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DIGITALISATION AND THE LABOUR MARKET: WORKER-LEVEL EVIDENCE FROM SLOVENIA

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ABSTRACT / RÉSUMÉ

Digitalisation and the labour market: Worker-level evidence from Slovenia

This paper provides evidence on the effects of digitalisation on the labour market in Slovenia using a unique dataset of Slovenian workers and firms for the years 2016 to 2020. Results show that at the firm level, digitalisation – measured in terms of ICT investment, is associated with positive and statistically significant effects on employment. However, job growth is not evenly distributed: High-skilled workers and younger workers benefit the most from employment gains, whereas there is little to no employment increases for low- and medium-skilled workers and older workers aged 50 or more. Furthermore, employment effects from digitalisation are strongest for private manufacturing firms. In contrast, ICT investment by state-owned firms is not associated with employment gains.

JEL classification codes: E22; E24; J62; O33

Keywords: ICT investment, employment, wages, labour reallocation

This Working Paper relates to the 2022 OECD Economic Survey of Slovenia, https://www.oecd.org/economy/slovenia-economic-snapshot/.

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Numérisation et marché du travail : Données au niveau des travailleurs en Slovénie

Cet article analyse des effets de la numérisation sur le marché du travail en Slovénie exploitant des données uniques sur les ouvriers et ouvrières slovènes pour les années 2016 à 2020. Les résultats montrent que la numérisation, mesurée en termes d'investissements dans les TIC au niveau de l'entreprise, est associée à des résultats positifs et des effets statistiquement significatifs sur l'emploi de l'entreprise. Cependant, la croissance de l'emploi n'est pas uniformément répartie: les ouvriers et ouvrières hautement qualifiés et les jeunes ouvriers et ouvrières bénéficient le plus, alors qu'il n'y a que peu ou pas d'augmentation de l'emploi pour ouvriers et ouvrières peu et moyennement qualifiés et les ouvriers et ouvrières âgés de 50 ans ou plus. En outre, les effets sur l'emploi de la numérisation sont les plus importants pour les entreprises manufacturières privées. En revanche, les investissements dans les TIC des entreprises publiques ne sont pas associés à des gains d'emploi.

Classification JEL: E22; E24; J62; O33

Mots Clés: Investissement dans les TIC, emploi, salaires, réaffectation de la main-d'œuvre

Ce Document de travail a trait à l'Étude économique de l'OCDE de la Slovénie 2022 https://www.oecd.org/fr/economie/slovenie-en-un-coup-d-oeil/.

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Digitalisation and the labour market: Worker-level evidence from Slovenia

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Introduction

Digitalisation can have substantial impacts on the labour market. Improvements in digital technologies, such as information and communication technologies (ICT), are creating demand for high-skilled IT professionals. At the same time, routine-intensive, low- and medium-skilled jobs in manufacturing are disappearing due to automation (Acemoglu and Restrepo, 2018[1]; Acemoglu and Restrepo, 2018[2]). More recently, the COVID-19 crisis accelerated this digital transformation. Many firms had to rapidly step up their IT capacities and introduce telework and other digital tools, such as online sales, to continue operating. A question remains about digitalisation's impact on inclusion in the labour market, as it is often low-skilled, low-income jobs that can be automated. In other words, is John Maynard Keynes' concern from the 1930s about automation leading to "technological unemployment" justified after all (Keynes, 1931[3])?

Economic theory predicts that the aggregate effect of digitalisation on employment is ambiguous (Caselli and Manning, 2019[4]). Robots, computers and software have the potential to replace workers as these technologies can automate routine-intensive jobs, leading to the displacement of workers and thus higher unemployment (Acemoglu and Restrepo, 2018[2]; Autor and Dorn, 2013[5]; Goos, Manning and Salomons, 2014[6]). Yet, digitalisation can also create general increases in employment as more productive firms tend to raise their labour demand (Acemoglu and Restrepo, 2018[7]; Bessen et al., 2020[8]; Gregory, Salomons and Zierahn, 2021[9]).

Moreover, digitalisation benefits some groups of workers more than others, which can have important consequences for labour market inclusion. Digitalisation increases demand for higher-skilled workers (Michaels, Natraj and Van Reenen, 2014[10]; Tang, Huang and Liu, 2021[11]). Such a process can lead to labour market polarisation if demand for high-skilled workers is raised at the expense of low- and middle-skilled workers (Acemoglu, Lelarge and Restrepo, 2020[12]; Acemoglu and Restrepo, 2020[13]). Furthermore, existing studies suggest that new hires are hardest hit by displacement, whereas incumbent workers often take on new tasks with their original employer (Dauth et al., 2021[14]). Yet, at the same time, younger workers are also more technologically adept than older workers. There can also be an interplay

[1] Martin Borowiecki and Jens Høj are members of the OECD Economics Department. Antonela Miho is member of the Paris School of Economics. The corresponding author is Martin Borowiecki (Martin.Borowiecki@oecd.org). The paper has benefited from comments and suggestions from Mame Fatou Diagne, Michael Koelle, Douglas Sutherland, Sébastien Turban (with the OECD Economics Department), Cyrille Schwellnus (with the OECD Directorate for Science, Technology and Innovation) and Gregor Zupan (with the Statistical Office of the Republic of Slovenia). Federico Giovannelli offered statistical and research support. Gemma Martinez provided valuable editorial assistance.

with gender as women remain underrepresented in high-skill, high-income jobs created by digitalisation (Aksoy, Özcan and Philipp, 2021[15]).

Labour market policies that keep labour markets fluid and facilitate job transitions help workers who are involuntarily displaced to find a new job. Labour markets with more dynamic job transition rates, such as Denmark, also have stronger skill accumulation and wage growth, as workers have strong incentives to change job or invest in training to get a better-paid job (Engbom, 2022[16]). In Slovenia, however, the centralised wage-setting process reduces the allocative efficiency of the labour market, which may negatively affect employment and wage growth. The wage setting process ensures that workers receive similar wage increases within a compressed wage structure, creating a disconnection between individual productivity and wages. This leaves workers with few incentives to change job or invest in training (OECD, 2020[17]; OECD, 2022[18]). More efficient labour reallocation can also support further digitalisation as scarce labour resources, which are crucial for implementing digital technologies, are freed up in underperforming firms to the benefit of more digitalised and productive firms (Andrews, Charlton and Moore, 2021[19]).

This paper investigates the extent to which digitalisation, measured in terms of firm-level ICT investment in hardware and software, promotes or reduces inclusion in the Slovenian labour market. In particular, it examines whether digitalisation leads to job creation or job destruction, and for which categories of jobs, notably high- versus low-skilled jobs. A related question is whether workers in ICT-intensive firms earn higher wages.

The analysis builds on a unique dataset of Slovenian workers and firms and links firm-level ICT investment to employment and wages of individual workers. It takes a broader view on digitalisation than the studies by Koch *et al*. (2021[20]), Bessen *et al*. (2020[8]) and Cheng *et al*. (2019[21]), which focus on robots and investment in automation technologies. It also contributes to a series of papers using linked employer-employee data in the OECD (OECD, 2021[22]; Azzopardi et al., 2020[23]).

Following the empirical literature, the paper uses an instrumental variable approach to estimate causal effects of digitalisation (Cette, Nevoux and Py, 2020[24]). Specifically, it uses changes to ICT intensity of the sector as an instrument for firm-level ICT investment. Results show that firms that invest more in ICT also employ more workers, but not necessarily at a higher wage, after controlling for firm productivity. Furthermore, employment gains are not evenly distributed: high-skilled workers benefit, but not low- or medium-skilled workers. Also, ICT-intensive firms employ more native Slovenians of both genders and more workers who are under 50 years old. ICT-intensive firms responsible for job creation are larger private companies operating in the manufacturing sector.

The following section presents the data and methodology. Section 3 continues with a presentation of the main results. Section 4 discusses the robustness of the results and caveats to the findings. Section 5 concludes.

1. Data and Methodology

Dataset and variables

The analysis uses a linked employer-employee dataset created using multiple administrative datasets and business surveys of the Slovenian Statistical Office (Table 1). The final sample for empirical analysis consists of 160 773 workers employed across 1 054 firms with 5 or more employees for the years 2016-2020 (Table 2). To construct the sample for empirical estimation, administrative worker-level data from the Structure of Earnings Survey was matched with administrative firm-level data in the Business Register and the Annual Accounts of Slovenia. The Business Registry provides information on the date of establishment of an enterprise, its ownership and sector. Annual Accounts provide information on labour productivity and exports. Then, this dataset was linked with the Investment Survey, which provides firm-level information on investment in fixed assets. In a final step, the resulting dataset was matched with firm-level information on ICT investment from the ICT Usage and E-commerce in Enterprises Survey (ICT Survey). The

Investment Survey and the ICT Survey are business surveys that provide information on investment activity based on a representative sample of Slovenian enterprises.

Table 1. Description of variables

Variable	Description	Level	Coverage	Source
Dependent variables				
Log of employment	The log of number of workers in the Structure of Earnings Survey	Enterprise	2016-2020	Business Register of Slovenia Structure of Earnings Survey
Log of real gross hourly wage	The log of the gross hourly wage (gross wage divided by the number of weeks employed times 36 hours per week)	Worker	2016-2020	Structure of Earnings Survey
Digital variable				
Log of ICT investment	The log of real investment in ICT hardware, software and data	Enterprise	2016-2020	ICT Usage and E-Commerce in Enterprises survey
Variables capturing worker and firm heterogeneity and control variables				
Enterprise-level				
Firm age	The log of the number of years the firm is in business	Enterprise	2016-2020	Business Register of Slovenia
Firm age group	Dummy categories for firm age based on ten-year groups: i.e., 0-10 years, 10-20 years, up to 40+ years.	Enterprise	2016-2020	Business Register of Slovenia
Firm size	Dummy categories for the size of the firm based on employment: small (5-49 employees); medium (50-249 employees) or large (250 or more employees)	Enterprise	2016-2020	Business Register of Slovenia
Ownership type	Dummy categories for the type of ownership of the firm as state-owned (including partly-state-owned) or private (including foreign)	Enterprise	2016-2020	Business Register of Slovenia
Sales export	The share of revenues from export sales	Enterprise	2016-2020	Annual accounts
Labor productivity	The log of labor productivity calculated as real value added divided by the number of employees	Enterprise	2016-2020	Annual accounts
Investment in fixed assets, other than ICT	The log of real investment in fixed assets, excluding ICT and software	Enterprise	2016-2020	Investment Survey
Manufacturing firm	A dummy for whether the firm's main activity is in the manufacturing sector, based on the NACE REV2 classification: 5-40.	Enterprise	2016-2020	Business Register of Slovenia
Worker-level				
Age	The number of years between the survey and the worker's birth year	Worker	2016-2020	Structure of Earnings Survey
Age category	Dummy categories based on worker age: 17-34, 35-50 and 50+.	Worker	2016-2020	Structure of Earnings Survey
Gender	A dummy variable indicating whether the worker is male or female	Worker	2016-2020	Structure of Earnings Survey
Nationality	A dummy variable indicating whether the worker is a Slovenian national or a foreign national	Worker	2016-2020	Structure of Earnings Survey
Occupational skill level	Dummy categories of the worker's skill level based on their ISCO occupational category: low (ISCO 5 and 9), medium (ISCO 4,7,8), high (ISCO 1, 2, 3)	Worker	2016-2020	Structure of Earnings Survey
Educational skill level	Dummy categories of the worker's skill level based on their ISCED educational achievement: low (ISCED 0-2), medium (ISCED 3-4), high (ISCED 5-8).	Worker	2016-2020	Structure of Earnings Survey
Income tercile	Categorical variable based on whether the worker's gross wage is in the bottom, middle, or top third of the total worker income distribution	Worker	2016-2020	Structure of Earnings Survey

Table 2. Descriptive statistics

	Mean	Standard Deviation	Observations
FIRM-LEVEL: Unbalanced panel of 1 054 firms			
Dependent variable			
Log of firm employment	4.300	1.074	2826
Digital variables			
Log of ICT investment	9.393	2.914	2826
Control variables			
Log of firm age	3.040	0.544	2826
Firm has 5-49 employees	0.384	0.486	2826
Firm has 50-249 employees	0.471	0.499	2826
Firm has 250+ employees	0.145	0.353	2826
Manufacturing sector	0.777	0.417	2826
Public ownership	0.085	0.279	2826
Private/foreign ownership	0.878	0.328	2826
Share of export sales in previous year	0.584	0.339	2826
Labour productivity in previous year	47714.480	39974.100	2826
Log of real investment in fixed assets, excluding ICT, in previous year	11.520	3.601	2826
Log of baseline (2016) ICT investment * time trend	66.579	21.517	2826
WORKER-LEVEL: Unbalanced panel of 160 773 workers			
Dependent variable			
Log of real worker gross hourly wage	2.322	0.457	443184
Worker-level controls			
Age	43.025	10.129	443184
Worker is 17-34 years old	0.336	0.472	443184
Worker is 35-49 years old	0.571	0.237	443184
Worker is 50+ years old	0.235	0.424	443184
Female	0.448	0.497	443184
Slovenian national	0.317	0.465	443184
Low occupational skill group	0.149	0.356	443184
Medium occupational skill group	0.505	0.500	443184
High occupational skill group	0.346	0.476	443184
Low educational skill group	0.138	0.344	443184
Medium educational skill group	0.592	0.491	443184
High educational skill group	0.271	0.444	443184
Low income tercile group	0.253	0.435	443184
Medium income tercile group	0.395	0.489	443184
High income tercile group	0.352	0.478	443184

Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

The matching process described above produces a linked employer-employee dataset with detailed information on each firm's performance, investments, and ICT usage, as well as workers' characteristics. However, a downside of the approach is sampling bias towards manufacturing as well as medium-sized and larger firms, reflecting their better coverage in investment and ICT business surveys, even after accounting for restrictions on sector and firm size central to the analysis. Manufacturing firms are overrepresented (they represent about 17% of the administrative dataset but over 78% of firms in the estimation sample). Medium and large sized firms (based on the numbers of employees) are overrepresented. Small firms with less than 50 employees represent over 90% of firms in the administrative dataset while they are only 38% in the estimation sample. Finally, the public sector is also overrepresented:

from 1% of firms in the administrative dataset to over 8% in the sample. Yet, for workers, the sample is representative when considering gender and skill group.

The data allows to link worker outcomes (wages) to firm-level characteristics, such as ICT investment. This gives a picture of the impact of a firm's digitalisation on full-time employees. The Structure of Earnings Survey dataset covers all workers in paid employment who performed the same profession full time throughout the observed year (i.e., at least 36 hours per week) and for the same employer. However, only workers that received at least 90% of the annual minimum wage in the observed year are covered. This excludes part-time employees and workers who changed job during a calendar year. Between-year job-mobility is, in general, well covered as workers that transition to another job during the year appear again in the Structure of Earnings Statistics in the following year. However, job-to-job transitions in 2020 are missing since observations for 2021 were not available at the time of the analysis. Finally, and following previous OECD literature (Gal et al., 2019[25]), this analysis covers only firms in manufacturing and service sectors (NACE REV2 10-82), excluding the financial sector (NACE REV2 64-66). It is conducted at the level of 2-digit NACE Rev 2 sectors and there are 43 NACE Rev 2 sectors present in the sample.

The dependent variables are firm-level employment and worker-level wages. Employment is calculated as the number of full-time employees. Employment is further broken-down given worker characteristics, for example, the number of high-skilled workers employed by the firm, or firm characteristics, for example, the number of workers employed in manufacturing firms. Wages refer to hourly real gross earnings of a worker. Gross nominal wages are deflated using consumer price indices from Eurostat National Account Statistics to ensure comparability over time.

The explanatory variable on digitalisation is firm-level ICT investment. The ICT survey covers a series of questions on IT inputs and outputs, such as turnover from e-commerce, the share of electronic e-invoices over all invoices, a high-speed broadband connection (100 or more Mbit/s), the use of a website for booking services, social media, as well as the adoption of new technologies such as robots and cloud computing. We chose to focus on ICT investment since it most broadly captures digitalisation across firm types, whereas the former variables may only be relevant in certain sectors and/or businesses. A log transformation was applied to all variables to estimate percent changes in employment and wages per percent change in ICT investment. The exception is labour productivity, which is negative for some firms. Nominal investment is deflated using gross fixed capital formation deflators from Eurostat National Account Statistics.

The analysis controls for various firm and worker-level characteristics that may also explain employment and wage developments. For instance, larger, more productive and export-oriented firms may have higher employment and wages than smaller, domestically-oriented firms. These factors may explain employment and wage developments rather than ICT investment. Firm-level controls include age, size (small, medium and large enterprise based on employment), a dummy for the manufacturing sector, and whether the firm is state- or privately owned. The analysis also controls for export sales, and investment in fixed assets, excluding ICT investment. Worker-level controls include age, gender and nationality, as well as the worker's skill level based on their educational attainment and occupation. Low-skill by education is defined using ISCED codes, as workers with at least a lower secondary education (ISCED 0-2), medium skill is those workers up to a post-secondary, non-tertiary education (ISCED 3-4), and high skill is those workers with tertiary education (ISCED 5-8). Occupational skill level uses the ISCO occupational categories: low skill corresponds to jobs in sales and services and un-skilled occupations (ISCO 5 and 9), medium-skill workers hold jobs as clerks, craft workers, plant and machine operators and assemblers (ISCO 4, 7 and 8), and high-skill workers are those who have jobs in managerial, professional, technical and associated professional occupations (ISCO 1, 2 and 3).

A caveat is that NACE Rev 2 sector information is not available at the firm-level. Instead, plant-level information on the sector of activity was used. Sector classification is straightforward for about 66% of firms, as about 37% of firms only have one plant and another 29% of firms have more than one plant that all operate in the same sector. For the rest, the following rule was applied: (1) The sector of the majority of plants of the firm in that year was used. (2) If this information was missing, the sector of the majority of plants of the firm across all years was imputed. (3) Lastly, if this was missing, the most common digital-intensive sector was used, following Calvino *et al*. (2018[26]). Using this method, a sector of main activity was imputed for all but 3% of firms in the administrative dataset, representing 3.5% of total employment. These firms were dropped from the analysis.

Empirical model for estimating employment and wage effects

The empirical specification consists of Equation 1 and 2. Equation 1 regresses firm employment on ICT investment over the years 2016 through 2020 as follows:

$$Y_{d,s,t} = \alpha_1 + \alpha_2 ICT_{d,s,t-1} + \alpha_X \boldsymbol{X_{d,s,t}} + \boldsymbol{\gamma_s \tau_t} + \varepsilon_{\boldsymbol{d,s,t}} \tag{1}$$

while Equation 2 regresses worker-level wages on firm ICT investment:

$$Y_{i,d,s,t} = \alpha_1 + \alpha_2 ICT_{d,s,t-1} + \alpha_X \boldsymbol{X_{d,s,t}} + \alpha_W \boldsymbol{W_{i,d,s,t}} + \boldsymbol{\gamma_s \tau_t} + \varepsilon_{\boldsymbol{i,d,s,t}} \tag{2}$$

where $Y_{(i),d,s,t}$ is the outcome variable (for an employee *i* working) for firm *d,* in sector *s,* in year *t*. This outcome variable – firm's log employment or worker's log hourly real gross wages, is regressed on the log level of the firm's ICT investment in the previous year, $ICT_{d,s,t-1}$. $\boldsymbol{X_{d,s,t}}$ represents a vector of firm-level controls, including the log of investment in fixed assets excluding ICT, the log of firm age, indicators for small, medium, or large size, the manufacturing sector, public ownership, and the share of export sales. The specification controls for unobserved sector-level trends that might affect a firm through sector-year fixed effects ($\boldsymbol{\gamma_s \tau_t}$). Standard errors are clustered at the sector-level to account for any sector-specific shocks. There are 43 clusters based on the 43 NACE Revision 2 sectors present in our final sample. When the outcome is worker-level log wages, the analysis also controls for worker characteristics, $\boldsymbol{W_{i,d,s,t}}$: age, age-squared, dummies for gender, nationality, and occupational and educational skill level (low, medium or high).

Economic theory predicts that firms that invest more in ICT have higher overall productivity. Higher productive firms may have higher labour demand which translates into higher employment (Gregory, Salomons and Zierahn, 2021[9]). Workers in more productive firms may also receive higher wages, holding all other worker and firm-level characteristics fixed. But this is not necessarily the case, as more productive firms might replace workers with ICT and robots, leading to lower employment and wages (Acemoglu and Restrepo, 2018[7]). Thus, the coefficient of interest α_2 can be positive or negative: as firms increase their level of ICT investment, they employ more (fewer) workers and at a higher (lower) wage.

Do all worker benefit as the level of ICT investment increases, or is it only certain types of workers that benefit from higher employment? To respond to this question, the results of Equation 1 are estimated using sub-samples of workers. For example, to consider employment differences across skill groups (either educational or occupational), separate regressions are estimated for high-skilled workers, medium-skilled workers and low-skilled workers. Other types of heterogeneity include income tercile groups, gender, nationality, and age group. Differences between female and male workers are also considered by categories of age groups. For firms, separate estimations are conducted for sector (service versus manufacturing sector), ownership type (state-owned versus private), firm size and firm age group. The same approach is applied to test for differential wage effects of ICT investment across workers (Equation 2).

Identification strategy

Endogeneity is a concern for the identification of employment and wage effects of digitalisation. Endogeneity can occur from reverse causality, whereby a larger firm invests more in ICT, or omitted variable bias, i.e., that there is an unobserved confounding factor that impacts both employment and/or wages and a firm's digitalisation.

To overcome these challenges, this analysis follows recent empirical literature on causal effects of digitalisation and employs an instrumental variable strategy (Acemoglu and Restrepo, 2020[13]; Cette, Nevoux and Py, 2020[24]). Specifically, digitalisation is estimated through an instrumental variable combining ICT-intensity of the firm and the ICT-intensity of the sector in which the firm operates. Changes to industry-level ICT intensity capture exogenous improvements in ICT technology which expand investment possibilities in a sector. For instance, sectors with a higher share of tasks that can be automated by computers will have a higher ICT intensity as firms increase their investment in these labour-replacing technologies. This also means that firms in more (less) ICT-intensive sectors will have stronger (weaker) incentives to increase their ICT investment as investment opportunities are higher due to exogenous technical advances. The instrument is strongly correlated to digitalisation yet is plausibly exogenous to the firm. Any impacts on firm's employment and wages arise only through exposure to sector-wide spillover effects. In other words, all firms are small relative to the overall sector, and an individual firm's decisions are unlikely to affect sector-wide measures of technology.

An advantage of the instrumental variable over firm-level ICT investment is that it is less prone to measurement error. ICT investment is an imperfect and very volatile measure of the level of digitalisation of a firm. Typically, investments fluctuate from year to year, and are often zero while the firm uses its installed equipment. In contrast, sector-level investment is less volatile and should attenuate this estimation bias.

There may be concerns that a single firm drives sector-wide ICT intensities as digital-intensive industries tend to become more concentrated. In order to account for industry concentration, sector-wide leave-one-out means are used that exclude firm *d*'s own contribution to sector-wide ICT intensity. Another concern is that unobserved sector trends, such as increased demand for a sector's output, could put upward pressure on investment (including in ICT) and employment for all firms in a sector. This would lead to biased estimates. To account for such unobserved sector trends, the analysis controls for sector-year fixed effects. An additional control is the baseline (2016) ICT investment of the firm. As baseline ICT investment is collinear with year fixed effects, it is multiplied with a linear time trend variable. After controlling for these factors, the instrumental variable should measure the employment and wage effects of additional ICT investment of an individual firm resulting from an expansion of investment possibilities in a sector.

In a first stage, firm-level ICT investment is regressed on the above-described variable combining ICT-intensity of the firm and the ICT-intensity of the sector:

$$ICT_{d,s,t} = \alpha_1 + \alpha_2 ICT_{d,s,t-1} \times \overline{ICT_{s,t}} + \alpha_X \boldsymbol{X_{d,s,t}} + \boldsymbol{\gamma_s \tau_t} + \varepsilon_{\boldsymbol{d,s,t}} \quad (3)$$

where $ICT_{d,s,t}$ is ICT investment of firm *d* operating in sector *s* at time *t*. It is regressed on the instrumental variable, i.e., the sectoral (sample) mean of the share of ICT investment in total investment in fixed assets of sector *s* at time *t* ($\overline{ICT_{s,t}}$), excluding firm *d*'s own investment, interacted with lagged ICT investment of firm *d*. All controls as in Equations 1 and 2 are included. The predicted values from Equation 3 are then taken to arrive at the instrumental variable:

$$\widehat{ICT}_{d,s,t-1} = \hat{\alpha}_1 + \hat{\alpha}_2 ICT_{d,s,t-1} \times \overline{ICT_{s,t}} + \hat{\alpha}_X \boldsymbol{X_{d,s,t}} + \boldsymbol{\hat{\gamma}_s \hat{\tau}_t} \quad (4)$$

The instrumental variable $\widehat{ICT}_{d,s,t-1}$ from Equation 4 is used to replace firm-level ICT investment, $ICT_{d,s,t-1}$ in Equation 1 or 2, which yields the second-stage estimation model equations for firm-level employment:

$$Y_{d,s,t} = \alpha_1 + \alpha_2 \widehat{ICT}_{d,s,t-1} + \alpha_X \boldsymbol{X}_{\boldsymbol{d,s,t}} + \boldsymbol{\gamma}_{\boldsymbol{s}} \boldsymbol{\tau}_{\boldsymbol{t}} + \varepsilon_{\boldsymbol{d,s,t}} \quad (5)$$

and worker-level wages:

$$Y_{i,d,s,t} = \alpha_1 + \alpha_2 \widehat{ICT}_{d,s,t-1} + \alpha_X \boldsymbol{X}_{\boldsymbol{d,s,t}} + \alpha_W \boldsymbol{W}_{\boldsymbol{i,d,s,t}} + \boldsymbol{\gamma}_{\boldsymbol{s}} \boldsymbol{\tau}_{\boldsymbol{t}} + \varepsilon_{\boldsymbol{i,d,s,t}} \quad (6)$$

The correlation between firm-level ICT investment and the instrumental variable is significant with a value of the F-statistics above 10 (Table B.1 in Annex B). As before, sector-year fixed effects control for other shocks and trends that simultaneously affect digitalisation and labour demand. In addition, standard errors are clustered by sector to account for potential issues arising from industry-wide shocks.

2. Results

OLS and baseline specification

Higher ICT investment is associated with higher employment, but not higher wages

Table 3 presents the results for employment and wages for the full sample of firms and workers using an ordinary least squares (OLS) specification and the baseline specification, i.e., the two-stage least square (2SLS) estimation with the instrumental variable (IV). Results from the OLS regressions show that ICT investment is positively and statistically significantly associated with employment. On average, a 1% increase in firm-level ICT investment is associated with a 0.04% increase in annual firm-level employment, and a 0.01% increase in the hourly wage (Column 1 and 4, respectively).

The results for the IV estimation confirm that firms with higher ICT investment have higher levels of employment (Column 2), but not higher wages once labour productivity is controlled for (Column 6). A one percent increase in ICT investment corresponds to a 0.06 percent increase in overall firm employment. These results are robust to the inclusion of a variety of control variables, as shown in Table C.1 and Table C.2 in Annex C.

Table 3. Main regression results: OLS lag and IV specification

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	**Log of employment**			**Log of hourly wage**		
	OLS	IV 2SLS	IV 2SLS	OLS	IV 2SLS	IV 2SLS
Log of ICT investment	0.043*** (0.008)	0.063** (0.030)	0.070* (0.037)	0.010*** (0.003)	0.039*** (0.014)	-0.013 (0.033)
Observations	2,850	2,826	2,826	444,081	443,184	443,184
R-squared	0.829	0.828	0.827	0.552	0.541	0.560
Firm controls	X	X	X	X	X	X
Worker controls				X	X	X
Log of labour productivity in previous year			X			X
Sector-year fixed effects	X	X	X	X	X	X
Mean of dependent variable	4.291	4.300	4.300	2.322	2.322	2.322
SD of dependent variable	1.077	1.074	1.074	0.457	0.457	0.457

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. Worker controls refer to: age, age-squared, dummies for gender, nationality, and occupational and educational skill level (low, medium or high). All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

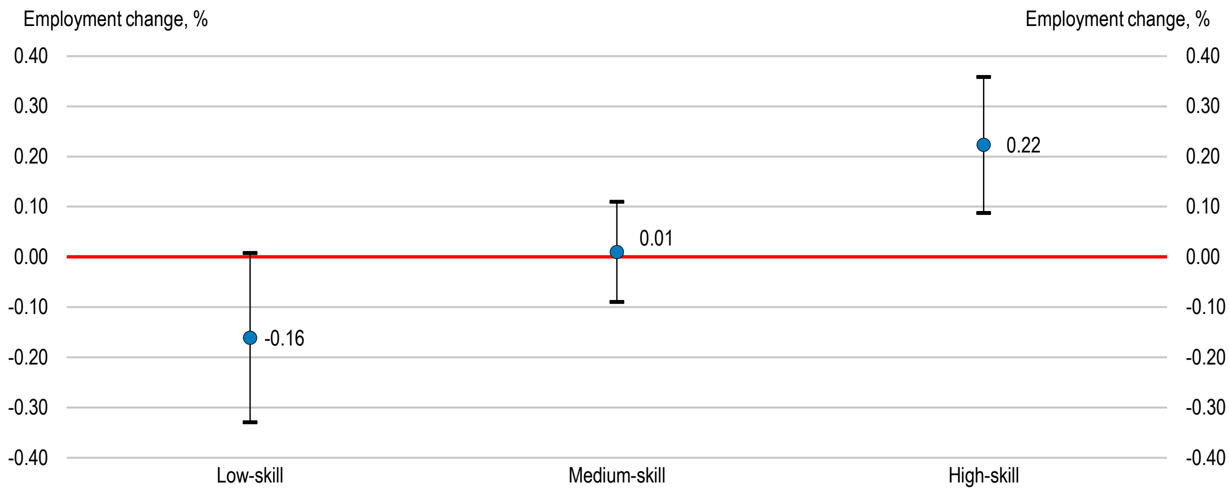
Heterogeneity by worker type

ICT investment encourages employment growth mainly for high-skilled workers

Figure 1 breaks down the aggregate results on employment by skill level of the worker (see Table C.3 in Annex C). The increase in the level of employment can be attributed to firms hiring more high-skilled workers. Compared to the aggregate 0.06% increase, the effect on employment more than triples for high skill educated workers. The effect is not significant for low- and medium-skilled workers. This points to skill-based polarisation in employment as firms increase their ICT investment. The result holds when using both educational attainment-based and occupation-based skill intensity measures.

Figure 1. Change in employment given workers' educational skill-intensity

For 1% change in ICT investment



Note: The figure shows coefficients and 95% confidence intervals for log of employment regressed on the log of ICT investment, using the IV (2SLS) specification. The coefficients are from three regressions using the log of employment of sub-samples of workers based on their skill-intensity. Controls for firm characteristics are the log of firm age, a dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Figure 1 shows that the employment gains are concentrated among Slovenian workers. Furthermore, higher ICT investment leads to the creation of jobs for mainly men. Although the coefficient for women is larger, it is non-significant, suggesting that there is more heterogeneity in how digitalisation affects female employment. Lastly, the jobs created are occupied by young and middle-aged workers, although the youngest workers (aged less than 35) benefit most.

Younger women and men benefit most from higher ICT investment

In order to understand the results given the gender of the worker, we consider possible heterogeneity by age group and separately for female and male workers. Figure 2 presents the results from this estimation (for the full results, see Table C.4 in Annex C). As before, ICT investment leads to the creation of jobs for young workers, for both female and male workers. While the coefficient for young female workers is greater than that of male workers, this difference is not statistically significant. It is important to put this effect in the context of the mean level of employment across all firms. For young males, the effect corresponds to an 9.6% increase relative to the mean, yet for young female workers, the effect represents a 32% increase relative to the mean.

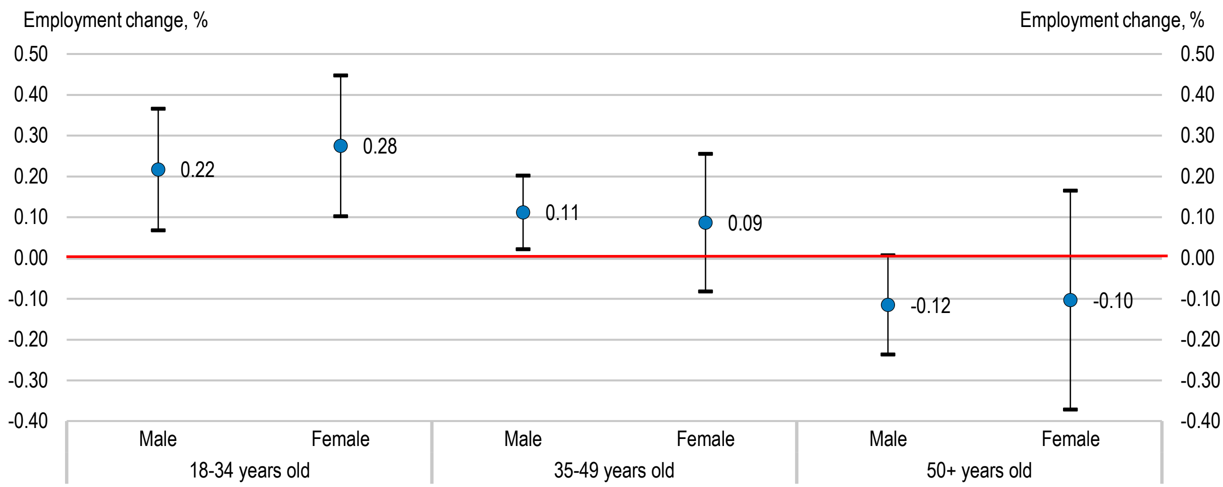
Table 4. Employment results given worker type

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	IV (2SLS) specification						
Dep. Var.	Log of employment						
Demographic	Nationality		Gender		Age group		
Type	Foreign	Slovenian	Male	Female	17-34	35-49	50+
Log of ICT investment	-0.131	0.083***	0.088**	0.099	0.209***	0.082**	-0.132*
	(0.078)	(0.030)	(0.043)	(0.079)	(0.061)	(0.038)	(0.073)
Observations	1,873	2,825	2,819	2,796	2,800	2,825	2,777
R-squared	0.371	0.797	0.766	0.712	0.625	0.792	0.634
Sector-year FE	X	X	X	X	X	X	X
Firm controls	X	X	X	X	X	X	X
Sector clusters	X	X	X	X	X	X	X
Mean of dependent var.	1.596	4.214	3.916	2.793	2.797	3.467	2.975
SD of dependent var.	1.347	1.106	1.089	1.432	1.18	1.104	1.309

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, and a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Figure 2. Employment change by gender and age group

For 1% change in ICT investment



Note: The figure shows coefficients and 95% confidence intervals for log of employment regressed on the log of ICT investment, using the IV (2SLS) specification. The coefficients are from six regressions using the log of employment of sub-samples of workers based on their age group and gender (2 X 3 combinations). Controls for firm characteristics are the log of firm age, a dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Heterogeneity by firm type

Job creation happens mostly in private manufacturing firms

Table 5 shows that the effect of job creation comes primarily from firms that operate in the manufacturing sector. For firms that operate in the service sector, the coefficient is negative and not significant. Moreover, employment effects are significant for privately-owned firms, while the effect is not significant for state-owned or partly state-owned enterprises.

Table 5. Employment results given firm sector and ownership

	(1)	(2)	(3)	(4)
Dep. Var.:	**Log of employment**			
Firm sector:	Services	Manufacturing	State-owned	Private
Log of ICT investment	-0.006	0.097***	-0.169	0.086***
	(0.087)	(0.027)	(0.366)	(0.016)
Observations	631	2,195	241	2,480
R-squared	0.801	0.823	0.801	0.814
Sector-year FE	X	X	X	X
Firm controls	X	X	X	X
Sector clusters	X	X	X	X
Mean of dependent var.	4.144	4.344	4.785	4.205
SD of dependent var.	1.059	1.075	1.19	1.006

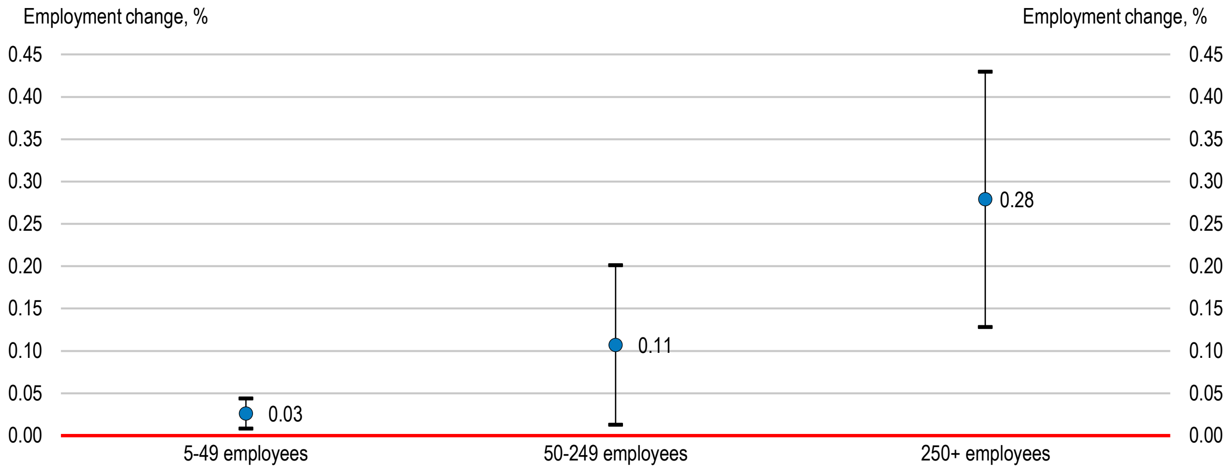
Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector (columns 3-4 only), and a dummy for public ownership (columns 1-2 only), the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Firms of all sizes contribute to job creation given higher ICT investment, although larger firms create relatively more jobs

Figure 3 shows that the effect is present for all firm size classes. Given an increase in ICT investment, there is a statistically significant increase in employment that is especially large for large firms, and smaller for smaller firms. See Table C.5 in Annex C for full results.

Figure 3. Employment change given the number of employees in the firm

For 1% change in ICT investment



Note: The figure shows coefficients and 95% confidence intervals for log of employment regressed on the log of ICT investment, using the IV (2SLS) specification. The coefficients are from three regressions using the log of employment of sub-samples of firms based on their category of firm size. In addition, we control for firm characteristics: log of firm age, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

3. Discussion and robustness checks

The results of the instrumental variable estimation are robust to using initial firm-level ICT intensity from 2016 as an instrument (Table C.6 in Annex C). The results are also robust to excluding 2020 from the analysis, suggesting that the findings are not influenced by the Covid-19 crisis, nor the data issues from the underreporting of job transitions in 2020 (Table C.7 in Annex C).

An important caveat is that the Structure of Earnings Survey covers only full-time employees who performed the same profession throughout the observed year (e.g., at least 36 hours per week) and for the same employer. Moreover, only employees that received at least 90% of the annual minimum wage in the observed year are covered. This excludes part-time employees and workers that changed job during a calendar year. As the labour market in Slovenia is heavily regulated, especially to discourage part time contracts, the number of part-time workers is unlikely to be a problem (OECD, 2020[27]). As for the second issue of mobility, between-year job-mobility is in general well covered as workers that transition to another job during the year appear again in the Structure of Earnings Survey in the following year. However, job-to-job transitions in 2020 are missing as observations for 2021 were not available at the time of the analysis. Nonetheless, results are robust to the exclusion of 2020 observations from the analysis (Table C.7 in Annex C).

Another issue is the high estimate for the employment effects of ICT investment. The instrumental variable estimate is 0.02%-point higher than the OLS estimate. This may be related to possible measurement error of ICT investment. Typically, firm-level ICT investment fluctuates from year to year and is often zero while the firm uses its installed ICT equipment, which may lead to a lower OLS estimate. Instrumenting firm-level ICT investment with sector-level ICT investment should attenuate this estimation bias.

Several limitations remain. First, the reported estimates may be a lower bound for the impact of digitalisation on employment. The analysis does not take into account positive demand spillovers to other sectors. For instance, job losses among low-skilled workers in manufacturing could be offset by job creation in the service sector (Dauth et al., 2021[14]). Second, the paper does not take into account possible negative employment effects of reallocation from less digitalised firms to more digitalised firms within a sector (Acemoglu, Lelarge and Restrepo, 2020[12]). And lastly, given its focus on Slovenia, it cannot directly compare the effect of labour market policies as these policies are set at the national level and do not provide sufficient variation over time for the estimation.

Summary and conclusions

This paper provides robust evidence on the relationship between digitalisation and job creation in Slovenia. First, the findings show that firm-level digitalisation leads to higher firm-level employment. The finding is robust to including a battery of controls, such as firm-level exports and productivity. However, the findings also point to factors that hamper the positive impact of digitalisation on the labour market. Specifically, investment in ICT is not associated with increases in wages, once controlling for higher productivity of ICT-intensive firms. In general, the wage premium for IT professionals is very low in Slovenia, hampering the reallocation of productive workers. This may reflect the centralised wage-setting process that ensures that workers receive similar wage increases within a very compressed wage structure. Such a process creates a disconnection between digitalisation and wages and reduces job mobility within a sector (OECD, 2022[18]).

Second, increases in employment are reserved for specific categories of workers. High skilled workers benefit the most, whereas there is little to no employment increases for medium and low skill workers. In addition, ICT-intensive firms employ workers of Slovenian nationality that are under 50 years old. Thus, digitalisation is indeed affecting inclusion in the labour market in Slovenia. These findings point to the importance of policies supporting adequate skill supply to reap digitalisation benefits, including policies that encourage training of workers. This contrasts with current policies, such as automatic seniority bonuses and wage compression, which disincentive firms from hiring older workers and workers from seeking higher qualifications.

Furthermore, younger workers (less than 35-years old) benefit from employment increases associated with greater digitalisation. In this age category, women tend to benefit more than men when considering women's average employment gains across all firms. This also means that young women have stronger employment gains in ICT-intensive firms than in non-ICT-intensive firms. This might reflect self-selection of highly skilled women into ICT. In this respect, more women could benefit from digitalisation if they pursue studies that lead to jobs in ICT-intensive firms.

Lastly, at the firm level, these results are driven by privately owned firms in the manufacturing sector. In contrast, ICT investment by service sector firms and by state-owned or partly state-owned firms is not associated with employment gains.

Overall, the results suggest that digitalisation increases labour demand by a sizeable amount. Yet, given the asymmetry in these employment gains, it is important that policies step in to encourage skill-upgrading among low- and medium-skilled workers. This is crucial so that these workers are not left-behind by the changing labour market, or do not drop out of the labour market. Future research could focus on the effectiveness of labour market policies in incentivising training and mobility among these workers, preferably in a cross-country perspective.

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Annex A. Data description

Table A.1 shows the descriptive statistics of the full sample and includes observations with missing values.

Table A.1. Descriptive statistics for full sample

	Mean	Standard Deviation	Observations
FIRM-LEVEL: Unbalanced panel of 6 967 firms			
Dependent variable			
Log of firm employment	3.378	1.174	18273
Digital variables			
Log of ICT investment	7.902	3.710	8511
Control variables			
Log of firm age	2.769	0.738	18247
Firm has 5-49 employees	0.056	0.230	18013
Firm has 50-249 employees	0.676	0.468	18013
Firm has 250+ employees	0.268	0.443	18013
Manufacturing sector	0.347	0.476	18273
Public ownership	0.064	0.244	18273
Private/foreign ownership	0.904	0.295	18273
Unknown ownership	0.033	0.178	18273
Share of export sales in previous year	0.477	0.348	5486
Labour productivity in previous year	44445.610	58205.750	10567
Log of real investment in fixed assets, excluding ICT, in previous year	11.073	3.518	5835
Log of baseline (2016) ICT investment * time trend	54.144	27.820	13178
WORKER-LEVEL: Unbalanced panel of 414 539 workers			
Dependent variable			
Log of real worker gross hourly wage	2.252	0.459	1330883
Worker-level controls			
Age	43.060	10.065	1330883
Worker is 17-34 years old	0.229	0.421	1330883
Worker is 35-49 years old	0.459	0.498	1330883
Worker is 50+ years old	0.312	0.463	1330883
Female	0.361	0.480	1330883
Slovenian national	0.919	0.273	1330883
Low occupational skill group	0.247	0.431	1328203
Medium occupational skill group	0.443	0.497	1328203
High occupational skill group	0.309	0.462	1328203
Low educational skill group	0.116	0.321	1330883
Medium educational skill group	0.630	0.483	1330883
High educational skill group	0.253	0.435	1330883
Low income tercile group	0.336	0.472	1330883
Medium income tercile group	0.370	0.483	1330883
High income tercile group	0.294	0.456	1330883

Annex B. Validity of the Instrumental Variable

Table B.1. IV estimation results, first and second stage

Endogenous var.	Log of lagged ICT investment	
Dependent var. (second-stage)	**Log of employment**	**Log of hourly real wage**
Second-stage coefficient	0.063**	0.039***
	(0.030)	(0.014)
First-stage coefficient	0.164***	0.083***
	(0.017)	(0.001)
F-statistic from first-stage	85.75	11900000
Observations	2,826	443,184
R-squared first-stage	0.374	0.585
R-squared second-stage	0.828	0.542
Sector-year FE	X	X
Firm controls	X	X
Worker controls		X
Sector clusters	X	X

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, and a dummy for public ownership. Firm productivity controls refer to: the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. Worker controls refer to: age, age-squared, dummies for gender, nationality, and occupational and educational skill level (low, medium or high). All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Annex C. Additional regression results and robustness tests

Table C.1. Robustness to controls: OLS specification

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Log of employment					
Log of ICT investment in previous year	0.145***	0.144***	0.144***	0.145***	0.036***	0.043***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.004)	(0.008)
Log of firm age					0.118***	0.105***
					(0.019)	(0.027)
Dummy: 5-49 employees					-2.671***	-2.473***
					(0.077)	(0.080)
Dummy: 50-249 employees					-1.603***	-1.513***
					(0.072)	(0.082)
Dummy: Manufacturing sector					0.077*	1.169***
					(0.046)	(0.072)
Dummy: Private ownership					-0.141***	-0.168**
					(0.048)	(0.063)
Share of export sales in previous year						0.171***
						(0.048)
Log of real investment in fixed assets, excluding ICT, in previous year						0.026***
						(0.008)
Baseline (2016) ICT investment * time trend						-0.006***
						(0.001)
Observations	5,528	5,528	5,528	5,528	5,527	2,850
R-squared	0.234	0.343	0.343	0.352	0.798	0.829
Sector FE		X	X			
Year FE			X			
Sector-year FE				X	X	X
Log of labour productivity in previous years						X
Sector clusters	X	X	X	X	X	X
Mean of dependent var.	3.95	3.95	3.95	3.95	3.951	4.291
SD of dependent var.	1.054	1.054	1.054	1.054	1.053	1.077

Note: *** p<0.01, ** p<0.05, * p<0.1. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Table C.2. Robustness to controls: IV specification

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Log of employment					
Log of ICT investment in previous year	0.107*	0.233***	0.231***	0.237***	0.061**	0.063**
	(0.060)	(0.029)	(0.029)	(0.028)	(0.030)	(0.030)
Log of firm age					0.093***	0.093**
					(0.028)	(0.034)
Dummy: 5-49 employees					-2.542***	-2.399***
					(0.157)	(0.147)
Dummy: 50-249 employees					-1.540***	-1.472***
					(0.107)	(0.109)
Dummy: Manufacturing sector					0.209	0.408***
					(0.215)	(0.105)
Dummy: Private ownership					-0.122**	-0.173***
					(0.053)	(0.062)
Share of export sales in previous year						0.171***
						(0.048)
Log of real investment in fixed assets, excluding ICT, in previous year						0.024***
						(0.007)
Baseline (2016) ICT investment * time trend						-0.010***
						(0.002)
Observations	5,394	5,394	5,394	5,394	5,393	2,826
R-squared	0.218	0.273	0.276	0.276	0.801	0.828
Sector FE		X	X	X	X	
Year FE			X	X	X	
Sector-year FE						X
Log of labour productivity in previous years					X	X
Sector clusters	X	X	X	X	X	X
Mean of dependent var.	3.982	3.982	3.982	3.982	3.983	4.3
SD of dependent var.	1.039	1.039	1.039	1.039	1.037	1.074

Note: *** p<0.01, ** p<0.05, * p<0.1. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Table C.3. Employment results, by workers' skill intensity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	IV (2SLS) specification								
Dep. Var.	Log of employment								
Skill type	Education			Occupation			Income level		
Level	Low	Medium	High	Low	Medium	High	Low	Medium	High
Log of ICT investment	-0.161*	0.01	0.223***	-0.071	-0.009	0.204***	-0.137*	0.055	0.244***
	(0.086)	(0.051)	(0.069)	(0.070)	(0.042)	(0.069)	(0.076)	(0.041)	(0.079)
Observations	2,371	2,826	2,788	2,177	2,754	2,810	2,502	2,802	2,757
R-squared	0.603	0.797	0.687	0.461	0.72	0.685	0.515	0.73	0.61
Sector-year FE	X	X	X	X	X	X	X	X	X

Firm controls	X	X	X	X	X	X	X	X	X
Sector cluster	X	X	X	X	X	X	X	X	X
Mean of dependent var.:	2.199	3.724	2.841	2.23	3.389	3.083	2.644	3.265	3.011
SD of dependent var.:	1.391	1.179	1.225	1.519	1.42	1.221	1.552	1.275	1.27

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Table C.4. Employment results, by gender and age group

	(1)	(2)	(3)	(4)	(5)	(6)
	IV (2SLS) specification					
Dep. Var.	Log of employment					
Age group	18-34 years old		35-49 years old		50+ years old	
Gender	Male	Female	Male	Female	Male	Female
Log of ICT investment	0.217***	0.275***	0.112**	0.087	-0.115*	-0.103
	(0.076)	(0.088)	(0.046)	(0.086)	(0.062)	(0.137)
Observations	2,763	2,183	2,811	2,670	2,739	2,404
R-squared	0.577	0.428	0.728	0.669	0.598	0.647
Sector-year FE	X	X	X	X	X	X
Firm controls	X	X	X	X	X	X
Sector cluster	X	X	X	X	X	X
Mean of dependent var.	2.557	1.415	3.042	2.165	2.577	1.92
SD of dependent var.	1.186	1.25	1.122	1.377	1.283	1.415

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Table C.5. Employment results, by firm size and firm age

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV (2SLS) specification							
Dep. Var.	Log of employment							
Group	Firm size			Firm age				
	Small	Medium	Large	0-9 years	10-19 years	20-29 years	30-39 years	40+ years
Log of ICT investment	0.026***	0.107**	0.279***	0.011	0.059*	0.102**	0.286	-0.135
	(0.009)	(0.048)	(0.077)	(0.038)	(0.030)	(0.042)	(0.185)	(0.211)
Observations	1,084	1,331	411	259	693	1,402	266	206
R-squared	0.186	0.219	0.54	0.766	0.825	0.833	0.819	0.841
Sector-year FE	X	X	X	X	X	X	X	X
Firm controls	X	X	X	X	X	X	X	X
Sector clusters	X	X	X	X	X	X	X	X
Mean of dependent var.	3.346	4.481	6.226	3.84	4.02	4.358	4.593	5.039
SD of dependent var.	0.32	0.548	0.692	0.882	0.957	1.049	1.137	1.195

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age (columns 1-3 only), dummy for small, medium, or large firms (columns 4-8 only), a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Table C.6. Robustness to using 2016 ICT investment for IV estimation

	(1)	(2)
	IV (2SLS) specification	
Dep. Var.	**Log of employment**	**Log of hourly wage**
Log of ICT investment	0.088**	0.074**
	(0.033)	(0.034)
Observations	2,700	443,184
R-squared	0.818	0.497
Sector-year FE	X	X
Firm controls	X	X
Worker controls		X
Sector clusters	X	X
Mean of dependent var.:	4.329	2.322
SD of dependent var.:	1.071	0.457

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.

Table C.7. Robustness to excluding the year 2020

	(1)	(2)	(3)	(4)
Dep. Var.	**Log of employment**		**Log of hourly wages**	
	OLS	IV (2SLS)	OLS	IV (2SLS)
Log of ICT investment	0.043***	0.066**	0.011***	0.041***
	(0.008)	(0.027)	(0.003)	(0.014)
Observations	2,168	2,146	337,919	337,056
R-squared	0.831	0.83	0.552	0.541
Sector-year FE	X	X	X	X
Firm controls	X	X	X	X
Worker controls			X	X
Sector clusters	X	X	X	X
Mean of dependent var.	4.289	4.298	2.309	2.308
SD of dependent var.	1.076	1.074	0.462	0.461

Note: *** p<0.01, ** p<0.05, * p<0.1. Firm controls refer to: log of firm age, dummy for small, medium, or large firms, a dummy for the manufacturing sector, a dummy for public ownership, the share of export sales in the previous year, and the log of investment in fixed assets, besides ICT and software, in the previous year. All regressions control for sector (NACE REV2) and year fixed effects. Robust standard errors clustered at the sector level (NACE REV2) in parentheses.
Source: Authors' calculations based on administrative and business survey data from the Statistical Office of the Republic of Slovenia.