SkillsPULSE

SKILLS - PREDICTING, UNDERSTANDING, AND LOCATING SHORTAGES IN EUROPE

D2.3 Building new data to understand the impacts of skill shortages and skill gaps on country-level performance

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Abbreviations

CO: Confidential

D: Deliverable

DEM: Demonstrator

DoA: Description of the Action

DoW: Description of Work

EC: European Commission

ESJS: European Skills and Jobs Survey

EU: European Union

GA: Grant Agreement

IPR Intellectual Property Rights

M: Month

PC: Project Coordinator

PM: Project Manager

PO: Project Officer

PP: Programme Participants

PU: Public

RE: Restricted

SC: Steering Committee

TM: Technical Manager

WP: Work Package

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1. Introduction

Our previous review of the measurement approaches adopted for capturing both skill shortages and skill gaps demonstrated an extremely thin literature, with no consistent approach adopted for the measurement of either form of skills mismatch. Focusing on skill shortages, measurement approaches focus on either subjective measures, based on employer surveys, or objective measures, based on external data related to occupations or firms. A number of key weaknesses are associated with existing measurement approaches including:

- Subjective approaches reflect the education levels and competencies required by firms, expressed in job postings' descriptions; however, it is not clear that these necessarily align to the skill levels or competency requirements of jobs.
- Objective measures are typically built using a range of indicators, many of which can be driven by factors unrelated to skill shortages.
- Neither subjective or objective measures take account of the supply of skills and competencies in the labour market and are predominantly demand-side driven.
- Existing approaches do not always distinguish between skills shortages and labour shortages. Labour shortages exist due to a lack of applicants willing to undertake a particular job, as opposed to a lack of candidates with the necessary skills to do the job effectively (skills shortages).

This report aims at developing a novel methodology for identifying potential skill shortages in the labour market. Our approach is to use the second wave of the European Skills and Jobs Survey (ESJS2) to identify what percentage of jobs, within each defined occupation, are likely to be difficult to fill should openings become available. The ESJS2 is an employee survey that reflects how skills and competencies are actually distributed in the labour market. However, the ESJS2 is a periodic cross-section dataset and while any measure of potential skill shortage will reflect the distribution of jobs in 2021, it also has drawbacks in that (a) the flow of jobs that are advertised may not accurately mirror the stock of existing jobs and (b) the estimates of potential skill shortages cannot be replicated for years subsequent to 2021. In order to overcome these limitations, we attempt to replicate our measure of potential skill shortages based on the ESJS2 using Lightcast data, which contains the near universe of online job vacancies across Europe, and reflects the distribution of current vacancies and can be estimated on an annual basis. The benchmarking of a measurement approach based on a dataset reflecting the current balance between labour demand and labour supply represents, in our view, a substantial advancement in the measurement of skills shortages at both a national and European level.

This work is informed by the literature review on skill shortages and skill gaps from McGuinness et al. (2018; forthcoming), which highlights that there is no consistent approach in measuring and classifying skill shortages. However, despite the lack of empirical evidence, skill shortages and their impacts are consistently a matter of both debate and concern among policy makers (McGuinness et al, 2018) and, as such, there is a clear need to develop more standardised definitions and measurement protocols at both National and European level.

We employ data from the 2021 European Skills and Jobs Survey, which is a broad employee-based survey on adult employees aged 24 to 65 in Europe. It provides workers' sociodemographic information as well as detailed job characteristics on skill requirements and task content, wages and job satisfaction. We identify several job characteristics that are likely to be associated with potential skill shortages at an occupational level (at ISCO 2-digit) and calculate the share of jobs that are likely to be difficult to fill, at an EU level and at member state level. **It should be noted that the ESJS2**

approach effectively measures the proportion of jobs that are likely, in our view, to be difficult to fill, should openings become available to the labour market.

We also employ 2021 job advertisement data from Lightcast. Lightcast is a private labour market analytics company that aggregates millions of job advertisements worldwide on a daily basis; they extract over 50 elements from the job postings descriptions and classify them according to standard labour market classifications. Similarly to the ESJS, within Lightcast data we identify several characteristics that are likely to be associated with difficult to fill vacancies and the proportion of jobs in each ISCO category that are difficult to fill across the EU and at member state level. **Therefore, our Lightcast approach will measure the proportion of current vacancies that we estimate will be hard to fill.** While the Lightcast measure is solely demand based, and may not precisely reflect the skill requirements of jobs, it is replicable over time.

We validate our Lightcast approach against the ESJS estimates to ensure that our skill shortage measure based on vacancy data broadly reflects the current distribution of skills and jobs actually employed within the labour market, and helps ensure that any policy measures designed on the basis of the estimates will be more likely to align with actual labour market needs. We validate our Lightcast approach by calculating the correlation between the potential skill shortages estimates in the two datasets within 2-digit ISCO occupation. As a further robustness check, within Lightcast data, we also introduce a measure for changing skill requirements, based on work by Deming and Noray (2020), to confirm that potential skill shortages are more likely to appear in occupations where skills demand has been evolving more quickly over time. Finally, following our validations, we estimate the share of potential skill shortages at 2-digit ISCO level for the EU and for all member states for 2022 and 2023 using Lightcast data.

2. Methodology

2.1 2021 European Skills and Jobs Survey (wave 2)

The 2021 European Skills and Jobs Survey is the second wave of the survey administered by Cedefop. It is a comprehensive and representative employee-based survey on adult employees aged 24 to 65 in the EU countries, plus Iceland and Norway, with a total sample of over 46,000 observations. The survey collects information on employees' sociodemographic, as well as detailed job characteristics on skill requirements and task content, working arrangements, wages, and job satisfaction.

By exploiting a broad set of detailed variables, we use a multi-dimensional approach, and we identify and impose several conditions/ job characteristics that are likely to be associated with potential skill shortages. We develop a set of indicators that capture explicit measures of job complexity, competency and experience requirements as well as higher wages. In order to distinguish skill from labour shortages, for many of our indicators we set the condition that various metrics exceed both the respective occupational average and the economy wide average. This implies that jobs with a relatively low skill content that lie above their occupational average are not identified as potential skill shortages.

The rationale for our approach is that genuine skill shortages should only appear in jobs with specific characteristics. For example, a job that has little complexity and requires very few skills is unlikely to be associated with a genuine skill shortage. By definition, a skill shortage implies that an employer cannot recruit a candidate with the required skills. If the job itself does not require complex skills, then genuine skill shortages should not be present. Of course, employers may sometimes find it difficult to recruit candidates for low-skilled and low-wage jobs, but this is likely not due to the pool of potential candidates not having the skills required to do the job. Rather, it may simply be that potential employees are unwilling to work in such a role at the advertised pay and conditions. Therefore, in order to be identified as an area of potential skill shortage, a job must meet each of the following criteria:

1. **Complex job within occupation:** One would expect that the higher the level of complexity of the job, the higher the likelihood for employers to have difficulties in recruiting a qualified candidate. We constructed a composite index that attempts at identifying more complex jobs within occupations, based on several variables that relate to the use of foundational skills within the jobs. In the survey questionnaire, employees are asked to rate their level of intensity in using reading, writing and math skills while doing their job (low, intermediate and high level of skills use). Dummy variables are derived for each of the three foundational skills, i.e., 'intermediate reading' is a dummy variable that takes value 1 if the respondent reported an intermediate intensity in using reading skills, 0 otherwise. Our index is the sum of intermediate and high level of foundational skills and ranges from 0 to 6[1]:

   Foundational index = intermediate reading + high reading + intermediate writing + high writing + intermediate math + high math

   We compute the average value of the index at an ISCO 2-digit occupational level; when the value of the index is higher than the average calculated at ISCO 2 digit occupational

[1] The variables used are C_READ5P, C_READ25P, C_WRITE5P, C_WRITE25P, C_MATHMED and C_MATHADV

level at, the job has a high level of complexity, and it is considered to have met a requirement for being a potential skill shortage.

2. **Economy-wide complex job:** In our analysis, we also want to take into account high complex jobs within the general economy, not only at an occupational level. Therefore, we compute the average value of the foundational index at point (1) at country level, and when the value of the index is above the average calculated at country level, the job is considered to be a complex job within the general economy/labour market, it is deemed to have met a requirement for being a potential skill shortage.

3. **High volume of task requirements within occupation:** One would expect that the higher the volume of task requirements required by a job, the higher the likelihood for employers to have difficulties in recruiting a qualified candidate. We constructed a composite task index that incorporates up to 17 tasks, using work organisation variables, creative tasks variables and digital skills variables.

   In the questionnaire, employees are asked several questions related to their work planning tasks. The question states: '*How often does your main job involve the following activities?'*. The tasks include: *choosing the methods or tools of your work*; *planning your work activities; reacting to situations that could not be anticipated; working on varying assignments; learning new things,* with respondents rating 1 if rarely or never, up to 4 if often and very often. Employees are also asked *'How often did you do any of the following activities as part of your main job in the last month?'.* The tasks include: *try to develop or create new or improved products or services; try to develop new or improved ways of doing your work***,** with respondents rating from 1 if rarely or never, up to 4 if often and very often.

   We also incorporate a digital index variable within our task index. In the questionnaire, employees are first asked whether or not they use any computing devices to do their job (i.e., desktop computer, laptop / notebook computer, tablet computer and smartphone). Individuals reporting using these devices are asked *'Did you use any of the computing devices from the previous question to do the following activities as part of your main job in the last month?'*. The questionnaire provides a very broad and comprehensive list of ten digital activities: from basic activities such as browsing the internet, writing and using Word, preparing presentations on PowerPoint and using simple excel functions Excel; to medium-intensity activities such as using advanced Excel functions, working with specialised, sector or occupation-specific software, and managing databases with SQL; to high-intensity activities such as coding with C++, Python and Java, writing programs using AI methods and developing or maintaining IT systems. The ten dummies related to each digital activity are then recoded accordingly into a categorical digital index, ranging from 0 (non-user), to 1 (basic use), 2 (medium use) and 3 (high use) of digital skills.
   Our composite tasks index is the sum of work organisation variables, creative tasks variables and digital skills variables[2]:

   Task index = choosing methods + planning activities + react to unexpected + working on varying assignments + learning new things + create new products + improve methods + basic digital skills+ medium digital skills + high digital skills

[2] The variables used are B_RTAUT, B_RTPLAN, B_RTEXP, B_RTVAR, B_RTLRN, C_CREAPRD, C_CREAMET, D_PC_CAT_WEB, D_PC_CAT_WORD, D_PC_CAT, D_PC_CAT_SHEET, D_PC_CAT_SPEC, D_PC_CAT_MACRO, D_PC_CAT_BASE, D_PC_CAT_PGR, D_PC_CAT_AI, D_PC_CAT_SYS.

We compute the average value of the task index at an ISCO 2-digit occupational level; when the value of the index is higher than the average calculated at ISCO 2-digit occupational level, the job has a high number of tasks, and it is considered to have met a condition for being a potential skill shortage.

4. **Economy- wide high task requirement:** In our analysis, we also want to take into account jobs with high task requirements within the general economy, not only at an occupational level. Therefore, we compute the average value of the task index at described above at country level, and when the value of the index is above the average calculated at country level, the job is considered to be a hight task demanding job within the general economy/labour market, and the job has met a condition for being a potential skill shortage.

5. **Long tenure:** As an experienced workforce is limited, and intermediate/senior positions require more experience than entry-level positions, it is more likely that skill shortages arise among intermediate/senior level positions, compared to entry-level positions Therefore, we impose the condition that jobs with tenure longer than one year are likely to be considered potential skill shortages.

6. **High wage within occupation:** If employers experience difficulties in recruiting qualified candidates for their vacancies, they may have to raise the salary in order to attract applicants. Therefore, jobs that are associated with skill shortages are likely to also have a higher-than-average wage. We compute the average monthly net wage at an ISCO 2-digit occupational level; when an employee's monthly net wage is higher than the average calculated at ISCO 2-digit occupational level, the job is considered to have met a condition for being a potential skill shortage.

7. **Economy wide- high wage:** We also want to take into account jobs with higher-than-average wage within the general economy, not only at an occupational level. Therefore, we compute the average monthly net wage at country level; when an employee's monthly net wage is above the average calculated at country level, the job is considered to be a potential skill shortage.

When all seven conditions above hold simultaneously, a job is identified as a potential skill shortage within the 2021 European Skills and Jobs Survey.

Note that in our analysis we exclude armed force and agricultural occupations (Armed Forces; Skilled agricultural, forestry and fishery workers; Agricultural, forestry and fishery labourers).

2.2 2021 Lightcast data

While the ESJS provides insights into the experiences of employees in the European labour market (labour supply), it is equally important to understand skills shortages from the perspective of employers (labour demand). As stated, the key advantage of developing a measure of potential skill shortages using this data is that estimates can be updated annually as new Lightcast data is published, and, due to the large sample sizes involved, replicated for individual member states. This considered, we use online job vacancy data from Lightcast (formerly Burning Glass Technologies) to identify potential skill shortages using metrics that, as far as is possible given the differences in the datasets, correspond to those set in the ESJS data.

Lightcast collects job vacancy data from numerous online billboards and websites, parsing vacancies into ready-to-use data for analysis. Their data collection tools extract more than 50 elements from each job posting. Where available, each job posting contains information such as the corresponding

sector (NACE), region (NUTS), occupation (ISCO), skill requirements (ESCO), geographical location, company name, type of contract, working arrangement (full-time/part-time), remote working arrangements, salary, educational requirements, experience and skill requirements. We use vacancy data for the EU-27 plus UK from 2021 to identify potential skill shortages (or "difficult-to-fill positions") in the labour market. We select data from 2021 to be time-consistent with the data collection for the ESJS, so that we analyse labour supply and labour demand over the same period of time.

We adopt a similar approach to our classification of skills shortages using the ESJS, in that we identify specific job vacancy conditions that are likely to be associated with potential skill shortages. Specifically, six criteria – relating to required competencies, experience requirements, salary requirements and vacancy duration – must be met. These criteria are outlined in turn below.

1. **High competency requirements within occupation:** We consider a vacancy to be a potential shortage if a vacancy contains an above average (mean) number of competency requirements within an occupation. This is measured as the average number of technical skill requirements per-vacancy within each ISCO 2-digit occupation. The underlying assumption is that vacancies that require a high number of competencies employers are more likely to experience difficulties in recruiting a qualified candidate (see Section 2.2.1).

2. **Economy wide high competency requirements:** We also consider a vacancy to be a potential shortage if a vacancy contains an above average (mean) number of competency requirements in their respective national economy. This is measured as the average number of skill requirements per-vacancy at the country level. The underlying assumption is that vacancies that post more skill requirements are comparatively less likely to be filled by applicants with a suitable skillset than vacancies with less competency requirements. This condition ensures that we are excluding vacancies with competency requirements that exceed the occupation mean but are below the average for the labour market as a whole. It is unlikely that such vacancies will be particularly difficult to fill.

3. **Previous Experience:** Similarly to the ESJS condition, since skill shortages are more likely to occur among experienced workforces, rather than at an entry level, we consider a vacancy to be a potential skill shortage if it requires at least one year of experience.

4. **High wage within occupation:** Similarly to the ESJS condition, if employers experience difficulties in recruiting qualified candidates for their vacancies, then this is likely to be reflected in a higher salary. We consider a vacancy to be a potential skill shortage if a vacancy posts a higher-than-average salary in the corresponding ISCO 2-digit occupation.[3]

5. **Economy wide- high wage:** We also want to take into account jobs with higher-than-average wage within the general economy, not only at an occupational level. Therefore, we consider a vacancy to be a potential skill shortage if a vacancy posts a salary higher-than-average computed at country level. This condition is set in order to exclude potential labour shortages, which may have above average wages for the occupation, from potential skill shortages.

[3] Since not all online job postings display salary information, our analysis is restricted to vacancies with information on the salary offered. On average, salary data coverage is approximately 30 per cent of all job postings published within a year. We acknowledge that this can be a limitation of our approach for condition 4 and 5.

6. **Duration Condition:** We consider a vacancy to be a potential shortage if the job vacancy remains published for a duration greater than 30 days (and less than 120 days, for reasons discussed in Section 2.2.1). This is based on the assumption that firms will seek to fill job vacancies as quickly as possible, subject to the constraint of the quality of applicants. In a scenario where companies struggle to find suitable qualified candidates, the vacancies will be online for longer. This means that vacancies with longer durations are more likely to be associated with potential skill shortages. There is some concern that the Lightcast data may simply report the duration of the advertisement rather than the duration of the vacancy, however, our approach will at least allow us to separate out those vacancies that have not been filled quickly (i.e., within 30 days).

In summary, positions with high skill requirements both at an occupational level and at country level, that require experience, that post above-average salaries both within occupation and within an economy and are published online for extended periods of time are associated with potential skill shortages / hard-to-fill vacancies. Where all six of these conditions apply to job vacancies, we identify them as potential skill shortages.

We apply the following restrictions to the Lightcast data for the purpose of analysis. First, we only include data where both salary information and experience requirements are available. Second, we only include data for which at least one “Hard Skill” or “Language” is present in the competency requirements. This is because we want to take into account the technical skills related to jobs, rather that soft and transversal skills. Third, we do not include vacancies that exhibit a duration (i.e. the number of days that the vacancy remains open to applicants) of 120 days or more. This is due to the nature of the Lightcast data. In many cases, it is not possible for Lightcast to determine the expiration date of a job vacancy. Where expiration dates are not available, Lightcast automatically assigns a duration of 120 days since the posting was published. This aspect of the data means that it is not possible to distinguish between 1) vacancies that are genuinely posted for 120 days and 2) vacancies where no expiration date is available. We therefore decided to exclude vacancies with durations of 120 days or more to ensure accurate measurement of vacancy durations.

Note that in our analysis we exclude armed force and agricultural occupations (Armed Forces; Skilled agricultural, forestry and fishery workers; Agricultural, forestry and fishery labourers).

3. Results

3.1 2021 European Skills and Jobs Survey (wave 2)

3.1.1 EU incidence of skill shortages across ISCO 2-digit occupation level

When all seven job conditions presented in Section 2.1 hold simultaneously, a job is identified as a potential skill shortage in the 2021 European Skills and Jobs Survey. According to our methodology, the overall EU share of jobs estimated to be potential skill shortages stands at around 3.5 per cent. We want to investigate in which occupations potential skill shortages are more likely to occur. In Table 1, we present the incidence of potential skill shortages across ISCO 2-digit level occupations. The first thing that is striking is that the overall incidence of potential skill shortages is relatively low and below 3 per cent for most occupations.

Table 1: Incidence of potential skill shortages across ISCO 2-digit level occupations, EU 27 + Norway and Iceland, ESJS

ISCO code	ISCO 2-digit category	Shortage rate
	Managers	
11	Chief executives, senior officials and legislators	9.44%
12	Administrative and commercial managers	7.13%
13	Production and specialised services managers	6.35%
14	Hospitality, retail and other services managers	6.69%
	Professionals	
21	Science and engineering professionals	8.51%
22	Health professionals	2.01%
23	Teaching professionals	6.63%
24	Business and administration professionals	7.19%
25	ICT professionals	7.83%
26	Legal, social and cultural professionals	4.26%
	Technicians and associate professionals	
31	Science and engineering associate professionals	5.34%
32	Health associate professionals	2.70%
33	Business and administration associate professionals	4.48%
34	Legal, social, cultural and related associate professionals	3.21%
35	Information and communication technicians	5.92%
	Clerical support workers	
41	General and keyboard clerks	2.40%
42	Customer services clerks	2.47%
43	Numerical and material recording clerks	2.77%
44	Other clerical support workers	2.54%
	Service and sales workers	
51	Personal service workers	0.70%
52	Sales workers	1.62%
53	Personal care workers	0.94%
54	Protective services workers	1.15%
	Craft and related trade workers	

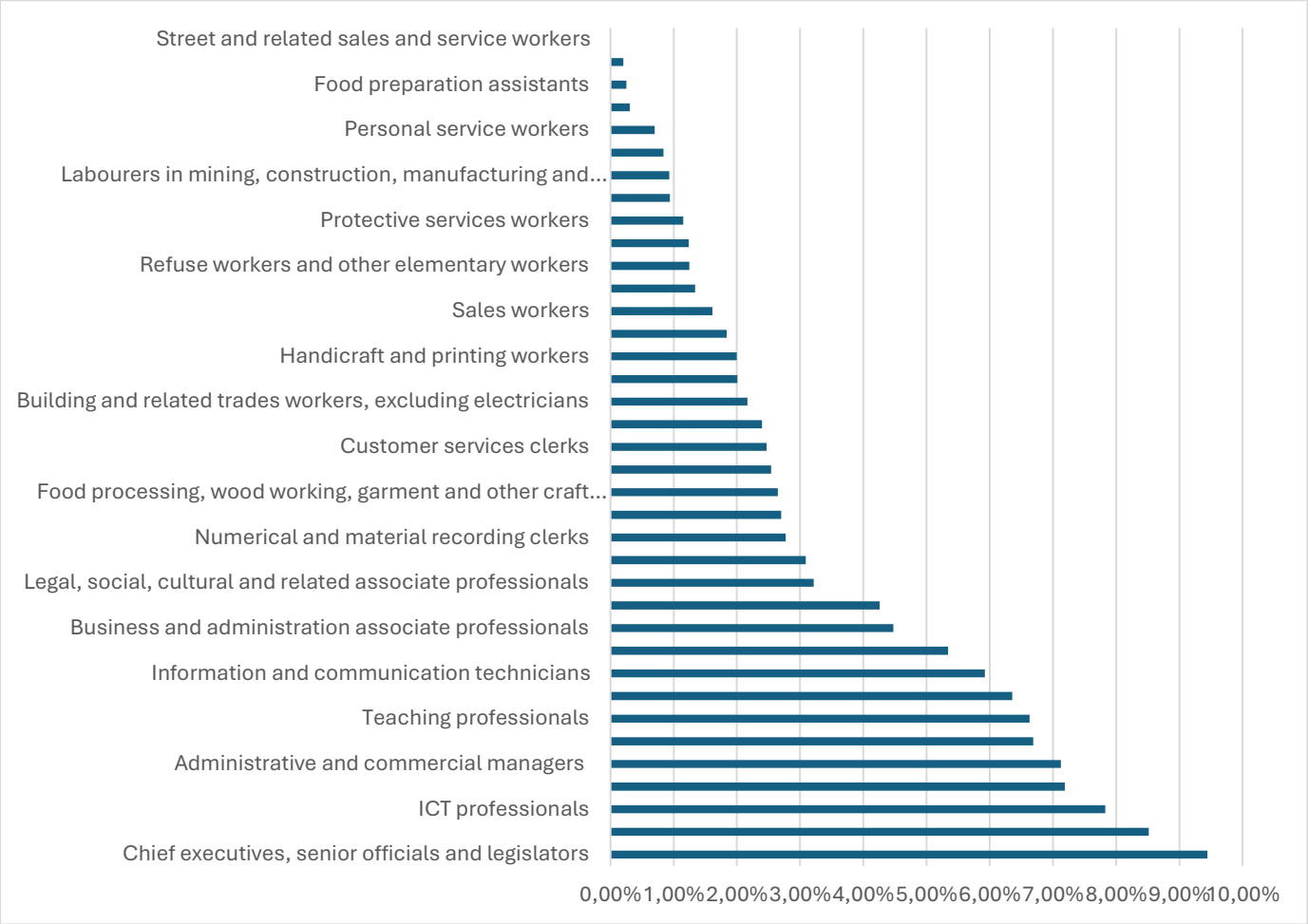
71	Building and related trades workers, excluding electricians	2.17%
72	Metal, machinery and related trades workers	1.24%
73	Handicraft and printing workers	2.00%
74	Electrical and electronic trades workers	1.84%
75	Food processing, wood working, garment and other craft and related trades workers	2.65%
	Plant and machine operators and assemblers	
81	Stationary plant and machine operators	1.34%
82	Assemblers	0.21%
83	Drivers and mobile plant operators	0.84%
	Elementary occupations	
91	Cleaners and helpers	0.30%
93	Labourers in mining, construction, manufacturing and transport	0.93%
94	Food preparation assistants	0.25%
95	Street and related sales and service workers	0.00%
96	Refuse workers and other elementary workers	1.24%
	NA/Unidentifiable	3.09%
	EU average	3.5%

Source: 2021 European Skills and Jobs Survey (authors' elaboration).

Note: total sample is 46,212 observations. Armed Forces, Skilled agricultural, forestry and fishery workers and Agricultural, forestry and fishery labourers are excluded from the analysis.

To get a clearer idea of the occupations at highest (lowest) risk of potential skill shortages, in Figure 1 we graphically show the occupational distribution of potential skill shortages. The distribution makes sense intuitively, with many of the occupations typically thought of as having skill related hiring difficulties emerging at the top end of the distribution. The highest share of potential skill shortages appears within Chief executives, senior officials and legislators (over 9 per cent). High shares of potential skill shortages are located among professional occupations (Science and Engineering, ICT, Business and Teaching Professionals) as well as other managerial positions (Administrative and Hospitality Managers); but potential skill shortages do exist along all the occupational distribution. As expected, elementary and service occupations have the lowest predicted incidences of potential skill shortages.

Figure 1: Potential skill shortages across ISCO 2-digit level occupations, ESJS



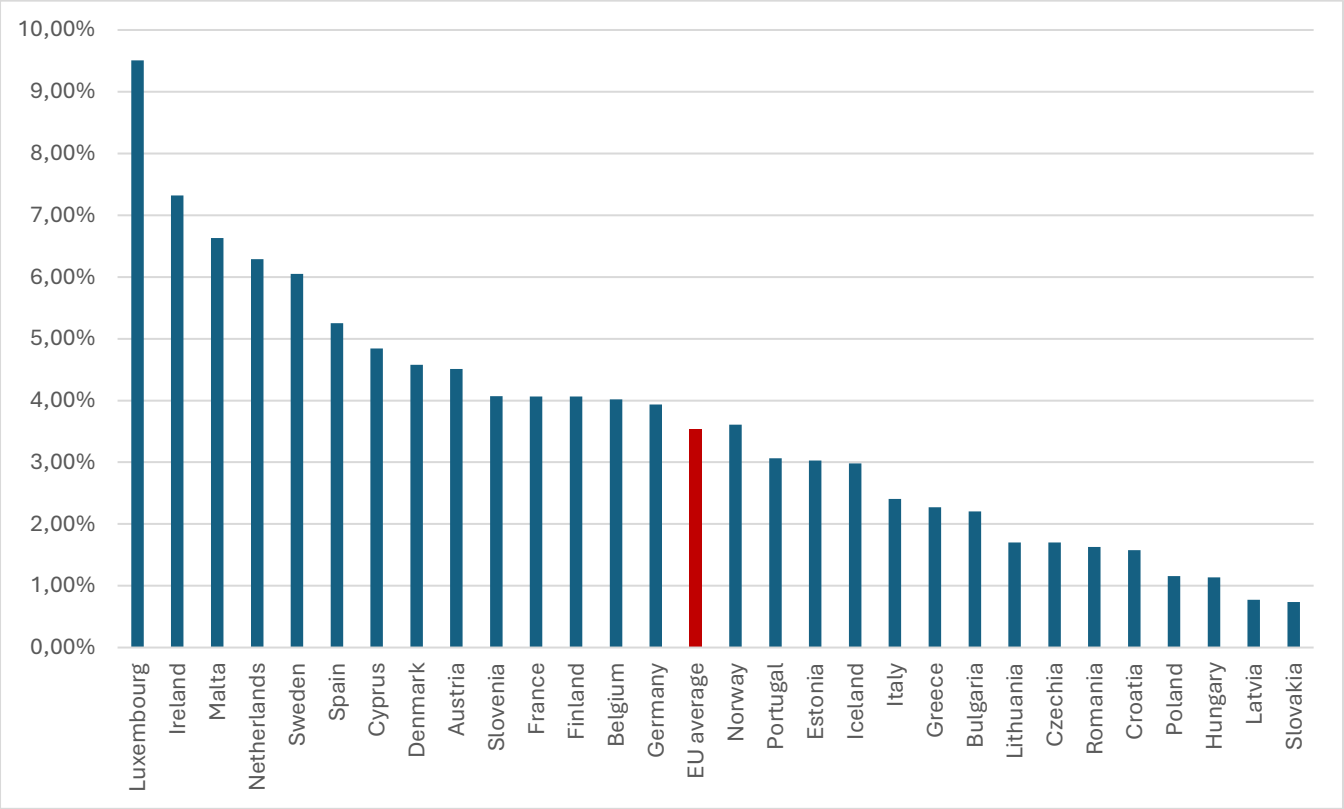
Source: 2021 European Skills and Jobs Survey (authors' elaboration).

Note: Armed Forces, Skilled agricultural, forestry and fishery workers and Agricultural, forestry and fishery labourers are excluded from the analysis.

3.1.2 Cross-country shares of potential skill shortages

We present the cross-country distribution of potential skill shortages in Figure 2; there is substantial heterogeneity across member states, indicating that the issue of skill shortages is much more problematic in some countries relative to others. Rates range from over 9 to less than one per cent. Countries such as Luxembourg, Ireland, Malta and the Netherlands appear to have the highest share of potential skill shortages, while Slovakia, Latvia, Hungary, and Poland have the lowest.

Figure 2: Cross-country shares of potential skill shortages, ESJS



Source: 2021 European Skills and Jobs Survey (authors' elaboration).

3.2 Lightcast data

3.2.1 Incidence of skill shortages across ISCO 2-digit occupation level

When all six job posting conditions analysed in Section 2.2 hold simultaneously, a vacancy is identified as a potential skill shortage within 2021 Lightcast data. According to our methodology, the overall EU + UK share of jobs estimated to be potential skill shortages stands at around 2 percent (40,996 potential shortages out of a total 2,023,357 vacancies in 2021). We want to investigate in which occupations potential skill shortages are more likely to occur. In Table 2, we present the incidence of potential skill shortages across ISCO 2-Digit occupational categories.

Table 2: Potential shortages, ISCO 2-digit occupational categories, 2021 (Lightcast)

ISCO code	ISCO 2-digit category	Total vacancies	Total potential shortages	Shortage rate
	Managers			
11	Chief executives, senior officials and legislators	6,451	190	2.9%
12	Administrative and commercial managers	140,420	5,777	4.1%
13	Production and specialised services managers	80,548	2,530	3.1%
14	Hospitality, retail and other services managers	28,930	1,104	3.8%
	Professionals			
21	Science and engineering professionals	118,416	3,728	3.1%
22	Health professionals	83,129	120	0.1%
23	Teaching professionals	65,046	541	0.8%
24	Business and administration professionals	163,917	6,808	4.2%
25	Information and communications technicians	43,973	961	2.2%
26	Legal, social and cultural professionals	49,468	354	0.7%
	Technicians and associate professionals			
31	Science and engineering associate professionals	72,299	1,407	1.9%
32	Health associate professionals	54,448	307	0.6%
33	Business and administration associate professionals	157,668	4,962	3.1%
34	Legal, social, cultural and related associate professionals	96,329	290	0.3%
35	Information and communications technology professionals	174,002	8,944	5.1%
	Clerical support workers			
41	General and keyboard clerks	67,120	425	0.6%
42	Customer services clerks	41,759	555	1.3%
43	Numerical and material recording clerks	52,888	712	1.3%
44	Other clerical support workers	20,752	148	0.7%
	Service and sales workers			
51	Personal service workers	41,836	123	0.3%
52	Sales workers	66,746	388	0.6%
53	Personal care workers	75,697	8	0.0%
54	Protective services workers	6,386	9	0.1%
	Craft and related trade workers			
71	Building and related trades workers, excluding electricians	15,607	32	0.2%
72	Metal, machinery and related trades workers	50,086	192	0.4%
73	Handicraft and printing workers	2,551	10	0.4%
74	Electrical and electronic trades workers	19,352	70	0.4%
75	Food processing, wood working, garment and other craft and related trades workers	20,483	42	0.2%
	Plant and machine operators and assemblers			
81	Stationary plant and machine operators	65,115	152	0.2%
82	Assemblers	9,043	24	0.3%
83	Drivers and mobile plant operators	42,955	64	0.1%

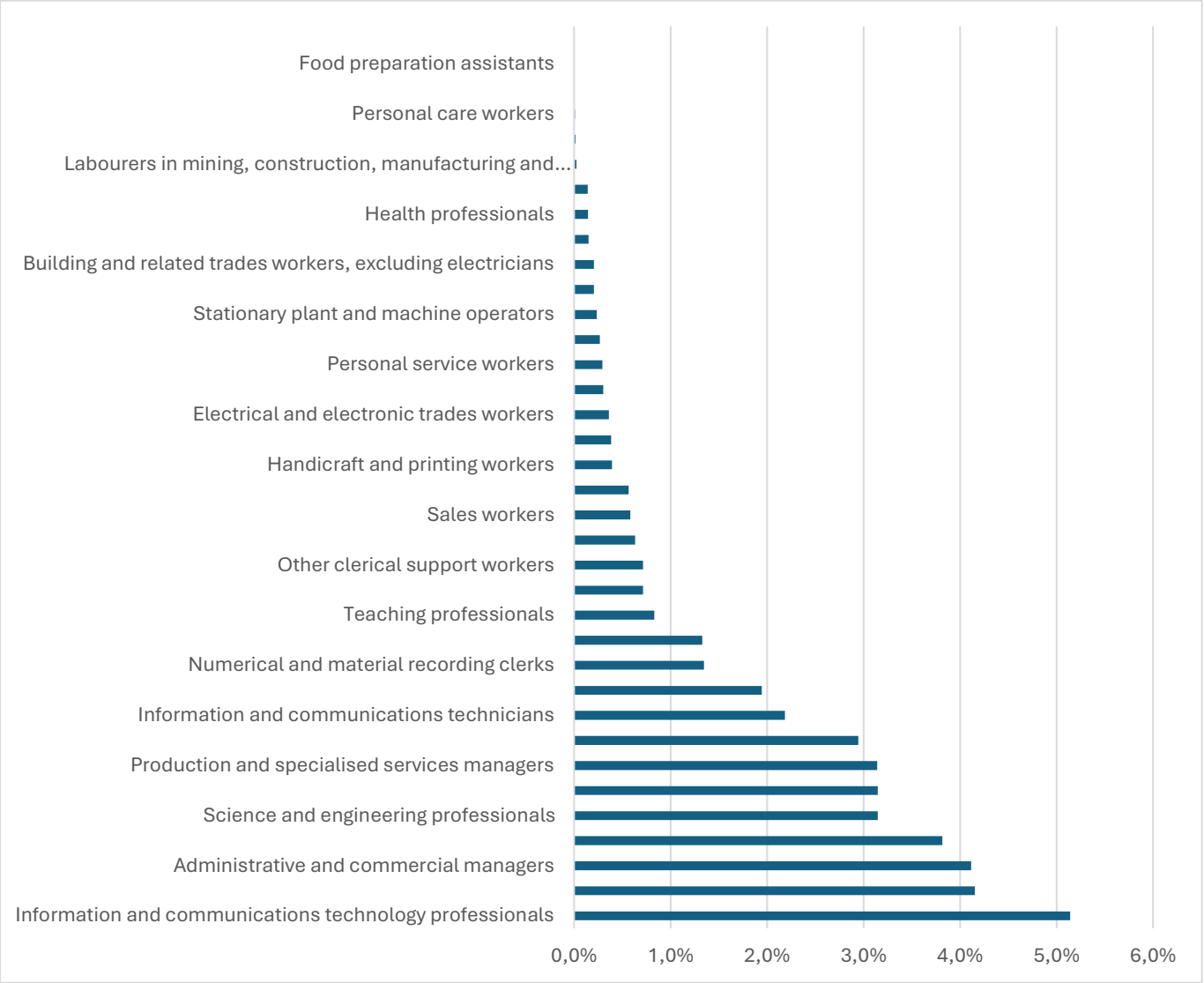
	Elementary Occupations			
91	Cleaners and helpers	16,576	0	0.0%
93	Labourers in mining, construction, manufacturing and transport	50,213	12	0.0%
94	Food preparation assistants	8,883	0	0.0%
95	Street and related sales and service workers	858	0	0.0%
96	Refuse workers and other elementary workers	7,185	1	0.0%
	Total	**2,017,135**	**40,990**	**2.0%**

Source: 2021 Lightcast data (author's calculations).

The estimated shares are comparatively lower than ESJS estimates. While the ESJS is a representative survey of all adult employees in Europe, Lightcast data represents the number of job openings over a period of time. Given that many high skills roles are filled from within organisations, it is not surprising that such positions account for a lower share of total job advertisements relative to their employment shares.

In Figure 3 we graphically show the occupational distribution of potential skill shortages and, again, these make intuitive sense. ICT professionals exhibited the highest potential skill shortage rate in 2021 (over five per cent), followed by Business and administration Professionals, and Administrative and Commercial Managers (over four per cent). Potential skill shortages are located among other professional and managerial occupations.

Figure 3: Potential skill shortages across ISCO 2-digit level occupations, Lightcast data



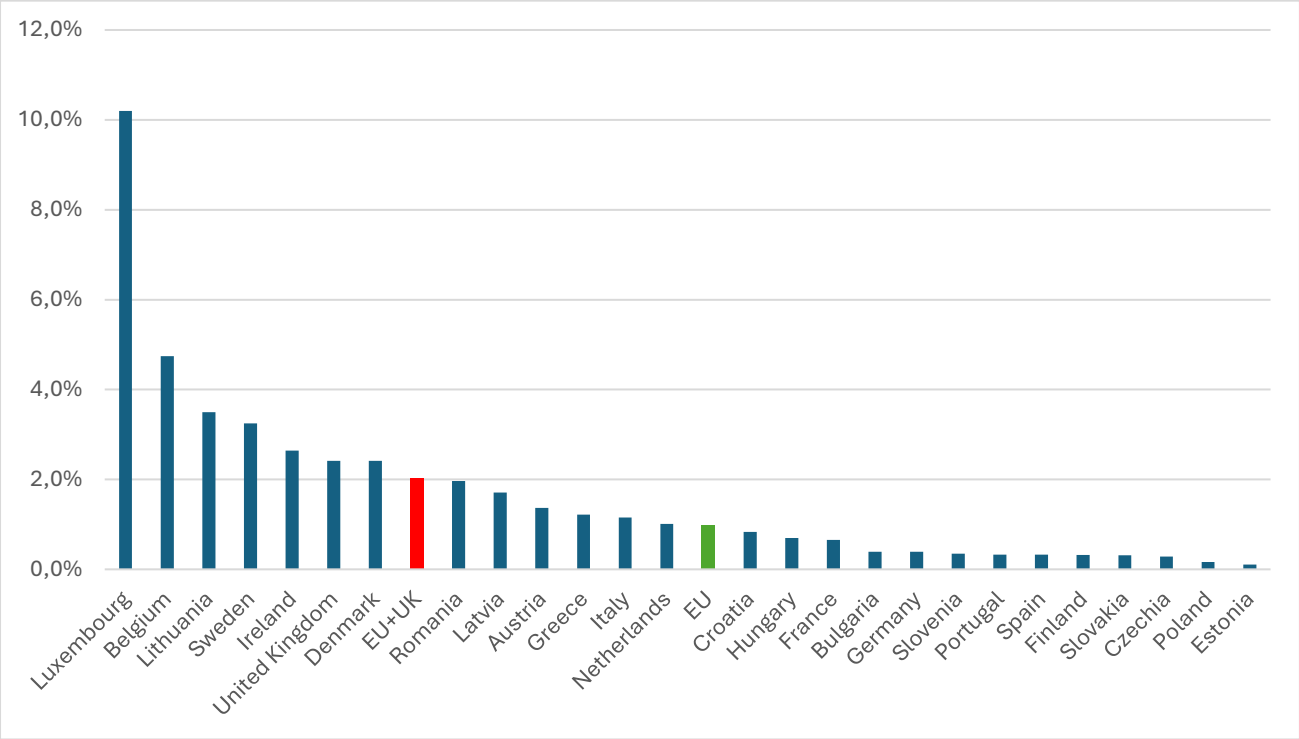
Source: 2021 Lightcast data (author's elaboration).

Note: Armed Forces, Skilled agricultural, forestry and fishery workers and Agricultural, forestry and fishery labourers are excluded from the analysis. 2-digit ISCO codes shown in occupation labels.

3.2.2 Cross-country shares of potential skill shortages

We also calculate the potential shortage rates for each individual country across the sample, which we graph in Figure 4 below. Luxembourg seems to display the highest shares of potential skill shortages, followed by Belgium and Lithuania; Estonia, Poland and Czechia display the lowest shared of potential skill shortages vacancies. The EU + UK average stands at 2 per cent, while if we consider only the EU 27 countries, the average is halved. Note that Cyprus and Malta are not included in the analysis due to small sample sizes.

Figure 4: Country-level rates of potential skill shortages (EU-27+UK; 2021, Lightcast)



Source: 2021 Lightcast data (author's elaboration).

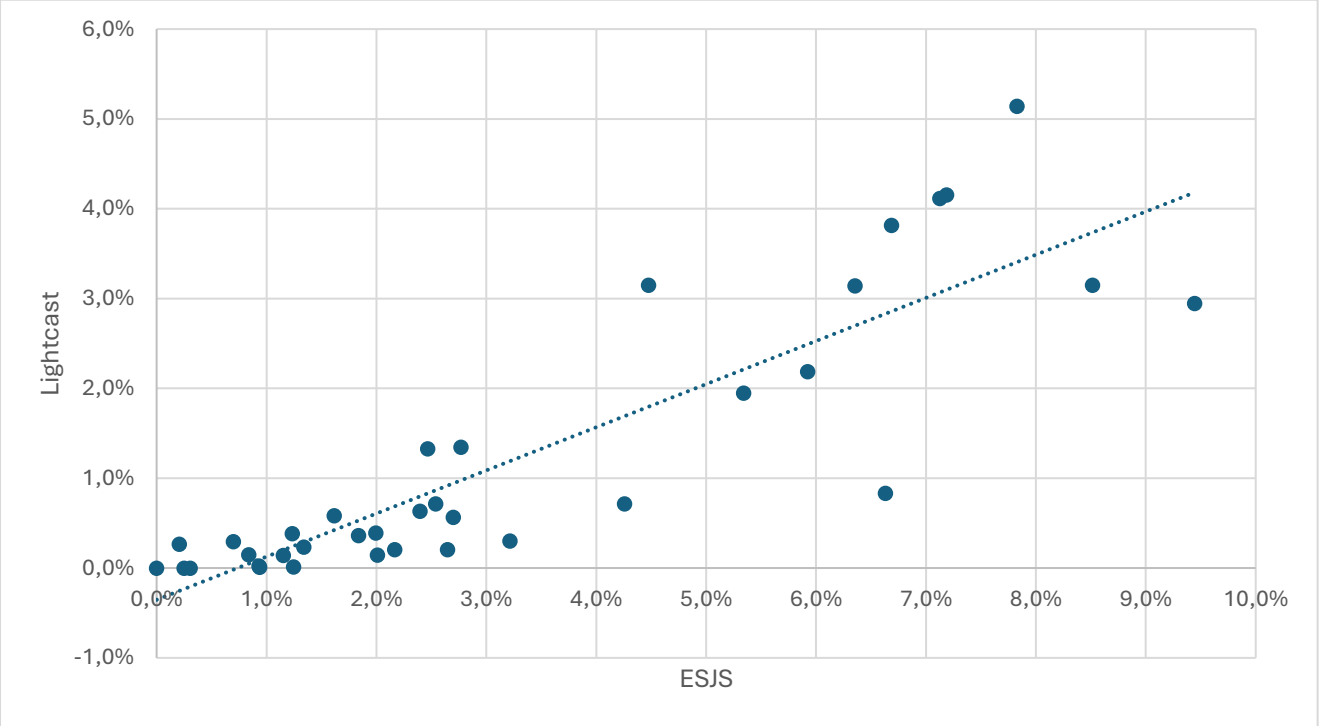
Note: Cyprus and Malta are not included due to small sample size.

We include a scatterplot with the country-level estimates from the ESJS and Lightcast in the Appendix (Figure 1A). The two sets of estimates are strongly positively correlated ($\rho = 0.60$).

3.3 ESJS skill shortages against Lightcast skill shortages

We validate our Lightcast approach against the ESJS estimates, by calculating the correlation between the potential skill shortages estimates in the two datasets. In Figure 5, we plot potential skill shortages rates in ESJS against potential skill shortages in Lightcast, at an occupational level. We find a positive correlation (ρ =0.87): occupations with high (low) shares of potential skill shortages in ESJS data, generally have high (low) rates of potential skill shortages in Lightcast data, although with some outliers. **This is a critical finding as it confirms that our Lightcast approach predicts the vacancies that are likely to be most difficult to fill in a way that is reflective of the current distribution of competencies and skills being demanded, and utilised, in the labour market, as measured by the ESJS.**

Figure 5: Potential skill shortages by occupation- ESJS estimates against Lightcast estimates



Source: 2021 European Skills and Jobs Survey and 2021 Lightcast data (author's elaboration).

3.3.1 Changing skill requirements and potential skill shortages rates

As the nature of work evolves, the skills required by employers change over time. This change can happen at varying rates, depending on differing characteristics associated with specific jobs. For example, the diffusion of Artificial Intelligence may have greater implications for the required skills associated with software developers than it might have for caterers. When skill requirements change, workers are required to up- or re-skill (i.e. via education or training) in order to secure desirable employment. This training burden has the potential to be larger in occupations where skill requirements change more rapidly, as the likelihood of more new skills being required is greater, meaning that more training may be required. Given that training takes time, and skill change happens continuously, the likelihood of the existence of sufficiently skilled labour is lower in jobs where skill change happens more quickly. In other words, potential skills shortages are more likely to occur in jobs that experience more rapid changes in tasks. We therefore examine how changing skill requirements, within occupations, relate to skill shortages.

To evaluate this relationship empirically, we use measures of occupational skill change that are calculated by Redmond, Kelly and Brosnan (forthcoming). Drawing on previous work by Deming and Noray, Redmond, Kelly and Brosnan (forthcoming) construct a measurement approach that is applied to EU online vacancy data. Their measure of skill change is based on Equation (1) below,

$$SkillChange_o = \sum_{s=1}^{S} \left| \frac{Skill_{s,o,2021}}{Vacancies_{o,2021}} - \frac{Skill_{s,o,2019}}{Vacancies_{o,2019}} \right| \quad (1)$$

Here, $Skill_{s,o}$ is the number of times some skill s appears in vacancies of ISCO 2-Digit occupational category o in the specified year. $Vacancies_o$ is the total number of posted vacancies for the corresponding occupational category. Therefore, we can understand $\frac{Skill_{s,o}}{Vacancies_o}$ to be the demand prevalence of a given skill within a given occupation. We calculate the absolute difference in demand prevalence for each skill within in each occupation between 2019 and 2021 (i.e. $\left| \frac{Skill_{s,o,2021}}{Vacancies_{o,2021}} - \frac{Skill_{s,o,2019}}{Vacancies_{o,2019}} \right|$).[4] This gives us an idea of the relative change in demand for each skill across time.

For example, if the skill "*SQL*" appeared 45 times out of 100 vacancies for Software Developers in 2019, but appeared 70 times out of 200 vacancies for Software Developers in 2021, this figure would be $|0.35 - 0.45| = 0.1$. Given that we examine the absolute value of the difference in prevalence across years, this measure is agnostic to the direction of skill change; the measure is positively driven by both increases and decreases in the demand for skills. We calculate the absolute difference in demand prevalence for all skills in a given occupation, including those skills that were demanded in 2019 and not 2021 (i.e. "obsolete skills"), and *vice versa* (i.e. "new skills"). We then sum the difference in proportions for all skills in an occupation to get a sense of total changing skill requirements in each occupational category. Each unit of $SkillChange$ is equivalent to one skill being present in 100 per cent of vacancies in one year and 0 per cent of vacancies in the other year.

[4] We select 2019 as our base year as it represents the earliest available year in the Lightcast data for which there is a sufficient volume of data to conduct a meaningful analysis.

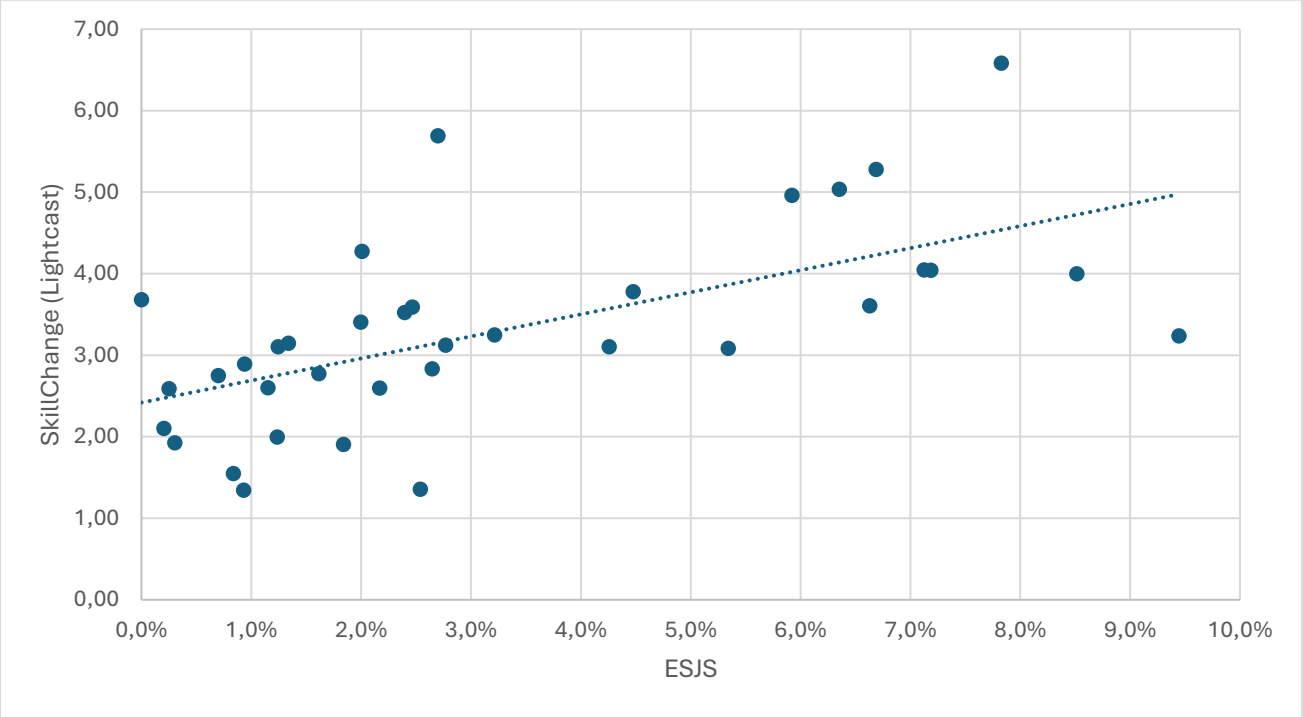
$SkillChange$ is positively dependent on both 1) the number of skills examined in a given occupation and 2) the magnitude of skill-specific change in demand prevalence over time. In other words, occupations with broader skillsets that have changed more over time will represent the highest values of $SkillChange$, while occupations with narrower skillsets and less change in demand prevalence will represent the lowest values. This measure has limitations. Under this approach, we consider a job with fifty skills that have all changed by 10 per cent between 2019 and 2021 ($SkillChange = 0.1 \times 50 = 5$) to have changed to the same extent as a job with five skills that have all changed by 100 per cent ($SkillChange = 1 \times 5 = 5$). It is arguable that the second case exhibits more skill change than the first case, as the entire skillset has been replaced over time. However, as there are only a total of five skills in this occupation ($S = 5$), $SkillChange$ is limited.

We note that Information and Communications Technology Professionals (ISCO 25), Health Associate Professionals (ISCO 22) and Hospitality, Retail and Other Services Managers (ISCO 14) exhibited the highest levels of skill change between 2019 and 2021 (see Appendix Table 1A for details). Contrastingly, Labourers in Mining, Construction, Manufacturing and Transport (ISCO 93), Other Clerical Support Workers (ISCO 44) and Drivers and Mobile Plant Operators (ISCO 83) were the three occupational categories with the lowest levels of changing skill requirements per online job markets. Broadly speaking, jobs with more of a technical focus – or at least require some basic digital competency – exhibited higher levels of skill change, while jobs with more of a manual focus (e.g. Cleaners and Helpers, Drivers and Mobile Plant Operators, Labourers), experienced lower levels of skill change over the two-year period.

We explore the association between changing skill requirements and potential skill shortages in the labour market. We graph the relationship between $SkillChange$ and the potential skill shortage rates calculated using the ESJS (Figure 6) and Lightcast (Figure 7) below, and we compute the correlation between skill shortages rates and the *SkillChange* measure.

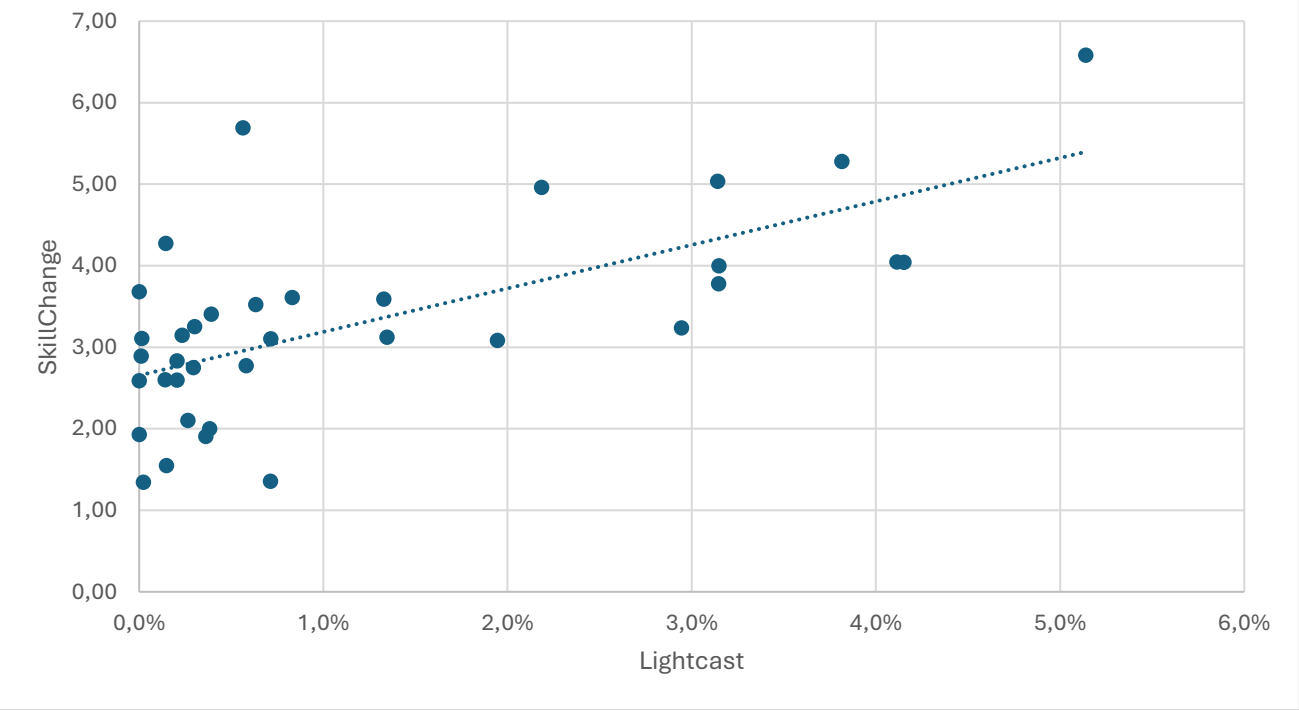
We do find that ESJS and Lightcast skill shortage rates are positively corelated with the *SkillChange* figure. This means that potential skill shortages are higher in occupations where skill requirements are changing more quickly.

Figure 6: Potential skill shortages rates (ESJS) against $SkillChange$ rates, ISCO 2-digit level (EU-27 + UK, 2021)



Source: 2021 European Skills and Jobs Survey and Lightcast data (author's elaboration).

Figure 7: Potential skill shortage rates (Lightcast) against $SkillChange$ rates, ISCO 2-digit level (EU-27 + UK, 2021)



Source: Lightcast data (author's elaboration).

The correlation coefficients for the shortage rates calculated using both the ESJS and Lightcast, as well as the corresponding occupational $SkillChange$ measure, are included in Table 3 below. The correlation between Lightcast shortages rates and *SkillChange* is 0.6, while the correlation coefficient between the ESJS rate and *SkillChange* is 0.61.

Table 3: Correlation table (Shortage rate- Lightcast); Shortage rate- ESJS; $SkillChange$ - Lightcast)

	Lightcast shortage rate	SkillChange (2019-2021)	ESJS shortage rate
Shortage Rate (Lightcast)	1.00		
SkillChange (2019-2021)	0.66	1.00	
Shortage Rate (ESJS)	0.87	0.61	1.00

Source: 2021 European Skills and Jobs Survey and Lightcast data (author's elaboration).

3.4 - Potential skill shortages rates across ISCO 2-digit occupations – 2022 and 2023 Lightcast data

As stated, the principal advantage of the Lightcast approach is that it can be replicated across years and countries, as new Lightcast data becomes available. As a robustness check, we next examine the incidence of potential skill shortages in later years of Lightcast data. Specifically, we identify potential skill shortages by applying the same conditions explained in Section 2.2 using job vacancy data from 2022 and 2023. It is important to assess whether potential skill shortages identified in Lightcast data in 2021 persist, increase or decrease in subsequent years. It is also important to confirm that subsequent Lightcast estimates continue to closely align with the distributions of skills and human capital being utilised within the labour market. We present the occupational distribution of skill shortage rates for 2021-2023 in Table 4 overleaf.

Generally, potential skill shortage rates are stable across time, with most occupational categories fluctuating within a band of ±1 percentage point between 2021 and 2023. Information and Communications Technology professionals, Business and Administration Professionals and Administrative and Commercial Managers display the highest share of potential skill shortages across the years, although ICT Professionals exhibited a decline of approximately two percentage points over the period of interest (from 5.1 to 3.1 per cent).

Table 4 Potential shortages, ISCO 2-digit occupational categories, 2021, 2022 and 2023 Lightcast data

ISCO code	ISCO 2-digit category	Potential shortage rate (2021)	Potential shortage rate (2022)	Potential shortage rate (2023)
12	Administrative and commercial managers	4.1%	3.2%	3.5%
82	Assemblers	0.3%	0.4%	0.7%
71	Building and related trades workers, excluding electricians	0.2%	0.3%	0.5%
33	Business and administration associate professionals	3.1%	2.6%	2.7%
24	Business and administration professionals	4.2%	3.2%	2.9%
11	Chief executives, senior officials and legislators	2.9%	2.5%	2.9%
91	Cleaners and helpers	0.0%	0.0%	0.0%
42	Customer services clerks	1.3%	0.9%	0.5%
83	Drivers and mobile plant operators	0.1%	0.1%	0.2%
74	Electrical and electronic trades workers	0.4%	0.4%	0.9%
94	Food preparation assistants	0.0%	0.0%	0.0%
75	Food processing, wood working, garment and other craft and related trades workers	0.2%	0.3%	0.2%
41	General and keyboard clerks	0.6%	0.5%	0.7%
73	Handicraft and printing workers	0.4%	0.3%	0.7%
32	Health associate professionals	0.6%	0.5%	0.7%
22	Health professionals	0.1%	0.2%	0.3%
14	Hospitality, retail and other services managers	3.8%	2.6%	2.0%
25	Information and communications technicians	2.2%	1.7%	2.3%
35	Information and communications technology professionals	5.1%	4.3%	3.1%
93	Labourers in mining, construction, manufacturing and transport	0.0%	0.1%	0.0%
26	Legal, social and cultural professionals	0.7%	0.6%	0.6%
34	Legal, social, cultural and related associate professionals	0.3%	0.3%	0.4%
72	Metal, machinery and related trades workers	0.4%	0.4%	0.7%
43	Numerical and material recording clerks	1.3%	1.3%	1.3%
44	Other clerical support workers	0.7%	1.0%	1.8%
53	Personal care workers	0.0%	0.0%	0.0%

51	Personal service workers	0.3%	0.2%	0.3%
13	Production and specialised services managers	3.1%	2.4%	2.6%
54	Protective services workers	0.1%	0.2%	0.4%
96	Refuse workers and other elementary workers	0.0%	0.1%	0.1%
52	Sales workers	0.6%	0.4%	0.7%
31	Science and engineering associate professionals	1.9%	1.4%	1.7%
21	Science and engineering professionals	3.1%	2.4%	2.4%
81	Stationary plant and machine operators	0.2%	0.3%	0.5%
95	Street and related sales and service workers	0.0%	0.1%	0.0%
23	Teaching professionals	0.8%	0.9%	1.2%

Source: Lightcast data (author's elaboration).

3.4.1 2021 ESJS skill shortages against 2022 and 2023 Lightcast skill shortages

We investigate the correlation between potential skill shortage rates derived from Lightcast data in 2022 and 2023 and potential skill shortages rates calculated from the 2021 ESJS produced in previous sections. In all cases, we observe a strong positive correlation between the figures, with Lightcast / ESJS correlation coefficients being approximately the same for all years of Lightcast data (ρ =0.88 in 2022 and ρ =0.89 in 2023). This reinforces the result that occupations with high (low) shares of potential skill shortages in 2021 ESJS data, generally have high (low) rates of potential skill shortages in Lightcast data, also when considering later years of data (see Appendix Figure 2A and 3A). This robustness check confirms that sequential estimates generated using Lightcast data continue to closely align, and reflect, the actual distribution of skills and human capital being utilised within labour markets.

Table 5: Correlation table (Shortage rate- ESJS; Shortage rate - 2021, 2022 and 2023 Lightcast data)

	ESJS, 2021	Lightcast, 2021	Lightcast, 2022	Lightcast, 2023
ESJS, 2021	1			
Lightcast, 2021	0.87	1		
Lightcast, 2022	0.87	0.99	1	
Lightcast, 2023	0.89	0.94	0.95	1

Source: 2021 European Skills and Jobs Survey and Lightcast data (author's elaboration).

4. Conclusion

As outlined by McGuinness et. al. (forthcoming), while policy makers and governments are continually alert to the potential risks of skill shortages and routinely implement policies designed to combat them, there is no consensus on how to measure them. The limited literature contains a number of subjective and objective measurement approaches to skill shortages, however, each of these has their weaknesses and very few can be easily replicated over time and / or across countries due to data constraints.

The objective of this study is to produce a meaningful indicator of potential skill shortages, based on vacancy data, that can be replicated annually at both EU and member state level, while distinguishing skill from labour shortages Our approach uses the second wave of the European Skills and Jobs Survey (ESJS2) to identify within each occupation the proportion of jobs that are likely to be difficult to fill should they come to the labour market. The ESJS2, is an employee survey, We use a multi-dimensional approach, by identifying several conditions that are likely to be associated with potential skill shortages. However, the ESJS2 is a periodic cross-section, and while any measure of potential skill shortage will reflect the distribution of jobs in 2021, it also has drawbacks in that (a) the flow of jobs that are advertised may not accurately mirror the stock of existing jobs, particularly, as many high skilled vacancies will be filled internally, and (b) the estimates of potential skill shortages cannot be replicated for years subsequent to 2021. In order to overcome these limitations, we attempt to replicate our measure of potential skills shortages based on the ESJS2 using Lightcast data, which will reflect the distribution of current vacancies and can be estimated on an annual basis at an EU and member state level. The benchmarking of a measurement approach based on a dataset reflecting the current distribution of skills and competencies being utilised within the labour market is, in our view, a substantial advancement in the measurement of skills shortages at both a national and European level.

The results of our analysis produce a meaningful indicator that aligns to prior expectations regarding the likely occupational distribution of skill shortages. The incidences of potential skill shortage are found to be generally much lower, at around 2 per cent of all vacancies across the EU and the U.K., relative to estimates produced using other approaches. Many of the occupations typically thought of as having skill-related hiring difficulties emerge at the top end of the occupational distribution. Our robustness checks are highly encouraging as they suggest that our Lightcast based estimates closely reflect the distribution of skill and competencies being employed within the labour market, and these relationships are stable as the Lightcast estimates extend beyond 2021. Our estimates also align to the expectation that the vacancies most likely to be potential skill shortages are in in occupations within which the skill content is changing more rapidly over time.

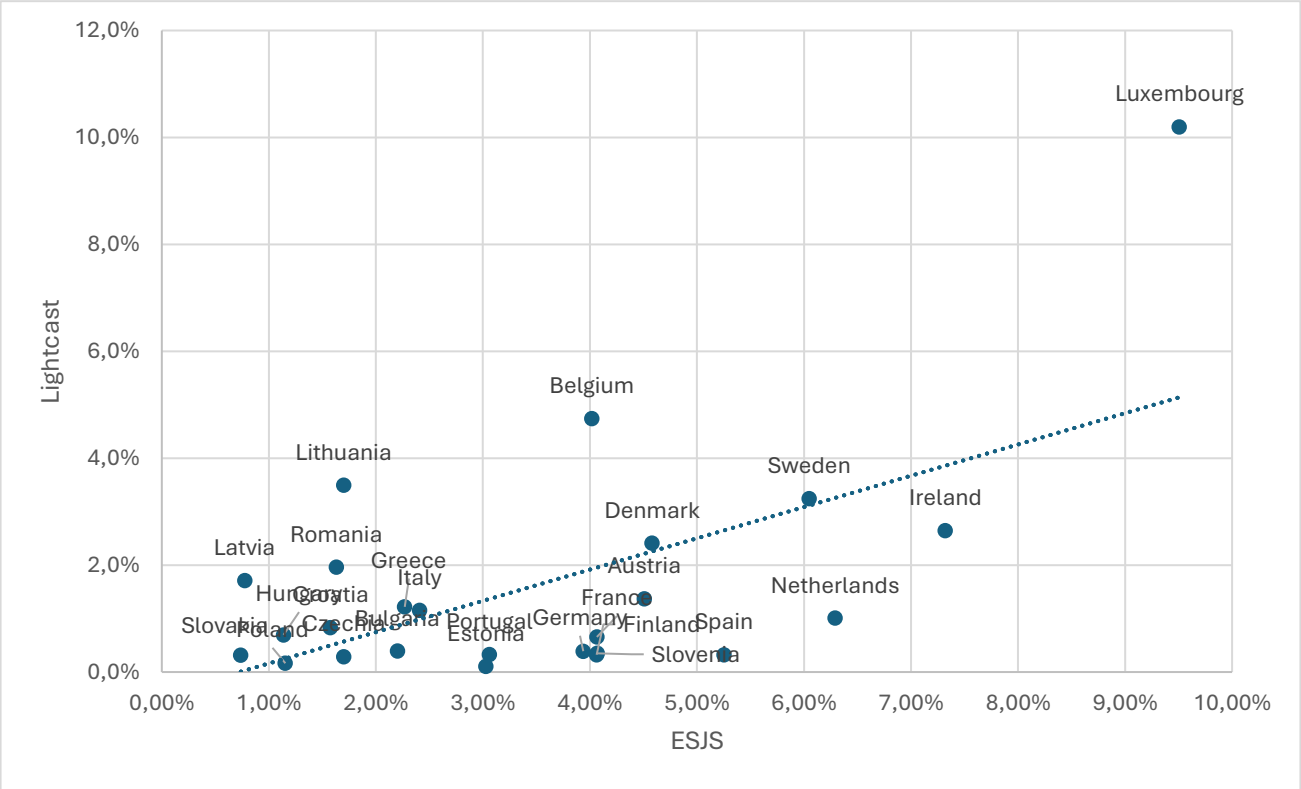
Appendix

Table 1A: $SkillChange$, ISCO 2-Digit Occupational Categories (EU-27+UK, 2019-2021)

ISCO 2-Digit Occupational Category	$SkillChange$ (2019-2021)
Information and communications technology professionals	6.58
Health associate professionals	5.69
Hospitality, retail and other services managers	5.28
Production and specialised services managers	5.04
Information and communications technicians	4.96
Health professionals	4.28
Administrative and commercial managers	4.05
Business and administration professionals	4.04
Science and engineering professionals	4.00
Business and administration associate professionals	3.78
Street and related sales and service workers	3.68
Teaching professionals	3.61
Customer services clerks	3.59
General and keyboard clerks	3.52
Handicraft and printing workers	3.41
Legal, social, cultural and related associate professionals	3.25
Chief executives, senior officials and legislators	3.24
Stationary plant and machine operators	3.15
Numerical and material recording clerks	3.12
Refuse workers and other elementary workers	3.11
Legal, social and cultural professionals	3.11
Science and engineering associate professionals	3.09
Personal care workers	2.89
Food processing, wood working, garment and other	2.83
Sales workers	2.78
Personal service workers	2.75
Protective services workers	2.60
Building and related trades workers, excluding electricians	2.60
Food preparation assistants	2.59
Assemblers	2.10
Metal, machinery and related trades workers	2.00
Cleaners and helpers	1.93
Electrical and electronic trades workers	1.91
Drivers and mobile plant operators	1.55
Other clerical support workers	1.36
Labourers in mining, construction, manufacturing and transport	1.35

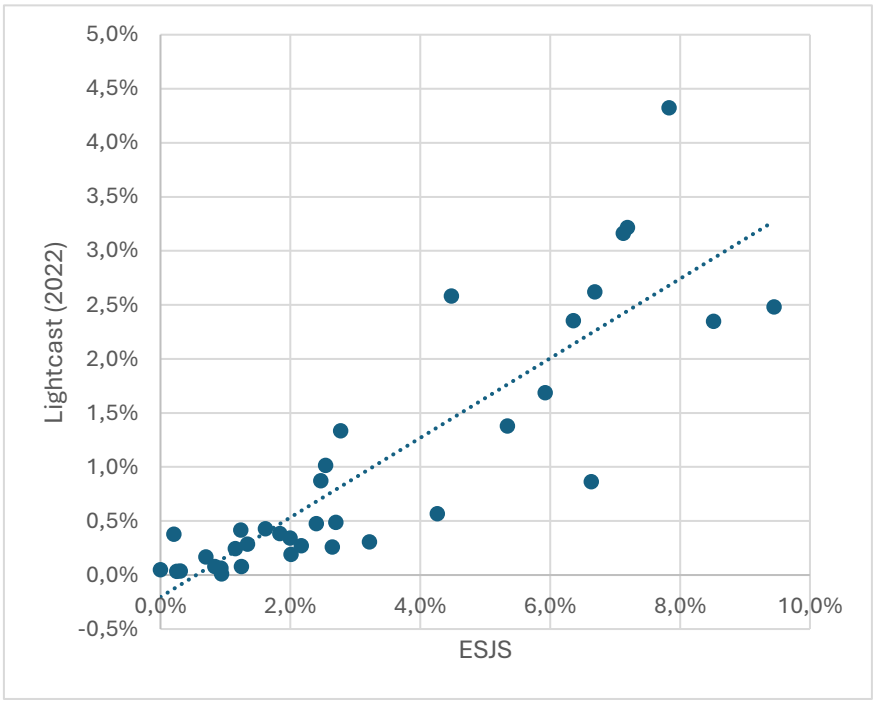
Source: Lightcast data (author's elaboration).

Figure 1A: Potential shortage rates (country-level estimates, ESJS and Lightcast, 2021)



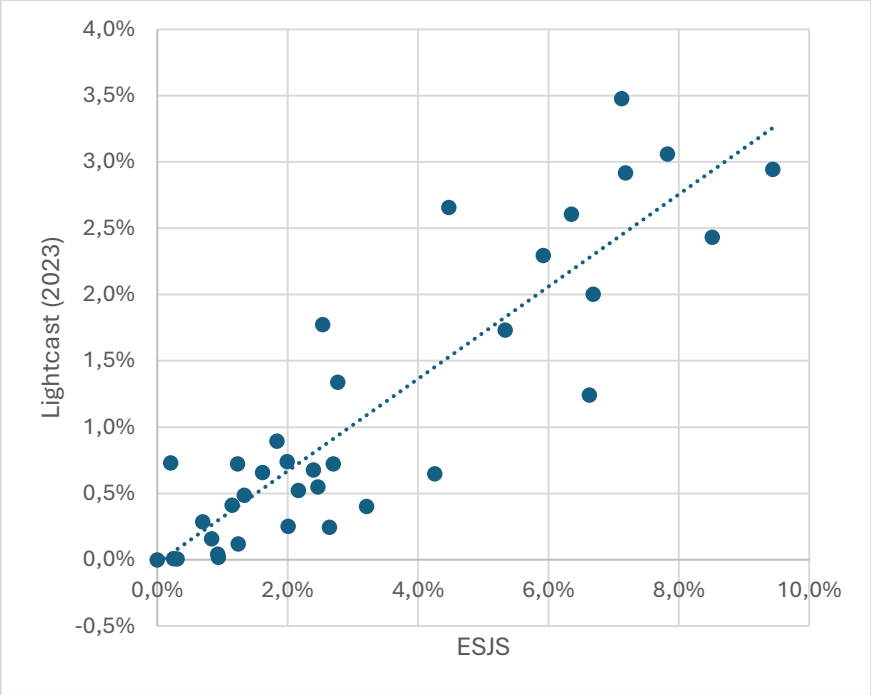
Source: ESJS (2021), Lightcast (2021) (author's elaboration).

Figure 2A: Potential skill shortages by occupation- 2021 ESJS estimates against 2022 Lightcast estimates



Source: 2021 European Skills and Jobs Survey and 2022 Lightcast data (author's elaboration).

Figure 3A: Potential skill shortages by occupation- 2021 ESJS estimates against 2023 Lightcast estimates



Source: 2021 European Skills and Jobs Survey and 2023 Lightcast data (author's elaboration).

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