

Skill Resilience — 4EU

SkillResilience4EU
Resilience through re-skilling and upskilling for European labour
markets in transition

D1.4 – Twin transition conceptual framework

**DISCLAIMER:
THIS DELIVERABLE IS
PENDING EU APPROVAL.**



**Funded by
the European Union**

Project information

Project acronym:	SkillResilience4EU
Full title:	Resilience through re-skilling and upskilling for European labour markets in transition
Grant agreement:	101177821
Programme and call:	HORIZON-CL2-2024-TRANSFORMATIONS-01-03 - Minimise costs and maximise benefits of job creation and job destruction
Project coordinator:	HVL
Contact:	SkillResilience4EU@hvl.no
Project duration:	36 months
Project website:	SkillResilienceEU.EU

Deliverable information

Deliverable number	D1.4
Deliverable title:	Twin transition conceptual framework
Dissemination level:	PU-Public
Deliverable type:	Report
License:	CC BY-NC-ND 4.0
Status:	Submitted
Due date:	31/10/2025
Submission date:	31/10/2025
Work Package:	1
Lead Beneficiary:	Universiteit Utrecht

Disclaimer

Funded by the European Union. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union. Neither the European Union nor the European Research Executive Agency can be held responsible for them.

All SkillResilience4EU consortium members are also committed to publish accurate and up to date information and take the greatest care to do so. However, the SkillResilience4EU consortium members cannot accept liability for any inaccuracies or omissions, nor do they accept liability for any direct, indirect, special, consequential or other losses or damages of any kind arising out of the use of this information.

Revision History

Date	Version	Author	Comment
15/08/2025	V0.01	Deyu Li, UU	Creation of document outline
26/10/2025	V0.02	Deyu Li, UU Benjamin Cornejo Costas, UU Ron Boschma, UU Maria Tsouri, HVL	First draft
30/10/2025	V0.03	Alexandra Sandu, LSE Magdalena Marczevska, UW Justyna Szczepanik, UW Magdalena Klimczuk-Kochańska, UW Gesa Pflitsch, BOKU Andreas Panagopoulos, UoC Antonis Proestakis, UoC	Review and comments by contributing partners in WP order
31/10/2025	V0.04	Deyu Li, UU Maria Tsouri, HVL	Final draft
31/10/2025	V0.04	Risk and Quality Manager, HVL	Final check and approval for submission
31/10/2025	V1.0	Coordinator, HVL	Final check and submission to the granting authority

Author List

Institution	First name and Name	Contact information
UU	Deyu Li	d.li1@uu.nl
UU	Benjamin Cornejo Costas	b.j.cornejocostas@uu.nl
UU	Ron Boschma	r.a.boschma@uu.nl
HVL	Maria Tsouri	maria.tsouri@hvl.no

Abbreviations and acronyms

Abbreviation or acronym used in this document	Explanation
AI	Artificial Intelligence
DEI	Digital Employment Index
ESCO	European Skills, Competences, Qualifications and Occupations
EU-LFS	European Labour Force Survey

GEI	Green Employment Index
ICT	Information and Communication Technology
ISCO	International Standard Classification of Occupations
OJA	Online Job Advertisement
VET	Vocational Education and Training

Glossary

Term	Definition used or meaning in the Acronym project	Reference or source for the definition if applicable
Digital Employment Index	The Digital Employment Index (DEI) is a composite indicator that measures the extent to which a region's workforce is employed in sectors and occupations that are highly exposed to, and engaged with, digital technologies. It combines employment shares with indicators of digital intensity, so that a higher DEI value indicates a region whose employment structure is deeply embedded in the digital economy and thus more prepared (or exposed) for the digital transition.	Deliverable 1.2
Green employment Index	The Green Employment Index (GEI) measures the extent to which a region's workforce is employed in environmentally sustainable and low-carbon sectors, by weighting employment levels against each sector's emission intensity. It indicates a region's exposure and readiness for the green transition in its labour market.	Deliverable 1.2
Skill mismatches	This occurs when sectors and industries are unable to meet, attract, or develop the necessary skills required for new and evolving jobs, or transfer them from other sectors and industries. It is often because training programs fail to keep pace with the changing demands of a region or sector. Additionally, a skills mismatch can occur at the individual level when an individual's skills differ from those required for a particular job.	European Commission, 2023; SkillResilience4EU proposal
Micro-level drivers	Micro-level drivers of the twin transition refer to the individual and firm-level behaviours that shape how technological and green transformations affect work. They include workers' learning, mobility, and skill investment decisions, and firms' choices in adopting technologies, reorganising tasks, and training employees. Together, these behavioural mechanisms determine how jobs evolve, skills are created or become obsolete, and how smoothly labour markets adjust to the green and digital transitions.	SkillResilience4EU proposal
Macro-level drivers	Macro-level drivers of the twin transition are the broad structural forces, such as technological innovation, climate and energy policies, global trade dynamics, and	SkillResilience4EU proposal

	<p>economic shocks, that shape the overall direction and pace of green and digital transformation across economies. They set the external conditions influencing how regions, sectors, and labour markets adapt to the twin transition.</p>	
--	---	--

Executive Summary

The ongoing global challenges and the twin transition of sectors results in a profound reshaping of the European labour market, jobs and necessary competencies and is likely to lead to skill mismatches. SkillResilience4EU aims to reframe the concept of resilience of the European labour markets under the fast-paced digital and green changes and related challenges, and to outline actionable pathways to narrow the labour market mismatches that this twin transition triggers, through reskilling and upskilling.

SkillResilience4EU's objectives are: (1) The development of a novel conceptual framework to understand the impacts of the twin transition on European labour markets, in particular job creation and job destruction processes, and the interplay between the twin transition and other micro and macro drivers of change. (2) The investigation of the complex mechanisms, dynamics, and challenges that European labour markets undergo through the twin transition, and the delivery of recommendations and practical resources to support decision makers in managing the twin transition, focusing on the inclusion of left behind groups and places. (3) The mapping and evaluation of educational and training programmes for reskilling and upskilling and to deliver recommendations and practical resources to support individuals and employers in managing the twin transition, focusing on career guidance and development. (4) The promotion and facilitation of the further uptake of the project's Key Exploitable Results and other outputs through active and broad dissemination towards key stakeholder groups.

As part of the SkillResilience4EU project, the goal of Work Package 1 (Twin transition conceptual framework) is develop a conceptual framework for the twin transition impact on European labour markets. Building on the first three deliverables of the Work Package 1, this report proposes **a novel and holistic conceptual framework** for understanding the impacts of the twin transition on European labour markets, in particular the job creation and job destruction processes, and the interplay between the twin transition and other micro and macro drivers of change. More specifically, the conceptual framework proposes **a place-based approach** for understanding the drivers of labour market resilience from both the macro and micro levels and the interactions between them in jointly affecting the skill mismatches at both the regional and the individual level.

The conceptual framework will serve as the theoretical foundation of the **SkillResilience4EU** project and will be applied in the following **Work Packages (2-6)** for advancing the research on the building blocks of the labour market resilience. It reflects the project's commitment to inter- and trans-disciplinary approaches that blend in scientific insights from economic geography, economics, innovation, and sustainability transition studies with knowledge from the fields of institution research and institutional theory, but also policy research, policy advocacy and evaluation. The project will also intersect with pedagogical science and practices, specifically education and training focus on adult and vocational training, social inclusion and working with vulnerable groups, to propose best practices and practical tools for re-skilling and upskilling.

By addressing the multi-dimensional drivers of labour market resilience, this framework position place-based approach as an actionable reskilling and upskilling pathways to narrow the labour market mismatches that digital, green and twin transitions trigger.

Furthermore, this conceptual framework will be amended in **Work Package 5**. The aim of this revision is to review and align results from WP1 to WP6 and converge towards a common and cohesive understanding of the multifaceted issues related to labour market resilience in the digital, green and twin transitions, not only for the selected sectors and regions but for a wider applicability.

Table of Contents

1	Introduction	9
2	Twin transition exposure indices and Job/skill dynamics indices	10
3	Labour market resilience in digital, green and twin transitions: a place-based conceptual framework	14
3.1	Macro level drivers, transition pathways and institutional context.....	16
3.2	Micro level drivers	18
4	Conclusions	19
5	References	20
	Annex 1: The Consortium	24
	Annex 2: Project Summary	25

List of Figures

Figure 1: Twin Transition Taxonomy	11
Figure 2: Twin Transitions in European regions.	11
Figure 3: Regional typology of skill endowments in digital and green transitions.....	13
Figure 4: Regional typology of skill demand in digital and green transitions.	13
Figure 5: Twin transition conceptual framework.	16

1 Introduction

The transition towards a green and digital economy has been on top of the policy agenda of European Commission for its new growth model¹. The green transition, driven by climate action, is an opportunity for Europe to achieve sustainable and inclusive growth, as well as energy and resource security because it could help reduce energy bills and dependence on fossil fuel imports. Simultaneously, the digital transition has the potential to create new opportunities for people and businesses, enhance climate resilience through smart technologies, and increase the innovation and productivity of the EU economy while supporting sustainable development goals.

Although the digital and green technologies have the potential in promoting economic and employment growth, the labour market implications and the welfare effects of the green and digital transitions are likely to be unequally disturbed across sector, region and social-demographic groups (OECD, 2023, 2024). The transformation of the European economy will only succeed if it is fair, inclusive and beneficial for every citizen (Dixson-Declève et al., 2023). Thus, large scale investment in reskilling and upskilling are needed to facilitate labour reallocation within and between sectors and territories in Europe to seize the opportunities and mitigate the job displacement effect of the digital and green transition (Cedefop, 2023).

As the final deliverable of the Work Package 1 of the SkillResilience4EU project, this deliverable aims to develop **a novel and holistic conceptual framework** for understanding the impacts of the twin transition on European labour markets, in particular the job creation and job destruction processes, and the interplay between the twin transition and other micro and macro drivers of change.

The conceptual framework integrates the theoretical and empirical insights from the *Deliverable 1.1 Knowledge base on the impact of twin transition on the European labour market*, *Deliverable 1.2 Twin transition matrix which maps the transformation level and potential of European regions and sectors in the digital and green transitions*, *Deliverable 1.3 Job skill matrix which maps the demand and supply of green and digital skills and jobs across European regions and sectors*, and guides the research in the SkillResilience4EU project on the labour market resilience in the digital, green and twin transitions.

More specifically, the conceptual framework proposes **a place-based approach** for understanding the drivers of labour market resilience from both the macro and micro levels and the interactions between them in jointly affecting the **skill mismatches** and **left-behind** at both the regional and the individual level.

- **Macro-level drivers:** understand how macro social-economic conditions, such as technological, institutional and policy change, will shape the direction and interactions of digital and green transitions, and the unique transition pathways of regions and sectors; understand how different actors respond and shape the

¹ European Growth Model, https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1467

macro social-economic conditions for twin transitions and the creation of quality job opportunities;

- **Micro-level drivers:** identify left-behind social-demographic groups, their skill mismatches and other drivers of left-behind, and incentives for behaviour change in upskilling and reskilling that fit the economic transition pathway of regions; Upgrade and redesign cost-effective training and education programs for upskilling and reskilling.

The remaining part of the document is organized as follows. Section 2 reviews the two inputs for developing the twin transition conceptual framework from earlier deliverables of the SkillResilience4EU project Work Package 1. Section 3 introduces the conceptual framework for understanding the labour market resilience in the digital, green and twin transitions. Section 4 concludes.

2 Twin transition exposure indices and Job/skill dynamics indices

This section reviews the two main inputs for developing the twin transition conceptual framework from the earlier deliverables *Twin transition matrix* (Deliverable 1.2) and *Job-skill matrix* (Deliverable 1.3) which build on the *Knowledge base on the impact of twin transition on the European labour market* (Deliverable 1.1).

The **Twin transition matrix** (Deliverable 1.2) is designed and used to estimate the progress and potential of each NUTS-2 region in Europe in the green and digital transitions. The green transition refers to the transformation of economic activities toward environmental sustainability, while the digital transition related to the diffusion of digital (ICT, AI, IoT etc) technologies across industries. We proposed a twin transition taxonomy (Figure 1) based on the Green Employment Index (GEI) and the Digital Employment Index (DEI)² we constructed in the Deliverable 1.2.

By intersecting GEI and DEI, we visualised how regions perform in both transitions simultaneously, identifying those well-prepared for the twin transition, those lagging behind, and those advancing in only one dimension. This intersection produced an explanatory map (Figure 2) that captures Europe's structural heterogeneity in twin transition progress. Regions in Scandinavia, Ireland, and the Benelux countries appear as Twin Transition Leaders, combining strong green and digital profiles, whereas regions of Southern and Eastern Europe remain Twin Transition Laggards, characterised by high emissions, low-digital employment structures.

² The GEI and DEI are constructed using the industry-level data on the greenhouse gas emissions, exposure to digital technologies developed by Prytkova et al. (2024), and the number of employees in each industry in each region from the Eurostat Structural Business Statistics. The indices reflect the extent to which the employment structure of regions is embedded in environmentally sustainable and digitally intensive sectors.

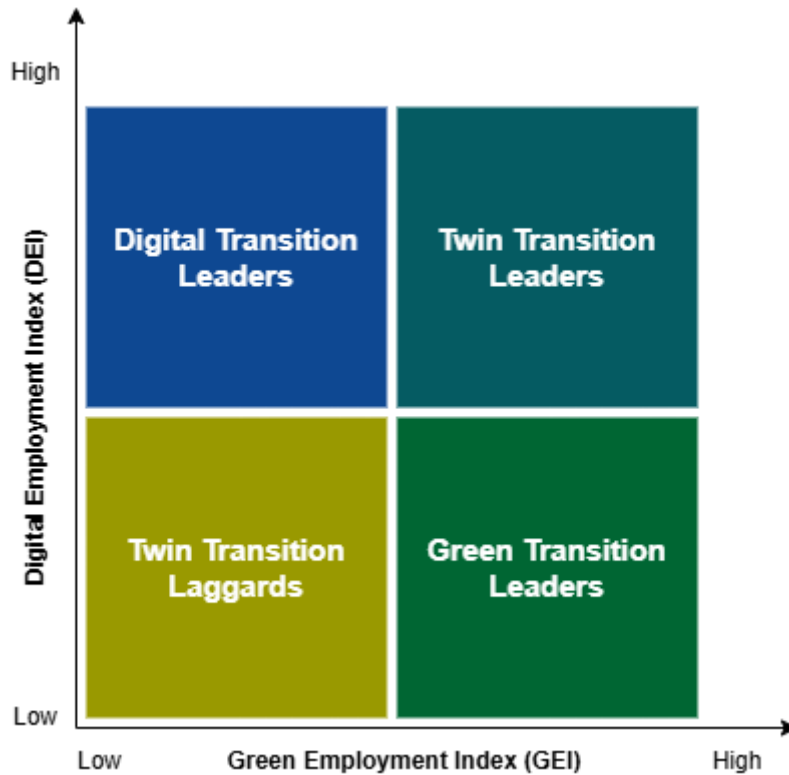


Figure 1: Twin Transition Taxonomy

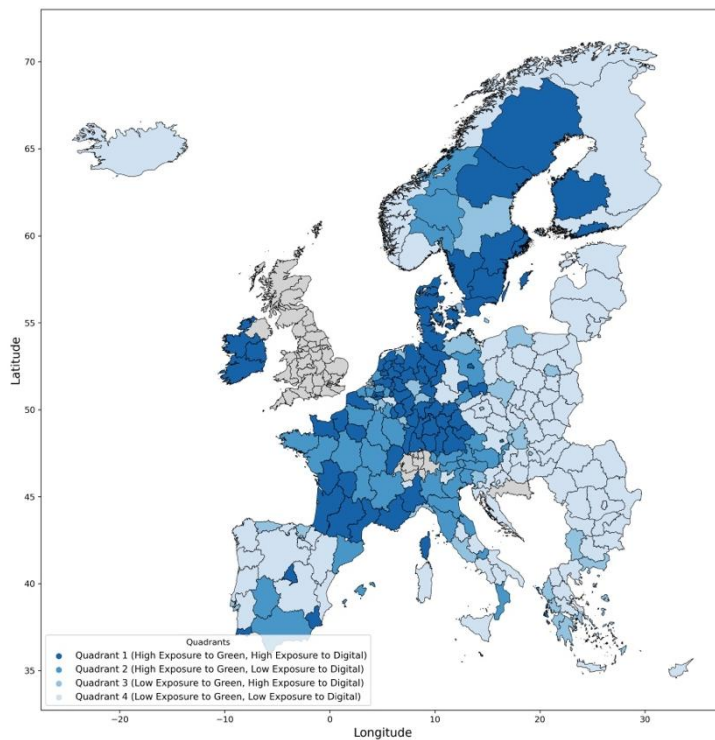


Figure 2: Twin Transitions in European regions.

To develop more the descriptive statistics, we estimated the transformative potential of each region. Drawing on the relatedness density concept (Boschma, 2017), we measured how likely a region can diversify its employment structure towards greener or more digital sectors based on the relatedness of its existing industries. Inspired by recent works on regional diversification into new skills, jobs, and technologies (Buyukyazici, 2023; Farinha

et al., 2019; Neffke et al., 2011), our approach identifies the capability space within which each region can evolve. Regions with dense networks of related industries can more easily adapt and reorient towards green and digital activities, while regions dominated by brown, low-relatedness sectors face higher barriers and risks of structural lock-in.

The calculation of each region's potential to achieve the twin transition also allowed us to assess which regions are lagging behind in their twin transition but might leverage the existing capabilities proxied as their existing industries to diversify their employment base into green and digital transitions. To this end, this mapping allows us to understand where regions stand and what potential they have and address the potential weaknesses and regions that might need policy intervention to achieve those transitions. As other works also showed, many regions show high ambition to participate in the twin transition (Barbero et al., 2025), but only a few may have a high potential to contribute to and profit from the green and digital transition (Bachtrögler-Unger et al., 2023). Furthermore, it is worth mentioning that the report also highlights that achieving a green transition does not mean achieving a digital transition, and sometimes the two of them can go in different directions.

The **Job skills matrix** (Deliverable 1.3) maps the endowments and demand of green and digital skills in each NUTS2 regions in Europe³ following the same approach of Twin Transition Matrix. This dual-sided approach enabled the identification of mismatches between the skills workers possess and the skills employers seek, particularly in emerging digital and green occupations (Caisl et al., 2025; Vona, 2021). The results confirmed substantial spatial disparities within and between European countries and regions in both the supply and demand of these skills. Western and Northern regions tend to have stronger digital skill bases, while green skills are more evenly distributed but often underutilised. Conversely, Eastern European regions frequently show lower digital skill endowments despite high employer demand, revealing a structural skills gap that increases the risk of unequal participation in the twin transition (Diodato et al., 2023).

³ Using data from the European Labour Force Survey (EU-LFS) and the European Skills, Competences, Qualifications and Occupations (ESCO) classification, we identified the supply side of skills, namely the regional endowments of green and digital skills embedded within its workforce. This revealed which regions and sectors have the highest readiness for the twin transition, i.e. the capacity to adapt to green and digital transformations, compared with the EU average. To capture the demand side, we drew on online job advertisements (OJAs) from the Eurostat Web Intelligence Hub Datalab, which uses text-mining techniques to classify vacancies by occupation (ISCO) and skill (ESCO). Based on the skills listed in the OJAs, we identified the demand for green and digital skills at the regional level.

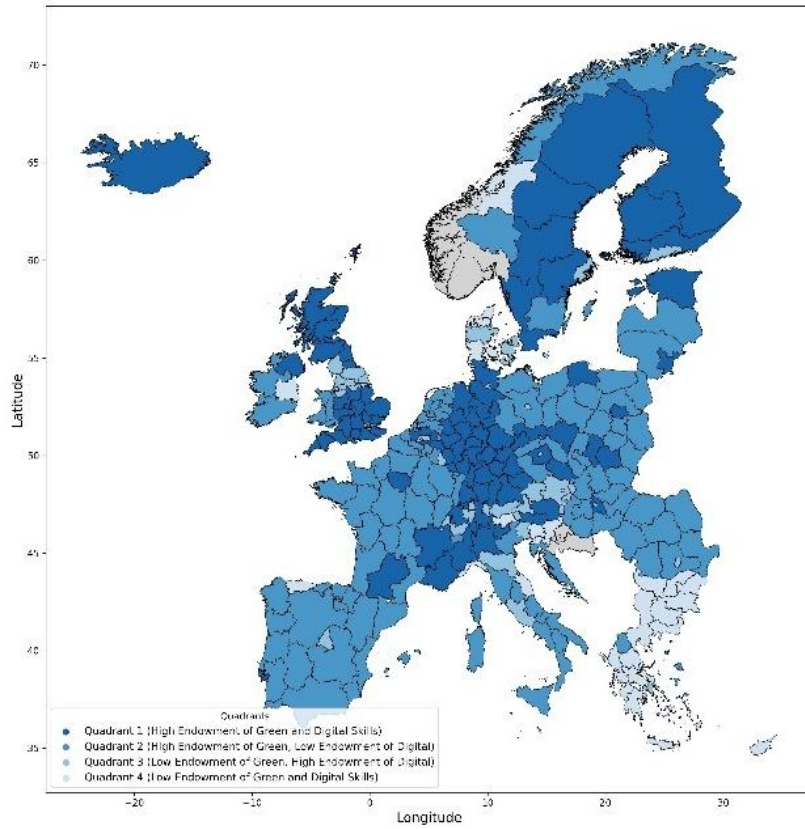


Figure 3: Regional typology of skill endowments in digital and green transitions.

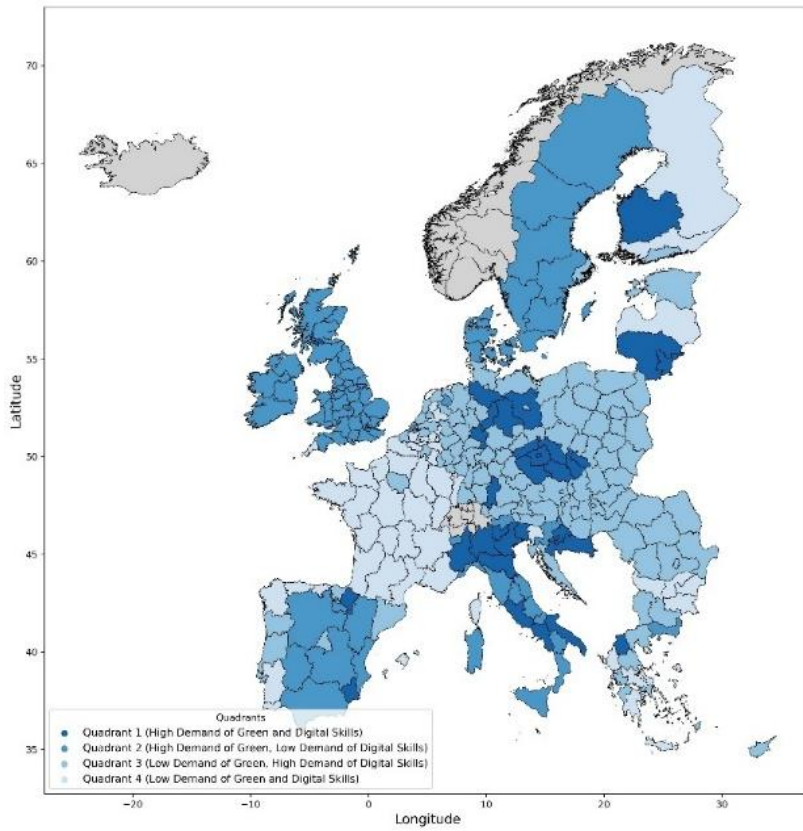


Figure 4: Regional typology of skill demand in digital and green transitions.

The sectoral analysis uncovered strong heterogeneity across industries, especially in Mining, Agriculture, and Information Technologies (IT), sectors that we assumed to have higher impact on the different dimensions of the twin transition. In agriculture, green skills dominate, while IT sectors show strong digital but weak green endowments, reflecting divergent adaptation paths. Mining, meanwhile, displays significant regional variation, with Scandinavian regions showing both high digital and green competencies, while many Eastern European mining regions lag behind. These findings mirror earlier evidence that sectoral structures and regional capabilities determine the pace and inclusiveness of the transition (Fazio et al., 2025). Importantly, we highlight that the green and digital transitions do not always evolve hand in hand. Some regions excel in one dimension but stagnate in the other, leading to hybrid or asymmetric transitions.

Such misalignments underscore the path-dependent nature of regional skill systems. Regions tend to build upon their existing industrial and occupational structures, reinforcing historical advantages or constraints (Buyukyazici et al., 2023). The coexistence of skill surpluses in some regions and shortages in others presents a core challenge for Europe's twin transition. To bridge these divides and to lead into useful indications of potential mismatches and left behind places and sociodemographic groups, SkillResilience4EU proposes the linking of the two matrices (Twin Transition Matrix and Job Skills Matrix). This will allow us to connect macro-level structural transformation with micro-level labour market dynamics, putting the base for a unified analytical framework for understanding Europe's twin transition. By aligning regional exposure to green and digital transformations (as captured through the GEI and DEI) with regional supply and demand of green and digital skills, we will identify where technological and environmental transitions are most likely to generate skill mismatches, job creation, or job destruction. This integration enables a multidimensional analysis that explains why some regions successfully adapt, thanks to high relatedness density, institutional capacity, and skill endowments, while others risk falling behind despite similar exposure levels. The combined framework basis reveals the coupling (or decoupling) between structural transition potential and human capital readiness, supporting evidence-based, place-specific policy interventions for reskilling, upskilling, and inclusive labour-market resilience.

3 Labour market resilience in digital, green and twin transitions: a place-based conceptual framework

While national frameworks set the strategic direction of the green and digital transitions, it is ultimately at the regional level that these structural transformations translate into tangible employment dynamics. Many existing studies suggest heterogeneous impacts of digital and green transitions across the local labour markets in Europe (Dauth et al., 2021; Guarascio et al., 2024, 2025; Hanna et al., 2024; Zaussinger et al., 2025).

Research on the job transitions of individuals also suggests that certain social-demographic groups of workers who are exposed to the job destruction of digital and green transitions are less likely to transit into new jobs, especially in their previous working locations (Barreto et al., 2024; Curtis et al., 2024; del Rio-Chanona et al., 2021; Lim et al., 2023). In sum, regions act as filter and mediators of change, either enabling job

creation through diversification and innovation, or constraining it due to structural lock-ins, skill shortages, or institutional inertia.

This deliverable therefore proposes a place-based approach in understanding the labour market resilience in digital, green and twin transitions (Figure 5). We conceptualize the **place-based labour market resilience** in the context of digital, green and twin transitions **as the ability of regions** in 1) **providing quality job opportunities** through innovation and diversification (Boschma, 2017; Henning et al., 2025; Neffke et al., 2011); 2) **enabling the successful job transitions** for local workers who might face the job-displacement or left-behind in the green and digital transitions.

Both macro and micro level drivers contribute to the labour market resilience of regions. More importantly, these macro and micro level drivers affect the **skill mismatch and left-behind of places and social demographic groups** through different **interconnected channels**, such as structural change of regional economy, institutional and policy change, organisational change, and skill and occupational dynamics. In the following two subsections, we will illustrate the connections between macro and micro-level drivers with these channels.

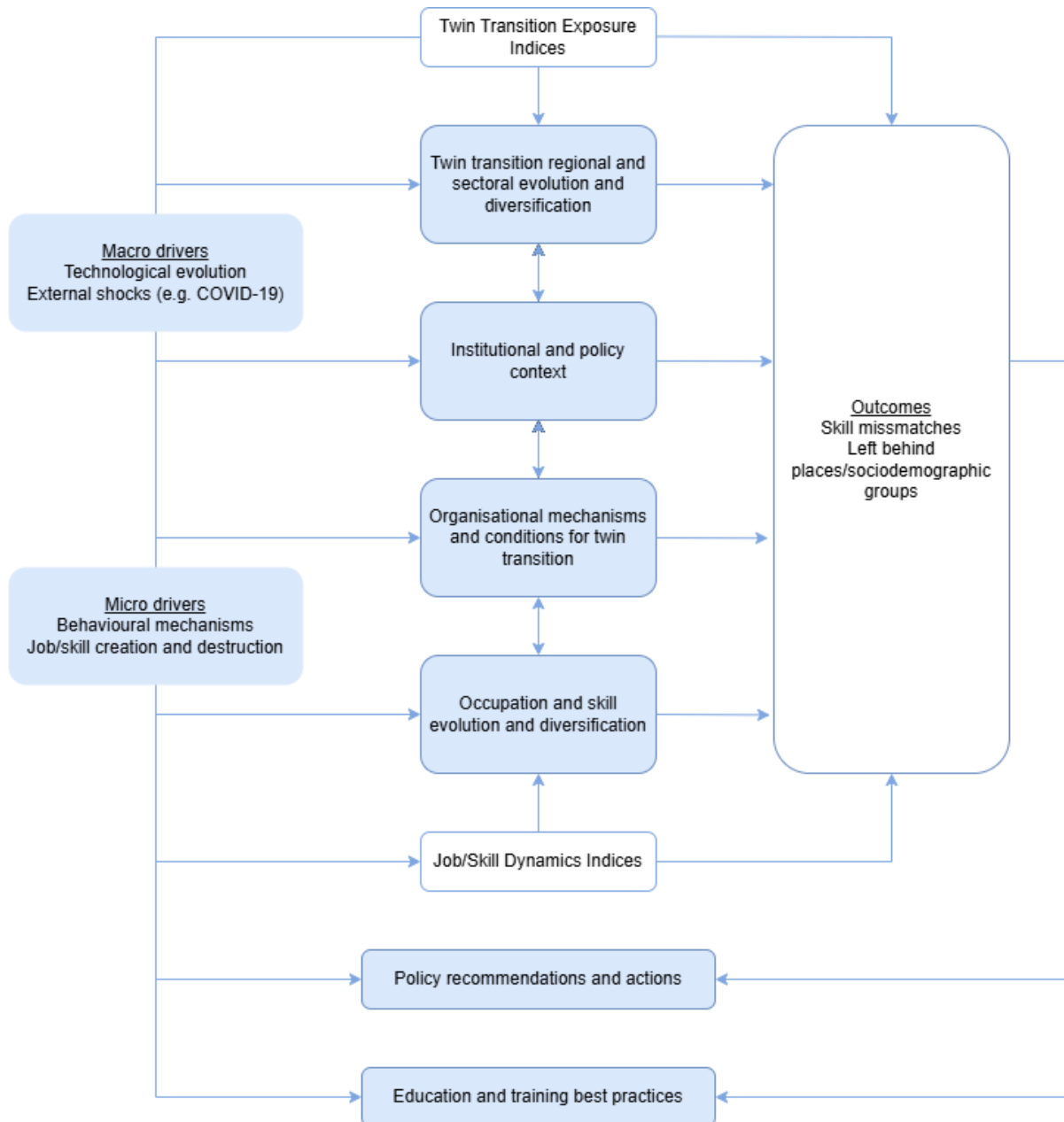


Figure 5: Twin transition conceptual framework.

3.1 Macro level drivers, transition pathways and institutional context

The political feasibility of digital and green transitions crucially depends on whether they can facilitate the smart, sustainable and just growth (Iammarino et al., 2019; Rodríguez-Pose & Bartalucci, 2024). If a large number of workers in a region experience similar consequences of job displacement and left-behind, it might create political instability and the rise of populism which will impede the future transitions (Rodríguez-Pose, 2018; Rodríguez-Pose et al., 2023). Thus, to fully understand the labour market resilience of European regions and sectors, it is important to understand how macro social-economic conditions will affect the direction of digital and green transitions and their interconnections in influencing the labour markets.

First, existing studies suggest that the labour market implications of green transition will differ in different transition pathways (Bücker et al., 2025; Lim et al., 2023; Zaussinger et al., 2025). For example, many existing studies consider the jobs in carbon-intensive sectors such as steel and cement at risk (Barreto et al., 2024). However, the adoption of green hydrogen and carbon capture and storage could facilitate the net-zero transitions of these sectors without displacing workers in these sectors (Zaussinger et al., 2025). Digital technologies could also play an important role in enabling green transition, such as smart grids, digital twins, carbon management system etc. (Bachtrögler-Unger et al., 2023; Popp et al., 2024). However, existing studies mostly analyse the labour market implications of digital transition and green transition separately (Aloisi, 2025). Many studies on the twin transition do not focus on the labour market implications (Bachtrögler-Unger et al., 2023; Diodato et al., 2023; Veugelers et al., 2023).

Thus, a deeper conceptualisation of the *interactive dynamics* of digital and green transitions is often lacking. The 'twin' aspect is frequently treated as two parallel processes (e.g., digitalisation merely *enabling* greening) rather than as an integrated, co-evolving mechanism. This conceptual framework, therefore, moves beyond a simple parallel analysis. It will explicitly examine *how* the green and digital transitions mutually shape, enable, and potentially conflict with one another. Building on the Twin transition indices, economic transition pathways of regions and sectors will be analysed, as well as the role of institutional factors, such as governance quality and institutional coherence (Rodríguez-Pose, 2020), in conditioning and shaping regions' and sectors' capacity to adapt to the green and digital transitions.

Second, the macro-economic conditions and the twin transition pathways of regions are not exogenous nor static. As suggested in the existing literature, the labour market resilience in the digital and green transitions will critically depend on the alignment of policies from different aspects, such as innovation policies that support the development and deployment of new digital and green technologies to achieve the growth potential (Dixson-Declève et al., 2023), climate and energy policies supporting the deployment of green technologies, climate and energy policies will also play an important role (Bücker et al., 2025; Lim et al., 2023; Marin & Vona, 2019; Zaussinger et al., 2025), labour market regulations protecting workers' rights in the digital and green transitions (Aloisi, 2025), and training and education policies supporting the upskilling and reskilling workers, especially displaced workers in order to narrow their skill mismatches with employers (Cirillo et al., 2024; Cnossen et al., 2024; Guo et al., 2022; Langer et al., 2023).

Given the complexity in the policy mixes for a resilient labour market in the digital, green and twin transitions, it is important to focus on the dynamics of institutions and actors involved, particularly at the regional level (**WP4**). This is even more so because the place-based policies at the European level, the Cohesion Policies is a policy mix that covers many aforementioned aspects (European Commission: Directorate-General for Regional and Urban Policy, 2024). The successful upskilling and reskilling practices will critically depend on the coherence of policy mixes and the alignment of institutions and actors involved.

Regional institutional settings play a key role in mediating between macro-level policy trends and local labour market needs in the context of the twin transition. They comprise

not only formal regulatory structures, such as laws and policies, but also normative and cognitive elements, including shared values and belief systems (Scott 2013) that shape which skills, jobs, and career paths are regarded as desirable for the future. These regional institutional settings both respond to higher-level political and economic developments and are simultaneously shaped by the agency of local actors (Grillitsch & Sotarauta, 2020). Local organisations, such as VET providers, firms, regional development agencies, or NGOs, act as agents of institutional change by forming partnerships, negotiating new place-based understandings of what skills and career paths matter in a transforming economy, and mobilising resources to align higher-level labour market strategies with regional needs (Hearne et al., 2025).

Overall, these macro-level insights will help understand regional trajectories in the green and digital transitions and identifying the left-behind places due to spatial skill mismatches, institutional barriers and policy misalignment. Combining these insights with the systematically mapping and evaluation of the effectiveness and impact of existing policies on labour market resilience in the content of green, digital and twin transitions (**WP5**), the SkillResilience4EU project will design a management tool tailored for policy makers for enabling the effective job transitions to narrow down the labour market mismatches.

3.2 Micro level drivers, skill mismatch, left-behind and upskilling and reskilling

Although existing literature suggested overall positive employment impacts of both digital and green transitions, there might be labour market frictions that displaced workers might face difficulties in transferring into new jobs created in the digital transition or green transition (Bücker et al., 2025; del Rio-Chanona et al., 2021; Frank et al., 2019; Zaussinger et al., 2025). This is even more crucial when the skills of the displaced workers become redundant or obsolete due to technological change. Both digital transition and green transition are significantly and rapidly changing the task and skill content of jobs (Consoli et al., 2016; Restrepo, 2024). The skill mismatch of these displaced workers set them on paths with job instability, permanently low earning, and left behind (Barreto et al., 2024; McGuinness et al., 2018; Neffke et al., 2024).

Building on the Job/Skill Dynamics Indices, patterns of unemployment, factors contributing to job losses or the lack of new job creation, and the impact of the spatial reallocation of jobs will be investigated (**WP2**) to identify vulnerable communities and socio-demographic groups. This is important for identifying the job transition pathways that could leverage the current skills of the displaced workers (Bücker et al., 2025; del Rio-Chanona et al., 2021; Zaussinger et al., 2025). If the skill gap is too large, customized training programs are needed to support the upskilling and reskilling of these displaced worker (McGuinness et al., 2018; Nedelkoska & Quintini, 2018).

At the same time, it is also important to focus on how organisations and other key actors are affected by the labour market challenges triggered by the digital and green transitions, and their strategies in addressing these challenges, including factors affecting their decisions in engaging the upskilling and reskilling of their employees (**WP3**). Furthermore, the drivers of the left-behind of certain social-demographic groups in digital and green

transitions is not simply due to the skill mismatch (Barreto et al., 2024; Neffke et al., 2024). It is important to further investigate the social inclusion and exclusion dynamics to fully understand the drivers of left-behind (**WP3**). Specifically, the experiences, perspectives, and motivations of at-risk social-demographic groups are important for identifying and classifying the primary barriers (e.g., financial, logistical, psychological, informational) influencing their social inclusion and exclusion.

Once the skill mismatch and the drivers of left-behind are identified, it is important to investigate the behavioural biases that are associated with the hesitancy towards up/reskilling activities by both employers and employees and create the right incentives for these individuals to engage in upskilling and reskilling programs (**WP2**). Behaviour lab experiments simulating labour market conditions serve as a crucial tool for disentangling the effect of diverse drivers at different levels that are linked to the hold-up problem in the labour market. The experimental framework designed within the SkillResilience4EU project introduces an innovative approach that enables researchers to distinguish between high and low-skilled employees and to examine their behaviour towards up/re-skilling activities, as well as their preferences regarding AI-based solutions. It will also provide the tools to investigate employers propensity to invest in up/re-skilling, and to examine how interactions between employers and employees in the job transition process influence the overall labour market structure. The experimental environment will also give the possibility to test different (soft) behavioural incentives and (hard) policy measures which can potentially enhance the skill and job transition pathways.

Overall, these different micro-level insights into the skill mismatch and left-behind social-demographic groups will help inform policy makers and education providers for supporting the upgrade and redesign of cost-effective upskilling and reskilling programmes (**WP5 and WP6**). More importantly, it is important to focus on the costs and benefits of these training programs including 1) narrowing down the local labour market skill mismatches; 2) effective inclusion of left-behind social demographic groups; 3) minimizing the cost of upskilling and reskilling.

4 Conclusions

This deliverable introduces the **Place-based labour market resilience framework**, a novel and holistic conceptualization that addresses the drivers of labour market resilience from both the **macro and the micro** levels and the interactions between them in jointly affecting the **skill mismatches and left-behind** at both the regional and the individual level in the digital, green and twin transitions.

- **Theoretical advancement:** guide the research on the labour market resilience in digital, green and twin transitions, particularly on the identification of **skill mismatches and left-behind places/social-demographic groups**.
- **Practical application:** 1) allow **individuals** in left-behind or at-risk social-demographic groups to assess whether their skills are fitting the requirements of the regional labour market; 2) allow **organizations** to assess the need for reskilling and upskilling of their employees; 3) equip **education and training providers** with the costs and benefits of the changes in reskilling and upskilling for just and

effective inclusion of the left-behind social-demographic groups and places in the future European labour market.

- **Policy development:** inform **policy makers** with the combined impact of the green and digital transitions on the labour markets for tailor-made policy mixes that will enable the effective job transitions to narrow down the labour market mismatches.

As the theoretical foundation of the **SkillResilience4EU** project, this framework will be applied in the following **Work Packages (2-6)** for advancing the research on the building blocks of the labour market resilience. It reflects the project’s commitment to inter- and trans-disciplinary approaches that blend in scientific insights from economic geography, economics, innovation, and sustainability transition studies with knowledge from the fields of institution research and institutional theory, but also policy research, policy advocacy and evaluation. The project will also intersect with pedagogical science and practices, specifically education and training focus on adult and vocational training, social inclusion and working with vulnerable groups, to propose best practices and practical tools for re-skilling and upskilling.

By addressing the multi-dimensional drivers of labour market resilience, this framework position place-based approach as an actionable reskilling and upskilling pathways to narrow the labour market mismatches that digital, green and twin transitions trigger. Furthermore, this conceptual framework will be amended in **Work Package 5**. The aim of this revision is to review and align results from WP1 to WP6 and converge towards a common and cohesive understanding of the multifaceted issues related to labour market resilience in the digital, green and twin transitions, not only for the selected sectors and regions but for a wider applicability.

5 References










- Aloisi, A. (2025). *Integrating the EU Twin (Green and Digital) Transition? Synergies, Tensions and Pathways for the Future of Work* (No. JRC140964). European Commission: Joint Research Centre.
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC140964/JRC140964_01.pdf
- Bachtrögler-Unger, J., Balland, P.-A., Boschma, R., & Schwab, T. (2023). Technological Capabilities and the Twin Transition in Europe. Opportunities for Regional Collaboration and Economic Cohesion. *WIFO Studies*.
- Barbero, J., A. Collado, L., Rodríguez-Crespo, E., & Santos, A. M. (2025). The twin transition in the European Union: Assessing regional patterns of EU-funded investments. *European Planning Studies*, 0(0), 1–21. <https://doi.org/10.1080/09654313.2025.2528882>
- Barreto, C., Fluchtman, J., Hijzen, A., Lombardi, S., Bennett, P., Bertheau, A., Chan, W., Gorshkov, A., Hambur, J., Johnstone, N., Lochner, B., Meekes, J., Mehdi, T., Muraközy, B., Nolan, G., Salvanes, K., Skans, O. N., & Vejlín, R. (2024). *The “clean energy transition” and the cost of job displacement in energy-intensive industries*. OECD.
<https://doi.org/10.1787/abf614d1-en>
- Boschma, R. (2017). Relatedness as driver of regional diversification: A research agenda. *Regional Studies*, 51(3), 351–364. <https://doi.org/10.1080/00343404.2016.1254767>

- Bücker, J., Rio-Chanona, R. M. del, Pichler, A., Ives, M. C., & Farmer, J. D. (2025). Employment dynamics in a rapid decarbonization of the US power sector. *Joule*, 9(2). <https://doi.org/10.1016/j.joule.2024.12.004>
- Buyukyazici, D. (2023). Skills for smart specialisation: Relatedness, complexity and evaluation of priorities. *Papers in Regional Science*, 102(5), 1007–1030. <https://doi.org/10.1111/pirs.12756>
- Caisl, J., Guarascio, D., & Reljic, J. (2025). Digital skills in Europe. A methodological and empirical assessment. In *Digital skills in Europe. A methodological and empirical assessment*. https://iris.uniroma1.it/bitstream/11573/1742753/1/Caisl_Digital_2025.pdf
- Cedefop. (2023). *Skills in transitions: The way to 2035*. Publications Office of the European Union. <https://data.europa.eu/doi/10.2801/438491>
- Cirillo, V., Mina, A., & Ricci, A. (2024). Digital technologies, labor market flows and training: Evidence from Italian employer-employee data. *Technological Forecasting and Social Change*, 209, 123735. <https://doi.org/10.1016/j.techfore.2024.123735>
- Crossen, F., Piracha, M., & Tchuente, G. (2024). Learning the Right Skill: Vocational Curricula and Returns to Skills. *Journal of Labor Economics*, 730123. <https://doi.org/10.1086/730123>
- Consoli, D., Marin, G., Marzucchi, A., & Vona, F. (2016). Do green jobs differ from non-green jobs in terms of skills and human capital? *Research Policy*, 45(5), 1046–1060. <https://doi.org/10.1016/j.respol.2016.02.007>
- Curtis, E. M., O’Kane, L., & Park, R. J. (2024). Workers and the Green-Energy Transition: Evidence from 300 Million Job Transitions. *Environmental and Energy Policy and the Economy*, 5, 127–161. <https://doi.org/10.1086/727880>
- Dauth, W., Findeisen, S., Suedekum, J., & Woessner, N. (2021). The Adjustment of Labor Markets to Robots. *Journal of the European Economic Association*, 19(6), 3104–3153. <https://doi.org/10.1093/jeea/jvab012>
- del Rio-Chanona, R. M., Mealy, P., Beguerisse-Díaz, M., Lafond, F., & Farmer, J. D. (2021). Occupational mobility and automation: A data-driven network model. *Journal of The Royal Society Interface*, 18(174), 20200898. <https://doi.org/10.1098/rsif.2020.0898>
- Diodato, D., Huergo, E., Moncada-Paternò-Castello, P., Rentocchini, F., & Timmermans, B. (2023). Introduction to the special issue on “the twin (digital and green) transition: Handling the economic and social challenges”. *Industry and Innovation*, 30(7), 755–765. <https://doi.org/10.1080/13662716.2023.2254272>
- Dixon-Declève, S., Dunlop, K., Renda, A., Charveriat, C., Christophilopoulos, E., Balland, P.-A., Isaksson, D., Martins, F., Mir Roca, M., Pedersen, G., Schwaag Serger, S., Soete, L., Stres, Š., Gołębiowska-Tataj, D., Walz, R., & Huang, A. (2023). *Industry 5.0 and the future of work: Making Europe the centre of gravity for future good quality jobs*. Publications Office of the European Union. <https://data.europa.eu/doi/10.2777/685878>
- European Commission: Directorate-General for Regional and Urban Policy. (2024). *Forging a sustainable future together: Cohesion for a competitive and inclusive Europe : report of the High Level Group on the Future of Cohesion Policy, February 2024*. Publications Office of the European Union. <https://data.europa.eu/doi/10.2776/974536>
- Farinha, T., Balland, P.-A., Morrison, A., & Boschma, R. (2019). What drives the geography of jobs in the US? Unpacking relatedness. *Industry and Innovation*, 26(9), 988–1022. <https://doi.org/10.1080/13662716.2019.1591940>
- Fazio, G., Maioli, S., & Rujimora, N. (2025). The twin innovation transitions of European regions. *Regional Studies*, 59(1), 2309176. <https://doi.org/10.1080/00343404.2024.2309176>
- Frank, M. R., Autor, D., Bessen, J. E., Brynjolfsson, E., Cebrian, M., Deming, D. J., Feldman, M., Groh, M., Lobo, J., Moro, E., Wang, D., Youn, H., & Rahwan, I. (2019). Toward understanding the impact of artificial intelligence on labor. *Proceedings of the National Academy of Sciences*, 116(14), 6531–6539. <https://doi.org/10.1073/pnas.1900949116>

- Grillitsch, M., & Sotarauta, M. (2020). Trinity of change agency, regional development paths and opportunity spaces. *Progress in Human Geography*, 44(4), 704–723. <https://doi.org/10.1177/0309132519853870>
- Guarascio, D., Piccirillo, A., & Reljic, J. (2024). *Will robot replace workers? Assessing the impact of robots on employment and wages with meta-analysis* (Working Paper No. 1395). GLO Discussion Paper. <https://www.econstor.eu/handle/10419/282318>
- Guarascio, D., Reljic, J., & Stöllinger, R. (2025). Diverging paths: AI exposure and employment across European regions. *Structural Change and Economic Dynamics*, 73, 11–24. <https://doi.org/10.1016/j.strueco.2024.12.010>
- Guo, Y., Langer, C., Mercorio, F., & Trentini, F. (2022). Skills mismatch, automation, and training: Evidence from 17 European countries using survey data and online job ads. *EconPol Forum*, 23(5), 11–15.
- Hanna, R., Heptonstall, P., & Gross, R. (2024). Job creation in a low carbon transition to renewables and energy efficiency: A review of international evidence. *Sustainability Science*, 19(1), 125–150. <https://doi.org/10.1007/s11625-023-01440-y>
- Hearne, D., Bailey, D., & de Ruyter, A. (2025). Regions and just transitions: Worker perspectives on electrification in two automotive regions. *Regional Studies*, 59(1), 2488205. <https://doi.org/10.1080/00343404.2025.2488205>
- Henning, M., Eriksson, R., Garefelt, P., Martin, H., & Elekes, Z. (2025). Job relatedness, local skill coherence and economic performance: A job postings approach. *Regional Studies, Regional Science*, 12(1), 95–122. <https://doi.org/10.1080/21681376.2025.2459148>
- Iammarino, S., Rodriguez-Pose, A., & Storper, M. (2019). Regional inequality in Europe: Evidence, theory and policy implications. *Journal of Economic Geography*, 19(2), 273–298. <https://doi.org/10.1093/jeg/lby021>
- Langer, C., Peiffer, J., & Wiederhold, S. (2023). Apprenticeship skills pay off on the labor market. *EconPol Forum*, 24(6), 39–43.
- Lim, J., Aklin, M., & Frank, M. R. (2023). Location is a major barrier for transferring US fossil fuel employment to green jobs. *Nature Communications*, 14(1), Article 1. <https://doi.org/10.1038/s41467-023-41133-9>
- Marin, G., & Vona, F. (2019). Climate policies and skill-biased employment dynamics: Evidence from EU countries. *Journal of Environmental Economics and Management*, 98, 102253. <https://doi.org/10.1016/j.jeem.2019.102253>
- McGuinness, S., Pouliakas, K., & Redmond, P. (2018). Skills Mismatch: Concepts, Measurement and Policy Approaches. *Journal of Economic Surveys*, 32(4), 985–1015. <https://doi.org/10.1111/joes.12254>
- Nedelkoska, L., & Quintini, G. (2018). Automation, skills use and training. *OECD Social, Employment and Migration Working Papers*, Article 202. <https://ideas.repec.org//p/oec/elsaab/202-en.html>
- Neffke, F., Henning, M., & Boschma, R. (2011). How Do Regions Diversify over Time? Industry Relatedness and the Development of New Growth Paths in Regions. *Economic Geography*, 87(3), 237–265. <https://doi.org/10.1111/j.1944-8287.2011.01121.x>
- Neffke, F., Nedelkoska, L., & Wiederhold, S. (2024). Skill mismatch and the costs of job displacement. *Research Policy*, 53(2), 104933. <https://doi.org/10.1016/j.respol.2023.104933>
- OECD. (2023). *Job Creation and Local Economic Development 2023: Bridging the Great Green Divide*. OECD Publishing.
- OECD. (2024). *Job Creation and Local Economic Development 2024: The Geography of Generative AI*. OECD Publishing. <https://doi.org/10.1787/83325127-en>
- Popp, D., Vona, F., Grégoire-Zawilski, M., & Marin, G. (2024). The Next Wave of Energy Innovation: Which Technologies? Which Skills? *Review of Environmental Economics and Policy*, 18(1), 45–65. <https://doi.org/10.1086/728292>

- Restrepo, P. (2024). Automation: Theory, Evidence, and Outlook. *Annual Review of Economics*, 16, 1–25. <https://doi.org/10.1146/annurev-economics-090523-113355>
- Rodríguez-Pose, A. (2018). The revenge of the places that don't matter (and what to do about it). *Cambridge Journal of Regions, Economy and Society*, 11(1), 189–209. <https://doi.org/10.1093/cjres/rsx024>
- Rodríguez-Pose, A. (2020). Institutions and the fortunes of territories. *Regional Science Policy & Practice*, 12(3), 371–386. <https://doi.org/10.1111/rsp3.12277>
- Rodríguez-Pose, A., & Bartalucci, F. (2024). The green transition and its potential territorial discontents. *Cambridge Journal of Regions, Economy and Society*, 17(2), 339–358. <https://doi.org/10.1093/cjres/rsad039>
- Rodríguez-Pose, A., Terrero-Dávila, J., & Lee, N. (2023). Left-behind versus unequal places: Interpersonal inequality, economic decline and the rise of populism in the USA and Europe. *Journal of Economic Geography*, 23(5), 951–977. <https://doi.org/10.1093/jeg/lbad005>
- Veugelers, R., Faivre, C., Rückert, D., & Weiss, C. (2023). The Green and Digital Twin Transition: EU vs US Firms. *Intereconomics*, 58(1), 56–62. <https://doi.org/10.2478/ie-2023-0010>
- Vona, F. (2021). *Labour markets and the green transition: A practitioner's guide to the task based approach*. Publications Office of the European Union.
- Zaussinger, F., Schmidt, T. S., & Egli, F. (2025). Skills-based and regionally explicit labor market exposure to the low-carbon transition in Europe. *Joule*, 9(2). <https://doi.org/10.1016/j.joule.2024.101813>

Annex 1: The Consortium

Short name	Full name	Homepage	Logo
HVL	Western Norway University of Applied Sciences	https://www.hvl.no/en/	
BOKU	BOKU University	https://boku.ac.at/en/	
LSE	London School of Economics	https://www.lse.ac.uk/	
UoC	University of Crete	https://www.uoc.gr/en/	
UW	University of Warsaw	https://en.uw.edu.pl/	
UU	University of Utrecht	https://www.uu.nl/en	
FHNW	University of Applied Sciences and Arts Northwestern Switzerland	https://www.fhnw.ch/en/	
BFI	Berufsförderungsinstitut Wien	https://www.bfi.wien/	
Simplon	Simplon.co	https://www.simplon.co/	
MOP	Municipality of Platania	https://www.platanias.gr/en/	

Annex 2: Project Summary

SkillResilience4EU - Resilience through re-skilling and upskilling for European labour markets in transition.

The twin transition (defined as the coexistence and interplay of the green and digital transitions) has enormous impacts on European labour markets. Because the green and digital transformations can feed into, facilitate, or hinder each other, it has been difficult to predict how labour markets will absorb and respond to changes and disruptions in employment conditions, skill needs and job availability and mobility. Other ongoing global challenges and macro-economic events, like the COVID-19 pandemic, also contribute to a profound reshaping of labour markets in Europe. New sectors emerge, existing sectors need to adapt and transform. New skills need to be developed or need to be transferred from other industries. Regions and sectors need to narrow labour market and skill mismatches to minimise the costs and to maximise the benefits of job destruction and job creation processes.

Different sectors and regions are affected in varying ways and intensities, either by green or digital transitions, or the combined impact of the twin transition. This unequal distribution of job creation and destruction processes may favour or leave behind places, sectors, and socio-economic groups and may threaten social cohesion and inclusion. The institutional and policy context needs to become more flexible and responsive to cope with the ongoing transformations and narrow down the labour market mismatches. Tailored and cost-effective policies and programmes for reskilling and upskilling, in particular for the most vulnerable and left-behind socio-demographic groups and places, need to be developed together with policy makers, VET providers, unions, public authorities, and other decision makers.

Funded by Horizon Europe, the European Union's Framework Programme for Research and Innovation, SkillResilience4EU will introduce a novel conceptual framework to describe and understand the impacts of the twin transition on European labour markets and will investigate the complex mechanisms, dynamics, and challenges that regions and institutions undergo by exploring selected sectors (tourism, food, transport, agriculture, and energy). The project will develop a management tool for policy makers to support them in managing labour markets in transition with recommendations for policy scenarios. SkillResilience4EU will also map and evaluate educational and training programmes for upskilling and re-skilling and will deliver recommendations and practical resources to support individuals and employers with specific focus on career guidance and development.

To achieve this ambition, the SkillResilience4EU consortium unites higher educational institutions (Western Norway University of Applied Sciences, Utrecht University, London School of Economics, University of Warsaw, University of Natural Resources and Life Sciences in Vienna, University of Crete, North-Western Switzerland University of Applied Sciences) one vocational training institute (BFI), one private training organization (Simplon.co) and a local public authority (Municipality of Platánias). The partners cover a whole range of expertise: economic geography, innovation studies, regional development, sustainability transitions, qualitative research, institutional research, policy research, labour and behavioural economics, education, arts and design, social inclusion, VET and lifelong learning. Coordinated by Western Norway University of Applied Sciences, the project was launched on 1st January 2025 and will run for 3 years.