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Returns to digital skills use, temporary employment, and trade unions in European labour markets

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Abstract

This paper investigates the moderating role of institutional factors on returns to ICT skill usage among different groups of workers in eight European labour markets. Using PIAAC data, the paper leverages the segmentation of contractual status, allowing for heterogeneous wage effects among workers holding permanent and temporary contracts. Furthermore, this study considers how gaps in ICT wage premiums mirror the compositional differences in national-specific trade union densities among contractual groups, demonstrating that wage premiums associated with ICT usage are not univocally defined by task content or demand-supply dynamics for specific sectors and occupations. The results highlight different returns between labour market segments according to national-specific trade union densities of temporary and permanent workers, revealing how the consequences of technological change are shaped by institutional cleavages.

Keywords

Information and computer technologies skills, wage premiums, European labour markets, temporary contracts, trade unions

JEL-Code

J2, E24, O30, J50

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Introduction

Over the past two decades, a substantial body of socio-economic literature has emphasised that the spread of computer-based technologies, taking the shape of robotisation and digitalisation of production and organisational processes, has significant implications for the functioning of labour markets. The pervasive adoption of these innovations entails a wider portion of the workforce nowadays being required to engage with computers, software, and electronic devices at work. This variation over time arises from structural compositional changes rather than drastic shifts in task content within occupations (Bisello et al., 2019). At the same time, the use of information and computer technologies (ICT) in the workplace is not merely a result of long-term changes in aggregate labour demand but also a pivotal factor contributing to heterogeneity in task content among different occupations, with stratified consequences at the micro, firm, and macro levels. ICT use is positively associated with occupational wages and returns and is responsible for wage dispersion between different workforce segments and occupational social classes (Fernandez Macias and Bisello, 2022). Accordingly, the computerisation of work activities has been examined as an aspect that, even after accounting for individual digital skills, has an independent effect on wage inequality in contemporary societies (Kristal, 2020).

In line with this recent stream of research, this paper aims to investigate the consequences of computerisation of work practice on the dynamics of wage inequality in the European labour market. More specifically, we focus on the role of institutional factors in shaping the ICT wage returns, looking at the individual contractual status and the contractual composition of trade unions as potential moderators of the relation at stake. We provide a micro-level analysis, and we test for heterogeneity in ICT wage returns in distinct labour market segments, distinguishing permanent and temporary workers and depending on national and contractual specific trade union density rates. This allows us to evaluate the extent to which returns to ICT skills are shaped not only by productive factors, such as individual skills and occupational task contents but also by micro-level labour market conditions and macro-level institutional features.

That being said, in terms of the specificities of ICT, the socio-economic debate has generally framed technological innovation as being associated with macro-level structural trends of occupational polarisation or occupational upgrading. Accordingly, technological change has been considered a significant catalyst for modifications in the returns to education, employment, and wage prospects of distinct segments of the workforce (Autor et al., 2003; Goos et al., 2014; Haslberger, 2021; Oesch and Rodríguez Menés, 2011). From an economic perspective, the extent to which these variations are consequential for social stratification largely depends on the overarching demand for specific occupations. Changes in demand have been associated with a shortage or redundancy of workers with high/low educational and skill endowments and, relatedly, with increasing educational gradients in employment opportunities, wage levels, and income stability among different groups whose skills and tasks are more or less complementary to technological advancements (Acemoglu, 2002; De Vries et al., 2020; Goldin and Katz, 2007; Hershbein and Kahn, 2018). However, although these changes have been empirically recognised in

most industrialised and developed countries, they have evolved at different paces and magnitudes in distinct national contexts.

Particularly within the sociological literature, cross-country divergences have been traced back to the heterogeneity of institutional factors. At odds with economic theories of skill-based or routine-based technological change, in which innovation is largely considered an exogenous factor with seemingly deterministic consequences for group-level inequalities, recent empirical evidence has pointed in the direction of possible context-specific effects (Barbieri et al., 2021; Klenert et al., 2020; Kristal and Edler, 2021; Minardi et al., 2023; Oesch and Piccitto, 2019). This suggests that factors such as labour market regulations and wage-setting institutions act as moderators to market-driven mechanisms associated with technological change (Meyer and Biegert, 2019; Oesch and Menes, 2011; Parolin, 2021). In fact, from a comparative perspective, the most pronounced direct effects of technological and digital changes have been observed in flexible and relatively unregulated labour markets (Acemoglu and Restrepo, 2020; Berger and Engzell, 2022).

Alongside other institutional elements and compositional differences in both national and local workforces, the presence and actions of trade unions have been found to prevent technological advancements from spurring consequential occupational and structural changes (Kristal and Cohen, 2017; Kristal and Edler, 2021). Consequently, unemployment elasticity tends to be higher in contexts with weaker trade unions, confirming their function as buffers (or even shelters) against the possible imbalances in supply and demand. Nevertheless, trade unions are expected to affect group-specific employment opportunities among different industries and local areas or among educational, occupational or cohort-based groups (Bechter and Brandl, 2015; Haapanala et al., 2023; Parolin, 2021). Similarly, technologically induced changes in labour demand for specific occupations have been found to respond to the strength, density, and internal composition of trade unions. Evidence and research on the distributive effects (i.e., group-level heterogeneity) of trade unions as moderators of technological change remains scarce. More nuanced perspectives suggest that possible insider-outsider dynamics may come into play as a by-product of trade union strategies and constituencies. These dynamics may result in varying levels of efficacy of trade unions, which may affect employment and wage prospects differently between incumbents and outsiders, prime-age workers and younger counterparts, or among diverse educational and skill groups (Beissinger and Baudy, 2015; Dauth et al., 2021; Mosimann and Pontusson, 2017).

Contribution: ICT skill usage and institutional cleavages

Building on this body of socio-economic literature, we analyse the wage premium associated with the on-the-job usage of ICT skills. Apart from their growing diffusion and demand, ICT skills (and ICT skill requirements) are analytically interesting for at least two reasons. First, they consist of a set of computer-based competencies that, in line with the skill-based technological change perspective, are largely complementary to a broad set of technological innovations (Acemoglu and Autor, 2011). Second, regarding recent trends in robotisation, ICT adoption is less constricted to the domain of industrial production and

can affect technical and organisational processes in a broader set of occupations and industries.

Three main features distinguish our contribution from previous studies on group-specific returns to technological change. First, we focus on the micro-level consequences of individual skill usage rather than investigating changes in wage distribution stemming from an exogenous variation in exposure to a given technology in a particular context. Second, we consider trade union moderation and different wage effects among workers with distinct contractual arrangements (temporary and permanent workers), leveraging the cleavages in terms of segmentation and dualisation dynamics between standard and non-standard workers. Third, we perform a macro-level comparison, concentrating on nation-specific trade union settings and testing the extent to which gaps in ICT wage premiums mirror compositional differences in trade union densities among contractual groups.

In doing so, we contribute to a rich body of socio-economic literature documenting how the distinction between temporary and permanent employment, far from being a mere normative and regulative fact, represents a stratifier of labour market advantages and serves as a relevant institutional dimension of labour market dualisation in contemporary European labour markets (Barbieri and Cutuli, 2016; 2018; Barbieri and Gioachin, 2022; DiPrete et al., 2006; Fauser and Gebel, 2023; Passaretta and Wolbers, 2019; Tomelleri, 2021). However, delving into the dynamics of trade union representation and discussing alternative scenarios in terms of the drivers of contractual segmentation are beyond the scope of this paper and have been more extensively explored elsewhere (e.g. Carver and Doellcast, 2021; Keune and Pedaci, 2020; Lindvall and Rueda, 2014; Meardi et al., 2021; Minardi, 2020; Pulignano et al., 2015; Pulignano and Signoretti, 2016; Thelen, 2014). Here, the focus could not be on directly testing for insider-outsider mechanisms in trade unions' strategies and representation dynamics, as this would require more fine-tuned data, not only in terms of ICT usage and type of contract but also in terms of individual trade union membership, employer-employee data, and firm or sectorial-level data (Bechter and Brandl, 2015; Bechter et al., 2012; Kostøl and Svarstad, 2023). In other words, our intention is not to provide conclusive evidence regarding trade unions' diversified strategies or different capacities to actively promote and obtain ICT returns for similar workers with distinct contractual groups. Instead, we aim to shed light on the sign, magnitude, and heterogeneity of net ICT wage premia according to both micro-level contractual arrangements and national macro-level trade union features, namely contractual-specific trade union density rates. To the extent of our knowledge, this is the first contribution focussing on the contractual distinctions in skill usage premiums and their interplay with national trade union features.

Our motivation for engaging with this topic also derived from three findings emerging from the literature on firm-sponsored learning opportunities and returns to skill development. The first is related to the presence of gaps in exposure to sponsored learning opportunities and the provision of formal training in favour of permanent workers (Cabrales et al., 2017; Cutuli and Guetto, 2013; Ferreira et al., 2018; Fouarge et al., 2012), with dualistic settings in terms of labour market regulations being particularly affected by a retrenchment of (potential) training provision (Bentolila et al., 2019; Bratti et al., 2018).

The second is linked to findings demonstrating differing returns to the training and skills between contractual groups, suggesting that even with equal exposure to training and potentially comparable skills, temporary workers tend not to be in a position to take full advantage of their competencies. The third is related to the fact that trade unions seem to have a role in shaping wage returns for permanent and temporary workers differently; that is, even if workforce representation in the workplace promotes learning opportunities regardless of contractual status, trade union coverage at the national level is more beneficial to permanent workers (Adolfsson et al., 2022). More broadly, our analysis points toward the institutional conditionality of the consequences of technological change. We argue that the extent to which ICT wage premiums are not primarily shaped by the task contents of the jobs nor by occupational-specific market-driven demand and supply mechanisms, alternative institutional settings, including country-level labour market regulation, characteristics of national industrial relations, and wage-setting schemes, can play a relevant part in addressing the socio-economic consequences of technological advancements.

Analytical strategy and preview of results

In this paper, rather than focussing on micro-level returns to skill endowments in themselves, we consider the actual use of ICT in the workplace (that we conceive of as largely demand-driven) to account for the heterogeneity across firms and productive contexts requiring the workforce to engage with ICT for productive or organisational reasons.

First, we ascertain the direction of the relationship between individual ICT usage and wage levels to prevent issues of reverse causality from blurring our line of reasoning. Individual supply-side self-selection into relatively ICT-intensive firms and ICT diffusion in specific firms at the meso-level could lead to endogeneity issues in the association between ICT and wages, thus affecting micro-level income capacity. For example, ICT diffusion in specific firms could play a role in increasing within occupation wage inequality or widening wage cleavages between permanent and temporary segments to the extent that the firm-level implementation of ICT is negatively associated with the share of non-standard employment (Cetrulo et al., 2019). This dynamic would then be magnified as long as highly productive firms are more likely to invest in ICT. It is reasonable to think that, on average, these firms tend to require more ICT use at work and/or pay higher wages, thereby providing higher ICT returns than less productive/innovative firms.

To overcome potential issues stemming from unobserved, context-specific/between-firm heterogeneity, we adopted a two-stage regression procedure implementing a shift-share instrumental variable on the use of ICT skills at work. In the same spirit as Cette et al. (2022) – but with a slightly different approach – we instrumented ICT skill use by using the leave-one-out mean of ICT skill use in the workplace for each sector, firm size, and ISCO code while excluding the values of the variable for all workers employed in the same country as individual *i*. In the same vein, we constructed a second instrument as the mean of ICT skill use at work within a country, industry, and ISCO, leaving out firms of size classes greater than the one considered for individual *i*.[1] Because these instruments

vary at the sector, firm size, and ISCO-cell level, their effects must be intended at this level of aggregation. This is a necessary compromise since no firm-specific information exists in the PIAAC dataset. Therefore, our instruments arguably represent the finest-grade tools for capturing this kind of endogeneity. As demonstrated in the sections on the empirical findings as well as in Section C of the appendix, the results relying on exogenous variation indicate a net positive effect of the ICT measure, which permits the use of the variable in its original form in the subsequent (core) part of the analysis.

We found a net ICT coefficient ranging between 4 and 6% of the hourly wage. Interestingly, despite the specificities of national contexts in terms of institutional and occupational structures, returns on ICT skill use were similar across countries and remained fairly stable and statistically significant even when job features and individual abilities and competencies, including numeracy, literacy, and, where available, problem-solving, were accounted for. This implies that our measure of ICT use, while located at the micro-level, was not intended as a proxy for a worker's individual technical/informatics skill endowment but rather as a measure of the ICT activities required and implemented in the production/business context in which the worker was involved. Within the occupational structure, exposure to ICT use is shaped according to institutional and productive national characteristics. For example, ICT distributions by ISCO were more compressed in countries such as Denmark and less compressed (i.e. more unequal) in contexts like Italy and Spain, highlighting the role of distinct occupational structures and different institutional configurations of vocational and training systems (see Section D in the appendix).

This finding suggests that ICT use can also influence the magnitude and trends of between-group inequality in distinct labour markets. The employment feature with the strongest stratifying effect on returns on ICT use was the individual contractual arrangement, with significantly lower returns for those holding temporary positions. The contractual cleavage varied across countries as the use of ICT for temporary contracts does not translate into wage premiums in contexts where union density is particularly skewed in favour of permanent workers.

The overall picture indicates a widespread wage effect of ICT use, irrespective of individual, sectoral, or occupational factors. These findings carry several relevant implications. First, they show how promoting digitalisation and innovation could benefit firms and local occupational structures and impact wage inequality trends (OECD, 2021). Second, they inform discussions on social stratification, inter-group inequalities, and labour market dualisation, both nationally and in comparative studies. Finally, they suggest the significant role of contract-specific union densities in shaping the wage gap between the two contract groups.

Data and methods

Data

The Program for the International Assessment of Adult Competencies (PIAAC) is a large-scale international study on vital adult cognitive and workplace skills. The study is

designed to assess adult skills over a broad range of abilities, from simple reading and numerical calculations to complex digital problem-solving capabilities. These abilities are measured and collected along with sociodemographic information and relevant information on the use of ICT skills in the workplace. Respondents who are not confident with computers are given a paper-and-pencil version of the questionnaire (see Figure A1 in the appendix). Despite its cross-sectional dimension, among databases that collect data on wages and skills, the PIAAC is undoubtedly the one that best captures on-the-job ICT skills use and is best suited to answer our research question. Our main variable of interest, *ictwork*, is an index that measures the use of ICT skills at work and is derived from seven items in the background questionnaire. The seven questions capture the frequency of the use of particular ICT skills for specific tasks in the respondents' current job, namely, email, Internet as a tool for understanding job-related issues, Internet to sell/buy products/services or banking, spreadsheet software like Excel, word processor use, and the use of a programming language. This variable is a compound index derived from the Organization for Economic Cooperation and Development (OECD) that ranges from 0 to 6 and summarises the seven abovementioned items.[2]

The sample is restricted to non-students, non-self-employed individuals aged between 16 and 65. To decrease the number of missing observations in the *ictwork* variable, we assigned a value of zero to those who decided to answer the paper-based questionnaire and those who failed the Computer Based Assessment (CBA).[3] To ensure that this operationalisation did not invalidate our results, we carried out further robustness checks using different thresholds according to the *ictwork* level of the least-skilled respondents of the two stages of the CBA test.[4] Our dependent variable was the logarithm of hourly wages (including bonuses), and it was regressed on structural and individual characteristics, such as occupation classification (ISCO, one digit), industry, public/private sector, education (ISCED, six levels), firm size, type of contract, gender, experience, tenure, on-the-job training, birth cohort, numeracy, literacy, and problem-solving (when available).

Another key variable was the ratio of permanent-temporary union density rates at the country level, derived from the OECD/AIAS database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention, and Social Pacts (ICTWSS). This ratio provides a composite measure of the structural underrepresentation of temporary contracts among trade union members in distinct national labour markets (OECD, 2019). This variable describes the relative advantage in terms of memberships/representation characterising permanent contracts in each national labour market. Analytically (if not theoretically), the use of this variable aligns with the hypothesis regarding different wage returns for temporary and permanent workers, assuming that trade unions can affect the magnitude of ICT returns and diversify ICT wage premia among distinct workforce segments. Notably, the trade union density ratio is a margin-free measure since it is not affected by the contractual composition of the national labour force (i.e. the respective sizes of temporary and permanent workers in each national context). This allowed us to test the extent to which ICT wage premia are associated with contractual group-specific features in terms of trade unions' membership behaviours and/or trade unions' recruitment capacities, and it proved useful in disentangling two alternative scenarios. On the one hand, the presence of possible insider-outsider dynamics typical of redistributive

conflicts, often explained in terms of active trade unions; strategies, largely determined by their internal constituencies. On the other hand, the occurrence of other dynamics of group differentiation not primarily shaped by groups; weight in trade unions; constituencies, favoured by the fact that the allocation of resources does not necessarily takes the shape of (or result in) a redistributive conflict, and it does not strictly follow a zero-sum game scheme between workforce segments. We restricted our analysis to the most representative labour markets in Europe from both a structural and institutional standpoint. We were also compelled to consider the availability of wage data and the size of country-level data to obtain a reliable model specification. The final sample consisted of 19,955 observations (see Table 1) distributed among eight countries: Denmark, France, Ireland, Italy, the Netherlands, Poland, Spain, and the United Kingdom. Unfortunately, we had to exclude Germany because of a lack of availability of income data. Nevertheless, our sample accounts for approximately 70% of the combined gross domestic product of the 27 EU member states and the UK and one-fifth of their workforce.[5] Descriptive statistics for the selected variables for permanent and temporary workers, respectively, are presented in Table 1.[6]

Trade union density rates are reported in Table 2. We built our ratio as the share of the union density rate for temporary workers over the union density rate for workers with permanent contracts. Data for Poland and Ireland are available only for the year 2016.

Model

To analyse the returns to ICT skills use, we employed a Mincer earnings function that relates a person's wages to their education, experience, and gender, as well as some structural variables such as occupation and industry. Here, we estimated nested models, including additional covariates and interactions, to check whether the coefficient of interest changes in significance and magnitude. This is more formally represented as

Table 1. Descriptive statistics by type of contract.

	Temporary				Permanent			
	Mean	Median	SD	*N*	Mean	Median	SD	*N*
Ln (hourly wage)	2.76	2.49	1.03	3424	3.24	2.87	1.18	16,116
Gender	0.55	1.00	0.50	3424	0.52	1.00	0.50	16,116
Age	32.91	29.00	11.99	3424	42.13	42.00	11.17	16,116
Experience	11.27	7.00	11.20	3424	20.79	20.00	11.50	16,116
Tenure	4.24	2.00	6.14	3423	12.05	9.00	10.07	16,107
Ictwork	1.53	1.44	1.10	3424	1.89	1.87	1.10	16,116
Numeracy[a]	271.18	273.44	49.79	3424	280.96	284.10	47.70	16,116
Literacy[a]	280.58	283.97	45.96	3424	283.34	286.61	43.25	16,116
Problem-solving[a]	292.20	294.19	41.08	2095	288.95	290.84	38.61	9778

[a]For these three domains, proficiency is considered a continuum of ability represented on a 500-point scale.

Table 2. Union density ratio for temporary/permanent workers by country.

Country	Reference year	UD temp. workers	UD perm. workers	Ratio
Denmark	2014	58.7	75.1	0.78
France	2013	2.9	12.8	0.23
Ireland	2016	26.3	30.1	0.87
Italy	2012	31.8	39.3	0.81
Netherlands	2011	9.0	21.0	0.43
Poland	2016	6.2	16.4	0.38
Spain	2010	11.4	20.6	0.55
UK	2013	14.3	26.4	0.54

$$y_i = X_{ik}\beta_k + \delta_c + \gamma_s + \varepsilon_i$$

where y is an *i*-dimensional vector referring to the logarithm of the hourly wage of individual *i* in country *c* working in sector *s*. X = (x_1, …, x_{13}) is the *i*-by-*k* matrix of independent variables, whose components, respectively, correspond to the individual level of the reported experience in the labour market and its square (x_1 and x_2 = *exp* and exp^2), to the index that measures the use of ICT skills at work (x_3 = *ictwork*) and represents our variable of interest, to the individual's gender (x_4 = *gender*), to the highest level of formal education obtained (x_5 = *educ* – ISCED in six categories), and to the individual's literacy, numeracy, and problem-solving capabilities obtained in the assessment (x_6 to x_8). We also controlled for the type of occupation (x_9 = *ISCO* – 1 digit), a dummy indicating those working in the public sector (x_{10} = *private*), firm size (x_{11} = *firm_size* – five categories), permanent versus temporary contract (x_{12} = *contract*), and the trade union density ratio between the two contract groups (x_{13}). δ_c and γ_s capture country and sector fixed effects, respectively, while ε_i represents an *i-dimensional* vector of i.i.d. normal error terms with finite unitary variances. We estimated the nested model specifications of the Mincer function and interacted *ictwork* with the contract type as well as the trade union density ratio.

The baseline model specification does not account for numeracy, literacy, and problem-solving capabilities, nor does it consider contract type and trade union density ratio. The full model specification incorporates all these variables and the interactions among our main variables of interest, namely *ictwork*, *contract,* and trade union density ratio. Our results are discussed in the following section.

Empirical results and discussion

Table 3 shows the nested specifications of the model illustrated in the "Model" section, starting with the basic model specification (1), adding literacy and numeracy (2), literacy, numeracy, and, where possible, problem-solving (2b), and, further, the type of contract (3). For the sake of clarity, we also added the two shift-share IV model estimates illustrated in the "Analytical strategy and preview of results" section and developed in the appendix (Section C). Column (4a) reports the instrument excluding the country of

individual *i,* while column (4b) excludes the firm size class of individual *i*. All model specifications account for country, sector (ISIC Rev.4, 1 digit), and ISCO fixed effects.

The results show that the ICT skills acquired in the workplace are significantly and positively correlated with hourly wages: one additional point in the *ictwork* index increases the hourly salary by 5%–6%. Considering additional factors that may lead to an increase in hourly wages does not change the sign and magnitude of the returns on the use of ICT skills at work, as the coefficient remains fairly stable in all specifications. Even if we look at the *ictwork* coefficients estimated in the IV setting, the results do not appear statistically different from the OLS estimates. In other words, possible unobserved factors do not seem to significantly affect returns on ICT skills (columns 4a and 4b vs all the OLS specifications). The coefficient estimated using the first instrument reduces the returns by one percentage point, confirming the main result of OLS estimates at the 95% level of significance. The second instrument, at the 99% level of significance, does not provide any relevant change in the coefficient.[7]

To be valid, an instrumental variable must be correlated with the dependent variable only through the endogenous variable (exogeneity) and, therefore, uncorrelated with the error term. Regarding our instrument, it seems reasonable to assume that the average ICT use level of workers in the same industry, size class, and ISCO but employed in other countries does not affect the income of workers in the same industry-firm-size-employment cell working in the reference country of individual *i*. More likely, within that cell, there may be firms competing in the European market (especially larger ones), which may encourage the use of ICT in firms in the country under consideration but not a direct increase in the workers' wages. Considering the second instrument, it is possible that our instrument is exogenous only when it excludes firm sizes that are, on average, more productive than the firm size for individual *i* (i.e. in a higher size class). This is why our instrument excludes firms in a size class higher than individual *i*. Additionally, thanks to the inclusion of the sector and ISCO fixed effects in the regressions, the leave-one-out mean strategy captures, respectively, the average ICT practices in the sector, occupation,

Table 3. Return to skills in terms of hourly wage.

	(1)	(2)	(2b)	(3)	(4a)	(4b)
	Baseline	lit_num	lit_num_ps	Contract	IV	IV2
Ictwork	0.06***	0.05***	0.05***	0.05***	0.04*	0.05**
	(0.00)	(0.00)	(0.01)	(0.00)	(0.02)	(0.02)
Permanent				0.11***	0.12***	0.11***
				(0.01)	(0.01)	(0.01)
ISCO FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
N	19,874	19,874	12,063	19,463	19,463	19,463
r2	0.829	0.829	0.857	0.837	0.837	0.837

Robust Standard errors in parentheses. |*$p < .05$, **$p < .01$, ***$p < .001$.

and firm size for the first instrument and in the sector, occupation, and country for the second one.

In summary, our instrument addresses the endogeneity problem by showing that: (i) if firm productivity can be a confounding factor, it goes in the same direction as *ictwork* (i.e. the IV coefficients have the same sign as the OLS ones) and (ii) it decreases ICT returns to a negligible extent. Thus, we are confident that what we have found so far will lead to, at worst, inappreciable overestimations of the returns on ICT skills.

Based on the analysis shown in Table 3, column 3, we continue by interacting the contract with our variable of interest to test for its moderating role at the micro-level. To better understand the relevance of the type of contract in shaping ICT returns, we calculated the marginal effects indicated in Figure 1. This figure shows that temporary contracts are worse off than their permanent counterparts. *Ceteris paribus*, being in a permanent position increased the returns on ICT skills by three percentage points. In this sense, the type of contract has a strong stratifying effect on ICT returns, with lower returns for those holding a temporary position.

At this point, we were interested in determining whether the contractual gaps in the returns on ICT skills differ among the countries considered in the analysis. We began by looking at the country estimates in Table 4. When individual characteristics, including individual abilities, and structural variables such as sector and industry are controlled for, the returns on ICT skill usage are similar across countries. Even though the point estimates range from 4% for France to 8% for the UK, there seems to be no significant difference across European countries.

Regarding the interaction with the contract variable, for the sake of clarity, we directly report the average marginal effects of the contract on skills in Table 5. Unlike in Figure 1, wage returns here are positive and reach statistical significance in all countries only for permanent workers. Therefore, it appears that the data do not allow for sufficiently large sample sizes to properly estimate the contractual gradient in returns on ICT skill usage within each country. Indeed, given the number of relevant covariates included in the model to isolate the effect of ICT skill usage (namely, individual characteristics and abilities, as well as structural variables such as industry and private/public sector), the cell-specific size and variability inevitably decrease, expanding the confidence intervals. This holds true particularly for temporary workers, who are, on average, much less numerous than permanent ones.

To confirm our argument regarding insufficient statistical power, we re-estimated our model by pooling countries together and running it separately for temporary and permanent workers, thus allowing interactions between contracts and the entire vector of independent variables. Table 6 shows the results of this exercise in the last two columns, confirming that the returns on ICT skill usage for temporary workers are, on average, positive and significant but still three percentage points lower than those of permanent workers.

Overall, our results suggest an institutional cleavage between contractual groups, indicating that when accounting for individual characteristics and skills, the type of contract still has a stratifying effect within sectors and occupations characterised by relatively homogenous tasks performed by workers.

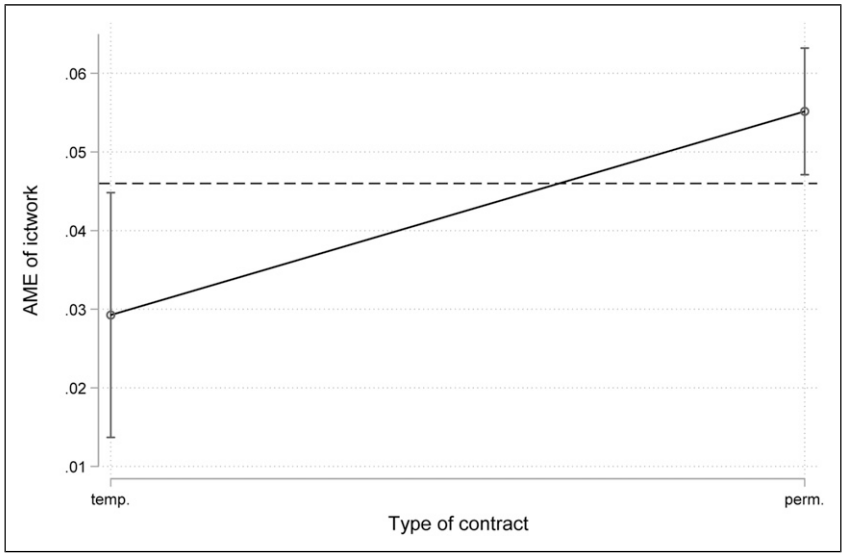

Figure 1. Average marginal effects (AME) of ictwork by type of contract, all countries (95% CI). Note: 'temp'. stands for temporary contract, and 'perm'. stands for permanent contract.

Table 4. Mincer earnings function on hourly wage by country.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Denmark	France	Ireland	Italy	Netherlands	Poland	Spain	UK
Ictwork	0.05***	0.04***	0.07***	0.05**	0.07***	0.05***	0.06***	0.08***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
N	3745	2770	2030	1177	2545	2543	1544	3601
r2	0.28	0.42	0.18	0.37	0.35	0.34	0.36	0.38

Robust Standard errors in parentheses. |*p < .05, **p < .01, ***p < .001.

As mentioned in the introduction and in the second section, the country-specific institutional context in general and the trade union setting in particular may play a crucial role in determining the consequences of technological advancements. Since the evidence clearly points to a contractual penalty in returns on ICT usage, we augmented our model with an interaction between contractual status and the country-contractual-specific trade union density rates. This allowed us to test for the salience of temporary employment in shaping ICT wage premiums, especially in contexts where union density is skewed in favour of permanent workers. Empirically, we examined the three-way interaction between *ictwork*, contract type, and the ratio between union density rates for temporary workers and permanent contracts. Thus, we focussed on national-specific trade union settings to check the extent to which gaps in ICT wage premiums between temporary and permanent workers mirror compositional differences in trade union densities among contractual groups.

Table 5. Average marginal effects of ictwork by type of contract.

Country	Contract	dy/dx	Std. err	t	P > |t|	[95% conf. interval]	
Denmark	Temporary	0.06	0.019	3.32	0.001	0.026	0.101
	Permanent	0.04	0.007	5.74	0.000	0.026	0.054
France	Temporary	−0.02	0.024	−0.93	0.355	−0.069	0.025
	Permanent	0.04	0.008	4.71	0.000	0.023	0.055
Ireland	Temporary	0.03	0.020	1.48	0.138	−0.009	0.068
	Permanent	0.08	0.019	4.35	0.000	0.046	0.121
Italy	Temporary	0.00	0.031	0.12	0.905	−0.058	0.065
	Permanent	0.06	0.016	3.42	0.001	0.023	0.087
Netherlands	Temporary	0.05	0.030	1.55	0.120	−0.012	0.107
	Permanent	0.06	0.011	5.68	0.000	0.042	0.087
Poland	Temporary	0.02	0.017	1.43	0.152	−0.009	0.057
	Permanent	0.06	0.012	4.75	0.000	0.034	0.082
Spain	Temporary	0.05	0.028	1.70	0.089	−0.007	0.104
	Permanent	0.05	0.013	4.12	0.000	0.028	0.080
UK	Temporary	0.04	0.023	1.77	0.076	−0.004	0.087
	Permanent	0.08	0.009	9.27	0.000	0.066	0.102

Table 6. Return to skills in terms of hourly wage (2).

	(3)	(3b)	(3c)	(3d)
	Contract	contract*ictwork	Temporary	Permanent
Ictwork	0.05*** (0.00)	0.03*** (0.01)	0.03** (0.01)	0.06*** (0.00)
Permanent	0.11*** (0.01)	0.08*** (0.02)		
permanent#ictwork		0.03** (0.01)		
ISCO FE	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Observations	19,463	19,463	3,424	16,039
Adj. R^2	0.84	0.83	0.78	0.84

Robust standard errors are in parentheses. |*p < .05, **p < .01, ***p < .001.

Figure 2 shows the wage returns in relation to the use of ICT skills in the workplace for the two types of contracts along the gradient of the union density ratio between temporary and permanent workers. The figure shows that the returns to *ictwork* increase as temporary contracts are unionised to a similar extent as permanent workers. As the ratio approaches 1 (i.e. the equilibrium between union density rates for temporary and permanent workers), the stratifying effect of the contract vanishes. On the other end of the spectrum, the relative underrepresentation of temporary employment comes with a significant (or even complete) compression of the ICT skill wage premium. Notably, the contractual-specific returns on ICT do not seem to fit in a zero-sum scenario since the returns on skills for

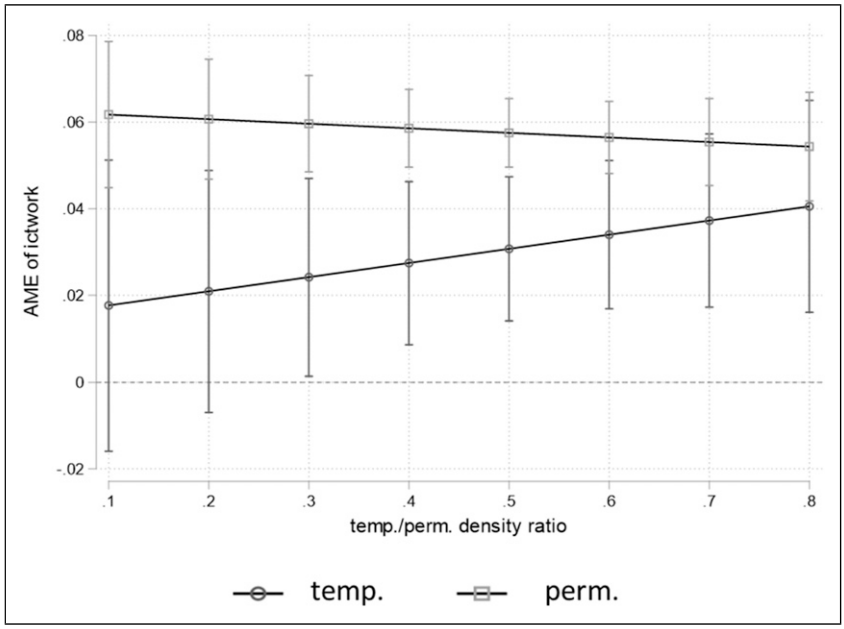

Figure 2. Average marginal effects of ictwork (AME), type of contract, and temporary/permanent density ratio (95% CI). Note: 'Temp'. stands for temporary contract, and 'perm'. stands for permanent contract.

workers with permanent contracts are statistically different from 0 and appear relatively stable, consistently higher, and inelastic.

To be more precise, the limited sample size for temporary contracts on the gradient scale restricted our accuracy, particularly at the lower end of the gradient (0.1 and 0.2). However, the figure shows statistically significant different trends up to 0.5; that is, when the unionisation rate of workers on permanent contracts is twice as high as that of temporary workers. Above this threshold, there appears to be no significant difference between the two groups, although the punctual estimates for temporary contracts are consistently smaller than those for permanent contracts.

In summary, workers with permanent contracts are always rewarded for their ICT skill usage, while the same cannot be said for workers with temporary contracts, whose returns on their skill use are contingent upon relatively high levels of unionisation.

Conclusion

In this paper, we examined the wage premium associated with on-the-job usage of ICT skills and the role of institutional factors in shaping ICT-related wage dynamics. Our study aligns with a growing body of socio-economic literature that connects differences in cross-country technology-related returns (variously defined in terms of robotisation,

digitisation, etc.) not only to structural dynamics in the overall demand for specific occupations but largely to variations in institutional factors. Our specific goal was to investigate the overall role of ICT usage in shaping individual income capacity, highlighting the effect of the contractual divide on ICT-related wage premiums.

In line with theories on the interplay between technical requirements and possible insider-outsider dynamics, we framed temporary employment as a prominent dimension of segmentation in the Western European labour market. According to labour market segmentation theories, we documented the existence of a contractual cleavage between temporary and permanent workers in returns on ICT skill use, with the contract being the main factor in moderating ICT returns among all individual and structural variables. Incorporating a macro-level comparison, we focused on national-specific trade union settings, looking at the extent to which gaps in ICT wage premiums between temporary and permanent workers derive from imbalances in the trade union densities of the two contractual groups. Despite the structural disparity in the relative weight of permanent and temporary workers in trade unions' constituencies, a convergence in trade union density rates between the two groups is associated with lower gaps in ICT wage returns.

We found that the use of ICT does not translate into relevant wage premiums for workers with temporary contracts in contexts where union density is particularly skewed in favour of permanent workers, that is, in national labour markets where workers' membership behaviours and trade unions' recruitment capacities are strongly stratified across the contractual cleavage. Roughly speaking, returns on the use of ICT skills for temporary workers grow as their unionisation approaches the levels of their permanent counterparts. For temporary workers to enjoy ICT-related wage premiums similar to their permanent counterparts, high levels of unionisation of temporary workers are needed. In fact, when the two rates equalise, the returns tend to be similar, and the wage gap in the returns on ICT skill use fades away. However, this is not the case for regular contracts, which display stable rewards. Our results do not appear to be consistent with a zero-sum game in which ICT wage returns of the two contractual groups appear (intrinsically) negatively associated.

All in all, with some caution, our results show that temporary workers are negatively affected by strong contractual segmentation in the diffusion of trade unions, at least according to the specific analytical framework and outcome at stake. ICT returns equalise when there is uniformity in trade union behaviours among both contractual groups, regardless of the structural representation of temporary workers in terms of trade unions' membership composition. This result aligns with previous studies that have demonstrated the partial independence of collective agreement contents from trade union constituencies (Benassi and Vlandas, 2016) and with research findings indicating that trade union structural difficulties in representing and recruiting outsiders are at least partially at the base of the penalisation of temporary contract holders (Pulignano et al., 2015).

That being said, our study entails some empirical and analytical shortcomings worth addressing. A possible limitation is represented by the cross-sectional nature of the analysis and the relatively limited number of countries considered in the study. From a broad analytical perspective, we oversimplified the complex links between trade unions, contractual cleavages, and computer-related technological change. We consciously did it

due to the specificity and novelty of the study at hand and out of analytical clarity. Recent theoretical and empirical contributions help fill this gap by theorising and documenting how these phenomena are intertwined and display a set of possible mutual feedback effects.[8]

More substantially, a further limitation is undoubtedly the consideration of a single institutional trait of the national labour market. Regarding labour market segmentation, the contractual-specific trade union density in our study was conceived and empirically treated as the main driver of gaps in ICT returns between temporary and permanent workers. Even if the empirical evidence points to the relevance of this specific trade union feature, future contributions could benefit from explicitly considering institutional complementarities and the complexity of collective bargaining systems (Garnero, 2021). A second aspect is the lack of a more in-depth analysis of the moderating role of trade unions at the regional or firm level. In the same vein, due to the lack of sector and contractual-specific data that can be merged with the micro-level data at hand, heterogeneity across occupations and sectors in ICT wage returns is captured by occupation and industry fixed effects. While this option represents a solution to account for the occupational structure and sectorial composition of national labour markets, it is insufficient to grasp the sectorial heterogeneity of trade unions (Bechter et al., 2012; 2015).

A final issue, not directly linked with collective bargaining systems, is the specific institutional feature used to grasp the potential role played by dualisation and segmentation dynamics. Arguably, an alternative measure of institutional segmentation could have been EPL (as a ratio); however, because the data in this study are derived from a cross-sectional form, we would have been forced to rely exclusively on country-specific cross-sectional levels of protection for distinct contractual groups, a practice that is increasingly criticised and progressively less frequent in the socio-economic literature. Nevertheless, we are confident that our approach in examining country, industry, and occupation-specific fixed effects enabled us to focus with a reasonable degree of precision on our main variables of interest (i.e. individual contractual status and contractual dualisation in trade union dynamics) due to the centrality of institutional factors in general and industrial relations in the debate on the macro- and micro-level spill-overs of technological change.

The evidence provided arguably paves the way for future contributions and raises several considerations worthy of further analysis. Determinants of the underrepresentation and lack of participation of temporary workers in trade unions point to possible endogeneity issues as they may be related either to less attractiveness of temporary workers for unions or to the fact that this selected group of workers entails little interest in union affiliation and lower utility of participation. The main findings of this study suggest that stratified participation and contractual-based recruitment gaps indeed appear to be consequential for labour market segmentation outcomes and inequality dynamics more broadly. Another aspect is related to an additional twofold interpretation of the findings, with implications going beyond the realm (but not outside the scope) of industrial relations. First, our results suggest that in shaping micro-level economic and occupational rewards, technological change will reasonably increase the role of meso-level factors such as firm and sector characteristics (OECD, 2021) or, at the micro-level, the influence of

other job characteristics, including the control of information at the workplace, as some scholars have recently proposed (Kristal, 2020). Second, if it is true that the skill requirements associated with technological change have an asymmetrical impact on different groups in the labour market, these distributive effects are not necessarily contingent upon occupational class or educational dimensions, as with skill and routine bias perspectives on technological change. We add to this literature by showing that ICT skill usage magnifies other cleavages within the workforce, such as the contractual one. If this holds true, it implies that technological advancements can significantly interplay with national labour market segmentation dynamics and dualisation dynamics in trade union representation.

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Supplemental Material

Supplemental material for this article is available online.

Notes

1. A more detailed discussion of the strength, validity, and test of the instruments is provided in the Appendix.
2. Please check the related OECD documentation in the references for further information.
3. The assumption behind this operationalisation was that respondents used pen and paper because they failed the computer test or because, from the beginning, they felt not confident completing the test via computer.
4. Our results remained substantially unchanged. See Section E in the appendix.
5. Source: OECD and Eurostat.
6. Table A1 in the appendix provides country-specific instead of contractual-specific descriptive statistics.
7. The coefficient is slightly smaller than the OLS coefficient at the level of the third decimal.
8. For example, digitalisation has been shown to be intertwined with flexibilisation dynamics (Eurofound, 2021), computerisation has been demonstrated to exert a net negative effect on unionisation trends (Kristal, 2019), and, as previously mentioned, trade unions may play a moderating role in mitigating the effects of technological change on national occupational structures in the context of possible insider-outsider dynamics (Kostol and Svarstad, 2023;

Parolin, 2021). In our view, this complexity poses serious issues concerning the possibility of empirically deriving conclusive, overarching causal claims regarding the phenomena under scrutiny.

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