UNTANGLED

Migration and the evolution of skill supply and demand

Authors:

Ronald Bachmann[1], Aya Elewa[2], Ludivine Martin[3], Isabelle Rabaud[2], Bertrand Verheyden[3], Marcel Voia[2]

[1] RWI, [2] LEO, [3] LISER

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Abstract

As the European labour markets are characterised by an increasing share of migrants, it is vital to identify recent differences in skills supplied by migrant workers compared to natives. This paper analyses the skill supply in European labour markets by workers' origin, providing evidence on the distribution of migrants across business sectors, occupations, and regions, as well as education level and age groups. These analyses over the period 2014 to 2021 and 19 EU countries reveal important differences between migrant and native workers. Using the current allocation of migrant and native workers across occupations, we identify the occupations that are under- or over-supplied in France and Germany over the period 2019 to 2021. We assess the role of migrants from European countries and from out of Europe in addressing the labour shortage faced by these two Western European labour markets. Using Online Job Vacancy data, we identify the composition and similarity of skill required of the most under-supplied occupations in France and Germany in 2021. We finally show the heterogeneity and evolution of skill demand within these occupations.

Keywords

Natives, migrants, sector, region, occupation, education level, age, under-/over-supplied occupations, skills

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1. Introduction

The European labour markets are massively impacted by the three megatrends studied in UNTANGLED, digitalisation, globalisation, and demographic changes. First, the recent changes induced by digitalisation deeply impact firms and workers and the COVID-19 economic crisis has sped up the phenomenon (Aminian *et al.*, 2021; Martin *et al.*, 2022). These factors have an impact on the characteristics of labour demand and on the task content of jobs, thus reinforcing the polarisation of the labour market (Autor, 2019; Burzyński, 2020). Second, trade shocks induced by globalisation increase worker flows and reallocate jobs across business sectors (Aghelmaleki *et al.*, 2022; Autor *et al.*, 2013; Guren *et al.*, 2015). Third, parallel demographic changes induced notably by population ageing (Schulz & Radvansky, 2014) create new job opportunities.

On a labour market profoundly impacted by digitalisation, globalisation and demographic changes, notably migration flows, it is vital to identify recent trends in skills supplied by migrant workers compared to natives. This will permit job seekers and employers to adjust to technological change by making informed choices in their respective labour supply and demand decisions.

The aim of the paper is, first, to identify the unequal distribution of migrants compared to natives across business sectors, occupations, education levels, age and regions in 19 European labour markets between 2014 and 2021. Second, it aims to analyse the skill supply markets by focusing on the composition of workers by origin in occupations that appear to be in shortage or in surplus in two countries, Germany and France, in 2019 and 2021.

Our analysis contributes to three strands of the literature. First, we provide additional evidence on the differences in characteristics between natives and migrants (e.g. Jestl *et al.*, 2015) by analysing the distribution of migrants and natives across five dimensions. Second, we contribute to the small literature that examines the occupations that are in shortage or surplus on the labour market (Brunello & Wruuck, 2021; McGrath, 2019), by providing evidence for France and Germany. Third, we contribute to the empirical evidence concerning the impacts of digital transformations on the labour market and especially those looking at the impact on occupations or tasks. Most of the existing papers study the US labour market, with few providing recent figures (e.g. Alabdulkareem *et al.*, 2018; Del Rio-Chanona *et al.*, 2021). We add to this literature with evidence related to the skill requirements of jobs that are in shortage or in surplus in France and Germany in 2019 and 2021.

The main results, based on the reweighted labour force survey for 12 European countries, show that migrants are unequally distributed across business sectors, occupations, and regions, and that they tend to differ from natives with respect to skills and age.

In Europe in 2021, as for natives, a quarter of African and North American migrants are employed in public services, while Asians and Latin Americans are more active in wholesale and retail trade and other services. Europeans are better distributed in all sectors. In the 19 EU countries, migrants of most origins are mainly employed in medium-skilled jobs (ISCO 4-8). North Americans are the only group that is more represented in high-skilled occupations (ISCO 1-3). Although high-skilled occupations employ around 45% of natives, they account for only 25-35% of jobs for migrants. In addition, low-skilled occupations (ISCO 9) are more prevalent among migrants than among natives. Approximately two-thirds of migrants from emerging and developing countries lack a tertiary degree. Nearly 40% of African migrants have a low level of education, while migrants from other origins typically have a medium education level, except for North Americans who mostly have a university diploma and Asian migrants, for whom the three levels of education are evenly distributed. With the exception of Asians, who are the youngest group, more than three-quarters of workers in Europe are under 50. Middle-aged workers (35-49) make up the largest share for all groups except North Americans. Older workers (50-64) account for about 40% of natives and North Americans, one-third of African and European migrants, and only 30% of Latin American migrants and 25% of Asian migrants. The regional analysis focuses on France and Germany and shows that while natives are evenly distributed throughout France, migrants are primarily drawn to the region surrounding Paris (Ile de France). In Germany, the situation is less polarised, and three regions (Baden-Württemberg, Bayern, and Nordrhein-Westfalen) are the most attractive for all workers, with the addition of Berlin for North and Latin Americans.

Using the current allocation of migrant and native workers across occupations, we identify the occupations that are under-/over-supplied by foreign workers relative to native workers in France and Germany. Using recent Online Job Vacancy (OJV) from Lightcast data, we identify the skill composition of occupations that are in the top position in terms of shortage or surplus and their similarity across the period 2019 to 2021. We measure the heterogeneity and evolution of skill demand within the occupations that mostly suffer from labour shortage (intensive margin of changes induced notably by technological progress), and changes in occupational structures that suffer from under-/over-supply of natives or migrant workers (extensive margin).

In 2021, we observe fewer occupations in shortage in France than in Germany. However, the German labour market is addressing these labour shortages through the crucial presence of migrant workers. Our analysis of the occupations in shortage in both countries reveals that five high-skilled occupations, primarily in Science, Technology, Engineering, and Math (STEM) fields, are affected. To address these shortages, it may be necessary to increase domestic education in these fields or attract more skilled migrants. In terms of the evolution of skills demand, we observe that the similarity of requested skills over the period 2019 to 2021 is higher for high-skilled occupations compare to medium skilled ones. In today's job market, the demand for digital skills is continually increasing. There is a particularly high demand for digital skills, especially for mathematicians, actuaries, and statisticians (which is in shortage in France), who need to process data using more and more advanced machine learning tools. In addition to technical expertise, being innovative, complying with the ethical principles, being able to adapt to changing situations and working in a team are highly sought-after soft skills in high-skilled occupations.

OJV data have some limitations regarding the representativeness. Nevertheless, Carnevale *et al.* (2014) using US data, estimate that around 60-70% of the total number of job vacancies are covered in online job postings. Cammeraat and Squicciarini (2021), using OJV from Australia, Canada, New Zealand, Singapore, the United Kingdom and the United States, and covering the 2010s decade, underline the following positive and negative points. On the positive side, they observe that OJV even though OJV data coverage varies across occupations and over time, the overall trends are consistent with official data. This is confirmed by Acemoglu *et al.* (2022) who compare the statistics of the US Bureau of Labor Statistics (BLS) Job Openings and Labor Turnover Survey (JOLTS) with Burning Glass data. They show that the trends are similar, and that especially high-skilled occupations such as 'managers', 'professionals' and 'technicians and associated professionals' are relatively well represented. Hershbein and Kahn, (2018) highlight that in the US, the largest differences between online job vacancies and the Current Population Survey's (CPS) in 2007 are found in relation to computer and mathematical occupations (relatively overrepresented in OJV data by about 11 percentage points). On the negative side, some occupations are underrepresented due to the recruitment process used in specific jobs. For example, Hershbein and Kahn (2018) find that construction workers are relatively underrepresented (by about 7 percentage points).

The paper is structured as follows. Section 3 reviews the empirical evidence about, first, the relation between migration and the supply of skills, second, the empirical evidence regarding

occupations in shortage or surplus, third, the related literature devoted to the identification of skill, their similarities and the speed of change. Section 4 describes the data and method and Section 5 presents the results. Section 6 concludes.

2. Related literature

2.1. Labour shortage and skill mismatch

Brunello and Wruuck (2021) provide a review of the recent economic literature on skill shortages and skill mismatch. They highlight that skill shortages vary with the business cycle and structural factors. On the one hand, they underline that skill shortages increase during economic expansions and decline during recessions. On the other hand, they highlight that structural changes such as demographic trends can add to skill shortages and at the same time can support the demand for new goods and services (like medical services and personal care linked to population ageing). Other structural factors such as globalisation, the role of exporting sectors, and technological change are other factors inducing sectoral dynamics that affect shortages on labour markets.

The issue of labour shortage or surplus is a main concern at the European level as evidenced by the reports produced by the European Commission (e.g., European Commission, 2021, 2023a), EU agencies (e.g., Eurofound, 2021; Eurofound & Cedefop, 2020; McGrath & Behan, 2017; McGrath, 2019, 2020, 2021), OECD (e.g., Causa, Abendschein, Luu, Soldani, *et al.*, 2022) or national analyses (e.g. the Labour Ministry (DARES) in France by Grobon *et al.* (2022); Martin and Baer, 2022 in Luxembourg).

While most of the exiting study focus on labour shortage or surplus at the sectoral level, few existing studies highlight the main occupations that are in shortage or surplus in some of the European labour markets (e.g., Martin & Baer, 2022; McGrath, 2019). Mcgrath (2019) proposes a shortage/surplus ratio to measure the phenomena based on the Labour Force Survey (LFS) that we use in the present analysis. His study reveals that technical competences are the most required in shortage occupations. Comparing LFS data with employment agency data from Luxembourg, Martin and Baer (2022), focus on the low- and medium-skilled occupations and underline that all occupations in shortage identified with employment agency data are identified in shortage with the McGrath ratio using LFS data.

At the skill level, other measures have been proposed. For instance, OECD (2017) computes an index of skill shortages using first, occupational indicators constructed by combining infor-

mation on hourly wage growth, employment growth and growth in hours worked by occupation and second, occupational skill indices using O*NET. The study reveals that some skills are in bigger shortages in half of the studied European countries such as reading comprehension, writing, speaking, active learning or critical thinking.

On the reasons for the shortage of certain occupations, three main arguments are generally invoked. First, bad working conditions and/or low wages. For instance, as underlined by Haskel and Martin (2001) on UK data, there are fewer shortages in firms offering a higher average wages compared to others. Second, limited mobility on the labour market due to lack of information. For instance, experimental evidence provided by Belot *et al.* (2019) on job seekers from UK reveal that they narrow their job search to occupations in which they have previous experience. Third, biased beliefs and their effects on job search. Caliendo *et al.* (2015) argue that each individual has a subjective belief about the impact of his or her search effort on the rate at which they get job offers. Using data of newly unemployed individuals in Germany, they show that the ones with an internal locus of control, i.e. those who believe that their actions can produce their desired results, are the ones that search more.

As part of the demographic trends due to globalisation, the integration of migrants on the European labour market has been the subject of some studies. First, researchers show that migrants are viewed as a solution to fill vacancies in shortage (Anderson & Ruhs, 2012). Second, the skill mismatch prevalence among migrants and natives has also been analysed (Jestl *et al.*, 2015; Visintin *et al.*, 2015). Jestl *et al.* (2015) using Labour Force Survey (LFS) compare the extent of 'job-skill mismatch' between migrants and natives within the EU. They find that over-education is more prevalent among migrant workers than among natives, especially in low-skilled occupations. Visintin *et al.* (2015) also find that skill mismatch is more common among migrants, although the extent of this phenomenon varies across countries of origin and destination countries.

2.2. Migration and the supply of skills

First of all, it must be noted that migration flows, especially among skilled workers, can only be fluid if some barriers are alleviated at the European level. Zimmermann (2005) points to the European Union's ageing population, the lack of skilled workers, and the high unemployment among low-skilled workers. He argues that a selective migration policy, which would specifically target skilled migrants, would foster growth and generate positive spillovers on all native workers. In order to reach this goal, he identifies two major issues, namely the lack of coordi-

nation on migration policies within the EU and the need for competitive institutional settings in order to support European companies' attractiveness in the international labour market (see Kerr *et al.*, 2016 for a review of the global mobility of high-skilled workers). Krause *et al.* (2017) analyse data from an online survey among European labour market experts, which confirms that there is a need for 'recognising professional qualifications more efficiently and harmonising social security systems'. The need for proper recognition of migrants' skills across European countries appears to be a challenge both to the economic success of migrants as well as to the development of harmonised data for research purposes. While Winterton (2009) who stressed that 'despite initiatives like the European Qualifications Framework there is still no consensus for adopting a common competence model and policy discussions continue to reveal confusion', progress have been made at the European Union (Barslund & Busse, 2014). Nevertheless, differences in approaches to skill formation still exist and are attributed to language and cultural issues. As far as research is concerned, skills *per se* are generally not measured by regular statistical agencies, and when they are, the lack of uniformisation or the lack of such information on migrant samples explains the scarcity of research on migrant skills. Instead, most studies rely on skill proxies, such as qualifications or the number of years of education. In light of this, research focused on education shows that migrants' degrees are not properly recognised in host countries. Together with language barriers, the lack of degree recognition generates misallocations of migrant workers. Brücker *et al.* (2021) exploit survey data merged with German administrative records to study the impact of occupational recognition. They find about 20% wage increases and 25% higher employment probability in the 3 years that followed recognition, leading migrants to assimilate in terms of wages.

On the impact of migration on native workers, Cattaneo *et al.* (2015) use longitudinal data to assess the impact of migration on natives' career paths. They show that, as the inflow of migrant workers increases, native European workers tend to move to occupations associated with higher skills and status, whereas their probability of unemployment does not increase. Faggian *et al.* (2017) provide a literature review of interregional migration with a focus on how human capital flows impact both receiving and sending economies. They identify two gaps in the literature, namely the relatively low coverage of the impact of migration on sending regions, and more importantly, the limited availability of data on migrant characteristics, especially skills. Since every occupation requires a specific mix of skills and abilities, the literature using data on mere education levels can only partially describe the interregional mobility of labour. This is particularly true in the context of migrant workers, since as discussed above, there are issues in the recognition of immigrants' educational attainment. A recent strand of the literature thus

goes beyond education levels and attempts to look deeper into workers' and occupations' skills. The O*NET Content Model provides structured information on the characteristics of each occupation, called occupation descriptors. These descriptors are based on a standardised, measurable set of variables obtained from worker surveys. To the best of our knowledge, this type of data has only been used for research on the US. Peri and Sparber (2009) use O*NET and individual US census data to show that migrant workers specialise in occupations requiring physical skills, whereas natives are more allocated to jobs involving communication tasks. Odriozola and Peña (2016) extend the work of Peri and Sparber (2009) by controlling for gender and length of residence. They find that length of stay generates some degree of occupational assimilation among male migrants, whereas female immigrants tend to be confined in a few 'niche jobs'. Sharpe and Bollinger (2020) also use O*NET data and find higher partial equilibrium effects on natives compared to previous research based on education and experience, in particular on the least skilled natives. In contrast, high-skilled natives benefit from immigration in terms of higher wages. Beyond higher substitutability among low-skilled workers, a possible explanation of the negative impact on low-skilled natives stems from the fact that many migrants employed in low-skilled jobs tend to achieve professional progress and skills development in sectors whose conditions are usually deemed unattractive (Moroşanu *et al.*, 2021). Finally, Tountopoulou *et al.* (2021) review the literature on international skill frameworks and use survey data to identify key skills for the labour market integration of migrant groups. They highlight the importance of (i) hard skills attached to specific tasks and (ii) transversal soft skills. They state that recruiting procedures would benefit from skills profiling and online tools of skill assessment.

The notion that migration flows respond to heterogeneous levels of unemployment and economic crises within the EU is vastly documented. Zhang and Lucey (2017) construct a novel brain drain/gain index to analyse the mobility of skilled workers in 30 European countries between 2001 and 2015. They find that a country's level of relative development within Europe affects net flows, with the most developed countries being net recipients of tertiary graduates at the expense of the least developed countries, although some exceptions exist. They also find that the 2008 economic crisis has exacerbated this gap. Arpaia *et al.* (2016) show that, from 1970 to 2013, when an asymmetric economic shock occurs inside the EU, about a quarter of that shock was absorbed within a year thanks to labour mobility. Shock-related movements have almost doubled since the introduction of the euro and have translated into more responsive real wages. Elsner and Zimmermann (2016) find an increase in migration to Germany from countries that were more hardly hit by the Great Recession, but that the magnitude of net flows

is insufficient to significantly reduce unemployment in the sending countries. Jauer *et al.* (2019) use regional panel data on pre- and post-crisis migration movements and find similar results for the EU and the US. For the EU, they find that most migratory flows are attributed to citizens from countries that recently joined the EU and third-country nationals. Beine *et al.* (2019) study the impacts of both long-term drivers of migration and the short-run economic fluctuations and find that both types of factors contribute to migration flows. They also show that the Schengen Agreement and the euro currency significantly increased the within-EU worker mobility.

When it comes to the consequences of the COVID-19 crisis, Bossavie *et al.* (2020) show that native workers in European NUTS 2 regions with a higher share of immigrants are less exposed to occupational vulnerability and are pushed towards working from home occupations. Highly (tertiary) educated native workers benefit from job safety in the presence of both high-skilled and low-skilled migrants. They find no evidence of such effect for less educated native workers and no impact neither on employment, nor on wages. As for seasonal agricultural workers, replacing migrants with natives does not appear as a long-term solution; relying on AI technology for picking crops seems more promising (see Mitaritonna & Ragot, 2020). Relying on European Labour Force Survey (EU-LFS 2018), Fasani and Mazza (2021) characterise migrants' occupations along four dimensions related to the role of workers' occupations in the response to the pandemic, the contractual protection they enjoy, the possibility of performing their job from home and the resilience of the industry in which they are employed. They estimate that, within industries and occupations, Extra-EU migrants and women are exposed to a higher risk of unemployment than native men and that women are losing jobs at higher rates than equally exposed men. More than 9 million immigrants in the EU14+UK area are exposed to a high risk of becoming unemployed due to the pandemic crisis, 1.3 million of whom are facing a very high risk. Economies particularly specialised in manufacturing suffer more from social distancing measures (manual jobs).

2.3. Detecting skill similarities and skill speed of change

We aim to detect skill similarities across occupations as well as the skill speed of change in the last years.

Regarding the classification of skills, the related state-of-the art revolves around two distinct approaches of classifying workers' skills. On the one hand, the first and most popular approach relies on information about tasks performed by workers. This results in the well-known differentiation between routine and non-routine work initiated by Autor *et al.* (2003) and enriched

later by Acemoglu and Autor (2011) or Lewandowski *et al.* (2022). In this strand of research, five tasks are often distinguished: (i) routine manual (e.g. picking or sorting, repetitive motions, operating or controlling machines); (ii) routine cognitive (e.g. record-keeping, calculating, bookkeeping, correcting texts or data, measuring length, or weight, or temperature, repetitive customer service), (iii) non-routine manual (e.g. manual dexterity, spatial orientation, repairing or renovating), (iv) non-routine analytical (e.g. forming/testing hypotheses, researching, analysing, evaluating and planning, designing, creativity, problem solving); (v) non-routine interactive (e.g. negotiating, lobbying, coordinating, organising, guiding, directing, motivating, communicating). Some other scholars do not disentangled sub-categories and focus on three tasks: routine, non-routine manual, non-routine cognitive as in Cortes (2016).

On the other hand, international organisations such as Cedefop, or OECD developed their own way of classifying skills. It relies on a distinction between three main skill families: (i) hard skills (e.g. customer services, foreign languages); (ii) soft skills (e.g. planning, team work); and sometimes iii) digital skills (Cedefop, 2017; Colombo, Mercorio, & Mezzanzanica, 2019; Fernández-Macías & Bisello, 2020; OECD, 2016). Both approaches generally use information from databases which are based on worker surveys or expert information, such as the Occupational Information Network (O*NET) or the European Skills, Competences, Qualifications and Occupations (ESCO). A relatively new approach to quantify skill needs is to use word embeddings and network community detection algorithms to extract skills directly for job advertisement (e.g. Djumalieva & Sleeman, 2018).

The extant evidence regarding skill similarities across occupations rely on various types of data coming from surveys, administrative data, training curricula, job descriptions or job offers (newspapers and/or online). Regarding surveys, Chuang (2020), studying recent data collected in the Vigo County of Indiana, US, provides an estimate of the potential of workers' skills mobility using respondents' perception about the displacement potential of their own skills. His main result is that about half of the respondents were not aware of their risk of skill obsolescence due to technological progress. Dworkin (2019) uses US data collected in 2016 (from the Bureau of Labour Statistics), assesses the skills, knowledge and abilities similarities between each pair of jobs and provides a transition recommendation model in order to ease the job transition of workers impacted by automation. He quantifies the potential benefit of increasing individual skills to facilitating both job transitions and within-occupation skill redefinition. Gathmann and Schönberg (2010), using German data (German Qualification and Career Survey, from BIBB and IAB) for four different years: 1979, 1985, 1991/92, and 1998/99, propose the concept of task-

specific human capital. The authors underline that employees move to occupations with similar task requirements with a distance of moves that declines with experience. In their methodology, they distinguish task-specific human capital (valuable only in occupations that require skills similar to the current one) from general skills in order to capture the transferability of each task-specific skills across occupations. Gathmann *et al.* (2020), using administrative data on firms and workers in Germany from 1975 to 2008 (German Social Security Records), focus on the effects of mass layoffs. The authors point out small effects on workers or even no effects for those younger than 50 years old who are geographically mobile and escape from the decline in local employment opportunities that are large. Bachmann *et al.* (2019), using the BIBB and worker-level administrative data, study the change in job tasks for Germany during the period 1979-2014. They confirm a strong decline in routine task intensity (RTI) over this time period and show that this has led to higher inflows into and outflows out of unemployment for routine workers.

Geel and Backes-Gellner (2011), applying the Lazear's skill-weights approach (Lazear, 2009) on German survey data (BIBB/BAuA Employment Survey 2005/06), identify clusters of occupations characterised by similar skill combinations and reveal that the probability of changing occupations is higher within a skill cluster than between skill clusters. Using the same methodology, Rinawi and Backes-Gellner (2021), on Swiss data (Social Protection and Labour Market-SESAM for the years 2004–2009), show that skills appear to be transferable across occupations. Nevertheless, a higher occupational specificity appear to be associated with lower job mobility and a longer period of unemployment. Using the Lazear's skill-weights approach on Swiss data from training curricula (vocational education and training (VET) curricula) matched with SESAM from the years 1999 to 2009, Eggenberger, Rinawi and Backes-Gellner (2018) reiterate the results that a higher occupational specificity induces a lower probability of occupational mobility. In terms of methodology, the Lazear's skill-weights approach allows to study occupational specificity at the level of single skills as well as the resulting bundles of these skills.

Alabdulkareem *et al.* (2018), on US job descriptions (from O*NET, 2014/15), calculate the overlap of a set of skills between job pairs using unsupervised clustering techniques and study skill proximity between occupations. They reveal a polarisation in two clusters that cover specific social-cognitive skills and sensory-physical skills of high- and low-wage occupations respectively. This polarisation constrains the career mobility of workers especially of low-skilled workers. Del Rio-Chanona *et al.* (2021), also provide an analysis of occupational mobility using US occupational transitions data, from January 2001 to September 2018. They generate an

occupational mobility network and their analysis takes into account occupations impacted by automation shocks and they highlight that in some regions of the occupational mobility network, workers easily find new jobs and in others regions, workers get trapped because there are no good alternatives, causing an increase of long-term unemployment. Alabdulkareem *et al.* (2018) and Del Rio-Chanona *et al.* (2021) both map skills complementarity (and produce a skillscape) by proceeding in four main stages (i) calculate the revealed comparative advantage of each skill in an occupation; (ii) calculate the minimum of the conditional probabilities of a pair of skills being effectively used by the same occupation; (iii) identify skill types using a unsupervised clustering techniques with a community detection algorithm; (iv) map the skillscape. Frank *et al.* (2018) exploit US data identifying the employment distribution of occupations across 380 US metropolitan statistical areas (MSAs) and combined statistical areas (CSAs) in 2014 in order to add a geographical mobility feature in the analysis. They show that the potential impact of automation in large cities is lower than in small cities because in large cities many jobs are in managerial and technical occupations less impacted by automation. Börner *et al.* (2018) use millions of academic publications, courses (from the Open Syllabus Project), and job advertisements (from Burning Glass technologies) published between January 2010 and December 2016 to study the misalignment between skills required on the labour market and skills provided by education institutions. They develop a topical base map covering skills that occur in job, course, and publication data and reveal that the demand for 'soft' social skills (like teamwork, communication, negotiation, and persuasion) increase with greater demand for 'hard' technical skills.

Atalay *et al.* (2018; 2020) investigate the change of skill requirements over time in US using the descriptions by keywords in job advertisements (published in newspapers) and observe that the soft skills about problem-oriented thinking have almost doubled in the US from 1950 to 2000. The trend towards these so-called 'analytical skills' has been fostered in particular by innovations in information and communication technology (ICT) and also takes place within narrowly defined job titles such as real estate agent. According to recent studies relying on online job vacancy data, the skill requirements by companies increase during the financial economic crisis. This is due to the fact that during a crisis the number of unemployed - including skilled workers - increases. This means that companies have a larger number of qualified workers at their disposal, who are usually the first to benefit from the economic recovery. For example, in the US, an increase in occupational demands has been observed in regions that experienced high unemployment during the 2007/08 financial crisis (Hershbein & Kahn, 2018;

Modestino *et al.* 2020). Nevertheless, during the recovery period (2010 to 2014) skill requirements by companies appears to fell (Modestino *et al.* 2016).

3. Data and method

The analysis uses the Eurostat Labour Force Survey (LFS), a large household survey that provides quarterly and yearly data on labour participation of individuals aged 15 and over as well as of individuals outside the labour force. The following analysis uses the annual data. The LFS is particularly suited for the analysis in this paper as it provides detailed information on the demographic background of individuals (like gender, age, nationality, or country of birth), their labour market status, previous work experience, region of residence, level of education and job characteristics like occupation, business sector, etc. The information on nationality and country of birth are useful to compare the prevalence of natives and migrants across business sectors, education levels, occupations, age classes in the European countries studied and across regions with a detailed focus on France and Germany.

As LFS sample weight are not specifically made to take care of the on repartition of migrants, we used data from the United Nation data and Eurostat data to reweight the data (see the box below). We restrict our analysis to European countries for which we have LFS data in 2014, 2019 and 2021 with accurate information regarding the country of origin of migrant workers. The 19 EU countries covered are the following: Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Spain, Sweden.

All statistics from LFS presented below focus on individuals living in the 19 EU countries studied[1], employed or unemployed during the year studied, aged between 15 and 65 years, and for whom we have information about their gender, education level (low, medium, high), occupations (ISCO 3[2] Digits), business sectors and regions where respondents live.

LFS provides information on an individual entering the labour market in the year studied and the occupation a year prior to the interview of individuals currently unemployed. Both are used to examine the prevalence of under-/over-supplied occupations of natives and migrants in France and Germany. The shortage/surplus ratio used to measure the over/under-supplied

[1] Except for Luxembourg, for which cross-border workers respondent in LFS in Belgium, France, or Germany are included.
[2] https://www.ilo.org/public/english/bureau/stat/isco/

occupations are based on the measures derived from the one proposed by Mcgrath (2019) on LFS:

> Shortage/surplus ratio = (number of recruits to the occupation in the year studied)/ (number of inactive in the year studied with previous experience of working in that occupation).

LFS data are complemented with online job vacancies data. The ones used in the paper consist of job ads published online in over 300 portals for France and Germany from 2019 to 2021. They are provided by Tabulaex/Lighcast. This is an analytics software company specialised on labour market issues, and it has developed a technology that collects automatically new openings, and stores their full description. The data are cleaned using algorithms to remove identical ads.

To extract hard, soft and digital skills requested in occupation, we propose a text mining-based analysis based on Natural language processing (NLP) that dissects the raw text of job advertisements and detects skills (Martin & Filipek, 2022). First, we use existing classifications of skills, such as the European Skills, Competences, Qualifications and Occupations (ESCO) framework, use also identified in existing research (for instance, for digital skill, Curtarelli *et al.*, 2016; Rimini & Spieza, 2016; Alekseeva *et al.*, 2021) and by hand on a sample of online job vacancies to detect emerging skills, we built a dictionary of hard, soft and digital skills.

To measure the similarity of hard, soft and digital skills requested in one occupation between 2019 and 2021, we computed the cosine similarity of two vectors of attributes A (skills in 2019) and B (skills in 2021), as:

$$SC(A,B) := \cos(\theta) = \frac{A.B}{||A||||B||} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

where A_i and B_i are the i^{th} components of vectors A and B, respectively.

BOX 1 – LFS reweighting procedure using United Nation and Eurostat external data

The United Nation provides migration datasets. It computes the migration stocks in each country by country of origin, sex and age.

The United Nation migration data are collected form all countries of the world on migrant population aged 25 years and older by gender, educational level and detailed country of birth from 1990 to 2020 (5 years intervals). Migration is defined according to country of birth. The migration numbers from United Nation data are representative for the population of migrants

from each of the destination countries. The 19 EU destination countries from with LFS data provided accurate information on migrant workers are: Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Spain, Sweden.

As the migrants LFS data is not made representative for the EU countries, we propose to generate population weights for migrants based on numbers taken from United Nation migration data set for the 19 EU countries that we analyse. There we calibrate the new LFS weights for each country separately using the two variables that are common to both United Nation migration data and to LFS data: gender, migration from one of the five defined regions of birth (Africa, Asia, Europe, North America, Central and South America).

More specifically, migration figures by gender and countries of birth refer to individuals whatever their age in the United Nation migration data. The total number of male and female is available for each pair of world region of country of origin (Africa, Asia, Europe, North America and Oceania, Central and South America) and destination country. As we restrict our analyses to individuals that are aged 15 years and older, we apply the percentage of migrants who are aged between 15 and 64 years in each EU destination country studied by distinguishing male and female.

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 that are in active population for natives, EU and non-EU individuals in each EU destination country studied in 2014, 2019 and 2021.

We use 2015 United Nation migration data and 2014 Eurostat values for reweighting LFS 2014 and 2020 United Nation migration data and 2019 or 2021 Eurostat values for reweighting LFS 2019 and 2021.

To do so we propose to 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 19 EU analysed countries.

In summary the procedure is based on a post-stratification adjustment[3] of the population using the two categorical variables, defined above (control variables) 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. The weights in France in 2021 are between 0.41 and 1.48 and in Germany in 2021 between 0.68 and 1.49.[4]

Appendix Table 1 presents the observed differences between no weights, LFS weights and the ones recalibrated using the United Nation data.

The final sample focuses on individuals living in the 19 EU countries studied (except for Luxembourg where cross-border workers are added), individuals that are employed or unemployed during the year studied, aged between 15 and 65 years, and for whom we have information about their gender, education level (low, medium, high), occupations (ISCO 3 Digits), business sectors and regions where respondents live. Thus, for example, the French sample in 2021 covers 31,292 observations of the original 39,895 observations aged between 15 and 65 years, and the German sample in 2021 covers 96,759 observations of the original 113,943 observations aged between 15 and 65 years.

4. Results

4.1. Distribution of natives and migrants across business sectors

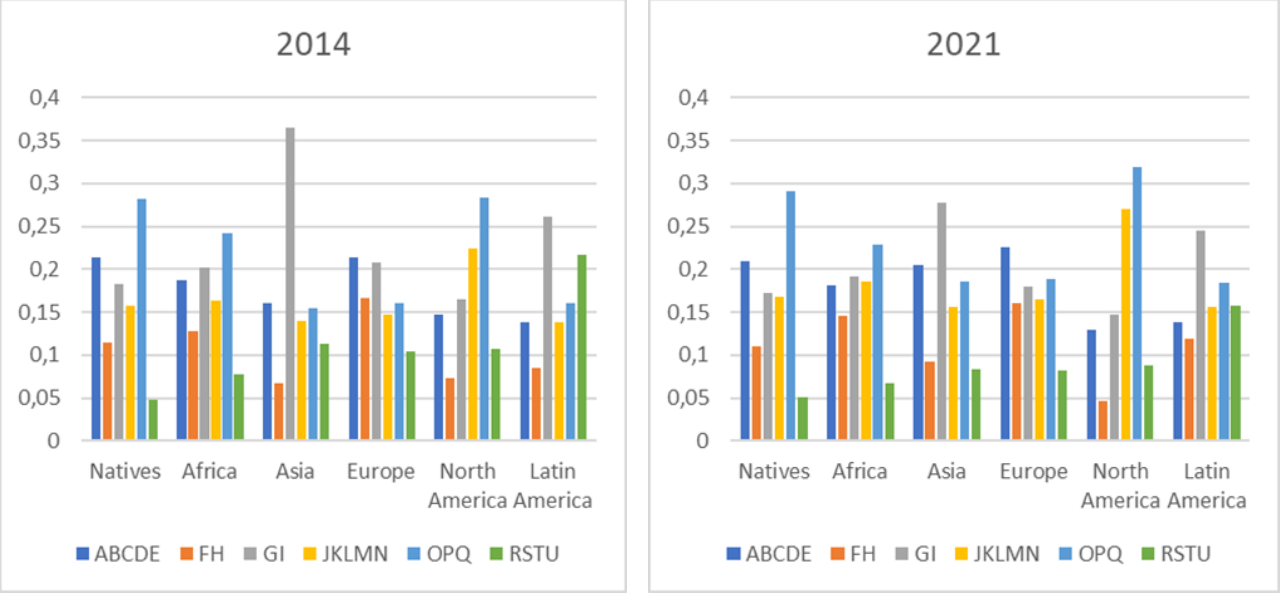
4.1.1. The European case

As for natives, about one fourth of migrants coming from Africa and from North America are employed in public services (based on the NACE Rev.2 acronym 'OPQ', which covers public administration, education, health, residential care and social work) (see Figure 1).[5] The proportion of Asians and Latin Americans involved in public services is lower (below 20%); instead the main sectors of activity of immigrants from these regions is wholesale and retail trade (GI:

[3] A post-stratification adjustment consists of breaking down the population into post-stratification cells defined by specific levels of the control variables, and adjusting the weights within each cell so that the weights sum to the known total.
[4] It must be noted that in France 2021, 2 occupations (835 and 521) have a small sample of migrants (below 20 observations), and Germany in 2021, 8 occupations are concerned (131, 224, 323, 324, 622, 835, 951, 952).
[5] All detailed statistic are available upon request form the authors.

accommodation and food service activities) and other services (RSTU). Finally, Europeans are more evenly distributed across all six sectors, with at least 15% active in each of the following sectors: agriculture and manufacturing (ABCDE), construction, transport and storage (FH), financial and professional services (JKLMN), as well as wholesale and retail trade (GI) and public services (OPQ).

Figure 1. Distribution of workers across economic sectors in Europe, by workers' region of origin



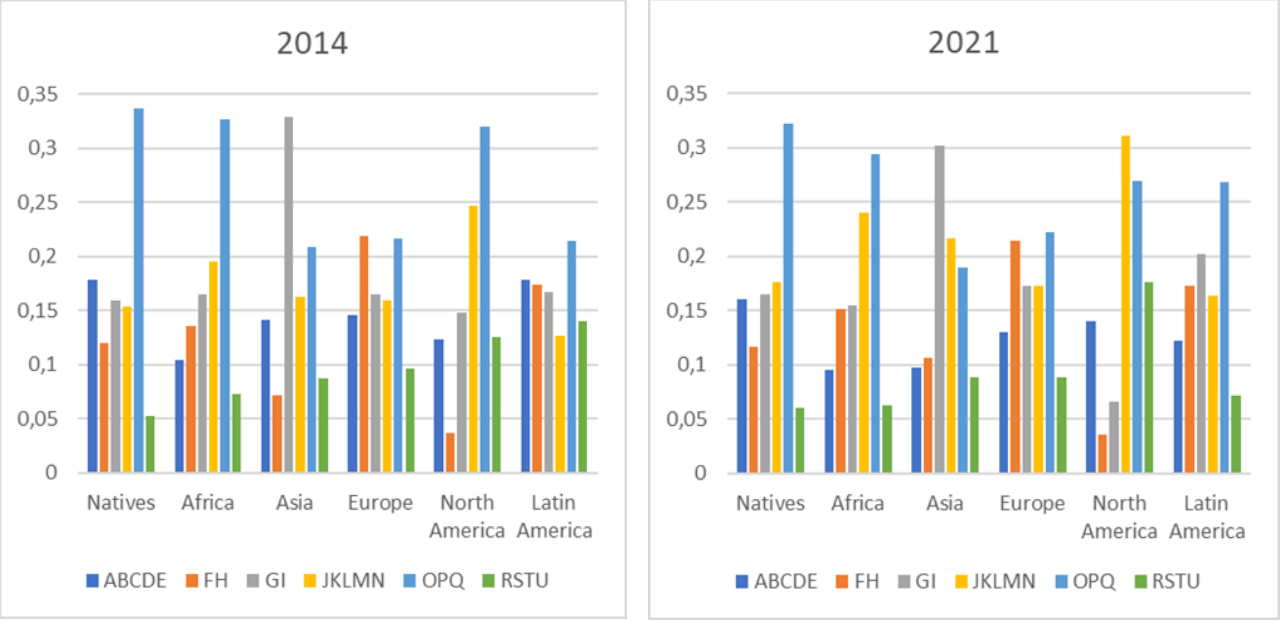
Sources: LFS 2014, 2021. For each region of origin, share of migrants living in the 19 EU countries by sectors. Sectors (NACE Rev.2): ABCDE: Agriculture, Manufacturing, FH: Construction, Transport and Storage, GI: Wholesale and Retail Trade, Accommodation and food service activities, JKLMN: Financial and Professional Services, OPQ: Public Administration, Education, and Health, RSTU: Other services

The sector representation of immigrants by region of origin has been relatively stable between 2014 and 2021, with a few exceptions. For all groups, the proportion of workers active in financial and professional services (NACE Rev.2 JKLMN) increased during this period. This was particularly the case for North Americans, whose share in this sector increased from 22.3% in 2014 to 27.1% in 2021. Another noticeable evolution is the decline in the proportion of Asians employed in wholesale and retail trade, accommodation and food service activities (NACE Rev.2 GI) (from 36.5% in 2014 and 27.8% in 2021). This decline has been compensated by homogeneous increases in the other 4 main sectors, due to larger increases in the total employment of Asians in these sectors rather than a decrease in the employment of Asians in wholesale and retail.

4.1.2. The French case

In the French case presented in Figure 2, public services (NACE Rev.2 OPQ) are the main employer of all groups, except for immigrants from Asia, who are mostly active in wholesale and retail trade, accommodation and food service (NACE Rev.2 GI, 32.9%). For North Americans, Financial and Professional Services also represent an important sector. Compared to all the other groups, Europeans and Latin Americans are overall homogeneously distributed across sectors. For European immigrants, the sector of Construction, Transport and Storage (21.9%) is closely followed by public services (21.6%).

Figure 2. Distribution of workers across economic sectors in France, by workers' region of origin



Sources: LFS 2014, 2021. For each region of origin, share of migrants living in France by sectors. Sectors (NACE Rev.2): ABCDE: Agriculture, Manufacturing, FH: Construction, Transport and Storage, GI: Wholesale and Retail Trade, Accommodation and food service activities, JKLMN: Financial and Professional Services, OPQ: Public Administration, Education, and Health, RSTU: Other services

Regarding the evolution over the period 2014-2021, the manufacturing and agriculture sector (NACE Rev.2 ABCDE) decreases for all populations except an increase among Latin Americans. In contrast, the share of workers involved in Financial and Professional Services increased among all groups. In particular, the share of workers employed in these services increased by 4.5, 5.4 and 6.5 percentage points among Africans, Asians and North Americans, respectively.

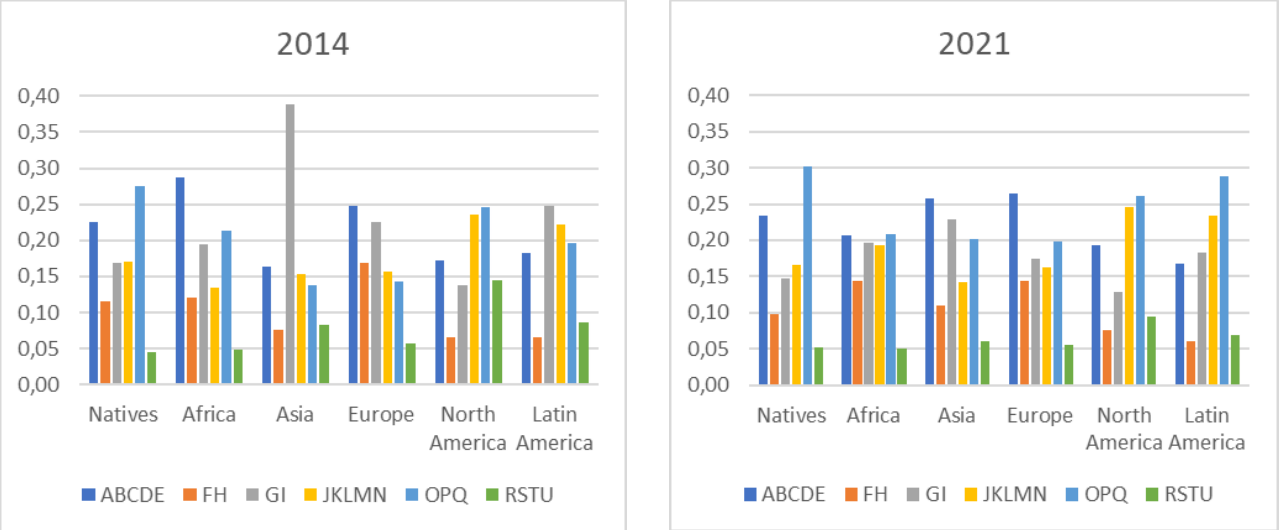
The proportion of workers involved in construction, transport and storage (NACE Rev.2 FH) remained quite stable within each group of origin, except among Asians, for whom this sector's employment share increased by 3.4% percentage points. In wholesale and retail trade, accom-

modation and food service activities (NACE Rev.2 GI) employment fell for Asians and even more for North Americans (from 14.8% to 6.6%).[6] The share of employment in public services (NACE Rev.2 OPQ) fell for immigrants from all regions except Latin America (+5.4 percentage points from 2014 to 2021) and Europe where it remained stable. The fall mainly occurred between 2014 and 2019, except for American migrants for which it dropped continuously. Finally, the share of immigrants involved in other services (NACE Rev.2 RSTU) decreased for Africans and Latin Americans (from 14.0% in 2014 to 7.1% in 2021), while it rose for North Americans (from 12.6% in 2014 to 17.6% in 2021). These later changes mainly occur during the last two years.

4.1.3. The German case

As for France, the largest sector employing immigrants is public services (NACE Rev.2 OPQ) (see Figure 3), except for Asians and Europeans. For European immigrants to Germany, the largest employer is manufacturing (NACE Rev.2 ABCDE), with 26.5% in 2021.

Figure 3. Distribution of workers across economic sectors in Germany, by workers' region of origin



Sources: LFS 2014, 2021, Germany. For each region of origin, share of migrants living in Germany by sectors. Sectors (NACE Rev.2): ABCDE: Agriculture, Manufacturing, FH: Construction, Transport and Storage, GI: Wholesale and Retail Trade, Accommodation and food service activities, JKLMN: Financial and Professional Services, OPQ: Public Administration, Education, and Health, RSTU: Other services

We observe a similar pattern for Asian migrants, 25.7% of whom are employed in manufacturing. American migrants are also frequently working in financial and professional services (NACE Rev.2 JKLMN): 24.7% for Northern Americans and 23.4% for Latin Americans.

[6] Note that this large variation also reflects the small size of the group of immigrants from this region.

In opposite, few Asians work in this sector, 14.2% in 2021. Wholesale and retail trade, accommodation and food service activities (NACE Rev.2 GI) is an important employer of Asian migrants (22.9%), but not for North Americans (12.8%). About 15% of African and European and 11% of Asian immigrants are employed in construction, transport and storage (NACE Rev.2 FH), while this proportion is only around 7% for immigrants from other origins. Finally, other services (NACE Rev.2 RSTU) employ around 6% of migrants from all origins, except for North Americans (9.5% in 2021).

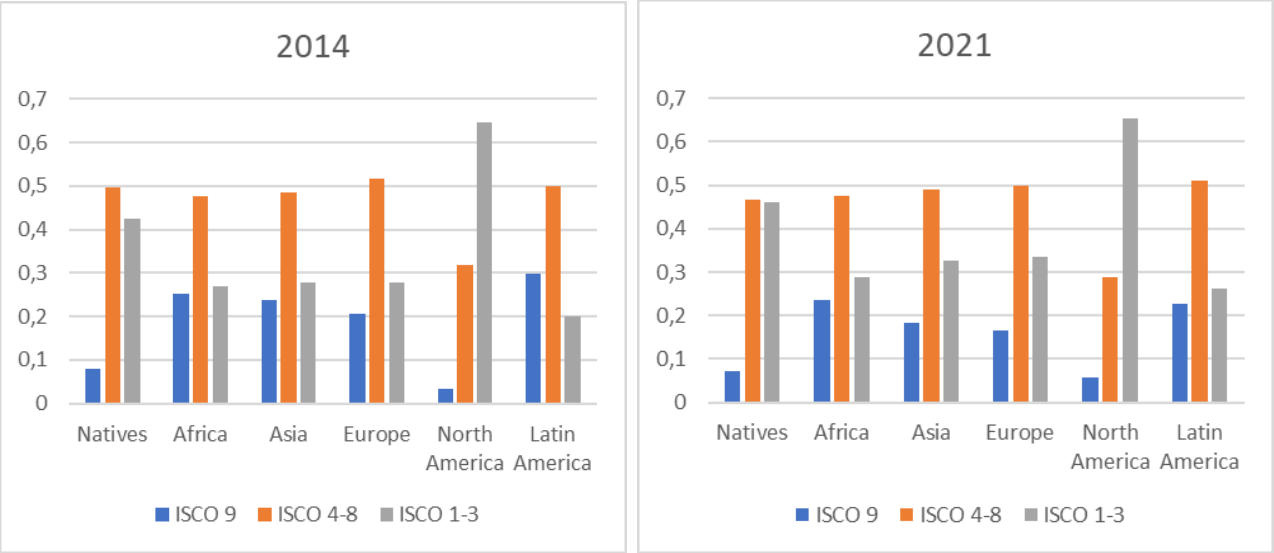
Regarding the evolution over the period 2014-2021, in contrast to France and in line with the strong German tradition of mechanics, chemicals and production goods, the share of workers employed in manufacturing (and agriculture) increased for all regions of origin (with the exception of immigrants from Africa). The rise was particularly sharp for Asian immigrants (16.4% in 2014 to 25.7% in 2021). The fall for Africans mainly occurred from 2014 to 2019 (28.7% and 19.5%), followed by a rebound in 2021 (20.7%). In public services (NACE Rev.2 OPQ), the share of migrants from all origins increased, the highest rise occurring for Latin Americans (19.7% in 2014 and 28.8% in 2021). The share of migrants employed in financial and professional services (NACE Rev.2 JKLMN) rose, except for Asians. The highest increase occurred for Africans (13.5% in 2014 and 19.4% in 2021). Migrants became less involved in wholesale and retail trade, accommodation and food service activities (NACE Rev.2 GI), except for North Americans and Africans, for whom the share remains constant. The sharpest fall occurred for Asians (38.8% in 2014 to 22.9% in 2021). As for North Americans, their share falls from 24.8% in 2014 to 18.2% in 2021. The share of workers employed in construction, transport and storage (NACE Rev.2 FH) increased for most origins, except for Latin Americans (for whom it remained stable around 6%) and for Europeans, for whom it decreased slightly (16.9% in 2014 to 14.4% in 2021). The rise was the most important for Asians (7.6% in 2014 to 12.3% in 2019, and then a fall to 11.0% in 2021). The proportion of workers involved in other services (NACE Rev.2 RSTU) remained stable for all migrants but Americans, for whom it decreased.

4.2. Distribution of natives and migrants across occupations

4.2.1. The European case

For the 19 EU countries (see Figure 4), migrants from most origins mostly work in medium-skilled occupations (ISCO 4-8).[7] About half of Europeans (49.9%) and Asians (49.0%) are indeed working in this skill interval. North Americans are the only immigrants who are more involved in majority (65.5%) in high-skilled occupations (ISCO 1-3). While 46.0% of natives are employed in high-skilled occupations, this skill level only represents 25 to 30% of the jobs of migrants from Africa and Latin America, and 33% for migrants from Asia and Europe. Finally, low-skilled occupations (ISCO 9) concern a fourth of African and Latin American migrants, 18% for Asians and 17% for Europeans, whereas only 7% of natives do this type of work.

Figure 4. Distribution of workers across occupations in Europe, by workers' region of origin



Sources: LFS 2014, 2021, 19 EU countries. For each region of origin, the average share of migrants living in 19 EU countries, per occupation. Occupations (ISCO-08 1D): ISCO 9: low-skilled occupations (elementary occupations), ISCO 4-8: medium-skilled occupations (clerical workers, service and sale workers, trade workers, operators), ISCO 1-3: high-skilled occupations (managers and professionals)

For all regions of origin, as well as for natives, the share of low-skilled occupations has fallen during the period; the only exception being for North American migrants. The greatest decrease occurred for Latin Americans (29.8% in 2014 to 22.6% in 2021). This fall is mainly counter-balanced by rising shares in high-skilled occupations, by a magnitude of about 6 percentage points for Latin Americans (20.2% in 2014 to 26.2% in 2021), Asians (27.8% in 2014 to 32.7%

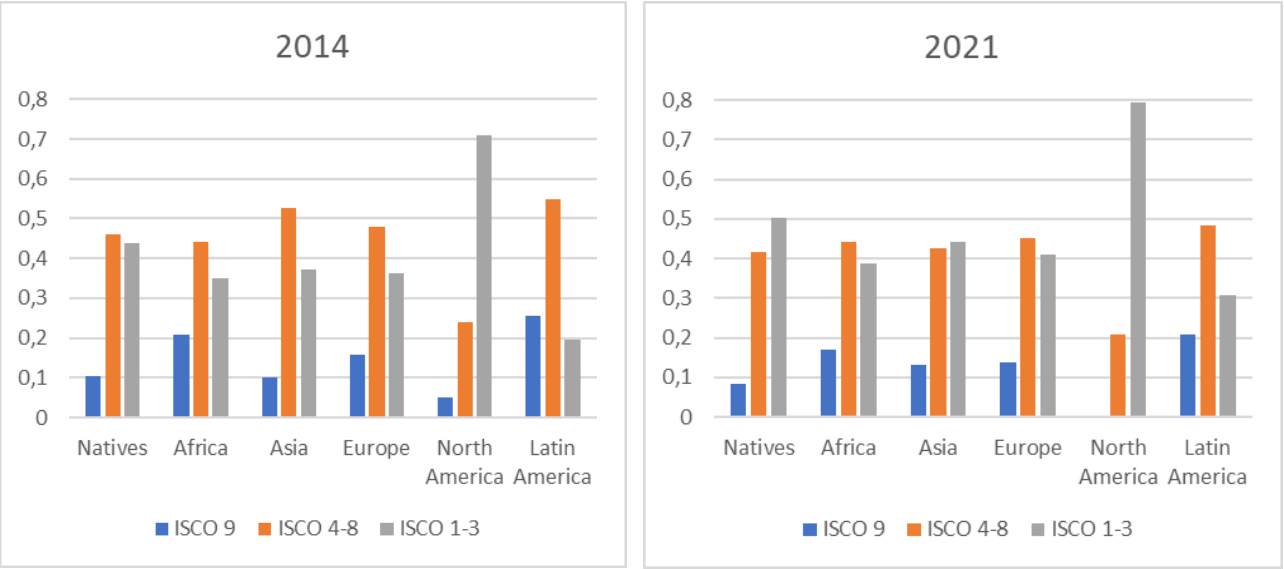
[7] The grouping of ISCO codes 1 digit to skill levels (low, medium and high skilled occupations) is done according to International Labour Organisation (2012).

in 2021), and Europeans (27.8% in 2014 to 33.6% in 2021). Consequently, the share of medium-skilled occupations remained mostly constant, except for Latin Americans (50.0% in 2014 to 51.2% in 2021), for Europeans (51.7% in 2014 to 49.9% in 2021) and for North Americans (31.8% in 2014 to 28.7% in 2021).

4.2.2. The French case

Figure 5 shows that high-skilled occupations (ISCO 1-3) are the most frequent occupations for natives and migrants from all origins in 2021. The highest share is observed for North Americans (79.3%). Medium-skilled occupations (ISCO 4-8) come second and range from 44.3% for Africans to 48.4% for Latin Americans, with the exception of North Americans with only 20.7%. Finally, low-skilled workers represent less than 15% of migrants, except for Latin Americans (20.8%) and Africans (17.1%).

Figure 5. Distribution of workers across occupations in France, by workers' region of origin



Sources: LFS 2014, 2021, France. . For each region of origin, the average share of migrants living in France, per occupation. Occupations (ISCO-08 1D): ISCO 9: low-skilled occupations (elementary occupations), ISCO 4-8: medium-skilled occupations (clerical workers, service and sale workers, trade workers, operators), ISCO 1-3: high-skilled occupations (managers and professionals)

Regarding the evolution over the period 2014-2021, the share of high-skilled occupations increased for natives and migrants from all origins. The rise is particularly marked for Latin Americans (from 19.5% in 2014 to 30.8% in 2021). As for medium skilled occupations, the share decreased for migrants from all origins but Africa, which remained stable. The most significant decreases occurred for Asians (from 52.7% in 2014 to 42.6% in 2021) and Latin Americans (from 54.8% in 2014 to 48.4% in 2021). The proportion of low-skilled occupation

decreased for migrants from all origins but Asia, for whom the proportion went from 10.1% to 13.1%. In opposite, for Europeans, the fall occurred between 2014 and 2019 (respectively 15.8% and 12.9%), with a rise up to 13.7% in 2021. The proportion of low-skilled occupation decreases for migrants from all other regions and reaches zero for North Americans.

4.2.3. The German case

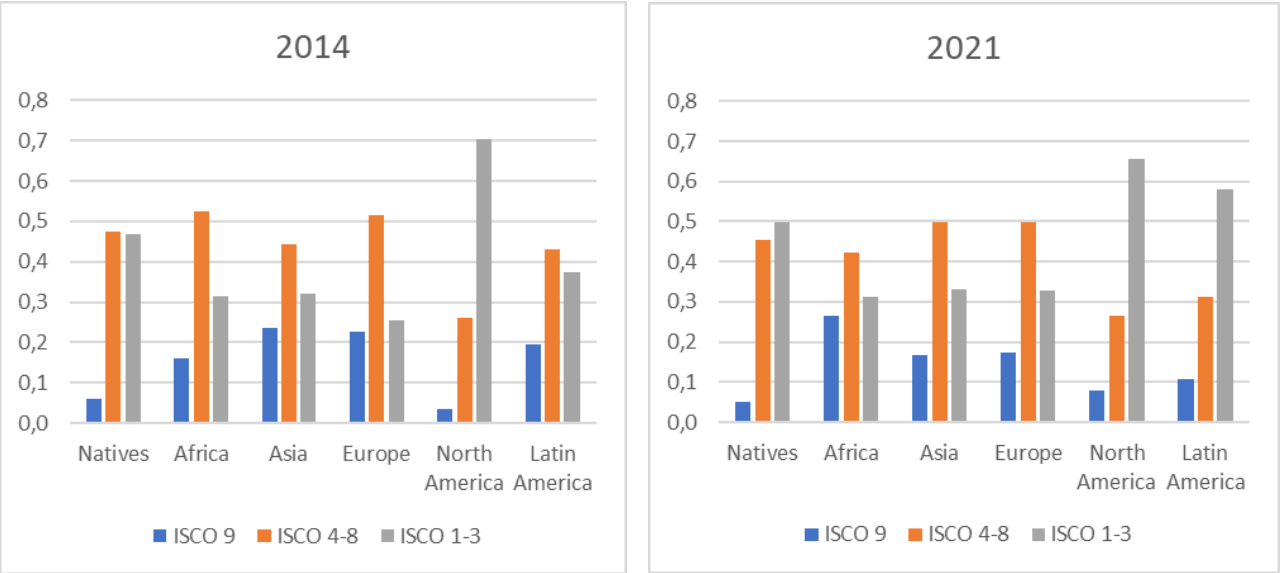
Figure 6 illustrates the German case. In 2014, North Americans have the highest percentage of workers in the high skill level (ISCO 1-3), at 70%, while the Africans group has the lowest percentage in this skill level, at 31%.

Asian, European and Latin American migrants have the highest percentage of workers in low-skill jobs, at 24%, 23% and 20% respectively. North Americans and Natives have the lowest participation in this skill level, at 4% and 6%.

Europeans have the highest percentage of workers in the ISCO 4-8 skill level, at 52%, while North Americans have the lowest percentage in this skill level, at 26%.

The natives group has the most evenly distributed percentage of workers across intermediate and high skill levels, with 47% in ISCO 4-8, and 47% in ISCO 1-3.

Figure 6. Distribution of workers across occupations in Germany, by workers' region of origin



Sources: LFS 2014, 2021, Germany. For each region of origin, the average share of migrants living in Germany, per occupation. Occupations (ISCO-08 1D): ISCO 9: low-skilled occupations (elementary occupations), ISCO 4-8: medium-skilled occupations (clerical workers, service and sale workers, trade workers, operators), ISCO 1-3: high-skilled occupations (managers and professionals)

These distributions are rather stable over the time period considered. It is notable that the African group has the most dramatic evolution with an increase in the ISCO 9 skill level and a decrease in ISCO 4-8 level, which may suggest a shift in the educational and training policies of the country. It is also notable that the North American group has the least change in all the skill levels. For Africans, there has been an increase of 11 percentage points in the share of workers in the ISCO 9 skill level, whereas the share of African workers in ISCO 4-8 skill level decreased by 10 percentage points.

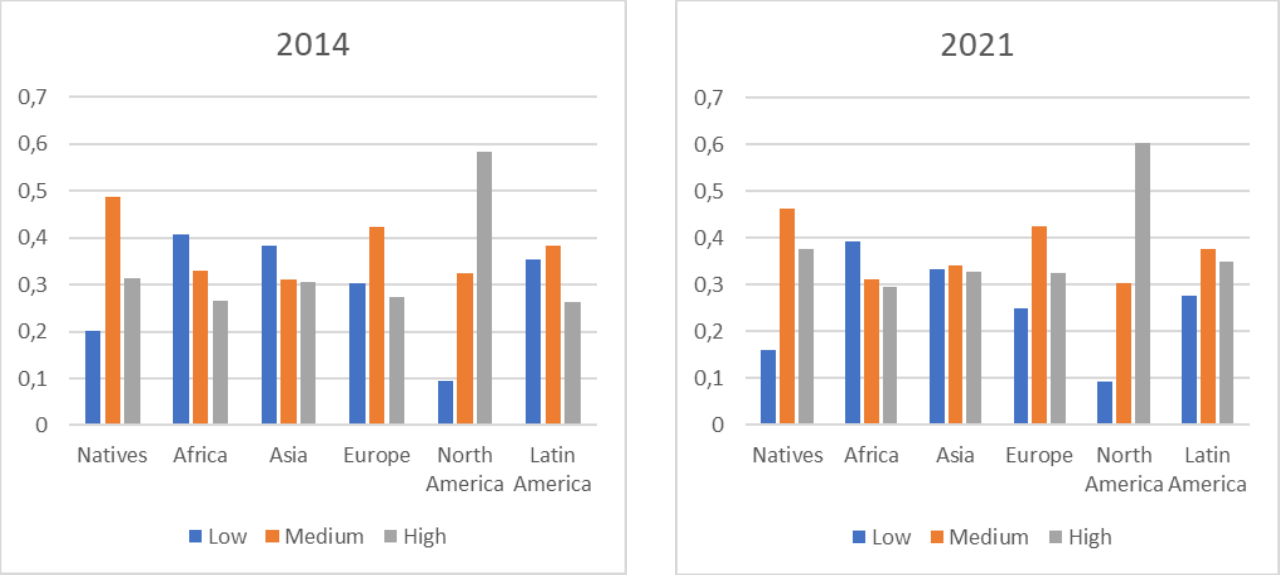
For Asians, the opposite phenomenon is observed, with a smaller magnitude: there has been a decrease of 7% in the number of workers in the ISCO 9 skill level and an increase of 6% in the number of workers in the ISCO 4-8 skill level.

4.3. Distribution of natives and migrants across education groups

4.3.1. The European case

Figure 7 show that in Europe in 2021, about two thirds of migrants coming from all emerging and developing countries do not have a higher education degree (70.4% for Africans in 2021), which is slightly more than natives (62.3%).

Figure 7. Distribution of workers' education levels in Europe, by workers' region of origin



Sources: LFS 2014, 2021, 19 EU countries. For each region of origin, share of migrants living in the 19 EU countries, by level of education. Education level (ISCED): Low: Lower secondary, Medium: Upper secondary; High: Third level

Only 39.7% of North Americans working in Europe do not have a higher education degree. Almost 40% of Africans have a low level of education, while the modal education level of

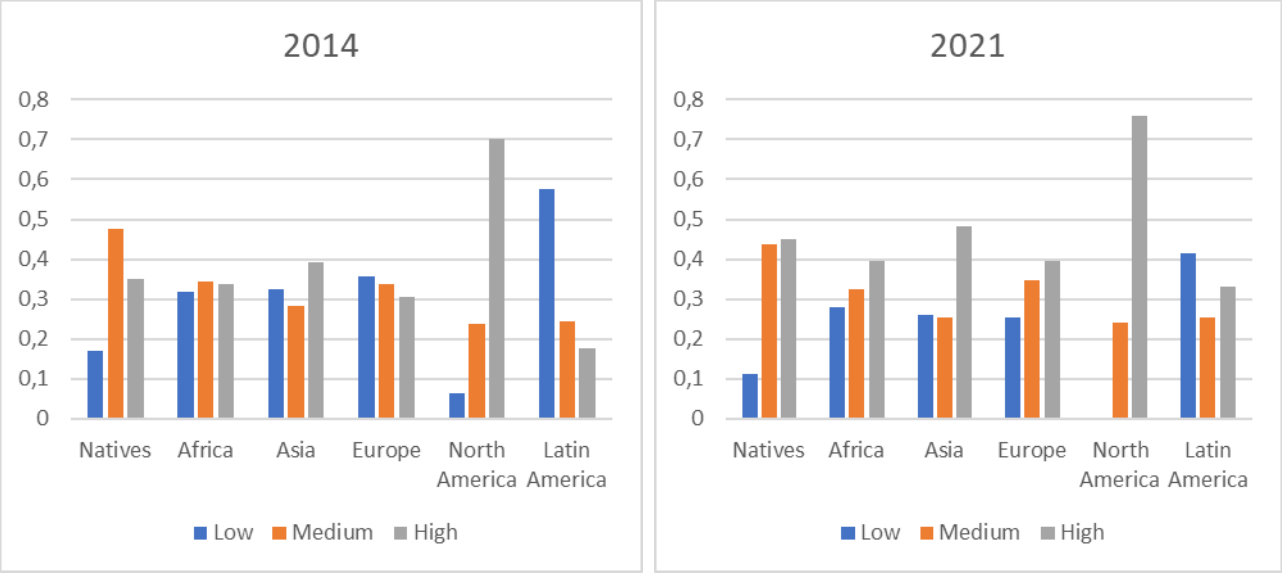
migrants from all other origins is medium, apart from North Americans who mostly have a university diploma (60.3%). Among Asian migrants, the three education levels are nearly equally distributed (a third each).

In terms of evolution over the period 2014-2021, the share of highly educated individuals rose for all origins. The highest growth occurred for Latin Americans (26.2% to 34.8%). For Europeans and Asians, this rise was compensated by an equivalent fall in the proportion of low educated: from 30.3% in 2014 down to 25.0 in 2021. The drop in low educated is also significant for Latin Americans (35.4% in 2014 and 27.6% in 2021). For migrants from other origins, the share of medium and low educated both decreased. The only exception are North American migrants for which only the share of medium educated fell (32.3% in 2014 and 30.3% in 2021).

4.3.2. The French case

In 2021, most workers have a high level of education, independently of their origin (see Figure 8). Latin Americans are the only exception, as they predominantly have low education (41.5% in 2021). We find the highest share of highly educated workers among North Americans (75.8%) and the lowest share among Africans (39.5%) and Latin Americans (32.9%). A fourth of Asians and of American migrants have medium education.

Figure 8. Distribution of workers' education levels in France, by workers' region of origin



Sources: LFS 2014, 2021, France. For each region of origin, share of migrants living in France, by level of education. Education level (ISCED): Low: Lower secondary, Medium: Upper secondary; High: Third level

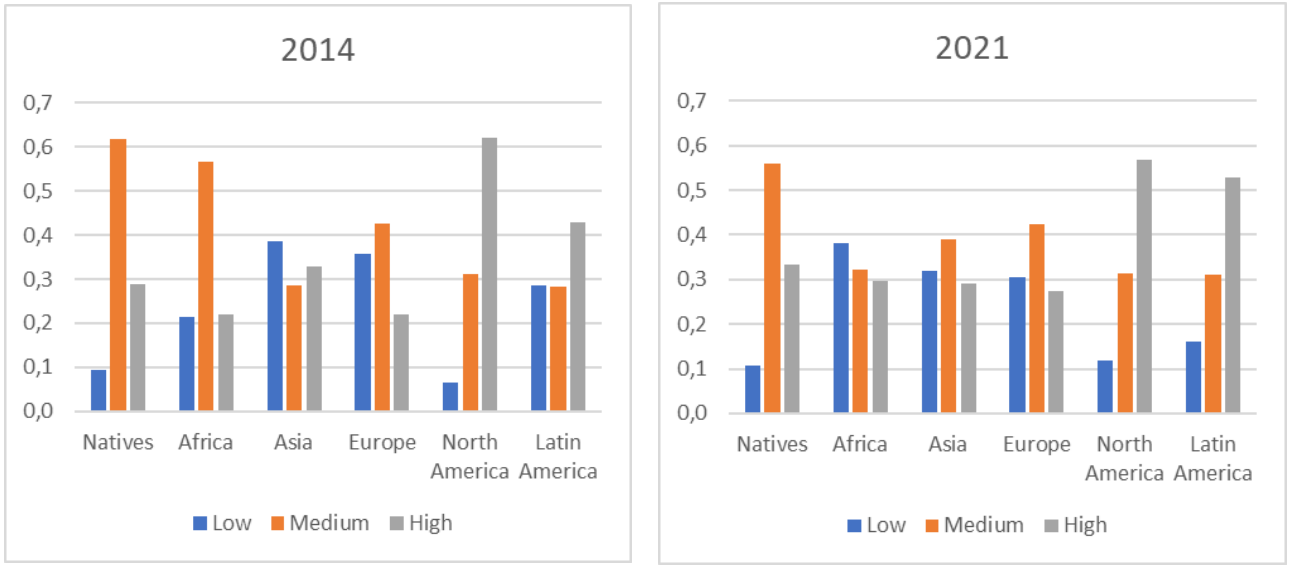
Over the period 2014-2021, the share of high educated rose for natives and all migrants, with the highest rise for Latin Americans (+15.2 percentage points), Natives (+10 percentage

points) and Asians and Europeans (+9 percentage points). For most regions of origin, this evolution is mostly compensated by a fall in the share of low educated individuals.

4.3.3. The German case

Figure 9 shows that for 2021, the regions of origin with the highest percentage of individuals with low education are Africa (38.0%) and Asia (31.9%), while the regions with the highest percentage are North America (56.9%) and Latin America (53.0%). The percentage of workers with medium education is the highest for natives (56.0%) and the lowest for North America (31.3%). The regions of origin with the highest representation of low educated workers are Africa (38.0%) and Asia (31.9%). Natives have a lower representation of workers with low education at 10.6%.

Figure 9. Distribution of workers' education levels in Germany, by workers' region of origin



Sources: LFS 2014, 2021, Germany. For each region of origin, share of migrants living in Germany, by level of education. Education level (ISCED): Low: Lower secondary, Medium: Upper secondary; High: Third level

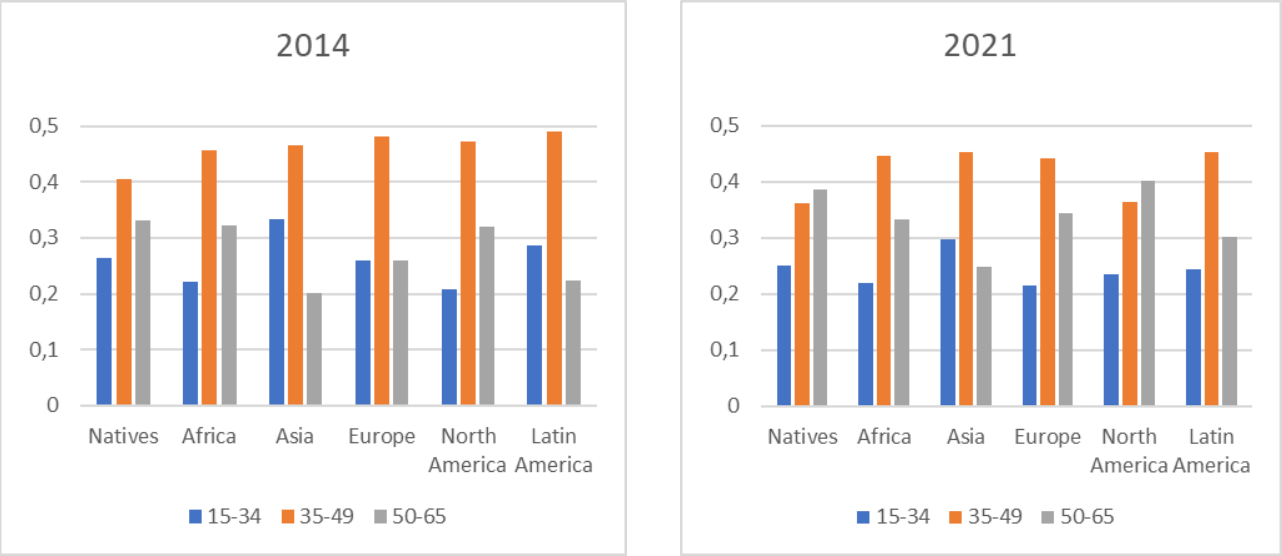
Overall, between 2014 and 2021 there was a shift towards higher education levels for workers in Germany, regardless of their region of origin, except for Latin Americans. Conversely, the percentage of workers with low education decreased for all regions between 2014 and 2021, except for Africans, for whom this share increased from 21.4% in 2014 to 38.0% in 2021.

4.4. Distribution of natives and migrants across age groups

4.4.1. The European case

As observed in Figure 10 , except for Asians, more than three quarters of workers are below 50 years. In 2021, for all populations except North Americans, the highest share is among medium-aged workers (35-49 years), between 40% and 50%. Older workers (50-64 years) represent about 39% of natives and 40% of North Americans, a third of African and European migrants, but only 30% and 25% of Latin Americans and Asian migrants, respectively. Overall, Asian migrants appear to be the youngest group on average.

Figure 10. Distribution of workers' age in Europe, by workers' region of origin



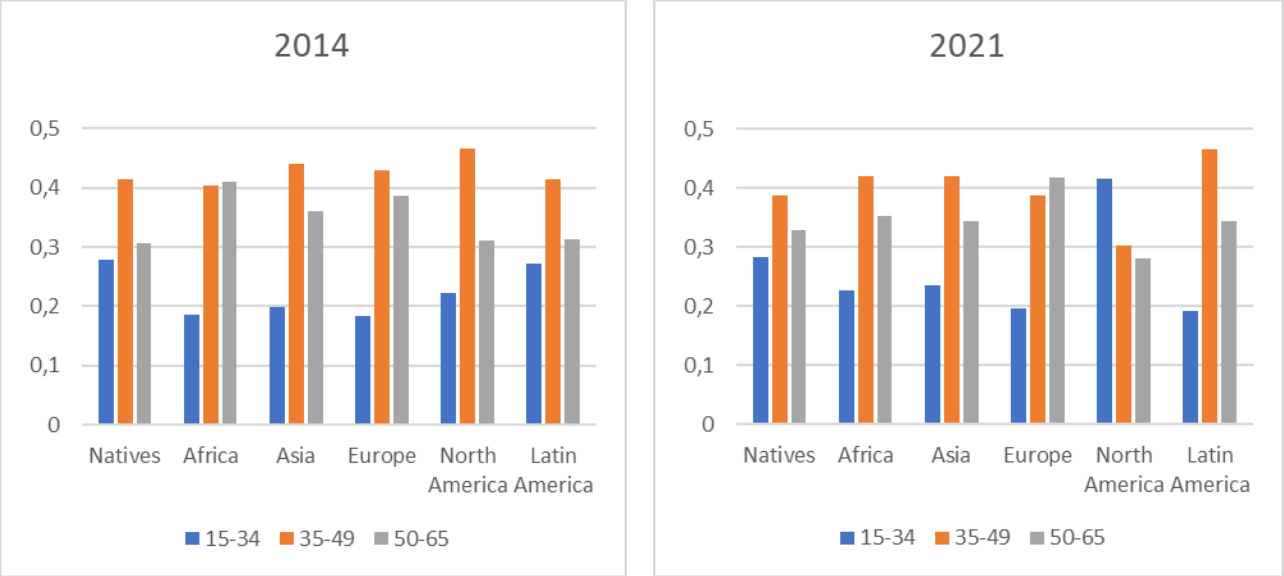
Sources: LFS 2014, 2021, 19 EU countries. For each region of origin, share of migrants living in the 19 EU countries, by age. Age: younger workers: 25-34 years, mature workers: 35-49 years, older workers: 50-65 years

Between 2014 and 2021, the proportion of workers above 50 increased for natives as well as all migrant groups. The highest fall of workers between 35 and 49 years of age occurred for North American migrants (from 47.2% in 2014 to 36.3% in 2021). The proportion of young workers fell for natives and most migrants, except for Africans for whom it remained constant (22.1% in 2021) and for North Americans for whom it increased (20.8% in 2014 and 24.5% in 2021). The highest fall among young workers occurred for Latin Americans (28.7% in 2014 and 24.4% in 2021).

4.4.2. The French case

In France, in 2021 (Figure 11), 80% of Europeans and Latin Americans, 77% of Africans and Asians, 72% of natives and 58% of North Americans are less than 50 years old. For natives and all regions of origin except Europeans and North Americans, medium-aged workers compose the main group, with the greatest proportion for Latin Americans (46.5% in 2021). Europeans have the highest share of seniors (41.8% in 2021), North Americans have the highest share of young workers (41.6% in 2021).

Figure 11. Distribution of workers' age in France, by workers' region of origin



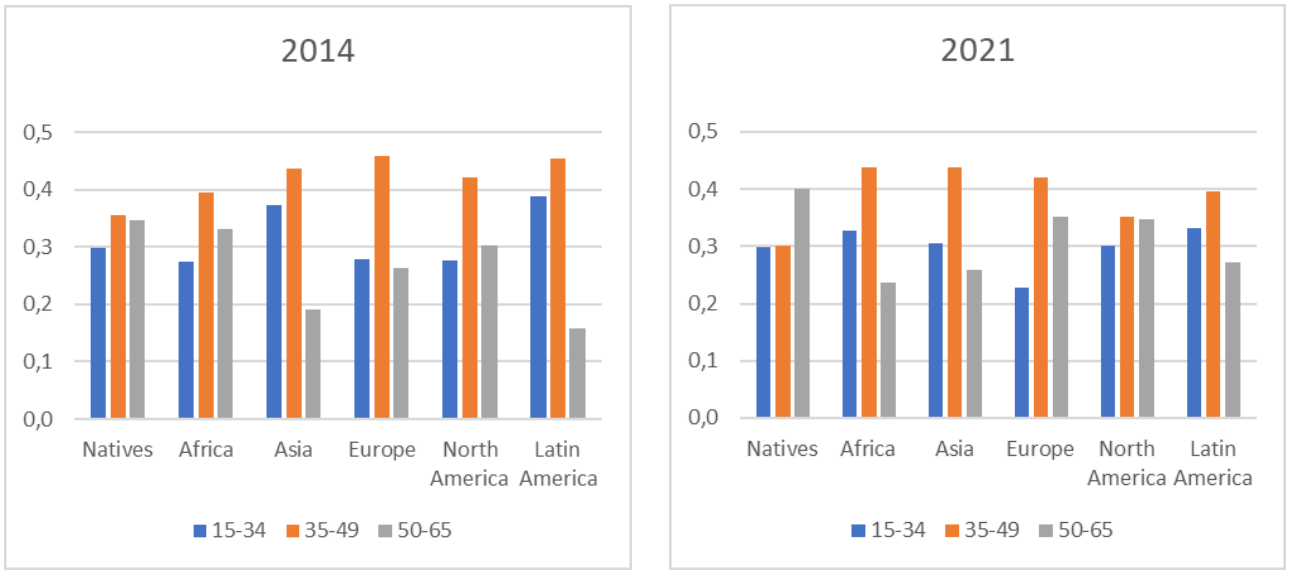
Sources: LFS 2014, 2021, France. For each region of origin, share of migrants living in France. Age: younger workers: 25-34 years, mature workers: 35-49 years, older workers: 50-65 years

Between 2014 and 2021, the share of young workers increased among natives and all migrant populations, except for Latin Americans (27.3% in 2014 and 19.1% in 2031). The highest rise in the proportion of young workers occurred for North Americans (33.4% in 2014 and 41.6% in 2021, mainly in the last two years). The proportion of medium-aged workers decreased among migrants from Asia, Europe and North America (46.6% in 2014 and 30.3% in 2021). Meanwhile, the share of medium-aged workers increased for Africans and Latin Americans (41.4% in 2014 and 46.5% in 2021). The proportion of senior workers fell for Africans, Asians and North Americans (32.0% in 2014 and 28.1% in 2021), as it rose for natives, Latin Americans and Europeans (38.7% in 2014 and 41.7% in 2021).

4.4.3. The German case

In Germany (Figure 12), more than two thirds of immigrants are below 50 years, and this proportion reaches 77% for European immigrants in 2021. Medium-aged workers represent the main group for all regions of origin. Latin American and African migrants show the highest proportion of young workers (33.3% and 32.6% respectively). Asians have the highest share of medium-aged workers (43.6%). Migrants originating from Europe and North America have the highest share of older workers (35.1% and 34.8%, respectively), but natives have the highest share of older workers (40%).

Figure 12. Distribution of workers' age in Germany, by workers' region of origin



Sources: LFS 2014, 2021, Germany. For each region of origin, share of migrants living in Germany, by age. Age: younger workers: 25-34 years, mature workers: 35-49 years, older workers: 50-65 years

Between 2014 and 2021, the share of young migrants rose for African immigrants (from 27.1% in 2014 to 32.6% in 2021) and North Americans (from 27.6% in 2014 to 30.1% in 2021), while the share of older workers among Africans and North Americans decreased by about 7 percentage points. The shares of both young and middle-aged workers decreased among immigrants from Asia, Europe and Latin America. There was a marked decrease in the share of mature workers among North American immigrants (from 42.2% in 2014 to 35.1% in 2021). Conversely, the highest rise in the share of older workers happened for Europeans (from 26.3% in 2014 to 35.1% in 2021).

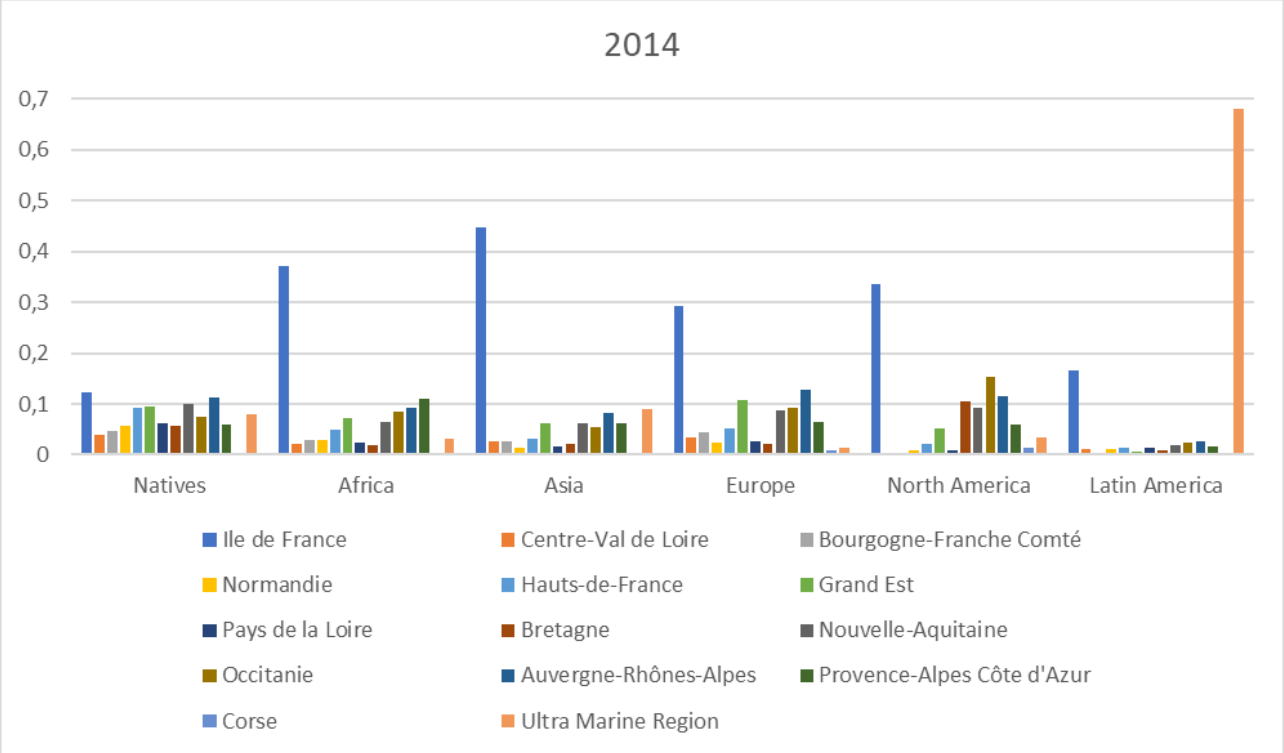
4.5. Distribution of natives and migrants across regions

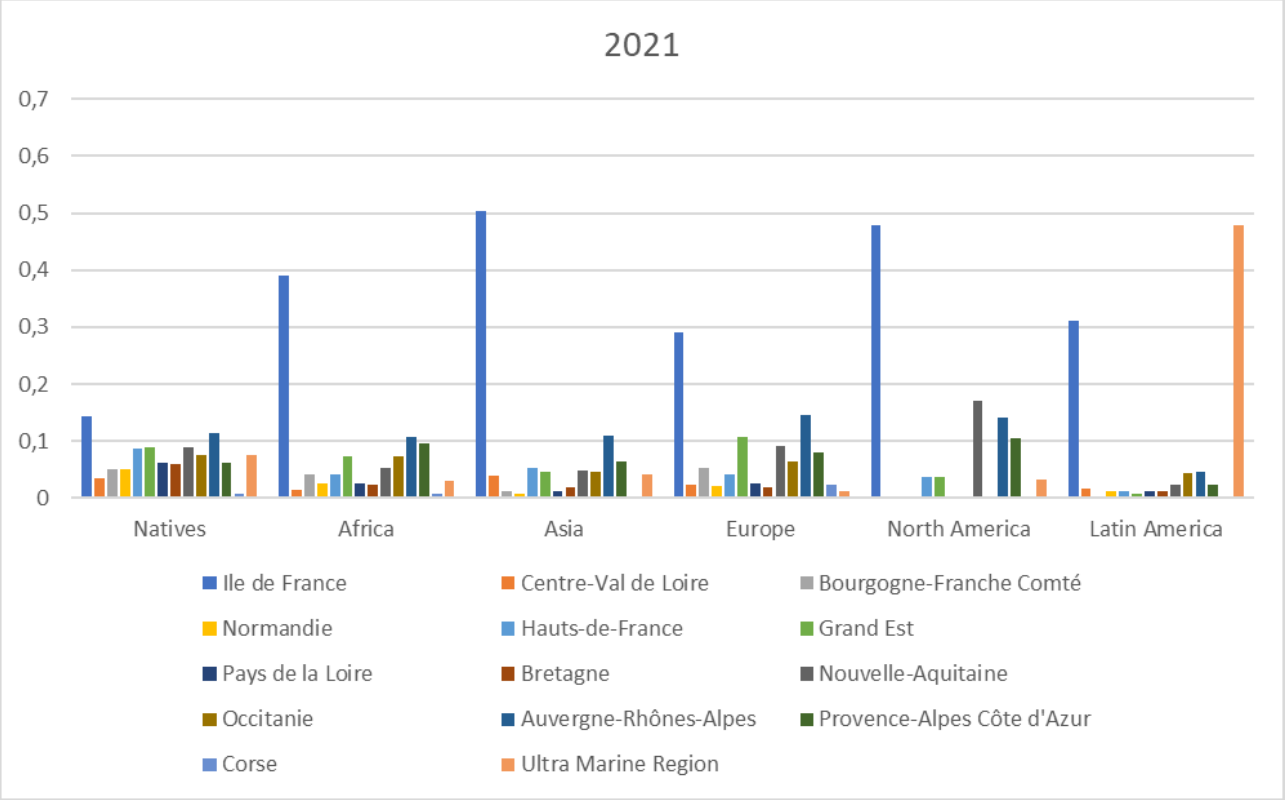
Due to the large number of regions among the 19 European countries studied, we focus the analysis of the geographical distribution of natives and migrants across regions only for the French and German cases. As the number of regions varies across the two countries, we also focus on these two countries' the top regions in terms of employment.

4.5.1. The French case

In France in 2021, Figure 13 shows that natives are more equally distributed across regions than migrants.

Figure 13. Geographical distribution of workers in France, by region of origin





Sources: LFS 2014, 2021, France. For each region of origin, the distribution of migrants, by French region of residency. Regions: NUTS 1

Nevertheless, the region including Paris (Ile de France), which is the most populated area, is the largest employer for natives (14.4%) and all migrants except for Latin Americans. Half of Latin Americans (47.8%) are indeed employed in the 'ultra-marine regions' located in the Caribbean.[8] The Ile de France attracts half of Asian migrants and of North Americans. The second top employer is the Auvergne-Rhône-Alpes region for natives, and migrants from all origins (11% to 14%), with the exception of Latin Americans. European migrants are well represented in the Grand Est region, which shares borders with Germany, Luxembourg and Belgium (10.7%). Africans and North Americans are in second instance located in Provence Alpes Côte d'Azur (9.6% and 10.5%, respectively). This pattern changed little over the period 2014-2021.

4.5.2. The German case

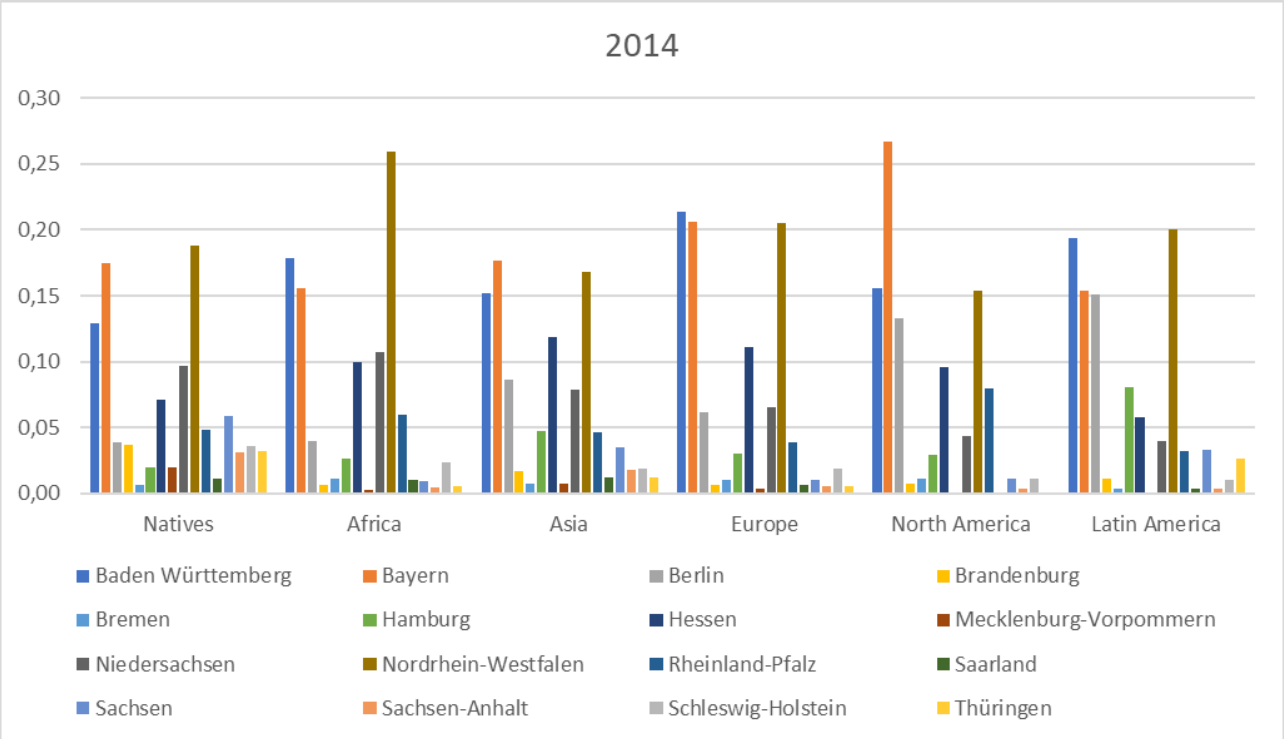
In Germany in 2021, we observe in Figure 14 that the situation is less polarised than the French one. Unlike in France, there is not one key region attracting most workers. Nordrhein-Westfalen employs the largest shares of workers, which corresponds to 20% of natives and a fourth of Africans, Asians, and Europeans. This region is the most populous German land and is including

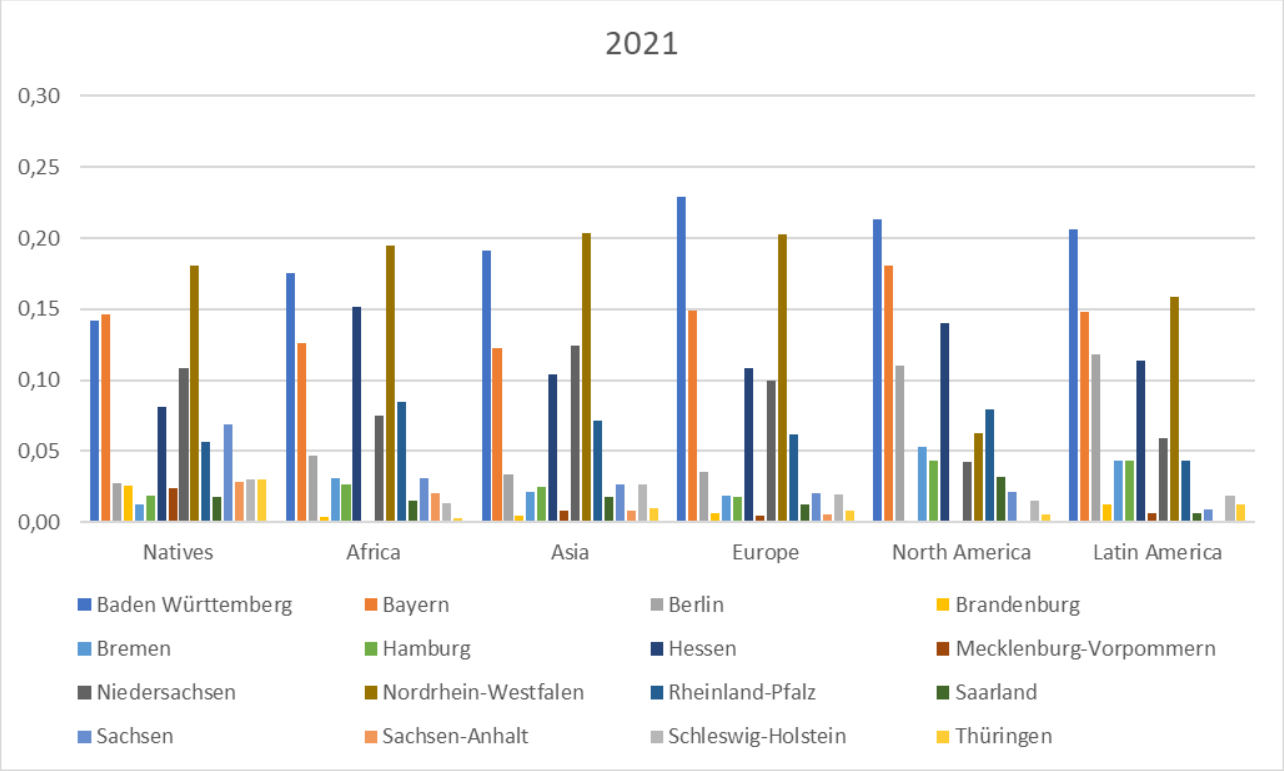
[8] In order to verify whether the particularity of 'ultra-marine regions' has an impact on the analyses of under-/over-supplied occupations, we will check the results when they are removed from the sample.

the large cities of Koln, Bonn, Düsseldorf, Dortmund and Essen. North Americans are more likely to work in Bayern (23.8%) and South Americans in Baden-Württemberg, which is covering the large cities of Stuttgart, Mannheim and Karlsruhe (20.1%).

Over the period 2014-2021, the share of Asians working in Bayern decreased from 17.7% to 12.2%, while the share of Asians in Baden-Württemberg increased (15.2% in 2014 and 19.1% in 2021). North Americans increased their presence in Baden-Württemberg (from 15.6% in 2014 to 21.3% in 2021) to the detriment of Bayern (from 26.7% in 2014 to 18.0% in 2021). The share of Latin Americans working in Nordrhein-Westfalen decreased from 20.1% in 2014 to 15.9% in 2021.

Figure 14. Geographical distribution of workers in Germany, by region of origin





Sources: LFS 2014, 2021, Germany. For each region of origin, the distribution of migrants, by German region of residency. Regions: NUTS 1

4.6. Under-/over-supplied occupations

Based on the ISCO 3 digits, we computed on LFS data the ratio proposed by Mcgrath (2019) to measure which occupations are in shortage (under-supplied) and which ones are in surplus (over-supplied, see Data and Method for more details) in France and Germany. They are reported in the tables below. First, we present the occupations that are under-supplied (or in shortage) and over-supplied (or in surplus) on the labour market. For the shortage occupations, we show the occupations when the Mcgrath ratio is above 1. For the over-supplied occupations we report only the top 5 with the lowest ratio.

4.6.1. The French case

The French labour market has a limited number of under-supplied occupations in 2019 and 2021, with four in high-skilled occupations, two in medium-skilled occupations and none in low-skilled occupations (see the two tables below). The occupations in shortage did not remain the same over time except for the occupation of Veterinarians (ISCO 225) but with a ratio that decreased from 3 to 1.

We observe that the majority of over-supplied occupations differ between 2019 and 2021, with the exceptions being Legislators and Senior Officials (ISCO 111) and Domestic, Hotel and Office

Cleaners and Helpers (ISCO 911) which remained over-supplied in both years. We also observe that some occupations, like vehicle, window, laundry and other hand cleaning workers (ISCO 912) go from being under-supplied in 2019 to being oversupplied in 2021 reveals that the shortage was cyclical and not structural.

Table 1. Under-supplied and oversupplied occupations in 2019 in France

ISCO 1-3 - High-skilled	Ratio	ISCO 4-8 - Medium-skilled	Ratio	ISCO 9 - Low-skilled	Ratio
Under-supplied occupations					
225 - Veterinarians	3	811 - Mining and Mineral Processing Plant Operators	2.3	912 - Vehicle, Window, Laundry and Other Hand Cleaning Workers	1.8
131 - Production Managers in Agriculture, Forestry and Fisheries	2.3	613 - Mixed Crop and Animal Producers	1.1		
252 - Database and Network Professionals	1.6				
223 - Traditional and Complementary Medicine Professionals	1.1				
Over-supplied occupations					
111 - Legislators and Senior Officials	0.2	515 - Building and Housekeeping Supervisors	0.2	933 - Transport and Storage Labourers	0.3
233 - Secondary Education Teachers	0.1	814 - Rubber, Plastic and Paper Products Machine Operators	0.2	962 - Other Elementary Workers	0.3
312 - Mining, Manufacturing and Construction Supervisors	0.1	742 - Electronics and Telecommunications Installers and Repairers	0.2	911 - Domestic, Hotel and Office Cleaners and Helpers	0.2
231 - University and Higher Education Teachers	0.1	815 - Textile, Fur and Leather Products Machine Operators	0.2	952 - Street Vendors (excluding Food)	0.1
234 - Primary School and Early Childhood Teachers	0.1	732 - Printing Trades Workers	0.1	932 - Manufacturing Labourers	0.1

Sources: LFS 2019. France. ISCO codes are ISCO-08 codes. The ratios are computed using Mcgrath (2019) on LFS as described in the method. A ratio is reported when there is at least one observation in new recruited or unemployed individuals in LFS. A ratio above 1 indicates that the occupation is in shortage or under-supplied. A ratio below 1 indicates that the occupation is in surplus or over-supplied

Table 2. Under-supplied and over-supplied occupations in 2021 in France

ISCO 1-3 - High-skilled	Ratio	ISCO 4-8 - Medium-skilled	Ratio	ISCO 9 - Low-skilled	Ratio
Under-supplied occupations					
212 - Mathematicians, Actuaries and Statisticians	1.7	835 - Ships' Deck Crews and Related Workers	1.6	-	
261 - Legal Professionals	1.4	742 - Electronics and Telecommunications Installers and Repairers	1.3		
226 - Other Health Professionals	1.2				
225 - Veterinarians	1.0				
Over-supplied occupations					
311 - Physical and Engineering Science Technicians	0.2	812 - Metal Processing and Finishing Plant Operators	0.1	931 - Mining and Construction Labourers	0.3
314 -Life Science Technicians and Related Associate Professionals	0.1	622 - Fishery Workers, Hunters and Trappers	0.1	*911 - Domestic, Hotel and Office Cleaners and Helpers*	0.3
143 - Other Services Managers	0.1	613 - Mixed Crop and Animal Producers	0.1	941 - Food Preparation Assistants	0.3
335 - Government regulatory associate professionals	0.1	831 -Locomotive Engine Drivers and Related Workers	0.1	921 - Agricultural, Forestry and Fishery Labourers	0.1
111 - Legislators and Senior Officials	0.1	511 - Travel Attendants, Conductors and Guides	0.1	912 - Vehicle, Window, Laundry and Other Hand Cleaning Workers	0.1

Sources: LFS 2021. France. ISCO codes are ISCO-08 codes. The ratios are computed using Mcgrath (2019) on LFS as described in the method. A ratio is reported when there is at least one observation in new recruited or unemployed individuals in LFS. A ratio above 1 indicates that the occupation is in shortage or under-supplied. A ratio below 1 indicates that the occupation is in surplus or over-supplied. *In italic*: occupations both in shortage or surplus in 2019 and 2021. When the 'ultra-marine regions 'are not included, one more occupation appear to be under-supplied: 315 - Ship and Aircraft Controllers and Technicians

4.6.2. The German case

In comparison to the French labour market, the German labour market has a higher number of under-supplied occupations with fifteen in 2019 and eleven in 2021, and all are high-skilled occupations.

Eight out of the eleven occupations in shortage in 2021, were in shortage in 2019. The shortage situation has worsened for some occupations. For instance, we observe that Medical Doctors (ISCO 221) have a ratio of 1.6 in 2019 that increases to 3.5 in 2021, that Database and Network Professionals (ISCO 252) have a ratio of 1.2 in 2019 that increases to 2 in 2021. On the contrary, the situation seems to improve some occupations. For instance, the Legal Professionals (ISCO 261) have a ratio of 1.3 in 2019 that decreased to 1.2 in 2021. The top first occupation in shortage in 2019 is no more in shortage in 2021, which are the Information and Communications Technology Services Managers (ISCO 133).

Table 3. Under-supplied and oversupplied occupations in 2019 in Germany

ISCO 1-3 - High-skilled	Ratio	ISCO 4-8 - Medium-skilled	Ratio	ISCO 9 - Low-skilled	Ratio
Under-supplied occupations					
133 - Information and Communications Technology Services Managers	2.0	-		-	
221 - Medical Doctors	1.6				
251 - Software and Applications Developers and Analysts	1.5				
214 - Engineering Professionals (excluding Electrotechnology)	1.3				
261 - Legal Professionals	1.3				
351 - Information and Communications Technology Operations and User Support Technicians	1.3				
241 - Finance Professionals	1.3				
242 - Administration Professionals	1.3				
231 - University and Higher Education Teachers	1.2				
252 - Database and Network Professionals	1.2				
313 - Process Control Technicians	1.1				
226 - Other Health Professionals	1.1				
243 - Sales, Marketing and Public Relations Professionals	1.1				
333 - Business Services Agents	1.1				
143 - Other Services Managers	1.1				
Over-supplied occupations					
312 - Mining, Manufacturing and Construction Supervisors	0.5	812 - Metal Processing and Finishing Plant Operators	0.3	933 - Transport and Storage Labourers	0.6
141 - Hotel and Restaurant Managers	0.5	421 - Tellers, Money Collectors and Related Clerks	0.3	941 - Food Preparation Assistants	0.5
234 - Primary School and Early Childhood Teachers	0.5	811 - Mining and Mineral Processing Plant Operators	0.2	921 - Agricultural, Forestry and Fishery Labourers	0.5
222 - Nursing and Midwifery Professionals	0.4	521 - Street and Market Salespersons	0.2	932 - Manufacturing Labourers	0.4
335 - Government regulatory associate professionals	0.3	835 - Ships' Deck Crews and Related Workers	0.1	911 - Domestic, Hotel and Office Cleaners and Helpers	0.4

Sources: LFS 2019. Germany. ISCO codes are ISCO-08 codes. The ratios are computed using Mcgrath (2019) on LFS as described in the method. A ratio is reported when there is at least one observation in new recruited or unemployed individuals in LFS. A ratio above 1 indicates that the occupation is in shortage or under-supplied. A ratio below 1 indicates that the occupation is in surplus or over-supplied

Table 4. Under-supplied and over-supplied occupations in 2021 in Germany

ISCO 1-3 - High-skilled	Ratio	ISCO 4-8 - Medium-skilled	Ratio	ISCO 9 - Low-skilled	Ratio
Under-supplied occupations					
221 - Medical Doctors	3.5	-		-	
252 - Database and Network Professionals	2.0				
242 - Administration Professionals	1.4				
251 - Software and Applications Developers and Analysts	1.3				
261 - Legal Professionals	1.2				
231 - University and Higher Education Teachers	1.2				
243 - Sales, Marketing and Public Relations Professionals	1.1				
215 - Electrotechnology Engineers	1.1				
241 - Finance Professionals	1.1				
212 - Mathematicians, Actuaries and Statisticians	1.1				
264 - Authors, Journalists and Linguists	1.0				
Over-supplied occupations					
141 - Hotel and Restaurant Managers	0.3	815 - Textile, Fur and Leather Products Machine Operators	0.2	911 - Domestic, Hotel and Office Cleaners and Helpers	0.4
265 - Creative and Performing Artists	0.3	732 - Printing Trades Workers	0.2	962 - Other Elementary Workers	0.3
262 - Librarians, Archivists and Curators	0.2	621 - Forestry and Related Workers	0.2	*921 - Agricultural, Forestry and Fishery Labourers*	0.3
315 - Ship and Aircraft Controllers and Technicians	0.2	753 - Garment and Related Trades Workers	0.1	912 - Vehicle, Window, Laundry and Other Hand Cleaning Workers	0.3
352 - Telecommunications and Broadcasting Technicians	0.1	413 - Keyboard Operators	0.1	*941 - Food Preparation Assistants*	0.2

Sources: LFS 2021. Germany. ISCO codes are ISCO-08 codes. The ratios are computed using Mcgrath (2019) on LFS as described in the method. A ratio is reported when there is at least one observation in new recruited or unemployed individuals in LFS. A ratio above 1 indicates that the occupation is in shortage or under-supplied. A ratio below 1 indicates that the occupation is in surplus or over-supplied. *In italic*: occupations both in shortage or surplus in 2019 and 2021

We observe, as in France, that the majority of over-supplied occupations differ between 2019 and 2021, with the exceptions being 141 - Hotel and Restaurant Managers (ISCO 141), Agricultural, Forestry and Fishery Labourers (ISCO 921) and Food Preparation Assistants (ISCO 941), which remained over-supplied in both years.

4.7. The role of migrant workers in addressing shortages in France and Germany

Migrant workers may play a significant role in addressing labour shortages in France and Germany. They often fill positions in industries such as agriculture, construction, and healthcare that have difficulty attracting and retaining native workers. Migrant workers also bring diversity and new skills to the workforce, which can benefit the economy as a whole. However, the integration of migrant workers into the workforce can also pose challenges, such as language barriers and discrimination.

To investigate the potential impact of migrants in addressing shortages in 2021 in the French and German labour market, we computed two more ratios. The Ratio 1 (already used above) includes all natives and migrants in the unemployed pool, providing a broad picture of the overall available job seekers in a given country. Ratio 2 specifically excludes European migrants from the unemployed pool, to provide an assessment of the role they play in a given country. Ratio 3 excludes all migrants from the unemployed pool, which can be used to specifically measure what will be the shortage situation without migrant workers. Each ratio has its own implications and can be used to gain a different perspective on the employment situation in a given country.

4.7.1. The French case

In France, the presence of migrant workers, particularly non-European workers, is crucial in addressing shortages in certain occupations. Without them, there would likely be a shortage of workers in two more occupations that are Software and Applications Developers and Analysts (ISCO 251) and Rubber, Plastic and Paper Products Machine Operators (ISCO 814).

In the first case, for Software and Applications Developers and Analysts, one reason of the shortage that will be worse without migrant workers is that this occupation require a high level of technical skill and education, and there may not be enough native graduates in France with the necessary qualifications. Additionally, the field of software and application development is constantly evolving, requiring workers to continually update their skills and knowledge. This can make it difficult for natives workers to keep up, especially if they do not have the resources or opportunities to do so. Another reason could be the competition from other countries with a more established tech industry that may attract migrant workers.

In the second case, as Rubber, Plastic and Paper Products Machine Operators occupation are physically demanding, low-paying, and require long hours, which can make them unattractive

to natives workers. Migrant workers, on the other hand, may be more willing to take on these jobs due to a lack of other employment options in their home countries.

Excluding European migrant workers from the unemployed pool for Mathematicians, Actuaries and Statisticians (ISCO 212) does not appear to have a significant consequence in terms of addressing shortages in this occupation, while excluding all migrants impact the level of the shortage ratio. This suggests that non-European migrants are playing a significant role in addressing the labour shortage faced by this occupation.

We observe the same pattern for Legal Professionals (ISCO 261), and Other Health Professionals (ISCO 226) for high-skilled occupations, Ships' Deck Crews and Related Workers (ISCO 835) and Electronics and Telecommunications Installers and Repairers (ISCO 742), for medium-skilled occupations. The shortage observed for Veterinarians (ISCO 225), is not impacted by the presence of not of migrant workers whatever their region of origin.

The shortage in Science, Technology, Engineering, and Math (STEM) occupations (ISCO 212, 225, 251) may need to be addressed through increasing domestic education in STEM fields, or attracting more skilled migrants.

Table 5. Role of migrants in under-supplied occupations in 2021 in France

ISCO 1-3 - High-skilled	Ratio all natives and migrants	Ratio no migrants from EU	Ratio no migrants	ISCO 4-8 - Medium-skilled	Ratio all natives and migrants	Ratio no migrants from EU	Ratio no migrants
212 - Mathematicians, Actuaries and Statisticians	1.7	1.7 ↔	2.2 ↗	835 - Ships' Deck Crews and Related Workers	1.6	1.6 ↔	2.0 ↗
261 - Legal Professionals	1.4	1.4 ↔	1.6 ↗	742 - Electronics and Telecommunications Installers and Repairers	1.3	1.3 ↔	1.5 ↗
226 - Other Health Professionals	1.2	1.2 ↔	1.4 ↗	814 - Rubber, Plastic and Paper Products Machine Operators	<1	<1 ↔	1.3 ↗
225 - Veterinarians	1.0	1.0 ↔	1.0 ↔				
251 - Software and Applications Developers and Analysts	<1	1.0 ↗	1.2 ↗				

Sources: LFS 2021. France. ISCO codes are ISCO-08 codes. The ratios are computed using Mcgrath (2019) on LFS as described in the method. When the 'ultra-marine regions 'are not included, some more occupations appear to be under-supplied, (i) when all natives and migrants are included: 315 - Ship and Aircraft Controllers and Technicians; (ii) when all migrants are not included: 216 - Architects, Planners, Surveyors and Designers

4.7.2. The German case

In Germany, the presence of migrant workers is crucial in addressing shortages in more occupations compared to France. Without them, there would likely be a shortage of workers in several high-skilled occupations. This can be seen by the fact that if European and non-European workers were not present, four more occupations would be in shortage (214 - Engineering Professionals (excluding Electrotechnology); 351 - Information and Communications Technology Operations and User Support Technicians; 333 - Business Services Agents; 225 - Veterinarians). Furthermore, five more occupations would be in shortage specifically with the absence of non-European migrants (213 - Life Science Professionals; 235 - Other Teaching Professionals; 226 - Other Health Professionals; 314 - Life Science Technicians and Related Associate Professionals; 334 - Administrative and Specialised Secretaries).

For occupations identified in shortage with the Ratio 1, we observe that some shortages will worsen without the non-presence of European migrants, that is the case for Database and Network Professionals (ISCO 252); Electrotechnology Engineers (ISCO 215); Mathematicians, Actuaries and Statisticians (ISCO 212). For the other eight occupations (221 - Medical Doctors; 242 - Administration Professionals; 251 - Software and Applications Developers and Analysts; 261 - Legal Professionals; 231 - University and Higher Education Teachers; 243 - Sales, Marketing and Public Relations Professionals; 241 - Finance Professionals; 264 - Authors, Journalists and Linguists), it will be the non-presence of all migrants that will be detrimental to the German economy. Indeed their presence in the workforce helps to ensure that these occupations can continue to function. The shortage observed for Mathematicians, Actuaries and Statisticians (ISCO 212), is not impacted by the presence of not of migrant workers whatever their region of origin.

Table 6. Role of migrants in under-supplied occupations in 2021 in Germany

ISCO 1-3 - High-skilled	Ratio all natives and migrants	Ratio no migrants from EU	Ratio no migrants
221 - Medical Doctors	3.5	4.5 ↗	6.2 ↗
252 - Database and Network Professionals	2.0	2.8 ↗	2.8 ↔
242 - Administration Professionals	1.4	1.5 ↗	1.7 ↗
251 - Software and Applications Developers and Analysts	1.3	1.5 ↗	1.9 ↗
261 - Legal Professionals	1.2	1.4 ↗	1.7 ↗
231 - University and Higher Education Teachers	1.2	1.4 ↗	1.7 ↗
243 - Sales, Marketing and Public Relations Professionals	1.1	1.2 ↗	1.4 ↗
215 - Electrotechnology Engineers	1.1	1.3 ↗	1.3 ↔
241 - Finance Professionals	1.1	1.1 ↔	1.2 ↗
212 - Mathematicians, Actuaries and Statisticians	1.1	1.1 ↔	1.1 ↔
264 - Authors, Journalists and Linguists	1.0	1.1 ↗	1.3 ↗
214 - Engineering Professionals (excluding Electrotechnology)	<1	1.1 ↗	1.2 ↗
351 - Information and Communications Technology Operations and User Support Technicians	<1	1.0 ↗	1.1 ↗
333 - Business Services Agents	<1	1.0 ↗	1.1 ↗
213 - Life Science Professionals	<1	<1 ↔	1.1 ↗
235 - Other Teaching Professionals	<1	<1 ↔	1.0 ↗
226 - Other Health Professionals	<1	<1 ↔	1.0 ↗
225 - Veterinarians	<1	1.2 ↗	1.5 ↗
314 - Life Science Technicians and Related Associate Professionals	<1	<1 ↔	1.0 ↗
334 - Administrative and Specialised Secretaries	<1	<1 ↔	1.0 ↗

Sources: LFS 2021. Germany. ISCO codes are ISCO-08 codes. The ratios are computed using Mcgrath (2019) on LFS as described in the method

4.8. Evolution of skill required in the top under-supplied occupations

We take the top first occupations under-supplied in 2021[9] and use online job vacancy data to identify the skills most required by employers in 2019 and 2021, the ones that disappear and the ones that appear. We distinguish skills that are stable ('stable'), those that gained popularity ('hot') or skills that did not appear in 2019 but appeared in 2021 from skills that lost popularity ('cold') or become obsolete ('obsolete').

4.8.1. The case of Mathematicians, Actuaries and Statisticians in France

On the French labour market in 2021, the most under-supplied occupation in high-skilled ones (ISCO 1-3) is Mathematicians, Actuaries and Statisticians (ISCO 212). The cosine similarity between 2019 and 2021 is high reaching 0.99.

For this occupation under-supplied on the French labour market, core skills that remain stable over time, include, not surprisingly, digital skills related to data management and analysis, with the use of artificial intelligence techniques, and skills related to report and communicate results. The compliance with standards and regulations and digital security and privacy appear also as core skills, as well as the necessity to adapt to changing situations and liaise with and support others in a multilingual environment.

Some other skills gained in popularity ('hot' in the following table and the alluvial graph), some are soft skills and concern the autonomy, enthusiasm and identification with the company's goals of employees. The capacity to be innovative (develop new products, think proactively, and identify improvement actions) gains in interest. The job also entails to analyse risk data and make predictions.

Some new skill requirements that appear ('new' in the following table) are soft skills like maintaining good relations with others (relate empathically and provide information), apply strategic thinking and make decisions. Organisation and attending events gain in popularity. The knowledge of the products/business sector appears more and more required.

Other skills have lost popularity ('cold' in the following table and the alluvial graph). They include traditional way of dealing with data (analysis and managing data, statistics) and using digital tools (information brokerage digital skills, basic digital skills) to the benefit of AI. The

[9] Because the French medium-skilled occupation in shortage suffers from being identified on a small sample (less than 20 observations), we present here both the first and the second medium-skilled occupation in shortage.

exigence in terms of master of the English language reduces. Acting reliably disappears at the profit of compliance to standards and rules and assuring digital security and privacy.

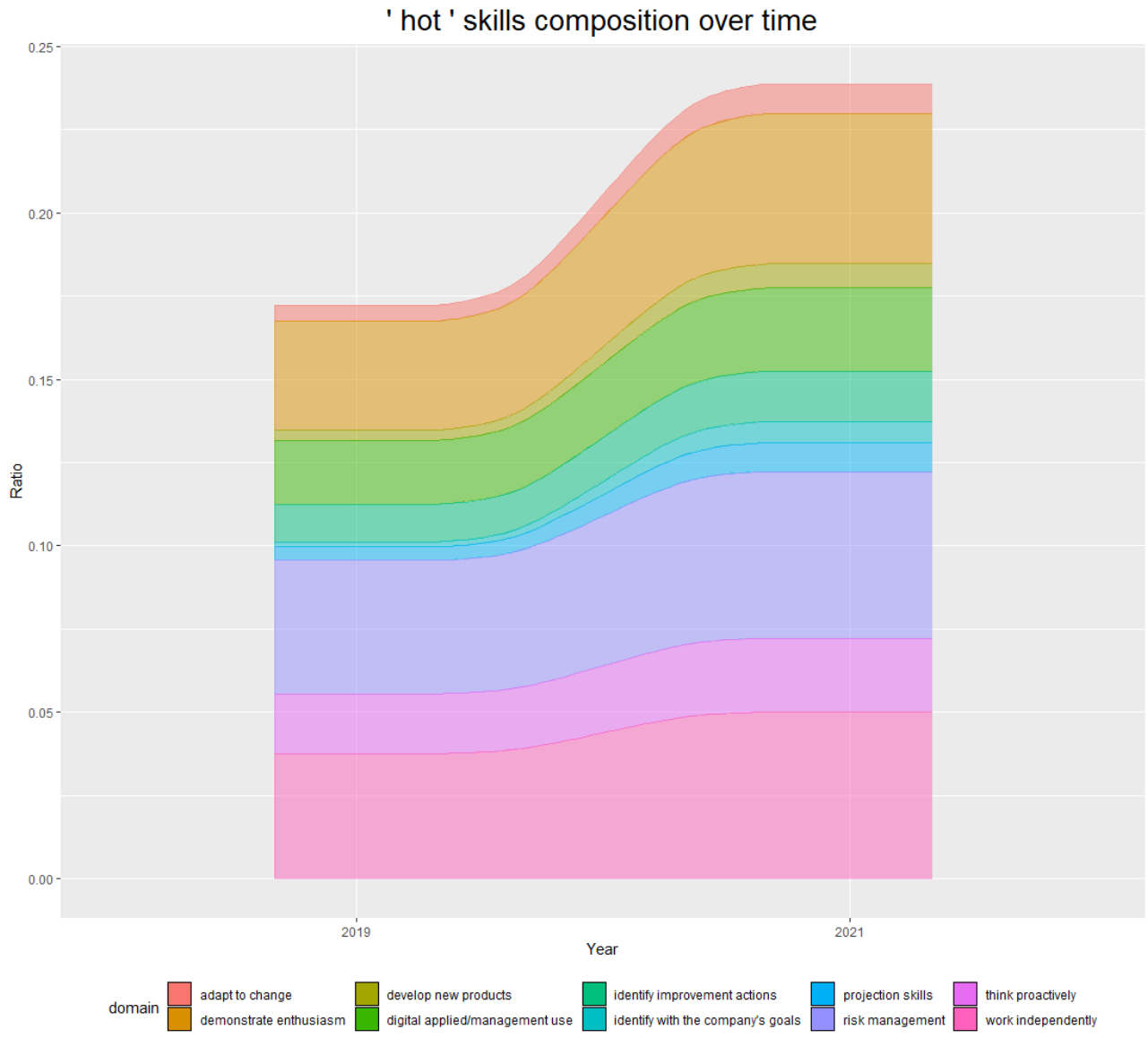
Some skills become obsolete like tolerate stress, lean project management or problem solving skills.

Table 7. Top 10 skills for the top shortage high-skilled occupation in France in 2021: Mathematicians, Actuaries and Statisticians (ISCO 212)

Stable	Hot	New	Cold	Obsolete
Compliance with standards and regulations	Demonstrate enthusiasm	Provide information	Analysis data	Tolerate stress
Artificial Intelligence	Work independently	Relate empathetically	Information brokerage digital skills	Lean project management
Liaise with others	Risk management	Attend events	Basic digital skills	Problem solving
Adapt to changing situations	Digital applied/management use	Knowledge of the products/business sector	Attention to detail	Communicate with other department
Monitor results	Identify with the company's goals	Make decisions	Statistics	
Use communication techniques	Projection skills	Adapt to different roles	English skills advanced level	
Provide technical support	Think proactively	Apply strategic thinking	Scientific research methodology	
Set up dates	Develop new products	Carry out event management	Managing data	
English skills medium level	Adapt to change		Maintain working relationships	
Digital security and privacy	Identify improvement actions		Act reliably	

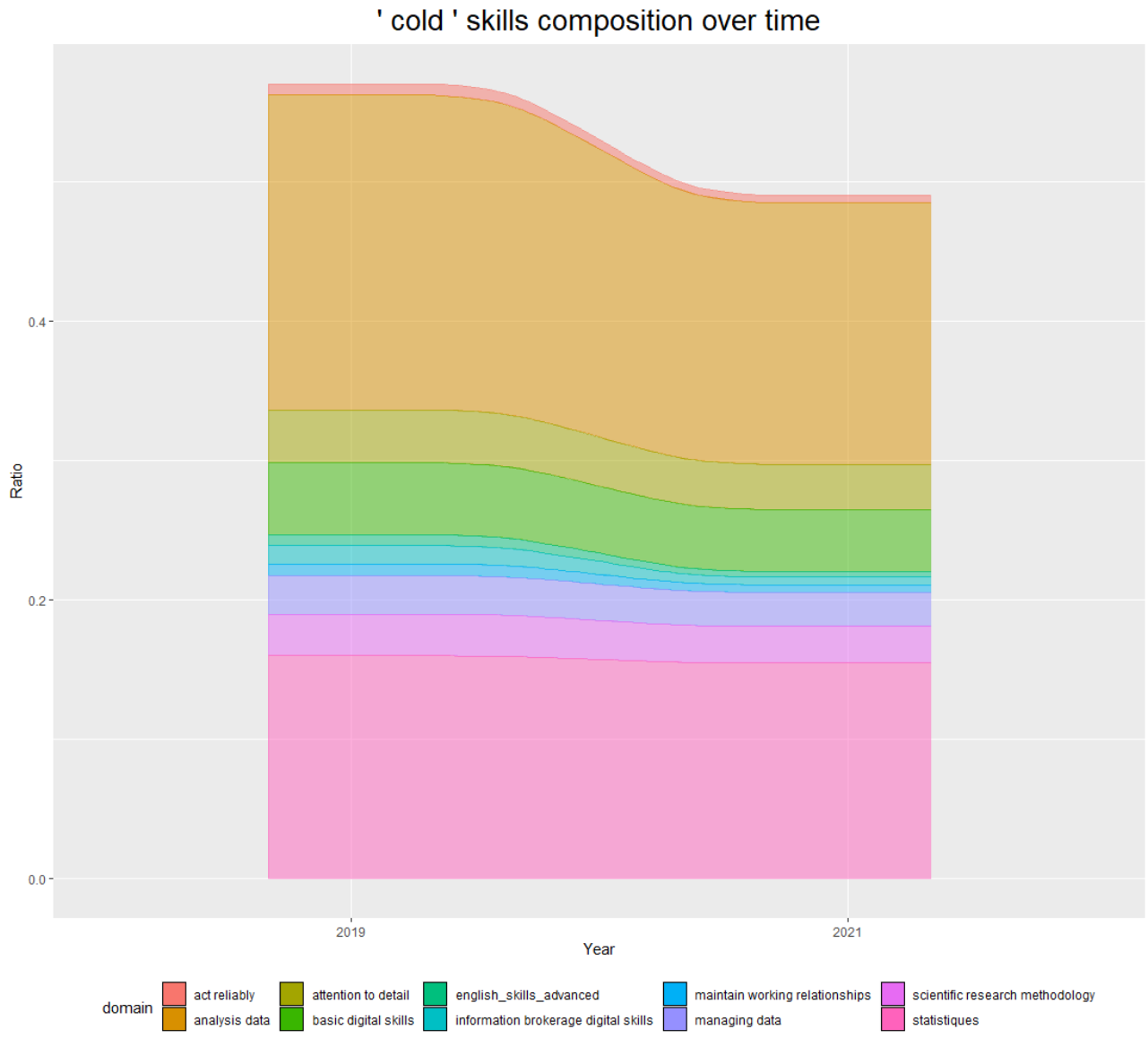
Sources: OJV data, comparison between 2019 and 2021. France

Figure 15. Top 10 ‘hot’ skills for the top shortage high-skilled occupation in France in 2021: Mathematicians, Actuaries and Statisticians (ISCO 212)



Sources: OJV data, comparison between 2019 and 2021. France

Figure 16. Top 10 'cold' skills for the top shortage high-skilled occupation in France in 2021: Mathematicians, Actuaries and Statisticians (ISCO 212)



Sources: OJV data, comparison between 2019 and 2021. France

4.8.2. The case of Ships' Deck Crews and Related Workers in France

On the French labour market of 2021, the most under-supplied occupation in medium-skilled ones (ISCO 4-8) is Ships' Deck Crews and Related Workers (ISCO 835). Based on the observation of job descriptions this occupation includes sailor, boatman, fisherman but also commando in the navy and cabin crew or stewards on cruise ships which may explain why the cosine similarity between 2019 and 2021 is low at 0.46.

For this medium-skilled occupation under-supplied on the French labour market, no skills appear to be stable.

Only two skills gained in popularity ('hot' in the following table and the alluvial graph) and are ensuring safety and teamwork.

Some new skill requirements appear ('new') like soft skills that relates to identify with the company's goals, work in an organised manner. Respecting rules and guaranteeing safety that are necessary to ensure safety gain in popularity. Manual tasks are also important in such jobs (manual dexterity, handling and moving objects, domestic services). As boats include more and more digital tools to, for instance, navigate and detect fish, and that cruise ships sell their services online, the digital skills requirement of the occupation increases (basic digital skills, digital applied/management use, information brokerage digital skills).

Some skills lost in popularity ('cold') like swimming that is implicitly required in such jobs or specific manual skills (cleaning, manoeuvring assistance, maintenance and repair).

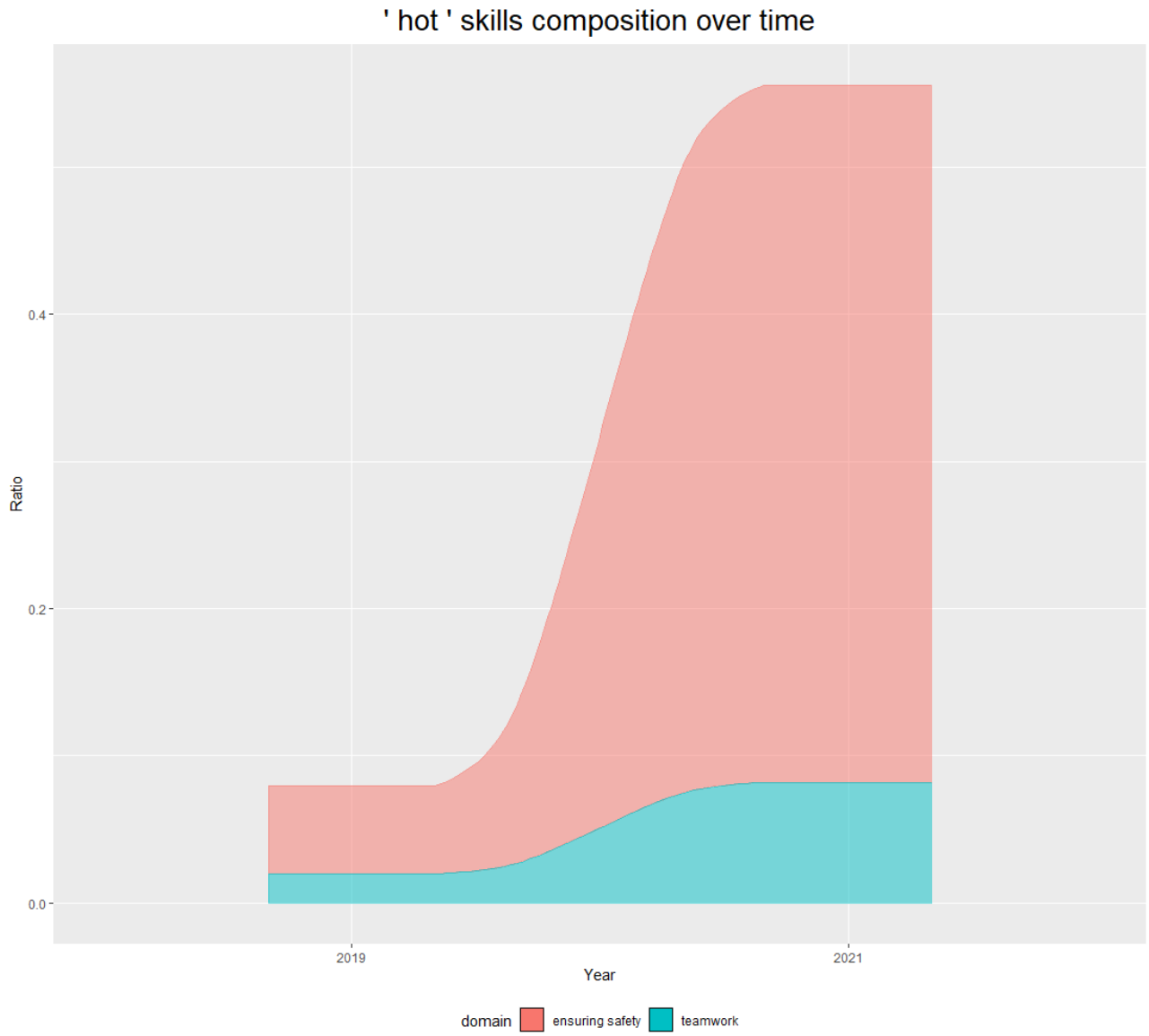
The skills that appear to become obsolete in the job descriptions relates to soft skills like manage human resources, coordinate components of the work, collaborate with others.

Table 8. Top 10 skills for the top shortage medium-skilled occupation in France in 2021: Ships' Deck Crews and Related Workers (ISCO 835)

Stable	Hot	New	Cold	Obsolete
-	Ensuring safety	Identify with the company's goals	Swimming	Coordinate components of the work
	Teamwork	Respect rules	Cleaning	Manage time
		Handling and moving	Maintenance and repair	Prioritise tasks
		Digital applied/management use	Manoeuvring assistance	Collaborate with others
		Basic digital skills	Work independently	Manage human resources
		Information brokerage digital skills	Demonstrate enthusiasm	Maintain working relationships
		Work in an organised manner		Act reliably
		Domestic services		
		Manual dexterity		
		Guaranteeing safety		

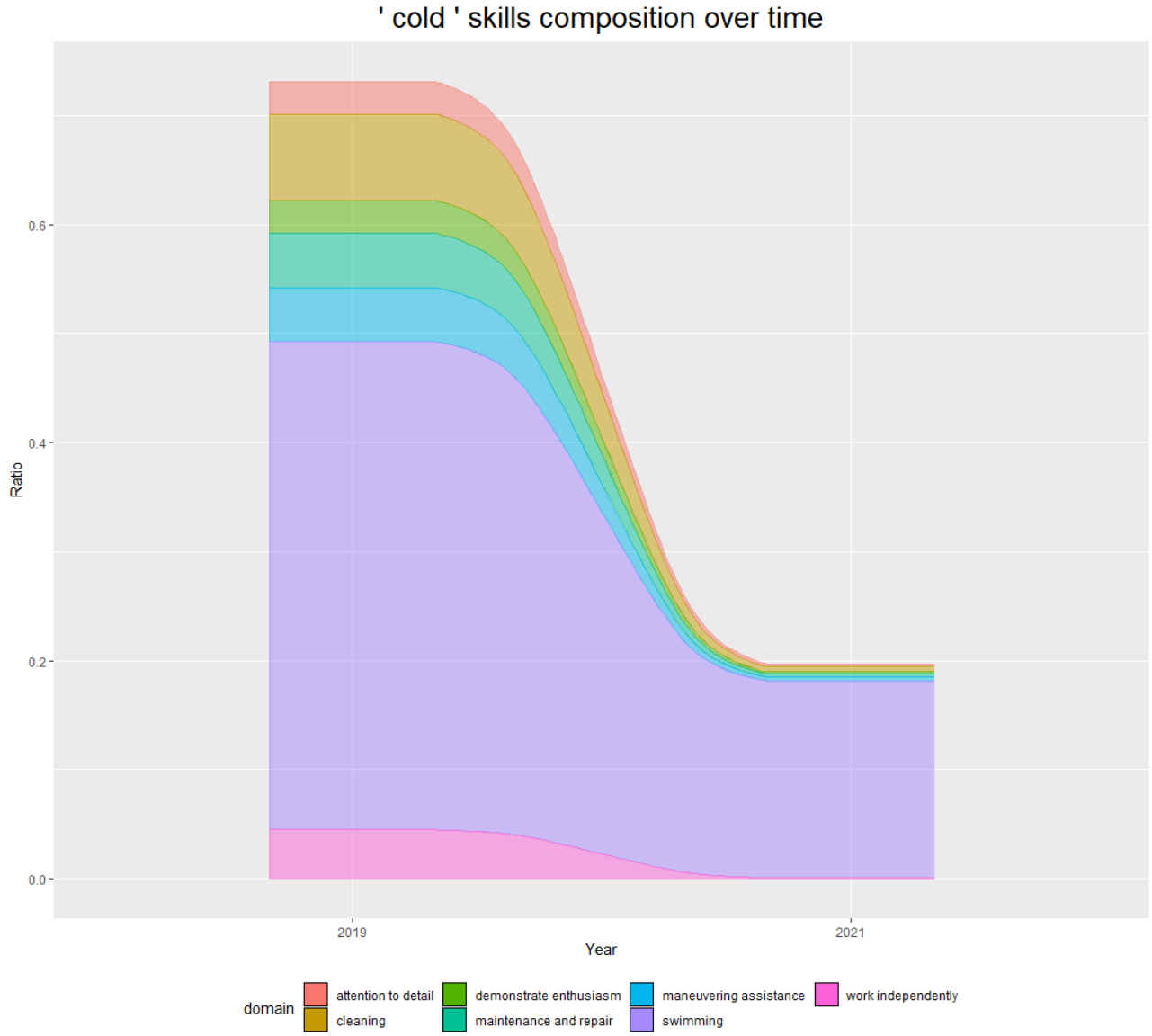
Sources: OJV data, comparison between 2019 and 2021. France

Figure 17. Top 10 ‘hot’ skills for the top shortage medium-skilled occupation in France in 2021: Ships’ Deck Crews and Related Workers (ISCO 835)



Sources: OJV data, comparison between 2019 and 2021. France

Figure 18. Top 10 'cold' skills for the top shortage medium-skilled occupation in France in 2021: Ships' Deck Crews and Related Workers (ISCO 835)



Sources: OJV data, comparison between 2019 and 2021. France

4.8.3. The case of Electronics and Telecommunications Installers and Repairers

Since the most under-supplied occupation in the 2021 French labour market in medium-skilled occupations (ISCO 4-8) is identified from a small sample of observations and becomes the second most under-supplied occupation when the overseas territories are not included, we also present here the skills demanded by employers hiring the second most under-supplied occupation (which becomes the first when the overseas territories are not included), that is Electronics and Telecommunications Installers and Repairers (ISCO 742). It mostly covers the job of electronics mechanic. The cosine similarity between 2019 and 2021 is high at 0.99.

For this medium-skilled occupation under-supplied on the French labour market, the skills that appear to be stable are mostly soft skills that relates to problem-solving, creativity and team management.

For the skills that are gaining in popularity ('hot' in the following table and the alluvial graph), some are hard skills like maintenance and repair, and most others are soft skills (like working independently, attention to detail). Certifications and habilitations are also values by employers. In addition, two digital skills experience a slight increase in demand, basic digital skills and digital applied/management use.

Table 9. Top 10 skills for the second medium-skilled occupation in shortage in France in 2021: Electronics and Telecommunications Installers and Repairers (ISCO 742)

Stable	Hot	New	Cold	Obsolete
Analyse problems for opportunities	Work independently	Make purchases	Information brokerage digital skills	Logic
Provide information	Maintenance and repair	Quality management	Analysis data	Manage personnel
Use logical reasoning	Teamwork	Manage several projects	Sector specific knowledge	Communicate with other department
Liaise with others	Attention to detail	Recruit members	Administrative management	
Develop creative ideas	Travelling	Hire human resources	Vocational techniques	
Be attentive	Operating systems	Organise labour	Production and manufacturing	
Digital security and privacy	Demonstrate enthusiasm	Contact customers	Assembly of equipment	
Team management	Basic digital skills	Personnel administration	Act reliably	
Team leader	Digital applied/ management use	Attend meetings	Think proactively	
Tolerate stress	Certifications and habilitations	Apply risk management processes	Manage human resources	
	Maintain trusts	Attend events	Proactivity	

Sources: OJV data, comparison between 2019 and 2021. France

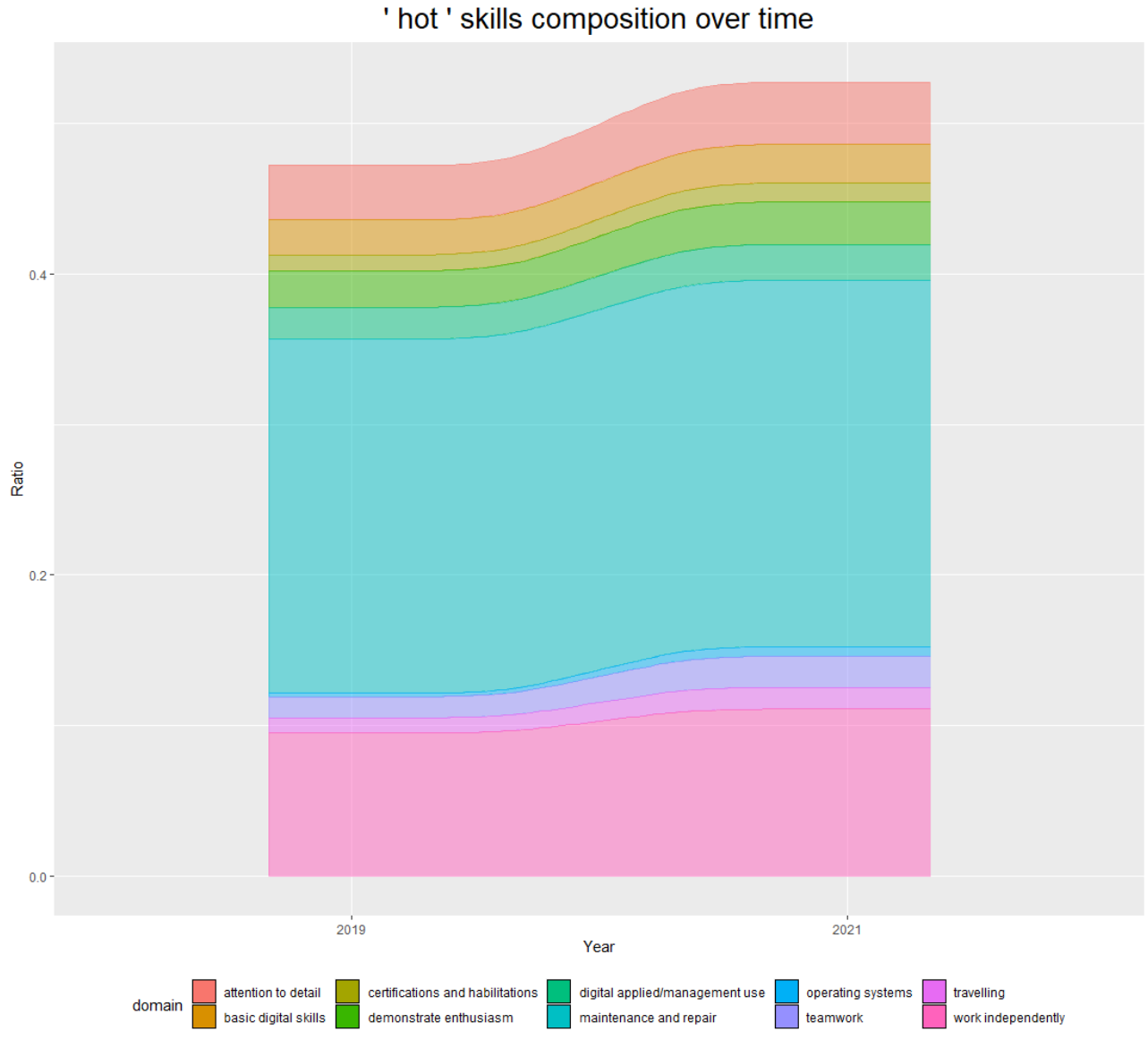
Some new skills appear ('new'), such as technical skills (hard skills) which consist in making purchases and managing quality, most of the others being non-technical skills (soft skills), such as hiring human resources, managing several projects.

Most of the declining ('cold') skills are experiencing a slight decline. Especially a digital skill (digital skills in information brokering) and analysing data experienced a decline. This may be

due to the fact that the position in a team of newly hired individuals may have changed between 2019 and 2021.

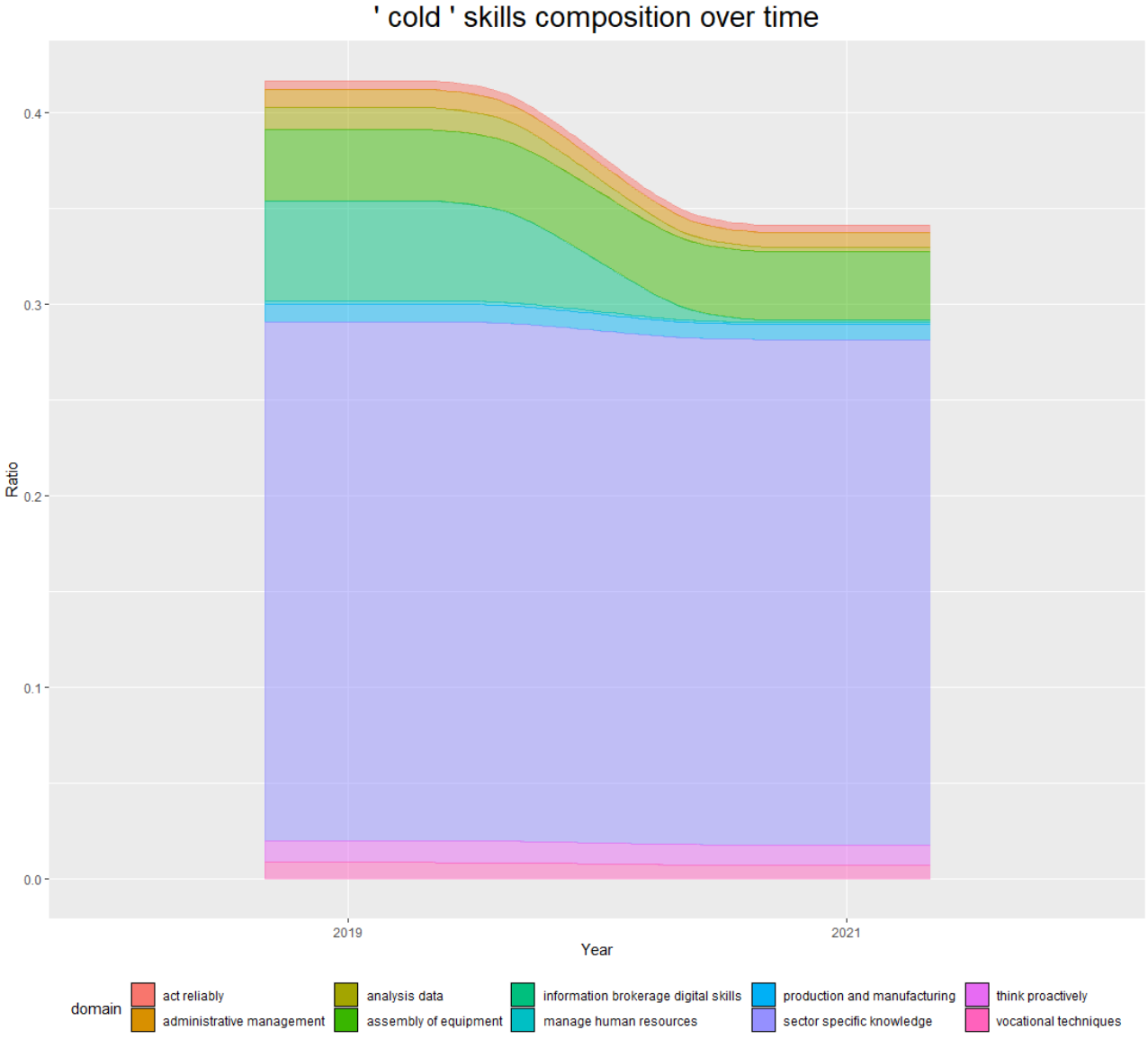
The skills that appear to become obsolete in the job descriptions relates to soft skills like logic and manage personnel.

Figure 19. Top 10 'hot' skills for the second medium-skilled occupation in shortage in France in 2021: Electronics and Telecommunications Installers and Repairers (ISCO 742)



Sources: OJV data, comparison between 2019 and 2021. France

Figure 20. Top 10 'cold' skills for the second medium-skilled occupation in shortage in France in 2021: Electronics and Telecommunications Installers and Repairers (ISCO 742)



Sources: OJV data, comparison between 2019 and 2021. France

4.8.4. The case of Medical Doctors in Germany

On the German labour market of 2021, the most under-supplied occupation in high-skilled ones (ISCO 1-3) is Medical Doctors (ISCO 221). The cosine similarity between 2019 and 2021 is high reaching 0.99.

For this occupation, the core skills that are still required in both years involve being innovative (develop new products, identify opportunities, proactivity) and thinking with precision (apply

strategic thinking, critical/analytical thinking) to take ethically decisions while guiding and supporting others.

Some skills gained in popularity ('hot' in the following table and the alluvial graph) and emphasise the importance of providing health assistance in their speciality while working in a team.

Some skill requirements that are 'new' relate to other 'stable' and 'hot' on guiding staff like mentoring, giving instructions while working in a team with coordinating communication within his or her team. Interestingly new skills appear and concern applying scientific research methodology and presenting reports.

In contrast, some skills have lost popularity ('cold') such as data management and analysis, or working independently (not surprising, given the increase in teamwork skills mentioned in job descriptions) and adapting to change, which becomes more concrete with the mention of various ability to think with precision in the stable skills.

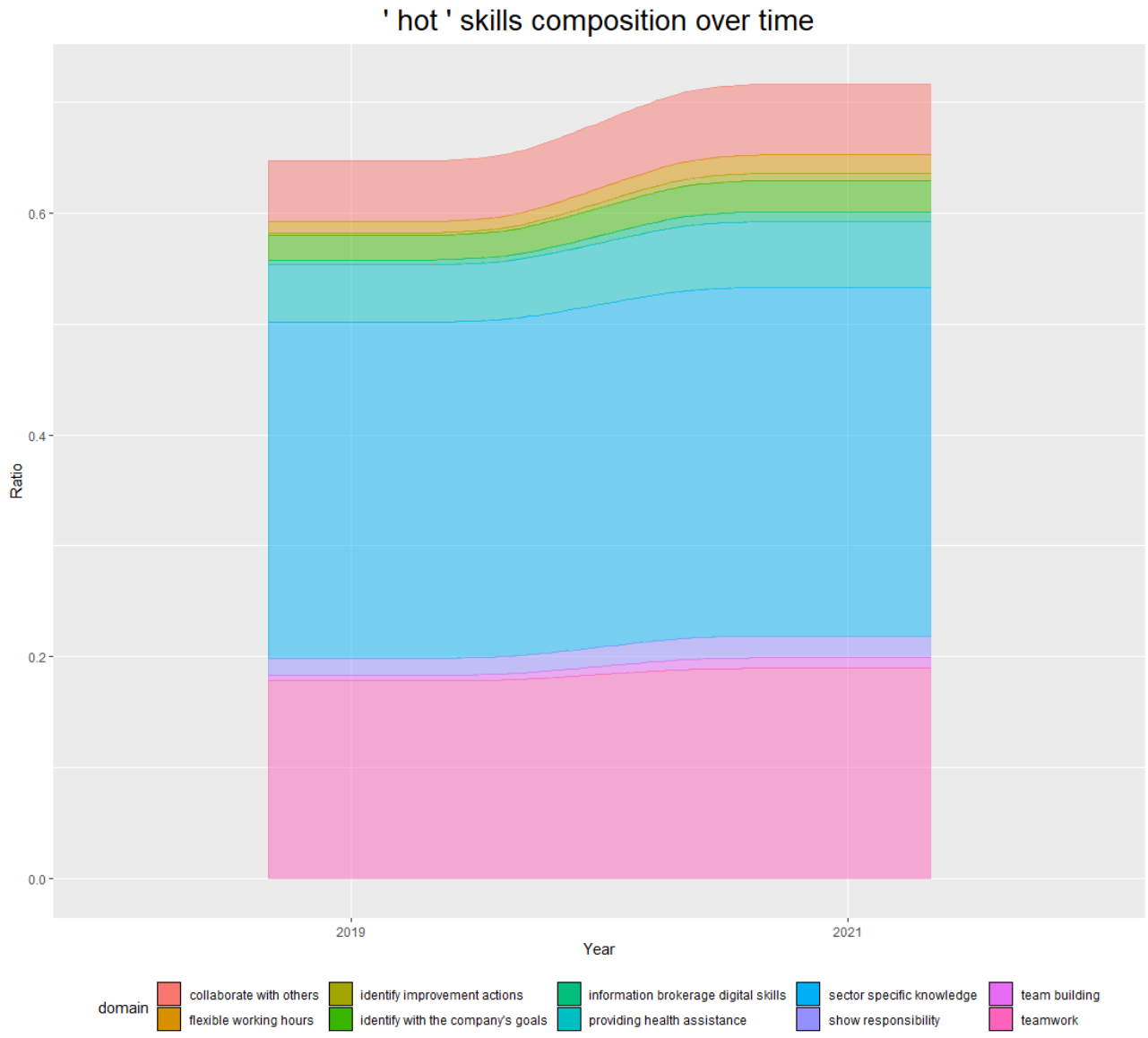
Some skills become obsolete like think creatively or provide information.

Table 10. Top 10 skills for the top shortage high-skilled occupation in Germany in 2021: Medical Doctors (ISCO 221)

Stable	Hot	New	Cold	Obsolete
Develop new products	Teamwork	Mentor individuals	Travelling	Provide information
Apply strategic thinking	Sector specific knowledge (health speciality)	Give instructions to staff	Managing data	Think creatively
Make decisions	Collaborate with others	Coordinate communication within a team	Digital security and privacy	Rhetoric
Ethics	Providing health assistance	Problem solving	Morality and integrity	
Support others	Flexible working hours	Scientific research methodology	Report analysis results	
Identify opportunities	Identify with the company's goals	Present reports	Analysis data	
Set up dates	Information brokerage digital skills		Adapt to change	
Critical/analytical thinking	Team building		Digital applied/ management use	
Proactivity	Identify improvement actions		Work independently	
Guide staff	Show responsibility		Basic digital skills	

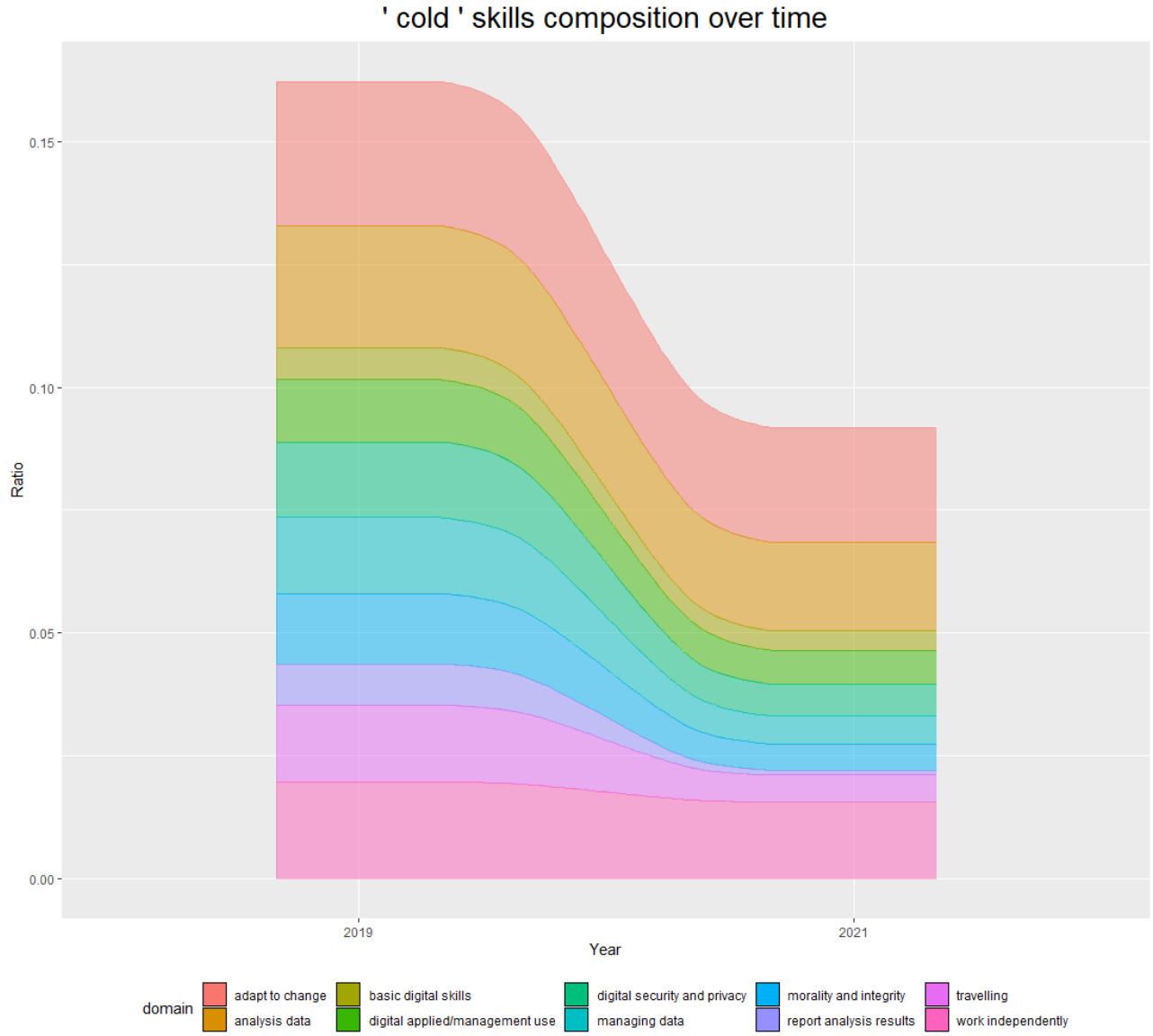
Sources: OJV data, comparison between 2019 and 2021. Germany

Figure 21. Top 10 'hot' skills for the top shortage high-skilled occupation in Germany in 2021: Medical Doctors (ISCO 221)



Sources: OJV data, comparison between 2019 and 2021. Germany

Figure 22. Top 10 ‘cold’ skills for the top shortage high-skilled occupation in Germany in 2021: Medical Doctors (ISCO 221)



Sources: OJV data, comparison between 2019 and 2021. Germany

5. Conclusion

This paper provides an empirical analysis of the labour shortages and surplus in some European labour markets where skills are supplied by natives and migrants coming from five broad regions of origin (Africa, Asia, Europe, North America and Australia, Central and Latin America).

In the first step of the analysis, we present statistics on 19 European countries (Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Spain, Sweden) with an emphasis on France and Germany. We provide evidence to what extent migrants are unequally distributed across sectors,

occupations, and regions, and to what extent they differ from natives with respect to education levels and age.

In the second part of the analysis, we identify the occupations that under-/over-supplied on the French and the German labour markets. We observe that few occupations are in shortage in France in 2021 compared to Germany. The presence of migrants is crucial in addressing the labour shortages faced especially by the German labour market. Comparing the occupations that are in shortage both in France and Germany in 2021, we show that five high skilled occupations are concerned. That are, Mathematicians, Actuaries and Statisticians (ISCO 212), Veterinarians (ISCO 225), Other health professionals (ISCO 226), Legal Professionals (ISCO 261), Software and Applications Developers and Analysts (ISCO 251). The shortage in Science, Technology, Engineering, and Math (STEM) occupations (ISCO 212, 225, 226, and 251) and the other high skilled occupation (ISCO 261) may need to be addressed through increasing domestic education in these fields, or attracting more skilled migrants.

In the third step of the analysis, we use Online Job Vacancy (OJV) data to identify the skills required by employers in the most sought-after occupations in shortage in the French and German labour market. For three of the four occupations studied, the similarity of requested skills is high over the period 2019-2021 (mathematicians, actuaries and statisticians, and electronics and telecommunications installers and repairers in France and medical doctors in Germany). The other occupation in shortage in France (ships' deck crews and related workers) cover various professions and is less similar when we compare 2019 and 2021. Digital skills are highly required especially for mathematicians, actuaries and statisticians that need to deal with data using more and more machine learning tools (AI) to perform their activities. We also observe that the use of digital tools increase the demand of digital skills for medium-skilled occupations. Being innovative, work ethically and in team are requested in the two high-skilled occupations studied. We observe that other soft skills, such as the ability to adapt to various changes, are also of great importance in most occupations.

With this analysis, our goal is to assist policy makers, educational institutions, and lifelong learning organisations in identifying the occupations that are currently facing shortages and surplus, as well as the skills that are needed to fill shortages. By providing this information, we aim to help these stakeholders narrow the skill gap that is present in labour markets and to ensure that workers and graduates have the necessary skills to succeed in the current and future job market.

For companies, various strategies should be used such as training and education programs for existing employees, and collaboration with educational institutions to develop a pipeline of skilled workers. Companies facing skill shortages may also explore other strategies besides attracting migrant workers to solve their workforce needs. One strategy is outsourcing, where a company contracts with other companies or individuals located abroad to perform certain tasks or services. This can help a company to access a wider pool of talent and expertise, without having to hire additional workers directly. Another strategy can be to invest in automation, which can also help companies to reduce labour costs. Automation can also help to fill certain skill shortages by allowing companies to perform tasks that would otherwise require hiring more workers. However, it's important to note that relying too heavily on outsourcing and automation may have negative consequences such as a lack of control over the quality of work. These strategies should be used in conjunction with other solutions such as allowing remote work, flexible working hours, to alleviate the labour and skills shortages they face.

For policy makers, the issue of migrant's diploma recognition is also important to consider. Migrants from outside Europe who have received education and training in their home countries may have indeed difficulty getting their qualifications recognised in the European Union. This can lead to a mismatch between the skills and qualifications of migrants and the requirements of the local labour market. As a result, many highly skilled non-European migrants may be forced to take lower-skilled jobs that do not match their qualifications or expertise. This can lead to underutilisation of their skills, which cannot be used to alleviate the skill shortages in certain occupations.

Furthermore, even if the mobility of workers on the labour market is not always easy, due to lack of information and/or confidence to be mobile, it can have a significant impact on the availability of skills in certain occupations. For instance, if there is a surplus of workers in a certain occupation, but the workers in that occupation have the skills and qualifications to move to another occupation that is in shortage with maybe better pay or working conditions, this could be used by employment agencies to alleviate the shortage.

The method of shortage/surplus identification used in the current analysis does have certain limitations.

It's important to note that the method of shortage identification used in this analysis is based on data and statistics which are not always perfect representation of the reality. These numbers may be affected by certain biases and limitations of the data collection methods and sources. For instance, our analysis does not take into account the potential arrival of graduates on the

labour market in the short term. Graduates from universities and vocational schools can bring new skills and qualifications to the workforce, which can help to alleviate shortages in certain occupations. However, the time lag between graduation and entering the workforce means that this influx of new workers may not be captured in an analysis using LFS data. This could lead to an overestimation of shortages in certain occupations, as the availability of new graduates is not reflected in the data. Therefore, it's important to consider these limitations when interpreting the results and to rely on other sources of data to supplement this analysis. One additional source of data that can be useful in assessing skill shortages is the assessment of skill shortages by companies themselves. By surveying employers and gathering information about their workforce needs and skill shortages, it will be possible to get a more accurate picture of the current labour market situation. Additionally, this type of data can provide insights into the specific skills that are in high demand, which can be useful for educational institutions and policymakers to develop training and education programs to address these shortages. Furthermore, getting the feedback from the companies can help to identify other solutions that companies might have implemented such as outsourcing, remote work, flexible working hours, and training programs for their employees. Furthermore, data on the career aspirations and expectations of workers and graduates can provide insight into the types of jobs and sectors that are most attractive to them, and can help to identify where there may be a mismatch between the skills and qualifications of workers and graduates and the needs of the labour market.

Appendix

Appendix Table 1. Comparison between no weights, LFS weights and new weights calibrated on United Nation & Eurostat data

		No weights	LFS weights	New weights
19 European countries	Natives	86.77	84.3	83.23
	Africa	1.70	2.75	2.69
	Asia	2.05	2.56	3.32
	Europe	8.19	8.17	8.94
	North America (& Australia)	0.21	0.22	0.25
	Latin (& Central) America	1.08	2.00	1.57
	Number of observations		949,599	
France	Natives	88.02	87.13	86.02
	Africa	5.82	6.64	6.72
	Asia	1.29	1.45	1.82
	Europe	3.63	3.91	4.8
	North America (& Australia)	0.12	0.14	0.16
	Latin (& Central) America	1.13	0.74	0.48
	Number of observations		31,292	
Germany	Natives	83.91	80.72	80.28
	Africa	0.75	0.93	0.69
	Asia	4.43	5.14	5.98
	Europe	10.30	12.44	12.58
	North America (& Australia)	0.22	0.25	0.21
	Latin (& Central) America	0.39	0.50	0.26
	Number of observations		96,759	

Sources: LFS 2021, 19 EU countries, France and Germany. Figures in percentage. Number of observations are non-weighted

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