Ref. Ares(2025)7156976 - 03/09/2025

Grant Agreement number: 101132559
Project acronym: ST4TE
Project title: Strategies for just and equitable transitions in Europe
Type of action: RIA

D1.3 The geography of the green, digital and twin occupations in Europe. Mapping Digital and Green Occupations and Twin Skill Readiness in EU Regions

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Due date	31/08/2025
Actual submission date	03/09/2025
Dissemination Level	Public

Abstract: This report maps green, digital, and twin occupations across European regions to assess the geography of jobs related to the twin transition. Using ESCO-based taxonomies and EU-LFS microdata, it highlights the uneven distribution of employment: digital jobs cluster in metropolitan, innovation-intensive regions, while green roles are more broadly spread across sectors and skill levels. Twin occupations remain limited and predominantly anchored in green capabilities. The analysis underscores regional disparities, the importance of enabling occupations, and offers reflections on potential policy responses.

Document Revision History

Date	Version	Author/Editor/Contributor	Summary of main changes / Status
18/08/2025	0.1	Andrea Ascani, Nicolò Barbieri, Stefano Basilico, Marianna Gilli, Alberto Marzucchi, Ugo Rizzo, Guido Sciavicco	First version of the report to be revised by Alessandro Palma, Sebastian Svenberg and Martin Hultman
03/09/2025	0.1	Andrea Ascani, Nicolò Barbieri, Stefano Basilico, Marianna Gilli, Alberto Marzucchi, Ugo Rizzo, Guido Sciavicco	Final version
03/09/2025	1.0	Christina Kakderi	Submission

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This project has received funding from the European Union's Horizon Europe under grant agreement No 101132559.

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1. Introduction

The convergence of digital and green transitions has the potential to fundamentally reshape Europe's economic landscape, driving innovation and productivity gains while also posing unprecedented challenges for the labour market (European Commission, 2020). These simultaneous "twin" transitions – the digitalisation of economic activities and the shift towards sustainability – are not merely technological shifts but economic and labour market transformations of historic scale. On one hand, the twin transition promises new sources of growth through cleaner technologies and advanced digital processes. The European Green Deal itself is conceived as "the EU's new growth strategy" to transform the Union into a fair and prosperous society with a modern, competitive and resource-efficient economy (European Commission, 2019). On the other hand, these transitions risk exacerbating regional and social disparities, as regions and workers differ greatly in their ability to adapt. Ensuring that the twin transition is inclusive and cohesive has thus become a central concern for European policy. Recent EU economic strategy stresses that Europe's shift towards a sustainable and digital economy "will only succeed if it is fair and inclusive and if everybody can gain from the opportunities the twin transition brings" (European Commission, 2022). This underscores the need for analytical frameworks that can identify which regions are prepared to capitalise on these opportunities and which are vulnerable to being left behind. In this context, understanding the geography of emerging "green" and "digital" occupations – and especially their areas of overlap – is not a trivial exercise in labour market analysis, but a key step towards assessing regional readiness for change.

From a labour economics perspective, the twin transition entails a non-negligible reconfiguration of skills and tasks across occupations. Rather than creating new industries, digitalisation and greening are transforming the task content of existing jobs, blurring the boundaries between traditionally distinct roles. In the task-based view of the labour market (Autor et al. 2003; Acemoglu and Autor 2011), occupations are conceived as bundles of tasks, each with varying susceptibility to automation, digital augmentation or substitution in the move to sustainable practices. This implies that the impact of the twin transition will be heterogeneous across occupations depending on their task composition. Many jobs will evolve as routine manual tasks are automated and new digital or "eco-centric" tasks emerge in their place. Indeed, the European Commission foresees that the green and digital transitions "will affect every part of our economy, society and industry", creating "new types of jobs that do not yet exist which need skills that we do not yet have" (European Commission, 2020). For example, a construction engineer's role may increasingly involve using digital twin simulations for energy-efficient design, while an automotive mechanic may shift from combustion engine repairs towards servicing electric drivetrains and battery systems. Crucially, the complementarity of skills is becoming a defining feature of this transformation: workers who can combine digital expertise with green knowledge are likely to be at a premium. As recent studies suggest, the economic value of a skill is increasingly determined by its synergy with other competencies, rather than its stand-alone utility (Stephany and Teutloff, 2024). Occupations that successfully bundle digital and sustainable skill sets – for instance, renewable energy technicians proficient in data analytics or AI-driven process optimisation – epitomise the kind of twin-skilled profiles that can drive innovation and accelerate the transition. At the same time, roles lacking such dual competencies may face greater risks of obsolescence or slower productivity gains. This underscores that the twin transition is not solely about technological deployment, but about re-bundling human capital: it demands far-reaching efforts in retraining,

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upskilling, and re-aligning workforce capabilities to meet dual digital-green skill demands (European Commission, 2021, COM(2021) 102 final).

The ability of different regions to navigate this looming labour market upheaval is highly uneven, reflecting deep-seated differences in industrial structure, human capital endowments and existing specialisations across Europe. Economically advanced regions often possess diverse skill bases, innovation infrastructures and specialised industry clusters that make them more adaptable to new technological and environmental imperatives. By contrast, regions with narrower industrial profiles or lower average skill levels may struggle to absorb twin transition shocks, risking further marginalisation as the economy changes. Insights from economic geography and evolutionary economics suggest that these patterns are far from random. Regional development trajectories tend to be path-dependent and contingent on "related" capabilities already present in the local economy. In particular, the emergence of new green or digital specialisations is often mediated by the proximity of those activities to a region's existing occupational and technological profile (Boschma 2005). A region whose workforce already possesses skills adjacent to renewable energy (e.g. electrical engineering) or to advanced ICT (e.g. software development) will find it easier to diversify into those fields than a region lacking such related skill pools. Thus, identifying spatial patterns of skill complementarity – where digital and green competences co-exist or could be combined – is of both conceptual and practical importance. It can reveal latent potentials for the twin transition in certain regions, as well as flag skill gaps in others that may hinder their ability to adapt. Early evidence indeed warns that, absent corrective policies, the twin transition could widen regional disparities. The European Commission's latest cohesion analysis has acknowledged the risk of a "widening gap between regions" in the context of the green and digital transformation, noting that more developed regions often have greater capacity to "master" the transition whereas less-developed regions face steeper challenges (Schwab & Crist, 2023). Highly developed core regions are generally better positioned to exploit new opportunities than peripheral regions that face higher adjustment costs. Anticipating these asymmetries is critical for designing timely interventions so that Europe's push towards sustainability and digitalisation does not come at the expense of greater territorial inequality. As the Commission's economic strategy emphasizes, policies must continue to "provide support to reduce regional and social disparities" during the twin transitions, for example through cohesion funds and the Just Transition Mechanism (European Commission, 2022).

This deliverable, prepared as part of a Horizon Europe project on the twin transition, directly addresses these issues by mapping the landscape of green, digital and twin-skill occupations across European regions. Its specific objectives are to:

- Classify and identify green, digital and twin occupations using a combination of task-based analysis and European labour taxonomy data. We build on established occupational classifications – notably the European Skills, Competences, Qualifications and Occupations (ESCO) framework – to identify "green" and "digital" jobs and classify "twin" jobs in the European context.
- Map the regional distribution of these occupations using harmonised employment data. Drawing on European Labour Force Survey (EU-LFS) microdata, we quantify the level of green, digital and twin- occupations in each NUTS-2 region. Identifying these spatial patterns is central to understanding each region's current workforce profile and its potential alignment with twin transition needs.

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- Introduce and examine the concept of “enabling occupations”, which refers to roles that are not explicitly green or digital or twin in themselves but play a crucial supportive role in facilitating the transitions across sectors. These are supposed to represent bridge occupations that have the potential to drive the growth in green, digital or twin occupations being in a skills landscape closer to these ones, and therefore we can expect green, digital and twin to be easier to emerge or increase.

By pursuing these objectives, the deliverable provides a foundational analysis of regional asymmetries in twin transition readiness. It offers both a conceptual lens and an empirical mapping to understand how Europe’s diverse regions are positioned in terms of the human capital needed for a green and digital economy. This foundation is indispensable for several reasons. Conceptually, it advances our understanding of labour market transformation by linking the task-based view of occupations with the geography of skill relatedness – illustrating how macro-level transitions are ultimately contingent on micro-level skill bundles and their regional aggregation. Empirically, it establishes baseline indicators of twin transition readiness (such as the share of employment in twin occupations, or the density of enabling roles) that can be tracked over time or used to target further qualitative investigations. From a policy standpoint, the insights from this mapping are highly relevant to EU cohesion and innovation strategies. They enable policymakers to pinpoint regions with strong complementarities between digital and green capabilities – potential lead markets or innovation hubs for the twin transition – as well as regions at risk of falling behind without additional support. In line with the EU’s goal of balanced and inclusive growth, identifying such spatial skill gaps is a precondition for effective, place-sensitive interventions. Ultimately, by shedding light on where Europe’s green and digital workforce assets lie, this deliverable helps ensure that the twin transition can be steered in a way that maximises overall gains while mitigating regional inequalities. It sets the stage for further research and action on how to strengthen regional skill ecosystems, foster occupational mobility and design training programmes that will allow all European regions to partake in – and benefit from – the green and digital future.

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2. Background literature

The transition toward a green and digital economy—often conceptualised as the "twin transition"—poses significant challenges and opportunities for regional labour markets. Identifying and mapping the spatial distribution of green and digital occupations is central to understanding regional readiness and shaping place-sensitive policy responses. This literature review synthesises contributions across labour economics, skill taxonomies, network analysis, and regional diversification.

2.1 Defining and classifying green and digital occupations

The operationalisation of green and digital occupations has increasingly relied on detailed taxonomies such O*NET (Occupational Information Network), but more recently also ESCO (European Skills, Competences, Qualifications and Occupations). Traditionally, much of the literature in labour economics has classified occupations through a task-based approach (Autor et al., 2003; Acemoglu and Autor, 2011). Under this framework, occupations are not treated as monolithic units, but as bundles of tasks, some of which are more susceptible to automation, digitalisation, or greening. This perspective allows scholars to capture the heterogeneity within occupations, focusing on the nature of tasks performed—for instance, whether tasks are routine or non-routine, cognitive or manual, problem-solving or interpersonal.

Task-based analysis has been foundational for studying technological change, automation risks, and labour market polarisation. Autor et al. (2003) pioneered the empirical modelling of the impacts of computerisation by distinguishing between routine and non-routine tasks. Subsequently, Acemoglu and Autor (2011) formalised this approach into a framework capable of explaining skill-biased technological change and evolving patterns of occupational demand. Many subsequent studies have used O*NET as the primary source of task descriptors, given its extensive, detailed and regularly updated information on job content in the United States.

However, the direct application of O*NET to European labour markets presents significant limitations. As highlighted by researchers such as Consoli et al. (2023), task profiles captured by O*NET may not fully align with the institutional, technological, and educational characteristics of European economies. Labour markets are path-dependent and institutionally embedded (Marsden, 1999), and thus occupation-task relationships can differ markedly across contexts.

To address this issue, ESCO was developed under the auspices of the European Commission, aiming to offer a Europe-specific classification of occupations, skills, and competences. ESCO aligns more closely with European standards and educational systems, reducing the risk of cross-contextual inefficiencies that arise when applying American taxonomies to European data. Unlike O*NET, ESCO also explicitly maps occupations to skills and qualifications, providing a more integrated view of human capital attributes. Nevertheless, ESCO has some notable limitations compared to O*NET. Its granularity in task descriptors is lower; for example, the dynamic updating of emerging digital and green skills is still relatively less systematic than in O*NET, where continuous input from occupational experts ensures timely reflection of labour market evolution (Handel, 2016).

Despite these challenges, ESCO represents a crucial advancement, particularly for research aiming to map green, digital, and twin occupations in Europe. It enables the context-sensitive operationalisation of concepts like skill complementarity and co-occurrence. As Stephany and Teutloff (2024) argue, the

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economic value of a skill is increasingly determined by its complementarity with other competences. Consequently, the ability to identify occupations where green and digital skills co-occur, or where such bundling is feasible, is pivotal for assessing regional readiness for the twin transition.

2.2. Skill relatedness, bundling, and labour market transitions

The success of the twin transition depends not only on the availability of green and digital occupations but also on the capacity of regional labour markets to support skill recombination and bundling. Skill ecosystems that can effectively combine green and digital competences are likely to exhibit greater resilience and adaptability in the face of technological and environmental transformations. Recent advances in network analysis have offered powerful tools to understand the structure and dynamics of occupational mobility and skill similarity. Alabdulkareem et al. (2018) and Hidalgo (2021) conceptualise skills and occupations as interconnected nodes in a "skill space", where proximity indicates a high degree of competence overlap. In this framework, transitions between occupations are more feasible when the underlying skill sets are closely related. Such network-based proximity measures provide a robust empirical foundation for estimating the connectability between green and digital skills (del Rio-Chanona et al., 2021).

Extending this approach, Stephany and Teutloff (2024) demonstrate that the complementarity between emerging AI-related skills (such as Python programming or cloud infrastructure management) and traditional digital competences significantly enhances labour market value. Skills that exhibit strong complementarities reduce transition costs for workers and employers alike, facilitating occupational mobility and upskilling pathways. By analogy, the identification of occupations where green and digital skills naturally co-occur—or can be easily recombined—could help policymakers pinpoint key nodes for fostering regional economic transformation toward sustainability and technological modernisation.

The broader literature on skill complementarity reinforces these insights. Wingender (2015), in the context of sectoral productivity, shows that high elasticity of substitution between skill types in agriculture leads to persistent productivity gaps. This suggests that sectors or occupations with low complementarities are structurally disadvantaged in adapting to new economic paradigms. Translating this into the green–digital context, occupations characterised by weak complementarities between sustainability-related and technological skills may face higher costs of transformation and greater frictions in workforce adaptation. Conversely, occupations with strong green–digital complementarities—such as technical installers proficient in digital diagnostics for renewable energy systems—can act as catalysts or anchor points for the twin transition (Neffke, 2019).

At the micro-foundational level, Weidmann and Deming (2021) highlight the role of social and collaborative skills in enhancing team productivity. Their findings show that individuals with high levels of social intelligence—termed "team players"—consistently improve collective outcomes, independently of their technical expertise. Given that many green and digital occupations increasingly require teamwork, problem-solving in interdisciplinary settings, and stakeholder engagement, the bundling of technical and social skills emerges as a critical dimension of twin readiness.

In sum, the literature underscores that the ability to bundle and recombine skills—both technical (green and digital) and socio-cognitive—is crucial for successful transitions at the occupational, organisational, and regional levels. Mapping such complementarities, using skill-relatedness metrics

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and network-based models, offers a promising pathway for identifying regions and sectors with high latent potential for driving the green and digital transitions.

2.3 Regional dimension

The regional and sectoral capacity to absorb and recombine green and digital competences—a prerequisite for the twin transition—varies markedly across the European landscape. This heterogeneity is grounded in long-standing differences in human capital endowments, technological infrastructures, and sectoral specialisation patterns. Recent research has demonstrated that regional diversification toward green and digital domains is not a random process but is path-dependent and mediated by relatedness among existing occupational and industrial capabilities (Boschma, 2005; Santoalha et al., 2021).

From a theoretical perspective, urban and regional economists have emphasised the role of agglomeration economies in fostering such transitions. Duranton and Puga (2004) offer a comprehensive taxonomy of micro-foundations—sharing, matching, and learning—that underpin agglomerative forces. These mechanisms facilitate knowledge recombination and skill complementarity, enhancing a region's absorptive capacity for new technologies and occupations. In particular, sharing indivisible facilities and matching specialised labour pools increase the probability of successful occupational and technological transitions within complex urban systems.

Empirical evidence from both European and U.S. contexts suggests that occupational diversification is more feasible when it proceeds via skill- or functionally-related pathways. Farinha et al. (2019) show that local synergy—defined as the co-location potential among occupations—is a critical determinant of job creation and occupational persistence. Similarly, Muneepeerakul et al. (2013) and Shutters et al. (2016) conceptualise cities as embedded in a network of occupational interdependencies, where transitions towards higher-value activities (e.g., green or digital occupations) are conditioned by the existing occupational portfolio. Their findings indicate that urban economies characterised by dense, interconnected occupational networks—particularly those combining creative and non-creative specialisations—display enhanced transition potential.

The analysis by Shutters et al. (2016), in particular, quantifies the proximity between a city's current occupational structure and a target configuration dominated by creative occupations. They demonstrate that progression toward a creative or knowledge-intensive economy necessitates not only specialisation in core creative occupations but also in complementary non-creative ones. This implies that sectoral readiness is a function not solely of existing capabilities but also of the structural interdependencies among occupations. Regions already specialised in adjacent, high-interdependence roles—regardless of their current "green" or "digital" status—may therefore possess latent potential for twin transition trajectories.

On the sectoral side, Barbour and Markusen (2007) stress that functional specialisation—in particular, the prevalence of knowledge-intensive business services (KIBS)—correlates strongly with regions' capacity to adopt green and digital practices. Such sectors act as enabling infrastructures for technological and organisational change, facilitating cross-sectoral knowledge transfer and institutional learning. Conversely, regions anchored in narrowly specialised, routinised manufacturing may experience greater structural inertia, especially in the absence of complementary service or technical support functions.

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Santoalha et al. (2021) reinforce these insights in the European context by showing that regions with a robust digital base and higher skill-relatedness to green domains are significantly more likely to diversify into green technologies. Their findings support a cumulative model, wherein existing digital capabilities catalyse green diversification—provided that occupational or technological proximity is sufficiently high. Importantly, their evidence suggests that enabling occupations and infrastructures—not necessarily green or digital per se—play a pivotal role in expanding the feasible set of transformation pathways. In sum, regional and sectoral readiness for the twin transition hinges on a complex interplay of occupational relatedness, functional specialisation, and the institutional and spatial configurations that support agglomerative dynamics.

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3. Data and Methods

3.1 Data

This analysis draws upon two primary data sources: the European Skills, Competences, Qualifications and Occupations classification (ESCO) and the European Labour Force Survey (EU-LFS). ESCO provides a standardised and multilingual taxonomy that systematically links occupations with the corresponding skills, competences, and qualifications. It offers detailed information on the skill profiles associated with each occupational category, including the nature of skills—such as green, digital, or transversal—thus enabling a nuanced classification of labour market requirements. Importantly, ESCO includes both an occupational pillar and a skills pillar, as well as mapping tables (so-called "skill-occupation relationships") that establish structured connections between the two. These mappings allow researchers and policymakers to match skill sets to specific occupations, assess skill shortages or surpluses, and explore potential pathways for upskilling or reskilling.

The EU-LFS, on the other hand, is a large-scale, harmonised household survey conducted across European countries. It provides detailed microdata on individual-level labour market characteristics, including employment status, occupation, industry, working hours, educational attainment, and demographic attributes. The EU-LFS is instrumental in analysing labour market dynamics, monitoring employment trends, and performing investigations into labour supply and demand across different population subgroups and time periods.

By integrating ESCO and EU-LFS, and by adopting a series of methodological strategies described in subsequent sections, we exploit the complementarity of these datasets to map the distribution of green, digital, and so-called twin occupations. In addition, we identify further categories of occupations—termed green enabling, digital enabling, and twin enabling—which, while not intrinsically green, digital, or twin in nature, nonetheless play a key role in facilitating the diffusion and operationalisation of such occupations within the labour market. Observing enabling occupations thus allows us to capture the skills that support the operationalisation of green and digital competences across a broader range of economic activities and associated tasks.

3.2 Classification of occupations

We employ the ESCO dataset (version 1.2.0) to assess the extent to which each occupation incorporates digital, green, and twin skills. First, we operate at the 5-digit ESCO level in order to ensure sufficient granularity (e.g. "3D modeller", code 2166.1). Second, we consider only those attributes explicitly classified as "skill/competence", thereby isolating the specific competences required to perform each occupation. Third, ESCO provides an internal classification of skills and competences as either green or digital. This allows us to quantify, for each occupation, the number of associated green and digital skills. As an initial step, we therefore compute the total count of green and digital skills linked to each 5-digit ESCO occupation.

Table 1 shows the 10 occupations with the highest number of green skills. Occupations like "Energy Analyst", "Energy Conservation Officer" and "Natural Resources Consultant" score at the top of this ranking. In this case, differently from what emerges in the case of digital skills (Table 2), also occupations belonging to "Elementary occupations" are present. This result is reliable since

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occupations related to waste sorting or recycling have a high degree of skills identified as green. Thus, green skills are highly present in the case of more routinised or lower-skill-levels occupations.

Occupation	ESCO Code	N Green Skills	N Total Skills	Perc. Green Skills
Energy Analyst	3112.5	13	16	81,25
Energy Conservation Officer	3112.6	8	10	80,00
Natural Resources Consultant	2133.8	18	23	78,26
Environmental Expert	2143.2	21	31	67,74
Sustainability Manager	1213.8	32	49	65,31
Recycling Worker	9612.1	17	27	62,96
Environmental Protection Manager	1349.13	18	29	62,07
Nature Conservation Officer	2133.9	25	43	58,14
Refuse Collector	9611.1	11	19	57,89
Sorter Labourer	9612.2	11	20	55,00

Table 1. The 10 occupations at ESCO 5-digit level with the highest percentage of green skills.

Table 2 shows the 10 occupations with the highest percentage of digital skills. The occupations with all the skills flagged as digital are clearly related to the development or to the managing of the most advanced technologies in the field ("Cloud DevOps Engineer", "Cloud Software Developer", "Data Engineer", "IoT Developer" and "Webmaster"). These 10 occupations at ISCO 1-digit level are belonging to the categories "Professionals", "Technicians and Associate Professionals" and "Clerical Support Workers". In general, those occupations require either some technical or analytical skills to support digital processes.

Occupation	ESCO Code	N Digital Skills	N Total Skills	Perc. Digital Skills
Cloud DevOps Engineer	2512.7	13	13	100,00
Cloud Software Developer	2512.8	11	11	100,00
Data Engineer	2511.20	16	16	100,00
IoT Developer	2512.9	8	8	100,00
Webmaster	3514.1	21	21	100,00
ICT System Administrator	2522.1	30	33	90,91
Data Entry Clerk	4132.1	16	18	88,89
Cloud Engineer	2512.1	22	25	88,00
ICT System Developer	2511.15	29	34	85,29
Database Administrator	2521.1	28	33	84,85

Table 2. The 10 occupations at ESCO 5-digit level with the highest percentage of digital skills.

Table 3 shows the occupations with the highest level of green and digital skills (twin) in combination. To create this ranking we considered only occupations which have both one green skill and one digital skill at least. For example, in the case an occupation has only one green skill but no digital skills it would score 0 in this share. The top occupations in this ranking reflect the need to have some green capabilities to lower the impact on the environment and some digital skills to control those processes. In fact, the occupations scoring the highest in this context are: "Natural Resources Consultant", "Smart

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Home Engineer", "Geographic Information Systems Specialist". All those occupations belong to either to "Managers" or "Professionals" or "Technicians and Associate Professionals" reflecting the fact that medium-high skilled workers performing less routinized tasks are the ones with the highest share of twin skills. Moreover, apart from few cases, the green skills are present to a higher extent with respect to digital skills in the top twin occupations.

Occupation	ESCO Code	N Green Skills	N Digital Skills	N Total Skills	Perc. Twin Skills
Natural Resources Consultant	2133.8	18	1	23	82,61
Smart Home Engineer	2151.2	4	10	18	77,78
Geographic Information Systems Specialist	2165.3	1	20	29	72,41
Sustainability Manager	1213.8	32	3	49	71,43
Environmental Protection Manager	1349.13	18	1	29	65,52
Remote Sensing Technician	3111.13	1	15	25	64,00
Nature Conservation Officer	2133.9	25	1	43	60,47
Environmental Technician	2133.15	25	3	47	59,57
Smart City Consultant	2421.8	14	5	32	59,38
Aquaculture Environmental Analyst	2133.2	16	2	32	56,25

Table 3. The 10 occupations at ESCO 5-digit level with the highest percentage of green and digital skills.

Takeaway #1.
Twin occupations are predominantly associated with green rather than digital skill profiles and qualify as 'high-skill' type of jobs.

To visualize the interdependencies between different occupations we produced a co-occurrence network in which occupations are the nodes and edges are skills in common between two or more occupations. To ease the visualization of the network we divided the occupations into 3 groups based on the skill level provided by the International Standard Classification of Occupations (ISCO). The first group is the one of "Managers" and "Professionals" which are in the category 4 as skill level. The second group is the one of "Technicians and Associate Professionals" which are in the category 3 as skill level. The third group is the one of "Workers, Assemblers"[1] (category 2) and "Elementary Occupations" (category 1). We divided the network including all occupations into three different subnetworks based on the categorization explained above. To ease the visual inspection of the subnetworks we use the ForceAtlas2 layout. This layout is simulating a system in which nodes repel themselves, while the edges attract the nodes which are connecting them. The main scope of the algorithm is to find the right layout which better reflects the structure of the network. Moreover, the size of the nodes is reflecting the number of connections with other nodes. To measure this, we use a well-known indicator from Social Network Analysis called degree centrality. The nodes highlighted in

[1] We intend as belonging to the category "Workers, Assemblers" all the ISCO 1-digit categories from 4 to 8 ("Clerical Support Workers", "Service and Sales Workers", "Skilled Agricultural, Forestry and Fishery Workers", "Craft and Related Trades Workers", "Plant and Machine Operators, and Assemblers").

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green are the ones which have a share of green skills higher than average, the nodes highlighted in blue are the ones which have a share of digital skills higher than average and the nodes highlighted in yellow are the ones which have a share of digital and green (twin) skills higher than average. The occupation shares considered for calculating the average are the ones with at least one green skill (in the case of the identification of green occupations), the ones with at least one digital skill (in the case of the identification of digital occupations) and the ones with at least one green and one digital skill (in the case of the identification of twin occupations).

Figure 1 shows the network of occupations and skills for the categories “Managers” and “Professionals”. There is a high presence of occupations scoring high in digital skills. Those occupations tend also to cluster together, which means that they have to a higher extent the same skills. There are very few green and twin occupations, and those are not really well connected with the other occupations. In general, the occupations pertaining to those categories tend to be highly digitalized with a low degree of green skills.

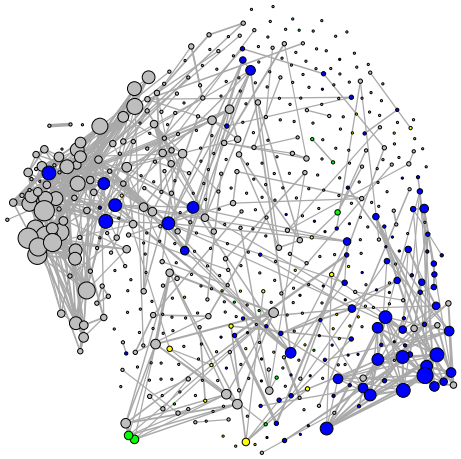

Figure 1. The network of occupations and skills for “Managers” and “Professionals” (ISCO skill level 4)

Figure 2 shows the network of occupations and skills for the category “Technicians and associate professionals”. In this case there are more occupations with a high share of green and twin skills with respect to the case of “Managers” and “Professionals”. Those occupations tend also to cluster together meaning that they share similar skills. Occupations with a high presence of digital skills are also present but they are quite scattered in the network without clustering.

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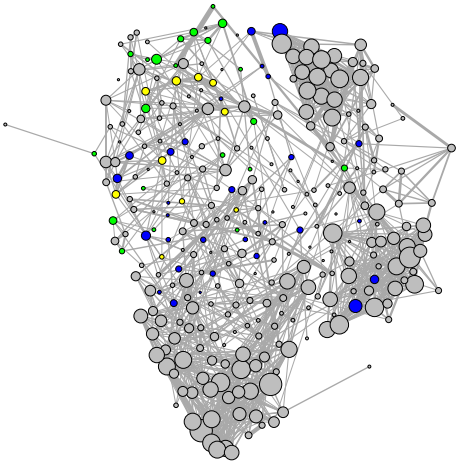

Figure 2. The network of occupations and skills for "Technicians and Associate Professionals" (ISCO skill level 3)

Figure 3 shows the network of occupations and skills for "Workers, Assemblers" and "Elementary Occupations". In this case there are many occupations identified as green and twin with high clustering. However, the presence of digital occupations is not very high as in the case of "Technicians and Associate Professionals".

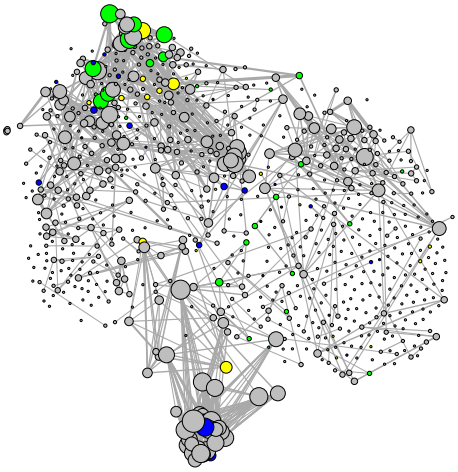

Figure 3. The network of occupations and skills for "Workers, Assemblers" (ISCO skill level 2) and "Elementary Occupations" (ISCO skill level 1)

To assess also the potential of other skills, which are not green or digital, to become in the future possibly green or digital we have also calculated a score of "green enabling", "digital enabling" and

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"twin enabling[2]" for each occupation. This measure reflects the share of skills within a focal occupation that co-occur at least once with a green or digital skill in another occupation. A higher score indicates a greater likelihood that the occupation will integrate additional green or digital skills in the future. Accordingly, for each occupation we compute six indicators: three capturing the direct share of green, digital, and twin skills, and three capturing the share of enabling green, digital, and twin skills.

3.3 Aggregation procedure

In this subsection, we describe how the ESCO 5-digit occupations were aggregated to the ISCO 3-digit level, in order to analyse the distribution of green, digital, and twin skills in Europe using EU-LFS (and OJA datasets). Using the six measures developed in the previous subsection, we aggregated 1,795 ESCO 5-digit occupations into 125 ISCO 3-digit categories, computing the average share for each[3].

Table 4 shows some descriptive statistics of the aforementioned variables. As the category enabling (green, digital and twin) is identifying all the skills which at least once occur with green and digital skills the maximum for those variables tends to be high. However, the standard deviation is higher in the case of the enabling variables which means that there is a higher level of dispersion. Subsequently, we show the occupations that at ISCO 3-digit level are scoring the highest for average digital, green and twin skills. There are some differences with respect to the tables showed above because not all the occupations in the same category at ISCO 3-digit level are scoring the same in terms of digital, green and twin skills.

Variable Name	N	Mean	SD	Min	Max
Average Digitalness	125	0,08	0,13	0,00	0,70
Average Greenness	125	0,04	0,07	0,00	0,52
Average Twinness	125	0,03	0,05	0,00	0,27
Average Digital enablingness	125	0,83	0,14	0,30	1,00
Average Green enablingness	125	0,71	0,18	0,21	0,98
Average Twin enablingness	125	0,58	0,19	0,14	0,88

Table 4. Descriptive statistics for the variables aggregated at ISCO 3-digit level

Table 5 shows the 10 occupations at ISCO 3-digit level with the highest average share of green skills. Also here there are similarities. For example, the category at ISCO 3-digit level called "Refuse Workers" is represented in Table 2 by the occupations named as: "Recycling Worker", "Refuse Collector" and "Sorter Labourer". When checking for where those occupations belong at ISCO-1 digit level we find them more distributed rather than in the case of digitalness. In fact, those top performing occupations belong to the categories "Managers", "Professionals", "Technicians and Associate Professionals", "Skilled agricultural, forestry and fishery workers", "Craft and related trades workers" and "Elementary

[2] In the case of twin we consider as enabling all the skills occurring with at least one green and one digital skill in the same occupation.

[3] The occupations at ISCO 3-digit level with the codes: "224", "631", "632", "633", "634" are not included since do not have any sub-occupation at ESCO 5-digit level.

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occupations". This result once more shows that when checking for green skills also low-skill occupations score high.

Occupation	ISCO Code	Average Greenness
Forestry and Related Workers	621	51,72
Refuse Workers	961	45,28
Life Science Professionals	213	28,11
Mixed Crop and Animal Producers	613	21,59
Market Gardeners and Crop Growers	611	16,24
Process Control Technicians	313	15,99
Painters, Building Structure Cleaners and Related Trades Workers	713	13,88
Production Managers in Agriculture, Forestry and Fisheries	131	12,48
Veterinarians	225	10,74
Engineering Professionals (excluding Electrotechnology)	214	8,73

Table 5. The 10 occupations at ISCO 3-digit level with the highest average share of green skills.

Table 6 shows the occupations at ISCO 3-digit level with the highest average share of digital skills. There are some similarities to what has been showed in table 1. We find some higher level (ISCO 3-digit) occupations scoring high in these categories as their lower level counterparts (ISCO 5-digit). For example, "Database and Network Professionals" is the category scoring higher for digitalness at ISCO 3-digit level, this category in the top occupations at ESCO 5-digit level is represented both by "ICT System Administrator" and "Database Administrator". When checking on ISCO 1-digit level we find that those occupations belong to "Managers", "Professionals" and "Technicians and Associate Professionals". This result confirms a pattern that favours occupations with a higher skill profile in the case of digital skills.

Occupation	ISCO Code	Average Digitalness
Database and Network Professionals	252	70,33
Telecommunications and Broadcasting Technicians	352	66,31
Information and Communications Technology Operations and User Support Technicians	351	64,63
Keyboard Operators	413	64,09
Software and Applications Developers and Analysts	251	62,29
Electrotechnology Engineers	215	37,45
Architects, Planners, Surveyors and Designers	216	30,87
Information and Communications Technology Service Managers	133	29,24
Electronics and Telecommunications Installers and Repairers	742	25,85
General Office Clerks	411	25,58

Table 6. The 10 occupations at ISCO 3-digit level with the highest average share of digital skills

Table 7 shows the 10 occupations at ISCO 3-digit level with the highest share of green and digital skills. As already pointed out when presenting Table 3 the share of skills for the occupations at ESCO 5-digit

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level are calculated only in the case in which at least one green and one digital skill occur together in an occupation. As in the previous cases (Tables 5 and 6) we find some similarities with respect to the more granular classification. In particular, the category at ISCO 3-digit level "Life Science Professionals" is also represented in the top 10 occupations at the ESCO 5-digit level by "Natural Resources Consultant", "Nature Conservation Officer" and "Aquaculture Environmental Analyst". When checking for the higher level occupations at ISCO 1-digit level similarly to the case of greenness we find that many categories are represented, like "Managers", "Professionals", "Technicians and Associate Professionals", "Skilled agricultural, forestry and fishery workers", "Craft and related trades workers" and "Plant and machine operators and assemblers".

Occupation	ISCO Code	Average Twinness
Life Science Professionals	213	27,24
Electrotechnology Engineers	215	25,16
Production Managers in Agriculture, Forestry and Fisheries	131	16,74
Engineering Professionals (excluding Electrotechnology)	214	12,45
Hotel and Restaurant Managers	141	11,85
Wood Processing and Papermaking Plant Operators	817	11,79
Life Science Technicians and Related Associate Professionals	314	11,72
Ship and Aircraft Controllers and Technicians	315	11,09
Electronics and Telecommunications Installers and Repairers	742	10,71
Market Gardeners and Crop Growers	611	10,38

Table 7. The 10 occupations at ISCO 3-digit level with the highest average share of green and digital skills

Afterwards, building on the ISCO 3-digit aggregation described above, we link the results with EU-LFS data to produce regional measures of skill embeddedness. These regional-level employment counts – calculated both in terms of raw frequencies and weighted by the individual sampling coefficients provided in the EU-LFS[4] - are obtained with a two-step aggregation procedure as follows. First, within each NUTS-2 region, we compute the share of workers employed in a given ISCO (1- or 3-digit) occupation relative to total regional employment. Second, we multiply this share by the corresponding ESCO-derived score of the occupation (average greenness, digitalness, twinness, green enablingness, digital enablingness, twin enablingness).

As a result, for each region–year observation we obtain a set of harmonised variables capturing the degree to which local employment structures embed green, digital, twin, and enabling skills. These indicators provide the basis for analysing the regional distribution of skill endowments and their evolution over time across Europe.

[4] In the subsequent analysis, we only rely on raw frequencies, as the results are extremely similar to those obtained using the individual sampling weights.

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4. Green, digital and twin occupations mapping in EU

4.1 Country-level analysis

We begin this section by providing an overview of the distribution of our occupation variables across countries. The initial reference set comprises the 27 Member States of the European Union plus Switzerland, Iceland and Norway. However, due to the absence of sufficiently detailed ISCO-08 codified occupational data, we excluded Bulgaria, Latvia, Malta and Slovenia from the analysis, resulting in a final sample of 26 countries.

Our primary variables of interest are: green occupations, digital occupations, and twin occupations. In addition, we construct the corresponding green-enabling, digital-enabling, and twin-enabling occupational categories. These variables are first computed at the ISCO-08 3-digit level. Specifically, for each NUTS-2 region and year, we calculate the share of each occupation (at the three-digit ISCO-08 level) over the total regional employment in that year.

We then aggregate these values by summing across NUTS-2 regions in order to derive country-level indicators, disaggregated by ISCO-08 1-digit occupation groups. Figure 4, Figure 5 and Figure 6 present the distribution of green, digital, and twin occupations, respectively, across Europe in 2022. The values are expressed as percentages of total national employment within each 1-digit occupational group. These figures provide a comparative snapshot of the sectoral and skill-based orientation of labour markets in the context of the twin transition.

Figure 4 displays the distribution of green occupations. A marked cross-country heterogeneity is observed, both in the overall incidence of green employment and in its occupational structure. Countries such as Romania and Greece exhibit relatively high shares of green jobs within low-skilled categories—particularly Elementary occupations and Skilled agricultural, forestry and fishery workers—indicating a green specialisation embedded in labour-intensive, often traditional sectors. By contrast, Sweden, Germany, and the Netherlands show higher concentrations in high-skilled occupations, notably among Professionals and Technicians, suggesting a green transition more aligned with knowledge-intensive and innovation-driven roles. This divergence underscores the dual nature of the green economy across Europe: while some Member States are embedding green practices into high-qualified occupations, others appear to rely on more operational or low-skilled green labour markets.

Figure 5 illustrates the distribution of digital occupations by country and occupational group. The pattern here is more polarised than in the green domain. Countries such as Finland, Sweden, Germany, and Ireland report a strong concentration of digital employment in high-skilled occupations—especially Professionals and Technicians and associate professionals—reflecting the advanced digital maturity and ICT-sector density of their economies. In contrast, Member States such as Romania, Check Republic and Hungary exhibit digital shares more concentrated in mid- or lower-skilled categories, such as Clerical support workers or Plant and machine operators. These differences suggest that while some countries have embedded digital competencies within core innovative sectors, others remain positioned in more peripheral or support-oriented digital functions. Notably, countries like France, Spain and Italy occupy an intermediate position, with non-negligible shares in technician roles but weaker representation among highly qualified digital professionals.

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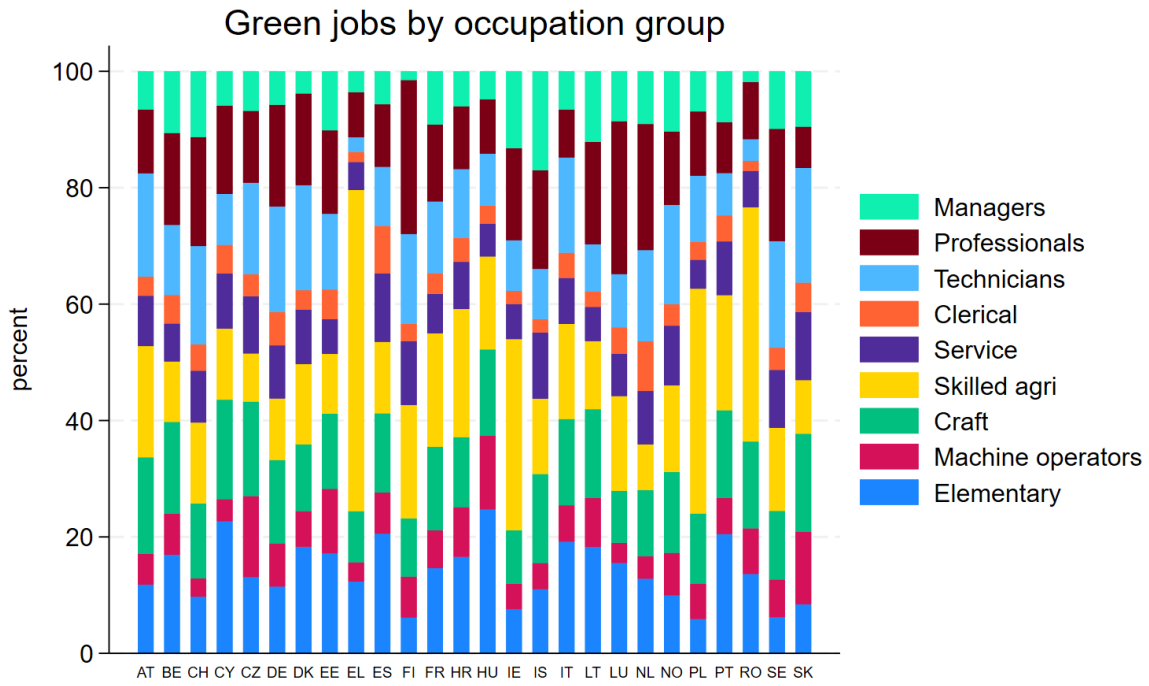

Figure 4. Green jobs by occupation group. Country comparison. 2022

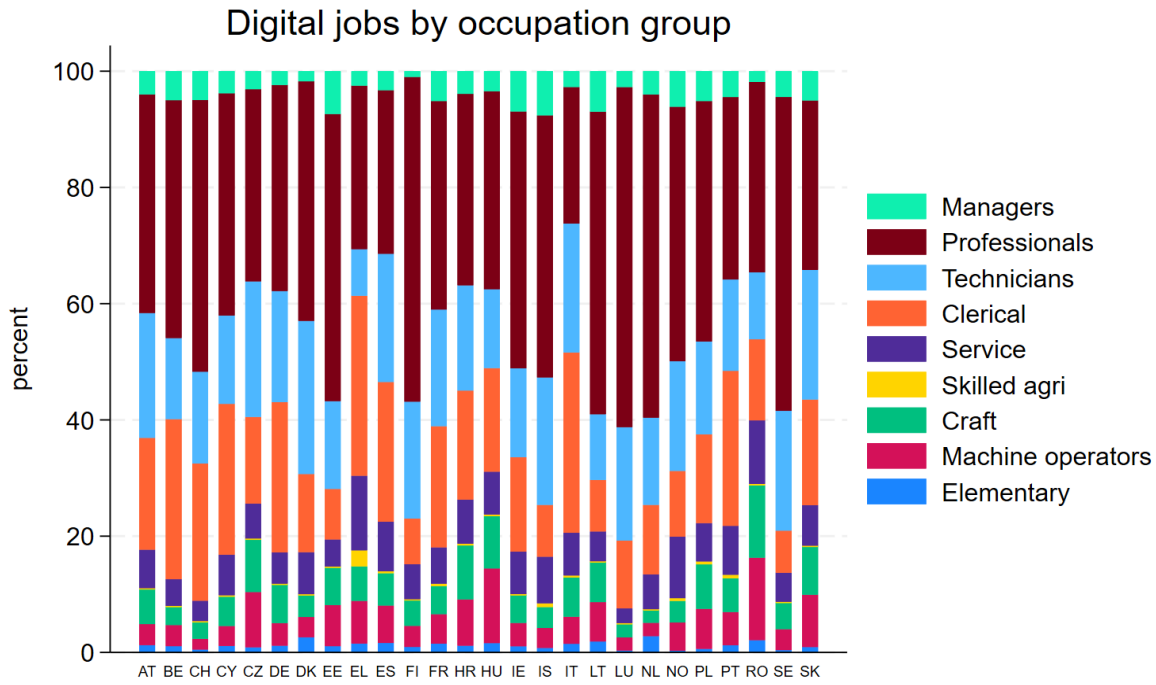

Figure 5. Digital jobs by occupation group. Country comparison. 2022

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Figure 4 and Figure 5 present a markedly divergent distribution of employment across occupational categories when comparing green and digital jobs. A key contrast emerges in the lower-skilled segments of the occupational hierarchy, particularly the ISCO-08 groups Skilled agricultural, forestry and fishery workers (group 6) and Plant and machine operators and assemblers (group 8). In green occupations, several countries display a non-negligible share of employment in lower-skilled categories. For example, in Romania, Greece, Poland, and Ireland, a substantial proportion of green jobs is concentrated in agriculture-related occupations (ISCO-08 group 6), where roles such as 'mixed crop and animal producers' or 'forestry and related workers' exhibit particularly high green content. This reflects a form of green specialisation anchored in resource-based sectors where environmental tasks are integrated into traditional activities such as sustainable farming, forestry management, or ecological conservation. Additionally, Plant and machine operators (group 8) also contribute meaningfully to green employment in some contexts, likely capturing roles related to recycling, waste processing, or energy-efficient production systems. By contrast, in the digital realm, we see a complete absence—or near-zero representation—of digital employment in these same occupational groups. The digital domain is more concentrated in high-skilled occupations, particularly Professionals (group 2) and Technicians and associate professionals (group 3), across virtually all countries. This polarised structure suggests that digital competencies remain tightly bound to formal education and knowledge-intensive roles, with limited penetration into manual or operational job categories.

Green jobs display a more transversal occupational profile, spanning both high- and low-skilled categories, rather than being confined to knowledge-intensive roles alone. This broader distribution suggests that the green transition may engage a wider share of the workforce across diverse sectors and qualification levels. However, the extent and nature of this inclusiveness vary considerably across countries, reflecting structural differences in labour markets and production systems. By contrast, digital employment remains more narrowly concentrated in high-skilled occupations, raising concerns that, without deliberate policy intervention, the digital transition could exacerbate existing inequalities in access to emerging labour market opportunities. In sum, the green transition appears to be more occupationally inclusive, characterised by a dual structure that encompasses both high- and low-skilled roles. In contrast, the digital transition remains more concentrated and exclusive, confined to a narrower set of occupations that typically require higher qualifications and are more directly aligned with advanced educational pathways.

Figure 6 presents the distribution of twin occupations—those simultaneously requiring both green and digital competencies—across countries and occupational groups. The pattern is the most fragmented among the three domains. While countries like Ireland, Luxemburg and Sweden maintain leading positions in high-skilled categories, particularly among Managers and Professionals, many countries show prevalent concentration in other occupational profiles. In Romania, Hungary and Slovakia, twin jobs appear predominantly in lower-skilled groups such as Elementary occupations and Plant and machine operators, indicating that the integration of green and digital tasks is currently more operational than strategic. These results point to an uneven diffusion of hybrid skill sets across the EU. In some contexts, twin transitions are being institutionalised through highly qualified roles, while in others, they emerge as task-based adaptations within manual occupations. The asymmetry across the occupational ladder further highlights the different institutional capacities and industrial structures underpinning the twin transition in each country.

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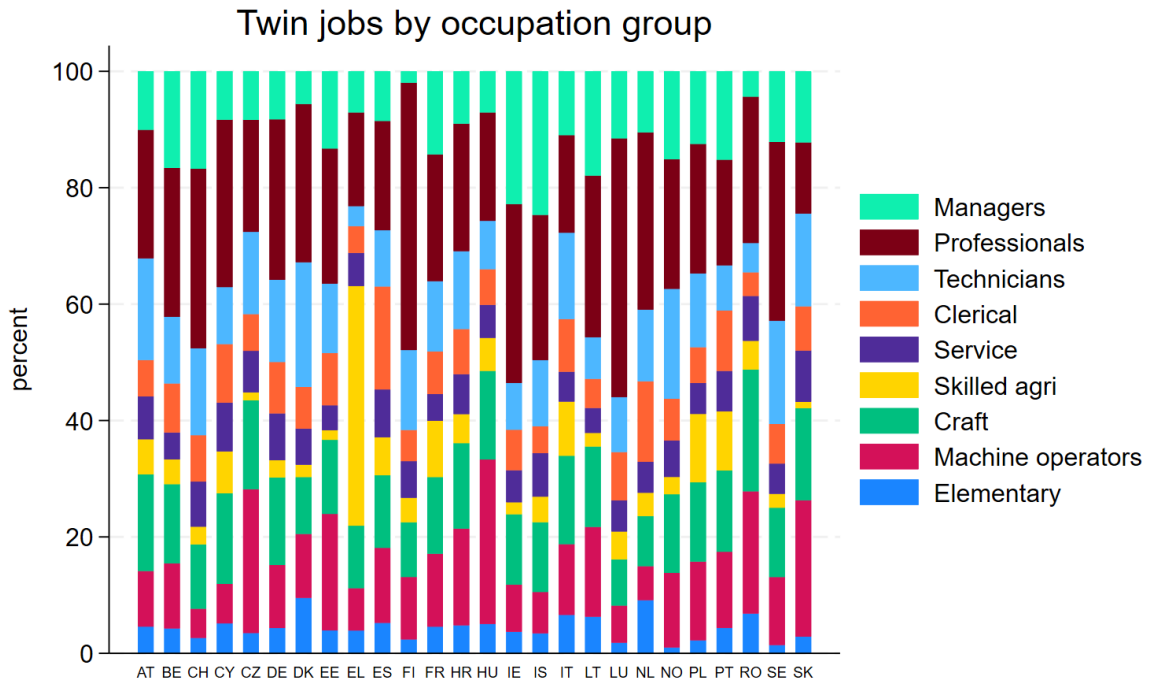

Figure 6. Twin jobs by occupation group. Country comparison. 2022

Figure 6, which presents the distribution of twin occupations, reveals a profile that combines features of both green and digital employment, yet aligns more closely with the structure observed in Figure 4 (green occupations) than with that in Figure 5 (digital occupations). Twin jobs are present across a broader set of occupational groups, including lower-skilled categories such as Skilled agricultural, forestry and fishery workers (ISCO-08 group 6), Plant and machine operators (group 8), and Elementary occupations (group 9)—all of which are prominent in the green domain but almost entirely absent from the digital one. This suggests that in several countries, particularly those with more traditional production structures, the integration of green and digital components is occurring in roles that are operational, rather than knowledge-intensive. At the same time, twin occupations also show some representation in high-skilled groups such as Professionals (group 2) and Technicians (group 3), mirroring the distribution seen in digital employment. These roles likely reflect the emergence of hybrid expertise at the intersection of environmental and technological domains, such as sustainability engineering, data-driven resource management, or green tech deployment. Taken together, the occupational structure of twin employment suggests a dual character: it extends the inclusiveness of green jobs by reaching into mid- and low-skilled categories, while also replicating the skill concentration typical of digital jobs at the upper end of the occupational hierarchy.

Taken together, Figure 4 to Figure 6 reveal distinct yet interrelated patterns in the sectoral and occupational structuring of green, digital, and twin employment across the European Union. While all three domains exhibit substantial cross-country heterogeneity, the nature and depth of that heterogeneity vary significantly. Green occupations show the widest dispersion across the skill spectrum, with certain countries (e.g., Romania, Greece, and Hungary) demonstrating a concentration in low-qualified groups—such as Elementary occupations and Skilled agricultural workers—whereas others (notably Sweden, Germany, and Luxemburg) display a more skill-intensive green employment

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structure. This bifurcation suggests alternative national pathways to environmental transition: one anchored in traditional sectors and the other in technologically advanced domains. Digital occupations, by contrast, are more sharply skewed toward high-skilled employment, particularly in northern and north-western Member States. Here, Professionals and Technicians dominate the digital labour landscape, reflecting the institutional embeddedness of ICT-intensive sectors in these economies. Countries on the periphery of this transition display digital employment mainly in mid- or low-skilled occupations, reinforcing the notion of a segmented digital uptake across Europe. Twin occupations—which combine green and digital skill requirements—are still in a formative phase and exhibit the most fragmented and asymmetric pattern. Advanced countries tend to concentrate twin jobs in high-skilled roles, while others show early evidence of hybridisation in operational tasks performed by lower-qualified workers.

Takeaway #2.
Green jobs span the entire skill spectrum, whilst digital jobs mostly concentrate in high-skilled roles.

Let us now move to explore the country distribution of enabling occupations. Figure 7 illustrates the distribution of green-enabling occupations, defined as roles not intrinsically green but functionally connected to green tasks through their associated skill sets. The figure highlights the presence of functionally adjacent occupations that, while not themselves green, possess skill profiles closely aligned with green activities. As such, it offers insight into the latent capacity of national labour markets to support the green transition. Countries such as Sweden, Finland, the Netherlands and Switzerland exhibit significant presence of green-enabling employment in mid- to high-skilled categories, notably among Professional and Technicians, and even Clerical Service and Sales workers. This suggests that these countries have developed institutional and organisational ecosystems where auxiliary roles—such as technical coordination, administrative planning, or environmental compliance—contribute structurally to green transformation. Conversely, countries which had shown specialisation in low-skilled green occupations, appear less represented in enabling roles.

Figure 8 presents the distribution of digital-enabling occupations, i.e. those roles that support digital processes without directly producing or applying digital technologies. A marked cross-country differentiation emerges. Advanced digital economies—such as Luxemburg, Sweden, Germany, and Finland—report a high incidence of digital enabling roles in both high- and mid-level occupations, particularly Managers, Technicians, and Clerical support workers. This configuration may suggest that digital transformation in these contexts is related to both ICT-specialised tasks, and also embedded across organisational structures, including supervisory, administrative, and coordination functions. On the other hand, countries such as Greece and Romania, which had displayed some positive incidence of digital core jobs in lower-skilled segments (e.g., machine operators), are also under-represented in highly qualified enabling roles.

Figure 9 shows the distribution of twin-enabling occupations—roles whose skill content positions them to support both green and digital functions, even though they are not directly embedded in either domain. This set of occupations constitutes the connective tissue of the twin transition, requiring an alignment of technical, procedural, and organisational capacities across two distinct but converging domains. The distribution is notably uneven. Sweden, Germany, and the Netherlands again exhibit strong relative presence in mid- and high-skilled categories—particularly among Technicians, Clerical support workers, and Service employees—suggesting that their labour markets are developing

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integrated structures capable of supporting complex coordination across green and digital domains. In contrast, several eastern and southern Member States, including Greece, Romania, and Hungary, show an incidence of twin-enabling roles mostly in low-skilled occupations. This divergence may point to a lack of capacity to bridge digital and green functions to the more decisional positions in the occupation ladder.

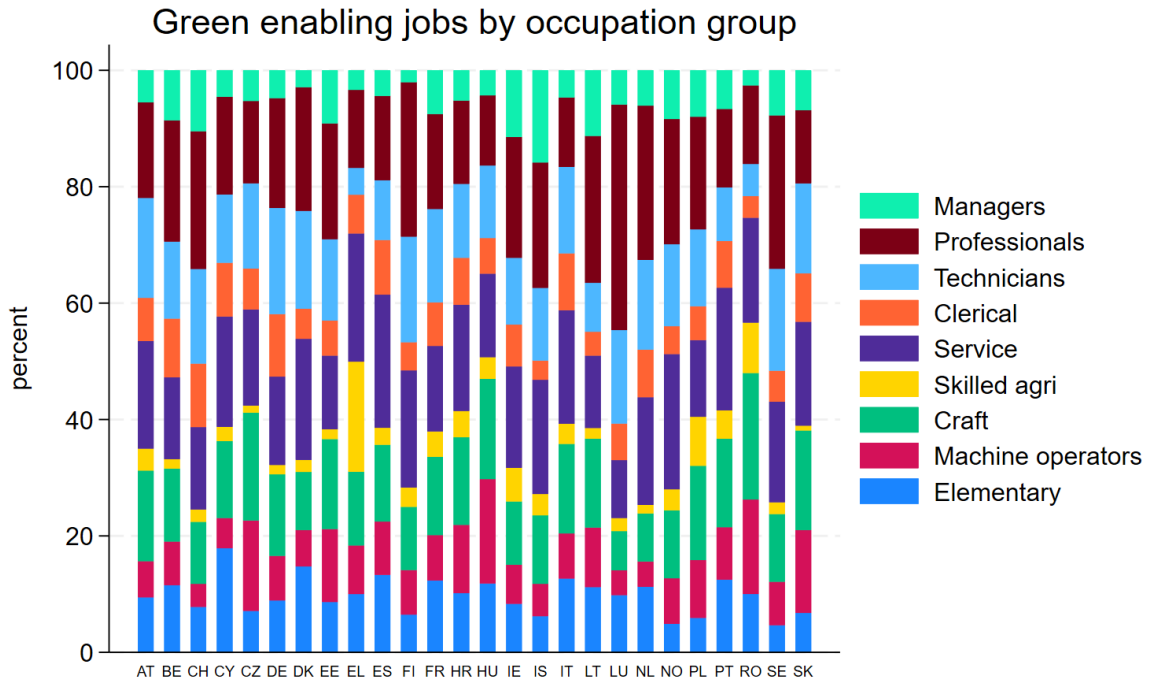

Figure 7. Green enabling jobs by occupation group. Country comparison. 2022

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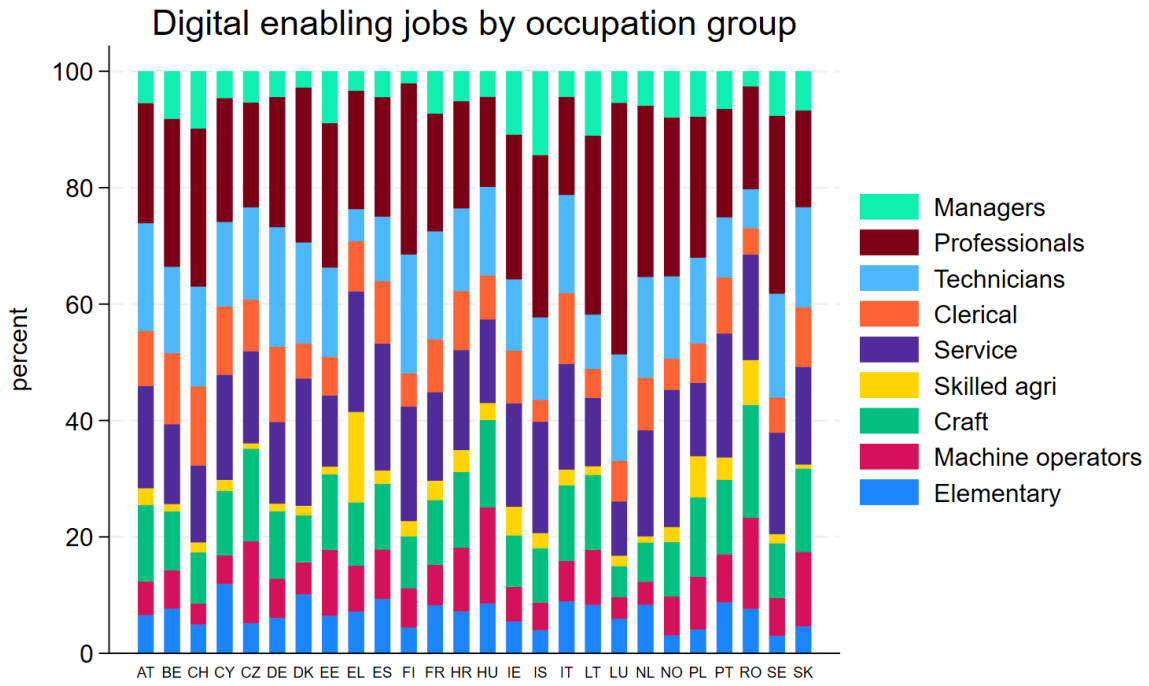

Figure 8. Digital enabling jobs by occupation group. Country comparison. 2022

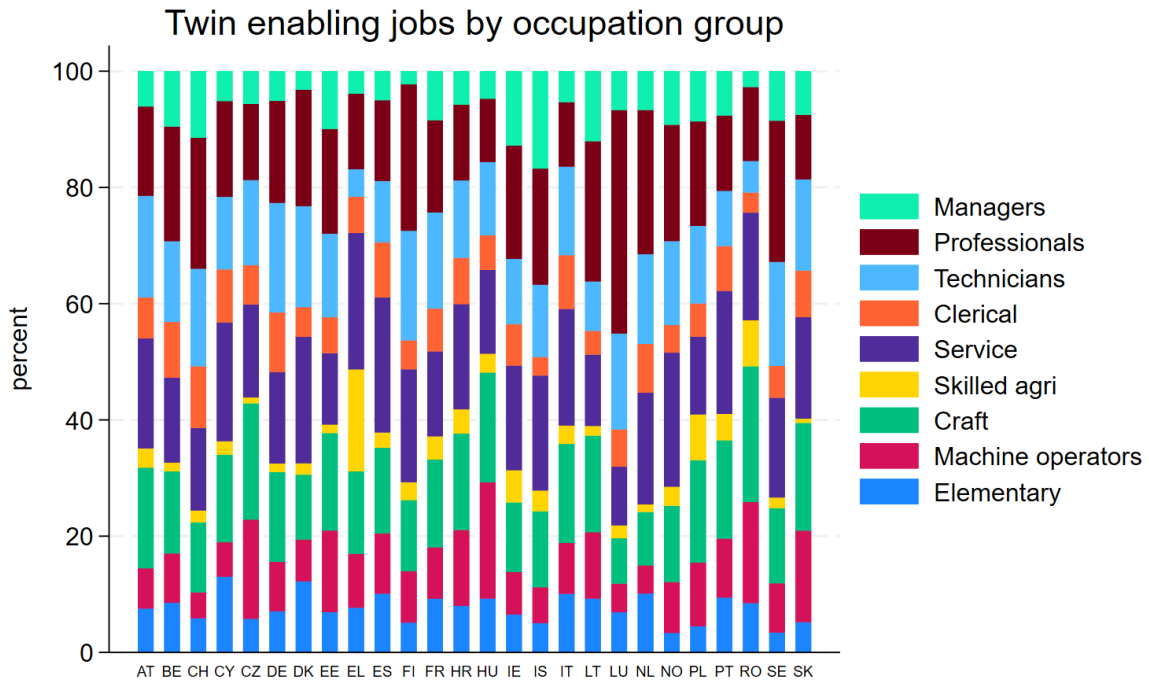

Figure 9. Twin enabling jobs by occupation group. Country comparison. 2022

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To complement the descriptive evidence presented in Figure 4 to Figure 9, we next turn to a comparative index-based analysis aimed at quantifying the degree of occupational specialisation across countries. Specifically, we compute relative advantage indicators by benchmarking each country's share of employment in green, digital, twin, and enabling occupations against the corresponding EU-wide average. This allows us to move beyond absolute distributions and assess how national labour markets are positioned—both in core and adjacent roles—with respect to the twin transition. The relative advantage index for each country, year, and occupation group, is defined as follows:

$$Relative\ Advantage_{c,y,g} = \log\left(\frac{s_{c,y,g}}{s_{EU,y,g}}\right)$$

Where $s_{c,y,g}$ denotes the share of employment in group g (e.g. green, digital, twin, or enabling) in country c and year y, and $s_{EU,y,g}$ denotes the corresponding share at the European level. This transformation implies that:

- $Relative\ Advantage_{c,y,g} > 0$ indicates a higher-than-EU average specialisation in that occupation group.
- $Relative\ Advantage_{c,y,g} < 0$ indicates a lower-than-EU average specialisation.

We adopt a log-transformed version of the standard Balassa index (Balassa, 1965) to compute relative occupational specialisation. While the original index identifies comparative advantage when a country's share exceeds the EU average (i.e. values above 1), it is not symmetric around the benchmark: for example, values of 2 and 0.5 represent unequal deviations above and below the reference point. Taking the natural logarithm resolves this asymmetry, producing a scale centred at zero and enabling a more intuitive interpretation of over- and under-representation, especially in graphical analysis. We adopt a log-transformed variant of the RCA index (Balassa, 1965), commonly employed for analytical symmetry and easier interpretation of relative specialisation.

Compared to the standard Balassa index (where values above 1 indicate specialisation and below 1 indicate under-representation), this log transformation simplifies interpretation and graphical representation, particularly in visual comparisons where a zero-centred scale is more intuitive. While related alternatives such as the symmetric RCA index (e.g., Dalum et al., 1998) exist, the log formulation directly expresses deviations in logarithmic terms and is suited to comparative graphical analysis.

The figures below illustrate the country-level relative advantage in green, digital, twin, and enabling occupations, disaggregated by occupational group. Figure 10 reveals marked heterogeneity in countries' relative specialisation in green occupations across different skill levels. Greece, Romania, Hungary, and Latvia exhibit strong comparative advantage in lower-skilled categories, notably Elementary occupations and Skilled agricultural, forestry and fishery workers. This suggests that green employment in these countries remains closely linked to resource-based sectors and manual environmental tasks. In contrast, Sweden, Germany, the Netherlands, Luxembourg show higher-than-average specialisation in high-skilled groups such as Professionals and Technicians and associate professionals. Intermediate cases, including France, Italy, and Portugal, present modest specialisation across both mid- and high-level occupations, suggesting a partially integrated green labour structure. This configuration points to a more knowledge-intensive green transition. The divergence across the

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skill ladder highlights two distinct national pathways: operational green employment versus technologically embedded green specialisation.

Figure 11 reports the distribution of the relative advantage of digital occupations. The distribution of relative specialisation in digital occupations is more polarised. Sweden, Finland, Germany, Ireland, and Luxembourg show strong positive values in high-skilled occupational groups, particularly Professionals and Technicians. This indicates the structural embedding of digital capabilities within innovation-driven sectors. By contrast, Greece, Romania, Hungary, and Latvia record comparative advantage mainly in lower or mid-skilled categories such as Clerical support workers or Machine operators, and exhibit under-representation in high-skilled digital roles. France, Italy, and Portugal again occupy an intermediate position, with modest strength in technician roles but weaker representation among higher-level digital occupations. This fragmented pattern underscores pronounced asymmetries in digital labour market structures across European countries.

Twin occupations—those requiring both green and digital competencies— are displayed in Figure 12 and show a quite fragmented and uneven distribution among the three domains. Sweden, Germany, and Finland maintain relative advantage in high-skilled occupations such as Professionals and Technicians, reflecting the emergence of hybrid expertise in advanced contexts. Conversely, Greece, Romania, Hungary, and Slovakia show comparative advantage in lower-skilled categories, particularly Elementary occupations and Plant and machine operators, suggesting that twin roles in these countries are more operational and task-based. Countries including Italy, Portugal, and Latvia show a mixed profile with moderate specialisation across both low- and mid-level occupations. This duality suggests that the integration of green and digital functions is still in a formative stage, with uneven diffusion across occupational hierarchies. The reversal in country rankings across the skill hierarchy indicates that while some countries are integrating twin skills into strategic roles, others are experiencing hybridisation primarily in manual or routine occupations.

Taken together, these patterns reveal important structural asymmetries in how European countries are positioned with respect to the green, digital, and twin transformations. Countries such as Germany, Sweden, and Finland tend to be specialised in high-skill domains, suggesting mature labour market systems aligned with innovation-driven growth. On the other hand, countries like Greece, Romania, and Hungary show higher relative specialisation in lower-qualified occupations, especially within the green and twin domains. These differences point to qualitatively distinct trajectories of transition, with some countries embedding green and digital dimensions in strategic and technical roles, while others reflect more operational or peripheral integration. The fact that rankings shift so noticeably across occupational groups indicates that national specialisation in green and digital employment cannot be assessed independently of occupational structure.

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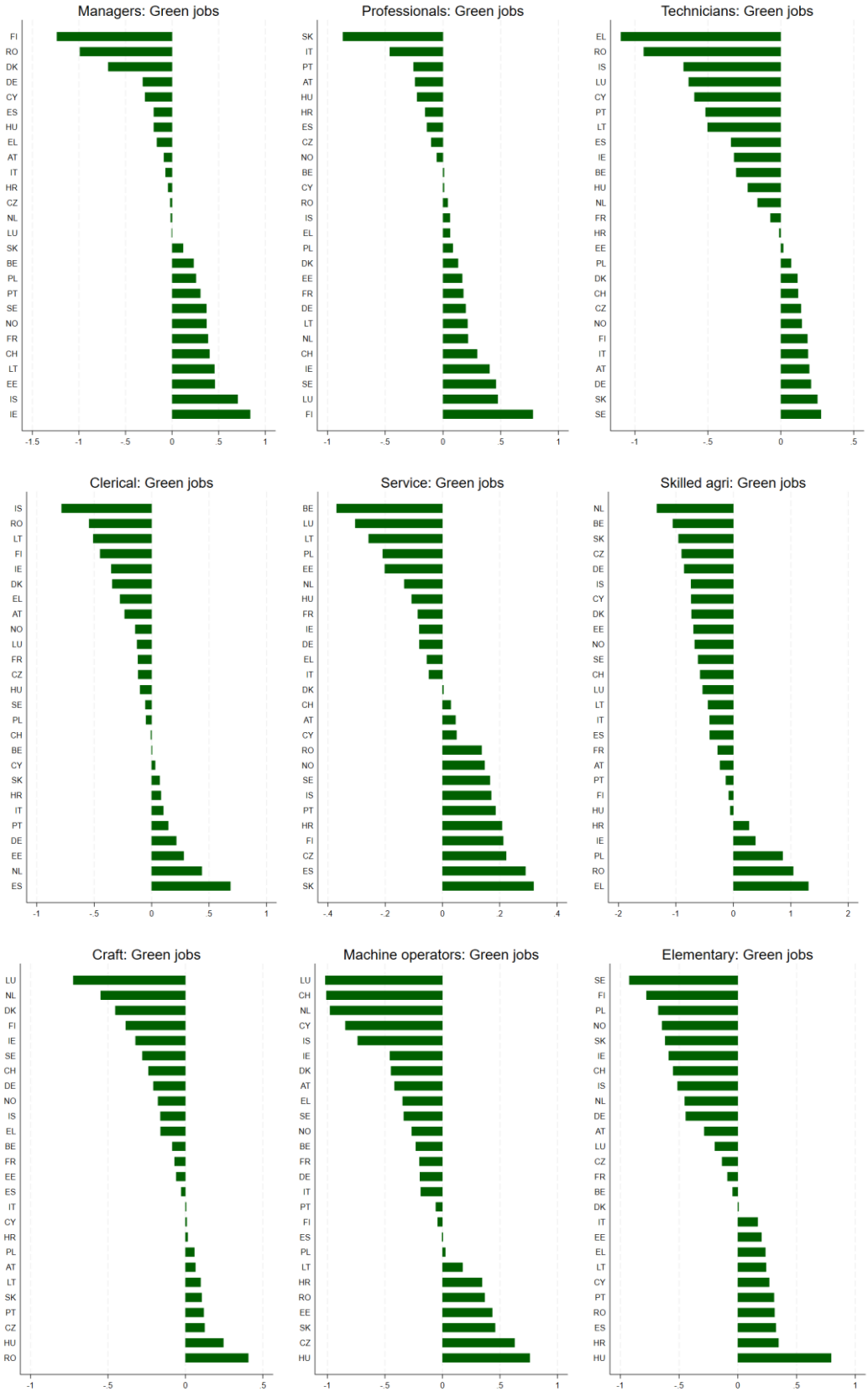

Figure 10. Relative comparative advantage of green occupations. Country comparison. 2022

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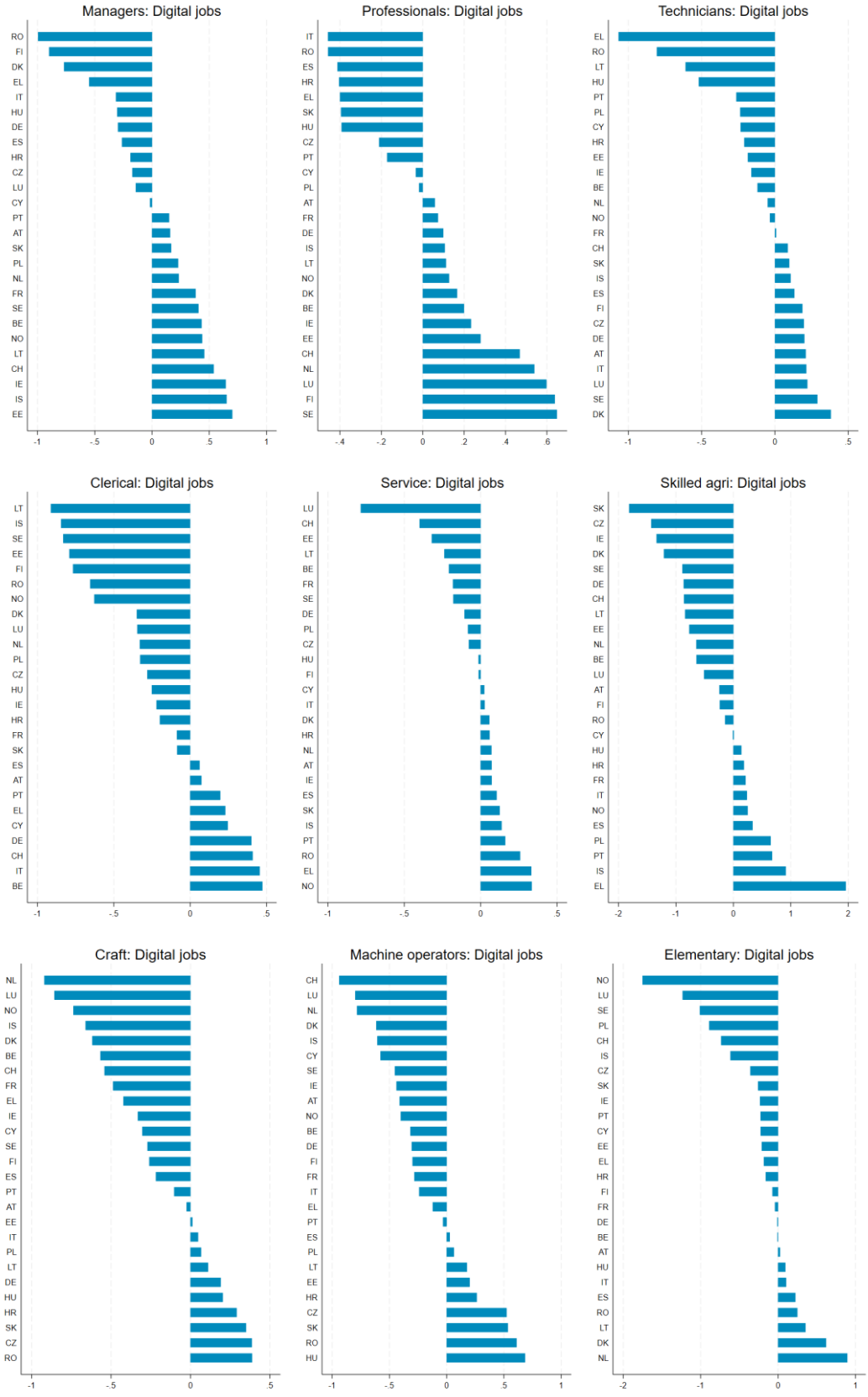

Figure 11. Relative comparative advantage of digital occupations. Country comparison. 2022

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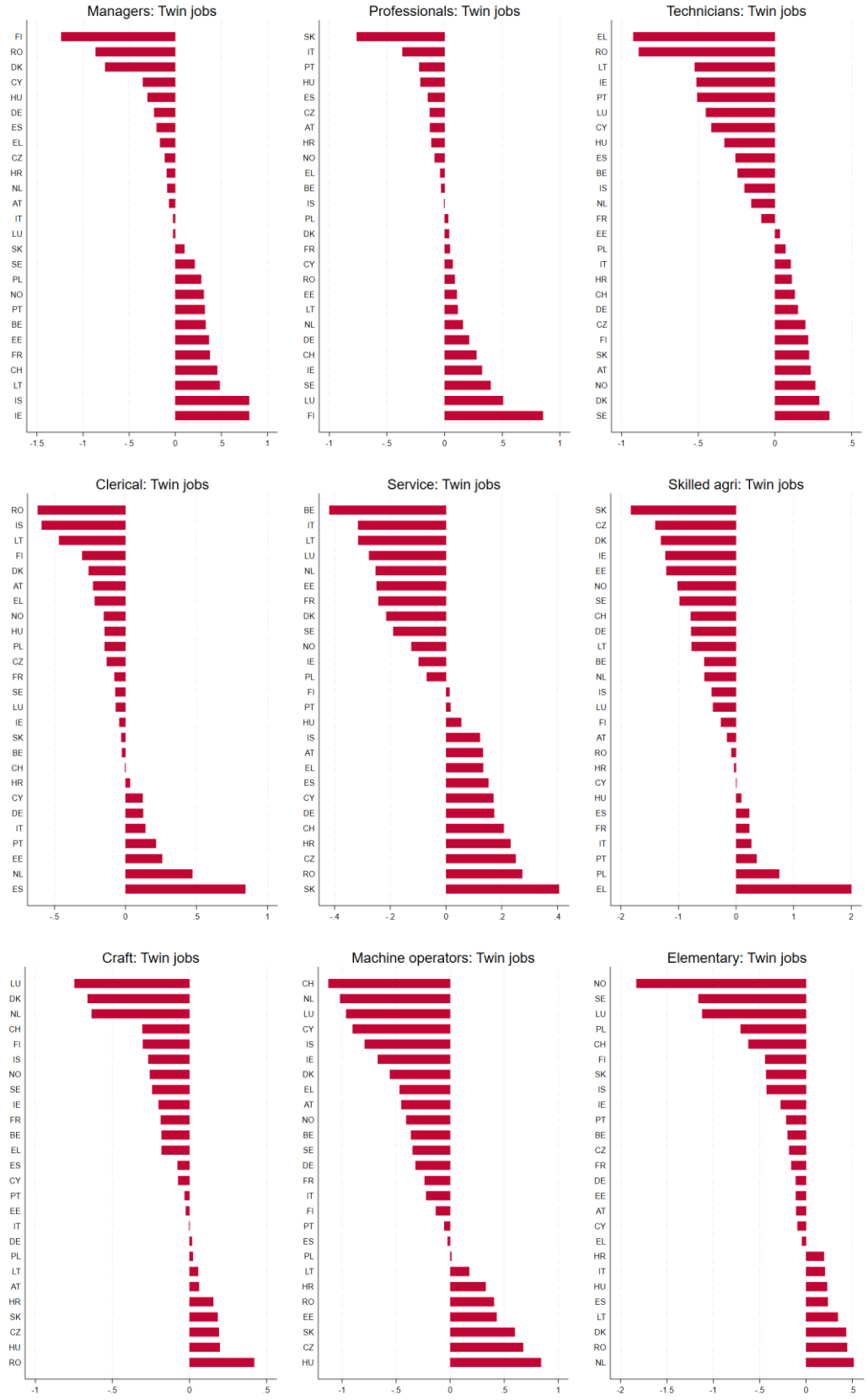

Figure 12. Relative comparative advantage of twin occupations. Country comparison. 2022

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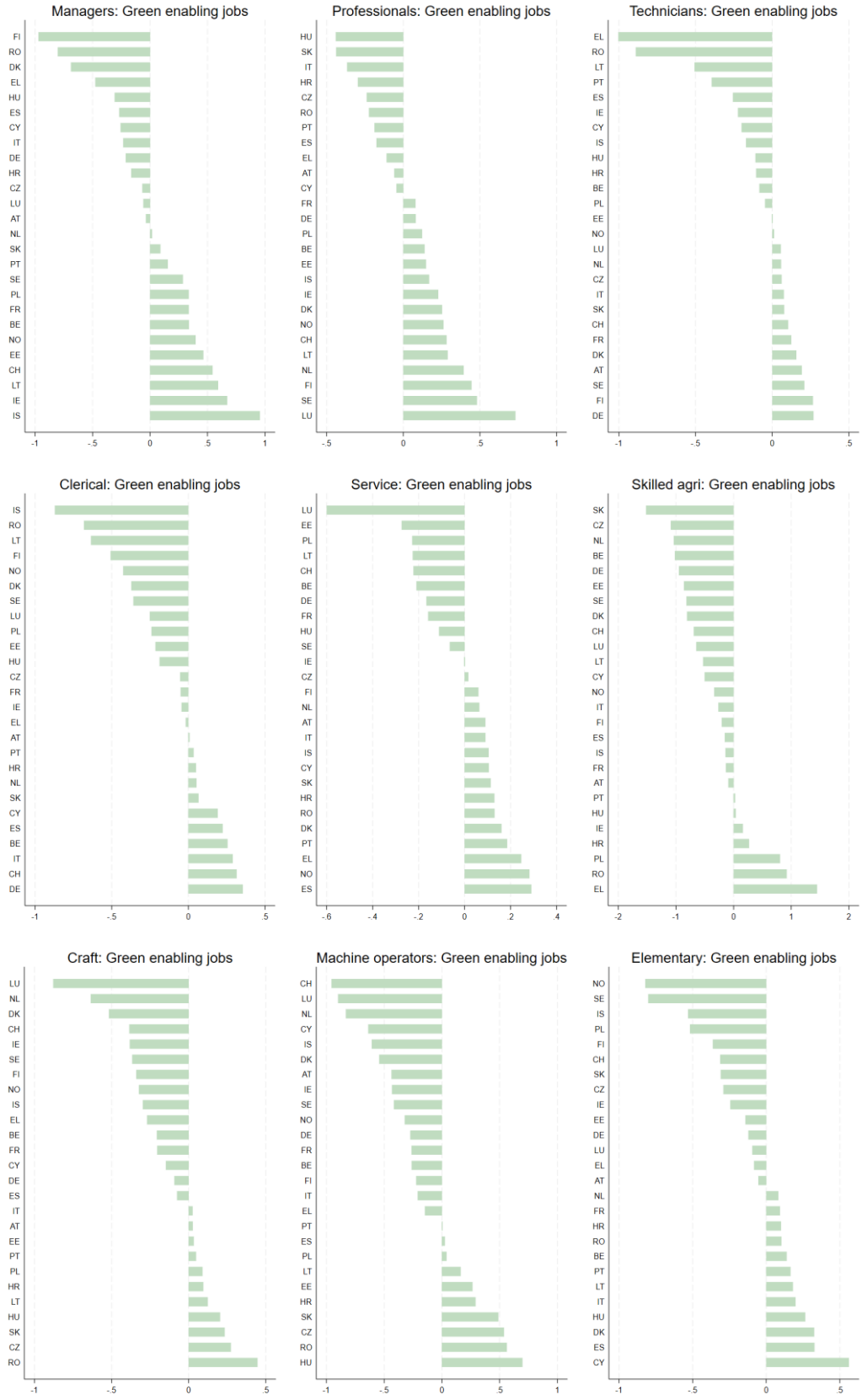

Figure 13. Relative comparative advantage of green enabling occupations. Country comparison. 2022

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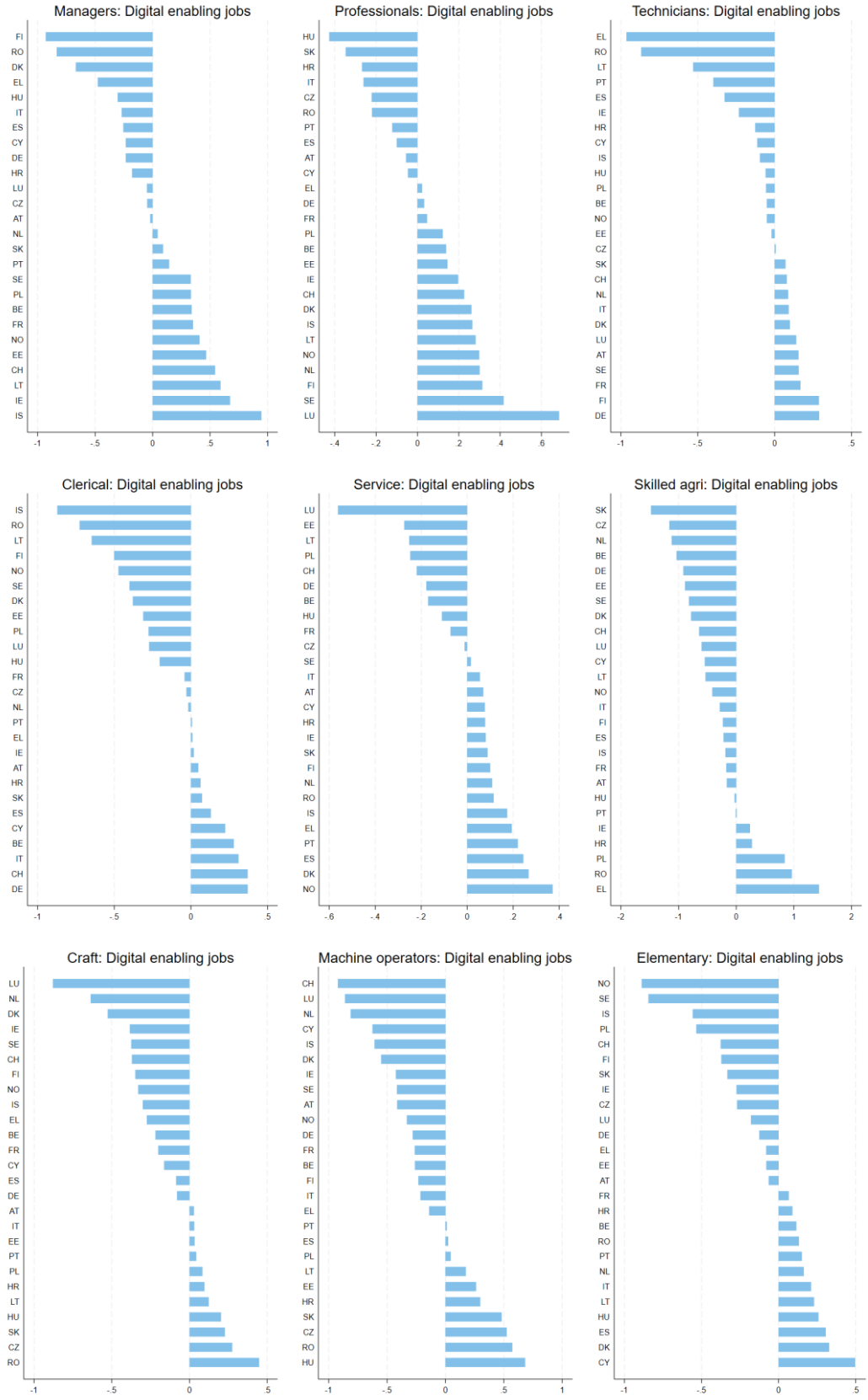

Figure 14. Relative comparative advantage of digital enabling occupations. Country comparison. 2022

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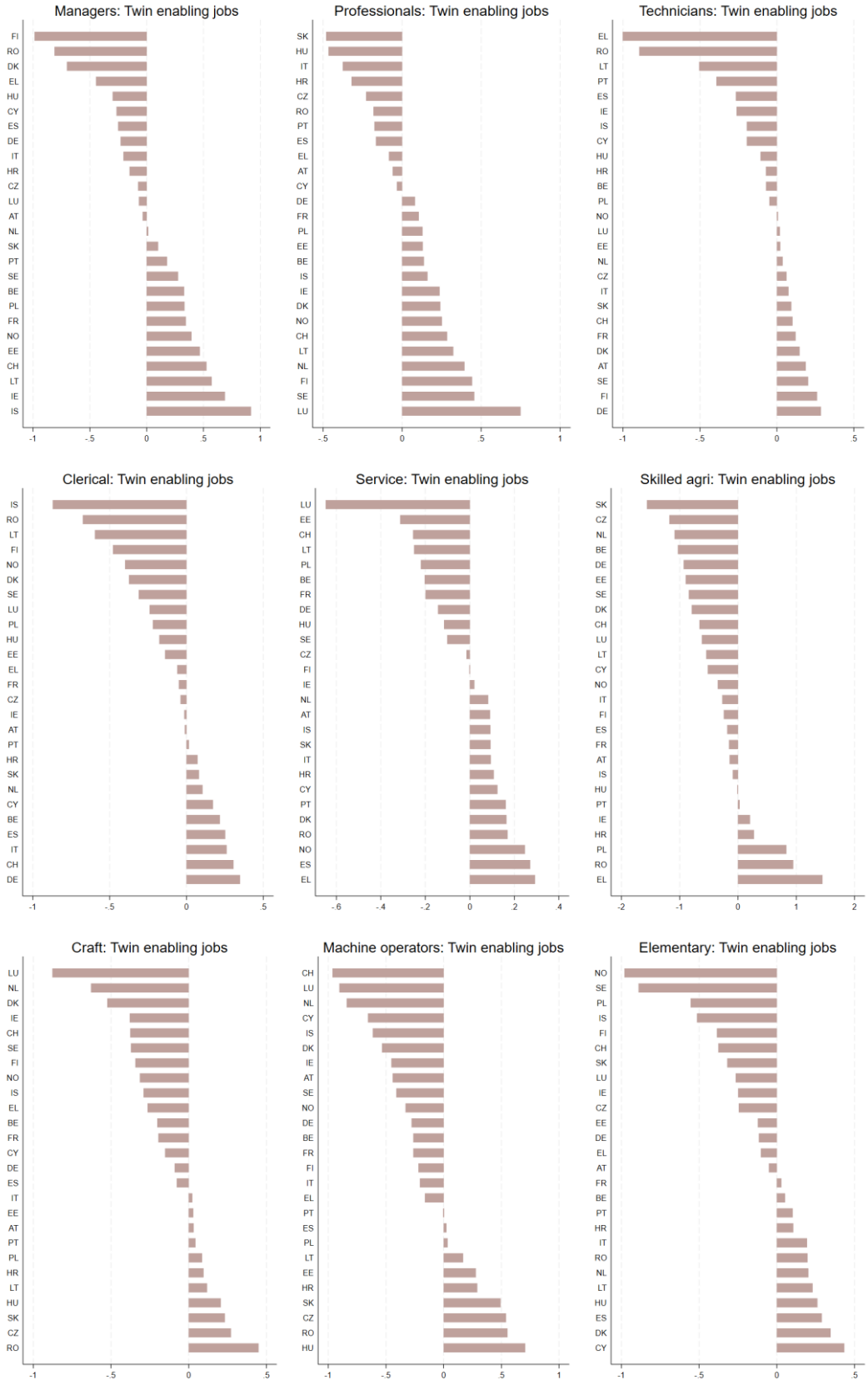

Figure 15. Relative comparative advantage of twin enabling occupations. Country comparison. 2022

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Figure 13 displays the relative advantage in green enabling occupations, highlighting those roles that, while not themselves classified as green, contribute functionally to the green transition (e.g., through administrative, technical, or logistical support). A key pattern here is the widening of green-related occupational presence across the skill distribution. Several countries that had shown strong specialisation in core green occupations—such as Germany, Sweden, and the Netherlands—also maintain a positive advantage in green enabling roles, particularly among Technicians, Clerical support workers, and even Service workers. This suggests that their green specialisation is embedded within broader labour market structures, not limited to a narrow elite of technical professionals. Conversely, Romania, Greece, and Hungary—which had demonstrated high specialisation in low-skill core green roles—appear more dispersed or even under-represented in green enabling occupations. Intermediate cases such as France, Italy, and Portugal reflect moderate integration of enabling roles across the skill ladder.

Figure 14 focuses on digital enabling occupations—roles that do not directly involve digital production or innovation, but are functionally linked to digital processes and tools. These include administrative, coordination, and supervisory functions that support digital operations. Countries such as Sweden, Germany, and Finland again demonstrate strong and consistent relative advantage in higher- and mid-level digital enabling occupations. Notably, Managers, Clerical workers, and Technicians all feature prominently in these countries' profiles. This may reflect the organisational integration of digital functions, suggesting that digital transformation is not confined to core technical roles but permeates managerial and operational layers as well. In contrast, countries like Romania and Slovakia appear more represented in digital enabling occupations of low-skill contents.

Figure 15 illustrates the distribution of twin enabling occupations, representing roles that support both green and digital functions without being intrinsically embedded in either. These are perhaps the most structurally complex occupations, requiring institutional and organisational alignment between two distinct (yet increasingly convergent) domains. The distribution is markedly uneven. The picture that emerge is very similar to the ones seen so far, with a marked divergence between countries. This divergence suggests that while some tasks may be hybridised at the operational level, the broader support structures necessary to sustain the twin transition remain heterogeneous. This fragmentation underlines the twin transition's dependence not only on occupational innovation, but also on institutional infrastructure and workforce coordination across domains.

When read in conjunction with the patterns observed in core green, digital, and twin occupations (Figure 10, Figure 11 and Figure 12), the enabling occupation profiles offer a deeper understanding of national trajectories. Countries like Sweden, Germany, and Finland not only lead in high-skilled core roles, but also show strong presence in enabling occupations—indicating broad-based and institutionally integrated transitions. In contrast, Greece, Romania, and Hungary display relative advantage in selected low-skilled core and enabling occupations. This highlights that the patterns of the green, digital, and twin transitions in these countries are likely to remain concentrated within the same occupational groups that currently characterise their trajectories, with limited prospects for upward mobility towards more highly qualified roles.

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Takeaway #3
Advanced regions dominate high-skilled green, digital, and twin occupations, whilst Eastern and Southern European regions specialise in lower-skilled variants, creating a dual-track transition across Europe.

4.2 Regional-level analyses throughout EU-LFS

4.2.1 Aggregate regional distribution of green, digital, twin and enabling occupations

We now turn our attention to regional-level analyses, which constitute the core of this report, as we are interested in mapping the distribution of green, digital, and twin occupations across regions and over time. Our temporal scope spans from 2016 to 2022, a choice motivated by two principal considerations. First, extending the analysis further back in time would render the assumption that job content remains constant increasingly difficult to defend. Indeed, we can reasonably expect occupations to evolve in the tasks they encompass, and consequently in their skills content. Our skill-occupation matrix and the green and digital skills classifications are time-invariant and refer to relatively recent years, as the ESCO version adopted represents the most recent framework developed in 2023. Second, we restrict our analysis to the 2016-2022 period because ISCO-08 data are available only for more recent years, and applying our occupation-skills matrix through an ISCO-level crosswalk would diminish the robustness of our analytical framework.

Let us recall that our variables of interest—green, digital, and twin jobs—are calculated as the share of each ISCO-08 3-digit occupation in the total number of occupations within that region-year. This share is then multiplied by the green, digital, or twin content of that occupation, where such content is calculated as described in Section 3. These occupation-level measures are subsequently aggregated at the regional level using the arithmetic mean. According to these metrics, Table 8 to Table 13 report the top and bottom 10 regions for each of these three occupation types: green jobs (Table 8 and Table 11), digital jobs (Table 9 and Table 12), and twin jobs (Table 10 and Table 13). It is important to note that this aggregation method combines occupations from all ISCO-08 groups, thereby neglecting the heterogeneity across major occupation categories that was documented in the previous section. Later in this section, we shall provide additional analysis examining variation across occupation groups at the regional level to address this limitation.

Looking at these tables, several patterns emerge that reinforce and extend the country-level findings discussed in the previous section. Green occupations show a pronounced geographical polarisation that aligns closely with the occupational structure observed in the country-level analysis. The top-performing regions are concentrated in Romania, Poland, and Greece—countries that, as demonstrated in Figure 1, exhibited strong specialisation in lower-skilled green occupations, particularly in elementary occupations and skilled agricultural work. Nord-Est (Romania) leads with a green jobs score of 0.067, followed by Podlaskie (Poland) and Sud-Vest Oltenia (Romania). This pattern suggests that green employment in these regions remains anchored in traditional, resource-based sectors where environmental practices are integrated into labour-intensive activities such as sustainable farming, forestry management, or ecological conservation. These patterns indicate that the concentration of green jobs in low-skilled occupations is more prevalent than their concentration

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in high-skilled occupations, mostly seen in Nordic and Western European countries, which is expected given that low-skilled green jobs tend to be more labour-intensive than their high-skilled counterparts.

Conversely, the bottom 10 regions for green occupations are dominated by capital regions and economically advanced areas—Hovedstaden (Denmark), Berlin (Germany), and various Belgian provinces—precisely those countries that Figure 1 showed to have higher concentrations of green employment in high-skilled categories. This apparent paradox reflects our aggregation methodology, which captures the overall intensity of green occupations across all skill levels. These advanced regions likely concentrate their green employment in highly specialised, knowledge-intensive roles that, whilst strategically important, represent a smaller share of total regional employment.

Digital occupations display a markedly different spatial distribution that mirrors the polarised pattern identified in Figure 2. The top 10 regions are dominated by capital cities and major metropolitan areas: Stockholm, Helsinki-Uusimaa, Zürich, Praha, and Budapest. This concentration reflects the advanced digital maturity and ICT-sector density of these urban economies, where digital employment is embedded within core innovative sectors and concentrated among professionals and technicians. The presence of Bucureşti-Ilfov (Romania) in the top 10, despite Romania's overall positioning in mid-skilled digital categories, underscores the metropolitan concentration effect where capital regions often diverge significantly from their national averages.

The bottom 10 digital regions are predominantly rural or peripheral areas, including several Greek regions (North Aegean, Ανατολική Μακεδονία Θράκη) and Romanian regions (Nord-Est, Sud-Est), confirming the fragmented digital uptake across Europe identified in the country-level analysis.

Twin occupations (Tables 3 and 6) exhibit the most heterogeneous pattern among the three domains, reflecting the formative stage of hybrid skill integration. Notably, Greek regions dominate the top rankings—Peloponnese, Ανατολική Μακεδονία Θράκη, and Thessaly—which appears counterintuitive given Greece's positioning in lower-skilled categories for both green and digital occupations individually. This suggests that twin occupations in these regions may indeed be emerging primarily in operational and task-based roles rather than strategic, high-skilled positions, as suggested by Figure 3.

The bottom 10 twin regions include several advanced areas such as Belgian provinces, Danish regions, and Norwegian territories. This pattern reinforces the notion that whilst these regions may excel in either green or digital specialisation separately, the integration of both domains into hybrid occupations remains limited. The presence of capital regions like Hovedstaden (Denmark) in the bottom rankings suggests that even economically advanced areas face challenges in developing integrated twin competencies.

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Country	Region	Green jobs score
Romania	Nord-Est	.067097
Poland	Podlaskie	.0636184
Romania	Sud-Vest Oltenia	.0587319
Greece	Peloponnese	.0586526
Poland	Masovian region	.0577544
Greece	Eastern Macedonia and Thrace	.0576809
Greece	Thessaly	.0568882
Greece	Central Greece	.055327
Greece	Western Greece	.0535274
Greece	North Aegean	.0534798

Table 8. Top 10 regions by green occupations. 2022

Country	Region	Digital jobs score
Sweden	Stockholm	.1228286
Finland	Helsinki-Uusimaa	.1182293
Switzerland	Zürich	.1179962
Czech Republic	Praha	.117489
Hungary	Budapest	.108423
Germany	Berlin	.107761
Belgium	Prov. Vlaams-Brabant	.1076548
Romania	Bucureşti-Ilfov	.1062517
Belgium	Prov. Brabant wallon	.1029712
France	Ile-de-France	.1028833

Table 9. Top 10 regions by digital occupations. 2022

Country	Region	Twin jobs score
Greece	Peloponnese	.0430509
Greece	Eastern Macedonia and Thrace	.0368701
Greece	Thessaly	.0368014
Greece	Central Macedonia	.0332546
Greece	Western Macedonia	.0331795
Greece	North Aegean	.0317799
Spain	La Rioja	.0304043
Romania	Vest	.0302433
Greece	Central Greece	.0299383
Poland	Dolnośląskie	.0293101

Table 10. Top 10 regions by twin occupations. 2022

These regional patterns collectively underscore the structural asymmetries identified in the country-level analysis, whilst revealing important within-country variations. The geographic concentration of digital occupations in metropolitan areas contrasts sharply with the more dispersed distribution of green occupations, reflecting fundamentally different spatial logics of economic organisation. Twin

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occupations, being at the intersection of these two domains, display the most complex and uneven spatial pattern, suggesting that the twin transition is still in its early stages and follows diverse regional trajectories across Europe.

Country	Region	Green jobs score
Denmark	Hovedstaden	.0196673
Belgium	Prov. Vlaams-Brabant	.0196807
Romania	Bucureşti-Ilfov	.0197503
Germany	Berlin	.0203325
Slovakia	Bratislavský kraj	.0213884
Belgium	Prov. Brabant wallon	.0214923
Norway	Oslo og Viken	.021573
Czech Republic	Praha	.0217707
Netherlands	Noord-Nederland	.0218021
Netherlands	Zuid-Nederland	.0218021

Table 11. Bottom 10 regions by green occupations. 2022

Country	Region	Digital jobs score
Romania	Nord-Est	.0428989
Greece	North Aegean	.0432895
Greece	Eastern Macedonia and Thrace	.0434467
Greece	Central Greece	.0436139
Romania	Sud-Est	.0438833
Greece	Western Macedonia	.0461388
Greece	Peloponnese	.0475077
Greece	Epirus	.0482914
Spain	Ciudad de Melilla	.0485007
Romania	Sud-Vest Oltenia	.0485594

Table 12. Bottom 10 regions by digital occupations. 2022

Country	Region	Twin jobs score
Belgium	Prov. Hainaut	.0175673
France	La Réunion	.0178079
Spain	Ciudad de Melilla	.0178429
Spain	Ciudad de Ceuta	.0184078
Belgium	Prov. Vlaams-Brabant	.0190376
Denmark	Hovedstaden	.0195055
Portugal	Região Autónoma dos Açores	.0195786
Denmark	Nordjylland	.0197025
Norway	Agder og Sør-Østlandet	.0198141
Denmark	Sjælland	.0198304

Table 13. Bottom 10 regions by twin occupations. 2022

The regional patterns identified in the previous tables provide a foundation for understanding the spatial distribution of core green, digital, and twin occupations across Europe. To complement this

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analysis and gain deeper insights into regional readiness for the twin transition, we now examine the distribution of these and their respective enabling occupations—those roles that, whilst not directly classified as green, digital, or twin, provide crucial support infrastructure for these transitions. Figure 16, Figure 17 and Figure 18 present the distribution in green and green-enabling, digital and digital-enabling, and twin and twin-enabling occupations respectively, offering a more comprehensive picture of regional capabilities beyond core specialisations.

The comparative analysis of green jobs and green-enabling jobs maps reveals distinct geographical patterns that provide important insights into the structural characteristics of European green labour markets. The distribution of green jobs shows a pronounced concentration in Eastern and Southern European regions, with notable clusters in Romania, Poland, Greece, and parts of the Balkans, alongside some peaks in France. Several regions display the highest intensity values, particularly in areas that correspond to countries which, as demonstrated in the earlier analysis (Table 8), exhibited strong specialisation in lower-skilled green occupations such as elementary jobs and skilled agricultural work.

The distribution of green-enabling jobs does not diverge too much from the core green jobs pattern, yet some notable differences emerge. Whilst Eastern European regions maintain relatively strong representation, there appears to be a somewhat more balanced distribution with enhanced presence in Central and Western European areas. The values for green-enabling jobs are substantially higher overall, reflecting the broader definitional scope of these occupations and their more pervasive presence across regional labour markets. These spatial patterns provide geographical confirmation of the occupational structures identified in the country-level analysis. The concentration of green jobs in regions corresponding to countries that showed specialisation in lower-skilled green occupations (Romania, Poland, Greece) is clearly visible in the spatial data. Similarly, the stronger green-enabling presence in regions from countries that demonstrated green employment in higher-skilled categories (Germany, Sweden, Netherlands) reinforces the notion of institutionally embedded green transitions.

The relative similarity between the two distributions, albeit with some geographical shifts, suggests that green-enabling infrastructure tends to develop in proximity to core green activities, though with some expansion into regions with stronger institutional and organisational capabilities. This pattern indicates that whilst enabling functions are not entirely decoupled from direct green production, they exhibit greater geographical flexibility and can emerge in contexts with appropriate supporting structures.

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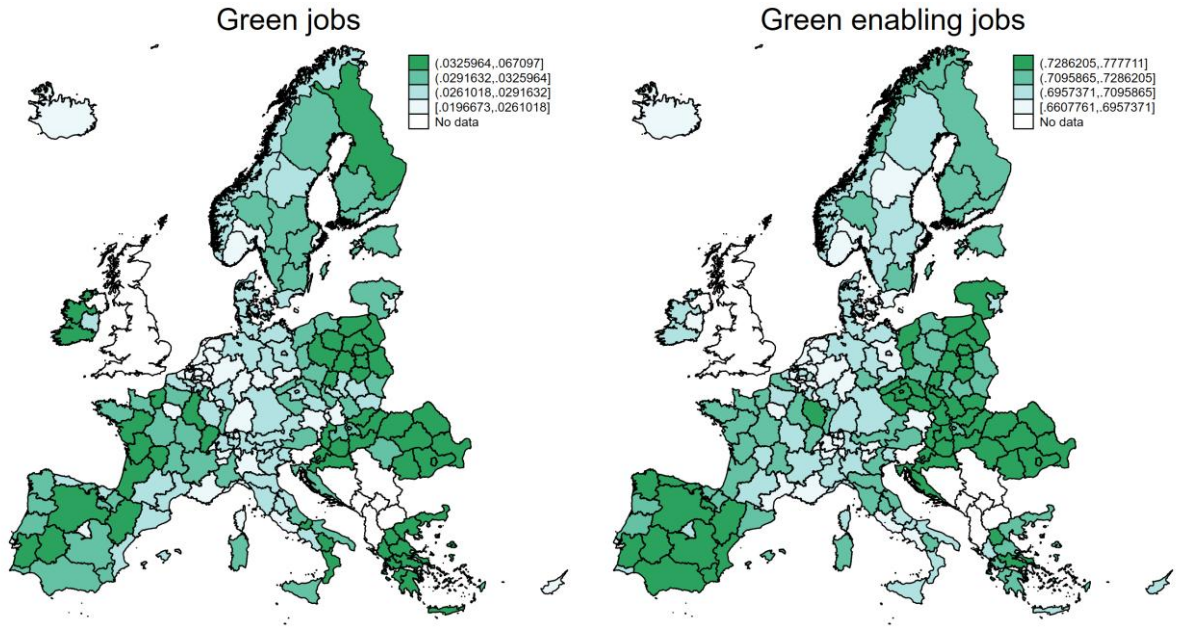

Figure 16. Distribution of green and green-enabling jobs across regions. 2022.

The comparative analysis of digital jobs and digital-enabling jobs maps (Figure 17) reveals markedly different geographical patterns compared to the green economy, reflecting the distinct spatial logics underlying digital transformation across Europe. The distribution of digital jobs shows a pronounced concentration in specific metropolitan areas and capital regions, with the highest intensity values clearly clustered in Stockholm, Helsinki, major German cities, and the main European capitals. This pattern strongly corresponds to the findings from Table 9, where major metropolitan areas dominated the top rankings for digital employment, reflecting the advanced digital maturity and ICT-sector density characteristic of urban economies. The distribution of digital-enabling jobs displays a distinctively different pattern, with a notable shift towards Northern and Western European regions. Scandinavia, in particular, shows exceptionally high concentrations, with many regions displaying the darkest purple shading indicating the highest quartile values. Central and Eastern European regions, including Poland and parts of Germany, also demonstrate strong digital-enabling presence, whilst Southern European regions, particularly in Italy and Greece, show considerably lower intensities.

The spatial divergence between digital jobs and digital-enabling jobs is more pronounced than observed in the green economy analysis. Whilst digital jobs exhibit a clear capital city and metropolitan bias—consistent with the earlier finding that digital employment is concentrated among high-skilled professionals and technicians—digital-enabling jobs show a more regionally distributed pattern with strong Nordic dominance. This suggests that digital-enabling capabilities have developed beyond the traditional ICT clusters, extending into regions with strong institutional capabilities and organisational sophistication. These spatial patterns provide geographical confirmation of the polarised structure of digital employment identified in the country-level analysis. The concentration of digital jobs in metropolitan regions corresponds precisely to countries that demonstrated strong specialisation in high-skilled digital occupations among professionals and technicians (Sweden, Finland, Germany, Czech Republic). The peripheral regions with limited digital job presence align with areas from

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countries that showed digital employment mainly in mid- or lower-skilled categories. However, the digital-enabling maps reveal that regions with high concentrations of enabling jobs may be positioned on the cusp of digital transformation. These occupations indicate proximity to digital transition—regions with substantial digital-enabling presence, particularly those in Scandinavia and parts of Central Europe, may find themselves better positioned to develop core digital capabilities as the transition progresses. Conversely, regions with limited enabling infrastructure may face greater challenges in achieving digital transformation, as they lack the occupational foundation from which digital transitions typically emerge.

Looking at the distribution of twin and twin-enabling jobs (Figure 18), we can see spatial patterns that bear non-negligible similarities to the green economy distribution, reflecting the strong influence of green components in twin occupation definitions. Twin jobs show concentrations in Eastern European regions, particularly Poland, Romania, and Finland, alongside a scattered presence in Southern Europe, including Greece and Spain. Twin-enabling jobs demonstrate even clearer parallels, with pronounced concentrations in Poland, Romania, and the Balkans, indicated by the darkest red shading representing the highest quartile values. By contrast, Western European regions, particularly Scandinavia and parts of Germany, display considerably lower twin-enabling intensities despite their strength in digital-enabling capabilities.

The spatial relationship between twin jobs and twin-enabling jobs is more complex than in the green domain, but seem to reveal that the twin transition is largely building upon existing green occupational infrastructures rather than creating entirely new spatial configurations. This alignment indicates that digital integration occurs within pre-established green contexts, providing geographical confirmation of the occupational structures identified in the country-level analysis. Regions with high concentrations of enabling jobs may therefore be positioned on the cusp of more comprehensive twin transition development, suggesting that successful pathways do not necessarily require strong standalone digital capacities, but can emerge through the progressive enhancement of established green foundations.

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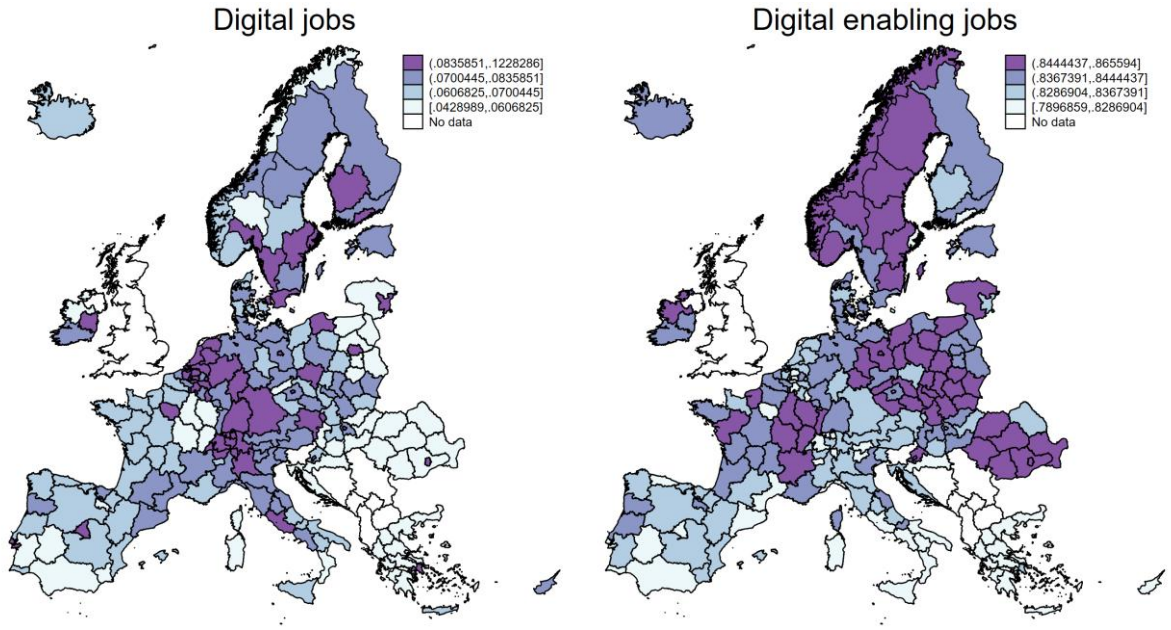

Figure 17. Distribution of digital and digital-enabling jobs across regions. 2022

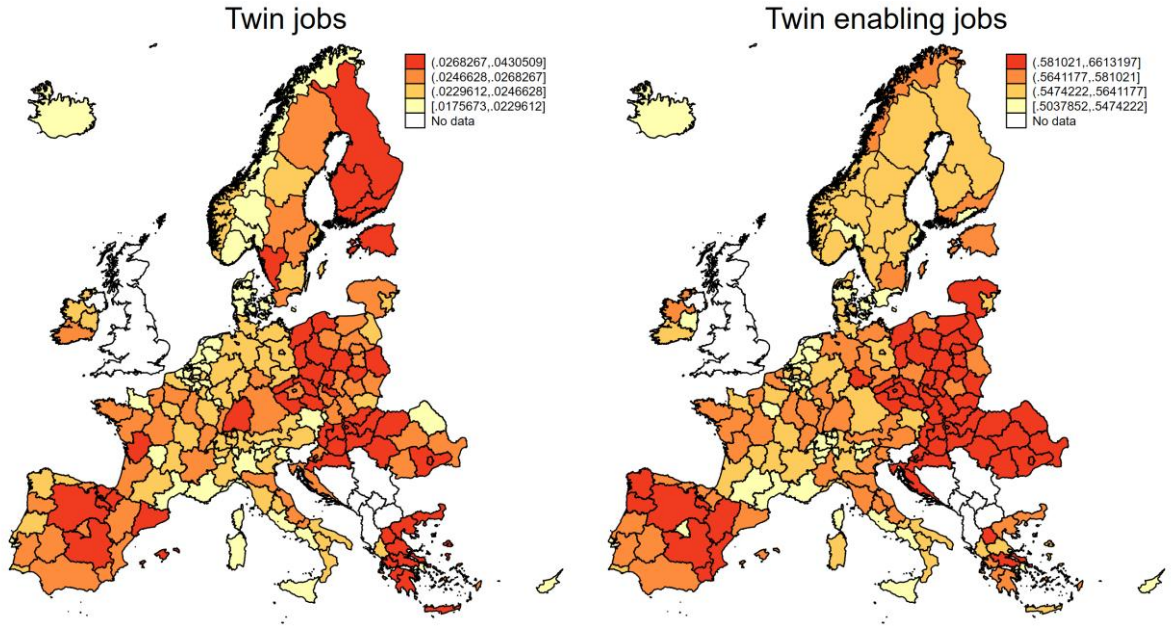

Figure 18. Distribution of twin and twin-enabling jobs across regions. 2022

Takeaway #4

Green and digital transitions exhibit fundamentally different spatial logics: green occupations disperse

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across diverse regional contexts, whilst digital employment concentrates in metropolitan areas, with twin transitions apparently emerging primarily in regions with established green foundations rather than digital clusters.

4.2.2 Regional distribution of green, digital, twin and enabling occupations by skill-level groups

To facilitate the analysis of occupational patterns across different skill levels, we aggregate the nine ISCO-08 major groups into three broader categories based on their skill level requirements and complexity of tasks performed. Following the inherent skill hierarchy embedded within the ISCO classification system, we define high-skilled occupations as comprising Managers, Professionals, and Technicians, which typically require tertiary education or extensive professional experience and involve complex problem-solving and decision-making responsibilities. Mid-skilled occupations encompass Clerical Support Workers, Service and Sales Workers, Skilled Agricultural, Forestry and Fishery Workers, and Craft and Related Trades Workers, representing roles that generally require secondary education or vocational training and involve moderately complex tasks with some degree of autonomy. Finally, low-skilled occupations include Plant and Machine Operators and Assemblers and Elementary Occupations, which typically require basic education and involve routine, standardised tasks with limited autonomy. This three-tier aggregation enables a clearer examination of how green, digital, and twin transitions manifest across different segments of the labour market whilst preserving the conceptual foundation of skill-based differentiation inherent in the ISCO framework.

Figure 19 and Figure 20 provide a comparative visualisation of the regional distribution of green and green-enabling occupations across Europe in 2022, disaggregated by skill-level groupings. Figure 19 reveals a distinct territorial bifurcation in the occupational structure of green employment. In line with the preceding argument, it is evident that in several Eastern and Southern European regions—notably Romania, Greece, and Southern Italy and Spain—green occupations are predominantly concentrated within low- and medium-skilled categories. This pattern reflects the integration of environmentally oriented tasks into traditional, resource-intensive sectors such as agriculture, forestry, and manufacturing, where manual and routine tasks remain prevalent. The core of green occupations in these regions appears embedded in existing sectoral specialisations, resulting in a labour-intensive rather than innovation-driven pathway. Conversely, in Northern and Central European regions—including parts of Germany, Sweden, and the Netherlands—green employment is more heavily represented in high-skilled occupations. Here, the green transition is associated with knowledge-intensive activities such as environmental engineering, sustainable infrastructure planning, and strategic resource management. This suggests a qualitatively different trajectory, where the green economy is being institutionalised within advanced technological and managerial domains.

Figure 20, which presents the distribution of green-enabling occupations, offers complementary insights to those emerging from Figure 19. While green-enabling roles are not intrinsically green, they are functionally adjacent through the possession of skill sets aligned with green activities. The spatial distribution of green-enabling employment broadly mirrors that of core green occupations, particularly in regions such as Romania, Greece, and Spain, where both categories are predominantly situated within low- and medium-skilled occupational groups. This overlap suggests that, in these contexts, the green transition is likely to unfold within the same segments of the labour market, with

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potentially greater difficulty in achieving upward mobility along the skills hierarchy due to the limited presence of high-skilled enabling functions.

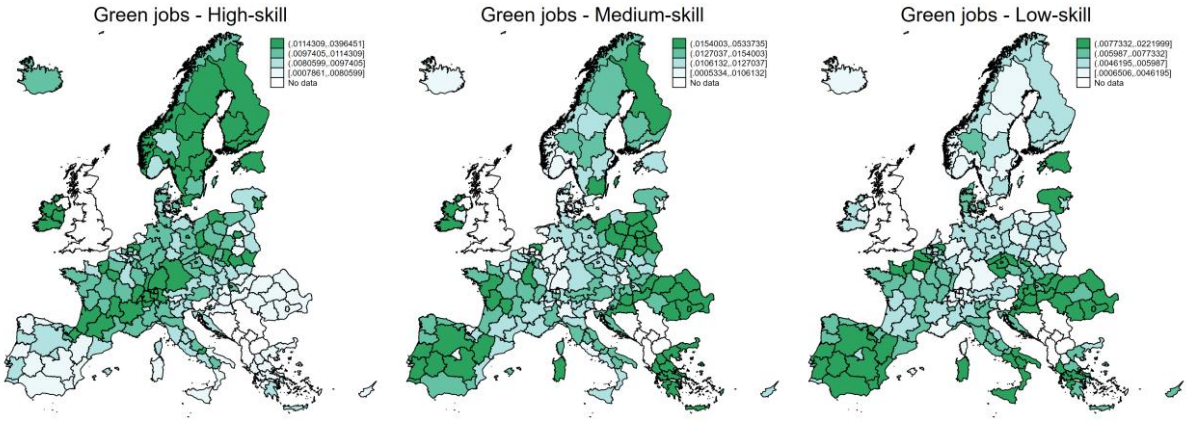

Figure 19. Regional distribution of green jobs by skill group. 2022

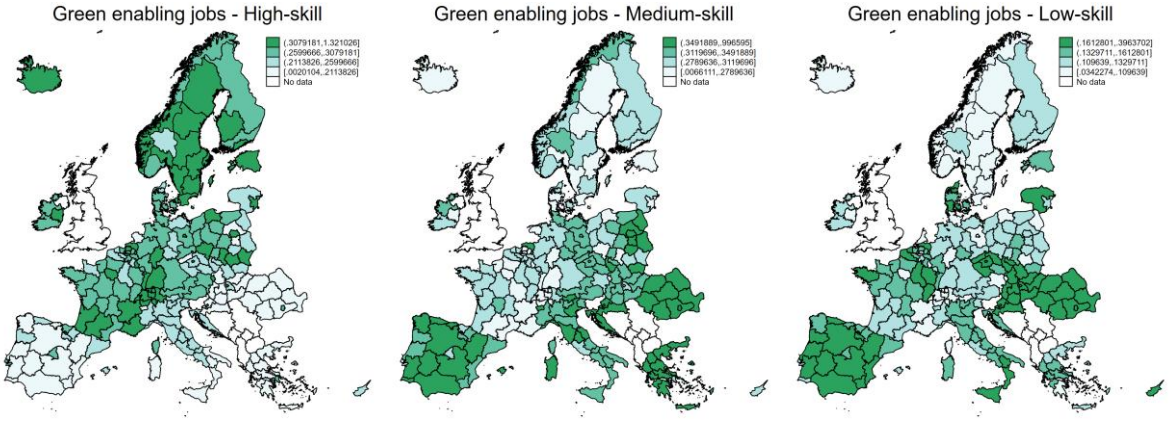

Figure 20. Regional distribution of green-enabling jobs by skill group. 2022

The comparative reading of Figure 19 and Figure 20 underscores a fundamental structural asymmetry in the geography of green labour markets across Europe. Core green occupations tend to be embedded in labour-intensive, low-skilled sectors in certain regions, while in others they are more closely associated with high-tech, knowledge-intensive roles. If regional readiness for the green transition depends not only on the prevalence of green jobs per se, but also on the presence of enabling occupations that facilitate the diffusion and operationalisation of green practices across the occupational spectrum, these figures suggest that markedly divergent trajectories may emerge across regions. Those regions that combine both dimensions—namely, a solid foundation of high-skilled green employment and a complementary layer of enabling occupations—are likely to be better positioned to sustain and institutionalise the green transition in a durable and systemic manner.

Figure 21 maps the distribution of digital occupations by skill level, revealing strong spatial differentiation and stratification across the digital occupational hierarchy. The high-skilled digital employment distribution shows pronounced concentrations in Scandinavia and in some German,

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Polish and Switzerland regions. Conversely Southern and Eastern European regions display considerably lower intensities, reflecting the metropolitan and innovation-driven nature of advanced digital competences. The medium-skilled digital jobs distribution presents a markedly different spatial pattern, with the highest concentrations appearing in Central European regions, particularly in Germany, Switzerland, and Italy. This pattern likely reflects the industrial specialisation of these regions in medium-tech manufacturing and machinery production, where digital technologies are increasingly integrated into operational and technical functions. Interestingly, many regions that ranked lower in high-skilled digital employment—especially in Central Europe—now display medium to high intensity of digital employment in this middle tier, pointing to a more industrial and operational embedding of digital roles, often linked to technical maintenance, ICT support functions, and digital administration. The low-skilled digital employment map reveals yet another distinct geographical configuration, with notable concentrations in Eastern European regions, particularly Romania, Hungary and Croatia and part of Poland, alongside scattered presence in Southern Europe including Spain and Portugal. The Nordic regions, which dominated high-skilled digital employment, show relatively low intensities in this category, whilst Eastern European regions display some of the highest values. This distribution suggests that digital employment in these regions is emerging primarily within routine or support-based functions, potentially in sectors such as basic data processing, machine operation involving digital interfaces, or logistical tasks involving ICT tools.

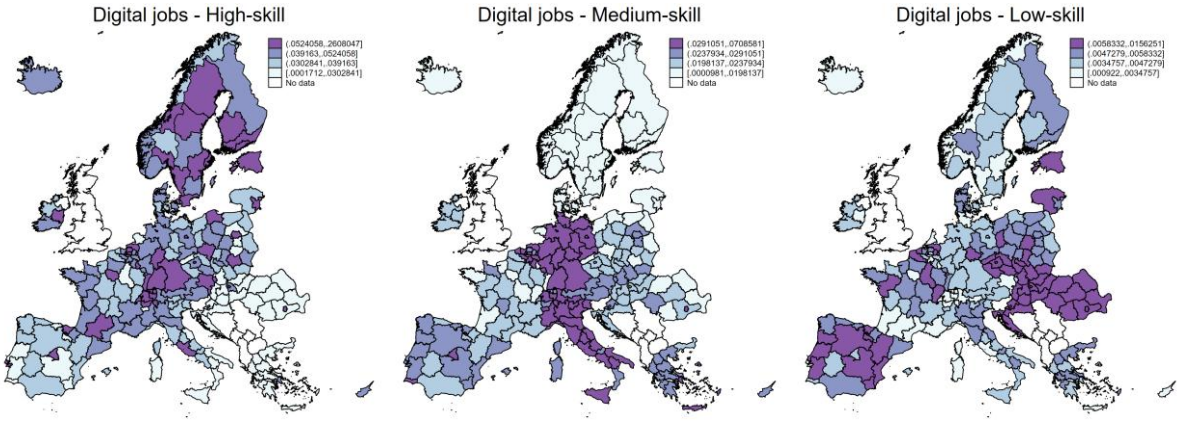

Figure 21. Regional distribution of digital jobs by skill group. 2022

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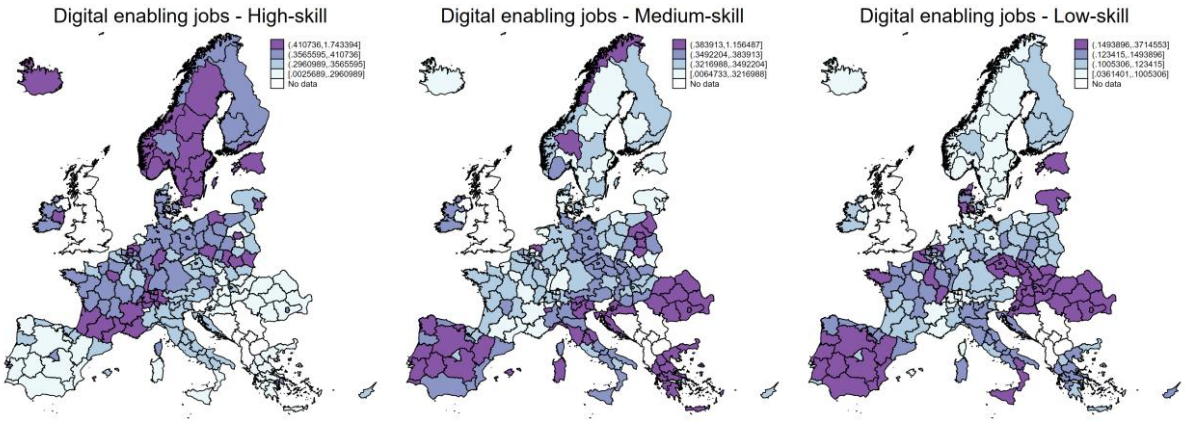

Figure 22. Regional distribution of digital-enabling jobs by skill group. 2022

Figure 22 depicts the regional distribution of digital-enabling occupations across Europe, disaggregated by skill level (high, medium, and low). These occupations do not involve the direct development or application of digital technologies but may represent the distribution of those occupations that are the closest to digital ones. The map of high-skilled digital-enabling jobs shows a strong concentration in Northern Europe and in some regions of France, Germany and Poland. These regions quite mirror the core areas identified in the previous figure for high-skilled digital occupations, suggesting a coherent digital ecosystem where both core and enabling functions are embedded in high-capacity institutional and organisational environments. In contrast, medium-skilled enabling occupations are more prevalent in Southern Europe and in some Eastern European and Balkan regions—previously characterised by weak high-skilled digital employment—also exhibit elevated shares of medium-skilled enabling roles. This suggests a broader diffusion of supporting functions in administrative, clerical, or coordination domains, potentially compensating for the absence of more specialised capacities. Low-skilled digital enabling jobs, finally, appear concentrated in South-Eastern and South-Western Europe—particularly in Romania, Greece, Spain, and parts of Italy. This pattern echoes the map of low-skilled core digital occupations, confirming that in these regions digital transformation proceeds through operational roles with limited autonomy or complexity.

Taken together, Figure 21 and Figure 22 highlight a clear distinction: while core digital jobs reflect a polarised geography—favouring high-skilled roles in Northern Europe and low-skilled ones in the South-East—digital enabling jobs reveal a more balanced and layered structure. Regions with limited core digital capabilities may still exhibit enabling potential, particularly in medium-skilled roles, pointing to latent capacity for digital transition.

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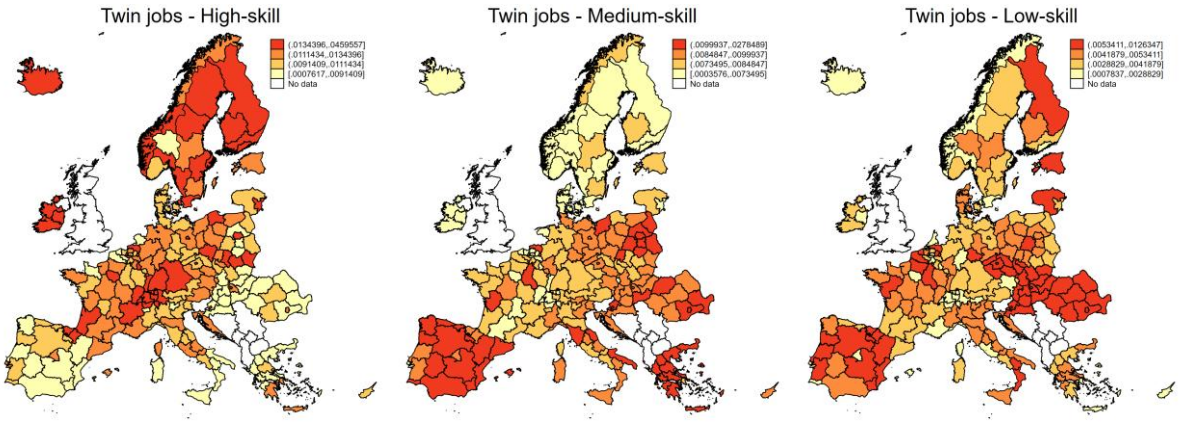

Figure 23. Regional distribution of twin jobs by skill group. 2022

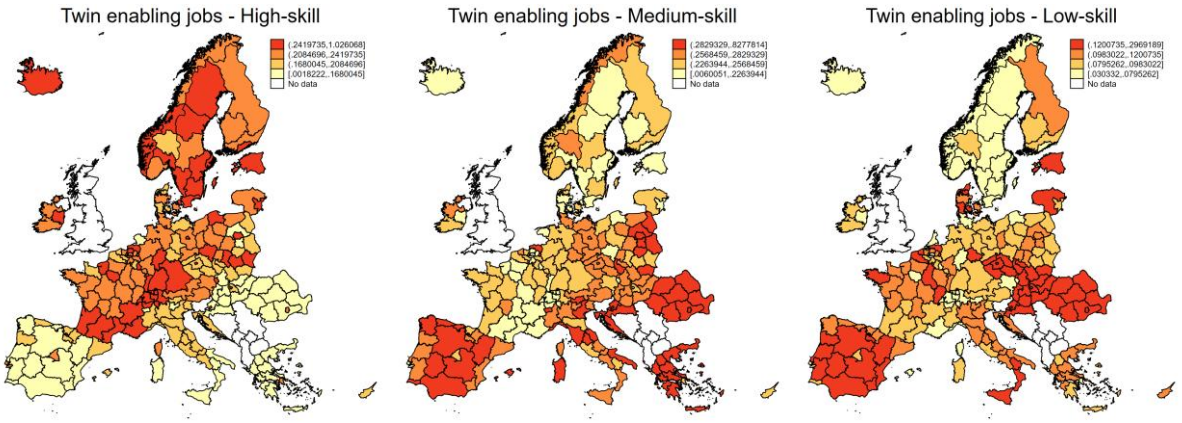

Figure 24. Regional distribution of twin-enabling jobs by skill group. 2022

Figure 23 provides a disaggregated view of the regional distribution of twin occupations—those simultaneously requiring green and digital skills—by skill level across Europe in 2022, while Figure 24 reports the corresponding distribution of twin-enabling occupations. Strikingly similar patterns emerge across the two, both reflecting a complex and uneven geography that diverges from the more polarised structure observed for purely digital occupations and differs in key ways from the spatial profile of green employment. Yet, despite these distinctions, the underlying duality remains: as with green and digital roles, we continue to observe a differentiation between regions specialising in high-skilled twin activities—typically concentrated in Northern and Western Europe—and those characterised by a prevalence of low- and medium-skilled twin functions, especially in Southern and Eastern regions.

High-skilled twin and twin-enabling occupations are most concentrated in Northern and Western Europe—particularly in Sweden, Finland, Ireland, the Netherlands, and parts of Germany and France. These regions combine a high incidence of upper-tier occupations with likely strong institutional and technological capacity in both environmental and digital domains, favouring the emergence of hybrid professional profiles such as data-driven sustainability experts, digital energy consultants, and green innovation strategists. By contrast, medium-skilled twin and twin-enabling occupations are more

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prevalent in Southern and Eastern European regions—especially in Spain, Portugal, Greece, and Romania. This pattern suggests the incorporation of green–digital tasks into technical and operational roles, including renewable systems maintenance, energy-efficient construction, or digitally monitored waste management. The observed spatial shift from North to South between high- and medium-skilled categories highlights a functional duality: while high-skill hybridisation is largely institutionalised in advanced economies, medium-skill integration appears to emerge through more task-based, operational channels. Low-skilled twin and twin-enabling occupations further reinforce this dual configuration, showing their highest prevalence in South-Eastern Europe—particularly in Greece, Romania, and the western Balkans. These regions remain anchored in labour-intensive production systems where basic forms of digital–green integration may occur through semi-automated machinery, recycling logistics, or low-threshold digital environmental monitoring.

Taken together, the evidence points to a clear differentiation in regional specialisation: while more advanced and innovation-driven regions concentrate twin activities in high-skilled roles, other areas—especially in the South and East—are developing twin capabilities primarily within low- and medium-skilled occupational segments. This division reflects distinct pathways into the twin transition, shaped by existing labour market structures and institutional capacities.

Takeaway #5
Skill-level disaggregation reveals pronounced territorial bifurcation: Northern and Central European regions embed green, digital, and twin transitions within high-skilled occupations, whilst Southern and Eastern European regions concentrate these transitions in low- and medium-skilled roles.

4.2.3 The dynamics of green, digital, twin and enabling occupations across regions

Having mapped the static distributions of green, digital and twin occupations across European regions, we now turn to their temporal dynamics between 2016 and 2022. This section examines regional patterns of occupational transformation over time, focusing on the growth trajectories of core occupations by skill level. To this end, we compute growth rates separately for high-, medium-, and low-skilled occupations, defined according to the ISCO-08 major group aggregation detailed in Section 4.2.2. Table 14 to Table 22 present the top 10 regions exhibiting the highest growth rates for green, digital, and twin occupations, disaggregated by skill level. These tables reveal some interesting patterns.

The growth of green occupations across skill levels reveals distinct geographical patterns that reflect different development trajectories. High-skilled green occupation growth (Table 14) is dominated by Southern and Eastern European regions, with Greek regions (Peloponnese, Κρήτη, Western Macedonia) occupying three of the top four positions, alongside Spanish autonomous cities (Ceuta and Melilla), Polish regions (Małopolskie, Podkarpackie), and Romania's Nord-Est. Notably, the regions experiencing the most rapid growth in high-skilled green occupations are those that, in 2022, still do not perform amongst the top regions in terms of absolute levels of such employment. This indicates that these regions, despite probably starting from very low baseline levels, are increasing their capacity the most rapidly, suggesting catch-up dynamics whereby previously peripheral regions are attempting to climb the ladder of high-skilled green capabilities.

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Country	Region	High-skilled Green jobs growth
Greece	Peloponnese	.6936116
Spain	Ciudad de Ceuta	.5318966
Greece	Κρήτη	.4935808
Spain	Ciudad de Melilla	.4727783
Poland	Małopolskie	.3591871
Romania	Nord-Est	.356132
Spain	Cantabria	.3391824
Poland	Podkarpackie	.3263068
Greece	Western Macedonia	.31042
Finland	Pohjois- ja Itä-Suomi	.28548

Table 14. Top 10 regions for the growth of high-skilled green jobs

Country	Region	Medium-skilled Green jobs growth
France	Guyane	.4799538
France	Limousin	.3692961
Belgium	Prov. Namur	.3584595
Norway	Nord-Norge	.2672987
Greece	North Aegean	.2561893
France	Poitou-Charentes	.2513046
Spain	Ciudad de Ceuta	.2499986
France	Pays de la Loire	.226675
France	Lorraine	.2187877
France	Aquitaine	.1984587

Table 15. Top 10 regions for the growth of medium-skilled green jobs

Country	Region	Low-skilled Green jobs growth
Romania	Sud-Vest Oltenia	.6840358
Romania	Nord-Est	.6447139
France	Guadeloupe	.4149251
Greece	Eastern Macedonia and Thrace	.4028373
Greece	North Aegean	.3957133
Switzerland	Ticino	.3597236
Greece	Thessaly	.3562641
Greece	Western Greece	.3179903
Spain	Ciudad de Ceuta	.3081579
Greece	Ionian Islands	.2945771

Table 16. Top 10 regions for the growth of low-skilled green jobs

Medium-skilled green occupation growth (Table 15) reveals a pronounced French regional concentration, with five French regions appearing in the top 10, including overseas territories (Guyane). Unlike the high-skilled pattern, the regions growing most rapidly in medium-skilled green occupations are those that were already positioned with high concentrations of these jobs. This

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pattern suggests that medium-skilled green growth is occurring primarily in regions with established institutional capabilities, indicating specialisation deepening rather than geographical convergence.

Low-skilled green occupation growth (Table 16) shows remarkable concentration in Romanian regions (Sud-Vest Oltenia, Nord-Est) and Greek regions (Ανατολική Μακεδονία Θράκη, North Aegean, Thessaly, Western Greece). Similar to the medium-skilled pattern, these are predominantly regions that were already characterised by high concentrations of such employment, indicating path-dependent consolidation where existing comparative advantages in labour-intensive green activities are being reinforced.

High-skilled digital job growth (Table 17) presents a markedly different geographical configuration from green occupations, with Ireland's regions dominating the top rankings—all three Irish NUTS-2 regions appear in the top seven positions. Polish regions feature prominently (Dolnośląskie, Podkarpackie, Pomorskie, Mazowiecki regionalny), alongside individual regions from Greece, Spain, and Lithuania. The Irish dominance likely reflects the country's strategic positioning as a European hub for multinational technology companies, whilst the strong Polish performance indicates successful digital transformation across multiple regions. Unlike high-skilled green growth, digital growth appears concentrated in regions with already established technological infrastructure and institutional capabilities.

Medium-skilled digital job growth (Table 18) shows a pronounced Iberian concentration, with Spanish regions and Portuguese regions dominating the rankings. This pattern suggests that medium-skilled digital transformation is proceeding rapidly in regions with relatively low baseline levels of medium-skilled digital employment compared to other European regions, but which possess high levels of digital-enabling employment that provide the foundational infrastructure for such growth. In turn, we could say that this growth appears to build upon existing sectoral strengths—particularly in those sectors not strictly digital but connected to them.

Country	Region	High-skilled Digital jobs growth
Ireland	Eastern and Midland	.6960258
Ireland	Southern	.6072598
Poland	Dolnośląskie	.5562036
Poland	Podkarpackie	.5368781
Greece	Ionian Islands	.5068514
Poland	Pomorskie	.4849858
Ireland	Northern and Western	.4791694
Spain	Illes Balears	.4768326
Poland	Mazowiecki regionalny	.4466941
Lithuania	Sostinės regionas	.4355903

Table 17. Top 10 regions for the growth of high-skilled digital jobs

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Country	Region	Medium-skilled Digital jobs growth
Spain	Ciudad de Ceuta	.8361509
Spain	Comunidad de Madrid	.705323
Portugal	Algarve	.5687032
Portugal	Região Autónoma dos Açores	.5011692
Portugal	Região Autónoma da Madeira	.4795845
Belgium	Prov. Vlaams-Brabant	.4114256
Spain	Illes Balears	.4100876
Spain	Región de Murcia	.3876045
Spain	Cataluña	.3725235
Portugal	Oeste e Vale do Tejo	.3704431

Table 18. Top 10 regions for the growth of medium-skilled digital jobs

Low-skilled digital job growth (Table 19) reveals concentration in Romanian regions (Sud-Vest Oltenia, Nord-Est) and Greek regions (South Aegean, Eastern Macedonia and Thrace, North Aegean, Western Greece), alongside Switzerland's Ticino and Croatia's Adriatic Croatia. This pattern mirrors low-skilled green growth, suggesting that basic digital task integration is occurring in regions with traditional labour-intensive production systems.

Country	Region	Low-skilled Digital jobs growth
Romania	Sud-Vest Oltenia	.4625468
Romania	Nord-Est	.446826
Greece	South Aegean	.4112663
Greece	Eastern Macedonia and Thrace	.407413
Greece	North Aegean	.4020953
Greece	Western Greece	.3504596
Switzerland	Ticino	.2968917
Croatia	Adriatic Croatia	.2841592
Greece	Western Macedonia	.2806177
Romania	Sud-Muntenia	.2788811

Table 19. Top 10 regions for the growth of low-skilled digital jobs

High-skilled twin job growth (Table 20) combines elements of both green and digital patterns, with Greek regions leading (Peloponnese, Western Macedonia, Crete), Spanish autonomous cities maintaining their presence (Ceuta and Melilla), and Polish and Romanian regions contributing significantly. This geographical distribution suggests that high-skilled twin development is emerging primarily in regions that are simultaneously experiencing growth in both green and digital domains, though following more closely the catch-up pattern observed in high-skilled green occupations rather than the infrastructure-building trajectory characteristic of high-skilled digital growth. The prominence of Greek and Eastern European regions in twin job growth suggests that these areas are developing integrated green–digital capabilities from relatively low baseline levels, indicating that peripheral regions are undergoing processes of catch-up in the acquisition of twin competencies.

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Country	Region	High-skilled Twin jobs growth
Greece	Peloponnese	.835309
Spain	Ciudad de Ceuta	.5135241
Greece	Western Macedonia	.4811273
Greece	Crete	.4759068
Spain	Ciudad de Melilla	.4355073
Spain	Illes Balears	.3890615
France	Guadeloupe	.37955
Poland	Małopolskie	.3667893
Romania	Nord-Est	.362637
France	Bourgogne	.34798

Table 20. Top 10 regions for the growth of high-skilled twin jobs

Country	Region	Medium-skilled Twin jobs growth
France	Lorraine	.4127073
France	Guyane	.3868103
Romania	Nord-Vest	.3236332
Romania	Nord-Est	.3128676
Romania	Sud-Vest Oltenia	.2710495
Romania	Sud-Est	.2686052
France	Poitou-Charentes	.2545371
France	Nord-Pas de Calais	.2422943
Romania	Sud-Muntenia	.2280045
France	Corse	.213685

Table 21. Top 10 regions for the growth of medium-skilled digital jobs

Medium-skilled twin job growth (Table 21) displays a notable Franco-Romanian axis, with French regions (Lorraine, Guyane, Poitou-Charentes, Nord-Pas de Calais, Corse) and Romanian regions (Nord-Vest, Nord-Est, Sud-Vest Oltenia, Sud-Est, Sud-Muntenia) accounting for nine of the ten top-performing regions. This distinct geographical pattern reveals two contrasting development trajectories within medium-skilled twin integration. Romanian regions represent areas that were already characterised by strong medium-skilled green employment, suggesting a pattern of specialisation deepening where existing green capabilities are being enhanced through digital integration. Conversely, French regions appear to be developing medium-skilled twin capabilities from a weaker baseline in traditional green occupations, indicating a more diversification-oriented approach where twin competencies emerge through the convergence of separate green and digital development streams. This dual pattern suggests that medium-skilled twin integration is following specific national pathways that differ not only from pure green and pure digital trajectories, but also embody fundamentally different approaches to capability building—one based on upgrading existing strengths and another on creating new hybrid competencies.

Low-skilled twin job growth (Table 22) shows identical patterns to low-skilled green occupation growth, with the same Romanian and Greek regions dominating the rankings. This overlap indicates that low-skilled twin development is essentially driven by green occupation dynamics, with digital

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components being integrated into existing green labour-intensive activities rather than representing independent twin capabilities.

Country	Region	Low-skilled Twin jobs growth
Romania	Sud-Vest Oltenia	.6840358
Romania	Nord-Est	.6447139
France	Guadeloupe	.4149251
Greece	Eastern Macedonia and Thrace	.4028373
Greece	North Aegean	.3957133
Switzerland	Ticino	.3597236
Greece	Thessaly	.3562641
Greece	Western Greece	.3179903
Spain	Ciudad de Ceuta	.3081579
Greece	Ionian Islands	.2945771

Table 22. Top 10 regions for the growth of low-skilled digital jobs

The spatial distribution of high-skilled occupation growth reveals both commonalities and important distinctions across the three domains. Figure 25 demonstrates that whilst certain regions exhibit strong performance across all three categories—notably parts of Poland, northern Italy, and some Scandinavian regions—other areas show more selective growth patterns that illuminate the underlying drivers of twin transition development. Particularly noteworthy are the differential patterns observed in France and the Iberian Peninsula. Several French regions display strong growth in digital and twin occupations but more modest performance in green high-skilled employment, suggesting that twin growth in these contexts is primarily driven by digital occupation development, with green components being integrated secondarily. This pattern indicates a digitally-led pathway to twin transition, where existing digital capabilities serve as the foundation for incorporating environmental competencies.

Conversely, Spanish and Greek regions exhibit a pronounced commonality between green and twin growth patterns, with both domains showing similarly high growth rates whilst digital growth remains more restrained. This suggests an alternative, green-led pathway to twin development, where existing environmental capabilities and policy frameworks provide the foundation for integrating digital components. Such regions appear to be developing twin competencies by enhancing their green specialisations with digital tools and methods rather than building from digital foundations.

This geographical differentiation confirms the presence of multiple pathways to high-skilled twin development across Europe. The digitally-led approach (evident in parts of France) and the green-led approach (visible in parts of Spain and Greece) represent distinct regional strategies that reflect different starting conditions, institutional capabilities, and sectoral strengths. The convergence of Poland, northern Italy, and Scandinavia across all three domains suggests these regions possess the institutional and economic foundations to pursue simultaneous development across green, digital, and twin competencies.

In line with the patterns observed in the previous tables, it is noteworthy that several regions previously characterised by low levels of high-skilled employment are now experiencing substantial

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growth. This may be interpreted as an encouraging sign of convergence in the development of high-level skills, even if such regions were expected to lag due to their initially lower baseline.

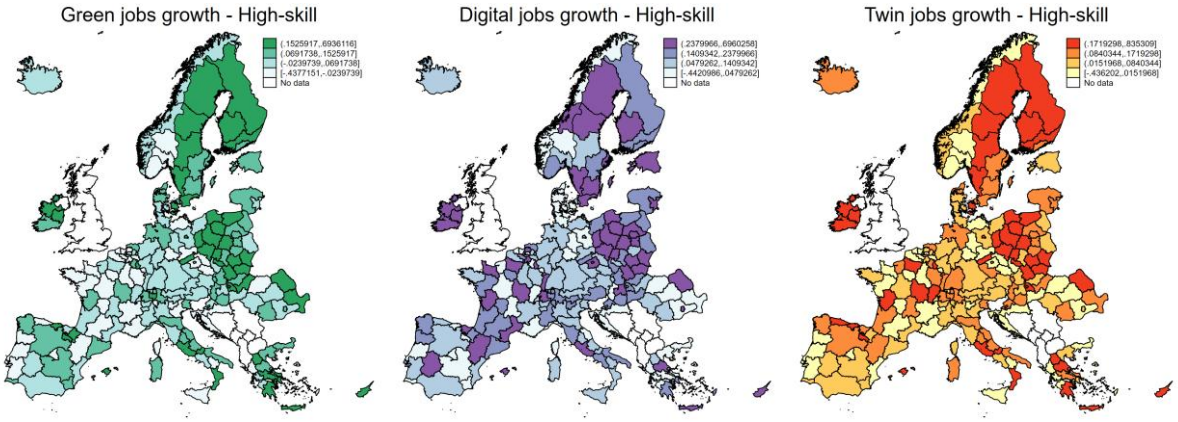

Figure 25. Growth of green, digital, and twin high-skilled occupations. 2016–2022

The spatial patterns of medium-skilled occupation growth reveal a more complex and differentiated geography than observed for high-skilled categories, with distinct regional clustering patterns that illuminate different pathways to twin transition at the intermediate skill level. Figure 26 demonstrates markedly divergent spatial distributions across the three domains, suggesting that medium-skilled transformation follows more specialised and sector-specific trajectories. Medium-skilled green occupation growth exhibits a distinctive Atlantic and northern European concentration, with particularly strong performance visible in western France, parts of Spain, Ireland, and Scandinavia.

Medium-skilled digital occupation growth presents a strikingly different spatial configuration, with pronounced concentrations in Central and Southern Europe. The most intensive growth appears in some regions of Germany and of northern Italy, alongside a strong Iberian cluster encompassing both Spain and Portugal. This pattern suggests that medium-skilled digital transformation is proceeding rapidly in regions with established manufacturing and service sector bases, where digitalisation of technical and administrative functions is accelerating.

Medium-skilled twin occupation growth reveals the most geographically concentrated pattern among the three categories, displaying intense clustering in Eastern and Central Europe. The highest growth rates are visible in France and Romania, with some Southern European regions also involved. The Franco-Romanian axis aligns with the tabular findings: this distribution confirms that medium-skilled twin integration is following highly specific geographical pathways that sometimes align with the green growth, and some other times align with the digital growth.

The comparison across the three maps reveals limited spatial overlap, indicating that medium-skilled transformation in each domain is driven by distinct regional comparative advantages and sectoral structures. Unlike the high-skilled level, where certain regions demonstrated capability across multiple domains, medium-skilled growth appears more specialised and path-dependent.

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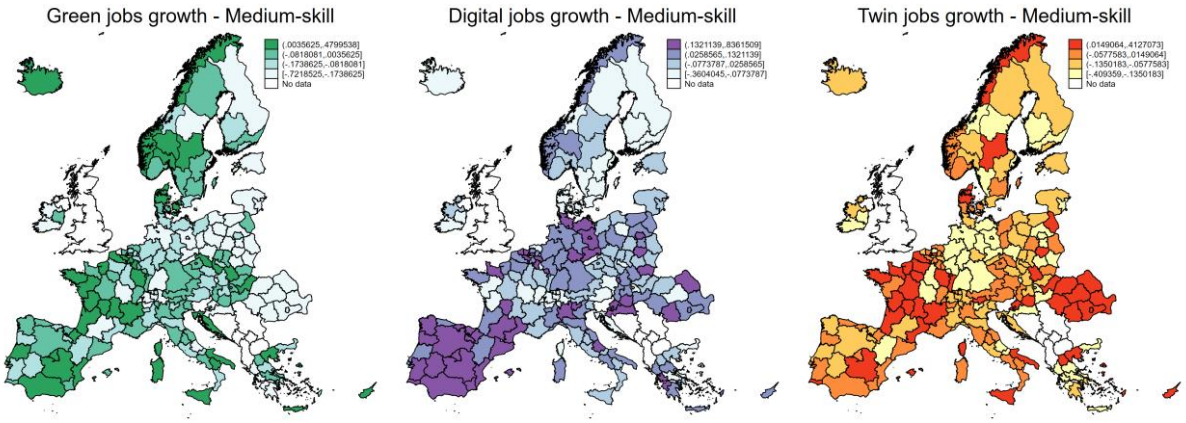

Figure 26. Growth of green, digital, and twin medium-skilled occupations. 2016–2022

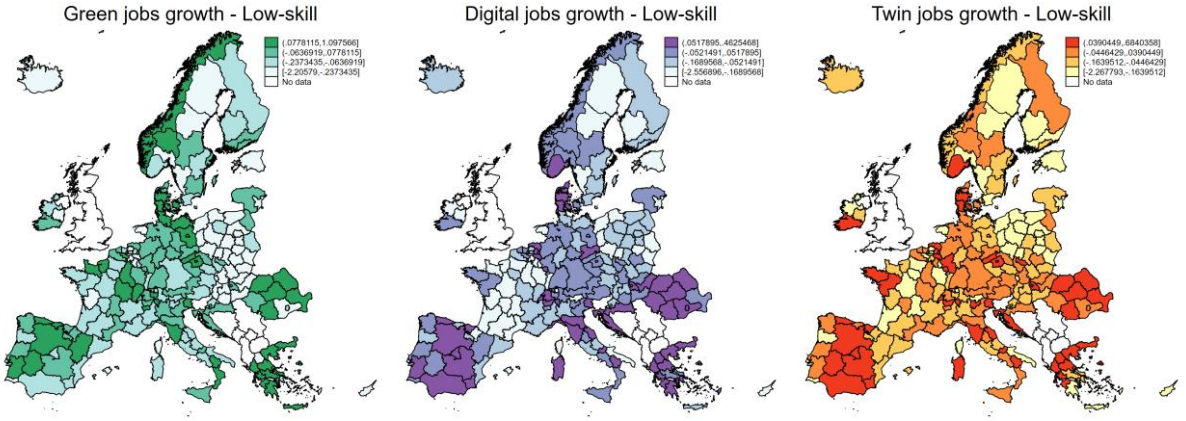

Figure 27. Growth of green, digital, and twin low-skilled occupations. 2016–2022

Finally, the spatial distribution of low-skilled occupation growth (Figure 27) reveals the most geographically concentrated pattern among the three skill levels, with pronounced clusters in South-Eastern Europe (particularly Romania, Greece, and the Balkans) and scattered presence elsewhere. This concentration is consistent across green, digital, and twin categories, reinforcing the notion that low-skilled twin transition development is proceeding through similar structural mechanisms across all domains.

The geographical concentration of low-skilled growth in regions with traditional resource-based economies suggests that this transformation is occurring through the progressive integration of basic environmental and digital tasks into existing labour-intensive production systems, rather than through the emergence of entirely new economic activities.

The dynamic analysis of green, digital, and twin occupation growth across European regions between 2016 and 2022 reveals fundamentally different geographical trajectories that reflect distinct pathways to economic transformation. Whilst high-skilled occupation growth demonstrates catch-up dynamics, with peripheral regions in Southern and Eastern Europe experiencing rapid expansion from low baseline levels, medium- and low-skilled transformations follow more path-dependent patterns where existing regional specialisations are being deepened rather than redistributed. This divergence

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suggests that the twin transition operates through multiple, simultaneous mechanisms: convergence at the high-skilled level as lagging regions develop knowledge-intensive capabilities, and consolidation at lower skill levels where established comparative advantages are reinforced.

The emergence of distinct national pathways to twin development—particularly the digitally-led approach in France and the green-led approach in Greece and Spain—indicates that twin transitions may follow heterogeneous patterns; however, further research is required to comprehend the consequences of these different skill-level foundations upon which the transition is taking place. The pronounced Franco-Romanian axis in medium-skilled twin growth exemplifies this diversity, representing two contrasting approaches: specialisation deepening where existing green capabilities are enhanced through digital integration (Romania) versus diversification where twin competencies emerge through cross-domain convergence (France). These findings underscore that regional readiness for the twin transition cannot be assessed independently of existing economic structures, skill distributions, and development trajectories, suggesting that effective policy interventions must be tailored to regional starting conditions rather than assuming uniform pathways across European territories.

Takeaway #6
Growth dynamics reveal catch-up patterns in high-skilled occupations, especially green, with peripheral regions experiencing rapid expansion, whilst medium- and low-skilled transformations follow path-dependent consolidation in existing specialised regions.

Takeaway #7
Regions demonstrate different twin transition pathways: digitally-led integration (e.g. French regions) versus green-led development (e.g. Spanish and Greek regions), indicating multiple routes to twin readiness.

4.3 Regional-level analyses throughout Online Job Ads

In order to corroborate the results obtained using the EU-LFS data aggregated at the ISCO 3-digit level, we perform a parallel analysis based on Online Job Advertisements (OJA), which allows us to work at the more granular ISCO 4-digit level. Specifically, we link ESCO 5-digit occupations to their respective ISCO 4-digit codes and compute, for each 4-digit occupation, the average intensity of green, digital, and twin skills using the same indicators introduced previously.

It is important to note that results derived from the OJA and EU-LFS datasets may diverge for several substantive reasons. First, the two data sources reflect fundamentally different dimensions of the labour market: while the EU-LFS captures the characteristics of the labour supply (or to be more precise the intersection between labour demand and supply), the OJA dataset reflects patterns in labour demand, as expressed through posted vacancies. As a consequence, skill intensities observed in OJA may be more sensitive to short-term fluctuations in employers' requirements, technological trends, or regulatory shifts, whereas LFS data tend to capture a more stable occupational composition. Second,

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the level of occupational aggregation differs between the two: OJA data are mapped to ISCO at the 4-digit level, permitting finer identification of skill content within occupational groups, while LFS data are limited to the 3-digit level due to coding constraints. This discrepancy may lead to differences in the estimated prevalence of green, digital, and twin occupations, especially in cases where substantial heterogeneity exists within 3-digit groups. Third, the two datasets may differ in terms of coverage, with OJA data being biased towards certain sectors (e.g. high-skilled or ICT-intensive occupations) and under-representing informal or low-skilled segments. Taken together, these factors imply that perfect alignment between the two sources should not be expected; rather, consistency in broad patterns across both datasets strengthens the validity of the findings.

The distributional patterns emerging from the OJA-based classification are broadly consistent with those previously identified using EU-LFS data, albeit with some notable differences that likely reflect shifts in labour demand. In the case of green occupations (Figure 28), the composition appears to have shifted away from skilled agricultural and clerical roles—relatively more prominent in the EU-LFS-based analysis—towards a greater prevalence of technicians. This reconfiguration may reflect evolving employer preferences or a more accurate representation of current job openings in sectors with a growing emphasis on environmental sustainability.

For digital occupations (Figure 29), the overall pattern remains consistent with the LFS-based findings, reaffirming the strong concentration of digital-intensive roles among high-skill categories. Notably, the relative dominance of professionals within the digital segment is even more pronounced in the OJA data, and this holds uniformly across all countries under consideration. This heightened concentration may reflect a persistent and widespread demand for advanced digital competencies within professional-level roles, as captured through job advertisements.

Figure 30 reports the classification of twin occupations—those combining green and digital attributes—that reveals a pattern that appears to lie somewhere between the two categories. While the majority of twin occupations are also concentrated within high-skill roles, akin to digital occupations, the OJA data also show a non-negligible presence in lower-skill categories. This latter feature is more reminiscent of the green profile, as observed in the LFS-based classification, suggesting that twin occupations may span a broader skill spectrum. Such a configuration is consistent with the dual nature of twin transitions, which require both high-level technical expertise and more operational roles that integrate sustainability and digitalisation at different points of the value chain.

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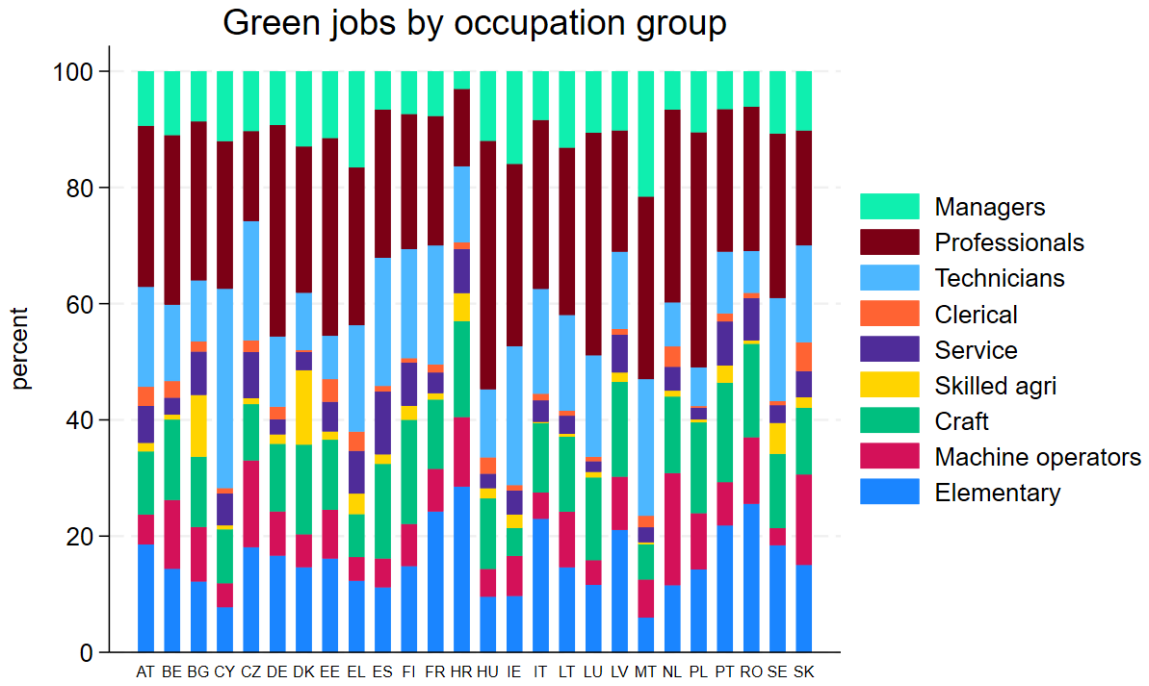

Figure 28. Green jobs demand by occupation group. Country comparison. OJA, 2022

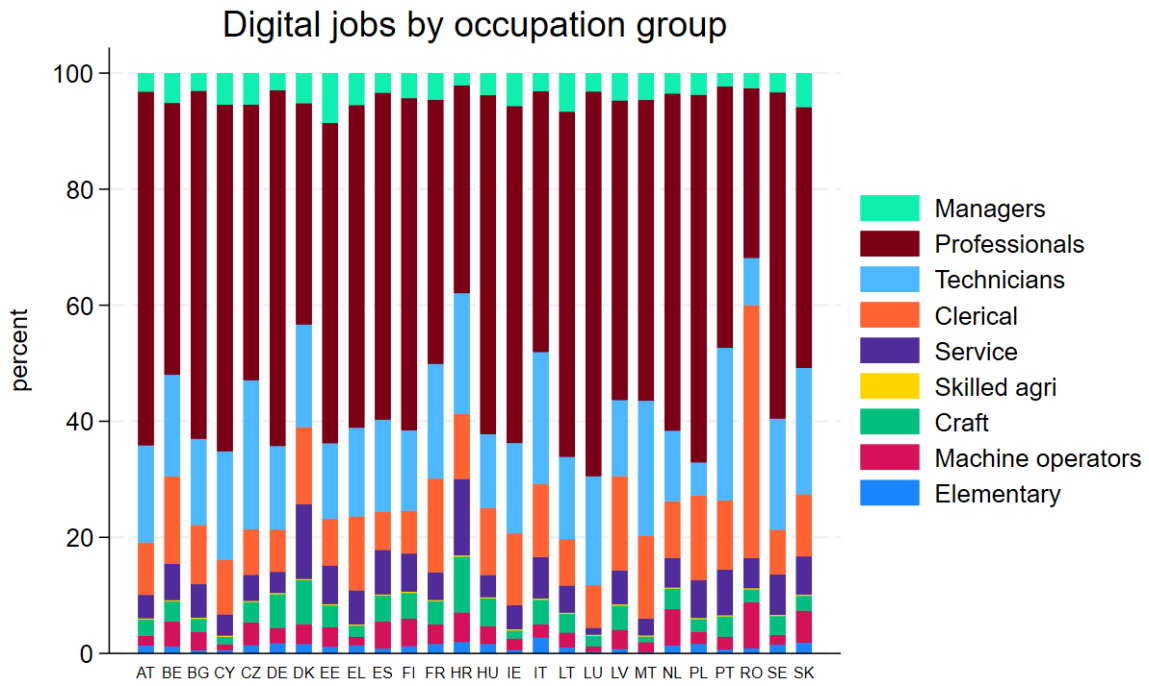

Figure 29. Digital jobs demand by occupation group. Country comparison. OJA, 2022

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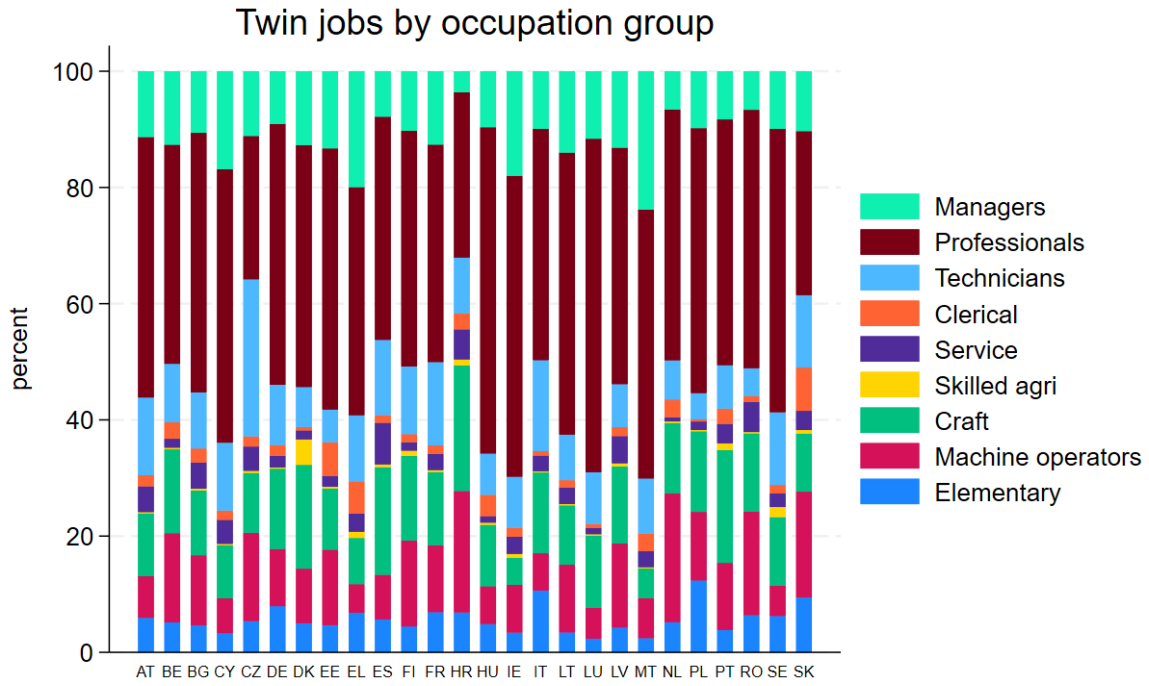

Figure 30. Twin jobs demand by occupation group. Country comparison. OJA, 2022

In summary, the analysis based on Online Job Advertisements complements and reinforces the findings obtained from the EU-LFS, while also offering additional granularity and insights into the evolving demand for green, digital, and twin skills. Despite inherent differences between the two datasets—most notably in terms of coverage, aggregation level, and underlying labour market dimension—the broad patterns remain largely aligned, suggesting that the observed trends are robust across both supply- and demand-side perspectives.

Specifically, the OJA data highlight a greater concentration of green occupations in technical roles, indicating a potential reorientation of green skill demand towards more specialised profiles. The digital category continues to exhibit a pronounced polarisation towards high-skilled occupations, with professionals being particularly prominent. Twin occupations display an intermediate configuration, blending the high-skill orientation of digital roles with a wider dispersion across the skill spectrum, reminiscent of the green cluster. Taken together, these findings provide nuanced evidence of how digitalisation and the green transition are reshaping occupational demand across Europe.

Takeaway #8
Green and twin transitions are increasingly concentrated in high-skilled occupations, with demand shifting notably towards technical and professional profiles.

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5. Conclusions

This deliverable has provided an in-depth mapping and analysis of green, digital, and twin occupations across European regions, offering a novel evidence base for understanding the geography of jobs in the context of the twin transition. By integrating ESCO-based occupational taxonomies with harmonised EU Labour Force Survey (EU-LFS) microdata and complementary job advertisement information, we have constructed a detailed account of how Europe's regional labour markets are positioned to adapt to the ongoing digital and green transformations. This empirical effort marks an important step towards operationalising the concept of "twin readiness" at the subnational level, with particular attention to the interaction between occupational structures, skill complementarities, and regional development trajectories.

The findings confirm that the twin transition is not merely a technological phenomenon, but a far-reaching process of labour market restructuring. The distribution of green and digital occupations across regions is uneven, reflecting persistent disparities in industrial composition, innovation capacity, education systems, and skill endowments. While digital occupations are heavily concentrated in metropolitan, innovation-intensive regions green occupations display a broader geographical spread, encompassing a wide range of industrial and service-based activities, including those tied to resource use, infrastructure, and public services. This differential spatial logic of green and digital employment underscores the importance of tailoring policy strategies to the specific strengths and challenges of different territories. Our findings show that the green transition in particular engages a wider share of the workforce, including medium- and low-skilled occupations. This element invites reflection on the value of recognising a broad range of "twin-skilled" roles, thereby capturing the heterogeneous realities of labour market transformation.

Crucially, the emergence of twin occupations—roles that integrate both green and digital skill components—remains limited but reveals distinctive patterns. They appear more strongly anchored in green than in digital capabilities, possibly reflecting an asymmetric process in which digital tasks are incorporated into existing green roles rather than generating new dual-purpose categories. The concentration of high-skilled twin jobs in more technologically advanced regions highlights the importance of institutional capacity, educational attainment, and innovation ecosystems in enabling this form of hybridisation, while also underscoring the substantial human capital investments required to expand and sustain a twin-skilled workforce.

The report has also introduced the concept of enabling occupations—those that, while not explicitly green or digital themselves, possess task structures and skill proximities that make them critical intermediaries for facilitating transitions. The presence of these enabling roles across regions is a strong indicator of latent adaptive capacity. Our analysis shows that regions with higher shares of enabling occupations are more likely to register growth in twin roles, suggesting that enabling occupations serve as structural bridges that support upskilling and task reconfiguration within the labour force. In this respect, enabling roles may be as important as core green and digital occupations for understanding how regions can progress towards transition goals.

The analysis of skill level distribution further reveals that while green occupations span the full skill spectrum—including medium- and low-skilled activities—digital occupations are predominantly high-skilled. This skill bias in digital employment presents particular challenges for inclusiveness, especially

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in less-developed regions where the educational infrastructure may not yet support large-scale high-skilled employment. Furthermore, our results demonstrate that Southern and Eastern European regions are more likely to specialise in the lower-skilled segments of the green and digital economy, while Northern and Central European regions dominate the high-skilled domain. This points to a broader question on the division of labour: while high-skilled roles are often associated with competitiveness, lower-skilled occupations remain functionally indispensable for the operation of sustainable societies. This distinction underscores the need to consider the complementarities between different categories of work in the transition process.

Nevertheless, dynamic patterns from 2016 to 2022 show signs of convergence in some areas. Several peripheral regions—particularly in Greece, Spain and Poland—have recorded high growth rates in high-skilled green occupations, indicating that catch-up dynamics are possible where policy and institutional support mechanisms are aligned. However, medium- and low-skilled roles remain more path-dependent and tied to existing specialisations, suggesting that without proactive strategies, the gap in high-skilled twin readiness could persist or even widen.

Importantly, the report identifies diverse regional pathways towards twin readiness. Some regions, such as those in France, appear to follow a digitally-led trajectory, while others—such as parts of Spain and Greece—demonstrate green-led transitions. This diversity of routes reinforces the argument for differentiated, place-sensitive policy frameworks. There is no single blueprint for achieving twin readiness; rather, regions must build on their existing capabilities, sectoral structures and institutional foundations to define viable and context-specific transition strategies.

In light of these findings, the implications for European policy are significant. The European Skills Agenda (COM(2020) 274), the Digital Compass (COM(2021) 118), the European Green Deal (COM(2019) 640), and the Just Transition Mechanism all underscore the need for inclusive, territorially balanced transformations. The evidence presented in this deliverable supports these strategic orientations and highlights the need to further embed spatial considerations into skill and innovation policy. In particular, policy interventions should:

- Strengthen place-based approaches that leverage regional comparative advantages while addressing structural deficits in skills and institutional capacity;
- Promote integrated upskilling and reskilling programmes that build hybrid competencies, particularly among enabling occupations;
- Support regional innovation ecosystems that facilitate knowledge spillovers and occupational mobility across (green and digital) domains;
- Provide sustained institutional support to less-developed regions to enable the development of high-skilled employment and avoid low-skill traps.

In methodological terms, the deliverable has contributed a replicable framework for assessing regional twin transition readiness by combining taxonomic detail (ESCO), quantitative employment data (EU-LFS), and conceptual innovations such as enabling occupations. This framework may serve as a reference point for future research on regional labour market transformation and skill system resilience.

Looking forward, an important avenue for further research concerns the interplay between occupations and the sectoral structures within which they are embedded. Occupations with high green or digital task intensity may, in practice, operate in industries characterised by significant energy use

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or carbon emissions. Accordingly, occupation-based indicators should be complemented with sector-level measures of net contribution to capture more accurately the overall dynamics of the twin transition. Future analyses should therefore seek to integrate occupational data with sector-level information on energy and material intensities, in order to provide a more comprehensive and quantitatively grounded assessment of regional transition trajectories. Such an approach would allow researchers to better capture the alignment—or misalignment—between labour market transformation and broader environmental constraints.

Finally, continued monitoring of occupational structures and transition dynamics will be essential. Research should expand on the role of firms, explore vocational training pipelines, and integrate longitudinal perspectives to capture the evolving nature of twin transition trajectories. As Europe advances toward its 2030 digital and climate objectives, ensuring that the benefits of these transformations are broadly shared remains an urgent task. The success of the twin transition will ultimately rest not only on technological innovation, but on the capacity of European regions to adapt, align, and evolve their labour systems in an inclusive and cohesive manner.

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