

# Work from home and Firms' Resilience: Evidence from the COVID-19 pandemic

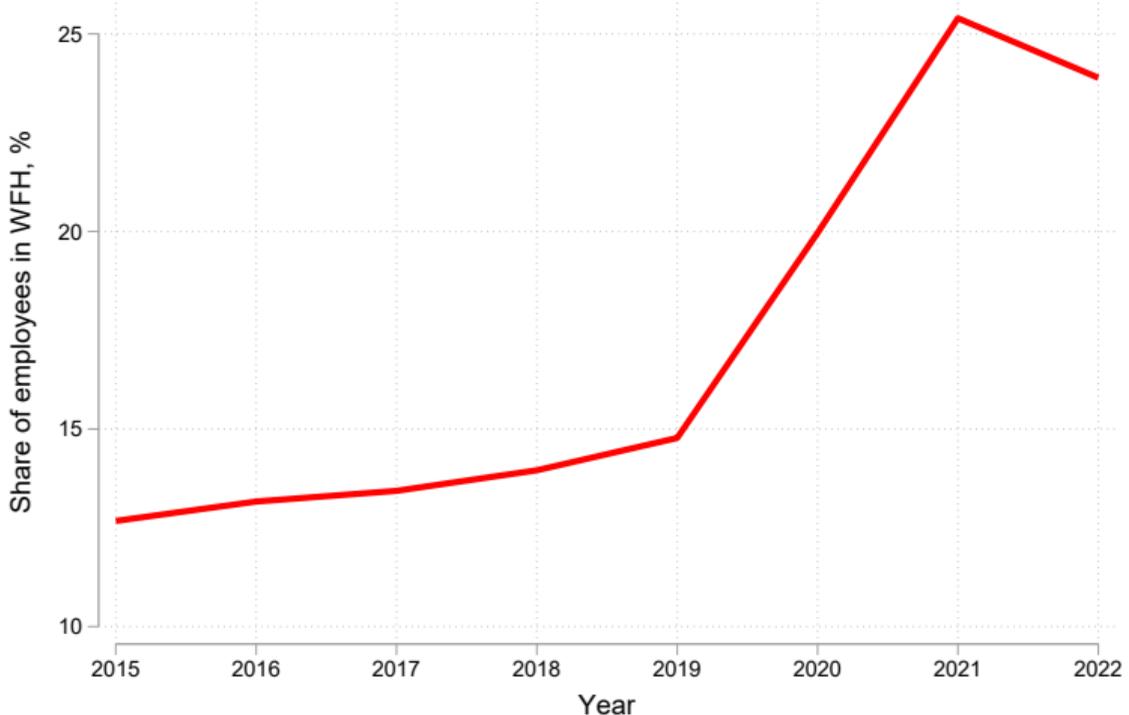
Filippo Boeri, Riccardo Crescenzi and **Davide Rigo**

EEA-ESEM Congress, Rotterdam, 26 August 2024

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# Large shift in WFH during the pandemic Martino, Crescenzi & Rigo (2024)



Share of employees in WFH, EU27, 2015-2022

## Existing Literature

Growing body of literature on the impact of remote work on firms:

- **Ambiguous effects** on firms and workers productivity

[ + ] RCTs Bloom et al. (2015); Choudhury et al. (2020); Angelici & Profeta (2023); Choudhury et al. (2024)

[ - ] Case studies during the pandemic Yang et al. (2021); Emanuel & Harrington (2022); Gibbs, Mengel & Siemroth (2023)

- Focus on a specific **large firm** and **context!**

⇒ Lack of causal evidence on the impact of WFH on a **large scale**

- Lack of comprehensive data on remote work
- Affected by **unobservables** (e.g. managerial capabilities)

## Motivations

- Small and medium-sized enterprises (**SMEs**) represent more than half of the aggregate employment and gross output in most modern economies [Kalemli-Ozcan et al. \(2024\)](#)
- Digital technologies adoption is **heterogeneous** across firms [Bloom, Sadun & Van Reenen \(2012\)](#)
  - Better-managed and larger firms can take advantage of new technologies because equipped with complementary [organisational capital](#) and [other knowledge-based assets](#)
  - Given the unanticipated nature of the pandemic shock, these heterogeneous responses are likely to be even more pronounced

## What we do

- Use unexplored administrative data on the **universe** of employees working from home for **Italy**
- Compare firm-level outcomes before and after the COVID-19 pandemic, and between firms adopting or not WFH
- Leverage the local availability of fibre internet connection to **instrument** for remote work adoption
- **Research question**: what are the heterogeneous effects of the pandemic-induced shift to WFH on firms?

### WFH – Italian Ministry of Labour and Social Policies

- [Universe of employees](#) fully or partially working from home
- Legal duty and [monetary incentive](#) to declare
- Due to COVID-19 the procedure was simplified ⇒ fill an [online form](#)

▶ [Summary stats](#)

## Additional Data Sources - Orbis Historical

### Orbis historical – Bureau van Dijk [▶ Coverage](#)

- Balance sheet information: number of employees, age, operating revenue, sales, total fixed assets
- Geographical information: latitude, longitude, address, postcode, city, NUTS-2, NUTS-3
- Data cleaning
  - Exclude single employee firm to maintain focus on an employment framework where firms offer designated office spaces for their staff
  - Focus on unconsolidated accounts
  - Exclude primary and public sector
  - Follow Kalemli-Ozcan et al. (2023) to clean for outliers

## Additional Data Sources

- **Broadband internet** – Italian Ministry of Enterprises and Made in Italy
  - Share of buildings with access to fibre technology
  - 2016-2021 at the census area level ( $\approx$  366k census areas) [▶ Example](#)
- **Ci Technology Database** – Aberdeen group (previously known as 'Harte Hanks')
  - Measures of firm-level ICT adoption from survey interviews, web-scraping and estimation
  - Number of laptops, number of servers, use of cloud computing
- **E-commerce** – BuiltWith
  - Scrape information from the near universe of websites from 2018 onwards
  - If a website has e-commerce tools (e.g. shopify) or online payment technologies
  - Lower bound since companies could sell through online marketplaces ( $<$  20% of online sales)

[▶ Summary stats](#)

## Empirical Strategy

$$\Delta \log(Y_i) = \alpha + \beta \Delta WFH_i + \gamma X_i + \delta_j + \delta_r + \varepsilon_i;$$

- $Y_i$  is a firm-level outcome variable  $\in \{ \text{sales, value added, TFP} \}$
- $\Delta$  indicates the difference between the year 2020 and 2019
- $WFH_i$  identifies whether a firm  $i$  used WFH in 2020
  - Extensive margin: when firm  $i$  has at least one employee in remote work
  - Intensive margin: firm  $i$ 's share of workers in WFH in total number of employees
- $X_i$  includes firm  $i$ 's number of employees, labour productivity and age in 2019
- $\delta_j$  and  $\delta_r$  accounts for travel-to-work-areas ( $> 500$ ) and 4-digit industry fixed effects
- Exclude firms using WFH before the pandemic (2.5k firms) and receiving fibre in 2020 (4.5k firms)

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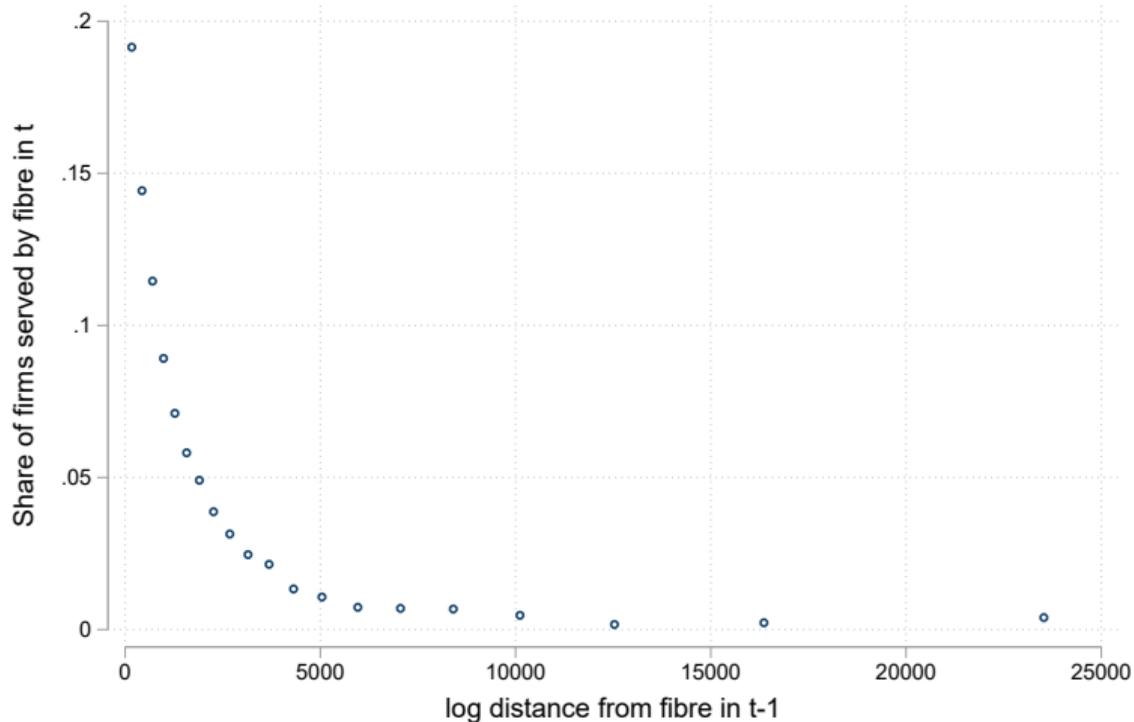
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## Local availability of fibre technology to instrument for WFH

- Exploit a **massive public investment** started by the Italian Government in 2015
- 'National Ultra-Broadband Plan' aimed at ensuring **100% coverage** of fibre technology by 2020
- Fibre roll-out was not fully completed [▶ Share fibre](#)
- Measure of **supply** rather than its actual consumption
- To minimise public spending  $\Rightarrow$  **adjacent territories**  $\Rightarrow$  driven by distance

## Fibre rollout is not driven by local economic conditions - Fact 1



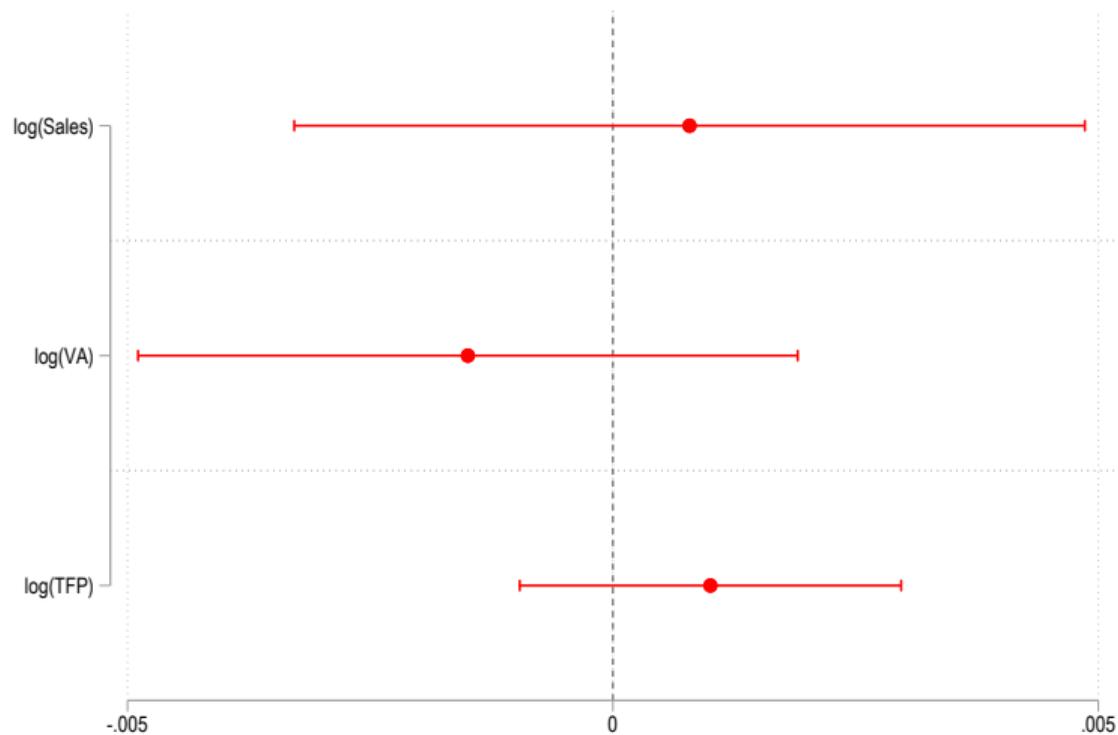
Probability of being served by fibre technology is  $\approx 0$  after 6 kms

## IV Relevance

- Fibre is more **suitable** than ADSL for remote working
  - Superior speed: fibre  $\geq 30$  Mbps vs ADSL  $\leq 7$  Mbps
  - Symmetrical upload and download capabilities
  - Speed not limited by the number of devices using bandwidth
  - Lower latency and more reliable
- ⇒ Crucial for **remote work tasks**: video conferencing, large file uploads, real-time applications
- Access to fibre technology strongly predicts WFH adoption

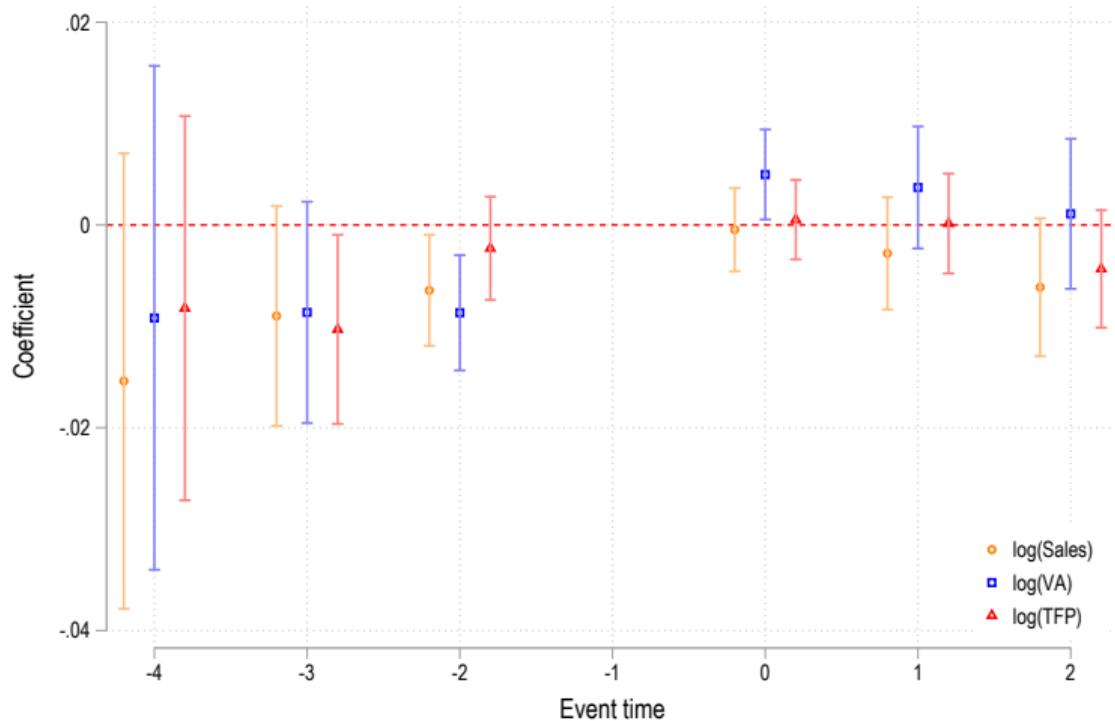
## IV Validity - Balancing

Are firms covered by fibre technology  $\neq$  in levels?



## IV Validity - Pre-trends

Are there **pre-trends** in fibre adoption?



## IV Validity - Other channels

Is fibre technology affecting firms **beyond** remote work?

	(1) WFH (dummy)	(2) $\Delta$ E-commerce	(3) $\Delta$ Online Payment	(4) $\Delta$ Laptops per Employee	(5) $\Delta$ Servers per Employee
Fibre	0.00507*** (0.000797)	0.000384 (0.000460)	-0.000748 (0.000498)	-0.000271 (0.000241)	-6.88e-05 (0.000186)
Observations	259,763	259,763	259,763	94,207	93,993
R-squared	0.237	0.011	0.008	0.026	0.047
Firm-level controls	✓	✓	✓	✓	✓
TTWA fixed effects	✓	✓	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓	✓	✓

## IV Results

	(1)	(2)	(3)
	$\Delta \log \text{Sales}$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
WFH (dummy)	-0.129** (0.0549)	-0.217*** (0.0713)	-0.225*** (0.0612)
Observations	259,763	259,763	259,763
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	40.6	40.6	40.6

## Robustness

- Intensity of WFH adoption ▶ Intensive WFH
- Compare firms within travel-to-work-area and type of area (rural, industrial, residential)  
▶ TTWA × Area
- Measure local availability of fibre technology as a buffer around the firm ▶ Buffer
- Reduced form results ▶ Reduced-form
- Cutting the data in different samples ▶ Manufacturing firms
- Exclude firms exiting the market in 2021 or 2022 ▶ Surviving firms
- Controlling for non-random exposure to fibre technology ▶ Map nodes ▶ Actual vs Expected fibre  
▶ Expected access to fibre

## Why firms chose WFH despite its disruptions?

- Some firms were **forced** by the governmental restrictions imposed to contain the spread of the virus
  - ▶ WFH trends
  - ▶ Forced vs unforced
  - ▶ Essential vs non-essential
- The transition to effective remote working is **complex**
  - ▶ High WFH potential and may **take time** to implement correctly
  - ▶ 2020-2022 period
- Given the sudden nature of the COVID-19 shock, **not** all firms were **prepared** for a shift to remote working, due to a lack of necessary ICTs, digital skills and organisational flexibility

	(1)	(2)	(3)
	$\Delta \log \text{ Sales}$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
WFH (dummy)	-0.148*** (0.0544)	-0.123** (0.0581)	-0.119** (0.0516)
WFH (dummy) $\times$ log(Laptops per employee)	0.0418** (0.0203)	0.0581** (0.0237)	0.0675*** (0.0215)
Observations	101,052	101,052	101,052
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	14.8	14.8	14.8

## Conclusions

- Focus on the sudden shift to remote work due to the pandemic
- Find (local) average **negative effects** on firms' performance and productivity
- Pre-pandemic **investments in ICTs** helped companies to take advantage of WFH
- The pandemic might have exacerbated existing disparities!

Thank You!

`d.rigo@lse.ac.uk`

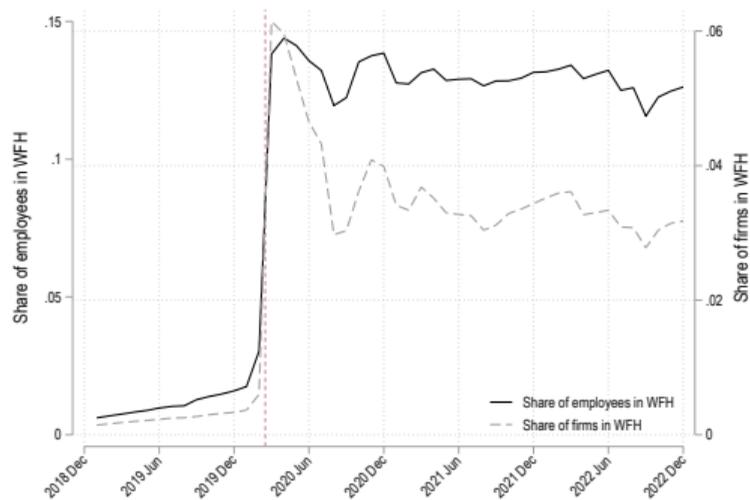
## Contribution to the literature

- **Firms' resilience** during the COVID-19 pandemic
  - WFH (+) Bai et al. (2021); Panikolaou & Schmidt (2022)
  - Managerial practices (+) Lamorgese, Schivardi et al. (2021)
  - Technological sophistication (+) Comin et al. (2022)
  - Digital capabilities (+) Cariolle & Leon (2022); Pierri & Timmer (2023); Oikonomou, Pierri, & Timmer (2023)
  - Digital infrastructure (+) Doerr et al. (2021)
- **Impact of remote work** on workers and productivity
  - (+) Bloom et al. (2015); Choudhury et al. (2021); Choudhury et al. (2022); Angelici & Profeta (2023)
  - (–) Emanuel & Harrington (2021); Gibbs et al. (2023); Atkin et al. (2023)
- **Impact of broadband internet** on firms
  - Asymmetric Digital Subscriber Line (ADSL) Size and productivity Canzian et al. (2019); De Stefano et al. (2014); De Stefano et al. (2018); trade Kneller & Timmis (2016); Malgouyres et al. (2021)
  - Fibre technology De Stefano et al. (2020)

## Institutional Setting

Italy offers an interesting institutional setting

- First advanced economy to be severely affected by the COVID-19 pandemic
- The Italian government immediately imposed a national lockdown in early March 2020 and a second lockdown in October 2020
- Italy had one of the largest fractions of workers switching to WFH in the EU  
[Eurofound \(2020\)](#)



Share of employees and firms in WFH, 2019-2022  
[Crescenzi, Giua & Rigo \(2024\)](#)

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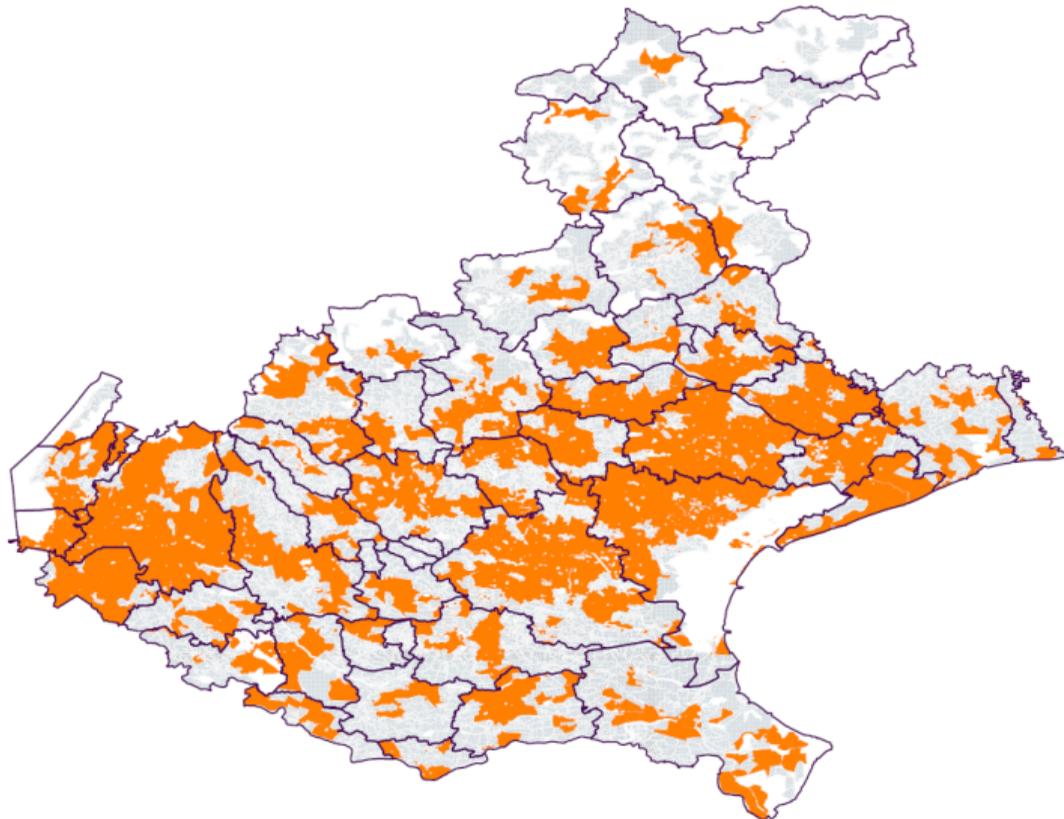
## OLS Results

	(1)	(2)	(3)
	$\Delta \log \text{Sales}$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
WFH (dummy)	0.0189*** (0.00108)	0.0297*** (0.00144)	0.0178*** (0.00146)
Observations	259,763	259,763	259,763
R-squared	0.204	0.156	0.144
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓

## Fibre rollout is not driven by local economic conditions - Fact 2

	(1)	(2)	(3)
	Fiber adoption	Fiber adoption	Fiber adoption
	New infrastructure in t	New infrastructure in t	New infrastructure in t
log distance from infrastructure (t-1)	-0.0507*** (0.00558)	-0.0473*** (0.00369)	-0.0462*** (0.00308)
$\Delta \log$ employment (t-4 - t-1)	-0.00163 (0.00148)	-0.00167 (0.00145)	-0.00148 (0.00152)
$\Delta \log$ avg. wage (t-4 - t-1)	0.000758 (0.00144)	0.000956 (0.00119)	0.00107 (0.00115)
$\Delta \log$ large firms share (t-4 - t-1)	0.00138 (0.00101)	0.000865 (0.000975)	0.00184* (0.00111)
Observations	100,094	100,094	100,094
R-squared	0.058	0.094	0.144
FE	NO	Province	TTWA

## IV identification strategy

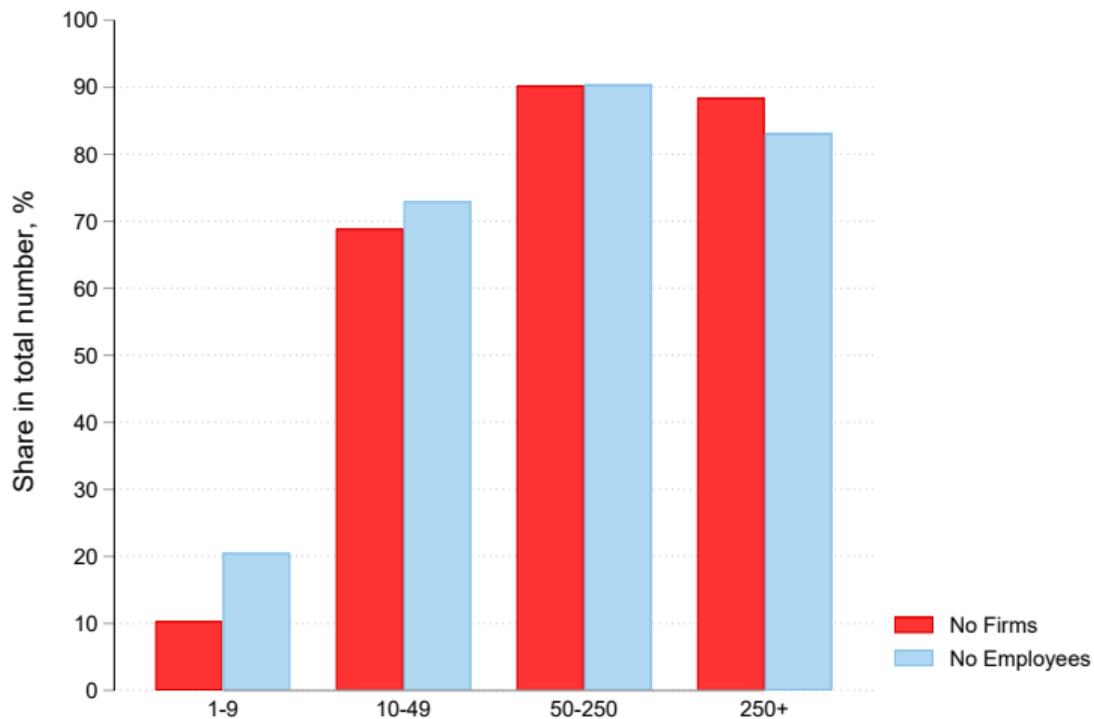


## Summary statistics on WFH, 1-digit NACE industries

Ateco 1-digit	Description	Sh firms in total	Sh firms in WFH	Sh Employees in total	Sh Employees in WFH
C	Manufacturing	0.26	0.18	0.37	0.13
D	Electricity, gas, steam & air conditioning supply	0.00	0.36	0.00	0.48
E	Water supply; sewerage, waste management	0.01	0.18	0.02	0.12
F	Construction	0.13	0.06	0.08	0.05
G	Wholesale & retail	0.25	0.10	0.18	0.10
H	Transportation & storage	0.05	0.11	0.09	0.10
I	Accommodation & food service activities	0.10	0.02	0.07	0.01
J	Information & communication	0.05	0.41	0.04	0.61
K	Financial & insurance	0.01	0.33	0.01	0.46
L	Real estate activities	0.02	0.15	0.01	0.15
M	Professional, scientific & technical activities	0.06	0.37	0.04	0.42
N	Administrative & support service activities	0.05	0.17	0.09	0.15

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## Share of firms and employees from Orbis in aggregate statistics



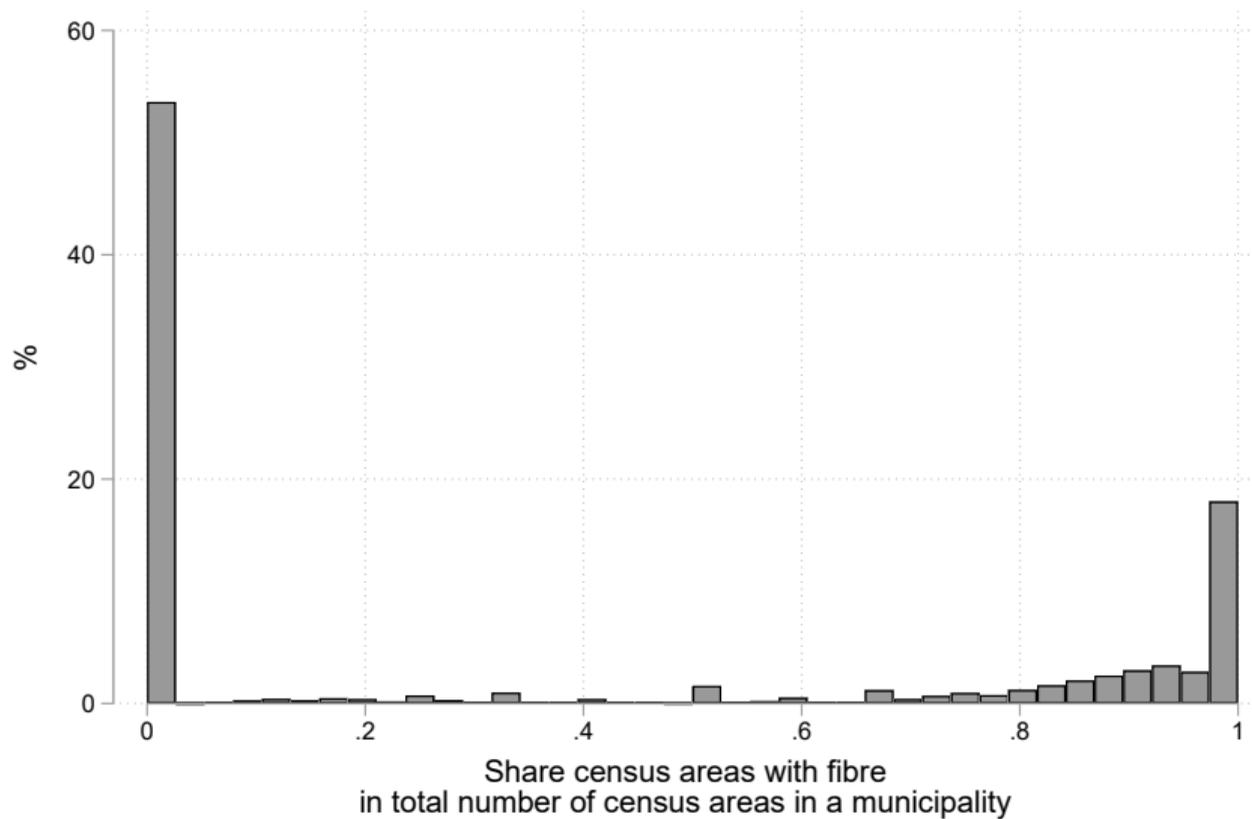
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## Summary statistics

Variables	Mean	St. Dev.	Median	Min	10pct	90pct	Max	Obs
<b>Firm Variables</b>								
$\Delta$ Sales	-0.14	0.45	-0.1	-1.64	-0.63	0.26	2.13	311041
No. Employees	19	106	7	2	2	32	15684	311041
Age	17	14	13	0	2	37	119	311041
<b>WFH Variables</b>								
WFH(dummy)	0.15	0.36	0	0	0	1	1	311041
WFH(share)	0.08	0.23	0	0	0	0.25	1	311041
<b>ICT Variables</b>								
No Laptops	3	16	1	0	1	5	3567	109071
No Servers	1	18	0	0	0	2	4466	109071
Cloud (dummy)	0.83	0.37	1	0	0	1	1	60864
<b>E-commerce Variables</b>								
E-commerce (dummy)	0.12	0.32	0	0	0	1	1	311041
Online Payment (dummy)	0.21	0.41	0	0	0	1	1	311041

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## Share Fibre Within Italian Municipalities



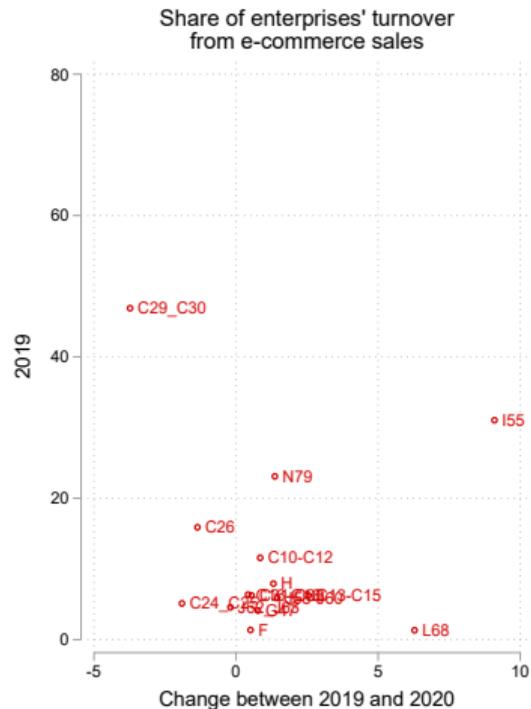
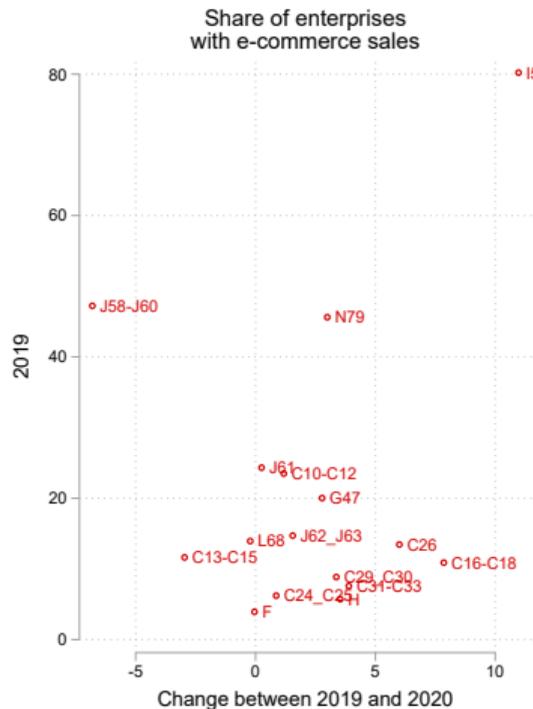
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## Share of firms with access to fibre, 2019

	All	Micro	Small	Medium	Large
<b>All</b>	0.86	0.86	0.83	0.83	0.88
<b>Region (1-digit)</b>					
South	0.85	0.85	0.84	0.84	0.87
Center	0.87	0.87	0.84	0.84	0.89
North	0.86	0.86	0.82	0.82	0.89
<b>Industry (1-digit)</b>					
Manufacturing	0.78	0.79	0.76	0.74	0.82
Energy	0.82	0.79	0.81	0.87	0.83
Construction	0.83	0.82	0.81	0.83	0.87
Non-financial services	0.89	0.89	0.89	0.89	0.89
<b>Type of location</b>					
Residential area	0.90	0.92	0.88	0.90	0.88
Mountain area	0.66	0.73	0.64	0.65	0.66
Industrial area	0.79	0.81	0.76	0.81	0.78
Rural area	0.64	0.67	0.63	0.64	0.63

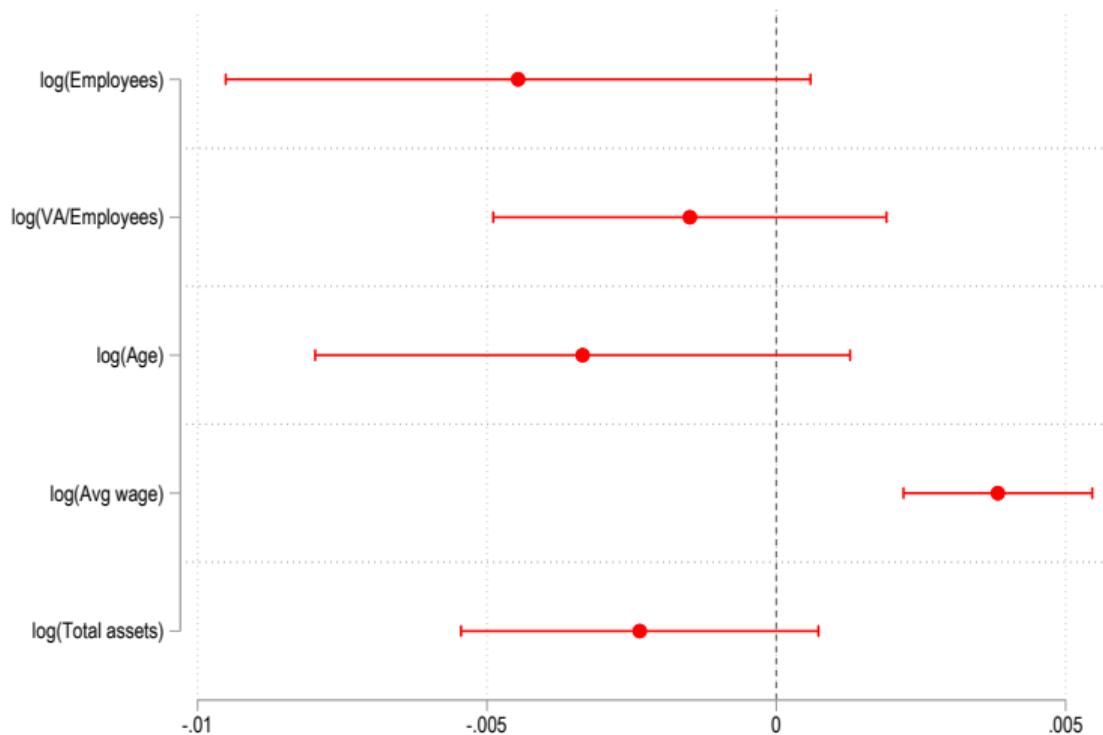
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# E-commerce Adoption in Italy



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## Balancing other firm-level outcomes



## Intensive margin of WFH adoption

	(1)	(2)	(3)
	$\Delta \log \text{Sales}$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
WFH (share)	-0.111** (0.0452)	-0.186*** (0.0576)	-0.193*** (0.0496)
Observations	259,763	259,763	259,763
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	78	78	78

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## Exclude firms exiting in 2021 or 2022

VARIABLES	(1) $\Delta \log \text{Sales}$	(2) $\Delta \log(\text{VA})$	(3) $\Delta \log(\text{TFP})$
WFH (dummy)	-0.123** (0.0533)	-0.177*** (0.0671)	-0.177*** (0.0583)
Observations	234,265	234,265	234,265
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	37.6	37.6	37.6

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## Manufacturing firms

	(1)	(2)	(3)
	$\Delta \log \text{Sales}$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
WFH (share)	-0.0922 (0.0580)	-0.224** (0.0896)	-0.173** (0.0725)
Observations	77,457	73,844	72,626
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	28	25.7	25.3

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## Reduced form results

	(1)	(2)	(3)
	$\Delta \log(\text{Sales})$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
Fibre	-0.00213*** (0.000824)	-0.00290*** (0.000992)	-0.00286*** (0.000804)
Observations	286,751	274,245	266,760
R-squared	0.223	0.154	0.142
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓

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## TTWA $\times$ Area (Residential, Rural or Industrial)

	(1)	(2)	(3)
	$\Delta \log \text{ Sales}$	$\Delta \log(\text{VA})$	$\Delta \log(\text{TFP})$
WFH (dummy)	-0.115** (0.0552)	-0.183*** (0.0694)	-0.198*** (0.0598)
Observations	259,638	259,638	259,638
Firm-level controls	✓	✓	✓
TTWA $\times$ Area fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	42.6	42.6	42.6

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## 15 km buffer around the firm

VARIABLES	(1) $\Delta \log \text{ Sales}$	(2) $\Delta \log(\text{VA})$	(3) $\Delta \log(\text{TFP})$
WFH (share)	-0.213** (0.0928)	-0.332*** (0.110)	-0.204** (0.0878)
Observations	259,763	259,763	259,763
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	15.6	15.6	15.6

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## Actual versus expected fibre

VARIABLES	(1) Fibre	(2) Fibre	(3) Fibre	(4) Fibre
Expected fibre	0.117*** (0.0245)	0.157*** (0.0186)	0.127*** (0.0264)	0.0257 (0.0399)
Observations	124,127	124,023	124,023	124,124
R-squared	0.014	0.064	0.108	0.243
NUTS-2 fixed effects	.	✓	.	.
NUTS-3 fixed-effects	.	.	✓	.
TTWA fixed effects	.	.	.	✓

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## Control for non-random exposure to fibre

VARIABLES	(1) $\Delta \log \text{Sales}$	(2) $\Delta \log(\text{VA})$	(3) $\Delta \log(\text{TFP})$
WFH (dummy)	-0.128** (0.0547)	-0.214*** (0.0710)	-0.223*** (0.0611)
Expected fibre	-0.00147 (0.00605)	-0.00672 (0.00794)	-0.00426 (0.00773)
Observations	259,763	259,763	259,763
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	40.4	40.4	40.4

## Essential versus Non-essential industries

VARIABLES	(1) Essential $\Delta \log \text{Sales}$	(2) Essential $\Delta \log(\text{VA})$	(3) Essential $\Delta \log(\text{TFP})$	(4) Non essential $\Delta \log \text{Sales}$	(5) Non essential $\Delta \log(\text{VA})$	(6) Non essential $\Delta \log(\text{TFP})$
WFH (dummy)	-0.0800** (0.0393)	-0.149** (0.0586)	-0.161*** (0.0503)	-0.368** (0.155)	-0.556*** (0.202)	-0.516*** (0.176)
Observations	113,693	113,693	113,693	146,083	146,083	146,083
Firm-level controls	✓	✓	✓	✓	✓	✓
TTWA fixed effects	✓	✓	✓	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓	✓	✓	✓
K-Papp F-stat	59.6	59.6	59.6	14.5	14.5	14.5

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## IV 2020-2022 results

VARIABLES	(1) 2020-2019 $\Delta \log(\text{TFP})$	(2) 2021-2019 $\Delta \log(\text{TFP})$	(3) 2022-2019 $\Delta \log(\text{TFP})$
Standardized values of treat	-0.214*** (0.0794)	-0.117* (0.0698)	-0.00707 (0.0733)
Observations	200,380	201,808	203,014
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	24.8	24.6	23.8

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## Forced versus unforced WFH adoption

VARIABLES	(1) Forced $\Delta \log \text{Sales}$	(2) Forced $\Delta \log(\text{VA})$	(3) Forced $\Delta \log(\text{TFP})$	(4) Unforced $\Delta \log \text{Sales}$	(5) Unforced $\Delta \log(\text{VA})$	(6) Unforced $\Delta \log(\text{TFP})$
WFH (dummy)	-0.335* (0.183)	-0.592** (0.245)	-0.622*** (0.218)	-0.182** (0.0832)	-0.300*** (0.106)	-0.338*** (0.0957)
Observations	237,835	237,835	237,835	241,176	241,176	241,176
Firm-level controls	✓	✓	✓	✓	✓	✓
TTWA fixed effects	✓	✓	✓	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓	✓	✓	✓
K-Papp F-stat	12.3	12.3	12.3	29.1	29.1	29.1

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## Firms with high WFH potential

VARIABLES	(1) $\Delta \log \text{ Sales}$	(2) $\Delta \log(\text{VA})$	(3) $\Delta \log(\text{TFP})$
WFH (dummy) $\times$ Low WFH potential	-0.173** (0.0759)	-0.294*** (0.104)	-0.299*** (0.0906)
WFH (dummy) $\times$ High WFH potential	-0.0373 (0.0293)	-0.0153 (0.0382)	-0.0421 (0.0341)
Observations	259,763	259,763	259,763
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	11.7	11.7	11.7

## Firms' size and WFH

	(1) $\Delta \log \text{ Sales}$	(2) $\Delta \log(\text{VA})$	(3) $\Delta \log(\text{TFP})$
WFH (dummy) $\times$ Employees 2-10	-0.466*** (0.170)	-0.819*** (0.216)	-0.707*** (0.187)
WFH (dummy) $\times$ Employees 11-25	-0.324** (0.149)	-0.497*** (0.186)	-0.606*** (0.166)
WFH (dummy) $\times$ Employees 26-50	-0.166 (0.119)	-0.275* (0.148)	-0.534*** (0.134)
WFH (dummy) $\times$ Employees 51-250	-0.0852 (0.101)	-0.187 (0.124)	-0.470*** (0.111)
Observations	259,763	259,763	259,763
Firm-level controls	✓	✓	✓
TTWA fixed effects	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓
K-Papp F-stat	11.9	11.9	11.9

## ICTs, size and WFH

	Employees < 10			Employees ≥ 10		
	Δ log Sales	Δ log(VA)	Δ log(TFP)	Δ log Sales	Δ log(VA)	Δ log(TFP)
WFH (dummy)	-0.538*	-0.269	-0.359	-0.340**	-0.364**	-0.343**
	(0.288)	(0.306)	(0.290)	(0.166)	(0.178)	(0.154)
WFH (dummy) × log(Laptops per employee)	-0.0508	-0.0531	0.00846	0.112***	0.0904**	0.0722**
	(0.0907)	(0.112)	(0.0939)	(0.0345)	(0.0403)	(0.0367)
Observations	32,030	32,030	32,030	69,215	69,215	69,215
Firm-level controls	✓	✓	✓	✓	✓	✓
TTWA fixed effects	✓	✓	✓	✓	✓	✓
4-digit industry fixed effects	✓	✓	✓	✓	✓	✓
K-Papp F-stat	11	11	11	8.7	8.7	8.7