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**Working Paper**

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GLO Discussion Paper, No. 719

**Provided in Cooperation with:**

Global Labor Organization (GLO)

*Suggested Citation:* Jerbashian, Vahagn; Vilalta-Bufi, Montserrat (2020) : The Impact of ICT on Working from Home: Evidence from EU Countries, GLO Discussion Paper, No. 719, Global Labor Organization (GLO), Essen

This Version is available at:

<https://hdl.handle.net/10419/226201>

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# The Impact of ICT on Working from Home: Evidence from EU Countries

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November 18, 2020

## Abstract

We use data from 14 European countries and provide evidence that the fall in prices of information and communication technologies (ICT) is associated with a significant increase in the share of employees who work from home. Similar results hold within age, gender, and occupation groups. There are notable differences across age groups, however. The effect of the fall in ICT prices on working from home increases with age. A rationale for such a result is that the preference for working from home increases with age.

**Keywords:** Working from Home; ICT; Age; Gender; Occupations

**JEL classification:** J23; J24; O33

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# 1 Introduction

Working from home has recently gained importance and prevalence because of the COVID-19 pandemic and lockdown policies (e.g., Brynjolfsson, Horton, Ozimek, Rock, Sharma, and TuYe, 2020, Eurofound, 2020). Many European countries are currently working towards easing regulations and promoting working from home. Meanwhile working from home has been on a steady rise for at least the last few decades in European countries and elsewhere (e.g., see Oettinger, 2011). According to the arguments of Autor (2001), the steady rise in working from home can be attributed to the rise in the use of information and communication technologies (ICT). These technologies include computers and the internet and can enable remote work.

In this paper, we empirically investigate the effect of the rapid fall in prices of ICT on working from home. We do so in a difference-in-differences framework in the spirit of Rajan and Zingales (1998). More specifically, we ask whether the fall in ICT prices has affected working from home more in industries that depend more on ICT compared to industries that depend less on ICT. We use industry- and country-level data from 14 European countries and 2008-2016 period to establish the results.

We find that the share of employed individuals who report that they at least sometimes work from home has increased with the fall in ICT prices. Similar results hold within age, gender, and occupation groups. These findings provide robust support for the hypothesis that information and communication technologies facilitate and increase working from home.

We create three age groups: young (younger than 30), medium-age (between 30 and 45), and old (older than 45). We also split occupations into high- and low-wage groups motivated by the evidence that information technologies complement high-wage occupations (e.g., Autor, Levy, and Murnane, 2003, Acemoglu and Autor, 2011, Jerbashian, 2019). We find that the effect of the fall in ICT prices on working from home is not statistically different across gender and occupation groups. However, there are statistically significant and economically meaningful differences across age groups. The fall in ICT prices has increased working from home among old more than among medium-age.

Moreover, the fall in ICT prices has increased working from home among medium-age more than among young. All these results are robust to a wide range of specification checks and alternative identifying assumptions.

A possible explanation for the differences across age groups is that the preference for working from home increases with age. For example, young individuals usually reside in the house of their parents in Europe, whereas medium-age and old individuals live in their own house. This can impede the willingness of young individuals to work from home as information and communications technologies proliferate. In turn, old individuals are usually averse to commute and travel which can amplify their willingness to work from home.<sup>1</sup> We do not test the latter argument for old individuals because of data limitations, but we make an attempt to test the argument for the young. In particular, we separate the sample according to marital status: single and married. This division is motivated by an observation that married individuals are more likely to live in their own house. We find that the results for married and single medium-age individuals are very similar, and these results are almost the same as the results with no marital status differentiation. This also holds for old individuals. The results for young individuals found without marital status differentiation are very similar to the results for single young individuals. In contrast, the results for married young individuals are very close to the results for medium-age individuals. All in all, these results corroborate our hypothesis.

A few earlier papers have studied alternative work arrangements and, in particular, working from home. Linda and Field-Hendrey (2002) emphasize the importance of working from home for women. Mas and Pallais (2017) and Maestas, Mullen, Powell, Wachter, and Wenger (2018) use a discrete choice experiment and stated-preference analysis and estimate that job applicants and employees are willing to accept lower wages for the opportunity to work from home. According to Bloom, Kretschmer, and Reenan (2009), these results can hold because work from home can improve work-life balance. Working from home can also be associated with increased productivity according to Bloom, Liang, Roberts, and Ying (2015). In turn, Oettinger (2011) and Mateyka, Rapino, and Landivar

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<sup>1</sup>Allen, Johnson, Kiburz, and Shockley (2013) and Bal and Jansen (2016), among others, support these arguments.

(2012) document that working from home has steadily increased in the US during the past two decades. Oettinger (2011) also offers evidence showing that working from home has especially increased in occupations that use ICT more intensively. Our results complement the results of Oettinger (2011) and contribute to these studies by showing that the fall in ICT prices is associated with increased work from home especially in industries that depend more on ICT as compared to industries that depend less on it. Our results suggest that policies which reduce ICT prices can promote working from home.<sup>2</sup>

We also contribute to the literature that studies the economic impact of information and communication technologies (e.g., Czernich, Falck, Kretschmer, and Woessmann, 2011, Jerbashian and Kochanova, 2017) and, in particular, the effect of these technologies on labor demand (e.g., Autor et al., 2003, Acemoglu and Autor, 2011, Jerbashian, 2019). We offer robust evidence that ICT can change labor demand and increase work from home.<sup>3</sup>

The next section describes a simple model to motivate the empirical test. The third section describes the data and its sources and our identification strategy. The fourth section summarizes the results. The last section concludes.

## 2 Theoretical Background

A fall in ICT prices would increase working from home more in industries that depend more on information technologies than in industries that depend less. We present a simple model to outline our assumptions and show how such an inference can hold. We also use this model to set the stage for the empirical analysis.

Employees can work on-site and from home. The tasks that employees perform on-site,  $n$ , and from home,  $h$ , are imperfect substitutes in production. The elasticity of substitution between these tasks is given by  $\varepsilon > 1$ . The producers hire employees and combine

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<sup>2</sup>The theoretical model of Brotherhood and Jerbashian (2020) suggests that policies, which reduce ICT prices and stimulate work from home, can also lead to lower output loss, infections, and death during pandemics such as the COVID-19.

<sup>3</sup>Falck, Heimisch-Roecker, and Wiederhold (2020) show that there are significant wage returns to ICT skills. Our results suggest that there are also non-monetary returns to ICT skills such as better opportunities to work from home.

information and communication technologies capital,  $K_{ICT}$ , with non-information technologies capital,  $K_{NICT}$ , to produce homogenous goods,  $Y$ . Their production function is given by

$$Y = \left[ \left( n^{\frac{\varepsilon-1}{\varepsilon}} + Ah^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \right]^{\alpha} (K_{ICT}^{\sigma} K_{NICT}^{1-\sigma})^{1-\alpha}, \quad (1)$$

where  $A > 0$  is the productivity of tasks performed at home relative to the tasks performed at the workplace and  $\alpha \in (0, 1)$  is a share parameter. The parameter  $\sigma$  represents the elasticity of the composite capital input ( $K = K_{ICT}^{\sigma} K_{NICT}^{1-\sigma}$ ) to  $K_{ICT}$  and it takes values between 0 and 1. It shows the importance of  $K_{ICT}$  in the composite capital input and the dependence of the industry production on  $K_{ICT}$ . We assume that  $A$  is a monotonically increasing function of the ratio  $K_{ICT}/K_{NICT}$ .

We assume that workers are endowed with 1 unit of time that can be used for leisure, on-site work, and teleworking. We assume that they have the following utility function:

$$U = \ln c + \ln \left( 1 - L \left( \frac{1}{A_n} u_n + \frac{1}{A_h} u_h \right) \right), \quad (2)$$

where  $c$  is proportional to  $Y$ ,  $Lu_n = n$ ,  $Lu_h = h$ ,  $u_n + u_h = 1$ , and parameters  $A_n > 0$  and  $A_h > 0$  identify the relative preference of converting hours into on-site work and working from home. We normalize  $A_n$  and set it to equal to 1.

The standard profit maximization implies that

$$\frac{K_{ICT}}{K_{NICT}} = \frac{\sigma}{1-\sigma} \frac{p_{NICT}}{p_{ICT}}. \quad (3)$$

This result holds because of the Cobb-Douglas combination of  $K_{ICT}$  and  $K_{NICT}$  and suggests that the empirical moment for computing the dependence of the industry on information and communication technologies,  $\sigma$ , is given by:

$$\sigma = \frac{p_{ICT} K_{ICT}}{p_{ICT} K_{ICT} + p_{NICT} K_{NICT}}. \quad (4)$$

The labor supply decisions imply that the allocation of time to working from home

$u_h$  is given by:

$$\frac{u_h}{1 - u_h} = \left( A_h A \left( \frac{K_{ICT}}{K_{NICT}} \right) \right)^\varepsilon, \quad (5)$$

which is increasing with  $K_{ICT}/K_{NICT}$ .

We normalize  $p_{NICT}$  and set it equal to 1. Using equation (3), it is straightforward to show that in this economy a fall in  $p_{ICT}$  increases the ratio  $K_{ICT}/K_{NICT}$ :

$$\frac{\partial}{\partial p_{ICT}} \frac{K_{ICT}}{K_{NICT}} = -\frac{\sigma}{1 - \sigma} \left( \frac{1}{p_{ICT}} \right)^2 < 0. \quad (6)$$

Moreover, the magnitude of this effect is larger in industries with a higher dependence on  $K_{ICT}$ . This is straightforward to verify by taking the derivative of the absolute value of (6) with respect to  $\sigma$ :

$$\frac{\partial}{\partial \sigma} \left| \frac{\partial}{\partial p_{ICT}} \frac{K_{ICT}}{K_{NICT}} \right| = \left( \frac{1}{1 - \sigma} \frac{1}{p_{ICT}} \right)^2 > 0. \quad (7)$$

This, together with equation (5), implies that  $u_h$  increases with the fall in  $p_{ICT}$  and it increases more in industries that depend more on ICT than in industries that depend less. Moreover, these differential changes are larger in groups that have a higher  $A_h$  according to equation (5).

These differential changes in  $u_h$  should be observed in the data as differential changes in the share of working from home. We look exactly for such disparities and differential changes in the empirical specification.

### 3 Data and Empirical Methodology

The data for working from home are from the harmonized, individual-level EU Labour Force Survey (ELFS). This survey asks employed individuals to report if they work from home usually, sometimes, or never. We use sample weights and compute the share of employed individuals who report that they work from home either sometimes or usually in each sample industry, country, and year. We exclude from the sample the individuals who are older than 65.

Industries have 1-digit NACE Rev. 2 coding. Our main sample excludes some of the industries because of potential large state involvement and a very limited number of observations in the labor force survey. Table 1 offers the list of sample industries and their average share of working from home in Panel *A*. Working from home varies significantly across industries. Around 30% of workers in the Information and Communication Industry report working from home at least sometimes. About 17% of employees report that they work from home at least sometimes in the Financial and Insurance Activities and Real Estate industries. In contrast, less than 4% of workers report working from home in the Accommodation and Food Service industry. Working from home has increased in all industries during the sample period according to the last column of Panel *A*.

We also retrieve information from the ELFS database on age, gender, and occupation. We do so to compute the share of employees working from home within each group. We create three age groups: young (younger than 30), medium-age (between 30 and 45), and old (between 45 and 65). In turn, we split the occupations into high and low wage groups motivated by arguments and evidence that information technologies complement high-wage occupations (e.g., Acemoglu and Autor, 2011, Jerbashian, 2019). The classification of occupations changes from ISCO-88 to ISCO-08 in 2011, and this way of splitting occupations has the additional convenience that it allows us to match these classifications. Occupations commanding high wages are Managers, Professionals, and Technicians and Associate Professionals and coincide in these classifications. We compute the share of employed individuals who report that they work from home at least sometimes in each of these categories.

Table 2 offers basic statistics for the WFH variable within each of these categories. Young workers tend to work significantly less from home than medium-age and old workers according to Panel *A*. The latter result can be justified by the preference to work from home, for example. There are no significant differences in terms of working from home between genders according to Panel *C*. The share of workers who report working from home at least sometimes is higher in high-wage occupations than in low-wage occupations according to Panel *D*. A rationale for this can be that the usual tasks of employees with



high-wage occupations are easier to perform at home than the usual tasks of employees with low-wage occupations. Importantly, working from home has increased in all these categories during the sample period according to the last column of Table 2.<sup>4</sup>

The data for information and communication technologies (ICT) are from the 2019 version of the EU KLEMS database (Adarov and Stehrer, 2019, Stehrer, Bykova, Jager, Reiter, and Schwarzhappel, 2019). These technologies include computing and communications equipment and computer software and databases. We use the share of ICT capital out of total capital to construct a proxy for industries' dependence on information and communication technologies. This proxy needs to identify the technological differences across industries, i.e.,  $\sigma$  in equation (4). We follow Rajan and Zingales (1998) and the literature motivated by their methodology and use data from US industries to accomplish this. The measure for industries' dependence on information and communication technologies (ICT Dependence) is defined as the share of ICT capital in total capital in US industries averaged over the 2008-2016 period. Its variation is across industries. Panel *B* of Table 1 reports the values of ICT Dependence in sample industries. The value of this measure is the largest in the Information and Communication industry where it stands at around 27%. It is the lowest in the Real Estate industry where a large share of capital is in terms of dwellings, buildings, and other structures.

The motivation for using data from US industries for ICT Dependence is that these industries are the world leaders in terms of investments in ICT and the level of ICT capital. Therefore, the confounding variation in the share of ICT capital in total capital because of temporary shocks is likely to be the smallest in US industries. To test this and the validity of this measure, we exploit time and industry variation in the share of ICT capital in total capital in US industries over the period 2008-2016 and the variation of the share of ICT capital in industries in the sample European countries. We also utilize the fact that there have been large investments in ICT over this period. The industry-level variation of the share of ICT capital in US industries accounts for nearly 100 percent of

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<sup>4</sup>Figure 1 illustrates the trend in the WFH in sample countries. Table I in the Appendix - Further Robustness Checks and Results shows that the pair-wise correlations of the WFH within groups are large which suggests a systematic pattern and supports the hypothesis that there is a technological cause for changes in the WFH.

the total variation.<sup>5</sup> Moreover, the share of ICT capital in US industries firmly correlates with the share of ICT capital in the industries of the sample European countries according to Panel *B* of Table 3. These observations suggest that the dependence measure used in this paper is likely to identify the technological differences across industries but not temporary shocks.<sup>6</sup>

We also need a measure for the price of information technologies  $p_{ICT}$ . To construct it, we obtain the price of investments in information and communication technologies in sample countries and years from the EU KLEMS database. Following the model, we normalize the price of investments in ICT with the price of investments in non-ICT capital and use it as the measure for the price of information technologies (ICT Price).

Given data availability, the main sample includes 14 Western European countries and focuses on the period between 2008 and 2016.<sup>7</sup> Table 3 offers the list of sample countries, the sample period for each country, and basic statistics for ICT Price in Panel *A*. ICT Price displays significant variation over time and across countries (see Table IV in the Appendix - Further Robustness Checks and Results). The over time variation can be largely attributed to the significant innovations in ICT that occurred over the sample years in the US and to the rise of ICT production in Asia and, in particular, in China. The country-level variation is likely to be stemming from regulations that affect the access to and adoption of ICT.<sup>8</sup>

Our empirical methodology follows the theoretical model, and our identification strategy is very similar to the one used by Rajan and Zingales (1998), Barone and Cingano (2011), and Jerbashian (2019). The dependent variable in all our estimations is the share of employees in industry  $i$ , country  $c$ , and year  $t$  who at least sometimes work from home

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<sup>5</sup>Table II and Table III report these results in the Appendix - Further Robustness Checks and Results.

<sup>6</sup>The measure of dependence used in this paper firmly correlates with similar measures used in the literature (see, e.g., Chen, Niebel, and Saam, 2016, Jerbashian and Kochanova, 2016, 2017). We perform a range of robustness checks for it in Table 6.

<sup>7</sup>There are data for earlier years than 2008 in the EU KLEMS and ELFS databases. We use data from 2008 onward because industry classification changes in the ELFS database from NACE Rev. 1 to Rev. 2 in 2008, and the EU framework agreement about teleworking has gained a wider adoption in EU countries after 2006.

<sup>8</sup>Figure 2 illustrates the fall in ICT prices taking the average across sample countries.

(WFH). Our main specification is:

$$\begin{aligned} \text{WFH}_{i,c,t} = & \beta \left[ \text{Industry } i\text{'s Dependence on ICT}_i \times (1/\text{ICT Price})_{c,t} \right] \\ & + \sum_c \sum_i \zeta_{c,i} + \sum_c \sum_t \xi_{c,t} + \eta_{i,c,t}, \end{aligned} \quad (8)$$

where  $\zeta$  and  $\xi$  are country-industry and country-year fixed effects respectively, and  $\eta$  is an error term.

The parameter of interest is  $\beta$ . It shows the effect of the fall in ICT prices on working from home. This is identified from the variation of ICT prices over time, the variation of ICT dependence across industries, and within country, time, and industry variation of the interaction term. We expect this coefficient to be positive, as we expect that working from home increases more with the fall in ICT prices in industries with higher ICT dependence as compared to industries with lower ICT dependence following the result in comparative static (7). We perform the same estimation for each age, gender, and occupation group. We do not have *a priori* expectations about differences across these groups.

This identification strategy involves trade-offs. An advantage of it is that it alleviates the endogeneity concerns because of the potentially omitted country- and industry-level variables with country-industry and country-year fixed effects. For example, these fixed effects control for the potentially confounding effects of regulatory and discriminatory practices that affect working from home. Admittedly, however, this test might not fully reveal the effects of the fall in ICT prices on working from home if there are economy-wide changes in working from home that are not different across industries. In such a case, this test can be also viewed as a test of whether industry-level differences exist.

Before reporting the estimation results, it is worth outlining the interpretation of the coefficient  $\beta$  and presenting a non-parametric estimate of the effect of the fall in ICT prices on working from home. Roughly speaking, the difference-in-differences estimator in the specification (8) splits the sample into four groups according to the magnitude of the fall in ICT prices and the level of ICT dependence. These four groups are composed of the industry-country pairs with high fall in prices and high dependence (HF&HD),

industry-country pairs with high fall in prices and low dependence (HF&LD), pairs with low fall in prices and high dependence (LF&HD), and pairs with low fall in prices and low dependence (LF&LD). An interpretation of  $\beta$  and a non-parametric estimate of the effect of the fall in ICT prices on working from home is given by the difference in the trends of working from home between HF&HD industry-country pairs relative to HF&LD industry-country pairs and LF&HD pairs relative to LF&LD pairs. This effect is positive if working from home grows at a higher rate in HF&HD industry-country pairs relative to HF&LD industry-country pairs than in LF&HD pairs relative to LF&LD pairs.

We take the residuals from a regression of WFH on country-industry and country-year dummies to illustrate the existence of such differential trends. Figure 3 shows that there are such disparities in working from home trends and that WFH has increased more rapidly in industries with high ICT dependence relative to industries with low ICT dependence, with the fall in ICT prices.

## 4 Results

Panel *A* of Table 4 reports the baseline estimate of  $\beta$  from the specification (8) using our main sample. The coefficient is positive and significant. This implies that working from home increases with the fall in ICT prices and this increase is larger in industries that depend more on ICT as compared to industries that depend less on ICT.

One way we can quantify these results and show their economic significance is as follows. We take the countries and years that rank in the 10th and 90th percentiles of the distribution of ICT Price and compute the difference between the inverse of ICT Price in these countries and years. Further, we take the industries that rank in the 90th and 10th percentiles of the distribution of ICT dependence and compute the difference between the dependence levels. Finally, we compute

$$\hat{\beta} \times \Delta 1/\text{ICT Price} \times \Delta \text{ICT Dependence}, \quad (9)$$

where  $\Delta$  stands for the difference operator between the 90th and 10th percentiles. The

computed effect is 0.101. These numbers correspond to the effect of moving from the pair of country-year with the highest ICT Price to the pair with the lowest ICT Price in the highest dependence industry relative to the lowest dependence industry. They suggest that the fall in ICT prices has a strong effect on working from home, at least relative to its mean, which is 0.121.<sup>9</sup>

We also estimate the specification (8) for each age, gender, and occupation group. Panels *B – H* of Table 4 report the results. These results are broadly consistent with the main result reported in Panel *A*. According to panels *B – D*, the effect of the fall in ICT prices on working from home increases with age. The differences in preferences for working from home and commuting across age groups can be an explanation for these results. Young individuals usually reside in the house of their parents and have limited personal space in European countries. In contrast, medium and old-age individuals usually live in their own houses. Moreover, old age individuals tend to be more averse to commuting than medium-age and young individuals.

In an attempt to test this hypothesis, we check the differences across age groups among single and married employees. A rationale for such a test is that married young individuals are more likely to live in their own house, while single young individuals are more likely to live in their parents' house. Living in their own house might give a stronger preference for working from home. In such a case, we expect that married young individuals behave similarly to medium-age individuals, while single young individuals are less affected by the change in ICT prices as they are less willing to work from home. The results reported in Table 5 support this hypothesis. The effect of the fall in ICT prices on working from home strictly increases with age for single individuals. In contrast, the effect of the fall in ICT prices on working from home among married young individuals is almost the same as and statistically not distinguishable from the effect on working from home among medium-age individuals.

Panels *E* and *F* of Table 4 report the results for gender groups. The fall in ICT price

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<sup>9</sup>The price difference between the 90th and the 10th country-year percentile amounts to a price fall of 70%. The fact that country-level variation in ICT prices is as important as yearly and country-year-level variation suggests that there is room for potentially large effects on working from home of policies on ICT prices (see Table IV in the Appendix - Further Robustness Checks and Results).

increases working from home for both males and females. The value of the estimated coefficient on the interaction term is larger for males than for females but these estimates are not statistically significantly different. There are almost no differences also between the effects of the fall in ICT prices on working from home in high- and low-wage occupations, even though working from home is more prevalent in high-wage occupations than in low-wage occupations. The results for occupation groups are reported in panels *G* and *H* of Table 4.<sup>10</sup>

In an attempt to rule out other explanations for our main results, we conduct a range of robustness checks. We further report exclusively the results for the general working from home measure. We have checked, however, that all our results are qualitatively the same for working from home measures within different groups.<sup>11</sup>

We estimate specification (8) using two alternative measures for ICT dependence in industries to rule out endogeneity and measurement concerns. Panel *A* of Table 6 reports the results when we use the sample initial value of the share of ICT capital in total capital in US industries as the dependence measure. The estimated coefficient is very similar to our baseline estimate in Panel *A* of Table 4. Next, we use as a measure of dependence the value of the share of ICT capital in total capital in industries of sample countries averaged over years. Such a measure of dependence is more appropriate if there are significant and structural differences in the parameter  $\sigma$  across countries. It can, however, attenuate the estimate of parameter  $\beta$  if those differences are because of temporary shocks. Panel *B* of Table 6 reports the results. The estimated coefficient is about twice lower than the baseline estimate suggesting that measurement error stemming from temporary shocks in this dependence measure can be attenuating the estimate.

It could be that the effect that we identify is not because of the fall in ICT prices but rather because of general structural changes in sample industries such as the substitution of capital for labor. This substitution could increase the employment of those who are more willing to accept non-wage benefits such as working from home. To test this

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<sup>10</sup>We have also checked that our results hold within education-level and marital status groups. We report these results in Table VI in the Appendix - Further Robustness Checks and Results.

<sup>11</sup>We offer results from further robustness check exercises in Table VII in the Appendix - Further Robustness Checks and Results.

hypothesis, we compute the share of total capital out of value added in US industries, average it over the sample period, interact it with the price of capital normalized by the price of the value added and add this interaction to the specification (8). Panel *C* of Table 6 reports the results. The estimate of the coefficient on the main interaction term does not change. In turn, the estimate of the coefficient on the newly added term is insignificant. This suggests that general structural changes in sample industries such as the substitution of capital for labor are not likely to play a role in changes in working from home.

The changes in ICT prices might be endogenous and affected by the demand for these technologies. We try testing this and alleviating such endogeneity concerns by dropping the industries that are the most likely to affect the demand for these technologies. More specifically, we drop from the sample industries where ICT capital is higher than the 75 percentile of the distribution of ICT capital across industries in each sample country and year. We estimate the specification (8) on this restricted sample and report the results in Panel *D* of Table 6. The estimate of the coefficient on the interaction term is slightly smaller than the baseline estimate in Panel *A* of Table 4. However, it is not statistically significantly different from the baseline estimate.

The Central and Eastern European countries Czechia, Hungary, Slovenia, and Slovakia joined the EU relatively recently and have been in a catch-up process in terms of the economy and labor markets with the remainder of the countries in the sample. Panel *E* of Table 6 shows that dropping these countries from the sample does not significantly affect our results. In Panel *F* we drop from the sample Luxembourg, Sweden and data for the Netherlands from 2015 and 2016, as there are patterns in the data for some industries in these countries and years that might be considered as irregularities.<sup>12</sup> Again, these sample restrictions do not affect our main results in a statistically significant way. Industries *J* and *K* have particularly high levels of ICT dependence. Even if this is not a concern given our identification strategy, we test the robustness of our results to their exclusion

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<sup>12</sup>The trends in working from home in some industries seem to be larger than the average in the sample in these countries. Moreover, working from home increases from about 0 to exactly 1 in some industries in Luxembourg.

in Panel *G*. The estimate of the coefficient on the interaction term declines in magnitude but stays positive and statistically significant. Finally, we trim the data for working from home from below and above within each country to exclude potential outliers. Panel *H* offers the results with trimmed data. These results are almost identical to the baseline results.

## 5 Conclusions

Working from home has become more prevalent over years and has gained significant importance especially very recently because of the COVID-19 pandemic and lockdown policies. The steady rise in working from home can be attributed to the rise in the use of information and communication technologies (e.g., Autor, 2001).

In this paper, we empirically investigate the effect of the fall in prices of ICT on working from home. We find that the share of employed individuals who report that they at least sometimes work from home has increased with the fall in ICT prices. We find similar results for age, gender, and occupation groups with some notable differences in age groups. The effect of the fall in ICT prices on working from home increases with age. An explanation for this result is that the preference for working from home increases with age because of home ownership and distaste for commuting. All in all, our findings provide robust support for the hypothesis that information and communication technologies facilitate and increase working from home.



## 6 Tables and Figures

Table 1: Working from Home in Sample Industries and ICT Dependence

| Industry Name                                  | Industry Code | A. Working from Home |       |       |       |       |          | B. ICT Dependence |  |
|--|---------------|----------------------|-------|-------|-------|-------|----------|-------------------|--|
|  |               | Obs.                 | Mean  | SD    | Min   | Max   | $\Delta$ | ICT Dependence    |  |
| Agriculture, Forestry and Fishing              | A             | 117                  | 0.112 | 0.097 | 0.000 | 0.449 | 0.020    | 0.002             |  |
| Mining and Quarrying                           | B             | 117                  | 0.091 | 0.146 | 0.000 | 1.000 | 0.043    | 0.006             |  |
| Manufacturing                                  | C             | 117                  | 0.089 | 0.069 | 0.009 | 0.274 | 0.055    | 0.035             |  |
| Electricity, Gas and Steam Supply              | D             | 117                  | 0.150 | 0.131 | 0.000 | 0.671 | 0.106    | 0.008             |  |
| Water supply and Sewerage                      | E             | 117                  | 0.078 | 0.068 | 0.000 | 0.263 | 0.054    | 0.015             |  |
| Construction                                   | F             | 117                  | 0.074 | 0.055 | 0.002 | 0.228 | 0.046    | 0.033             |  |
| Wholesale and Retail Trade; Repair of Vehicles | G             | 117                  | 0.084 | 0.058 | 0.007 | 0.238 | 0.044    | 0.070             |  |
| Transportation and Storage                     | H             | 117                  | 0.062 | 0.045 | 0.003 | 0.234 | 0.037    | 0.031             |  |
| Accommodation and Food Services                | I             | 117                  | 0.038 | 0.029 | 0.001 | 0.162 | 0.024    | 0.012             |  |
| Information and Communication                  | J             | 117                  | 0.295 | 0.169 | 0.032 | 0.623 | 0.137    | 0.244             |  |
| Financial and Insurance Activities             | K             | 117                  | 0.170 | 0.117 | 0.011 | 0.624 | 0.114    | 0.128             |  |
| Real Estate Activities                         | L             | 117                  | 0.171 | 0.115 | 0.000 | 0.581 | 0.051    | 0.001             |  |
| Professional and Support Service Activities    | M-N           | 117                  | 0.166 | 0.107 | 0.008 | 0.406 | 0.079    | 0.173             |  |

Note: Panel A of this table offers the descriptive statistics of working from home in sample industries.  $\Delta$  refers to the change in the WFH over the sample period in each industry averaged across countries. Panel B offers the values of the measure of dependence on information technologies (ICT Dependence) in sample industries. See Table 7 in the Data Appendix for complete descriptions and sources of variables.

Table 2: Working from Home within Gender, Age, and Occupation Groups

| <i>A. Age Groups</i>        | Obs  | Mean  | SD    | Min   | Max   | $\Delta$ |
|-----------------------------|------|-------|-------|-------|-------|----------|
| Young                       | 1630 | 0.075 | 0.048 | 0.015 | 0.248 | 0.049    |
| Medium-Age                  | 1635 | 0.142 | 0.078 | 0.044 | 0.399 | 0.068    |
| Old                         | 1635 | 0.128 | 0.073 | 0.04  | 0.383 | 0.061    |
| <i>B. Gender</i>            | Obs  | Mean  | SD    | Min   | Max   | $\Delta$ |
| Male                        | 1637 | 0.130 | 0.081 | 0.034 | 0.381 | 0.058    |
| Female                      | 1631 | 0.121 | 0.059 | 0.027 | 0.327 | 0.079    |
| <i>C. Occupation Groups</i> | Obs  | Mean  | SD    | Min   | Max   | $\Delta$ |
| High                        | 1632 | 0.216 | 0.055 | 0.111 | 0.405 | 0.085    |
| Low                         | 1636 | 0.053 | 0.032 | 0.014 | 0.157 | 0.035    |

Note: This table offers basic statistics for working from home in age, gender, and occupation groups.  $\Delta$  refers to the change in the WFH over the sample period averaged across countries and industries. See Table 7 in the Data Appendix for complete descriptions and sources of variables.

Table 3: Sample Countries, ICT Price and Correlations with ICT Dependence

| Country     | <i>A. Basic Statistics for ICT Price</i> |       |       |       |          | <i>B. Correlations</i> |
|-------------|--|-------|-------|-------|----------|------------------------|
|             | Mean                                     | SD    | Min   | Max   | $\Delta$ | ICT Dependence         |
| Austria     | 1.098                                    | 0.083 | 0.991 | 1.226 | -0.024   | 0.852                  |
| Czechia     | 1.012                                    | 0.024 | 0.977 | 1.051 | -0.007   | 0.842                  |
| Denmark     | 1.056                                    | 0.074 | 0.951 | 1.194 | -0.027   | 0.795                  |
| Finland     | 1.124                                    | 0.153 | 0.847 | 1.337 | -0.054   | 0.616                  |
| France      | 1.210                                    | 0.232 | 0.878 | 1.526 | -0.060   | 0.947                  |
| Germany     | 1.043                                    | 0.049 | 0.961 | 1.103 | -0.017   | 0.924                  |
| Italy       | 0.974                                    | 0.024 | 0.944 | 1.017 | 0.009    | 0.880                  |
| Luxembourg  | 1.034                                    | 0.032 | 0.990 | 1.093 | -0.008   | 0.902                  |
| Netherlands | 1.033                                    | 0.073 | 0.877 | 1.131 | -0.032   | 0.907                  |
| Slovakia    | 0.999                                    | 0.024 | 0.938 | 1.023 | 0.009    | 0.838                  |
| Slovenia    | 1.083                                    | 0.083 | 0.962 | 1.205 | -0.021   | 0.864                  |
| Spain       | 1.037                                    | 0.058 | 0.930 | 1.124 | -0.023   | 0.961                  |
| Sweden      | 1.264                                    | 0.231 | 0.924 | 1.553 | -0.043   | 0.770                  |
| UK          | 1.024                                    | 0.070 | 0.908 | 1.128 | 0.027    | 0.871                  |

Note: Column 1 of this table lists sample countries. The sample period is 2008-2016. Panel A offers basic statistics for the price of information technologies (ICT Price). Column 5 of Panel A offers the average change in ICT Price over the sample period in each country ( $\Delta$ ). Panel B offers the pairwise correlations of the measure of dependence on information technologies (ICT Dependence) and the shares of ICT capital share in the industries of the sample European countries. All correlations are significant at least at the 5% level. See Table 7 in the Data Appendix for complete descriptions and sources of variables.

Table 4: Main Results

|                                 | Age Groups          |                     |                      |                     |
|---------------------------------|---------------------|---------------------|----------------------|---------------------|
|                                 | <i>A. Main</i>      | <i>B. Young</i>     | <i>C. Medium-Age</i> | <i>D. Old</i>       |
| ICT Dependence<br>× 1/ICT Price | 0.740***<br>(0.107) | 0.354***<br>(0.131) | 0.626***<br>(0.132)  | 1.001***<br>(0.127) |
| Obs                             | 1620                | 1612                | 1617                 | 1617                |
| R2 (Partial)                    | 0.022               | 0.003               | 0.011                | 0.043               |
|                                 | Gender              |                     | Occupation Groups    |                     |
|                                 | <i>E. Male</i>      | <i>F. Female</i>    | <i>G. High Wage</i>  | <i>H. Low Wage</i>  |
| ICT Dependence<br>× 1/ICT Price | 0.768***<br>(0.114) | 0.440***<br>(0.153) | 0.615***<br>(0.137)  | 0.614***<br>(0.134) |
| Obs                             | 1619                | 1613                | 1614                 | 1618                |
| R2 (Partial)                    | 0.022               | 0.004               | 0.009                | 0.021               |

Note: This table offers the results from the estimation of the specification (8). Panel *A* offers the baseline result. In panels *B – H*, working from home is computed within age, gender, and occupation groups. See Table 7 in the Data Appendix for complete descriptions and sources of variables. All regressions include country-industry and country-year dummies and use the least-squares estimation method. Standard errors are in parentheses. Standard errors are bootstrapped and two-way clustered at industry- and country-year-level. R2 (Partial) is the R-squared of the model where country-industry and country-year dummies have been partialled out. \*\*\* indicates significance at the 1% level, \*\* at the 5% level, and \* at the 10% level.

Table 5: Results for Age Groups by Marital Status

| Age Groups - Single             |                    |                      |                     |
|---------------------------------|--------------------|----------------------|---------------------|
|                                 | <i>A. Young</i>    | <i>B. Medium-Age</i> | <i>C. Old</i>       |
| ICT Dependence<br>× 1/ICT Price | 0.325**<br>(0.147) | 0.767***<br>(0.179)  | 0.913***<br>(0.191) |
| Obs                             | 1612               | 1611                 | 1608                |
| R2 (Partial)                    | 0.002              | 0.010                | 0.013               |

| Age Groups - Married            |                    |                      |                     |
|---------------------------------|--------------------|----------------------|---------------------|
|                                 | <i>E. Young</i>    | <i>F. Medium-Age</i> | <i>G. Old</i>       |
| ICT Dependence<br>× 1/ICT Price | 0.736**<br>(0.353) | 0.627***<br>(0.164)  | 0.997***<br>(0.145) |
| Obs                             | 1525               | 1614                 | 1616                |
| R2 (Partial)                    | 0.003              | 0.007                | 0.032               |

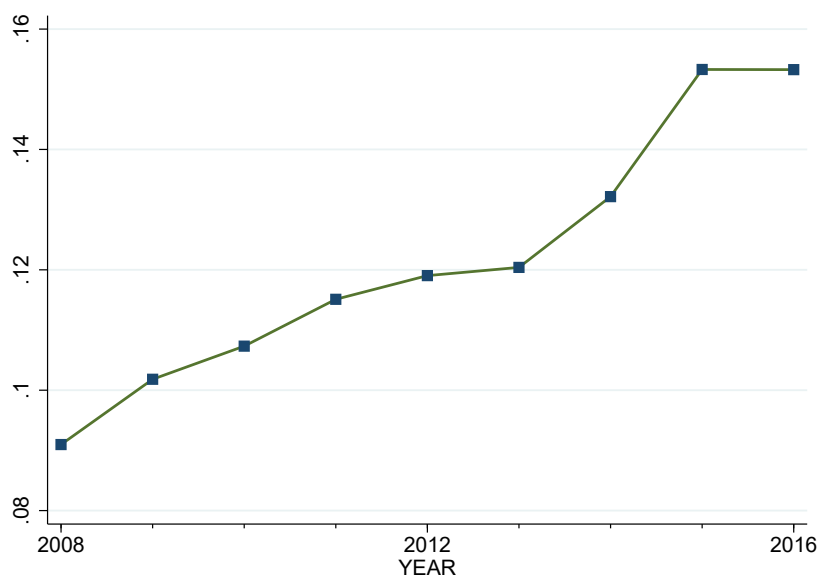
Note: This table offers the results from the estimation of the specification (8) for the WFH computed within age and marital status groups. See Table 7 in the Data Appendix for complete descriptions and sources of variables. All regressions include country-industry and country-year dummies and use the least-squares estimation method. Standard errors are in parentheses. Standard errors are bootstrapped and two-way clustered at industry- and country-year-level. R2 (Partial) is the R-squared of the model where country-industry and country-year dummies have been partialled out. \*\*\* indicates significance at the 1% level, \*\* at the 5% level, and \* at the 10% level.

Table 6: Robustness Checks - Measures, Additional Variables, and Sample Restrictions

|   | <i>A. ICT Dependence (2008)</i> | <i>B. Share of ICT Capital</i>      | <i>C. Capital Dependence</i> | <i>D. W/o High ICT Using</i> |
|---|---------------------------------|-------------------------------------|------------------------------|------------------------------|
| ICT Dependence<br>× 1/ICT Price         | 0.723***<br>(0.112)             |                                     | 0.734***<br>(0.105)          | 0.631***<br>(0.176)          |
| Share of ICT Capital<br>× 1/ICT Price   |                                 | 0.334***<br>(0.068)                 |                              |                              |
| Capital Dependence<br>× 1/Capital Price |                                 |                                     | -0.013<br>(0.553)            |                              |
| Obs                                     | 1620                            | 1620                                | 1620                         | 1368                         |
| R2 (Partial)                            | 0.022                           | 0.015                               | 0.024                        | 0.006                        |
|   | <i>E. W/o CEE Countries</i>     | <i>F. W/o LU, SE, NL 2015, 2016</i> | <i>G. W/o J and K</i>        | <i>H. Trimmed</i>            |
| ICT Dependence<br>× 1/ICT Price         | 0.705***<br>(0.107)             | 0.581***<br>(0.118)                 | 0.324**<br>(0.137)           | 0.708***<br>(0.106)          |
| Obs                                     | 1269                            | 1360                                | 1368                         | 1573                         |
| R2 (Partial)                            | 0.020                           | 0.043                               | 0.002                        | 0.033                        |

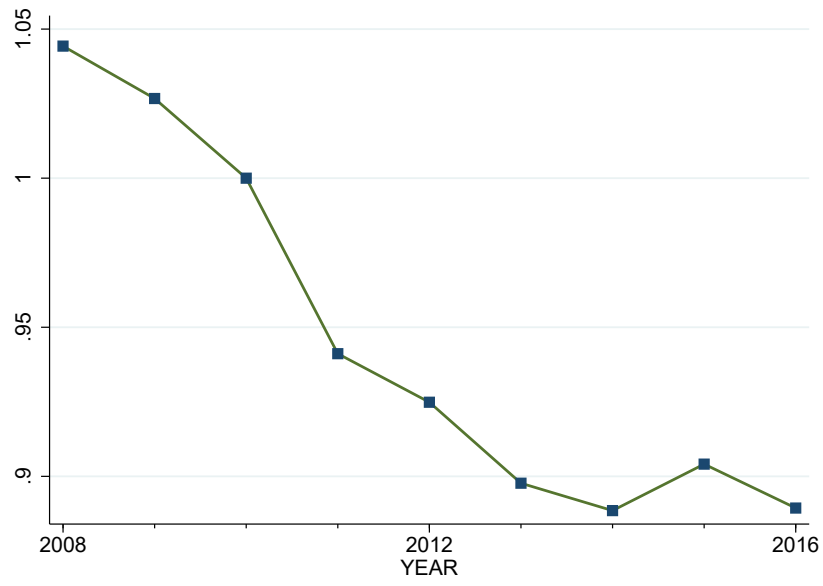
Note: This table offers the results from robustness check exercises. The dependant variable is WFH. Panels *A* and *B* offer the results from the estimation of the specification (8) using ICT Dependence (2008) and Share of ICT Capital as the dependence measures. Panel *C* offers the results from the estimation of an augmented version of the specification (8) which has an additional interaction term. In Panel *D*, we exclude from the sample the industries where ICT capital is higher than the 75th percentile of the distribution of ICT capital across industries in each sample country and year. We exclude from the sample the Central and Eastern European countries (Czechia, Hungary, Slovenia, and Slovakia) in Panel *E*. We exclude Luxembourg, Sweden, and data from the Netherlands for 2015 and 2016 in Panel *F*. Industries *J* and *K* are excluded from the sample in Panel *G*. Finally, we trim the data for working from home within each country to exclude potential outliers. Panel *H* offers the results from the estimation of the specification (8) with trimmed data. These data exclude the values of WFH below the 2nd percentile and above the 98th percentile of the distribution of WFH (over industries and years) in each country. All regressions include country-industry and country-year dummies and use the least-squares estimation method. Standard errors are in parentheses. Standard errors are bootstrapped and two-way clustered at industry- and country-year-level. R2 (Partial) is the R-squared of the model where country-industry and country-year dummies have been partialled out. \*\*\* indicates significance at the 1% level, \*\* at the 5% level, and \* at the 10% level.

Figure 1: Working from Home in Sample Countries



Note: This figure illustrates the trends in the WFH which is averaged across sample industries and countries. See 7 in the Data Appendix complete descriptions and sources of variables.

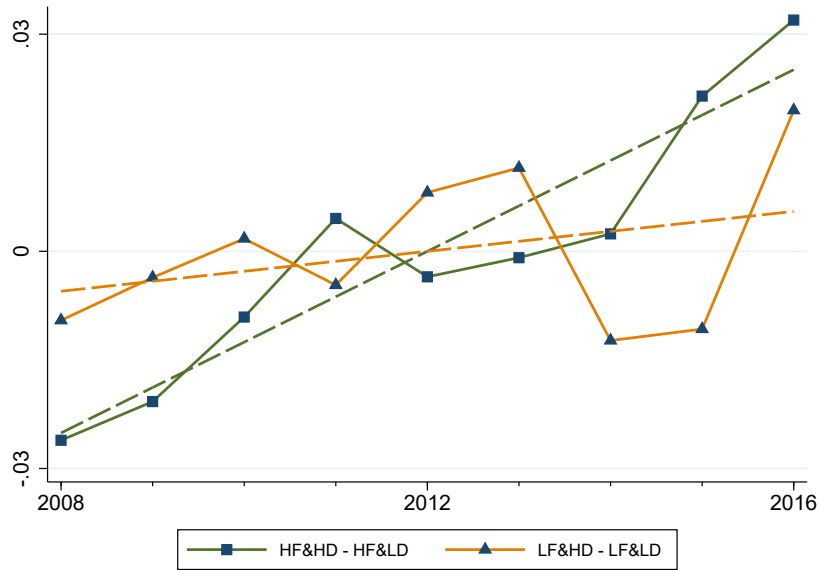
Figure 2: The Price of Information Technologies (ICT Price)



Note: This figure illustrates the evolution of the price of information and communication technologies relative to the price of capital (ICT Price). This relative price is averaged across countries. See Table 7 in the Data Appendix for complete descriptions and sources of variables.



Figure 3: Working from Home in High and Low ICT Dependence Industries



Note: This figure illustrates the differences in the trends in the working from home variable (WFH) in industry-country pairs with high and low ICT dependence and high and low fall in ICT prices. The curves with square tick symbols are the difference between WFH in industries with high ICT Dependence and industries with low ICT Dependence in countries where the fall in ICT Price is relatively high (HF&HD - HF&LD). The curves with triangle tick symbols are the difference between WFH in industries with high ICT Dependence and industries with low ICT Dependence in countries where the fall in ICT Price is relatively low (LF&HD - LF&LD). The curves in this figure are the residuals from an OLS regression of WFH on country-industry and country-year dummies. In each of the four groups, these shares are averaged over countries and industries. An industry has high (low) dependence on ICT if its ICT Dependence is above (below) the average ICT Dependence across industries. The fall in ICT Price in a country is relatively high (low) if the fall in ICT Price in that country is lower (higher) than the average change in ICT Price across countries. See Table 7 in the Data Appendix for complete descriptions and sources of variables.

# A Data Appendix

Table 7: Definitions and Sources of Variables

| Variable Name         | Definition and Source   |
|-----------------------|---|
| ICT Dependence        | The share of ICT capital in total capital in US industries averaged over the 2008-2016 period as given by equation (4). ICT includes computing and communications equipment and computer software and databases. Authors' calculations using data from EU KLEMS.  |
| ICT Dependence (2008) | The share of ICT capital in total capital in US industries in 2008 as given by equation (4). Authors' calculations using data from EU KLEMS.  |
| Capital Dependence    | The ratio of physical capital and value added in US industries averaged over the 2008-2016 period. Authors' calculations using data from EU KLEMS.  |
| Capital Price         | The price of investments in physical capital relative to the price of value added in sample countries. We use the inverse of this measure in estimations. Source: EU KLEMS.   |
| ICT Price             | The price of investments in information and communication technologies relative to the price of investments in physical capital in sample countries ( $p_{ICT}$ ). We use the inverse of this measure in estimations. Source: EU KLEMS.   |
| $\Delta$ 1/ICT Price  | The difference between the value of 1/ICT Price in 2016 and its value in 2008. Source: EU KLEMS.  |
| WFH                   | The share of employed individuals who report that they work at home least sometimes out of the total number of employed individuals in each industry, country, and year. We use individual-level sample weights from the EU LFS and exclude individuals older than 65 for computing this measure. Source: Authors' calculations using data from EU LFS. |
| Share of ICT Capital  | The share of ICT capital in total capital in sample industries, countries, and years. Authors' calculations using data from EU KLEMS.   |
| Group                 | Description   |
| Age Group             | There are three age groups: young (between 15 and 30), medium-age (between 30 and 45) and old (between 45 and 65).  |

**Table 7 – (Continued)**

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| Variable Name             | Definition and Source   |
|---------------------------|---|
| Occupation Group          | There are two occupation groups: high-wage occupations include the major groups 1, 2, and 3 from both classifications ISCO-88 and ISCO-08. Low-wage occupations include the rest of the major groups (from 4 to 9). |
| High ICT Using Industries | The industries where ICT capital is higher than the 75 percentile of the distribution of ICT capital across industries in each sample country and year.   |
| Marital Status            | There are two groups: married and single (single, divorced, and widowed are in one category).   |

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*Data Sources:* December 2015 release of the EU Labour Force Survey database; November 2019 release of the EU KLEMS database.

*Country Sample:* Austria, Czechia, Denmark, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Slovakia, Slovenia, Spain, Sweden, and the UK.

*Industry Sample (NACE rev. 2):* A, B, C, D, E, F, G, H, I, J, K, L and M-N.

*Sample Period:* 2008-2016.

## Acknowledgements

We gratefully acknowledge the financial support from the Spanish Government through grant RTI2018-093543-B-I00, MCIU/AEI/FEDER, UE. All errors remain our own.

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## B Appendix - Further Robustness Checks and Results

This section presents the results from further robustness check exercises. It also offers additional results. We conduct robustness checks with respect to the regression method, empirical specification, and sample. We present the results for the general working from home. We have performed all these robustness checks for demographic groups and have obtained results which are very similar to the results presented in the paper.

Working from home variable is from  $(0, 1)$ . We estimate the specification (8) using Tobit censored from  $(0, 1)$  and present the results in Panel *A* of Table VII. The estimate on the coefficient is almost the same as the baseline estimate reported in Panels *A* of Table 4. We also estimate the specification (8) using Quantile regression method and present the results in Panel *B* of Table VII. The estimate on the coefficient is somewhat lower but not statistically different from the baseline estimate.

Our data also contain information from small Baltic states Estonia, Lithuania, and Latvia and NACE Rev. 2 industries O, P, Q, R, S, T, and U. We exclude these countries and industries from our main sample because of data imperfections and potential large state involvement in production. We estimate the main specification (8) using a sample that includes these countries and industries and report the results in Panel *C* of Table VII. The estimate on the coefficient is very close to the baseline estimate.

We also check that our results are robust to two alternative empirical specifications and their corresponding identifying variations. The first alternative empirical specification regresses the long difference in the WFH on the sample initial value of the share of ICT capital and country fixed effects and has the following form:

$$\Delta \text{WFH}_{i,c} = \beta_{LD,1} \times \text{Share of ICT Capital (2008)}_{i,c} + \sum_c \tilde{\xi}_c + \tilde{\eta}_{i,c}, \quad (10)$$

where  $\Delta$  stands for the difference between 2016 and 2008 values,  $\tilde{\xi}$  are country fixed effects and  $\tilde{\eta}$  is an error term. We expect to obtain a positive estimate of  $\beta_{LD,1}$  since it

implies that as ICT prices fall industries that had a higher Share of ICT Capital (2008) have higher growth in working from home over sample years as compared to industries that had a lower Share of ICT Capital.

The second alternative empirical specification regresses the long difference in the WFH on the sample initial value of the share of ICT capital interacted with the long difference in 1/ICT Price and country fixed effects. It has the following form:

$$\begin{aligned} \Delta \text{WFH}_{i,c} = & \beta_{LD,2} \left[ \text{Share of ICT Capital}_{i,c,2008} \times \Delta 1/\text{ICT Price}_{i,c} \right] \\ & + \sum_c \hat{\xi}_c + \hat{\eta}_{i,c}, \end{aligned} \quad (11)$$

where  $\Delta$  stands for the difference between 2016 and 2008 values,  $\hat{\xi}$  are country fixed effects, and  $\hat{\eta}$  is an error term. This specification is closer to the specification (8) and especially when we use as a dependence variable the Share of ICT Capital. We expect that the coefficient on this interaction term to be larger than the coefficient on the Share of ICT Capital (2008) in specification (10) in case we are identifying the correct effect of the fall in ICT prices on working from home. This is because the estimated coefficient in the specification (10) can be expected to be attenuated since it is missing important information in such a case.

Panels *D* and *E* of Table VII present the results from estimations of specifications (10) and (11). The estimates of  $\beta_{LD,1}$  and  $\beta_{LD,2}$  are positive and significant. Moreover,  $\beta_{LD,2} > \beta_{LD,1}$  further suggesting a correct identification of the effect of fall in ICT prices on working from home.

## Education-Level and Marital Status Groups

We also retrieve from the ELFS database information about education levels and marital status. There are three education levels in the ELFS: low, medium, and high. Low-level corresponds to pre-primary to lower-secondary education. Medium-level corresponds to secondary to post-secondary and non-tertiary education, and high-level corresponds to tertiary education. We use all three levels of education in our analysis. Marital status is



either married or single which also includes divorced and widowed.

We estimate the specification (8) for these groups and report the results in Table VI. These results are broadly consistent with our baseline results reported in Panel A of Table 4. The value of the estimated coefficient on the interaction term for highly educated employees is lower than the value of estimated coefficients for employees with medium- and low-level education. However, these estimates are not statistically different. The value of the estimated coefficient for married is also statistically not different from the value of the estimated coefficient for single individuals.

We have performed all these robustness check exercises for all groups. The results reported in the text stay qualitatively unaltered.

## C Appendix - Tables and Figures

Table I: Correlations among Working from Home within Age, Gender, Education-Level, Marital Status, and Occupation Groups

| <i>A. Age Groups</i>        | Industry-Country-Year | Industry-Country | Industry | Country | Year  |
|-----------------------------|-----------------------|------------------|----------|---------|-------|
| Young & Medium-Age          | 0.935                 | 0.960            | 0.893    | 0.743   | 0.972 |
| Young & Old                 | 0.911                 | 0.966            | 0.838    | 0.695   | 0.965 |
| Medium-Age & Old            | 0.981                 | 0.987            | 0.943    | 0.883   | 0.983 |
| <i>B. Gender</i>            |                       |                  |          |         |       |
| Male & Female               | 0.750                 | 0.829            | 0.771    | 0.974   | 0.980 |
| <i>C. Education-Levels</i>  |                       |                  |          |         |       |
| High & Medium               | 0.528                 | 0.757            | 0.791    | 0.933   | 0.899 |
| High & Low                  | 0.756                 | 0.861            | 0.879    | 0.954   | 0.980 |
| Medium & Low                | 0.715                 | 0.879            | 0.918    | 0.973   | 0.950 |
| <i>D. Marital Status</i>    |                       |                  |          |         |       |
| Single & Married            | 0.888                 | 0.937            | 0.981    | 0.960   | 0.988 |
| <i>E. Occupation Groups</i> |                       |                  |          |         |       |
| High & Low Wage             | 0.624                 | 0.668            | 0.849    | 0.815   | 0.953 |

Note: This table reports the pairwise correlations between working from home in age, gender, education-level, marital status, and occupation groups. In Column 3, we report correlations for data with a country-industry-year-level variation. In Column 4, we take averages across years and report correlations for data with a country-industry-level variation. In Column 5, we take averages across countries and years and report correlations for data with an industry-level variation. In Column 6, we take averages across industries and years and report correlations for data with a country-level variation. In Column 7, we take averages across countries and industries and report correlations for data with a yearly variation. All correlations are significant at least at the 5% level.

Table II: ANOVA for the Share of ICT Capital in US Industries

| Source                 | Partial SS | df  | MS    |
|------------------------|------------|-----|-------|
| Total                  | 0.642      | 125 | 0.005 |
| Industry               | 0.639      | 13  | 0.049 |
| Year                   | 0.001      | 8   | 0.000 |
| Year $\times$ Industry | 0.002      | 104 | 0.000 |

Note: This table reports the results from an ANOVA exercise for the share of ICT capital in total capital in US Industries. We use the average of this share over the period 2008-2016 as the measure of ICT dependence. The variation in the data are at the industry-year-level, and we perform ANOVA along each of these dimensions.

Table III: ANOVA for the Share of ICT Capital in Industries of Sample European Countries

| Source                    | Partial SS | df   | MS    |
|---------------------------|------------|------|-------|
| Total                     | 12.165     | 1745 | 0.007 |
| Industry                  | 8.818      | 13   | 0.678 |
| Country                   | 0.375      | 13   | 0.029 |
| Industry x Country        | 2.779      | 167  | 0.017 |
| Year                      | 0.006      | 8    | 0.001 |
| Year x Industry           | 0.016      | 104  | 0.000 |
| Year x Country            | 0.024      | 104  | 0.000 |
| Year x Industry x Country | 0.142      | 1336 | 0.000 |

Note: This table reports the results from an ANOVA exercise for the share of ICT capital out of total capital in industries of sample European countries. The variation in the data are at the country-industry-year-level, and we perform ANOVA along each of these dimensions.

Table IV: ANOVA for ICT Price

| Source                | Partial SS | df  | MS    |
|-----------------------|------------|-----|-------|
| Total                 | 2.273      | 125 | 0.018 |
| Country               | 0.769      | 13  | 0.059 |
| Year                  | 0.613      | 8   | 0.077 |
| Year $\times$ Country | 0.890      | 104 | 0.009 |

Note: This table reports the results from an ANOVA exercise for the price of information and communication technologies relative to the price of capital (ICT Price). The variation in the data are at country-year level, and we perform ANOVA along each of these dimensions.

Table V: Working from Home within Education-Level and Marital Status Groups

| <i>Panel A. Education-Level</i> | Obs  | Mean  | SD    | Min   | Max   | $\Delta$ |
|---------------------------------|------|-------|-------|-------|-------|----------|
| High                            | 1631 | 0.212 | 0.068 | 0.084 | 0.411 | 0.075    |
| Medium                          | 1612 | 0.056 | 0.040 | 0.004 | 0.200 | 0.028    |
| Low                             | 1633 | 0.093 | 0.055 | 0.026 | 0.289 | 0.042    |
| <i>Panel B. Marital Status</i>  | Obs  | Mean  | SD    | Min   | Max   | $\Delta$ |
| Single                          | 1634 | 0.147 | 0.087 | 0.040 | 0.389 | 0.062    |
| Married                         | 1636 | 0.201 | 0.101 | 0.063 | 0.443 | 0.070    |

Note: This table offers basic statistics for working from home in education-level and marital status groups.  $\Delta$  refers to the change in the WFH over the sample period averaged over countries and industries. See Table 7 in the Data Appendix and Table VIII in the Appendix - Further Robustness Checks and Results for complete descriptions and sources of variables.

Table VI: Working from Home within Education-Level and Marital Status Groups

| Education-Levels                |                    |                     |                     |
|---------------------------------|--------------------|---------------------|---------------------|
|                                 | <i>A. High</i>     | <i>B. Medium</i>    | <i>C. Low</i>       |
| ICT Dependence<br>× 1/ICT Price | 0.357**<br>(0.145) | 0.655***<br>(0.150) | 0.617***<br>(0.194) |
| Obs                             | 1613               | 1615                | 1594                |
| R2 (Partial)                    | 0.002              | 0.020               | 0.008               |

| Marital Status                  |                     |                     |
|---------------------------------|---------------------|---------------------|
|                                 | <i>D. Single</i>    | <i>E. Married</i>   |
| ICT Dependence<br>× 1/ICT Price | 0.720***<br>(0.108) | 0.831***<br>(0.123) |
| Obs                             | 1616                | 1618                |
| R2 (Partial)                    | 0.017               | 0.026               |

Note: This table offers the results from the estimation of the specification (8) for WFH computed within education-level and marital status groups. See Table 7 in the Data Appendix and Table VIII in the Appendix - Further Robustness Checks and Results for complete descriptions and sources of variables. All regressions include country-industry and country-year dummies and use the least-squares estimation method. Standard errors are in parentheses. Standard errors are bootstrapped and two-way clustered at industry- and country-year-level. R2 (Partial) is the R-squared of the model where country-industry and country-year dummies have been partialled out. \*\*\* indicates significance at the 1% level, \*\* at the 5% level, and \* at the 10% level.

Table VII: Robustness Checks - Quantile and Tobit Regressions, All Sample, and Empirical Specification

|  | <i>A. Tobit</i>     | <i>B. Quantile</i>                 | <i>C. All</i>       |
|--|---------------------|------------------------------------|---------------------|
| ICT Dependence<br>× 1/ICT Price                | 0.735***<br>(0.087) | 0.506***<br>(0.090)                | 0.696***<br>(0.097) |
| Obs  | 1620                | 1620                               | 2556                |
| R2 (Partial)                                   |                     |                                    | 0.017               |
|  | <i>D. Long Diff</i> | <i>E. Long Diff w/ Interaction</i> |                     |
| Share of ICT Capital (2008)                    | 0.262***<br>(0.042) |                                    |                     |
| Share of ICT Capital (2008)<br>× Δ 1/ICT Price |                     | 0.657***<br>(0.146)                |                     |
| Obs  | 180                 | 180                                |                     |
| R2 (Partial)                                   | 0.123               | 0.088                              |                     |

Note: This table offers the results from additional robustness check exercises. See Table 7 in the Data Appendix and Table VIII in the Appendix - Further Robustness Checks and Results for complete descriptions and sources of variables. The dependant variable is WFH in Panels *A – C*. Panels *A* and *B* report the results from the estimation of the specification (8) using Tobit(0, 1) and Quantile regressions. Panel *C* reports the results for a sample which includes Estonia, Latvia, Lithuania, and industries O, P, Q, R, S, T, and U. The dependant variable is the change of WFH over the period 2008-2016 in Panels *D – E*. Panel *D* reports the results from the estimation of the specification (10). Panel *E* reports the results from the estimation of the specification (11). Standard errors are in parentheses. Regressions in panels *A – C* include country-industry and country-year dummies. Regressions in panels *D* and *E* include country dummies. Standard errors are bootstrapped and two-way clustered at industry- and country-year-level in panels *A – C*, and R2 (Partial) is the R-squared of the model where country-industry and country-year dummies have been partialled out. Standard errors are bootstrapped and clustered at country-level in panels *D – E*, and R2 (Partial) is the R-squared of the model where country dummies have been partialled out. \*\*\* indicates significance at the 1% level, \*\* at the 5% level, and \* at the 10% level.

Table VIII: Additional Definitions and Sources of Variables

| Variable Name               | Definition and Source  |
|-----------------------------|--|
| Share of ICT Capital (2008) | The share of ICT capital in total capital in sample industries and countries in 2008. Authors' calculations using data from EU KLEMS.  |
| $\Delta$ 1/ICT Price        | The difference the value of 1/ICT Price in 2016 and its value in 2008. Source: EU KLEMS.   |
| $\Delta$ WFH                | The difference between the value of WFH in 2016 and its value in 2008. Source: Authors' calculations using data from EU LFS.   |
| Group                       | Description  |
| Education-Level             | There are three education-level groups: low, medium, and high. Low education-level corresponds to pre-primary to lower-secondary education (0-2 of ISCED-97). Medium education-level corresponds to secondary to post-secondary and non-tertiary education (3-4 of ISCED-97). High education-level corresponds to tertiary education (5-6 of ISCED-97) |