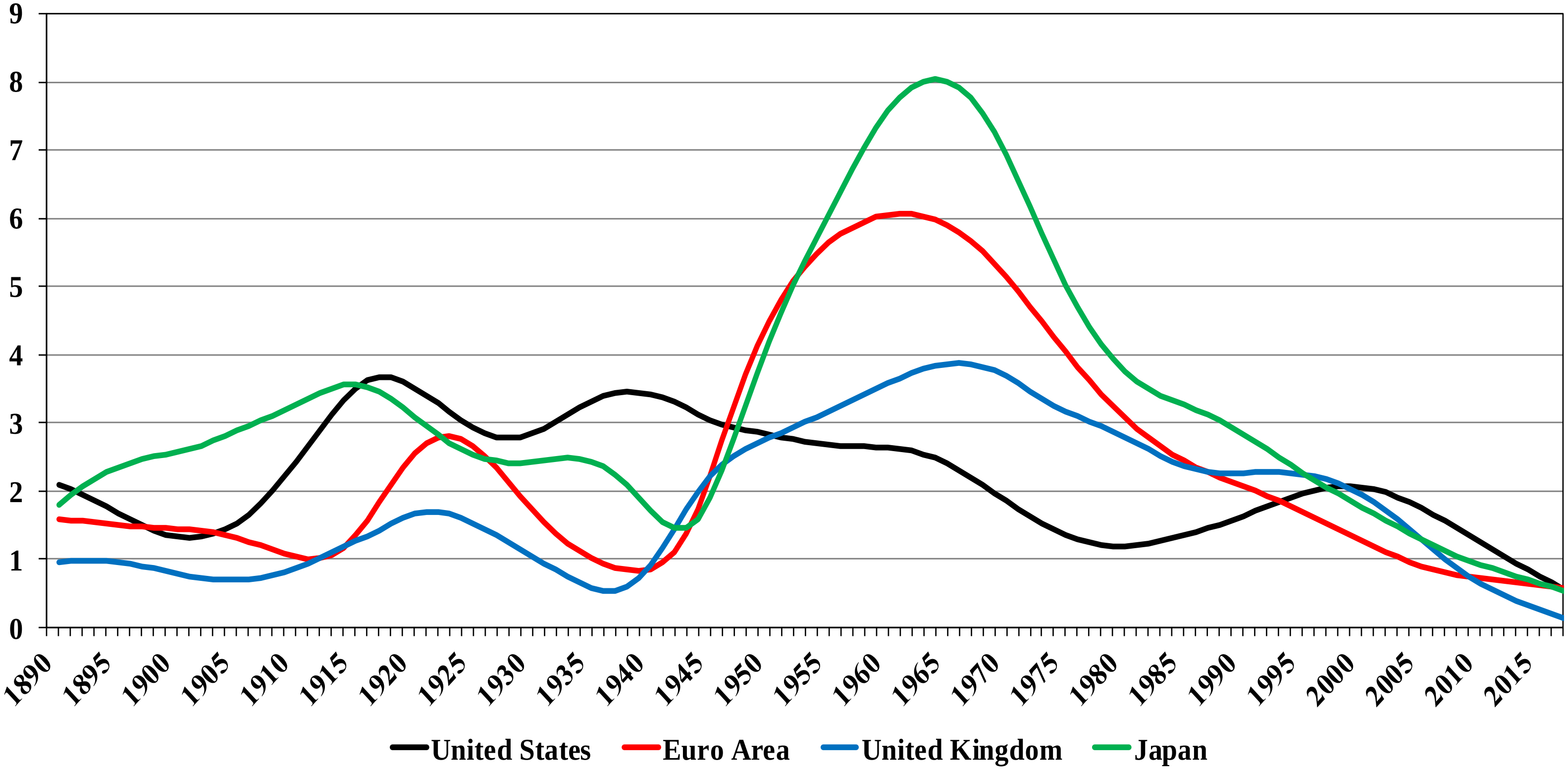
Contents

1. Introduction

Average annual growth rate of labor productivity per hour

Smoothed indicator (HP filter, λ = 500) **- Whole economy – 1891-2018 – In %**

Source: Bergeaud, Cette and Lecat (2016) - See: www.longtermproductivity.com



- Productivity slowdown over recent decades
- Productivity growth rates now at the lowest in 150 years (outside WW periods)
- Where are productivity gains from digitalization? Risk of *Secular Stagnation*?

1. Introduction

Growth accounting decomposition – United States

Source: Cette, Devillard and Spieza (2020, Forthcoming)

GDP growth (in %) and contributions (in pp)	Period 1	Period 2	Period 3	Period 4	Period 5
United States	1960 1975	1975 1995	1995 2005	2005 2019	1960 2019
GDP (1)	3,66	3,16	3,39	1,76	2,99
Hours (2)	1,38	1,88	1,01	0,71	1,33
Productivity (3) = (1)-(2)	2,28	1,29	2,38	1,05	1,67
Capital deepening (4)	0,67	0,25	0,58	0,40	0,45
ICT capital total (5) = (6)+(7)+(8)	0,11	0,27	0,43	0,20	0,24
Hardware (6)	0,06	0,15	0,21	0,05	0,11
Software and databases (7)	0,03	0,09	0,14	0,11	0,09
Telecommunication eqpt (8)	0,03	0,04	0,07	0,04	0,04
Robots (9)	0,00	0,01	0,03	0,03	0,02
Non ICT capital and non robots capital (10) = (4)-(5)-(9)	0,55	-0,03	0,13	0,16	0,19
TFP (11) = (3)-(4)	1,61	1,03	1,79	0,65	1,22
Education (12)	0,45	0,27	0,20	0,17	0,28
Robotisation (13)	0,01	0,03	0,08	0,10	0,05
Residual (14) = (11)-(12)-(13)	1,15	0,73	1,51	0,38	0,89

- Decrease of ICT contribution, slight increase of robot contribution
- Large decrease of residual *TFP* contribution
- Where are productivity gains from digitalization? Risk of *Secular Stagnation*?

1. Introduction

Growth accounting decomposition – Euro Area

Source: Cette, Devillard and Spieza (2020, Forthcoming)

GDP growth (in %) and contributions (in pp)	Period 1	Period 2	Period 3	Period 4	Period 5
ZONE EURO 2	1960 1975	1975 1995	1995 2005	2005 2019	1960 2019
GDP (1)	4,60	2,44	2,12	1,09	2,61
Hours (2)	-0,71	-0,22	0,93	0,37	-0,01
Productivity (3) = (1)-(2)	5,31	2,66	1,19	0,72	2,63
Capital deepening (4)	2,03	0,97	0,43	0,42	1,02
ICT capital total (5) = (6)+(7)+(8)	0,17	0,23	0,24	0,14	0,19
Hardware (6)	0,11	0,12	0,11	0,03	0,09
Software and databases (7)	0,03	0,09	0,10	0,09	0,08
Telecommunication eqpt (8)	0,03	0,02	0,03	0,02	0,03
Robots (9)	0,00	0,03	0,08	0,05	0,04
Non ICT capital and non robots capital (10) = (4)-(5)-(9)	1,86	0,71	0,11	0,24	0,79
TFP (11) = (3)-(4)	3,28	1,69	0,77	0,30	1,61
Education (12)	0,59	0,38	0,21	0,31	0,39
Robotisation (13)	0,01	0,08	0,24	0,15	0,12
Residual (14) = (11)-(12)-(13)	2,68	1,23	0,32	-0,16	1,10

- Decrease of ICT contribution and of robot contribution
- Large decrease of residual *TFP* contribution
- Where are productivity gains from digitalization? Risk of *Secular Stagnation*?

1. Introduction: motivation and context

- In recent decades, **simultaneously global productivity slowdown** and **firm level analyses indicate large impact from ICT and digitalization on productivity** level/growth
  For instance among others: Andrews *et al.* (2018), Gal *et al.* (2019a and 2019b)

  Same for modelized approaches, mainly through DSGE models
  For instance among others: Etro (2009), DeStefano *et al.* (2019), Tamegawa *et al.* (2014 and 2015), …
- **Puzzling**
  It reminds us of the 1987 Solow paradox: "*You can see the computer age everywhere, but in the productivity statistics*"
- Higher consensus concerning the **impact of robotization and digitalization on labor share**
- Previous analyses find **negative impact on *LS*** through different types of mechanisms
  For instance among others: Dinlersoz and Wolf (2018), Acemoglu and Restrepo (2018), Aghion *et al.* (2019), Acemoglu et al, (2020)

1. Introduction: aim of the paper

- **Analyses the impact of the employment of ICT specialists** (in-house and external) **and the use of digital technologies** (cloud and big data) **on productivity and labor share**
- **Uses a firm level dataset of French firms**
  - 1065 firms with at least 20 employees in the manufacturing sector in 2018
  - From two BdF datasets: survey on factor utilization (FUD) and firm level annual financial statements (FIBEN)
- **Estimates relations** explaining Labor Productivity (*LP*), Total Factor Productivity (*TFP*), Labor Share (*LS*) by the use of ICT specialists or digital technologies
- **OLS and IV methods**
  - Instruments for the IV method: **Bartik (1991) method**
  - Leave-one-out mean at the industry level
- **Between-firm approach**

1. Introduction: main findings

- **Empirical results:**
  - **Use of ICT specialists** (through internal or external employment) **and use of digital technologies** (cloud and big data)
    Improves *LP* and *TFP* by about 17 to 23%
    Decreases *LS* by about 2.5 pp
  - **Means very large impact of ICTs and digitalization** on productivity and labor share
  - **Confirmation of previous literature results**
    With an original approach: between firm estimates
    With an original dataset on French firms

2. Data: two firm-level dataset

- **FIBEN:** Accounting data from fiscal documents
  - All French firms with annual turnover > €750,000 or with outstanding credit > €380,000
  - About 200,000 firms
  - Information on size, age, industry, … of the firm
  - **Allow us to calculate *LP*, *TFP* and *LS* at the firm level**

- **FUD:** Survey on Factor Utilisation Degrees
  - Manufacturing industries
  - Plants with more than 20 employees
  - Information on Capital Utilization Rate (CUR), Shiftwork, …
  - **Specific questions in 2018 on the use of Internet, ICTs and Digitalization**
    - *“For how many years have you been using an internet connection?*
    - *“Do you employ in-house ICT specialists? If yes, for how many years?”*
    - *“Do you employ external ICT specialists? If yes, for how many years?”*
    - *“Have you ever used cloud computing services? If yes, for how many years?”*
    - *“Have you ever analyzed big data? If yes, for how many years?”*
  - →1,349 complete answers to these questions

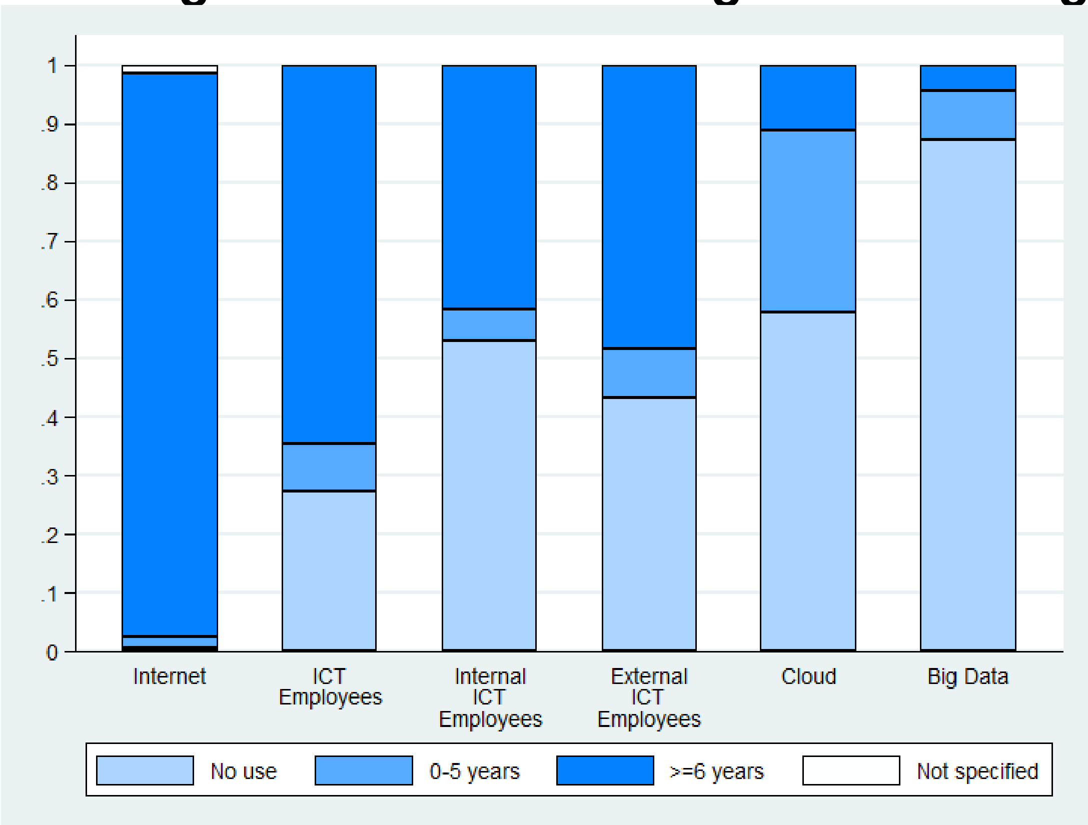
2. Data: final sample

- **Final dataset used for estimates**
  - Merger and cleaning of these two datasets (FIBEN and FUD)
  - 1,065 French firms / obs
  - More than 20 employees
  - Manufacturing industries
  - 2018

- **Rich information at the firm-level**
  - Productivity: Labor productivity (LS) and Total factor productivity (TFP)
  - Labor share (LS)
  - Employment of inhouse and external ICT specialists
  - Use of cloud and use of big data
  - Age, Size, Industry, Use of shiftwork, Capital utilization rate

2. Data: descriptive statistics

- **Average use of ICTs and digital technologies**



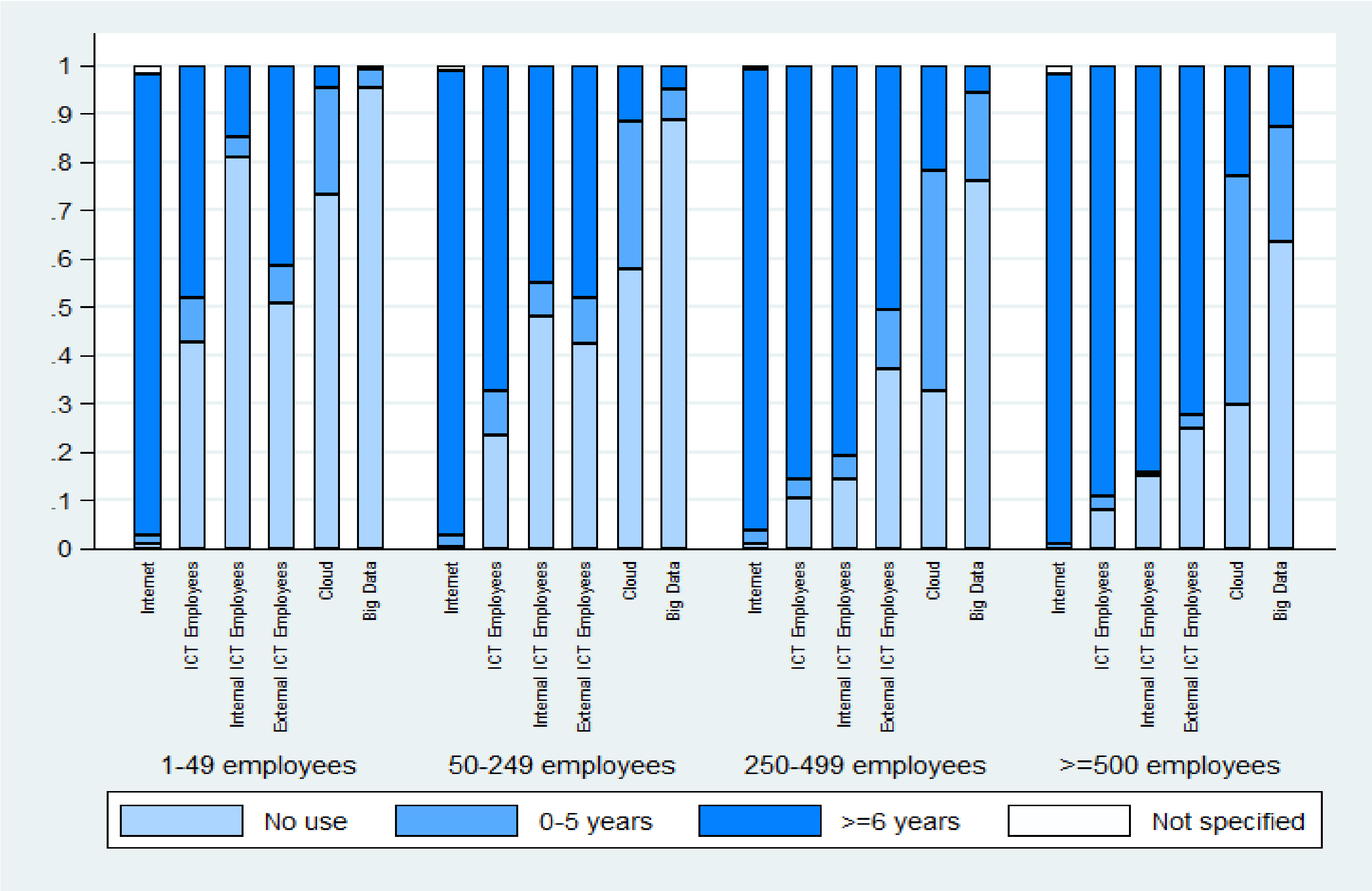
Sources: FIBEN and FUD survey (Banque de France)

- **Consistent with results from Eurostat ICT survey**

2. Data: descriptive statistics

- **These uses vary across size and sector**

  The use increases with the firm size



Sources: FIBEN and FUD survey (Banque de France)

2. Data: multiple correspondence analysis

- **A multiple correspondence analysis:**
  - **Over the four ICT and digital basic variables** (0 or 1 for each)**:** ICT employment internal or external, Cloud, Big Data
  - ***Comp1*:** First principal component
    Explains 43% of the overall variation in the use of ICTs and Digital technologies
  - ***Comp2*:** Second principal component
    Explains 22% of the overall variation in the use of ICTs and Digital technologies
  - → We use only *Comp1* in estimates

3. Estimated model and identification

- **Estimated model**

  $$Y_i = \beta_1 . DIG_i + \beta_2 . CUR_i + \beta_3 . Shiftwork_i + \beta_4 + \delta_{S_i} + \delta_{A_i} + \delta_{I_i} + \varepsilon_i$$

  - *i* : Index of the firm
  - Y: Log of the variable of interest, LP, TFP or LS
  - *DIG*: ICT or digital variable
    - *Comp1*, continuous
    - *Int. ICT*, *Ext. ICT*, *Cloud* or *Big Data*, originally 0 or 1
    - For some estimates, we distinguish <= 5 years and > 5 years
  - *CUR*: Continuous variable
  - *Shiftwork*: 0 or 1
  - δ_{Si}: Size fixed effects
    - 4 size categories: 20 to 49 employees, 50 to 249 employees, 250 to 499 employees, 500 employees or more
  - δ_{Ai}: Age fixed effects
    - 5 age categories: 20 years or less, 21 to 35 years, 36 to 50 years, 51 to 70 years, 71 years and above
  - δ_{Ii}: Industry fixed effects
    - 11 categories of manufacturing industries

3. Estimated model and identification

- **Estimated model**

$$Y_i = \beta_1.DIG_i + \beta_2.CUR_i + \beta_3.Shiftwork_i + \beta_4 + \delta_{S_i} + \delta_{A_i} + \delta_{I_i} + \varepsilon_i$$

- β_1: Expected >0 for *LP* and *TFP* and <0 for *LS* (see literature previouly mentioned)
- β_2: Expected >0 for *LP* and *TFP* and <0 for *LS* (see Cette *et al.* 2016a and 2016b)
- β_3: Expected >0 for *LP* and *LS* as *Shiftwork* more frequent when capital to labor ratio is high, <0 for *TFP* as working time is shorter when *Shiftwork* is used (see Anxo *et al. eds.* 1995)
- β_2 and β_3: Significant estimated values, expected estimated sign, not reported below
- β_4: not reported either

3. Estimated model and identification

- **Potential endogeneity issues**
  - Reverse causality: firms with higher productivity are more likely to adopt digital technologies
  - Omitted variable bias: many other firm and industry characteritsics are likely to influence firm productivity

- **Identification**
  - OLS and IV estimates
    We report below only IV estimates
  - For IV estimates, instruments inspired by Bartik (1991)
    Instruments: leave-one-out mean in the sector
  - Include a large set of controls in the estimates

4. Results: Impact on productivity

➢ Impact on productivity

Table1: Impact on *LP* and *TFP* (in log) of Comp1

	(1)	(2)
Explained Var.	Log(LP)	Log(TFP)
Comp1	0.00823***	0.00546***
	(0.00166)	(0.00138)

Table 2, Impact on *LP* (in log) of ICT and Digital variables

	(1)	(2)	(3)	(4)	(5)
Int. ICT	0.157***				0.132***
	(0.0213)				(0.0225)
Ext. ICT		0.0464***			0.0216
		(0.0177)			(0.0197)
Cloud			0.0678***		0.0239
			(0.0167)		(0.0152)
Big data				0.141***	0.104***
				(0.0346)	(0.0339)

Table 3: Impact on *TFP* (in log) of ICT and Digital variables

	(1)	(2)	(3)	(4)	(5)
Int. ICT	0.102***				0.0797***
	(0.0244)				(0.0262)
Ext. ICT		0.0483***			0.0309*
		(0.0166)			(0.0184)
Cloud			0.0606**		0.0314
			(0.0246)		(0.0242)
Big data				0.0894***	0.0617***
				(0.0241)	(0.0231)

○ **Significant positive impact of *Comp1* synthetic index on productivity, on both *LP* and *TFP***
An increase by 1 SD of *Comp1* would increase *LP* and *TFP* by 5.9% and 3.9% respectively

○ **High impact of ICT and digital technologies on *LP***
The employment of ICT specialists and the use of digital technologies could improve *LP* by about 23%

○ **High impact of ICT and digital technologies on *TFP***
The employment of ICT specialists and the use of digital technologies could improve *TFP* by about 17%

Robust standard errors clustered at the sector level (11 categories of industries) are reported between parentheses
The *t* statistics are reported as follows:
* p<0.10, ** p<0.05, *** p<0.01.

4. Results: Impact on productivity

➢ Learning by doing effect (LDE) or Second-mover advantage (SMA)

Table 4: Impact on *LP* (in log)

	(1)	(2)	(3)	(4)	(5)
Int. ICT ≤ 5	0.140***				0.139***
	(0.0379)				(0.0361)
Int. ICT > 5	0.160***				0.126***
	(0.0237)				(0.0259)
Ext. ICT ≤ 5		-0.0428			-0.0491
		(0.0414)			(0.0350)
Ext. ICT > 5		0.0654***			0.0370*
		(0.0162)			(0.0194)
Cloud ≤ 5			0.0548***		0.0172
			(0.0191)		(0.0175)
Cloud > 5			0.104***		0.0455*
			(0.0243)		(0.0245)
Big data ≤ 5				0.154***	0.117***
				(0.0459)	(0.0454)
Big data > 5				0.118***	0.0644
				(0.0337)	(0.0395)

○ **Concerning *LP***,
- ICT:
  Nothing clear for *INT. ICT* and
  Clear LDE for the use of *Ext. ICT*
- Digital:
  Clear LDE for the use of *Cloud* and clear SMA for the use of *Big Data*

Table 5: Impact on *TFP* (in log)

	(1)	(2)	(3)	(4)	(5)
Int. ICT ≤ 5	0.124***				0.118***
	(0.0318)				(0.0301)
Int. ICT > 5	0.0972***				0.0698*
	(0.0316)				(0.0358)
Ext. ICT ≤ 5		0.00227			-0.00847
		(0.0323)			(0.0270)
Ext. ICT > 5		0.0581***			0.0394**
		(0.0179)			(0.0187)
Cloud ≤ 5			0.0495*		0.0205
			(0.0274)		(0.0268)
Cloud > 5			0.0920***		0.0609**
			(0.0241)		(0.0296)
Big data ≤ 5				0.120***	0.0933**
				(0.0382)	(0.0386)
Big data > 5				0.0336	-0.00785
				(0.0243)	(0.0251)

○ **Concerning *TFP***,
- ICT:
  Clear SMA for the use of *Int. ICT* and
  As for *LP*, **clear LDE for the use of *Ext. ICT***
- Digital:
  As for *LP*, **clear LDE for the use of *Cloud* and clear SMA for the use of *Big data***

Robust standard errors clustered at the sector level (11 categories of industries) are reported between parentheses
The *t* statistics are reported as follows:
* p<0.10, ** p<0.05, *** p<0.01.

5. Results: Impact on labor share

Table 6: Impact of *Comp1*

Comp1	-0.00147*** (0.000542)

- **Significant negative impact of *Comp1* synthetic index on LS**
  An increase by 1 SD of *Comp1* would decrease *LS* by 1.1pp

Table 7: Impact of ICT and Digital variables

	(1)	(2)	(3)	(4)	(5)
Int. ICT	-0.0315*** (0.0100)				-0.0292** (0.0118)
Ext. ICT		-0.00719 (0.00877)			-0.00351 (0.00964)
Cloud			-0.00227 (0.00744)		0.00742 (0.00733)
Big data				-0.0299*** (0.0116)	-0.0248** (0.0125)

- **High impact of ICT, through *Int.I CT*, and digital technologies through *Big data*, on *LS***
  The use of in house ICT specialists and the use of big data would decrease the *LS* by 2.9pp and 2.5pp respectively

Robust standard errors clustered at the sector level
(11 categories of industries) are reported between parentheses
The *t* statistics are reported as follows:
* p<0.10, ** p<0.05, *** p<0.01.

6. Conclusion

- **Method**
  - Use of an original dataset of 1,065 French firms for the year 2018
  - Data on the use of ICT specialists (in house or external) and digital technologies (Cloud and Big data)
  - Identification through IV approach, instruments inspired by Bartik (1991) Instruments: leave-one-out mean in the sector

6. Conclusion

- **Results**
  - **Productivity**
    - Large positive impact of ICT specialists (in house or external) and digital technologies (*Cloud* and *Big data*) on productivity, on both *LP* and *TFP*
    - Use of ICT specialists and digital technologies could improve productivity level by 23% for *LP* and 17% for *TFP*
    - Learning by doing mechanisms for the use of *Ext.ICT* and the use of *Cloud*
    - Second mover advantage for the use of *Big data*
  - **Labor share**
    - Large negative impact of *Int.ICT* and *Big data* on the *LS*
    - Use of *Int.ICT* and *Big data* could decrease *LS* by 2.9pp and 2.5pp respectively

6. Conclusion

- **Results**
  - **Productivity**
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    - Second mover advantage for the use of *Big data*
  - **Labor share**
    - Large negative impact of *Int.ICT* and *Big data* on the *LS*
    - Use of *Int.ICT* and *Big data* could decrease *LS* by 2.9pp and 2.5pp respectively

- **Consistent with the literature highlighting the role of TIC and digital**
  - Provide new evidence on impact of TIC and digital at the firm-level, positive for productivity *(LP* and *TFP*), negative for *LS*
  - Using French firms of more than 20 employees in the manufacturing industry
  - Such orders of magnitude need to be confirmed by other firm-level studies

6. Conclusion

- **How to reconcile these results with the observed global productivity slowdown?**
  - Large impact on productivity level
  - Need of other continuous Digital innovations to benefit from a large impact on growth rate over a long period

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- **How to reconcile these results with the observed global productivity slowdown?**
  - Large impact on productivity level
  - Need of other continuous Digital innovations to benefit from a large impact on growth rate over a long period

- **Where are we in Digital revolution?**
  - As Van Ark (2016) said, the current pause in the productivity gains from the Third Industrial Revolution could in fact be a period of transition between the creation and installation of new technologies and their full deployment
  - Same as with previous technological revolutions, see David (1990): 50 to 60 years passed between the invention of a working electric dynamo in 1868 and its full exploitation in production
  - Need time and will require major changes to our institutions and to our methods of production and of management
  - Need of common explanations of the general productivity slowdown For instance, circular relation between real interest rates and productivity gains (see Aghion *et al.*, 2019, Bergeaud *et al*., 2020)

6. Conclusion

- **Risks and positive prospects**
  - **Need of a global productivity revival** to finance the sustainability of the economic organization, the social system and possibly the institutions of developed countries
  - The **context of the COVID-19 threat** has boosted the use of digital technologies by firms and households
  - Starting point for an acceleration of ICT and digital diffusion?
  - This is one possible positive impact of the pandemic event: **to open the door more widely to the third industrial revolution**