SkiLMeeT

Indicators to measure past, current and forecasted skill shortages and mismatches

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Grant agreement no. 101132581

Deliverable: D3.4 Report past, current, forecast skills

Due date: 30.06.2026

Funded by the European Union

Document control sheet

Project Number:	**101132581**
Project Acronym:	SkiLMeeT
Work-Package:	3
Last Version:	20.06.2026
Issue Date:	30.06.2026

Classification

Draft	x
Final	
Confidential	
Restricted	
Public	x

Legal notice

This project has received funding from the European Union's Horizon 2022 Research and Innovation programme under grant agreement No. 101132581. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority can be held responsible for them.

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Abstract

This report develops indicators to measure labour and skills shortages, as well as skills mismatches, at the occupational level, building on the datasets produced in Tasks 2.1, 2.2, and 2.3. To assess past and current labour shortages, we constructed indicators based on new hires, unemployment rates, and skills possessed by employees, using data from the EU Labour Force Survey (EU-LFS) and the European Skills and Jobs Survey (ESJS). For the analysis of skills shortages and mismatches, we examine indicators related to the perception of over- and under-skilling, wages, working hours, and employment growth, drawing on EU-SILC, EU Labour Force Survey (EU-LFS) and the European Working Conditions Survey (EWCS).

To project future labour market developments, the report applies a theoretical model that endogenises the skill content of tasks across occupations, the equilibrium prices of skills, and the allocation of workers across occupations, sectors, and regions. The model outputs are used to generate projections of future labour demand across European countries.

Keywords: Labour shortage, skill shortage, skill mismatch.

1 Introduction

The aim of this report is to create comprehensive indicators of past, current and future labour and skills shortages, as well as skills mismatches, at occupational level. Leveraging data from other SkiLMeet Tasks (2.1, 2.2 and 2.3), our objective is to provide a nuanced understanding of past and current skills dynamics, and to project future labour market trends.

To assess historical and current labour shortages, we analyse data from the EU Labour Force Survey (EU-LFS) and the CEDEFOP European Skills and Job Survey (ESJS), examining key metrics such as new hires, unemployment rates and skills possessed by employees. This enables us to identify persistent discrepancies between labour demand and supply across sectors.

To identify skills mismatches, we draw on datasets including the EU Statistics on Income and Living Conditions (EU-SILC), EU-LFS and the Eurofound European Working Condition Survey (EWCS) to extract key metrics of skills mismatch, wages, working hours and employment growth. The diversity of data sources may affect the degree of comparability between indicators and between groups of countries.

To forecast the future of employment, we use a theoretical model that considers: i) the skill content of tasks across occupations, ii) equilibrium skill prices; iii) The allocation of workers across occupations, sectors and EU regions.

By simulating workers' sorting patterns, the model generates projections of future labour demand and skill requirements that account for technological advancements, demographic shifts, and economic trends. This approach combines empirical analysis with forward-looking modelling to provide policymakers, training providers and industry leaders with actionable insights to address emerging labour market challenges.

To describe the labour market dynamics indicators, we produce in this report for the European Union, we grouped European Union countries covering four parts of the European Union: Western, Nordic, Eastern, and Southern Europe. This classification is based on geographical criteria, the various stages of European integration, and some shared economic characteristics.

The Western group comprises the founding members of the European Union as well as states that joined the European integration process at key stages in its development: France, Germany, Austria, Belgium, the Netherlands and Ireland. The Nordic group comprises the Nordic countries that are members of the European Union, namely Denmark, Finland and Sweden. The Eastern group mainly comprises the countries of Central and Eastern Europe that joined the European Union from 2004 onwards, notably

Czechia, Bulgaria, Hungary, and the Baltic states. Finally, the Southern group comprises the countries of southern Europe that joined the EU at various times: Greece (1981), Portugal, Spain (1986), Italy (1957), Malta and Chypre (2004).

This classification allows for the comparison of groups of countries with relatively similar historical trajectories and socio-economic profiles. The Western and Nordic groups are characterised by high income levels, relatively stable labour markets and well-developed social protection systems, making them relevant benchmarks for the analysis of advanced economic and social policies. Conversely, the Southern and Eastern groups face more pronounced structural challenges, such as GDP per capita below the European average, higher unemployment rates and incomplete economic convergence trajectories. Studying these groups thus provides a better understanding of certain persistent imbalances within the European Union.

However, the dominant economic sectors reveal different development models in the four European regions. Western Europe is characterised by a diversified, export-oriented economy driven by advanced services, such as finance and consultancy, and high-value manufacturing industries, such as automotive and aerospace. Northern Europe is notable for its innovation-based economy, with a strong focus on information technologies, green energy, and pharmaceuticals. Southern Europe's economies are more vulnerable to external shocks such as the COIVD-19 pandemic or climate-related events due to their reliance on traditional sectors such as tourism and agriculture. Eastern Europe is characterised by transitioning economies, where manufacturing, information technology and agriculture play a central role. The region continues to attract foreign investment thanks to its combination of a skilled workforce, competitive labour costs, and growing integration into European supply chains.

The four groups aim to highlight general regional trends whilst acknowledging the existence of significant internal heterogeneities. For example, the economic and social situations in Greece and Italy, although they belong to the same group, may differ significantly in several respects. These national specificities will be considered in the analysis where relevant.

2 Past and current labour and skills shortages

2.1 Labour shortage

We use the McGrath approach (described in deliverable D2.3). This approach developed by McGrath (2021, 2020, 2019); and McGrath and Behan (2017), also used by Bachmann et al. (2023), proposes a calculation of a shortage/surplus ratio suited for the Labour Force Survey (LFS).

The calculation is as follows: *(number of recruits to the occupation in the year under review) / (number of inactive persons in the year under review with previous work experience in this occupation)*. McGrath (2021) most recent report on EU25 combines the data of the LFS with the EURES National Coordination Offices from the latter half of 2020 and the first quarter of 2021. The report estimates that 28 occupations, employing 14% in the EU workforce in 2020 (27 million of workers) are classified as shortages, with 19 occupations classified as shortages of high magnitude. Additionally, the most prominent occupations in shortage were healthcare and STEM (science, technology, engineering, and mathematics) occupations at all levels.

2.1.1 Data and methods used to calculate the European indicators

Following the McGrath approach, we use the EU-Labour Force Survey (data available from EUROSTAT MICRODATA) to calculate the shortage/surplus ratio as the following = (number of recruits to the occupation ISCO 3 digits[1] in the year under review) / (number of inactive persons in the year under review with previous work experience in this occupation ISCO 3 digits). The reference population covered is the population aged 15-64 with no missing values in their occupation codes.

As LFS data is not made representative for migrants present in EU countries, aligned with Bachmann et al. (2023), we use external data to generate population weights for migrants. These weights are based on numbers taken from United Nation migration dataset for the EU countries that we analyse Moreover, as not all migrant individuals are part of the active population of each destination country, we also use Eurostat data and apply the percentage of 15-64 years that are in active population for natives, EU and

[1] For details regarding ISCO 3 digits, see https://ilostat.ilo.org/methods/concepts-and-definitions/classification-occupation/

non-EU individuals in each EU destination country studied in three points of time 2014, 2019 and 2021, due to data limitation in the United Nation migration dataset.

We use 2015 United Nation migration data and 2014 Eurostat values for reweighting LFS 2014 to 2016, 2019 United Nation migration data and 2019 Eurostat values for reweighting LFS 2017 to 2019, and 2021 United Nation migration data and 2021 Eurostat values for reweighting LFS 2021 to 2023.[2] We use weight calibration procedures based on iterative proportional fitting, or raking outlined in (Deville et al., 1993), to adjust the final sample for differences between the demographic composition of our sample and the actual populations in the EU analysed countries. In short, the procedure is based on a post-stratification adjustment[1] of the population using the two categorical variables (control variables: gender and region of origin: Africa, Asia, Europe, North America, Central and South America) that are available for both the population and the sample to break down the population.

The procedure is implemented in Stata by (Kolenikov, 2014) as Stata package 'ipfraking'. We are implementing this package to generate the population weights for the LFS data based on the two common control variables.

Due to data unavailability certain years, 17 EU countries are covered for the periods 2014-2019 & 2021-2023:

Table 1. Labour Force Survey – EU-17 Countries covered

Code	**Name**	**Code**	**Name**
	Western countries		**Eastern countries**
AT	Austria	CZ	Czechia
BE	Belgium	EE	Estonia
FR	France	HU	Hungary
DE	Germany		**Southern countries**
IE	Ireland	IT	Italy
NL	The Netherlands	EL	Greece
	Nordic countries	PT	Portugal
FI	Finland	ES	Spain

[2] Due to the COVID-19 pandemic shock in 2020, this year is excluded from the analysis.

DK	Denmark	CY	Cyprus
SE	Sweden		

The data table contains the country code (AT, BE, etc.), the year, the ISCO 3-digit codes, and the labour shortage indicator.

2.1.2 Differences and variations between country types and countries

To present the differences and variations between countries and country types, we have organised the labour shortage indicator into ISCO groups, as shown in the table below.

Table 2. ISCO groups

ISCO groups	Description
1	Managers
2	Professionals
3	Technicians and associate professionals
4	Clerical support workers
5	Service and sales workers
6	Skilled agricultural, forestry and fishery workers
7	Craft and related trades workers
8	Plant and machine operators, and assemblers
9	Elementary occupations

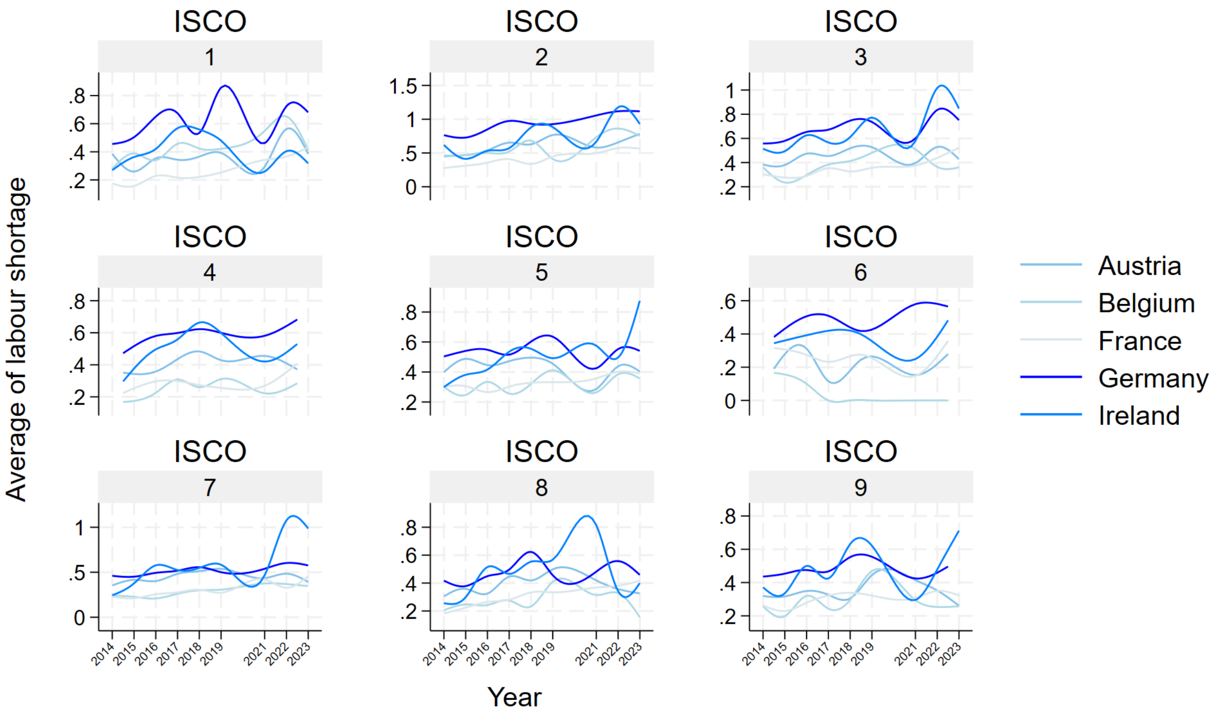
2.1.2.1 Western countries

For the Western European countries considered, labour shortages were generally not present (values of the measure below 1) and the measure was relatively stable before 2019[3]. From 2021 onwards, however, a pronounced increase was observed, reflecting the greater imbalance in labour markets following the COVID-19 crisis. Tensions were primarily concentrated in skilled professions (ISCO groups 2 and 3), particularly in Germany and Ireland, as well as in certain technical occupations like ISCO group 7.

[3] Due to the presence of missing values that may bias the results, The Netherlands observations are not reported in the figure of Western countries.

Germany stands out with being above other western counties for many ISCO groups. Ireland has experienced several recent peaks in different ISCO groups. Overall, these countries share a common dynamic of increasing labour shortages since 2020, but with varying intensity and occupational structure.

Figure 1. LFS – Labour shortage in Western countries

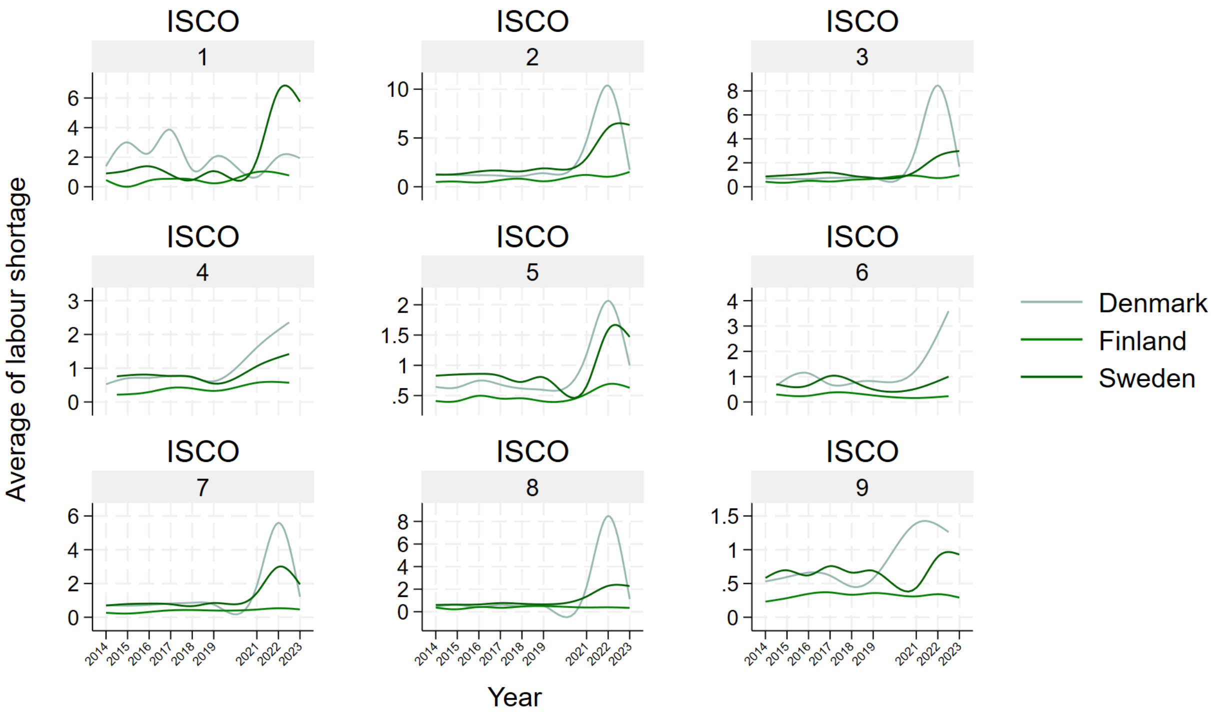


2.1.2.2 Nordic countries

Labour shortages are significantly more severe and widespread in the Nordic countries than in the rest of Europe. Before 2020, most ISCO groups in Nordic countries were around the threshold of 1. Denmark stands out in particular, having experienced very high and persistent levels, with extreme peaks in several ISCO groups, especially in ISCO 1.

After 2020, except Finland, the other two countries experienced labour shortages in most occupational groups. Denmark and Sweden have also experienced a sharp intensification of post-COVID labour market tensions, in most occupations. Overall, these countries have very tight labour markets that are close to full employment, where recruitment difficulties are structural and have worsened since 2021.

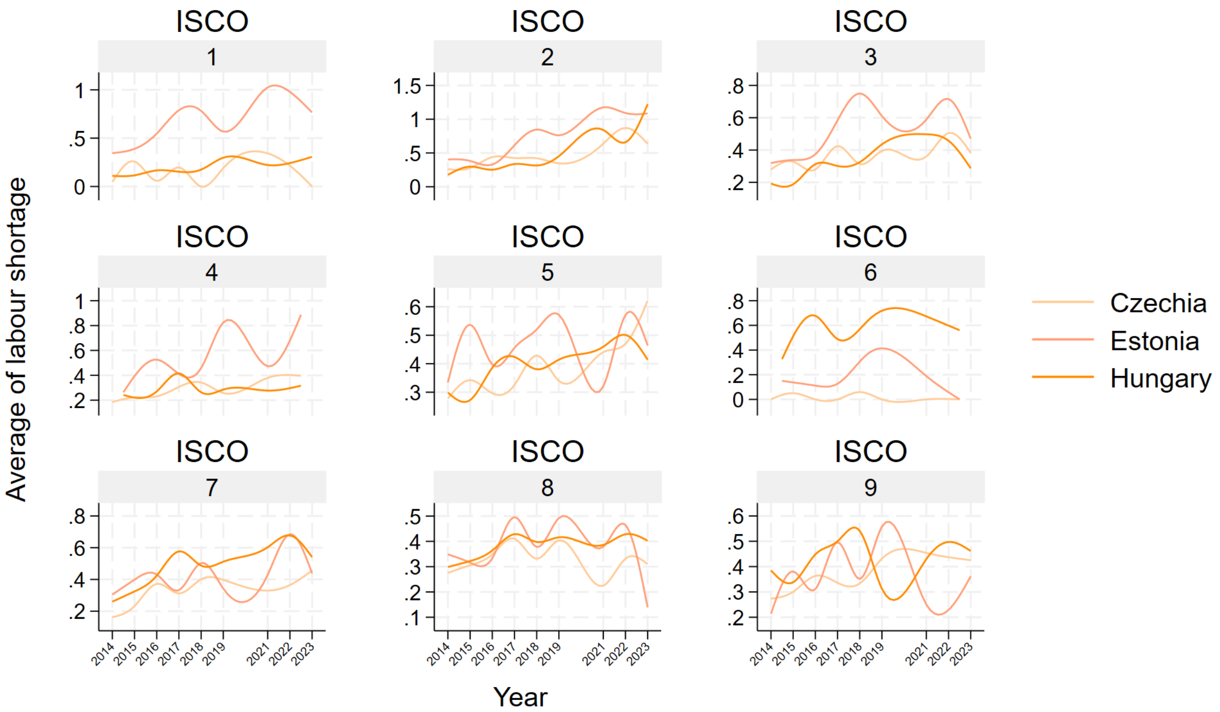
Figure 2. LFS – Labour shortage in Nordic countries



2.1.2.3 Eastern countries

For the three Eastern European countries considered, some few labour shortages appear only after 2020 for manly one ISCO group, the 2, in two countries. Before 2019, significant and irregular peaks were observed in the measure, but it stays below the threshold of 1. Focusing on Estonia, the figure suggests structural imbalances in certain labour market segments, where after 2020, these tensions intensified, especially in ISCO group 2 and only temporarily in ISCO group 1. Czechia stands out with being often below other countries for most of occupations. Hungary, on the other hand, exhibits a more moderate upper trend. Overall, these countries didn't' reveal specific concern about labour shortages.

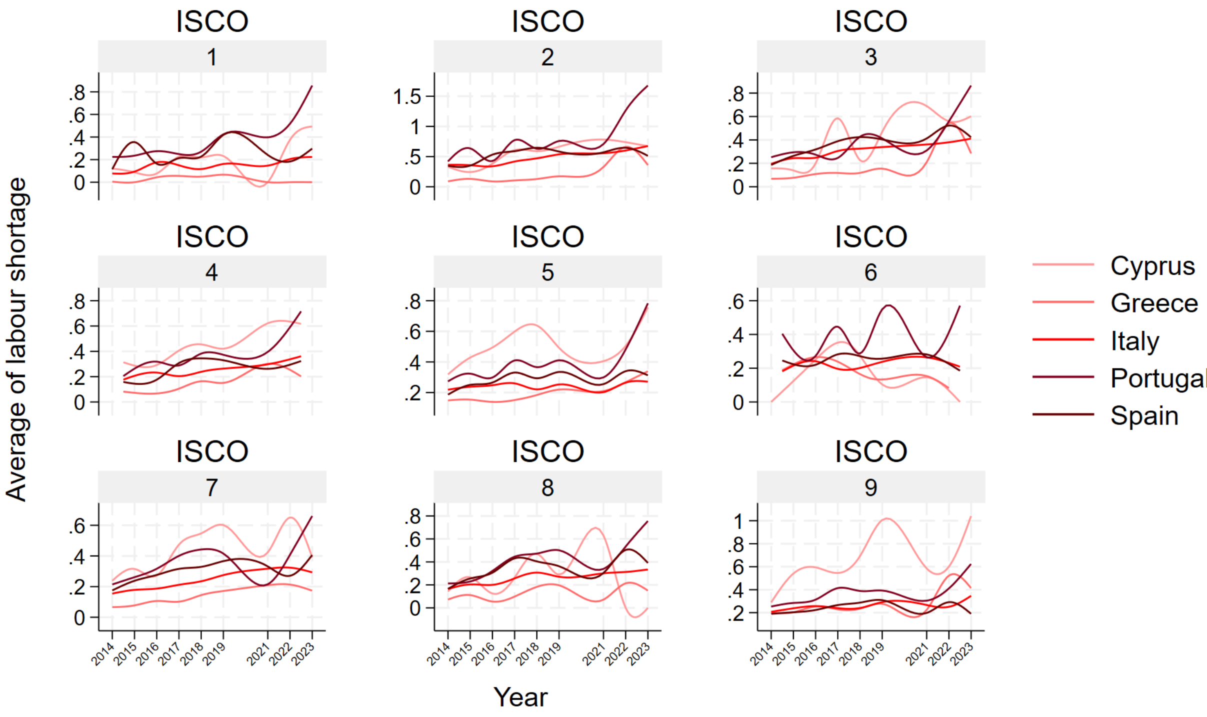
Figure 3. LFS – Labour shortage in Eastern countries



2.1.2.4 Southern countries

Labour shortages in Southern countries are not pronounced. As in other parts of Europe, ISCO 2 appears to be in shortage after 2020 but only in Portugal. Cyprus exhibits significant volatility, with occasional increases in several occupational categories, especially in ISCO 9 in 2019 and 2023. Greece reveals low values suggesting more labour surplus than in other countries. Italy and Spain stand out for their remarkable stability and consistently low levels (below the threshold of 1) throughout the period, reflecting a less tight labour market. Overall, these countries are characterised by sporadic, sector-specific shortages, reflecting labour markets that are still characterised by a certain excess supply of labour.

Figure 4. LFS – Labour shortage in Southern countries



2.1.3 Key trends and developments

Labour shortages have intensified across the European Union since 2021, but there are considerable regional disparities. While Western and, in particular, Nordic countries are experiencing ongoing shortages in skilled occupations, Eastern and Southern Europe are still facing more moderate labour market tensions. These differences reflect variations in economic performance, demographic trends and labour demand.

In Western Europe, prior to 2019, labour shortages were limited. However, since 2021, labour market pressures have increased significantly in the wake of the COVID-19 crisis, particularly in skilled occupations (ISCO 2 and 3). Specifically, Ireland has experienced several recent spikes across various occupational groups. The Nordic countries are experiencing the strongest and most widespread labour market tensions, particularly in Denmark and Sweden.

In Eastern Europe, shortages have emerged primarily after 2020 in ISCO Group 2, but remain low overall. Estonia shows growing structural imbalances, while the Czechia has particularly low levels. Hungary has shown a moderate increase, but there are no major labour market tensions.

In Southern European countries, shortages remain limited, with only certain sectoral tensions emerging, particularly in Portugal and Cyprus. Greece, Italy and Spain continue to have relatively relaxed labour markets.

2.2 Skills & Skills mismatches

For the skills mismatches, we draw on datasets including EU-SILC, ESJS and EWCS to explore the skills, perception of skills shortages, wages, working hours and employment growth

2.2.1 Skills

2.2.1.1 Data and methods used to calculate the European indicators

As skills are not covered in other mobilized datasets such as EU-LFS, we mobilise the CEDEFOP European Skills and Job Survey (ESJS, available from CEDEFOP) collected in 2014 and 2021. As the questionnaire changed, we propose to calculate various skills indicators at the ISCO 2-digit level, as described in the following table.

Table 3. CEDEFOP European Skills and Job Survey – Skills covered

Topic	ESJS 1	ESJS 2	
	All indicators are standardised	All indicators are standardized	
Basic literacy skills	Q22A_1_scale Importance of skill (0 - 10)	Variable composed of: C_WRITE1P (Yes/No) +	Write any texts, on paper or on computer screens, that are at least one (1) page long or longer
		C_WRITE5P (Yes/No) +	Write any texts that are at least five (5) pages or longer
		C_READ5P (Yes/No) +	Read any texts that are at least five (5) pages or longer
		C_READ5P (Yes/No)	Read any texts, on paper or on computer screens, that are at least one (1) page long or longer
		Variable composed of: C_WRITE25P	Write any texts that are at least twenty-five (25) pages or longer

Advanced literacy skills	Q22A_2_scale - Importance of skill (0 - 10)	(Yes/No) +	
		C_READ25P (Yes/No)	Read any texts that are at least twenty-five (25) pages or longer
Basic numeracy skills	Q22A_3_scale - Importance of skill (0 - 10)	Variable composed of: C_MATHBAS + (Yes/No)	Perform any simple calculations with numbers, for instance adding, subtracting, multiplying or dividing
		C_MATHMED (Yes/No)	Use simple algebra or mathematical formulas, for instance calculating fractions or percentages or trying to find an unknown quantity
Advanced numeracy skills	Q22A_4_scale- Importance of skill (0 - 10)	C_MATHADV (Yes/No)	Use any kind of more advanced mathematics, algebra or statistics, for instance calculus, regressions, simulations
Basic ICT skills	Q22A_5_scale- Importance of skill (0 - 10)	Variable composed of: D_PCWEB (Yes/No) +	Use the internet for browsing, sending emails or using social media for your work
		D_PCWORD (Yes/No) +	Write or edit text, for instance using Word or similar software
		D_PCPPT (Yes/No) +	Prepare presentations of your work, for instance using PowerPoint or similar software
		D_PCSHEET (Yes/No)	Use spreadsheets, for instance using Excel or similar software
Moderate ICT skills	Q22A_6_scale- Importance of skill (0 - 10)	Variable composed of: D_PCMACRO (Yes/No) +	Using the more advanced functions of spreadsheets, for instance macros or complex formulas
		D_PCSPEC (Yes/No)	Work with any specialised, sector or occupation-specific software, for instance for accounting, legal analysis, inventory control
Advanced ICT skills -	Q22A_7_scale- Importance of skill (0 - 10)	Variable composed of: D_PCBASE (Yes/No) +	Manage and merge databases, for instance using Access, Oracle or

Importance of skill (0 - 10)			similar software and related query techniques (e.g. SQL)
		D_PCPGR (Yes/No) +	Write programs or coding using a computer language, for instance C++, Python, Java, Visual Basic etc.
		D_PCAI (Yes/No) +	Write programs using artificial intelligence methods, for instance machine-learning or deep-learning algorithms
		D_PCSYS (Yes/No)	Develop or maintain IT systems, hardware or software
Technical skills	Q23A_1_scale-Importance of skill (0 - 10)	E_DEFJOB (Yes/No)	Do you need to further develop any of the following skills to do your main job even better? Do you need to further develop any of the following skills to do your main job even better?
Communication skills	Q23A_2_scale-Importance of skill (0 - 10)	Variable of C_COMTEACH (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never - reversed) +	Teach or train people
		C_COMCARE (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never - reversed)	Provide emotional support or personal care to others
Team-work skills	Q23A_3_scale-Importance of skill (0 - 10)	C_TEAM (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never –reversed)	Work in a team i.e. together with a group of people who plan their work to achieve shared objectives
Customer handling skills		Variable composed of: C_COMADVC	Provide advice or counselling to people

	Q23A_5_scale-Importance of skill (0 - 10)	(1. Always or very often 2. Often 3. Sometimes 4. Rarely or never –reversed) +	
		C_COMPPT (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never – reversed) +	Give oral presentations of products, services or ideas linked to your work
		C_COMOUT (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never – reversed) +	Deal with people who do not work in your company or organisation, for instance customers or clients
		C_COMSELL (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never – reversed)	Try to convince people to do or buy something
Problem-solving skills	Q23A_6_scale-Importance of skill (0 - 10)	Variable composed of: C_PRBINFO (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never –reversed) +	Search for relevant information or documentation, for instance in books or on the web, to solve problems
		C_PRBINPT (1. Always or very often 2. Often 3. Sometimes 4. Rarely or never – reversed) +	Get input from co-workers or others to solve problems
		C_PRBINPT (1. Always or very often 2. Often 3. Sometimes 4.	Try out new ideas to solve problems

		Rarely or never – reversed)	
Learning skills	Q23A_7_scale- Importance of skill (0 - 10)	C_CHWKLRN (1. More time 2. About the same time 3. Less time – reversed)	Learning new things
Planning and organisation skills	Q23A_8_scale- Importance of skill (0 - 10)	Variable composed of: C_CHWKPLAN (1. More time 2. About the same time 3. Less time – reversed) +	Planning your work activities
		C_CHWKAUT (1. More time 2. About the same time 3. Less time – reversed)	Choosing the methods or tools of your work

The data table contains the country code (AT, BE, etc.), the year, the ISCO 2-digit codes, and the skills indicators. For the presentation of descriptive statistics, we focus on ICT skills in the four EU regions.

2.2.1.2 Differences and variations between country types and countries

2.2.1.2.1 Western countries

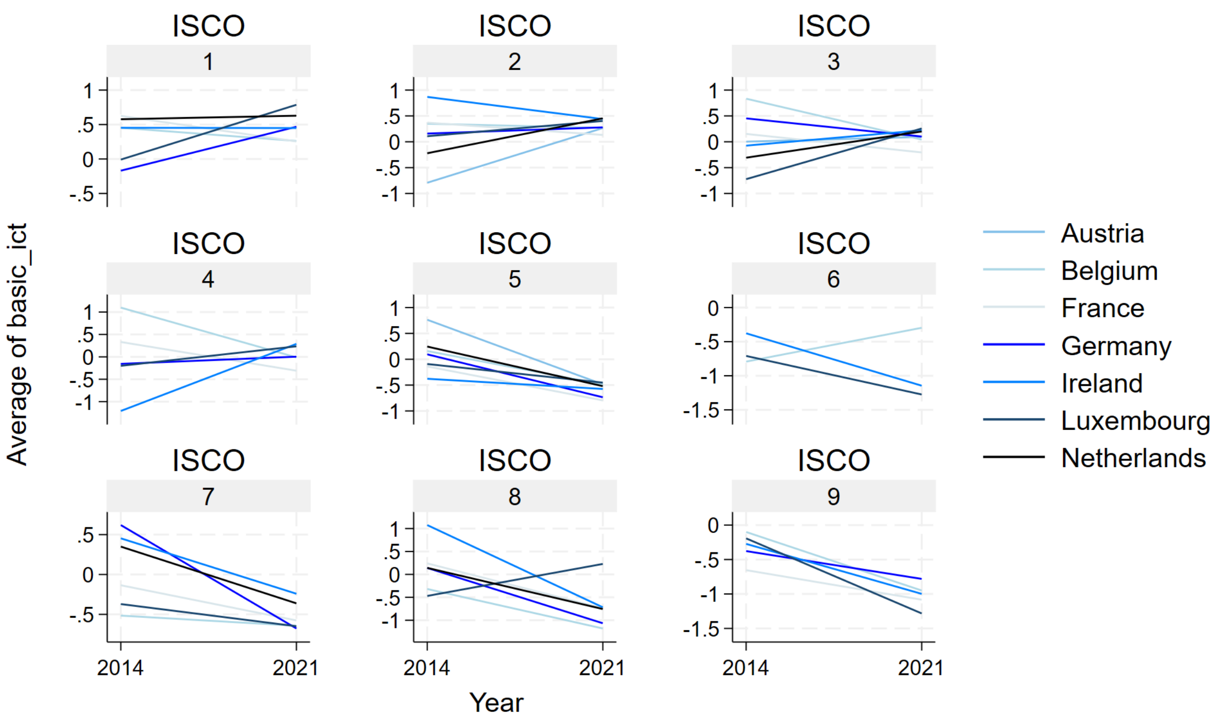
The figures below highlight significant variation in ICT skills across ISCO groups, countries across Western Europe, and over time between 2014 and 2021. Overall, there has been a marked improvement in ICT skills among the most highly skilled groups (ISCO 1-3). For example, in Germany and the Netherlands, for ISCO 1, levels rose from negative values in 2014 to clearly positive values in 2021, particularly for advanced skills. Similarly, Luxembourg shows very strong progress in this group, notably in basic and moderate ICT.

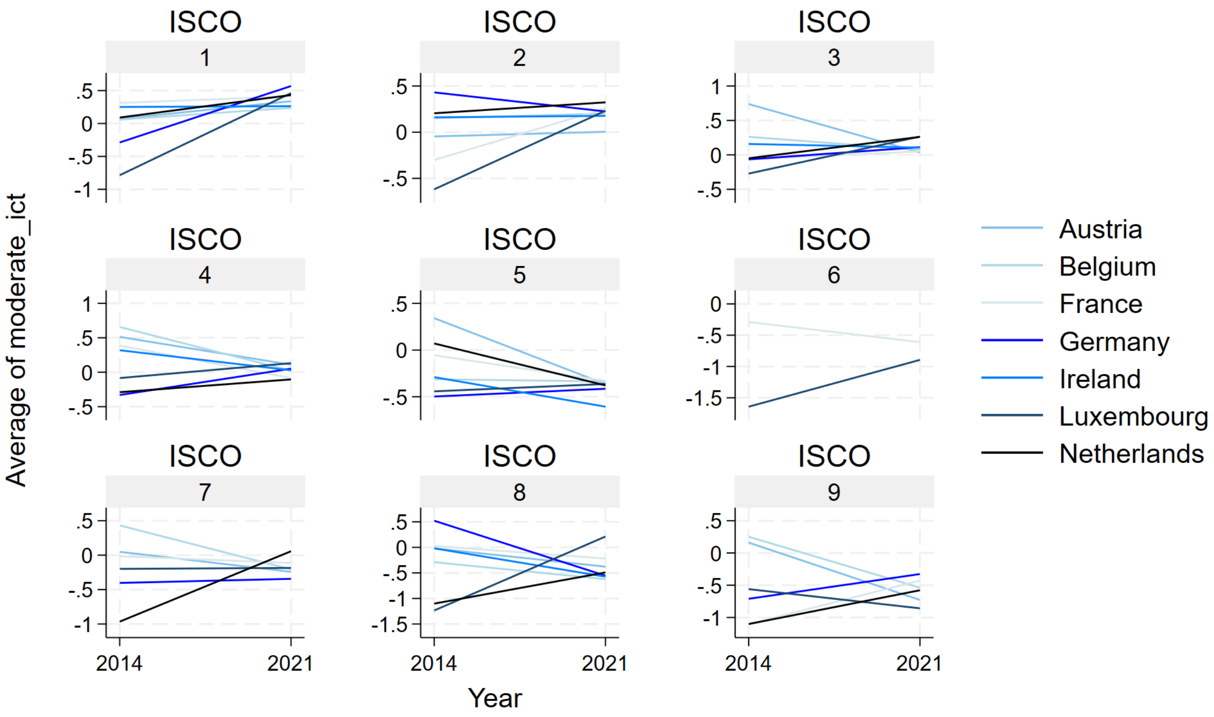
Conversely, for the intermediate groups (ISCO 4-5), the trend is more mixed, even negative. Several countries recorded a decline between 2014 and 2021, particularly for basic and moderate skills. This suggests a possible relative lag of these categories in the digital transition.

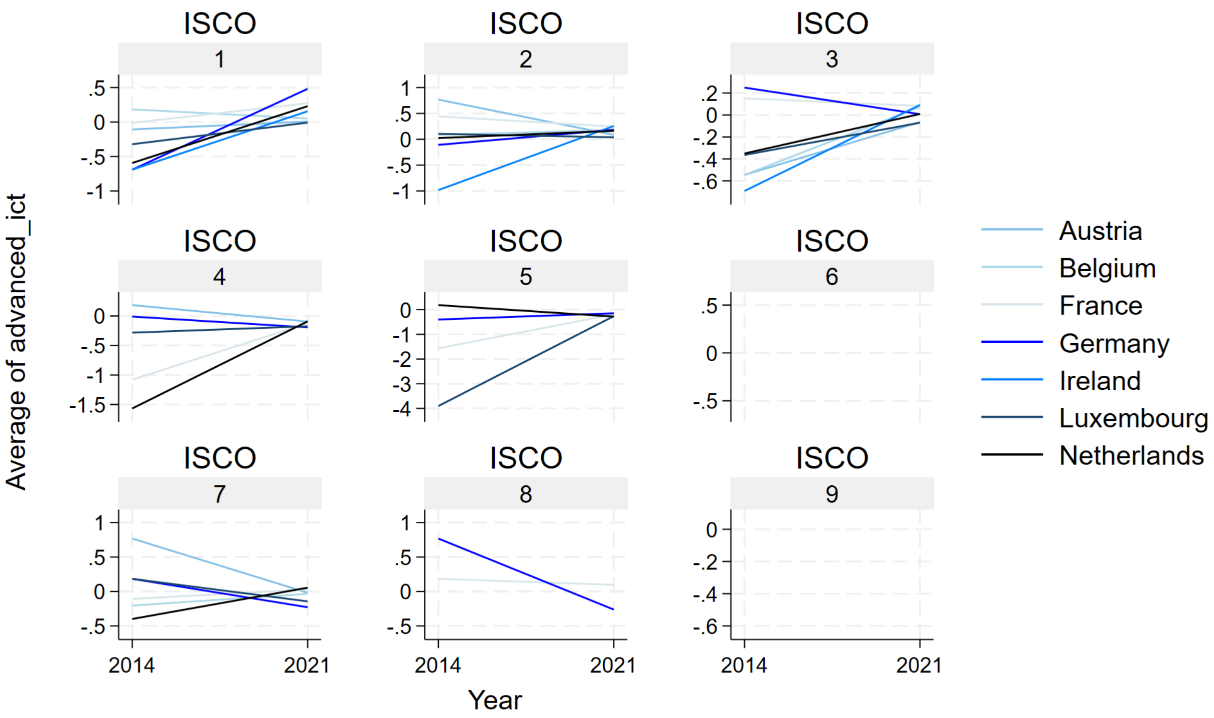
For the low-skilled groups (ISCO 6-9), ICT skill levels are generally low and often negative, with a deterioration in several countries. In 2021, the values remain very low (or even very negative), particularly in Belgium and Germany for basic skills. This reflects a growing polarization of digital skills in the labour market. Finally, advanced ICT skills appear to be progressing more slowly than basic and moderate skills, and remain negative in several ISCO groups in 2014, highlighting the difficulty of adopting the most complex digital skills.

Even if the presence of missing values, particularly for certain countries and ISCO groups, limits the comparability of trends, these results suggest an increase in digital skills but also a widening of inequalities based on occupations.

Figure 5. CEDEFOP ESJS – ICT skills in Western countries







2.2.1.2.2 Nordic countries

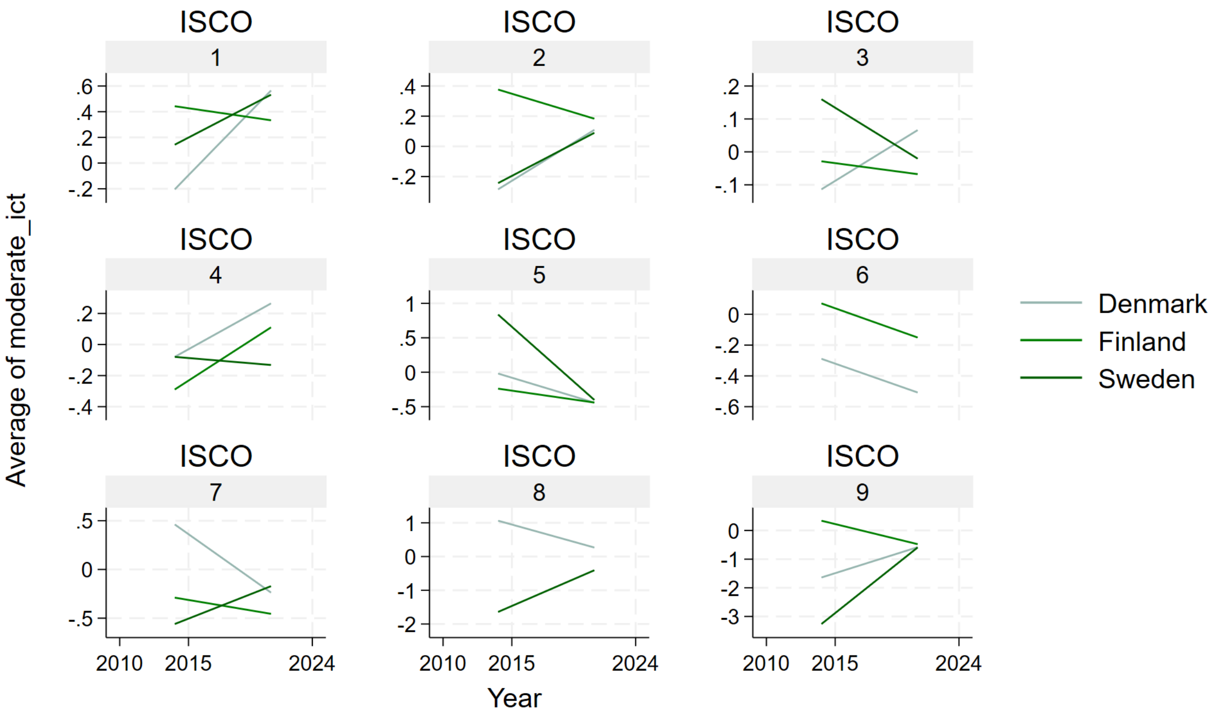
The Nordic countries generally exhibit relatively high levels of ICT skills among the most highly skilled groups (ISCO 1–2), though trends varied between 2014 and 2021. For managers (ISCO 1), there has been a clear improvement in Denmark, with marked progress across all three dimensions (basic, moderate, and advanced ICT). Sweden also maintains high levels, despite a slight decline in basic ICT, while Finland shows a more mixed picture, notably with a decline in advanced ICT skills between 2014 and 2021. In the other high-skilled occupations (ISCO 2–3), trends remain positive for basic ICT skills, but with few improvements. For moderate skills, all three countries were positive in ISCO 2, but only Denmark is positive and growing for ISCO3.

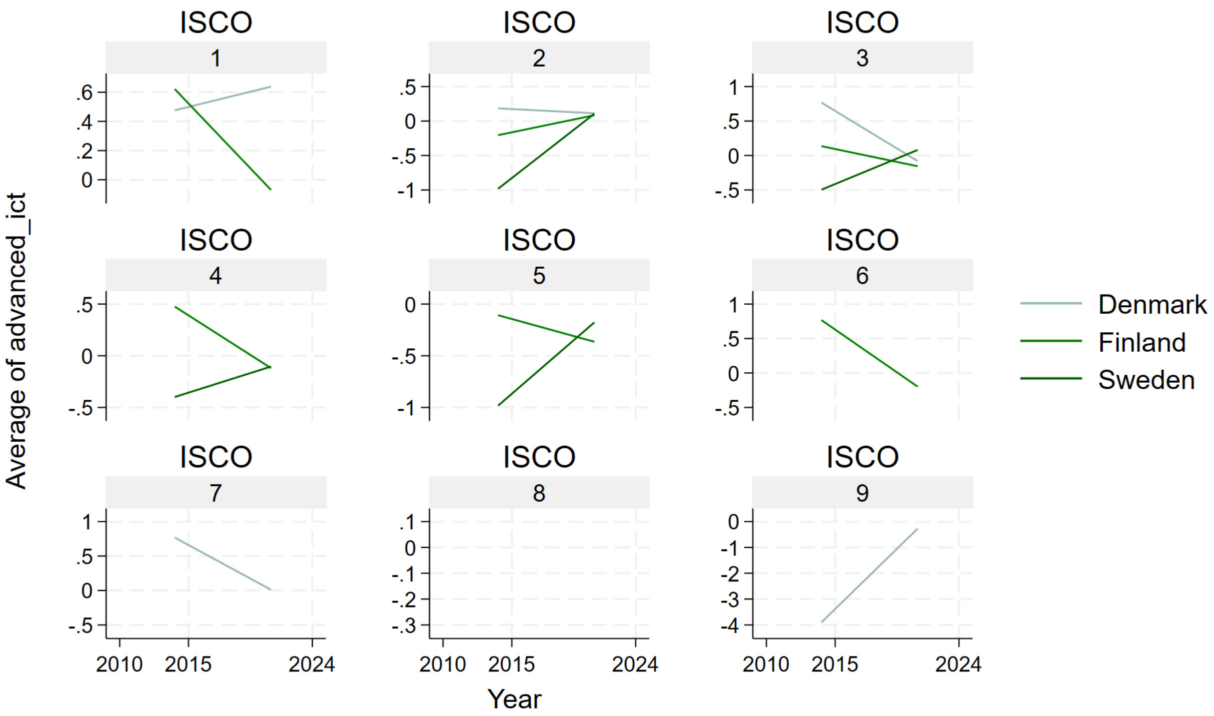
For ISCO 4, basic and moderate ICT skills generally improved between 2014 and 2021, but appear negative for advanced ICT skills. For ISCO 5, a clear decline appears in all three countries, except for Sweden in advanced ICT skills but still below zero. This trend is particularly pronounced in Finland and Sweden, where ICT skills fell sharply, especially for basic and moderate skills.

In ISCO groups 6 through 9, levels are generally below zero and declining, reflecting a persistent difficulty in integrating digital skills into low-skilled jobs.

It is also worth noting the presence of missing values, particularly for advanced ICT skills, which limits comparability over time and may skew the interpretation of trends. Despite this, a clear trend emerges. the Nordic countries combine high levels of ICT skills for skilled jobs with increasing polarization at the expense of low-skilled jobs.

Figure 6. CEDEFOP ESJS – ICT skills in Nordic countries


Average of moderate_ict
ISCO 1
ISCO 2
ISCO 3
ISCO 4
ISCO 5
ISCO 6
ISCO 7
ISCO 8
ISCO 9
Denmark
Finland
Sweden
2010
2015
2024
Year


Average of advanced_ict
ISCO 1
ISCO 2
ISCO 3
ISCO 4
ISCO 5
ISCO 6
ISCO 7
ISCO 8
ISCO 9
Denmark
Finland
Sweden
2010
2015
2024
Year

2.2.1.2.3 Eastern countries

Eastern European countries are catching up in terms of ICT skills, though there is significant variation across countries and skill levels. For the most highly skilled groups (ISCO 1-2), in most countries there was an overall improvement between 2014 and 2021.

Countries such as Poland, Romania, and Slovakia show clear progress, notably with a shift from sometimes low or negative values to positive levels across all three dimensions of ICT skills. Bulgaria and Hungary also follow this trend, although advanced skills remain limited in some occupations. However, this progress is less consistent in certain countries such as the Czechia or the Baltic states, where advanced skills are stagnating or even declining despite improvements in basic and moderate ICT skills. Latvia, for example, experienced a marked decline in several dimensions between 2014 and 2021.

In the intermediate occupations (ISCO 4-5), the results are more mixed. Some countries show moderate gains, but others show stagnation or even declines, particularly in advanced skills. This suggests that the uptake of digital skills remains incomplete in these occupational categories.

For low-skilled occupations (ISCO 6-9), a clear decline appears across all countries. ICT skills turned predominantly negative in 2021, with particularly sharp declines in Bulgaria, Hungary, and the Baltic states.

Finally, despite a few exceptions, Eastern European countries are characterized by a strong polarization of digital skills. The progress observed among skilled workers contrasts with very low levels among the lower skilled, highlighting the persistent challenges in spreading ICT skills across the labour market.

Figure 7. CEDEFOP ESJS – ICT skills in Eastern countries

2.2.1.2.4 Southern countries

Southern European countries show an overall positive trend in ICT skills among the high-skilled groups (ISCO 1-3) between 2014 and 2021, although this progress varies by country. Spain, Portugal, and Italy stand out with marked increases, particularly in moderate and advanced skills, shifting from levels that were sometimes negative in 2014 to clearly positive values in 2021. Greece also shows a notable improvement, particularly among managers (ISCO 1), except for advanced ICT skills.

However, some countries, such as Cyprus, show a more mixed picture, with a decline in ICT skills in 2021 among the most highly skilled groups. Malta, for its part, starts from relatively low levels but records significant progress, particularly for ISCO 1 and 2 and basic and moderate ICT skills.

For intermediate groups (ISCO 4-5), the results highlight some improvements. Several countries, such as Spain and Portugal, continue to make progress, while others, such as Cyprus, Greece or Malta, show a decline between 2014 and 2021, particularly for advanced skills.

For the low-skilled groups (ISCO 6-9), a clear downward trend emerges across most Southern countries for basic and moderate ICT skills. In most countries, advanced ICT skills remain below 0.

Finally, the presence of missing values, particularly for certain countries and groups in 2014, limits the comparability of trends. Despite this, the results suggest an improvement in digital skills in high-skilled jobs, but also a strong polarization, with low-skilled workers lagging far behind in improving their moderate and advanced ICT skills.

Figure 8. CEDEFOP ESJS – ICT skills in Southern countries

2.2.1.3 Key trends and developments

European labour markets have made significant progress in acquiring digital skills, particularly among highly skilled occupations. However, this progress is uneven across regions and occupational groups.

The persistence of digital divides, coupled with an increasing skills mismatch, especially among intermediate and low-skilled workers, highlights the need for targeted lifelong learning and upskilling policies to ensure a more inclusive digital transition across Europe.

Between 2014 and 2021, digital (ICT) skills improved overall in Western Europe, particularly among the most highly skilled occupations (ISCO 1-3). In contrast, intermediate (ISCO 4-5) and lower-skilled (ISCO 6-9) groups showed weaker or even negative trends, revealing a growing polarisation of digital skills in the labour market. Furthermore, advanced ICT skills are improving more slowly and remain underdeveloped in several occupational categories.

Eastern European countries experienced an overall catch-up in digital skills between 2014 and 2021, particularly among the most skilled occupations (ISCO 1-2), with marked progress in some countries. However, results remain mixed for intermediate occupations and advanced skills, which are stagnating or declining in some countries. For low-skilled jobs (ISCO 6-9), ICT skills remain low and are often declining, revealing a strong digital divide in the labour market.

Southern European countries generally improved their digital skills between 2014 and 2021, particularly in the high-skilled occupations (ISCO 1-3). In contrast, the results are more mixed for intermediate and low-skilled occupations, with several countries experiencing stagnation or a decline in advanced ICT skills in particular. A strong digital divide is revealed by these trends, with low-skilled workers significantly lagging behind in acquiring moderate and advanced digital skills.

Overall, the Nordic countries have high levels of digital skills in skilled occupations (ISCO 1-3), with some countries making particularly marked progress between 2014 and 2021. However, ICT skills, especially advanced ones, remain low or are declining for intermediate and low-skilled occupations (ISCO 4-9). These countries therefore combine strong digital proficiency among skilled workers with growing polarisation at the expense of low-skilled jobs.

In the Nordic countries, over-skilling is rising sharply between 2010 and 2024 across nearly all occupational categories, with particularly marked increases in Sweden and Denmark. This trend affects skilled, intermediate, and low-skilled jobs alike, reflecting a widening mismatch between skills and jobs.

Under-skilling shows a more mixed picture, with a decline in several skilled occupational groups but more uneven trends in intermediate and low-skilled jobs. Overall, the Nordic countries are experiencing a rise in over-skilling alongside levels of under-skilling that are sometimes persistent or on the rise, reflecting structural changes in the labour market or the expansion of higher education.

2.2.2 Perception of over- and under-skilling

2.2.2.1 Data and methods used to calculate the European indicators

We mobilize the European Working Conditions Survey (EWCS) from Eurofound to measure the perception of being under-skilled or over-skilled during the period from 2010 to 2024. The data table contains a ventilation by country at the ISCO08 2-digit level. The 27 EU countries are covered.

The data table contains the country code (AT, BE, etc.), the year, the ISCO 2-digit codes, and the perception of being under-skilled or over-skilled indicators.

2.2.2.2 Differences and variations between country types and countries

2.2.2.2.1 Western countries

In Western European countries, the Figure below shows that for the perception of being over-skilled the overall trend is upward in all occupational categories. However, some differences emerge across both countries and ISCO groups.

In high-skilled occupations, countries such as Luxembourg and Ireland display particularly strong increases in many occupations. Germany also shows a clear upward trend, but more moderate. In contrast, France tends to remain relatively stable or shows only slight increases over time, indicating a more limited change in perceived over-skilling. For intermediate-skilled occupations, ISCO 4 reveals a growing trend while ISCO 5 shows a slight upward trend. For low-skilled occupations, there are some cross-country disparities. For example, ISCO 7 shows a sharp rise in countries like Austria, Luxembourg, Netherlands and Ireland, while remaining lower and more stable in others such as France, Germany and Belgium.

Overall, these patterns suggest that over-skilling is becoming more widespread, but its intensity varies significantly depending on both occupational group and national context.

Concerning the perception of being under-skilled, the overall trend between 2010 and 2024 is more mixed than for over-skilling.

For high-skilled occupations, most countries exhibit a decline in under-skilling, particularly in ISCO 2. For intermediate-skilled occupations, in most countries, levels remain relatively stable or even increase in some countries, indicating that improvements in skill matching are uneven across countries. For low-skilled occupations, the figure exhibits heterogeneous patterns, with no clear common trend across countries. For instance, some countries such as Belgium, Netherlands and Luxembourg display pronounced peaks around 2015, especially in ISCO groups 8 and 9. For ISCO 9, Ireland and Luxembourg reveal a large increase of under-skilling.

Overall, the results suggest that, unlike over-skilling, under-skilling does not follow a clear trend, but rather reflects more complex and fluctuating dynamics in skill mismatches across European labour markets.

Figure 9. Eurofound EWCS – Perception of over-skilling in Western countries

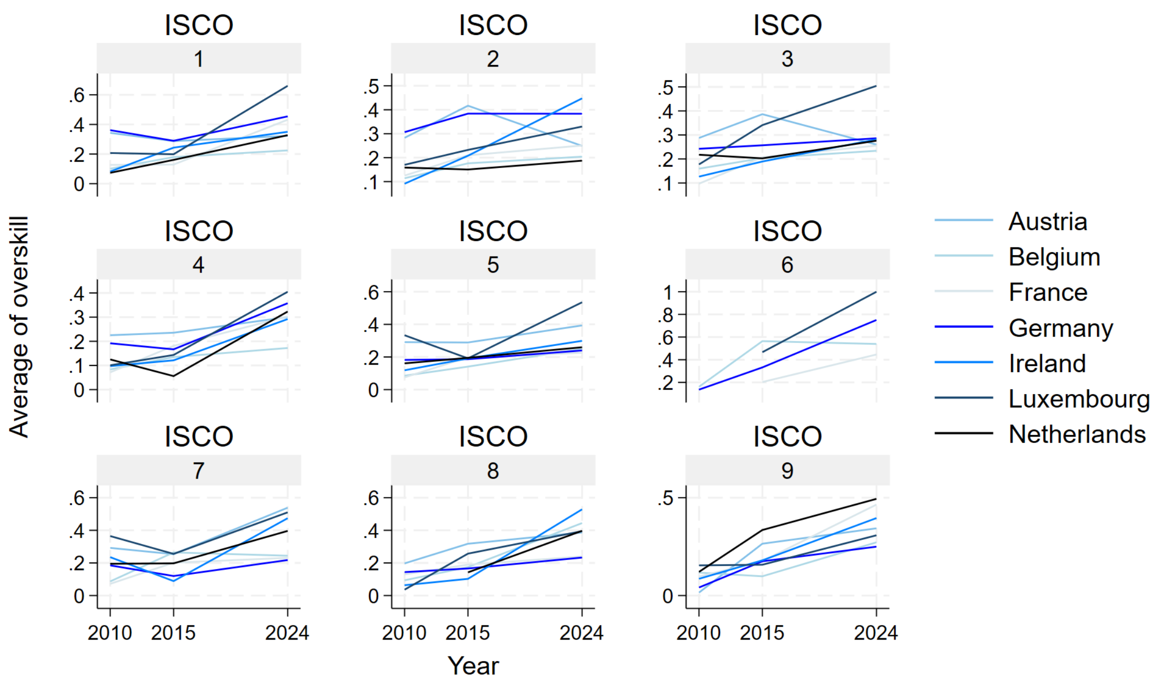
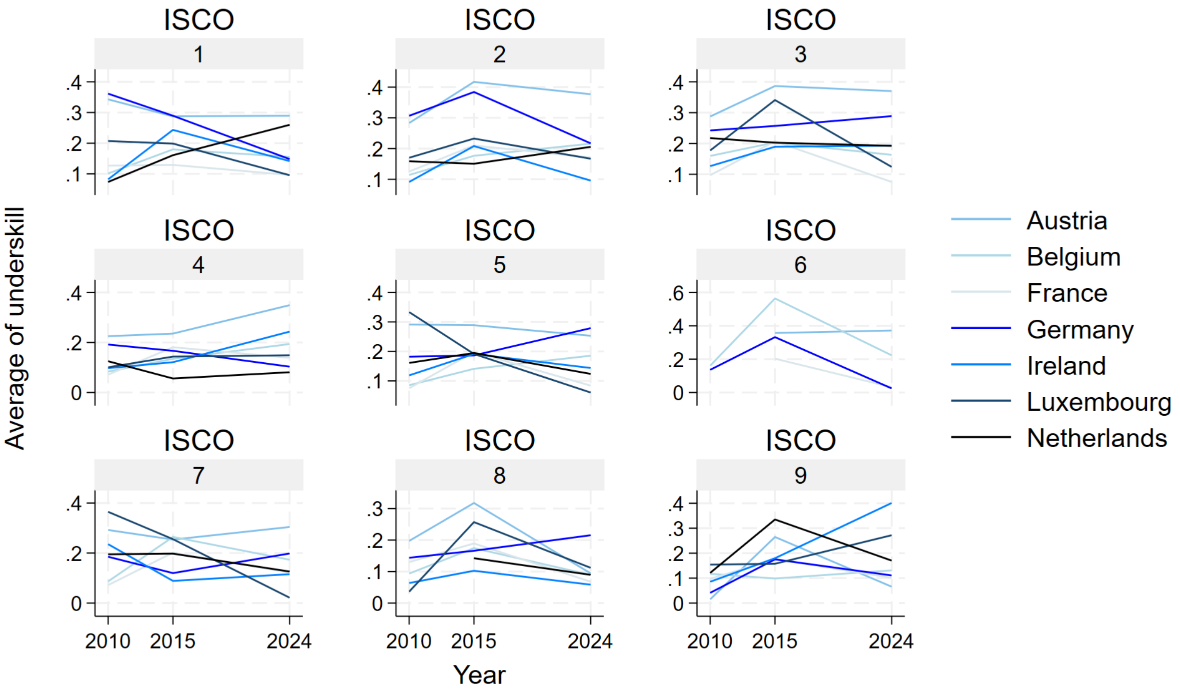


Figure 10. Eurofound EWCS – Perception of under-skilling in Western countries



2.2.2.2.2 Nordic countries

The figure below shows that there has been a significant increase in over-qualification across all ISCO categories in the Nordic countries between 2010 and 2024, except for ISCO 1 in Finland.

The upward trend in the perception of over-skilling is particularly strong for high-skilled occupations in Sweden, reaching 40% of the employed population in 2024. For ISCO 2, all three countries converge at around 25% of the employed population in 2024. In ISCO 3, the increase reaches around 35% of the employed population in Denmark and Sweden, while in Finland, the trend is flatter, reaching 25% of the employed population in 2024. Sweden experiences the greatest increase in intermediate-skilled occupations in both ISCO groups 4 and 5. For low-skilled occupations, a reduction was seen between 2010 and 2015, but the trend was largely positive afterwards. In ISCO 9, following a flat curve between 2010 and 2015, the increase is significant, reaching 60% of the employed population in Denmark and Sweden.

Five out of nine ISCO groups expect a downward trend in under-skilling. The downward trend is particularly strong for high-skilled occupations in Sweden, reaching 10% of the employed population in 2024. For ISCO 2, all three countries converge at around 10% of the employed population in 2024. In ISCO 3, all three countries converge, reaching around 15% of the employed population in 2024. For intermediate-skilled occupations (ISCO 4), Sweden experienced the largest increase, while Denmark saw a decrease. For low-skilled occupations (ISCO 7), there was a reduction between 2010 and 2015, after which the trend was largely positive, except in Denmark where it remained at 10% of the employed population. In ISCO 8, we observe specific trends in each country: Sweden decreased, Denmark peaked in 2015 and then experienced the largest decrease. Finland's curve is flat. For ISCO 9, the trend is upwards.

Overall, there has been a clear rise in over-skilling in the Nordic countries, combined with uneven and sometimes increasing levels of under-skilling. This is likely to reflect structural changes in job content or an expansion of higher education.

Figure 11. Eurofound EWCS – Perception of over-skilling in Nordic countries

Figure 12. Eurofound EWCS – Perception of under-skilling in Nordic countries

2.2.2.2.3 Eastern countries

A general upward trend in the feeling of being over-qualified is observed across most Eastern European countries and ISCO groups between 2010 and 2024. This increase is particularly pronounced after 2015, suggesting a general intensification of skill mismatches over time.

In high-skilled occupations (ISCO groups 1 to 3), there is heterogeneity in trends across countries. For example, Hungary experienced a clear increase in ISCO group 1, while Romania and Bulgaria experienced slight fluctuations in ISCO groups 2 and 3, respectively. Intermediate-skilled occupations (ISCO groups 4 and 5) show an upward trend between 2015 and 2024, with around 40% of the employed population feeling over-skilled in 2024. For low-skilled occupations, the trend is also upward for most countries between 2015 and 2024.

Overall, while over-skilling appears to be rising in Eastern Europe, the extent and intensity of this trend vary significantly across countries and occupational groups, highlighting the importance of national labour market structures and sectoral compositions.

Trends regarding under-skilling in Eastern European countries appear more heterogeneous than those regarding over-skilling.

In high-skilled occupations (ISCO groups 1 to 3), the majority of countries experienced a decrease following a peak in 2015. However, some exceptions are evident, such as Romania, which experienced a significant increase in ISCO groups 1 and 3. For intermediate-skilled occupations (ISCO groups 4 to 5), the trends are flat in almost all countries, except for Lithuania (ISCO 4). The trends for low-skilled occupations (ISCO groups 6 to 9) are also flat in almost all countries. However, there are some exceptions, such as Romania, which experienced a peak in 2015 followed by a sharp decrease in ISCO 7, and Bulgaria, which experienced a significant decrease in ISCO 9 over the period 2010-2024.

By 2024, there was still no clear convergence across countries. While some indicators suggest modest improvements in skill matching, differences across national labour markets persist. Overall, the results suggest that under-skilling in Eastern Europe is evolving unevenly, reflecting country-specific dynamics rather than a uniform trend.

Figure 13. Eurofound EWCS – Perception of over-skilling in Eastern countries

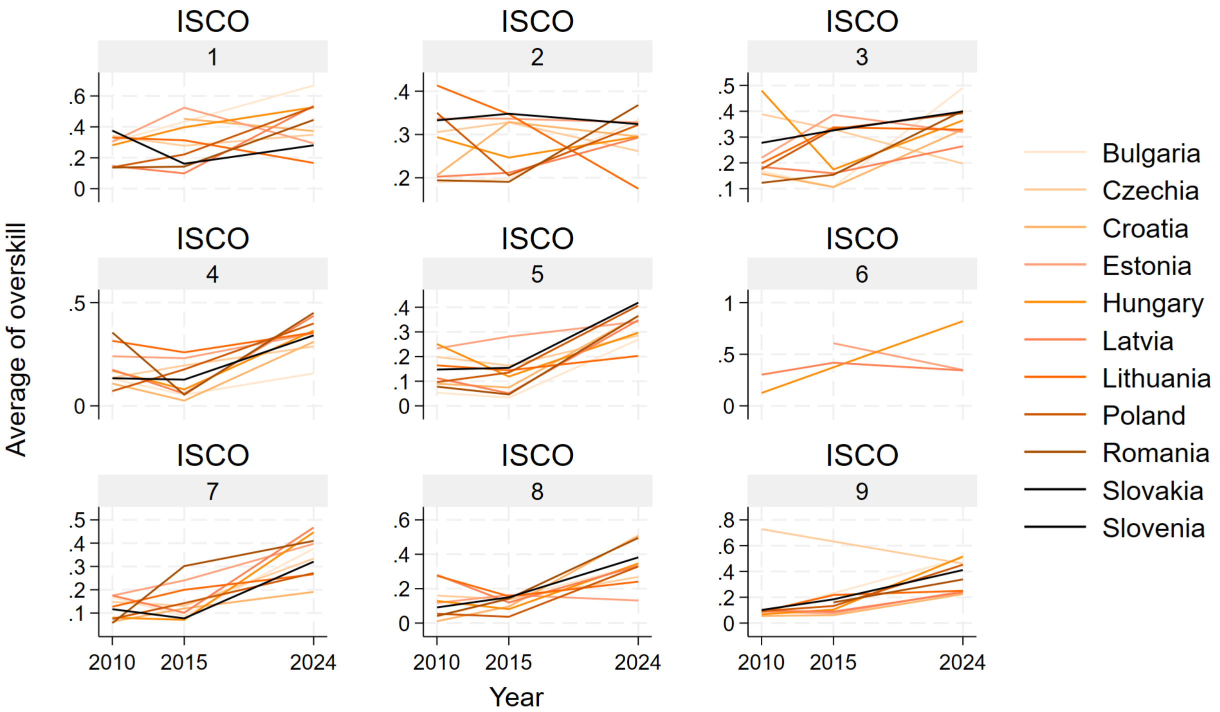
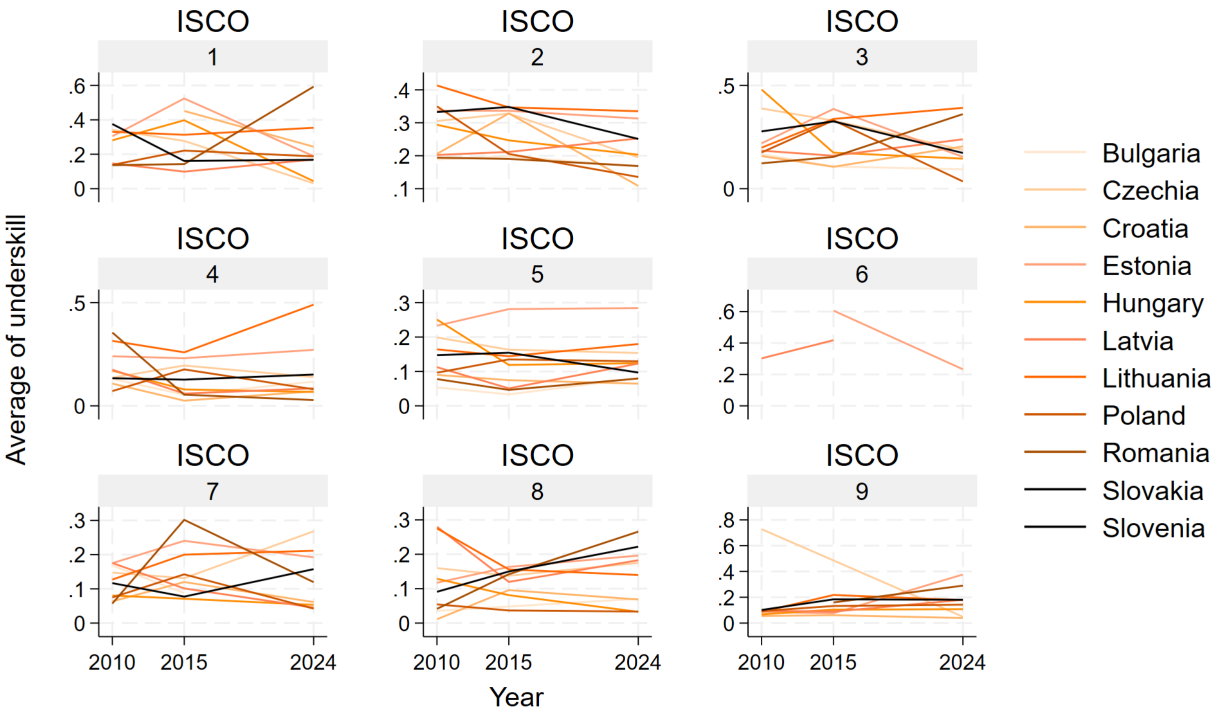


Figure 14. Eurofound EWCS – Perception of under-skilling in Eastern countries



2.2.2.2.4 Southern countries

For Southern European countries, the data indicate an overall increase in over-qualification across several occupational categories, although the magnitude and consistency of this trend vary between countries.

Sharp increases in high-skilled occupations (ISCO groups 1 to 3) are observed in Cyprus (ISCO groups 1, 2 and 3), Greece (ISCO groups 1 and 3) and Spain (ISCO group 3). Some countries experienced a peak in 2015, such as Italy (ISCO group 1) and Malta (ISCO group 2). For intermediate occupations, the trend is upwards for most countries, with a convergence around 30% of the employed population in ISCO 5. The trend is also upward for most countries in low-skilled occupations (ISCO 7) between 2015 and 2024, except for two countries where it is almost flat. Malta experienced a peak in ISCO 8 in 2015, but in 2024 the level is lower compared to most other southern countries. In ISCO 9, Cyprus also experienced a peak, with all countries reaching between 30% and 40% of their employed population by 2024.

The general trend regarding under-skilling shows a slight decline in most countries. However, it is important to note the presence of missing values, particularly for certain countries and ISCO groups in 2024, which limits comparability.

In 2015, most countries had under-skilling levels of around 20% in high-skilled occupations. Since then, Portugal has experienced a sharp increase, while Spain has remained flat and Cyprus and Malta have seen slight declines. For ISCO 2, the overall trend from 2010 to 2024 shows a decrease, with Malta peaking in 2015. After 2015, the trend has remained largely unchanged for most countries, except for Cyprus (which increased) and Portugal (which decreased). For ISCO 3, Cyprus shows a significant increase after 2015; Portugal exhibits a large reduction following a peak in 2015; Malta's under-skilling declined steadily throughout the period (2010–2024); while Italy and Spain saw slight increases and Greece remained flat. The trends for intermediate-skilled occupations are generally decreasing or flat, except for Cyprus, which experienced an increase after 2015 for ISCO 5. In low-skilled occupations, under-skilling for ISCO 7 decreased across all countries except Cyprus, which saw a significant increase from 2015, and Italy, which remained almost flat. For ISCO 8, the trends are flat for all observed countries. A large decrease in under-skilling is observed for Cyprus and Portugal, which attain low levels for ISCO 9, while the trends for other countries are flat, close to zero. Overall, the results reveal a dual dynamic in Southern Europe: increasing over-skilling alongside only partial and uneven reductions in under-skilling, underscoring persistent structural imbalances in labour markets.

Figure 15. Eurofound EWCS – Perception of over-skilling in Southern countries

Figure 16. Eurofound EWCS – Perception of under-skilling in Southern countries

2.2.2.3 Key trends and developments

In the European Union, the perception of over-skilling has increased across Europe over the past decade, suggesting a growing mismatch between workers' qualifications and their job roles. Although under-skilling follows more heterogeneous patterns across countries and occupations, these findings highlight the need for better alignment between education and training systems and labour market needs.

In Western European countries between 2010 and 2024, the perception of over-skilling increased across all occupational categories, and some countries experiencing particularly sharp increases. The perception of under-skilling, however, follows a more varied and less uniform trend. While a decline is observed in several skilled occupations, intermediate and low-skilled jobs exhibit more fluctuating and indicator trends depending on the country, with some significant peaks in certain countries.

In Eastern European countries, the perception of over-skilling increased overall between 2010 and 2024, particularly after 2015, across most occupational groups. This increase was particularly observed in intermediate and low-skilled occupations, although the extent of the increase varied significantly across countries and labour market structures. Under-skilling, however, is evolving in a more heterogeneous manner, with no clear common trend emerging across Eastern Europe. While several countries recorded a decline in skilled occupations after 2015, other categories have remained generally stable, with some country-specific increase in countries such as Romania and Bulgaria.

Between 2010 and 2024, the perception of over-skilling generally increased across several occupational categories in Southern European countries, particularly in skilled and intermediate jobs. The sharpest increases were observed in Cyprus, Greece and Spain, while Malta and Italy experienced mainly temporary spikes around 2015. The perception of under-skilling is trending slightly downward in most Southern European countries. However, there are some exceptions, notably in Cyprus, where levels are rising across several ISCO groups, revealing persistent imbalances in the labour market.

2.2.3 Hourly wages

2.2.3.1 Data and methods used to calculate the European indicators

As wages are not covered in other dataset like EU-LFS, we mobilise the EU-SILC cross sectional data (data available from EUROSTAT MICRODATA) to calculate the annual wage at ISCO 2-digit level. Due to data unavailability certain years, we use the same EU-LFS countries and years so that 17 EU countries are covered for the periods 2014-2019 & 2021-2023:

The data table contains the country code (AT, BE, etc.), the year, the ISCO 2-digit codes, and the wage.

2.2.3.2 Differences and variations between country types and countries

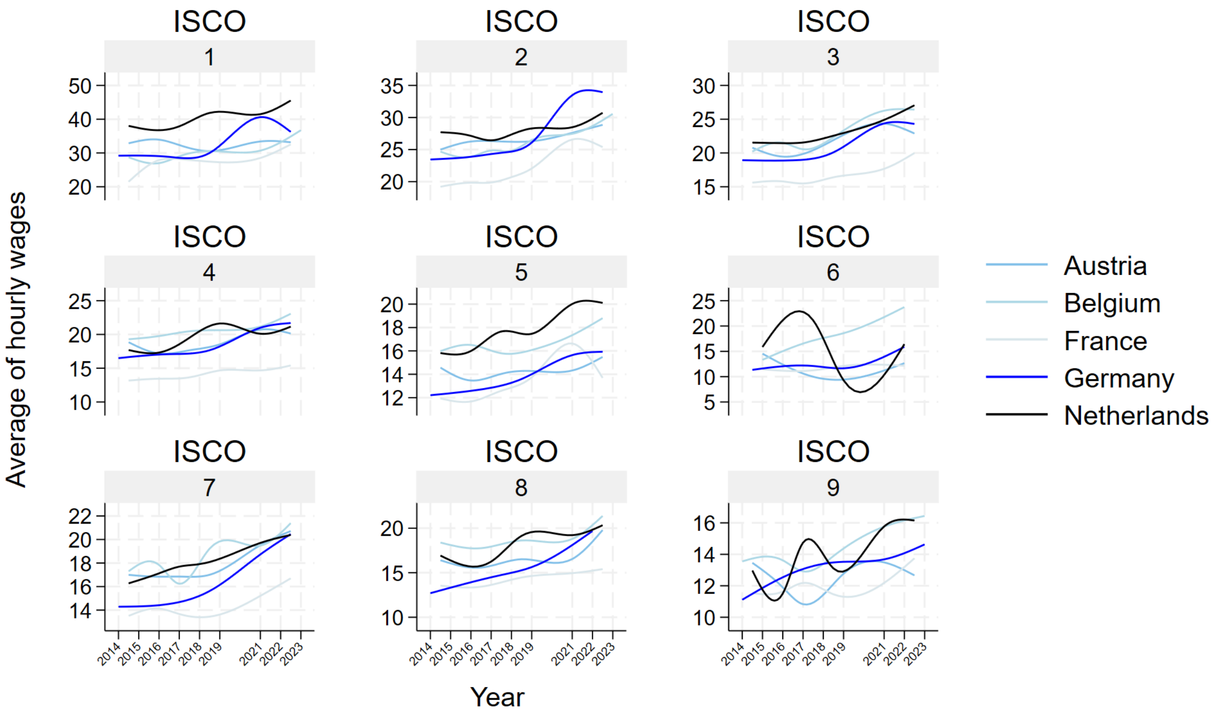
2.2.3.2.1 Western countries

Hourly wages in Western Europe have shown heterogeneous but generally dynamic growth, with a common trend of moderate increases before 2019 and acceleration after 2020, which is likely linked to post-pandemic effects such as labour market tensions, inflation and stimulus policies.

In Germany, a sharp increase in hourly wages is evident, particularly for managers (ISCO 1), rising from around €30 to around €39. Progress is visible across all occupations, indicating the widespread dissemination of wage increases. In Belgium, there has been a continued increase, particularly for higher earners (ISCO 1), rising from €30 to €36. This evolution highlights relative stability, with more linear growth than in other countries in this region. France has experienced moderate growth. The Netherlands has seen steady growth, particularly for occupations requiring mid-level qualifications.

In Ireland, hourly wages are highly volatile, but there has been a strong overall increase: managers (ISCO 1) have seen an increase from around €35 to around €48. Austria is more unstable than its neighbours, with some occupations experiencing stagnation.

Figure 17. EU_SILC– Hourly wages in Western countries



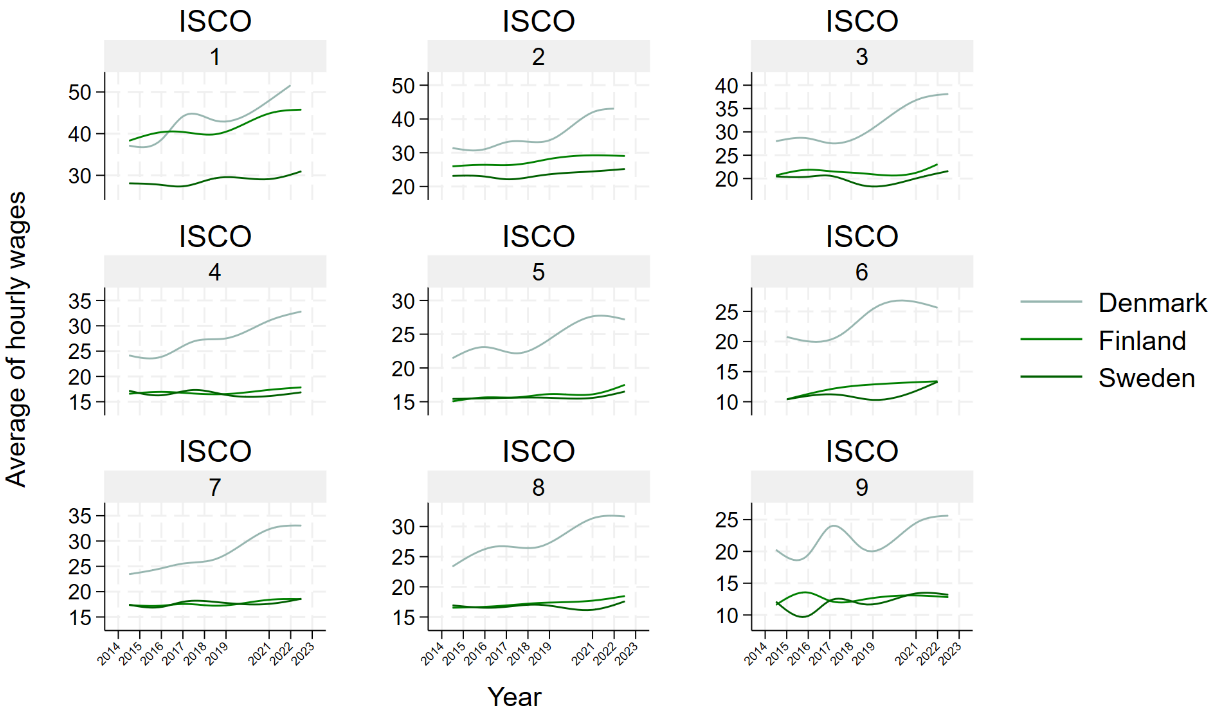
2.2.3.2.2 Nordic countries

The Nordic countries are characterised by high hourly wages, which have grown moderately but steadily throughout the analysed period. This region continues to be a model of competitive compensation in Europe, offering stability alongside relative equity.

Denmark has shown strong wage growth, particularly for high earners (ISCO category 1): Rising from ~€39 to ~€55 over the analysed period. There was a marked increase after 2020, which is likely linked to a post-Covid effect, such as increased demand, a shortage of skilled labour or wage policies.

This trend reflects uneven growth, favouring the most skilled jobs. In contrast, Finland and Sweden demonstrate more stable and gradual growth in hourly wages, with less volatility than Denmark. Differences across skill levels remain moderate, confirming a tradition of reducing wage inequality. Sweden and Finland thus demonstrate a balanced approach where wage increases benefit all occupational categories.

Figure 18. EU_SILC– Hourly wages in Nordic countries

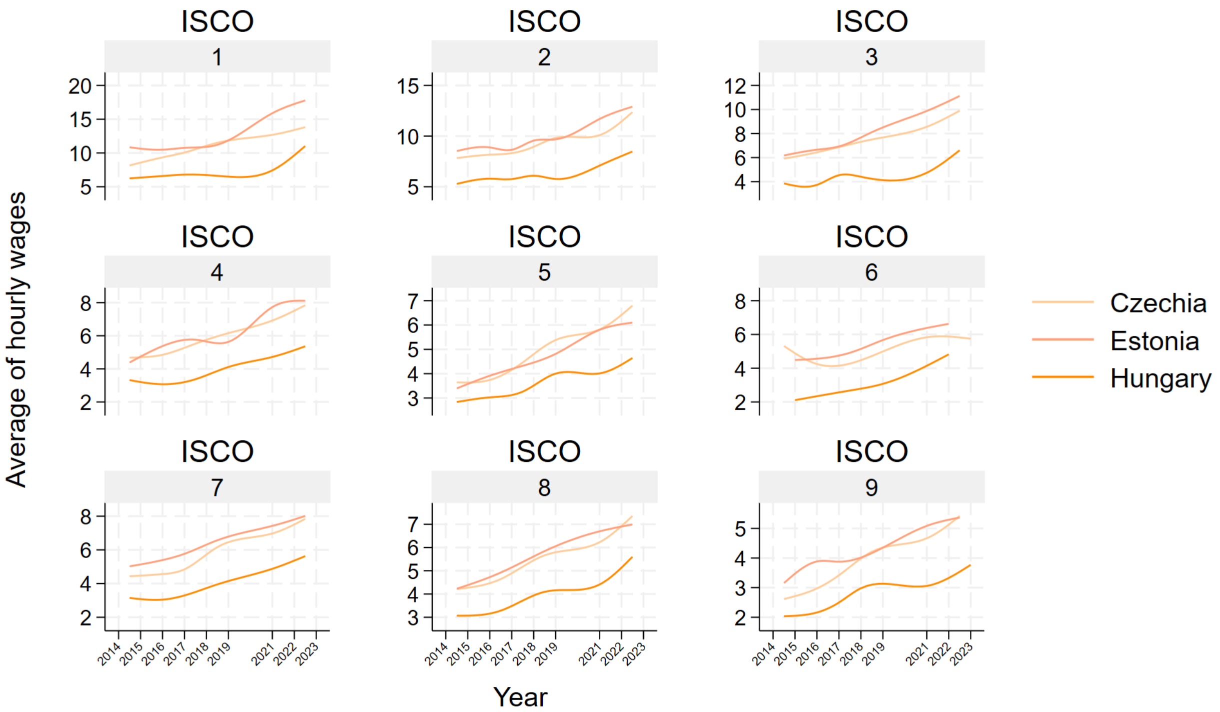


2.2.3.2.3 Eastern countries

Eastern European countries are characterised by strong relative growth in hourly wages, reflecting a process of catching up with Western Europe. Although initial levels were much lower, this part of Europe has seen rapid and continuous growth throughout the studied period.

Over the period, the Czech Republic saw hourly wages in several categories almost double. This robust growth illustrates a significant improvement in wage conditions. Estonia experienced a sustained and steady rise in wages, confirming a stable trajectory of economic growth. Hungary experienced strong growth, particularly after 2019, which suggests an accelerating effect due to economic policies, labour shortages or foreign investment.

Figure 19. EU_SILC– Hourly wages in Eastern countries

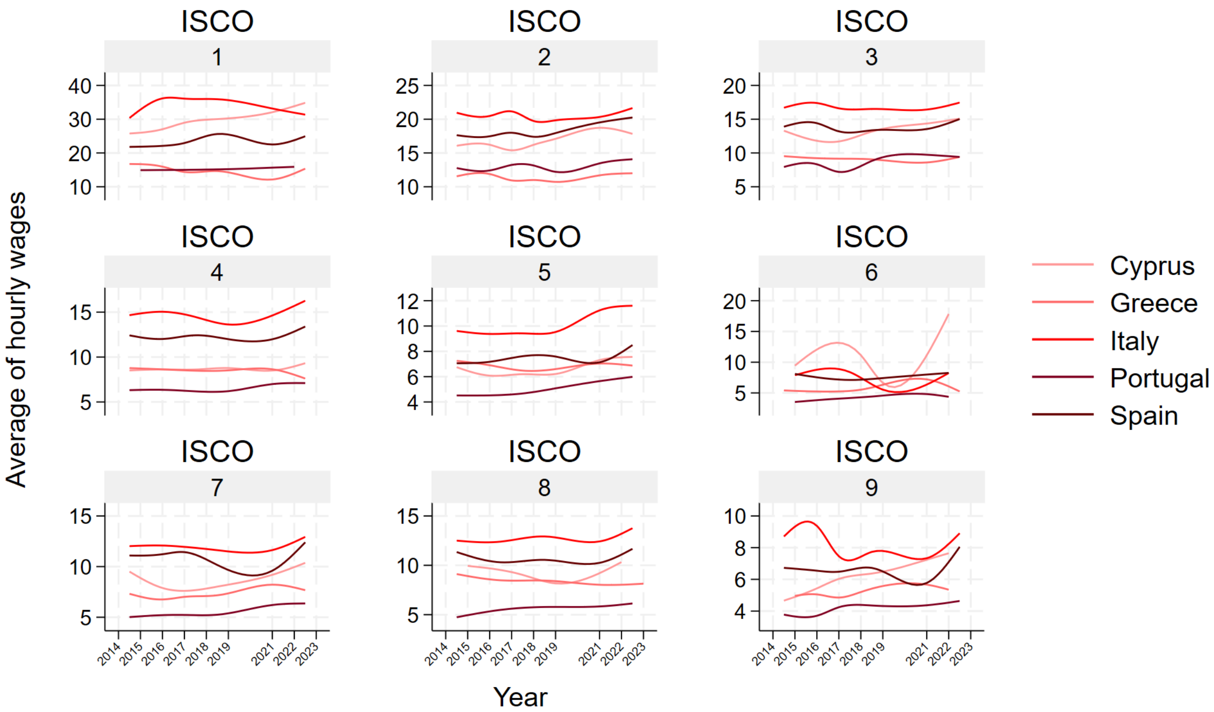


2.2.3.2.4 Southern countries

Southern Europe is characterised by weak to moderate growth in hourly wages, which is often accompanied by instability. Unlike other European regions, this area struggles to demonstrate robust wage dynamics, with significant differences between countries.

In Spain, for example, hourly wages have seen slow but steady growth, reflecting an economy that is recovering from successive crises. In Italy, however, wages have remained virtually stagnant in several sectors. In Portugal, growth has been gradual but low compared to the European average. Greece experienced a significant decline between 2014 and 2017, which was linked to the sovereign debt crisis. The U-shaped trajectory of several occupational groups (particularly managers) illustrates the depth of the crisis. The situation in Cyprus is highly volatile, with significant year-on-year fluctuations.

Figure 20. EU_SILC– Hourly wages in Southern countries



2.2.3.3 Key trends and developments

Hourly wages have increased across all European regions, albeit at different rates, reflecting diverse economic conditions and labour market dynamics. While Eastern Europe is experiencing rapid wage convergence, Western and Nordic countries continue to benefit from strong wage growth. Meanwhile, Southern Europe is showing more moderate increases, highlighting the persistent disparities in earnings across the European labour market.

In Western Europe, hourly wages have risen steadily but unevenly. Growth accelerated after 2020 due to labour market tightness, inflation and certain wage policies. Germany and Ireland have seen sharp increases, particularly in skilled occupations, while Belgium and the Netherlands have experienced more moderate growth.

In Eastern Europe, wages have risen sharply, reflecting the region's efforts to catch up with other part of Europe.

Conversely, Southern European countries have experienced quite stable growth, with Italy on top for most of the ISCO groups.

The Nordic countries continue to have the highest hourly wage levels in Europe, with stable and sustained growth, especially in Denmark since 2020. Finland and Sweden are characterised by a more moderate and stable trends in wages across occupations.

2.2.4 Working hours

2.2.4.1 Data and methods used to calculate the European indicators

The working hours are extracted from EU-LFS data. We calculate the average usual number of hours worked per week by country and year at the ISCO 3-digit level. We restrict the sample to employed individuals with a full-time employment contract and less than 81 hours per week declared for work. The same weights as those calculated from the labour shortages are used. The same EU 17 countries for the periods 2014-2019 & 2021-2023 are covered.

The data table contains the country code (AT, BE, etc.), the year, the ISCO 2-digit codes, and the working hours.

2.2.4.2 Differences and variations between country types and countries

Weekly working hours in Western Europe have remained broadly stable, with only a slight decline since 2019–2020. Cross-country differences are more pronounced than changes over time, with the Netherlands recording the shortest working hours and agricultural occupations consistently working the longest hours.

The Nordic countries are characterised by relatively low and stable weekly working hours, reflecting strong working time regulation. Denmark consistently records the shortest working hours, while agricultural occupations (ISCO 6) remain the exception, with substantially longer working hours than other occupational groups.

Weekly working hours in Eastern Europe remained broadly stable between 2014 and 2023, with only modest differences across countries. Czechia generally recorded the longest working hours, while agricultural occupations continued to stand out with substantially higher working hours than other occupational groups.

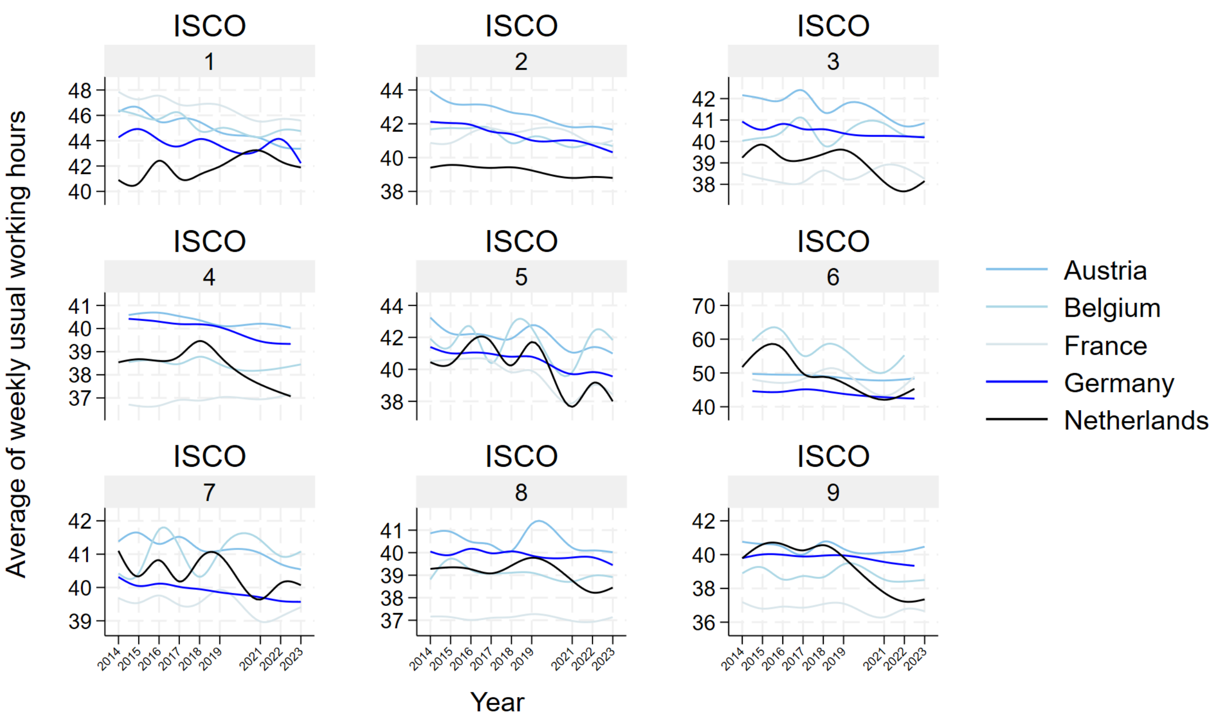
Weekly working hours in Southern Europe remained broadly stable between 2014 and 2023, despite marked differences across countries. Greece consistently recorded the longest working hours, while agricultural and manual occupations continued to work substantially longer hours than other occupational groups.

2.2.4.3 Western countries

In Western countries, working hours have remained relatively stable over time across most occupations, though notable declines have been observed since 2019–2020. Differences between countries are more pronounced than temporal variations.

The Netherlands consistently has the lowest working hours in several categories. Belgium and Austria often have the highest levels, particularly for certain skilled or technical professions. Germany generally occupies an intermediate position, with a fairly stable trend over time. Agricultural occupations (ISCO 6) remain atypical, with very long working hours.

Figure 21. LFS – Weekly usual working hours evolution in Western countries



2.2.4.4 Nordic countries

The Nordic countries have relatively low and stable weekly working hours compared to other European countries. While there are differences between countries, these remain generally limited.

Denmark consistently has the lowest levels in almost all occupational categories. Sweden and Finland have slightly higher levels, with greater fluctuations depending on the profession.

Changes over time remain moderate, though some occupation categories have experienced more noticeable variations since 2019–2020. Overall, working hours primarily range between 37 and 41 hours per week, reflecting the Nordic model characterised by significant working time regulation. As in other parts of Europe, ISCO category 6 has the highest working hours by far.

Figure 22. LFS – Weekly usual working hours evolution in Nordic countries

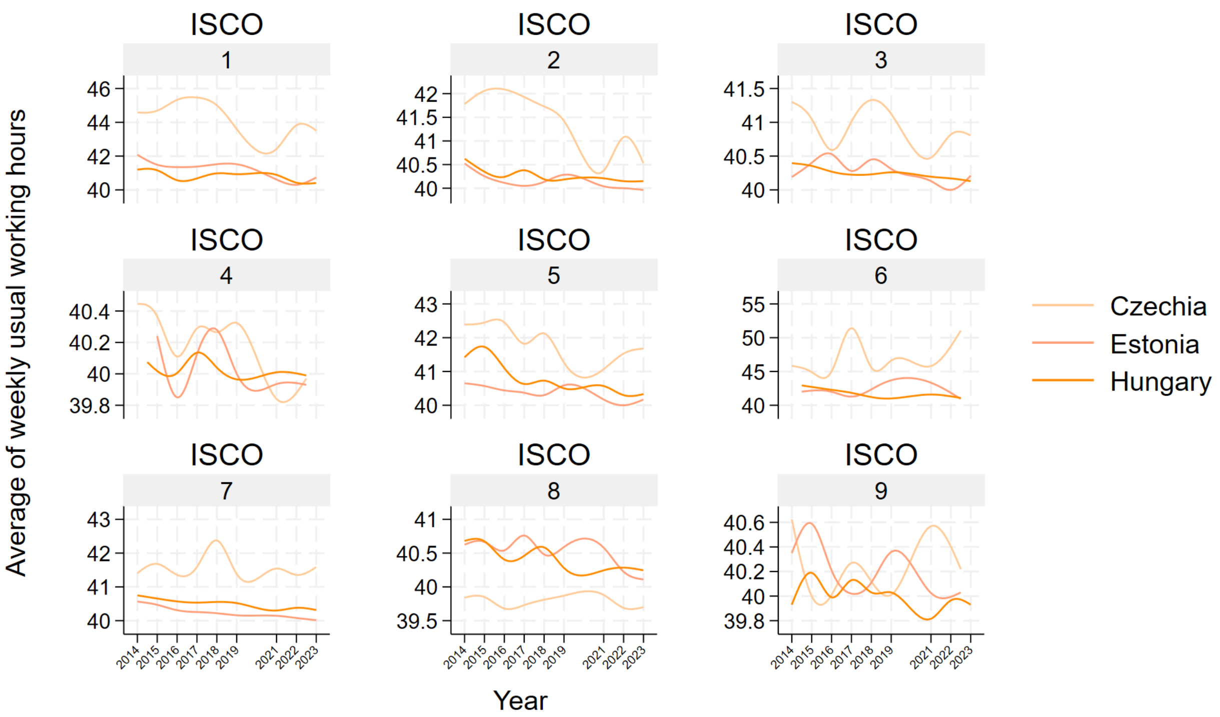
2.2.4.5 Eastern countries

Overall, the usual number of weekly working hours remained relatively stable between 2014 and 2023 in the three countries studied. The modest variations observed reflect a certain continuity in working time regimes over the period.

Czechia most often recorded the highest working hours, with particularly significant differences in certain occupational categories. Estonia and Hungary had lower, more similar levels, with a slight downward trend in several categories.

However, differences between countries remained moderate for most ISCO groups, except in a few specific professions. As in other EU countries, agricultural work and related occupations demonstrate significant specificity, likely due to seasonality and activity constraints. Administrative, technical and manual categories (ISCO 3, 4, 8 and 9) appear particularly stable, suggesting a consistent organisation of working hours in these professions.

Figure 23. LFS – Weekly usual working hours evolution in Eastern countries



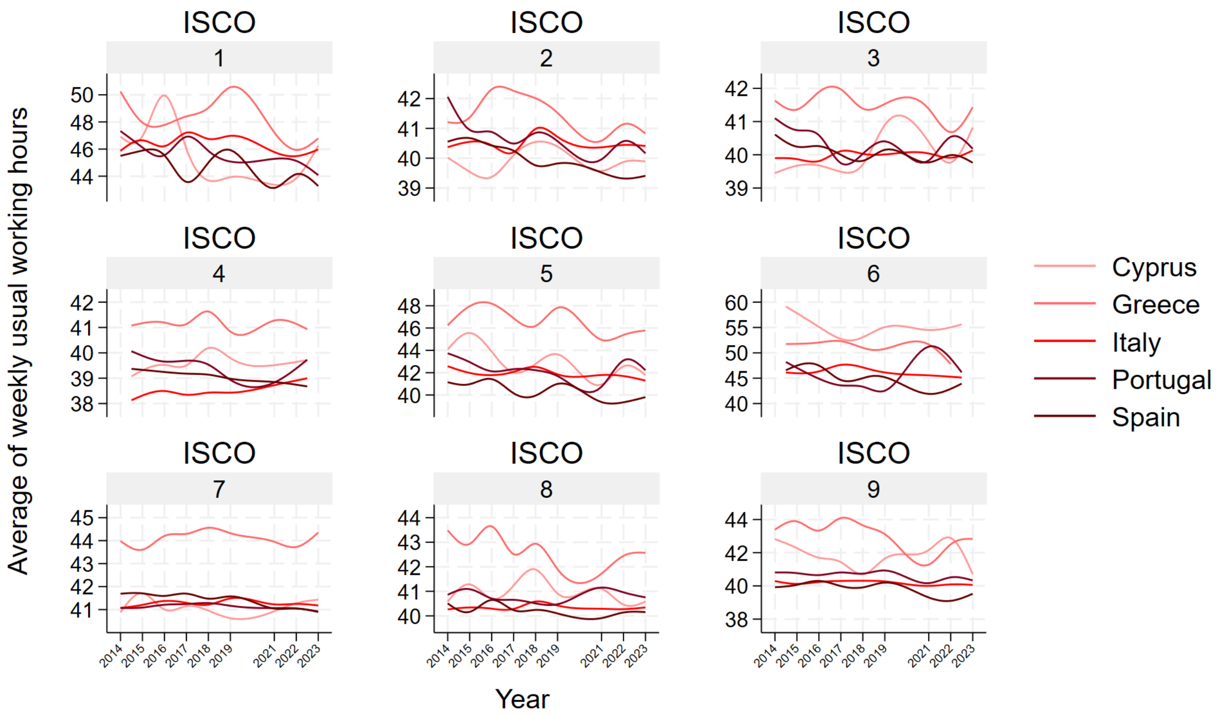
2.2.4.6 Southern countries

The figure shows that there has been relative stability in the usual weekly working hours in the studied Southern European countries between 2014 and 2023. However, the differences between countries are more pronounced here than in other European groups.

Greece clearly stands out with the highest working hours in almost all occupational categories. Meanwhile, Italy, Portugal and Spain exhibit relatively close and stable intermediate levels. Cyprus often occupies an intermediate position, but with greater fluctuations depending on the profession.

A slight decline in working hours appears in some occupation categories after 2019–2020 without any major disruption. We also observe a clear contrast between agricultural and manual jobs (ISCO 6-7), which are associated with longer hours, and more skilled or administrative professions, which are characterised by greater stability around the 40-hour standard.

Figure 24. LFS – Weekly usual working hours evolution in Southern countries



2.2.4.7 Key trends and developments

The usual number of working hours per week remained stable across the European Union between 2014 and 2023, with only a slight decline observed after 2019–2020. This suggests that working time arrangements have changed little over the past decade despite major economic shocks.

Weekly working hours in Western Europe have remained relatively stable since 2019–2020, with only a slight overall decline. Cross-country differences are more pronounced than temporal changes: the Netherlands records the shortest average hours.

Nordic countries exhibit consistently low and stable weekly working hours, a pattern attributed to strong labour time regulations. Denmark has the shortest hours in the region.

In Eastern Europe, weekly working hours have shown little change between 2014 and 2023, with only minor cross-country variation. Czechia typically records the longest hours.

Southern Europe has maintained relatively stable weekly working hours between 2014 and 2023, despite significant cross-country disparities. Greece consistently has the longest hours.

2.2.5 Employment growth

2.2.5.1 Data and methods used to calculate the European indicators

The employment growth is based on EU-LFS data. We calculate the number of employed people by country and year at the ISCO 3-digit level. The growth rate between two consecutive years (except around 2020) is calculated. The weights calculated from the labour shortages are used. The same EU 17 countries for the periods 2014-2019 & 2021-2023 are covered.

The data table contains the country code (AT, BE, etc.), the year, the ISCO 3-digit codes, and the employment growth.

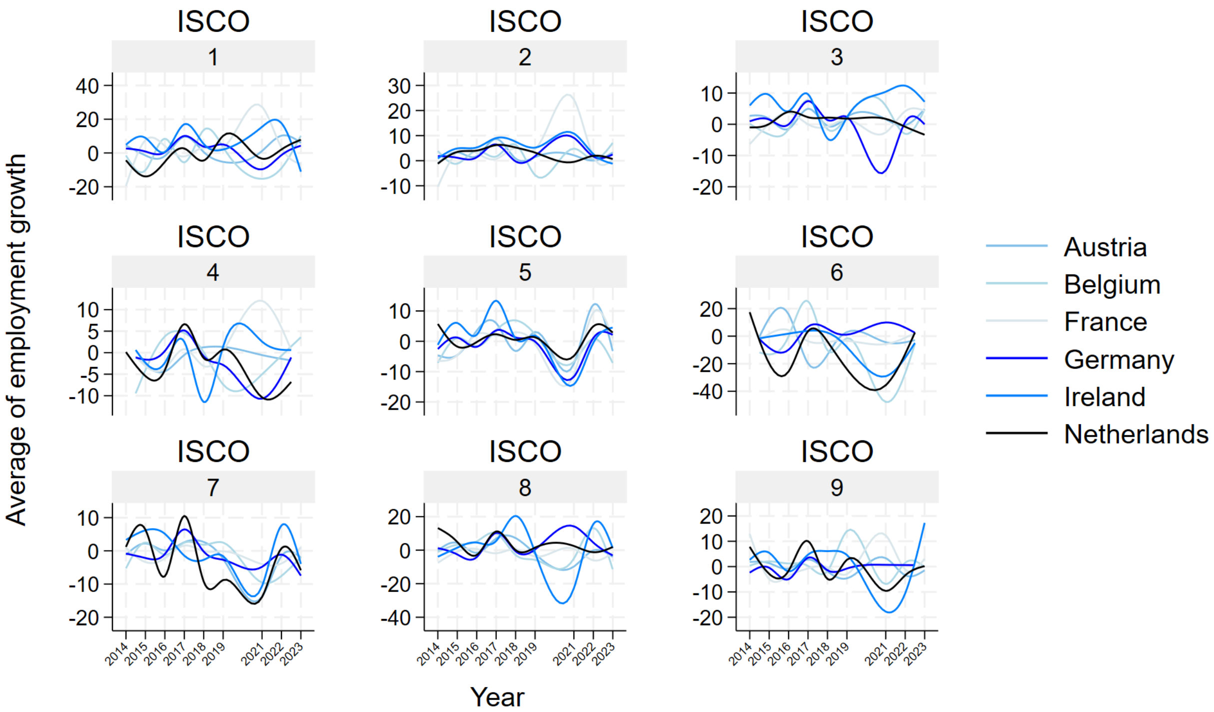
2.2.5.2 Differences and variations between country types and countries

2.2.5.2.1 Western countries

Unlike other regions of Europe, Western Europe is characterized by more stable and moderate growth, with less volatility. The region has shown relative resilience, although some countries have experienced one-off shocks.

Germany has followed a relatively stable trajectory, with moderate growth in skilled jobs (ISCO categories 1-3). However, it has not been immune to disruption, as evidenced by the 2021 shock (e.g. a 22% decrease in ISCO category 3). France experienced a fairly sharp recovery after 2021, particularly in intermediate jobs (ISCO category 2 grew by 16.9% in 2021). Services (ISCO category 5) also grew, confirming a positive trend in this sector. Belgium and the Netherlands have shown moderate fluctuations without extremes. However, there has been a persistent decline in manual occupations (ISCO categories 6-8), reflecting structural challenges in these sectors. Prior to the crisis, Ireland stood out for its very strong momentum, with dramatic increases such as +25% in 2017 for ISCO category 1. However, its trajectory subsequently became more volatile, illustrating increased sensitivity to economic shocks.

Figure 25. LFS – Employment growth in Western countries

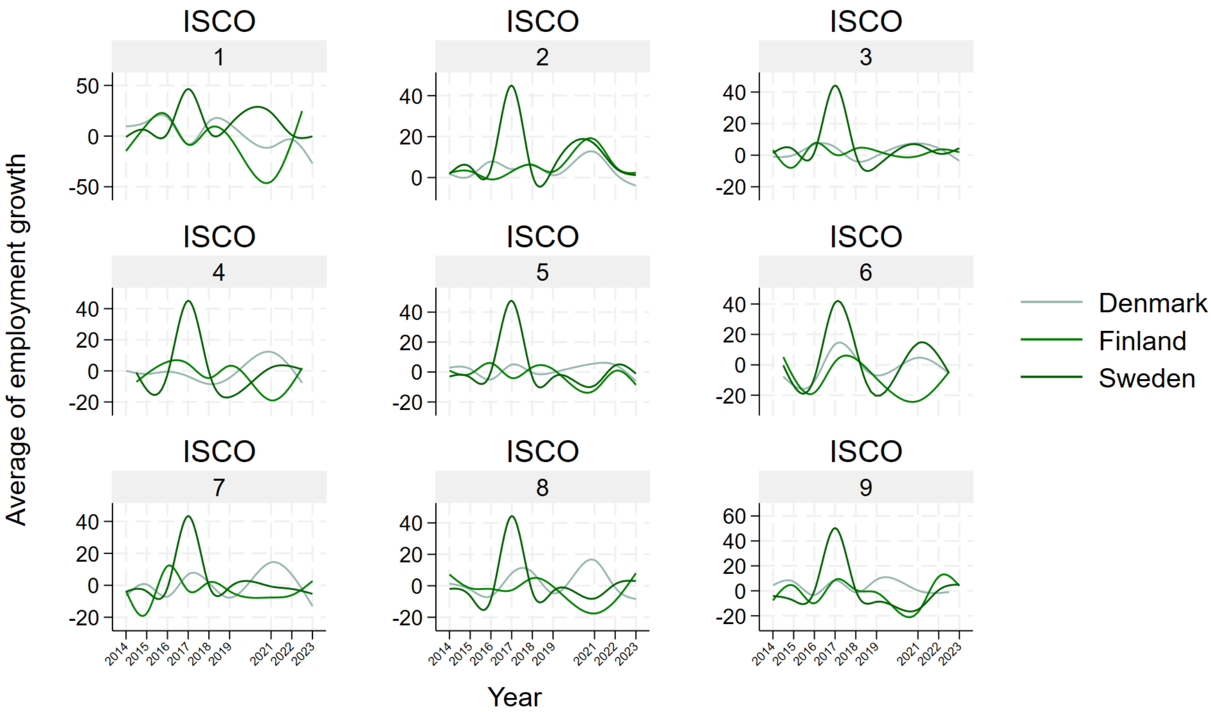


2.2.5.2.2 Nordic countries

The Nordic countries are characterised by an economic trajectory that is both highly volatile and remarkably resilient. Prior to 2019, these countries typically experienced more robust growth, followed by an economic shock in 2021 and a partial recovery in subsequent years.

Sweden experienced an exceptional surge in 2017, with dramatic increases in employment across nearly all sectors ranging from 40% to 47%. Denmark is characterised by many fluctuations. It experienced strong growth prior to 2019, followed by a sharp decline in 2023, particularly among ISCO 1 and ISCO 7 (-30%). Finland's trend is more uneven, with significant declines in several categories, particularly in 2021, but also occasional rebounds, such as an increase in ISCO 1 in 2023.

Figure 26. LFS – Employment growth in Nordic countries

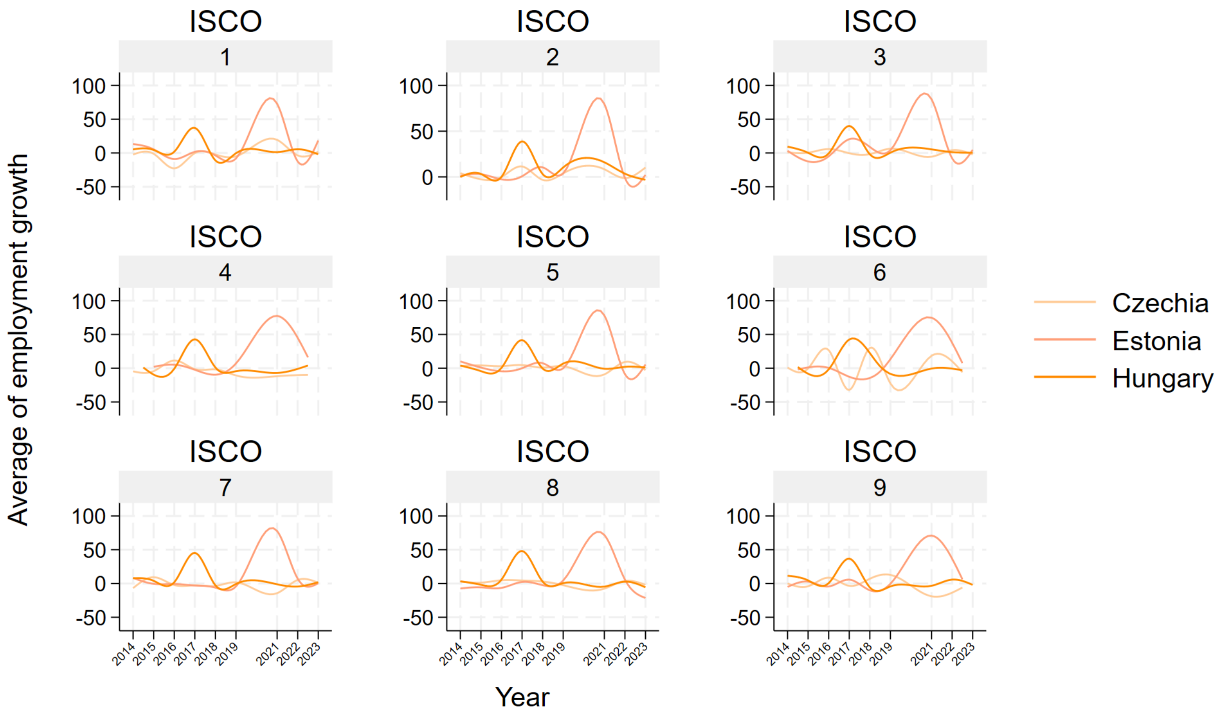


2.2.5.2.3 Eastern countries

Eastern Europe is characterised by extremely high volatility, with phases of economic catch-up and periods of growth that can be very strong. The region exhibits contrasting dynamics, ranging from rebounds to persistent instability.

Estonia experienced an economic boom in 2021, with increases reaching +70% in nearly all categories. This post-crisis recovery was particularly notable, demonstrating the country's capacity for rapid recovery from economic shocks. Meanwhile, Hungary experienced a widespread boom in 2017, with growth ranging from 30% to 46%, depending on the category. Following this prosperous period, the country stabilised, although instability remains a defining feature of its economy. Czechia shows moderate but persistent fluctuations. Instability is particularly evident in low-skilled occupations (ISCO categories 6-9), reflecting structural challenges in these sectors.

Figure 27. LFS – Employment growth in Eastern countries



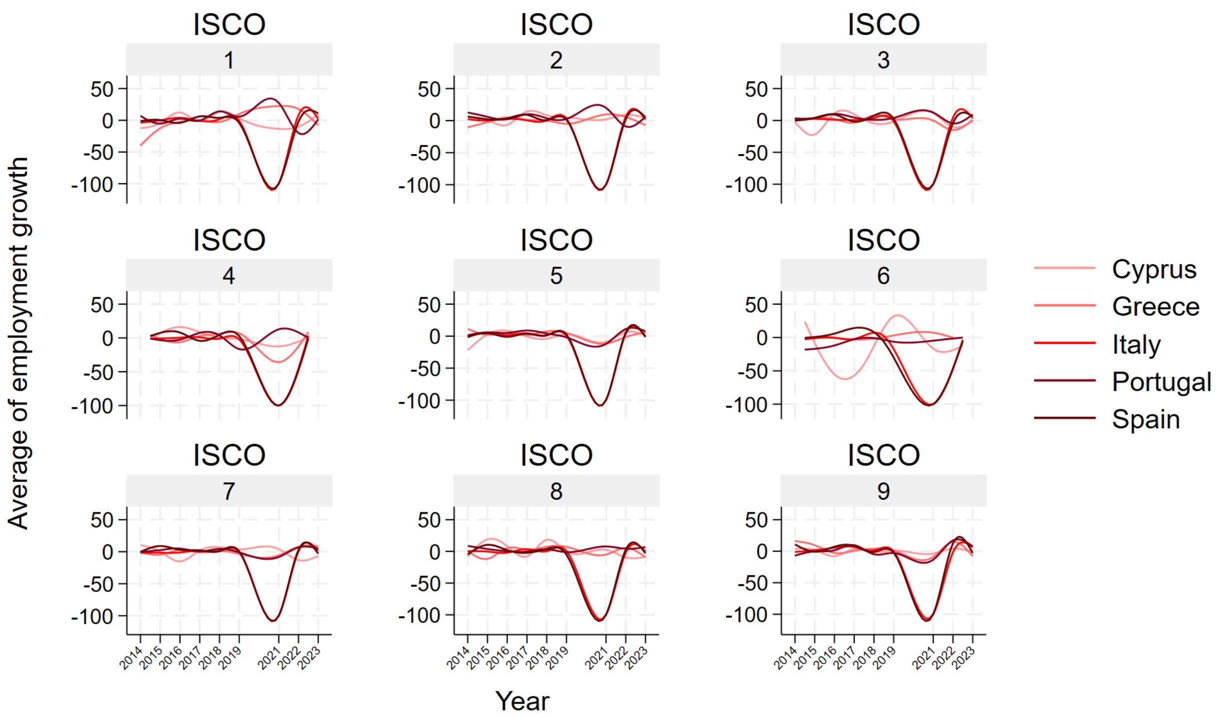
2.2.5.2.4 Southern countries

Southern Europe is characterized by significant structural instability, with crises, particularly the COVID-19 pandemic, having a notably severe impact. This region has been hit harder than others, with several countries experiencing sharp economic contractions. [4] Most of Southern European countries experienced have experienced a flat rate. However, Spain and Italy, experienced a collapse in 2021, with sharp declines in many occupations associated with the crisis. A partial recovery was observed thereafter, though it did not erase the scars of the crisis. Greece has been affected by the legacy of the sovereign debt crisis, with sharp contractions beginning in 2014. This volatility illustrates a particularly fragile and sensitive economy. In contrast, Portugal has shown a more positive trend recently, with growth since 2021 contrasting with the difficulties faced by other countries in the region. This rebound suggests gradual resilience, although structural challenges persist. Cyprus is characterised by

[4] It should be noted that, for graphical presentation purposes, a lower threshold was set at -100.

fluctuations, particularly in manual occupations (e.g. ISCO 8), reflecting a small economy that is highly sensitive to cyclical variations and external shocks.

Figure 28. LFS – Employment growth in Southern countries



2.2.5.3 Key trends and developments

Employment growth remained resilient across the European Union between 2014 and 2023, despite major economic shocks. However, its intensity and stability varied considerably across regions. Western and Nordic countries demonstrated greater resilience and recovery capacity, whereas Eastern and Southern Europe experienced more uneven trajectories. This reflects persistent structural differences in labour market performance and economic adjustment.

Despite some one-off shocks, particularly in Germany, France and Ireland, Western Europe has experienced relatively stable and moderate employment growth between 2014 and 2023. However, there has been a structural decline in manual jobs, although certain occupations have grown in some countries since 2021.

Eastern Europe has exhibited high volatility in Estonia, while the growth rate has remained around zero in most occupations in Czechia and Hungary.

Most Southern European countries experienced a flat curve. Spain and Italy were hit by a recession linked to the Coronavirus crisis, while Greece was affected by the legacy of the sovereign debt crisis, experiencing sharp contractions from 2014 onwards. Portugal has shown a more gradual recovery since 2021.

The Nordic countries combine high volatility with a strong capacity for recovery. After periods of sustained growth prior to 2019, they experienced significant shocks around 2021, followed by partial recovery.

2.3 The dataset produced at a glance

Table 4 provides an overview of the dataset created.

Table 4. Past and current labour and skills shortages and mismatches dataset

Name of the indicators	Level of granularity	Indicators produced
labour_short	ISCO 3-digit and countries (17 EU)	Labour shortage
basic_literacy advanced_literacy basic_numeracy advanced_numeracy basic_ict moderate_ict advanced_ict technical_skill com_skill team_skill custo_skill pbsol_skill learn_skill plan_skill	ISCO 2-digit and countries (27 EU)	14 skills
mean_overskill mean_underskill	ISCO 2-digit and countries (27 EU) (2010; 2015; 2024)	Skill mismatch (under/over skilled)
mean_wageG_perH	ISCO 2-digit and countries (17 EU)	Wages per hours worked
mean_uh	ISCO 3-digit and countries (17 EU)	Usual working hours
employment_growth	ISCO 3-digit and countries (17 EU)	Employment growth

3 Forecast of the future of employment

To forecast the future of employment, we use a theoretical model previously developed by Burzynski et al. (2023). This model considers, the skill content of tasks across occupations, equilibrium skill prices, the allocation of workers across occupations, sectors and European regions. By simulating workers' sorting patterns, the model generates projections of future labour demand and skill requirements that account for technological advancements, demographic shifts, and economic trends.

The general equilibrium is the straightforward conjunction of goods, firms and labour market equilibria, along with a macro income consistency criterion. Formal definitions state that an economy is in general equilibrium when all markets are cleared and total expenditure in a given region equals the total income earned by workers in that region. See by Burzynski et al. (2023) for details.

The model is built on the following 4 groups of occupation, while within those groups the similarity of occupations is large and that having more groups is significantly more complicated computationally.

Table 5. Occupation groups

Occupation groups	ISCO1D	Description
O1	1	Managers
O2	2	Professionals
	3	Technicians and associate professionals
O3	4	Clerical support workers
	5	Service and sales workers
O4	6	Skilled agricultural, forestry and fishery workers
	7	Craft and related trades workers
	8	Plant and machine operators, and assemblers
	9	Elementary occupations

3.1 Data and methods

3.1.1 Data sources

Labor Market The main data sources for the numerical exercise are derived from Eurostat. First, the Labour Force Survey (LFS) is used to calculate the supply of different types of workers in all NUTS1 geographical regions. To estimate the continuous distributions of worker skills, we use an algorithm that minimises the distance between the empirical (i.e. the distributions observed in the data) and the modelled wage distributions. Next, we use the Structure of Earnings Survey (SES) to create non-parametric kernel estimates of occupational wage distributions for native workers of all educational backgrounds and occupations in 100 European regions.

Migration The model's objective is to determine the number of people who move between European regions by education level, a figure that is not easily obtained from existing data sources. To achieve this, the DIOC database is used alongside data on country-pair-specific common borders, language and Schengen area dummies from CEPII (Head and Mayer, 2014), as well as country-specific wages by education level derived from Eurostat's SES.

Education We also use the Wittgenstein Centre for Demography and Global Human Capital (2023) projections by education level for three Shared Socioeconomic Pathways that correspond to slow, medium and fast rates of increase in the proportion of people with a college education.

Automation In our model, three factors are affected by automation: the relative productivity of labour compared to capital; the occupational input required in different sectors; and the amount of capital invested in automation. In order to make projections for 2033, we first identify the key relationships between the core macroeconomic variables. (1) We identify the relationship between automation intensity and labour share using data on compensation to value added (the left-hand-side variable) and the share of IT and software capital in total capital (the right-hand-side variable). (2) We also account for the impact of robotisation on labour share evolution in production using International Federation of Robotics (IFR, 2020) data. (3) We compute country- and sector-specific time trends in the share of computer hardware and software within the total capital stock, as well as trends in the total number of industrial robots, using EU-KLEMS data. (4) Using the estimates from the above steps, we calculate the change in the country-sector labour share for our medium automation scenario. (5) To model changes in occupational inputs within sectoral production functions, we employ microdata on occupational-sector income shares from the Structure of Earnings Survey (SES, 2010, 2014, 2018) provided by Eurostat. (6) A direct implication of automation in our model is an increase in the stock of automation capital, including ICT equipment, software, and databases. According to our analysis, this type of capital is assumed to be perfectly substitutable with labour and has increased considerably in the last two decades, as shown by EU-KLEMS data.

Regional Trade by Sectors Trade matrices by region and aggregated sector are computed using the OECD's Trade in Value Added (TiVA) dataset and the EU regional trade database created by the JRC and PBL (Thissen et al., 2015).

Macro Indicators The final data inputs for the calibration procedure are the macroeconomic data for European economies. We collect labour and capital stock data by sector (including structures and automation capital) from Eurostat, as well as 2018 sectoral GDP values. These are then decomposed into employee compensation, capital compensation, and corporate profits by eight aggregated sectors. These are supplemented by data on price levels (PPP indexes), interest rates and firm demographics (number of active firms, survival rates and exit rates). We also use sector- and country-specific trends in total assets and ICT equipment between 2001 and 2018 to calculate contemporary and future structure stocks as the difference between these two variables. We determine future working-age population counts using projections from the Wittgenstein Centre for Demography and Global Human Capital (2023).

Exogenous parameters In order to complete the input of reference data for the model, the values of several external parameters must be set. Two of these are the elasticities of substitution between sector-specific goods and between goods within each sector. In line with a substantial body of literature on industrial organisation and trade (e.g., Simonovska and Waugh, 2014), these values are set to 3 and 4, respectively. We then assume that the minimum productivity level in each sector is normalised to one. To define the sector-specific elasticities of substitution between capital and labour, we refer to Chirinko and Mallick (2017), setting the vector of σs to (0.6, 0.41, 0.74, 0.36, 0.63, 1.16, 0.24, 0.27). Finally, in line with Ottaviano and Peri (2012), we set the elasticities of substitution between educational attainment and origin groups to 2 and 20, respectively.

3.1.2 Calibration of projections

In our model, automation influences the structure of the economy in various ways. Firstly, it alters the relative productivity of capital and labour within the aggregated production function. Secondly, it affects the relative importance of occupations in generating added value. Thirdly, automation is reflected in a direct change to the supply of automated capital, which perfectly substitutes labour. Finally, it influences the pattern of capital accumulation.

The reference scenario

Our aim is to provide reasonable projections for the future state of the European economy at the horizon of 2033. All the simulation results therefore refer to the new equilibrium of the European economy in 2033, since the core of our model is calibrated using 2018 data. This reference projection for 2033 serves as a no-automation baseline assuming no change in automation patterns between 2018 and 2033.

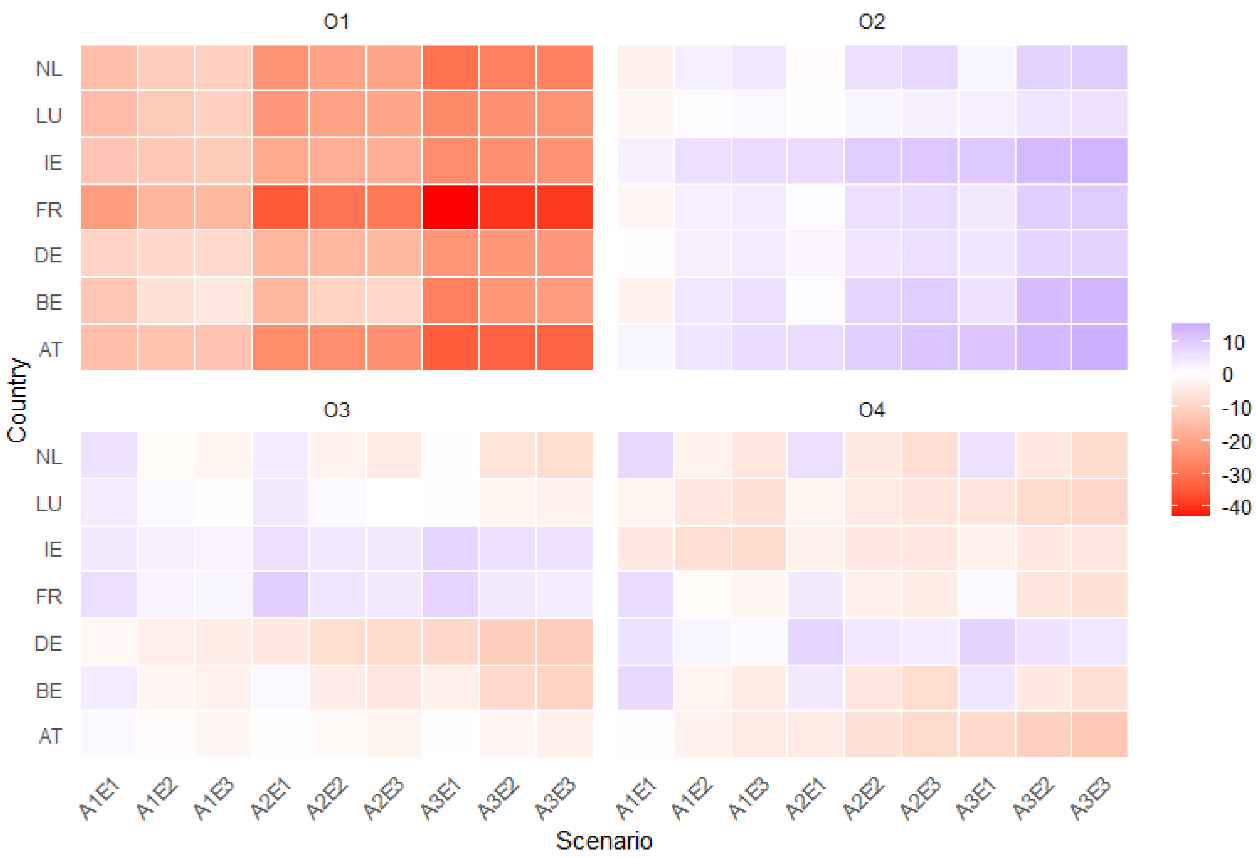
The projections

Our projections built on scenarios for automation (labelled with prefix A) and education (labelled with prefix E). To generate low- and high-impact scenarios, we take the benchmark projection (labelled as A2E2) and apply a uniform reduction/increase of key automation variables by 50% (the numbers for scenarios A1 and A3 equal -50% and +50% of changes reported in the A2 scenario). We also take advantage of alternative projections for the education structure of European populations by the Wittgenstein Center. The country-specific education scenarios are labelled E1, E2, E3 for low, medium and high acquisition of higher education. This enables us to run nine projections spanning over all combinations of A1-A3 and E1-E3 scenarios.

3.2 Differences and variations between country types and countries

3.2.1 Western countries

Figure 29. Change in employment in 2033 versus the reference scenarios – Western countries



Note: Occupations groups are labelled 01, 2, 3, 4, see Table 5 for details. Automation scenarios are labelled A1, A2, A3 for low, medium and high impact of automation, education scenarios are labelled E1, E2, E3 for low, medium and high acquisition of higher education.

Figure 30. Change in employment in 2033 versus the reference scenarios – Western countries

The figure above illustrates the different impact of automation that relates to pre-generative AI digital transformations and education will have on employment in Western European countries by 2033. Several key findings emerge. For O1 occupations, the effects are consistently negative in all scenarios. Job losses become more pronounced as automation intensifies (from A1 to A3), even in favourable educational scenarios. France appears to be the country most exposed to these effects, with particularly sharp declines under high-automation scenarios. This suggests that O1 occupations likely correspond to routine or easily substitutable tasks that were already widespread before the rise of generative AI.

O2 occupations generally exhibit the most favourable results. The effects are positive in almost all countries and tend to increase with more ambitious educational scenarios. This suggests that these occupations benefit more from the diffusion of digital technologies, likely because they involve cognitive, technical or organisational skills that complement digital tools.

O3 occupations demonstrate positive or only mildly negative effects in several countries. Gains become more visible in scenarios combining high levels of education (E2-E3). This indicates that improving skills enables the more favourable absorption of digital transformations, turning some automation into productive complementarity rather than pure substitution.

For O4 occupations, the effects are more varied but remain moderate overall. Some countries see gains in high-education scenarios, while others remain close to the baseline. This may reflect a more diversified sectoral structure or institutional differences in labour market adaptation.

Geographically, France stands out due to its higher sensitivity to automation scenarios, particularly for O1. Smaller, more open countries such as Luxembourg, the Netherlands and Ireland appear to exhibit more moderate or balanced effects, potentially due to their greater sectoral specialisation in advanced services and skill-intensive activities.

Overall, the figure suggests that automation and education changes were already creating significant polarisation in the labour market even before the advent of generative AI: routine occupations experienced job losses, while occupations complementary to digital technologies benefited from gains, especially with acquisition of higher education.

3.2.2 Nordic countries

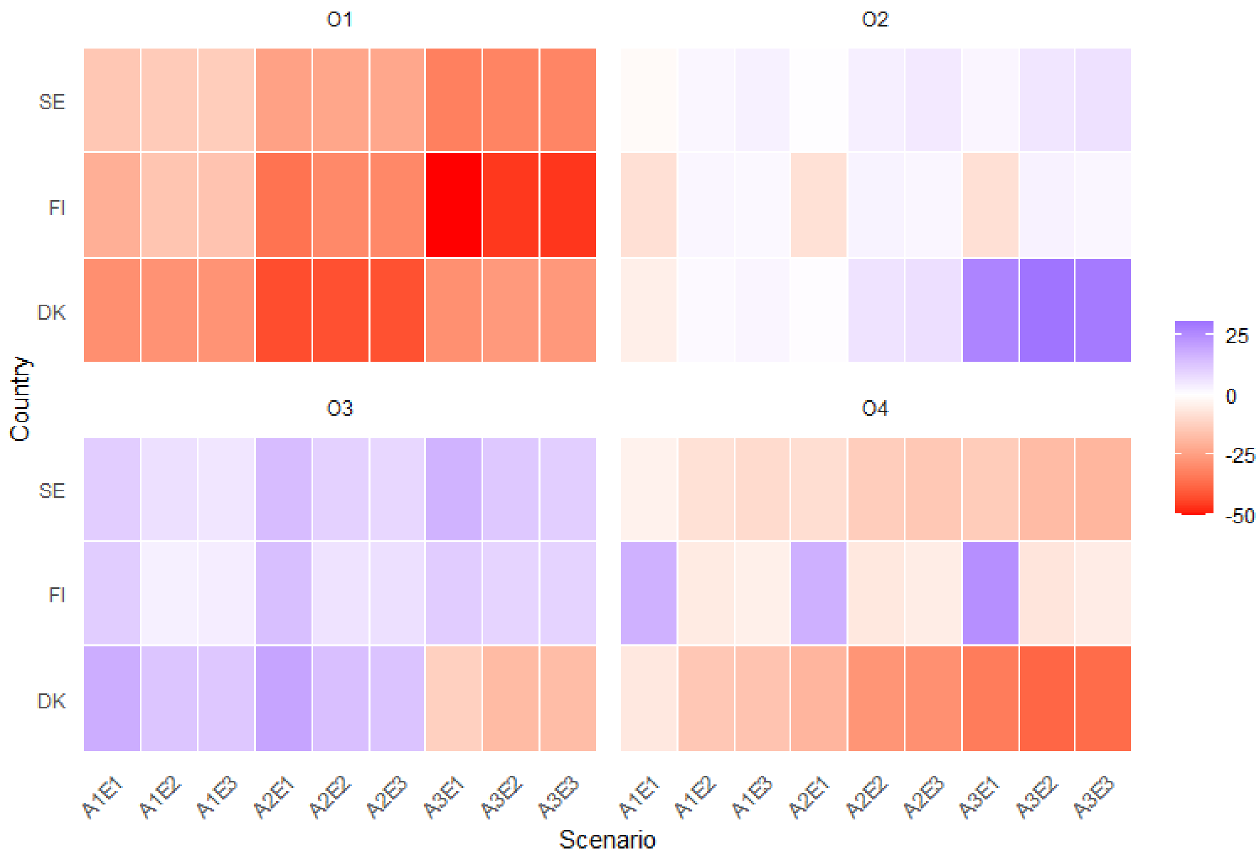
The figure for the Nordic countries reveals a different trend compared to other European regions.

For O1 occupations, the effects are negative in all Nordic countries, but the intensity varies significantly. Finland appears to be the most affected, experiencing substantial losses in highly automated scenarios (A3), while Sweden sees more moderate declines. Denmark presents a particular trajectory: substantial losses are seen in intermediate automation scenarios, but these seem slightly less pronounced in the highest automation scenarios. Overall, these results suggest that O1 occupations are still vulnerable to technological substitution processes.

In contrast, O2 occupations show positive effects in almost all scenarios. Denmark stands out in particular, with very high job gains in scenarios combining strong automation with high levels of education. This indicates that Nordic economies can transform digital investments into productive complementarity, primarily due to their high-performing educational systems and strong capacity for skill adaptation.

The results for O3 occupations are the most favourable of all. Sweden and Finland record significant and relatively stable gains in all scenarios, while Denmark exhibits a contrasting trend: while gains remain high in A1 and A2 scenarios, they decrease in the most advanced automation scenarios. This may indicate that, beyond a certain level of digitalisation, some intermediate tasks also become more easily automatable.

Figure 31. Change in employment in 2033 versus the reference scenarios – Nordic countries



Note: Occupations groups are labelled 01, O2, O3, O4, see Table 5 for details. Automation scenarios are labelled A1, A2, A3 for low, medium and high impact of automation, education scenarios are labelled E1, E2, E3 for low, medium and high acquisition of higher education.

O4 occupations exhibit greater heterogeneity. Finland experiences positive or near-zero effects in several scenarios, particularly as education progresses. In contrast, Denmark experiences increasing losses as automation intensifies, particularly in A3 scenarios. Sweden occupies an intermediate position, experiencing moderately negative but relatively stable effects.

Overall, the Nordic countries appear to be in a better position to benefit from automation, thanks to their high level of human capital, the widespread adoption of digital technologies, and labour market institutions that facilitate skill adaptation. Nevertheless, the results indicate that these economies still face significant substitution risks for certain routine occupations. Educational scenarios therefore play a central role in the ability of the Nordic countries to transform digitalisation into net job creation rather than destruction.

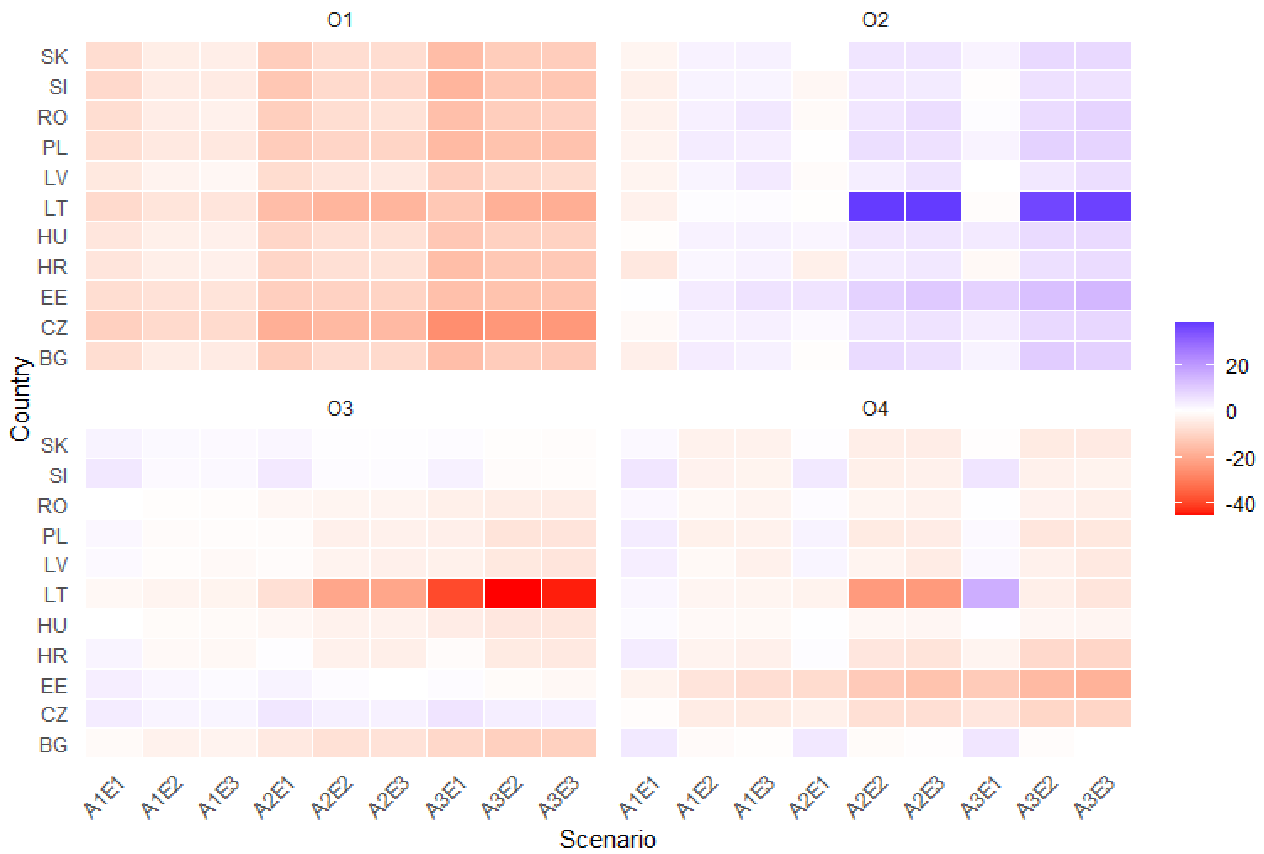
3.2.3 Eastern countries

The figure shows that, by 2033, the effects of automation and education acquisition on employment will be more pronounced and more heterogeneous in Eastern Europe than in other part of the EU, especially Western Europe.

For O1 occupations, the effects are generally negative across all countries and scenarios. Job losses gradually increase with the intensification of automation (from A1 to A3), confirming that these occupations are particularly susceptible to technological substitution. However, the declines appear, on average, to be slightly less severe than in some Western European countries, which may reflect either a more gradual diffusion of digital technologies or an economic structure that is still more oriented towards intermediate sectors.

O2 occupations show significantly more favourable effects. Several countries record substantial job gains in medium or high automation scenarios, particularly when education levels improve. Lithuania stands out in particular, with very significant gains under certain scenarios combining automation and skill upgrading. This suggests that digital transformation can support demand for intermediate-skilled labour in several Eastern European economies when accompanied by sufficient educational investment.

Figure 32. Change in employment in 2033 versus the reference scenarios – Eastern countries



Note: Occupations groups are labelled 01, 2, 3, 4, see Table 5 for details. Automation scenarios are labelled A1, A2, A3 for low, medium and high impact of automation, education scenarios are labelled E1, E2, E3 for low, medium and high acquisition of higher education.

The results for O3 occupations are much more varied. While some countries, such as the Czech Republic and Slovakia, experience slightly positive or near-zero effects, others, particularly Lithuania, face significant losses in high automation scenarios. This indicates that certain O3 occupations are exposed to a high risk of restructuring in economies that are strongly integrated into European industrial value chains, where the automation of productive tasks can occur rapidly.

O4 occupations tend to have moderate, albeit varied, effects depending on the country. While some countries experience slightly positive effects in highly educated scenarios, others, notably Bulgaria and Estonia, record more significant losses as automation increases. These differences may reflect variations in sectoral structure, work organisation, or the adaptability of labour markets to institutional changes.

From a regional perspective, the chart suggests that Eastern European economies respond more polarisingly to digital transformation. Some countries appear to be able to capitalise on digitalisation by rapidly upgrading their skills, while others remain more vulnerable to the effects of technological substitution. The disparities observed between countries thus highlight the importance of educational policies and continuous training in supporting the digital transition.

Overall, the results show that digital transformations had already had a significant impact on the employment structure in Eastern Europe even before the emergence of generative AI. However, the effects appear less uniform than in Western Europe, with contrasting national trajectories depending on the level of industrial specialisation and the adaptability of educational and productive systems.

3.2.4 Southern countries

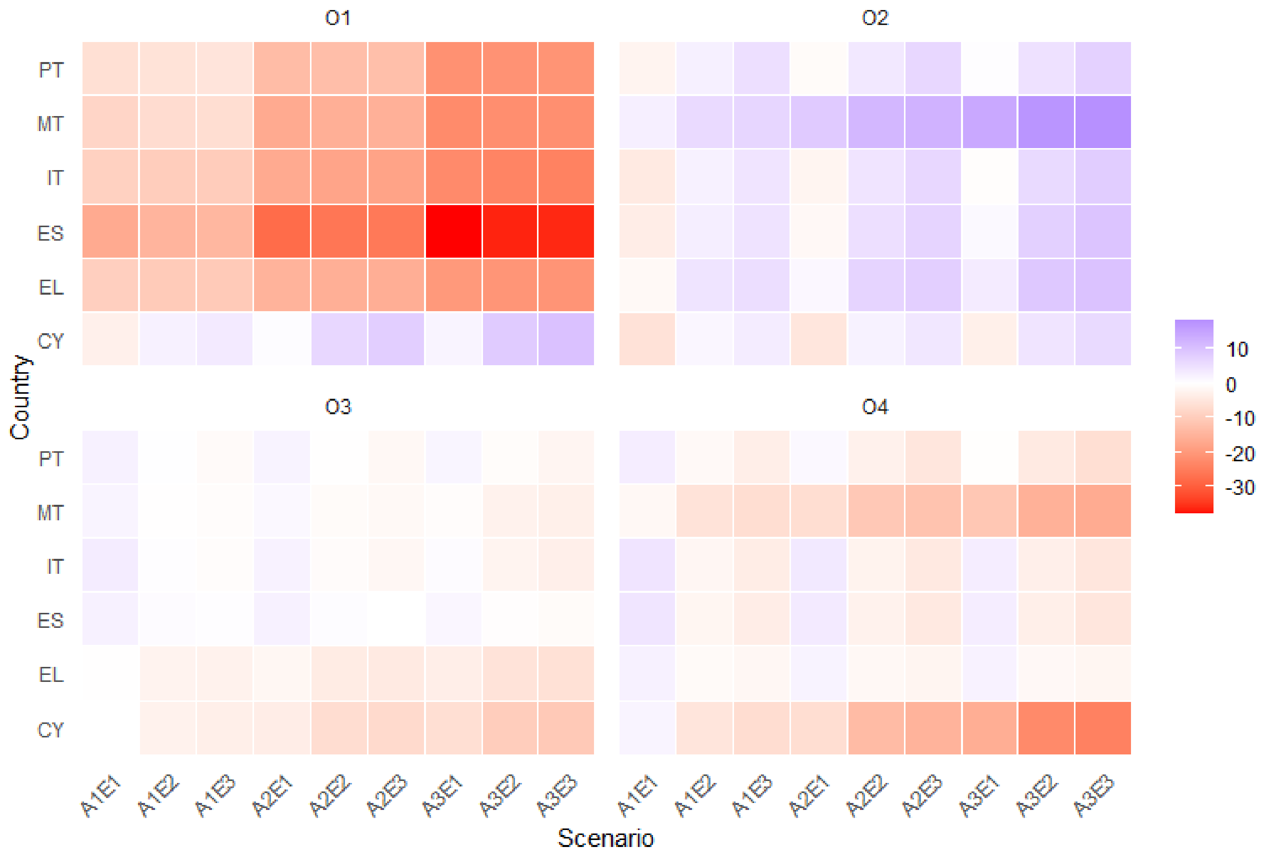
The figure for Southern European countries shows varying intensities across occupations and automation/education scenarios.

For O1 occupations, the effects are clearly negative in all countries, becoming more pronounced as automation intensifies. Spain appears to be the most affected country, experiencing significant job losses in A3 scenarios even when education levels rise. Portugal, Italy and Greece also experience notable declines, albeit to a lesser extent. However, Cyprus shows much more moderate effects and even slightly positive outcomes in some ambitious educational scenarios. These results suggest that O1 occupations in southern European economies are highly susceptible to technological substitution processes linked to the digitalisation of pre-generative AI, likely due to the prevalence of routine or administrative tasks.

In contrast, O2 occupations show largely positive effects. These gains become more significant under more favourable educational scenarios, indicating the important role of skill upgrading in adapting to digital transformations. Malta stands out with its high and relatively homogeneous gains across all scenarios, and Greece also shows significant positive effects. This suggests that smaller economies can benefit more from digital technologies when combined with an appropriate human capital base.

For O3 occupations, the effects are generally close to zero or slightly positive in several countries, but turn more negative in certain high-automation scenarios. Greece and Cyprus experience more noticeable losses in A3 scenarios, which may indicate the vulnerability of certain intermediate activities to digital restructuring. Conversely, Spain and Italy experience relatively moderate effects, suggesting a greater capacity to absorb technological changes in these occupations.

Figure 33. Change in employment in 2033 versus the reference scenarios – Southern countries



Note: Occupations groups are labelled 01, O2, O3, O4, see Table 5 for details. Automation scenarios are labelled A1, A2, A3 for low, medium and high impact of automation, education scenarios are labelled E1, E2, E3 for low, medium and high acquisition of higher education.

Results for O4 occupations are more contrasting. Some countries, such as Italy and Spain, experience relatively stable and occasionally slightly positive effects in favourable educational scenarios. In contrast, Cyprus and Malta experience more significant losses when automation increases, which suggests that certain service activities are particularly vulnerable to digital technologies.

From a regional perspective, southern countries appear to be generally more sensitive to the negative effects of automation on routine occupations, but they also benefit more from scenarios combining digitalisation and improved education levels. The observed differences between countries likely reflect variations in economic specialisation, particularly between service-, tourism-, or administration-oriented economies.

Overall, the figure suggests that automation exacerbates certain forms of labour market polarisation in southern countries: the most substitutable occupations suffer significant losses, while complementary occupations can achieve substantial gains when sufficient skill investments are made.

3.3 Key trends and developments

The forecasting exercise highlights that automation and educational shifts were already driving labour market polarisation before the emergence of generative AI. Routine occupations experienced job losses, while roles that complemented the digital landscape gained traction, particularly in Western countries and among those with higher education qualifications.

Digital transformations had already reshaped employment structures in Eastern Europe, but the effects were less uniform than in Western Europe. National outcomes varied based on industrial specialisation and the adaptability of education and production systems.

In Southern Europe, automation intensified polarisation: occupations that could easily be replaced by technology saw significant job losses, while complementary roles only gained ground where sufficient skill investments had been made.

The Nordic countries are best positioned to benefit from automation thanks to their high level of human capital, widespread digital adoption and flexible labour market institutions that support skill adaptation. Nevertheless, even there, routine occupations remain at risk of being replaced.

Educational policies will be crucial in determining whether digitalisation leads to net job creation or destruction in the Nordics. Without targeted upskilling, automation could exacerbate inequalities, even in the most prepared economies.

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4 Conclusion

Over the period 2014–2023, European labour markets underwent profound structural transformations, reflecting the combined effects of technological change, demographic trends, economic recovery following successive crises, including the Great Recession, COVID-19, and inflation, and shifts in labour demand. These developments have contributed to substantial changes in employment opportunities across occupations and skill levels.

One of the most significant trends has been the increasing prevalence of labour and skills shortages. While labour shortages were already observable before the COVID-19 pandemic in certain occupations, they intensified sharply from 2021 onwards. These labour shortages are particularly concentrated in high-skilled occupations (ISCO 1 digit 2 and 3)[5]. Countries characterised by strong economic growth and rapid digitalisation, such as Nordic countries, have experienced particularly acute recruitment difficulties. This suggests that labour demand is evolving more rapidly than the supply of relevant skills, creating growing mismatches within European labour markets.

At the same time, occupations involving routine, repetitive, or easily codifiable tasks have continued to decline. Many jobs classified within ISCO groups 4-9 are increasingly exposed to automation. Although

[5] See table 2 for details.

the pace of decline varies across countries and sectors, the overall trend points towards a gradual erosion of middle- and low-skilled routine employment. Workers lacking opportunities for upskilling and reskilling are therefore at greater risk of labour market exclusion, reinforcing existing inequalities.

Technological change, and particularly the diffusion of automation, has further accelerated these transformations. Occupations that complement digital technologies (such as software development, data analysis, cybersecurity, engineering, and advanced professional services) have expanded considerably over the last decade. In contrast, occupations centred on standardised administrative, clerical, or production tasks have become increasingly vulnerable to technological substitution. Importantly, the trend we observed predates the recent emergence of generative AI, although the rapid development of AI applications may amplify labour market dynamics in the coming years.

Taken together, these developments point to a growing segmentation of European labour markets between occupations that benefit from technological progress and those facing increasing pressure from automation and evolving skill requirements. The evidence suggests that future labour market performance in the European Union will depend not only on job creation, but also on the capacity of education, training, and lifelong learning systems to equip workers with the skills needed in a changing economy. Strengthening workforce adaptability, reducing skills mismatches, and supporting transitions towards emerging occupations will therefore remain central policy challenges for the European Union in the years ahead.

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List of Tables

Skills for labour markets in the digital and green transition

SkiLMeeT is a research project carried out by eight research institutions, exploring how the digital and green transformation of European economies are changing the demand for skills. We analyse the scope of skills shortages and mismatches, identify their drivers and propose innovative ways to reduce skills gaps.

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This project has received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement No 101132581.

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