ICT Investment and Unemployment in Welfare States

A Panel Data Analysis by Educational Level in OECD Countries

Tobias Achim Rau

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Author: Tobias Achim Rau
Email: contact@tobiasachimrau.de

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1 Introduction

The increasing digitalization and automation of work are fundamentally transforming labor markets worldwide. A key driver of this transformation is investment in information and communication technologies (ICT), which contributes significantly to productivity growth and innovation (OECD, 2019, p. 49).

While technological advances often increase demand for highly skilled workers, the role of low-skilled labor remains ambiguous. The distinction between skills and tasks is crucial, as technology tends to automate or outsource specific tasks, reshaping job profiles (Acemoglu & Autor, 2011, p. 1045). This dynamic contributes to labor market polarization: employment grows at the high and low ends of the skill distribution, while middle-skill jobs decline (Acemoglu & Autor, 2011, p. 1070).

ICT investment may accelerate these trends by increasing demand for high-skilled labor while displacing lower-skilled tasks (Balsmeier & Woerter, 2019, pp. 2–4). Technological change not only eliminates jobs through automation but also creates new occupations, especially in areas combining human cognitive abilities with digital tools (Brynjolfsson & McAfee, 2014, pp. 210–214).

This paper investigates how national ICT investment affects unemployment across different educational levels in OECD countries. The study asks:

> **"How does national ICT investment influence unemployment rates across educational levels in welfare states?"**

The findings aim to contribute to the debate on digitalization's labor market effects and provide evidence for policy decisions on labor market regulation and education.

2 Related Literature and Hypotheses

2.1 Digitalization, ICT Investment, and Labor Markets

Digitalization and automation have deeply transformed labor markets, particularly affecting employment structures across skill levels. Routine-intensive tasks—both manual and cognitive—are increasingly automated, with low- and medium-skilled jobs most at risk of displacement (Frey & Osborne, 2013; Goos et al., 2014). Simultaneously, demand has risen for high-skilled workers with analytical and technological competencies (Autor et al., 2013). This phenomenon is often described as job polarization (Autor, 2015).

ICT investment is a key driver of this transformation. Studies show that ICT-intensive firms gain efficiency and competitiveness, but these benefits are unequally distributed across the workforce (Brynjolfsson & McAfee, 2014; Corrado et al., 2018). While creating new jobs in digital sectors, ICT investment often accelerates the automation of routine tasks, putting low-skilled workers at greater risk of unemployment.

2.2 Welfare State Institutions and Labor Market Polarization

Institutional frameworks shape how countries adapt to technological change. Welfare state regimes differ in their capacity to mitigate adverse effects of digitalization. Nordic welfare states, with strong labor market policies and active training systems, may better cushion job polarization (Esping-Andersen, 1990). Liberal regimes, emphasizing market flexibility and minimal social protection, may experience stronger polarization (Hall & Soskice, 2001). Central European and Southern European regimes present mixed patterns, depending on their regulatory structures and inclusiveness (Ferrera, 1996).

2.3 Theoretical Framework

This study builds on Schumpeter's concept of *creative destruction*, where technological progress disrupts existing structures but enables long-term economic renewal (Schumpeter, 1976). Theories of *skill-biased technological change* (SBTC) and *routine-biased technological change* (RBTC) further explain how digitalization increases demand for high-skilled labor while eroding routine jobs (Goos et al., 2014; Violante, 2008).

2.4 Hypotheses

Based on the literature, we propose three testable hypotheses:

- **H1:** Countries with higher ICT investment exhibit lower unemployment rates among high-skilled workers.

- **H2:** Higher ICT investment is associated with higher unemployment among low-skilled workers, due to the automation of routine tasks.
- **H3:** Welfare state regimes moderate the polarization effect. Nordic regimes exhibit less labor market polarization, while liberal regimes show stronger polarization.

3 Data and Methods

3.1 Data Sources

This study uses data from the OECD, which provides harmonized economic and social statistics across countries (OECD, 2025). The main variables are ICT investments (OECD, 2022c) and unemployment rates by educational attainment (OECD, 2022f). Control variables include GDP per capita (OECD, 2022d), trade union density (OECD, 2022e), tertiary education share (OECD, 2022a), and employment protection regulation (OECD, 2022b). Welfare state type is classified following Esping-Andersen (Esping-Andersen, 1990).

The dataset covers 35 OECD and selected non-OECD countries[1] from 2005 to 2022, resulting in 3973 observations after merging and cleaning.

ICT investments (share of GDP) capture gross fixed capital formation in digital infrastructure, software, and technologies. Unemployment rates are disaggregated by educational attainment: low (no or lower secondary education), medium (upper secondary or vocational training), and high (tertiary education).

Missing values for trade union density, tertiary education share, and labor market regulation were linearly interpolated or extrapolated. GDP per capita was rescaled (per 1000 USD) for interpretability.

3.2 Operationalization

The dependent variable is the unemployment rate (`UNEMPLOYMENT_RATE_PERCENT`), by education level. The main independent variable is ICT investment (`ICT_INVEST_SHARE_GDP`), defined as the share of GDP invested in ICT assets (OECD, 2022c).

Control variables:

- **GDP per capita** (`GDP_PER_CAPITA`): measures economic prosperity (OECD, 2022d).
- **Trade union density** (`PERCENT_EMPLOYEES_TUD`): captures collective bargaining strength (OECD, 2022e).
- **Tertiary education share** (`PERCENT_TERTIARY_EDUCATION`): proxy for human capital (OECD, 2022a).
- **Labor market regulation** (`REGULATION_STRICTNESS`): degree of employment protection (OECD, 2022b).

[1] Australia, Austria, Belgium, Bulgaria, Brazil, Canada, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Türkiye, Slovak Republic, Slovenia, United Kingdom, United States.

- **Welfare state type** (`WELFARE_STATE`): Nordic, Central European, Anglo-Saxon, Southern European, Post-socialist (Esping-Andersen, 1990).

3.3 Analytical Strategy

We apply fixed-effects (FE) panel models to estimate the impact of ICT investment on unemployment by education level. FE models control for unobserved country-specific heterogeneity and focus on within-country variation over time. Random-effects models are not used due to potential correlation between unobserved heterogeneity and explanatory variables (Wooldridge, 2010).

We include year fixed effects to account for macroeconomic shocks and technological trends. Interaction terms between ICT investment and welfare state type allow us to assess institutional moderation of ICT effects on labor markets.

4 Results

4.1 Descriptive Results

Table 1 presents descriptive statistics for the key variables across the sample of 35 OECD and selected partner countries (2005–2022). ICT investments range from 0.7% to 8.7% of GDP, with a mean of 2.5%. Unemployment rates vary substantially, with a mean of 8% and values ranging between 0.8% and 50%. GDP per capita shows significant dispersion, ranging from 13.3k to 137.7k USD (mean: 43.7k USD). Trade union density and tertiary education shares also display considerable cross-country heterogeneity.

Table 1: Descriptive statistics (2005–2022)

Variable	Mean	SD	Min	Max
ICT investment (% of GDP)	2.46	0.98	0.73	8.69
Unemployment rate (%)	7.95	6.34	0.82	49.89
GDP per capita (1000 USD)	43.73	17.13	13.34	137.72
Union density (%)	28.45	20.71	4.50	92.20
Tertiary education share (%)	33.65	9.27	12.87	59.96
Labor regulation (0-6)	2.19	0.83	0.00	4.88

Country-level trends reveal substantial differences. For example, Sweden shows persistently high ICT investment (4–5% of GDP) and low unemployment among high-skilled workers. Spain illustrates stronger cyclical effects, with low-skilled unemployment peaking during crises, while ICT investment increased moderately over time. Poland experienced declining unemployment across all skill groups alongside relatively stable ICT investment. These patterns suggest that macroeconomic context and institutional settings, rather than ICT investment alone, drive short-term employment dynamics.

Figure 1 illustrates these relationships for selected countries representing different welfare regimes. The plots highlight variation in unemployment trajectories by education and modest correlations with ICT investment levels.

Figure 1: ICT investment and unemployment trends by education in selected countries

4.2 Descriptive Results

5 Multivariate Results

Table 2 summarizes the fixed-effects models with controls. ICT investment shows a positive and significant association with unemployment across all education groups: low-skilled (2.302***), medium-skilled (1.157***), and high-skilled (0.455***). The strongest

association is found for low-skilled workers, supporting the hypothesis that digitalization disproportionately affects routine and low-skill jobs.

Table 2: Fixed-effects models with controls

	Low skill	Medium skill	High skill
ICT investment	2.302***	1.157***	0.455***
GDP per capita	-0.194***	-0.153***	-0.083***
Tertiary share	0.606***	0.282***	0.140***
Union density	0.128***	0.106***	0.025+
Labor regulation	-0.147	-0.118*	-0.085*
R^2	0.304	0.308	0.272

ICT investments are associated with higher unemployment in flexible labor markets (Anglo-Saxon countries). Interaction models (Table 3) show that institutional settings significantly moderate these effects. In post-socialist states, ICT investment effects on unemployment are significantly weaker compared to Anglo-Saxon regimes (e.g., -5.200*** for low-skilled). In Southern European states, ICT investments are linked to lower unemployment for medium- and high-skilled workers. Nordic states show a small positive interaction for high-skilled unemployment (+0.639*), possibly reflecting fast digital transitions that challenge even highly educated workers.

Table 3: Interaction models: ICT investment × welfare regime

	Low skill	Medium skill	High skill
ICT investment (base: Anglo-Saxon)	4.671***	3.246***	1.259***
× Post-socialist	-5.200***	-3.579***	-1.415***
× Central European	-0.871	-0.594	-0.302
× Nordic	0.220	-0.317	0.639*
× Southern European	-1.801	-3.066***	-2.880***
R^2	0.337	0.333	0.306

Macroeconomic controls, such as GDP per capita, remain robust and negative across models, indicating that stronger economies are associated with lower unemployment. The inclusion of welfare regime interactions increases the explanatory power (R^2) by about 3-5 percentage points, highlighting the relevance of institutional context in shaping the employment effects of digitalization.

Overall, the findings suggest that ICT investments contribute to labor market polarization but that institutional factors can buffer or amplify these effects depending on the welfare regime.

6 Robustness

7 Policy Discussion

7.1 Conclusion

The results of this study provide valuable insights into the relationship between *ICT investments* and the *unemployment rate* across different educational levels. They reveal significant associations and highlight the role of institutional frameworks in shaping the employment effects of digitalization. This research contributes to the academic debate on the interactions between technological progress, labor market structures, and political institutions, offering practical implications for policymakers, businesses, and educational systems.

Hypothesis **H1**, that *ICT investments* are associated with lower *unemployment rates* among highly skilled workers, is not supported by the findings. Contrary to expectations, higher *ICT investments* correlate with increased unemployment even for the highly qualified, challenging the classical assumption of skill-biased technological change that highly skilled workers generally benefit from digitalization. This may be explained by the increasing automation of not only simple but also knowledge-intensive tasks.

Hypothesis **H2**, that *ICT investments* increase unemployment among low-skilled workers, is supported by the results. The strongest positive effect appears for the low-skilled group, suggesting that simple jobs are particularly affected by automation. This aligns with skill-biased technological change and job polarization theories, which argue that digitalization displaces middle-skill jobs while benefiting high-skill workers.

Hypothesis **H3**, that institutional factors such as welfare state regimes can mitigate the negative effects of *ICT investments*, is partially confirmed. Interaction models show that post-socialist and Southern European welfare states dampen the negative employment effects of digitalization, whereas Anglo-Saxon countries display a clear positive relationship between *ICT investments* and rising unemployment. This indicates that institutional structures play a crucial role in how digitalization impacts labor markets.

Control variables provide additional insights. GDP per capita consistently exhibits a significant negative effect on unemployment across all education groups. Labor market regulation stabilizes employment for the highly skilled but tends to correlate with higher unemployment for the low-skilled. The share of tertiary education positively affects unemployment in all groups, indicating that increased education alone does not offset the negative impacts of digitalization.

Overall, these findings emphasize that the effects of *ICT investments* are highly context-dependent and intertwined with institutional frameworks. While digitalization leads to job losses in some countries, it can stabilize or even foster employment in others. This calls for comprehensive policy approaches combining technological investments with labor market and education policies to manage structural change socially and effectively.

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A Anhang

A.1 Projektdateien

Alle Projektdateien (R-Code, TeX-Dateien, sowie alle Datensätze) welche für die Arbeit und die Analyse genutzt wurden, sind gebündelt im folgenden GitHub Repository zu finden (der erste Link führt zum Repository - der zweite direkt zum R-Script):

https://github.com/TAR-IT/powi-bachelorthesis

https://github.com/TAR-IT/powi-bachelorthesis/blob/main/R/script.R