Skill Resilience 4EU

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

D2.2 – Identification of left-behind groups and places

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Abbreviations and acronyms

Abbreviation or acronym used in this document	Explanation
AI	Artificial intelligence
ARDECO	Annual Regional Database of the European Commission
CEE	Central and Eastern Europe
COVID-19	Coronavirus disease 2019
DTI	Development Trap Index
EU	European Union
EU27	European Union of 27 member states
GDP	Gross domestic product
GVA	Gross value added
HHI	Herfindahl-Hirschman Index
HRST	Human resources in science and technology
LBI	Left-Behind Index
LBPI	Left-Behind Places Index
NEET	Not in employment, education, or training
NUTS	Nomenclature of Territorial Units for Statistics
NUTS-2	Nomenclature of Territorial Units for Statistics - level 2
OECD	Organisation for Economic Co-operation and Development
OGI	Opportunity Gap Index
SD	Standard deviation
SkillResilience4EU	Resilience through re-skilling and upskilling for European labour markets in transition
TSI	Transitioning Sectors Index
VET	Vocational education and training
WP	Work package

Glossary

Term	Definition used or meaning in the Acronym project	Reference or source for the definition if applicable
Left-behind places	Areas where prolonged economic marginalisation, population loss, and weakening institutions have combined to produce cumulative disadvantage across several overlapping dimensions. Their condition is defined not only by current underperformance but by a persistent widening gap relative to other regions and to their own historical baseline.	(Bernard et al., 2025; Fiorentino et al., 2024a; Rodríguez-Pose, 2018)
Left-behind groups	Categories of workers and job-seekers who are structurally more exposed to the costs of economic restructuring and less able to access its benefits. This includes people with low formal qualifications, older employees in contracting industries, young people with no stable employment or training, and women concentrated in sectors undergoing major disruption.	(Barreto et al., 2024; Causa et al., 2024; Vandeplas et al., 2022)
Twin Transition	The concurrent move toward a fully digitalised economy and a carbon-neutral society, generating changes in how industries operate, what skills are valued, and which jobs grow or disappear. In this project, it serves as the overarching context within which regional and labour-market vulnerability is assessed.	(European Commission, 2020, 2021)
Left-Behind Places Index (LBPI)	A measure of core regional economic conditions, drawing on GDP/capita, workforce productivity, and employment rate. It combines a snapshot of current standing with a trend component to distinguish regions that are stagnating from those on a path of improvement or deterioration.	
Opportunity Gap Index (OGI)	A measure of how evenly labour-market access is distributed across different segments of the population. It draws on indicators covering youth disengagement, older worker participation, educational attainment, and the gender employment gap to map where inclusion remains weakest.	
Transitioning Sectors Index (TSI)	A measure of how well a region's industrial base is positioned to absorb pressures from automation and decarbonisation. It reflects the diversity, knowledge content, and adaptability of local	

	economic sectors rather than their current size or output.	
Left-Behind Index (LBI)	An aggregate measure that brings together the LBPI, OGI, and TSI into a single vulnerability score for each region. It is designed to capture compound disadvantage, where weaknesses across economic, social, and sectoral dimensions overlap and reinforce each other.	
Development Trap Index (DTI)	An index which captures simultaneous weakening across the three core dimensions of economic performance -income, productivity, and employment - relative to several benchmarks.	(Diemer et al., 2022)

Executive Summary

This deliverable, part of the SkillResilience4EU project, identifies left-behind places, population groups, and sectors across European regions in the context of the twin transition. The analysis recognises that while these transformations create new opportunities for growth and employment, they also create uneven adjustment pressures shaped by underlying differences in economic structure, labour-market conditions, demographic dynamics, and sectoral composition. Understanding where vulnerability is clustered and more importantly, how it is evolving is essential for designing effective policy responses that reach those most in need.

The analysis covers 247 NUTS-2 regions across EU27, Norway, and Switzerland over the period 2014–2024. It adopts a multidimensional framework that combines recent socio-economic conditions (level-based indices) with medium-term trajectories (slope-based dynamic indices) to capture both persistent disadvantage and emerging vulnerability. Three complementary dimensions are constructed: the Left-Behind Places Index (LBPI), capturing core regional economic performance through GDP per capita, labour productivity, and employment rates; the Opportunity Gap Index (OGI), capturing labour-market vulnerability across population groups defined by age, education, and gender; and the Transitioning Sectors Index (TSI), capturing sectoral structure and adjustment capacity in relation to digitalisation and decarbonisation pressures. These three dimensions are combined into an overall Left-Behind Index (LBI), providing an integrated assessment of multidimensional vulnerability. All indices are standardised using z-scores and constructed using equal weighting, with indicator selection informed by correlation analysis to ensure internal consistency while avoiding redundancy. The analysis is further complemented by a Regional Development Trap Index (DTI), which identifies regions simultaneously decelerating across income, productivity and employment relative to multiple benchmarks.

The four main findings are as follows:

On economic performance, the LBPI confirms a persistent core–periphery structure, with the most disadvantaged regions concentrated in southern Italy, Greece, Romania, Bulgaria, and parts of eastern Poland and Hungary. However, the dynamic analysis reveals an important countertrend: Central and Eastern European regions are converging rapidly, while many regions in Germany, Austria, Scandinavia, and the Netherlands are losing ground. Indeed, many currently well-positioned European regions are on a relative downward trajectory, signalling that the geography of economic vulnerability in Europe is changing and that the future of left behind regions may differ considerably from the current structural map.

On labour-market inclusion, opportunity gaps follow a southern arc rather than a east–west gradient, with the highest disadvantage in southern Italy, Greece, southern Spain, and parts of Romania. A notable finding is the relative deterioration of opportunity gap trajectories in much of the western European core, where youth disengagement has been growing, while older worker participation is declining, even though these regions remain structurally strong on labour-market indicators. This dimension also reveals that economic performance and labour-market conditions do not always align: several economically productive regions harbour high levels of exclusion.

On sectoral structure, vulnerability is more geographically fragmented than on the other two dimensions, shaped by industrial legacies and the pace of structural transformation rather than broad macro-regional patterns. A key development is the widening polarisation over the decade:

both the most favourable and the most vulnerable groups have grown, suggesting increasing divergence in sectoral adjustment capacity. Within-country variation is also pronounced, with countries such as Germany and Italy showing sharp internal splits between regions with sustained adaptability and those lacking it.

The overall LBI reveals that compound disadvantage remains concentrated in a well-defined southern and eastern periphery (Greece, southern Italy, Romania, and southern Spain), while compound advantage is anchored in a western and northern core supplemented by a growing number of Central and Eastern European metropolitan hubs. The number of regions in the most vulnerable class declined from 2014 to 2024, driven by convergence in Central and Eastern Europe, but the persistence of Greek, southern Italian, and Romanian regions in this group underscores that convergence has been geographically selective. We also find that a large group of European regions are at risk of becoming left behind. They enjoy structurally favourable conditions today but display weakening trajectories across all three dimensions.

A complementary analysis examines whether regions are simultaneously losing economic momentum across income, productivity and employment relative to their own recent past, their national context, and the European average - revealing a further dimension of vulnerability that the LBI framework alone does not capture. Regions showing this pattern are concentrated not in the traditional European periphery but across western and northern Europe. Many of these regions remain structurally favourable on the LBI but show consistent weakening of underlying growth dynamics. This points to a form of emerging vulnerability that structural indicators alone may not yet fully reflect.

Therefore, three cross-cutting themes emerge. First, structural conditions and dynamics often point in different directions, underscoring the importance of combining static and dynamic measures. This is reinforced by the development trap analysis, which shows that weakening economic momentum is most prevalent in regions that currently appear structurally strong. Second, the twin transition is arriving at a moment of considerable regional differentiation, where a large group of regions showing emerging vulnerability represents a distinct policy challenge. Third, vulnerability is multidimensional, and the dimensions do not always align, meaning that policy responses calibrated to a single measure of disadvantage may miss important aspects of other regional risk.

The findings provide an empirical baseline for subsequent project work on skills, labour-market adjustment, and policy responses targeting vulnerable regions and groups. The vulnerability profiles developed here offer a spatial and structural reference point for assessing where skills mismatches and adjustment pressures are likely to be most acute, and where targeted intervention may be most needed to ensure that the twin transition does not deepen existing spatial and social divides.

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1 Introduction

The twin transition, the shift towards a digital economy and a climate-neutral society, is reshaping (and will continue to reshape for the foreseeable future) regional economies, labour markets, and sectoral structures across Europe. Driven by rapid technological adoption, the decarbonisation of production systems, and evolving patterns of demand and employment, these transformations are changing the conditions under which regions and workers operate. While these transformations create new opportunities for growth and employment, they also add uneven adjustment pressures across regions and population groups (European Commission, 2018a, 2020, 2021, 2025). The pace and nature of change are not uniform: differences in economic structure, labour-market conditions, demographic dynamics, and sectoral composition mean that some regions and communities are better positioned to adapt, while others face a higher risk of being left behind (Burbridge, 2025; Frey and Osborne, 2017; Rodríguez-Pose, 2018).

Indeed, the distribution of adjustment costs and opportunities is shaped by underlying structural factors. Regions characterised by weaker economic performance, declining populations, limited labour-market participation, or less diversified economic structures may face greater challenges in adjusting to technological change and decarbonisation. The capacity to absorb and respond to structural shifts depends not only on current economic conditions but also on the availability of skills, infrastructure, institutional quality, and access to investment (Álvarez et al., 2023; Farole et al., 2011; Rodríguez-Pose, 2013; Tödtling and Trippl, 2005). Similarly, certain population groups face disproportionate barriers to employment and reskilling during transition. Older workers displaced from declining industries often struggle to find comparable reemployment, especially where their skills are sector-specific and relocation is not a realistic option (Barreto et al., 2024; Causa et al., 2024; Lim et al., 2023; Vandeplas et al., 2022). Workers with lower educational attainment are more exposed to automation and AI-driven labour market restructuring, and less able to access the kinds of jobs that green and digital transformation generates (Causa et al., 2024; Frey and Osborne, 2017; Manning and Aguirre, 2026). Young people outside education and the labour market risk early and persistent exclusion. Meanwhile, gender gaps in employment mean that a significant share of the potential workforce remains underutilised, with women consistently underrepresented in both green and high-polluting occupations across European labour markets (Causa et al., 2024). At the sectoral level, industries characterised by lower knowledge intensity, high carbon exposure, or limited adjustment capacity may be more exposed to structural change and face greater risks of employment loss or economic contraction (Burbridge, 2025).

Understanding which places, groups, and sectors are most exposed to these pressures is key for designing effective policy responses. The analysis is complemented by a Regional Development Trap index (Diemer et al., 2022) which provides a forward-looking assessment of whether underlying economic momentum is strengthening or weakening across regions, independently of their current structural position. Without a clearer picture of where vulnerability is concentrated and how it is evolving, there is a risk that transition policies may fail to reach those most in need, exacerbating existing inequalities and deepening spatial and social divides (Dijkstra et al., 2020; European Commission, 2022; Rodríguez-Pose, 2018). At the same time, vulnerability is not a fixed condition: some regions and groups may be experiencing declining trajectories even where current conditions appear favourable, while others may be on a path of gradual recovery despite historically weak starting positions.

As such, central to this analysis is the concept of left-behind places, which, while now widely used in both academic and policy discourse, refers to more than simply weak economic performance at a given point in time. It defines regions that have experienced sustained relative decline across multiple dimensions (e.g. economic output, employment, productivity, access to

services, and institutional capacity), often as a result of deindustrialisation, demographic decline, and prolonged underinvestment (Fiorentino et al., 2024a; Iammarino et al., 2019; Rodríguez-Pose, 2018). Furthermore, left-behindness is inherently relational: places fall behind relative to other regions that are advancing and relative to their own past trajectories (Diemer et al., 2022; MacKinnon et al., 2024). It is also multi-dimensional, meaning that economic, social, and institutional disadvantages tend to overlap and reinforce one another rather than occurring in isolation (Bernard et al., 2025; Comim et al., 2024). Finally, the political consequences of these spatial inequalities have also become increasingly visible, with long-term regional decline closely associated with rising support for populist and Eurosceptic movements across Europe (Dijkstra et al., 2020; Rodríguez-Pose, 2018).

Against this background, this deliverable identifies left-behind places, population groups, and sectors in the context of the twin transition. The analysis adopts a multidimensional approach combining recent socio-economic conditions with medium-term trajectories to capture both persistent disadvantage and emerging vulnerability. This dual focus allows for the identification of regions that are structurally disadvantaged, as well as those where conditions are deteriorating over time and where future vulnerability may be compounding.

Therefore, the framework distinguishes three complementary dimensions. The first focuses on left-behind places, capturing core regional economic performance, including output, productivity, and employment capacity. The second focuses on opportunity gaps, capturing labour-market vulnerability across population groups defined by age, education, and gender. The third focuses on transitioning sectors, capturing sectoral structure and adjustment capacity in relation to both digitalisation and decarbonisation pressures. Each dimension is constructed using a combination of level indicators and slope-based measures to reflect both current conditions and the direction of recent change. These dimensions are subsequently combined into an overall index to provide an integrated assessment of multidimensional left-behind dynamics across European regions.

By combining static indicators with slope-based measures, the analysis captures both current positioning and the direction of change. This allows the identification of regions and population groups that may face increasing vulnerability, even where current conditions appear relatively favourable. The resulting framework aims to provide a robust and policy-relevant basis for identifying places, groups and sectors at risk of being left behind during the twin transition and contributes to a broader understanding of uneven adjustment patterns across European regions.

1.1 Purpose of the document

This deliverable has two main aims. The first is to identify left-behind places, groups, and sectors across European regions by developing a multidimensional framework that captures the structural conditions shaping regional vulnerability in the context of the twin transition. The second is to assess how these patterns evolve over time, distinguishing between regions that are persistently disadvantaged and those where conditions are declining or improving along recent trajectories. Together, these aims provide both a cross-sectional picture of where vulnerability is concentrated and a dynamic account of how risks are shifting across European regions.

To address the first aim, the analysis develops a multidimensional framework focusing on the structural economic conditions, and labour-market factors that may constrain the ability of regions to adapt to the green and digital transitions. Rather than relying on single indicators, the approach combines multiple dimensions to identify regions where a broad range of socio-economic conditions signal a heightened risk of being left behind. This allows for a more robust

characterisation of vulnerability than any individual indicator could provide and ensures that regions facing compound disadvantages across several dimensions are appropriately identified.

For the second aim, the framework distinguishes between static positioning and dynamic trajectories. Static indices capture the relative socio-economic position of regions at a given point in time, while dynamic indices measure the direction and pace of change over the period analysed. This distinction is analytically important: it allows the identification of regions that are structurally disadvantaged but on an improving trajectory, as well as regions that are currently well positioned but showing signs of decline. By incorporating both dimensions, the framework moves beyond a snapshot assessment and provides a more forward-looking characterisation of vulnerability.

To operationalise this framework, the analysis captures regional vulnerability across three complementary dimensions. The first focuses on core economic performance, reflecting a region's capacity to generate output, sustain productivity, and provide employment. The second focuses on labour-market inclusion, capturing how different population groups, defined by age, education, and gender, are positioned in the labour market and the extent to which structural barriers limit their participation. The third focuses on sectoral adjustment capacity, assessing whether a region's economic structure and industry mix leave it well or poorly equipped to absorb the pressures associated with digitalisation and decarbonisation. These three dimensions are grounded in the broader literature on left-behind places, which consistently identifies economic underperformance, labour-market exclusion, and limited structural adaptability as the defining features of regions at risk of falling behind (Bernard et al., 2025; Fiorentino et al., 2024a; Iammarino et al., 2019; MacKinnon et al., 2022; Rodríguez-Pose, 2018). Each dimension is assessed using both level indicators and slope-based measures to reflect current conditions and the direction of recent change. The three dimensions are subsequently combined into an overall measure of multidimensional vulnerability across European regions, the construction and composition of which are set out in the methodology.

The indicators underpinning each dimension are selected on the basis of conceptual relevance, data availability, and correlation analysis, ensuring internal consistency within dimensions while avoiding redundancy across them. All indices are constructed at the NUTS-2 regional level and standardised by year to allow relative comparison across space and over time.

The resulting framework provides an empirical basis for identifying regions and population groups at risk of being left behind in the context of the twin transition, and for assessing how these risks evolve over time. The results are intended to support subsequent work in the project on skills, labour-market adjustment, and policy responses targeting vulnerable regions and groups. This includes the identification of regions where labour-market conditions and sectoral structures may limit the ability to benefit from transition-related employment and growth opportunities, and where targeted intervention may therefore be most needed.

1.2 Intended readership

This document is intended for readers with an interest in identifying left-behind places, groups, and sectors in the context of the green and digital transition. It is primarily addressed to policy analysts, researchers, and practitioners working at European, national, and regional levels who may need a structured analytical framework to examine how structural socio-economic conditions, demographic dynamics and labour-market vulnerabilities shape the risk of regions and population groups being left behind during the twin transition. Readers are assumed to have a working familiarity with regional policy analysis and socio-economic indicators, though the

framework and methodology are presented in sufficient detail to be accessible to those approaching the topic from adjacent disciplines or policy domains.

The report is designed to be relevant for users involved in the analysis and monitoring of cohesion, green transition, digitalisation, labour-market, and skills policies. By providing comparable indicators and a dynamic perspective on regional trajectories, the analysis supports evidence-based interpretation of how the twin transition may reinforce existing inequalities and create uneven adjustment pressures across places, groups, and sectors. The framework is also useful to users who may want to move beyond aggregate assessments and identify where vulnerability is spatially concentrated.

In addition, the report may be of interest to the research community working on regional development and economic geography, as it offers an integrated macro-level approach to analysing left-behind dynamics in the context of the twin transition. By combining level conditions with medium-term socio-economic trajectories, the framework identifies regions where structural constraints may limit the ability to benefit from the opportunities associated with green and digital transformation

1.3 Relationship with other deliverables

This deliverable builds on Deliverable 2.1, which examined regional transition pathways in the context of the green and digital transition. While Deliverable 2.1 focused on transition readiness and trajectories, Deliverable 2.2 complements this perspective by identifying places, population groups, and sectors facing structural disadvantages and increased risks of being left behind. The two deliverables are analytically distinct but conceptually linked: readiness and vulnerability are not simply mirror images of one another, and a region may display moderate transition readiness while still harbouring significant pockets of labour-market vulnerability or sectoral exposure. Together, the two deliverables provide a combined assessment of transition capacity and transition-related vulnerability across European regions.

The results of Deliverable 2.2 provide a macro-level identification of left-behind places, groups, and sectors, supporting the interpretation of the project's sectoral case studies. The quantitative mapping developed here offers an empirical baseline against which qualitative evidence gathered through interviews and focus groups in selected regions and sectors can be situated and contextualised. By situating case study regions within broader patterns of structural vulnerability, the framework helps to assess the extent to which findings from individual cases reflect wider regional dynamics and supports the transferability of lessons across different territorial and sectoral contexts.

In addition, the findings inform the design and interpretation of the focus groups conducted in subsequent tasks. The identification of vulnerable regions and population groups provides a structured basis for discussing transition-related challenges, skills needs, and labour-market adjustment processes with stakeholders. In particular, the dynamic dimension of the framework, which captures not only current conditions but recent trajectories, helps to ground stakeholder discussions in an evidence-based account of how vulnerabilities are evolving, rather than relying solely on static snapshots of disadvantage.

The deliverable also connects to subsequent analytical work within the project on skills supply and demand, labour-market adjustment, and policy responses. The vulnerability profiles developed here provide a spatial and structural reference point for assessing where skills mismatches and adjustment pressures are likely to be most acute, and where the gap between

transition-related labour-market opportunities and the adaptive capacity of local economies and workers may be widest.

Overall, Deliverable 2.2 contributes to the project's analytical framework by providing a vulnerability-focused perspective that complements transition readiness measures and supports the interpretation of uneven impacts of the twin transition across regions, population groups, and sectors. By combining static and dynamic assessments across multiple dimensions, it offers a layered empirical foundation that connects macro-level regional analysis with the sectoral, qualitative, and policy-oriented strands of the broader project.

2 Methodology and methods

2.1 Defining and characterising left-behind places and groups

The concept of ***left-behind places*** has become one of the key frameworks in contemporary regional studies and economic geography for understanding the uneven spatial consequences of economic restructuring, globalisation, and policy change. While the term gained widespread public and political currency more recently, the underlying phenomena it describes has much deeper roots in processes of deindustrialisation, demographic decline, and institutional erosion that have unfolded over several decades(Fiorentino et al., 2024a; Iammarino et al., 2019; MacKinnon et al., 2024). Rodríguez-Pose (2018) characterised the neglected regions fuelling political upheaval as "places that don't matter", arguing that their systematic marginalisation in favour of agglomeration-focused development strategies had motivated a territorial backlash through the ballot box, with strong spatial rather than just social foundations. Dijkstra et al. (2020) provided further empirical evidence for this argument, mapping the geography of discontent across electoral districts in the EU-28 and finding that support for Eurosceptic parties was primarily driven by long-term local economic and industrial decline. Understanding what constitutes a left-behind place, and how left-behindness can be defined and measured, is therefore key for both analytical clarity and the design of effective policy responses.

However, defining left-behind places is far from straightforward. Fiorentino et al. (2024a) argue that they are not simply areas with low income or high unemployment at a single point in time; rather, they are places that have experienced sustained relative decline across multiple, often interconnected dimensions - economic, social, institutional, and political. This multi-dimensionality is a recurring theme in the literature. Bernard et al. (2025), in their comprehensive framework for the European Union, distinguish between absolute deprivation -poor performance on key indicators in level terms - and relative decline - a deterioration of position over time - arguing that genuine left-behindness involves the intersection of both. Their operationalisation spans economic performance, demographic dynamics, accessibility to services and infrastructure, and quality of governance, yielding distinct typologies of left-behind regions including deindustrialised areas, peripheral rural zones, and post-socialist transition regions.

A key insight from this body of work is that left-behindness is inherently relational and shaped by ongoing processes of change. Places are not left behind in isolation; they are left behind relative to other places that are advancing and relative to their own historical trajectories (Fiorentino et al., 2024a; MacKinnon et al., 2024). MacKinnon et al. (2024) stress that the concept must be situated within broader debates about the geography of discontent and the structural processes generating uneven development, including global economic restructuring, national policy frameworks, and place-specific historical legacies. They caution against treating left-behind places as static, bounded units with fixed characteristics, advocating instead for approaches that foreground the dynamic processes through which places come to be left behind. This understanding is reinforced by Diemer et al. (2022), whose concept of the "regional development trap" identifies regions stuck in cycles of underperformance relative to their own past and to their national and EU peers which is a condition that can affect not only the poorest regions but also formerly prosperous, middle-income areas that have experienced prolonged stagnation.

Gansauer (2025) advances this argument further by proposing a relational framework that defines left-behindness as a process of peripheralisation rooted in the relations of capitalism and power, rather than just a static condition of relative disadvantage.

Furthermore, the language of left- behind carries important normative and political weight. Pike et al. (2024) provide a geographical etymology of the term, demonstrating that while the English-language formulation has become dominant, analogous concepts exist across European languages (e.g *délaissé* in French and *abgehängt* in German), each carrying distinct connotations. Indeed, the term implies agency: someone or something has done the leaving, which directs attention to the structural drivers of spatial inequality, including globalisation, technological change, austerity, and the deliberate centralisation of public services. Both Pike et al. (2024) MacKinnon et al. (2024) caution against treating left-behind as a neutral, purely descriptive label, given its potential for political instrumentalisation.

Beyond its territorial dimension, left-behindness is also a social condition: while the spatial framing has dominated both academic and policy discourse, a growing body of scholarship insists that the concept cannot be reduced to territorial disadvantage alone. Places are not homogeneous units: within any given region, the costs and benefits of structural economic change are distributed unevenly across social groups, and the individuals most exposed to transition-related risk are often those least visible, with the twin transition intensifying this concern. Automation and AI-driven displacement concentrate their effects on workers in routine and manual tasks, who are disproportionately older, less formally educated, and more likely to be employed in the declining industries that decarbonisation targets (Causa et al., 2024; Frey and Osborne, 2017; Manning and Aguirre, 2026). The green economy, meanwhile, is not a neutral replacement: the jobs it generates tend to demand higher qualifications, different sectoral experience, and geographical mobility that many displaced workers cannot easily supply (Barreto et al., 2024; Vandeplas et al., 2022). Moreover, for young people entering the labour market during periods of rapid structural change, the risk takes a different form: rather than being displaced from existing jobs, they face the prospect of never securing a stable foothold in the first place. Prolonged disengagement from both employment and education during formative years produces damaging effects that persist well beyond the transition period itself (Caroleo et al., 2020; Redmond and McFadden, 2023). Gender compounds all of these dynamics. Occupational segregation means that women are structurally underrepresented in the sectors both leaving and entering the economy, raising the prospect that transition-driven restructuring reproduces existing inequalities rather than resolving them (Causa et al., 2024). Taken together, this literature establishes that group-level vulnerability during structural transition operates partly independently of regional context, and that a comprehensive understanding of who risks being left behind during the twin transition requires looking at both the places and the people most exposed - a dual focus that also raises distinct methodological challenges for how left-behindness is identified and measured.

Methodologically, the measurement of left-behindness has also evolved. Traditional approaches based on single indicators such as GDP per capita or unemployment rates have given way to multi-dimensional frameworks that better capture the compound nature of regional disadvantage. Comim et al. (2024) develop a method for assessing deprivation across multiple dimensions such as including income, employment, education, health, and connectivity, without

imposing arbitrary weighting schemes or collapsing distinct forms of disadvantage into a single score. Indeed, their internationally comparative analysis demonstrates that left-behindness is not confined to any single country or region type, and that different combinations of deprivation characterise different left-behind places. Furthermore, Iammarino et al. (2019) document persistent and, in many cases, widening gaps between leading and lagging regions across Europe, driven by the concentration of innovation, skilled labour, and investment in a small number of metropolitan cores. Their distinction between converging, stagnating, and declining regional trajectories provides a useful lens for understanding how different parts of Europe are evolving and why some regions remain unable to participate in broader processes of growth. Kemeny and Storper (2020) extend this analysis by examining how disruptive innovation and the changing geography of labour demand are driving the growing divergence between 'superstar cities' and places being left behind, creating self-reinforcing cycles of advantage and disadvantage that represent a systemic feature of contemporary economic geography.

An important strand of the literature highlights that left-behindness extends well beyond conventional economic indicators. MacKinnon et al. (2022) argue that the challenges facing left-behind places cannot be addressed through growth-oriented development strategies alone. Drawing on the foundational economy concept, they show how left-behind places are often characterised by the withdrawal or degradation of essential services such as healthcare, education, food provision, housing, and utilities, processes linked to austerity and the centralisation of public provision. This perspective redirects attention from productivity and competitiveness to the material conditions of everyday life and the social infrastructure that underpins well-being. Along similar lines, Benner et al. (2024) identify weak institutional environments, limited innovation capacity, brain drain, and path dependencies rooted in declining industries as defining features of left-behind places, arguing that these characteristics complicate not only economic recovery but also the navigation of sustainability transitions which is of direct relevance to regions which are adapting to the twin transition.

The policy implications of this literature are also important. Fiorentino et al. (2024b) argue that policy responses have often been inadequate, relying on short-term, growth-oriented interventions that fail to address root causes such as deindustrialisation, sustained underinvestment, and weakening institutional capacity. Instead, there is a need for sustained, long-term, place-sensitive frameworks that combine economic investment with social infrastructure rebuilding and democratic empowerment. Benner et al. (2024) extend this argument by highlighting the double challenge facing left-behind places: addressing existing socio-economic deficits while simultaneously navigating the green and digital transitions, requiring integrated approaches rather than treating economic revitalisation and sustainability as separate agendas. Rodríguez-Pose (2018) similarly insists that place-sensitive policies must go beyond welfare transfers and large-scale infrastructure projects to tap the untapped potential of neglected territories, warning that continued inaction risks deepening the political instability that spatial inequality has already generated.

Overall, the literature on left-behind places reveals a concept that is multi-dimensional, relational, dynamic, and politically charged. Left-behindness cannot be reduced to a single indicator or a snapshot in time; it encompasses sustained relative decline across economic, social, institutional, and infrastructural dimensions, shaped by the interaction of global forces,

national policies, and local legacies. The growing divergence between dynamic metropolitan regions and places experiencing development traps or peripheralisation underscores the systemic nature of these inequalities (Diemer et al., 2022; Gansauer, 2025; Kemeny and Storper, 2020).

This understanding directly informs the analytical framework developed in this deliverable. Building on the literature reviewed above, left-behind dynamics are identified across three complementary dimensions. The first captures **left-behind places**, focusing on core economic performance through GDP per capita, labour productivity, and employment rates, indicators that together reflect a region's capacity to generate and distribute economic output (Bernard et al., 2025; Diemer et al., 2022; Fiorentino et al., 2024a; Iammarino et al., 2019). The second captures ***opportunity gaps***, focusing on labour-market vulnerability across population segments, including unemployment, youth disengagement, educational disadvantage, ageing workforce participation, and gender employment gaps (Bernard et al., 2025; Comim et al., 2024; Dijkstra et al., 2020). The third captures ***transitioning sectors***, focusing on sectoral structure and adjustment capacity, including structural change, economic diversification, employment reallocation, job stability, and knowledge intensity (Benner et al., 2024; Iammarino et al., 2019; Kemeny and Storper, 2020). Each dimension reflects a distinct channel through which the twin transition may generate or deepen regional vulnerability, and together they provide a comprehensive mapping of left-behind dynamics across European regions. These three dimensions are then combined into an **overall left-behind index** that provides a more comprehensive measure of regional vulnerability across economic performance, labour market inclusion, and sectoral adaptability. The construction and composition of these indices are set out in the following subsection.

2.2 Analytical approach for identifying left-behind dynamics

The analysis adopts a multidimensional vulnerability perspective to identify places, population groups, and sectors at risk of being left behind in the context of the green and digital transition. The approach focuses on structural socio-economic disadvantage, demographic dynamics, labour-market vulnerability and sectoral adjustment capacity that may constrain the ability of regions to adapt to transition-related pressures. This approach recognises that the twin transition does not unfold on within a neutral space: existing regional inequalities, variations in institutional capacities, and structural conditions shape the extent to which regions and workers are able to absorb and respond to the demands of green and digital transformation. Where structural conditions are already weak, transition-related pressures may compound existing disadvantage rather than create new opportunities, raising important political economy dilemmas which may ultimately undermine the very viability of the twin transitions.

The conceptual foundation of the framework draws on the broader literature on left-behind places and regional divergence, which has highlighted the persistence of spatial inequalities in Europe and the tendency for structural disadvantage to reinforce itself over time (Fiorentino et al., 2024a; Iammarino et al., 2019; MacKinnon et al., 2024; Martin et al., 2021; Rodríguez-Pose, 2018). In this context, being left behind is understood not simply as a condition of low current performance, but as a combination of structural weakness and limited adaptive capacity, namely the lack of resources to respond to external shocks or structural shifts in ways that sustain employment, productivity, and social cohesion. The twin transition introduces a new set of external pressures that interact with these pre-existing conditions, making it important to assess

vulnerability not only in terms of current socio-economic positioning but also in terms of the direction and pace of change.

The framework distinguishes between structural positioning and dynamic trajectories. Structural positioning is captured through standardised indicator values reflecting socio-economic conditions at specific points in time, providing a cross-sectional assessment of where regions and population groups stand relative to one another. Dynamic trajectories are derived from slope-based measures estimated over the study period (2014–2024), allowing the identification of regions experiencing improvement, decline, or persistent disadvantage over time. This distinction is important in the context of the twin transition, where regions may display similar structural conditions at a given moment but follow divergent adjustment paths. A region with an average current performance but a deteriorating trajectory may face greater future vulnerability than a region with weaker current conditions but a consistent pattern of improvement.

This perspective is particularly relevant where environmental and technological change interacts with existing production structures, demographic trends, and labour-market configurations. Regions characterised by weaker economic performance, population decline, ageing, labour-market exclusion, or limited sectoral diversification may face greater challenges in adapting to the twin transition. The capacity to adjust depends not only on economic conditions but also on the availability of skills, the flexibility of local labour markets, the diversification of the economic base, and the degree to which existing sectoral structures are exposed to decarbonisation or automation pressures. By combining structural indicators with trend-based measures, the analysis captures both persistent disadvantage and emerging vulnerability.

Therefore, for each dimension, composite indices are constructed using standardised indicators aligned so that higher values represent greater vulnerability. Static indices capture relative structural disadvantage at a given point in time, while dynamic indices capture the direction and pace of change over the period of analysis. For the overall left-behind index, the combination of static and dynamic scores allows the identification of four analytically distinct trajectories: a) regions that are persistently disadvantaged and are witnessing their relative position worsen; b) regions that are structurally weak but on an improving path; c) regions that are currently well positioned but showing growing signs of deterioration; and d) leading regions on an upward trajectory. Dimension-specific quadrant classifications follow a similar logic, with labels tailored to reflect the particular nature of each index. This typology provides a more detailed basis for identifying transition-related vulnerability than a cross-sectional analysis alone and supports a more targeted and forward-looking approach to policy analysis.

2.3 Data sources, spatial coverage, and time frame

The analysis is conducted at the NUTS-2 level, as this spatial scale is widely used in European regional analysis and is consistent with cohesion policy monitoring and comparative territorial assessments. NUTS-2 regions represent the primary unit for the allocation of EU structural funds and provide a meaningful level of aggregation for capturing socio-economic heterogeneity within countries while maintaining comparability across member states.

The indicator set was compiled following a review of datasets, drawing primarily on Eurostat and ARDECO sources (European Commission, Joint Research Centre, 2024). Indicators were retained only where sufficient temporal continuity and spatial coverage were available across EU Member States, as well as Norway and Switzerland. Variables with limited time coverage or incomplete regional availability were excluded to ensure consistency across dimensions and comparability across regions. The allocation of indicators across dimensions reflects both conceptual

distinctions and the aim of avoiding duplication, with correlation analysis used to identify and remove redundant variables within each dimension.

The analysis covers the period 2014–2024, reflecting the longest interval for which consistent regional time series are available across most indicators. This period spans a range of key structural developments, including the adoption of major green and digital policy frameworks, and the economic disruptions associated with the COVID-19 pandemic, providing a strong basis for assessing medium-term trajectories. The ten-year window is also useful to distinguish structural trends from short-term cyclical fluctuations. It also allows for the identification of regions experiencing persistent disadvantage as well as those where conditions have been improving or declining over the medium term

Where short gaps were present in the time series, moving averages were applied to smooth short-term fluctuations and ensure temporal consistency. In cases where values for 2024 were missing, the most recent available observation was carried forward.

All indicators were harmonised to a consistent regional framework based on the NUTS 2021 classification to ensure spatial and temporal comparability. Where regional boundaries changed over time, standard allocation procedures were applied to maintain continuity across successive NUTS versions. These adjustments were applied uniformly and do not affect the comparative interpretation of regional vulnerability patterns.

All variables were standardised using z-scores. Indicator directions were aligned so that higher values consistently represent greater left-behind vulnerability. This harmonisation ensures internal consistency across dimensions and supports the construction of composite indices.

2.4 Construction of level-based indices (initial structural conditions)

Level-based indices are constructed to capture the relative structural positioning of regions in terms of left-behind vulnerability. These indices reflect economic, labour-market and sectoral conditions that may constrain the regional adaptation to the twin transition, providing a cross-sectional assessment of where regions stand relative to one another at a given point in time.

All indicators are standardised as z-scores across regions for each year of analysis, ensuring cross-regional comparability and eliminating scale differences. Indicator directions are aligned so that higher values consistently represent greater left-behind vulnerability, while lower values indicate more favourable structural conditions. Where an indicator is positively associated with disadvantage in its original form, such as unemployment rate, no transformation is required. Where an indicator is negatively associated with disadvantage, such as GDP per capita or employment rate, the sign was reversed prior to standardisation. This alignment ensures that all indicators contribute to composite indices in a consistent and interpretable direction.

Composite level-based indices were calculated as the unweighted mean of the standardised indicators:

$$Index_d = \frac{1}{n}\sum_{i=1}^{n} z(X_{i,r}) \,,$$

$where$:

$z(X_{i,r})$ represents the standardised value of indicator ***i*** for region ***r***
n represents the number of indicators included in the index
d – denotes each dimension

Equal weighting is consistent with established practice in the construction of composite indices for regional vulnerability assessment(OECD and Joint Research Centre - European Commission, 2008). In order to avoid any single indicator or group of closely related indicators dominating the composite, a correlation analysis is carried out before finalising the indicator set. Indicators with a pairwise Pearson correlation coefficient exceeding 0.8 are identified as redundant, and one of the correlated pair removed, retaining the indicator with greater conceptual relevance to the dimension in question. This threshold is consistent with standard practice in composite index construction for removing collinear variables while preserving the breadth of conceptual coverage within each dimension (Dormann et al., 2013).

The **Left-Behind Places Index (LBPI)** captures structural regional disadvantage by combining three indicators.

- GDP per capita reflects the overall level of regional economic development and is the most widely used summary measure of material prosperity and structural convergence across European regions;
- The employment rate (20–64) captures the extent to which the working-age population is engaged in the labour market, reflecting both demand-side conditions and structural participation barriers that shape a region's capacity to translate productive potential into broadly shared economic output;
- Labour productivity per person employed captures structural competitiveness and economic efficiency, reflecting the degree to which the regional economy generates high-value output independently of the size of the employed workforce.

The inclusion of both GDP per capita and labour productivity per person employed reflects a conceptual distinction between these two measures that is particularly relevant in a left-behind context. GDP per capita reflects aggregate economic output relative to the total resident population, and is therefore sensitive to demographic structure, inactivity, and labour-market participation rates. Labour productivity isolates the efficiency of the employed workforce independently of these participation effects, reflecting capital intensity, technological adoption, and the knowledge intensity of the regional production structure. The employment rate bridges these two measures by capturing the share of the working-age population that is economically active, a dimension along which regions with similar productivity levels can diverge substantially in terms of aggregate economic performance. Their joint inclusion is therefore conceptually justified and consistent with established regional competitiveness frameworks that treat aggregate development and productive efficiency as distinct analytical components (Dijkstra et al., 2023; Iammarino et al., 2020).Together, the indicators in this dimension identify regions characterised by low levels of economic development, weak labour market participation, and low productivity, conditions that may limit adaptive capacity in the context of the twin transition.

The **Opportunity Gap Index (OGI)** captures labour-market vulnerability across population groups through five indicators.

- The unemployment rate provides a baseline measure of labour-market performance, identifying regions where a significant share of the active population is unable to find employment.
- The NEET rate, the share of young people neither in employment, education, nor training, encapsulates youth disengagement from both the labour market and human capital

formation, identifying regions where the next generation of workers faces early and potentially persistent exclusion.
- The employment rate of older workers captures the degree to which the working-age population aged 55–64 remains attached to the labour market, reflecting both demand-side barriers and structural features of regional labour markets that may limit participation among older cohorts.
- The share of the population with low educational attainment measures structural human capital deficits that may constrain the ability of the workforce to adapt to the skills demands of green and digital transformation.
- The gender employment gap denotes persistent inequalities in labour-market access between men and women, identifying regions where a significant share of the potential workforce remains structurally underutilised.

Together, these indicators identify regions where population groups face structural barriers to labour-market participation and adaptation. The selection of these groups is not arbitrary. There is considerable evidence that the costs of structural economic change fall unevenly across the population. Young people disengaged from both employment and education risk long-term scarring that limits their future labour-market prospects(Causa et al., 2024; Redmond and McFadden, 2023) . Older workers displaced from declining sectors face a different but equally serious problem: skills that do not transfer easily, limited geographical mobility, and few pathways back into comparable employment. (Barreto et al., 2024; Causa et al., 2024; Lim et al., 2023). Additionally, lower-skilled workers occupy precisely the roles that technology is replacing, yet tend to lack the qualifications needed to move into the emerging jobs that decarbonisation and digitalisation are generating(Causa et al., 2024; Frey and Osborne, 2017; Manning and Aguirre, 2026). Evidence from across European labour markets confirms that transitions from unemployment into green jobs are significantly more likely for workers with higher education, while women remain underrepresented in both green and carbon-intensive occupations (Causa et al., 2024). Thus, gender employment gaps reflect persistent structural inequalities that transition-related shifts may reproduce or widen, particularly where new jobs concentrate in sectors and occupations in which women remain underrepresented(Causa et al., 2024). The Opportunity Gap Index therefore serves as the main instrument in this deliverable for identifying left-behind groups, capturing the demographic and human-capital dimensions of vulnerability that shape who is, and who may not be in a position to adapt.

The **Transitioning Sectors Index (TSI)** assesses the sectoral adjustment capacity of a place through six indicators.
- The shift-share structural change index for agriculture (Dunn Jr., 1960) measures the extent to which regional employment remains concentrated in the primary sector. It gauges exposure to the structural decline and automation pressures that have historically characterised agricultural employment across European regions.
- The shift-share structural change index for manufacturing appraises the degree to which regional employment is concentrated in traditional manufacturing activities, identifying regions most exposed to the displacement effects associated with industrial automation, offshoring, and decarbonisation of production processes.
- The inverse Herfindahl-Hirschman Index (HHI) measures economic diversification, with lower diversification indicating greater dependence on a narrow range of sectors and therefore higher exposure to sector-specific shocks or transition-related disruption (Frenken et al., 2007; Rhoades, 1993).
- Net job growth evaluates the overall dynamism of the regional labour market, distinguishing between regions generating new employment and those experiencing net employment contraction over the analysis period.

- Employment volatility captures instability in regional employment patterns over time, reflecting the degree to which regional labour markets are subject to structural disruption rather than gradual and stable adjustment.
- The share of human resources in science and technology (HRST) is a proxy for knowledge intensity, identifying regions with a limited pool of skilled workers capable of driving or absorbing the innovation demands associated with green and digital transformation.

Together, these variables identify regions with declining traditional sectors, limited economic diversification, unstable employment dynamics, and weak knowledge intensity, characteristics that may constrain the ability to generate or absorb twin transition-related employment opportunities.

An **overall Left-Behind Index (LBI)** was constructed as equal-weighted mean of the three dimensions:

$$\mathrm{LBI} = (\mathrm{LBPI} + \mathrm{OGI} + \mathrm{TSI}) \,/\, 3$$

This overall index provides an integrated measure of multidimensional vulnerability while preserving equal weighting across places, labour market opportunity gaps and transitioning sectors. While aggregation into a single index involves some loss of detail relative to the individual dimension indices, the overall LBI allows for a synthetic cross-regional comparison of a region' compound disadvantage by identifying regions that are simultaneously vulnerable across places, groups, and sectors.

2.5 Construction of dynamic (slope-based) indices

To be able to assess changes in left-behind vulnerability over time, dynamic indices are constructed using region-specific linear trends estimated for each indicator over the analysis period (Gardiner et al., 2006). Rather than comparing conditions at two discrete points in time, the trend-based approach uses all available observations within the study window to estimate the underlying direction and pace of change, providing a more robust characterisation of medium-term trajectories that is less sensitive to year-specific fluctuations or data anomalies.

For each indicator and region, the following model was estimated:

$$\boldsymbol{X_{r,t} = \alpha_r + \beta_r \times year_t + \varepsilon_{r,t}},$$

where :

$X_{r,t}$ represents the value of the indicator for region $\boldsymbol{r}$ in year $\boldsymbol{t}$
α_r represents region-specific intercept (constant)
β_r represents the slope coefficient capturing the trend over time for region r.
$year_t$ represents the time variable
$\varepsilon_{r,t}$ represents the error term

The estimated slope coefficients capture the direction and magnitude of change over time. To enable comparison, the coefficients are standardised using z-scores and aligned so that higher values indicate worsening left-behind dynamics. Dynamic indices are then calculated as the unweighted mean of these standardised slopes, following the same indicator structure as the level-based indices, ensuring consistency between structural conditions and trends over time.

An overall dynamic left-behind index is also calculated as the equal-weighted mean of the three dynamic dimensions, allowing for the identification of regions that are improving, stable, or becoming more vulnerable across multiple dimensions simultaneously.

Finally, by combining static and dynamic measures, the analysis distinguishes between persistent structural disadvantage, improving trajectories, and emerging vulnerability in the context of the twin transition, and supports the identification of emerging vulnerability before it is reflected in structural indicators.

2.6 Construction of the Development Trap Index

To complement the multidimensional vulnerability assessment developed through the LBI framework, the analysis also incorporates a Regional Development Trap index following the methodology developed by Diemer et al. (2022). While the LBI captures structural disadvantage and its recent trajectory, the Development Trap Index (DTI) addresses a distinct question: whether regions are at the same time losing economic momentum relative to their own recent past, their national context, and the European average.

Both frameworks draw on the same three core variables, namely GDP per capita, labour productivity, and employment, but operationalise them in different ways. The LBI assesses where regions stand relative to the European average and whether that position has been improving or worsening. The development trap index assesses whether the growth rates of these variables are simultaneously decelerating across multiple benchmarks at once. Indeed, a region can be converging toward the EU average on the LBI and therefore showing an improving trajectory, while at the same time experiencing the kind of self-reinforcing growth deceleration that the development trap framework is designed to identify. Thus, the two measures complementary rather than redundant dimensions of regional economic performance.

The index is constructed using GDP per capita and gross value added per worker at 2015 constant prices, and the employment-to-population ratio for the working-age population. For each variable, three accelerations are computed annually using rolling five-year growth windows:

- the own-past acceleration, which compares current five-year growth against the preceding five-year growth rate for the same region;
- the national deviation, which compares the region's current growth rate against the national average growth rate for the same period, excluded for countries with a single NUTS2 region;
- the EU deviation, which compares the region's current growth rate against the European average growth rate.

For each acceleration, a binary dummy variable is assigned a value of one if the acceleration is positive and zero otherwise. The DTI is then defined as one minus the share of positive dummies across all valid acceleration dimensions, with higher values indicating greater risk of being in a development trap. DTI scores are bounded between zero and one by construction. Finally, average DTI scores are computed over 2010–2024, providing a fifteen-year window that smooths year-specific volatility and captures persistent rather than cyclical trap dynamic.

2.7 Summary

The preceding subsections have set out the conceptual and methodological foundations of the analytical framework used in this deliverable. The framework combines a multi-dimensional

vulnerability perspective, grounded in the literature on left-behind places and regional divergence with a dual static–dynamic analytical design applied across 247 NUTS-2 regions in EU27, Norway, and Switzerland over the period 2014–2024.

The conceptual starting point is that left-behindness should not be reduced to a single indicator or a snapshot in time. As the literature reviewed in Section 2.1 makes clear, it involves sustained relative decline across economic, social, and institutional dimensions, shaped by the interaction of global forces, national policies, and local legacies. The framework developed here translates this understanding into three complementary composite indices which cover economic performance, labour-market inclusion, and sectoral adjustment capacity. Each is constructed using standardised indicators aligned so that higher values represent greater vulnerability. These three dimensions are then combined into an overall index to capture compound disadvantage.

The key analytical feature of the framework is its ability to distinguish between structural positioning and the direction of change. Level-based indices capture where regions stand relative to one another at a given point in time. Slope-based indices, estimated from region-specific linear trends over the full study period, capture how they have been evolving. This distinction is particularly important in the context of the twin transition, where adjustment pressures may affect regions that have not traditionally been considered at risk. A region that is currently well positioned but on a declining trajectory faces a different challenge from one that is structurally weak but converging, with both require different policy responses.

By combining static and dynamic scores, the framework supports a quadrant classification that assigns each region to one of four trajectories : persistently disadvantaged regions (weak position and declining trajectory), catching-up regions (weak position but improving trajectory), regions at risk of falling behind (favourable position but declining trajectory), and low-risk regions (favourable position and improving or stable trajectory). This typology is applied to each of the three dimensions individually and to the overall index, providing a differentiated and forward-looking picture of regional vulnerability that goes beyond what a cross-sectional assessment alone could deliver. The results of this classification, including the spatial patterns, shifts over the study period, and the interaction between dimensions, are presented in Section 3.

3 Results

3.1 Left-behind Places Index (2014 & 2024)

The Left-Behind Places Index captures structural regional economic disadvantage through GDP per capita, labour productivity, and the employment rate. Figure 1 presents the spatial distribution of this index in 2014 and 2024, with regions classified into five groups based on their standardised scores relative to the European average.

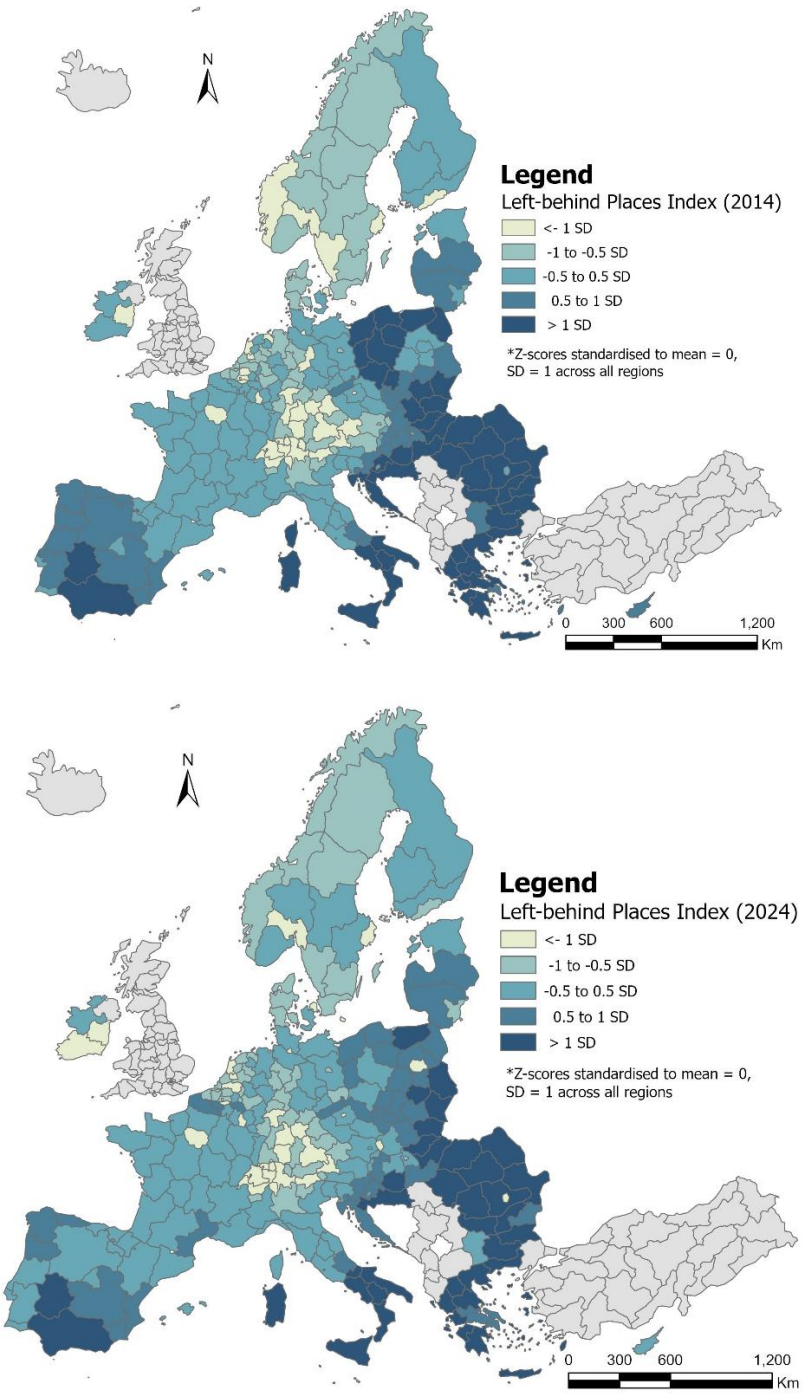


Figure 1 - Left-behind Places Index 2014 (top) and 2024 (bottom)

The overall spatial pattern reveals a persistent core-periphery structure. In both years, the most favourable economic conditions (class 1) are concentrated in southern Germany and Switzerland through the Benelux countries and into Scandinavia, together with capital regions such as Paris, Dublin, and Copenhagen. These regions combine high GDP per capita, strong labour productivity, and high employment rates. At the opposite end, the most vulnerable regions (class 5) are concentrated in southern Italy, Greece, Romania, Bulgaria, and parts of eastern Poland and Hungary which are regions characterised by low output per capita, weak productivity, and low employment rates(European Commission, 2022; Iammarino et al., 2019).

Comparing the two time points reveals both continuity and key shifts. The number of regions in the most vulnerable class fell from 53 in 2014 to 41 in 2024, suggesting a degree of convergence at the lower end of the distribution. This improvement has been driven primarily by Central and Eastern European regions: several regions all moved out of class 5 over the decade. These shifts reflect the continued catch-up process in parts of the EU's eastern periphery, supported by the cohesion policy and investments (European Commission, 2022).

Among the best-performing regions, the composition of the group has changed. The core remains in Switzerland, southern Germany, the Netherlands, and the Nordic capitals, but several Central and Eastern European capital regions, including those encompassing several capitals (Warsaw, Bratislava, and Bucharest) have moved into this class by 2024, reflecting rapid economic growth in eastern metropolitan hubs that are gradually closing the gap with their western counterparts, although their surrounding regions continue to lag (Diemer et al., 2022; Egri and Lengyel, 2024). At the same time, several regions in Austria, Belgium, northern Germany, and Scandinavia slide down the ranking. This signals a weakening in parts of the traditional European core. Much of France, central and northern Spain, the Baltic states, and parts of central Italy sit close to the European average. Their future trajectories will likely depend on how local economies respond to the pressures and opportunities of the twin transition.

The indicator profiles across the five classes are consistent (see Annex 1). The most favourable regions combine high GDP per capita with strong productivity and high employment. Among the most vulnerable, low output and weak productivity are present throughout, but the employment rate gap is the sharpest distinguishing feature, suggesting that in the most left-behind places, the key economic challenge is not just low output but the persistent difficulty of encouraging the working-age population to work (European Commission, 2018b).

3.2 Left-behind Places Index – slope-based dynamics (2014-2024)

The slope-based dynamics of the Left-Behind Places Index captures how regional economic performance has evolved over the 2014–2024 period. The key pattern is a broad east-west divide in the direction of change. Regions showing more improvement are clustered in Central and Eastern Europe, and Ireland, regions that have experienced rapid gains in GDP per capita, productivity, and employment over the decade (FitzGerald and Honohan, 2023; Goecke and Hüther, 2016).

At the other end, regions with declining trajectories are found mostly in two clusters. The first covers much of Germany, where GDP and productivity growth have slowed relative to the European average and employment gains have been modest. Several Austrian, Scandinavian, and Benelux regions show a similar pattern of relative deceleration. The second includes a number of French regions, particularly in the north and centre, as well as some parts of the northern Netherlands and Norway where economic momentum has weakened. These trends are consistent with the structural headwinds facing mature, export-oriented economies in western and northern Europe, including rising energy costs following the disruption of Russian gas

supplies, growing competitive pressures from Asian producers in key industrial sectors, and a broader slowdown in productivity growth linked to delayed digitalisation and underinvestment in public infrastructure (Draghi, 2024; Durán Laguna, 2024; Grömling, 2025).

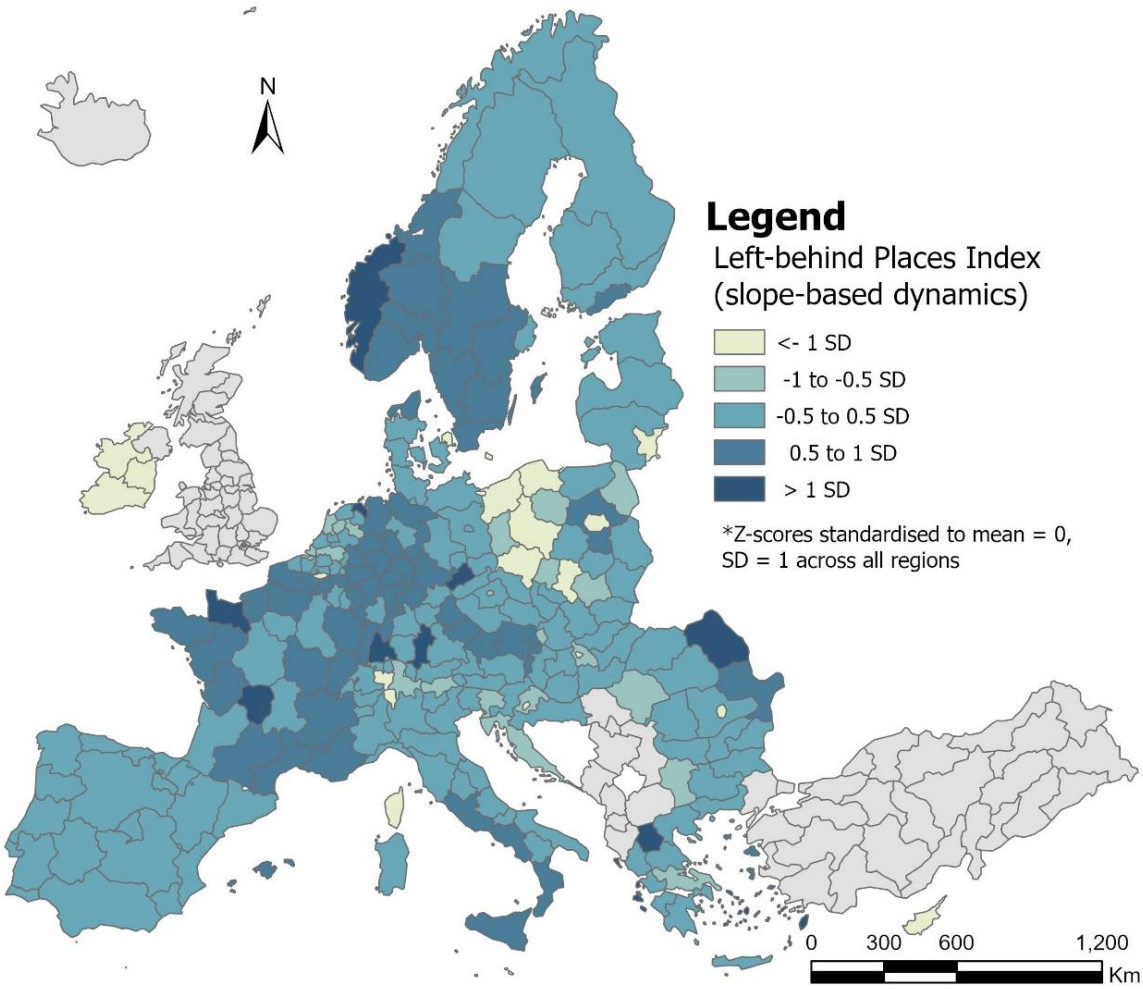


Figure 2 - Left-behind Places Index (slope-based dynamics 2014 - 2024)

The indicator profiles confirm these patterns (see Annex 1). Among the most rapidly improving regions, GDP, productivity, and employment all grew together. In declining regions, the slowdown came mainly from weaker GDP and productivity growth, while employment trends show more variation. This suggests that in parts of western Europe, the economic challenge is less about labour market participation and more about the pace of productivity growth and value creation.

Taken together, the dynamic map reveals that the traditional European core is not uniformly maintaining its advantage. While many Western regions remain structurally well positioned, their growth trajectories have weakened relative to faster-growing regions in the East. This has implications for the twin transition: regions that are currently favourable but losing momentum may face growing adjustment pressures if productivity growth continues to slow, while rapidly converging eastern regions may be building the economic capacity needed to absorb at least some of the transition-related shocks.

3.3 Left-behind Places Index (levels vs dynamics)

Figure 3 plots the LBPI for 2014 (z-scores) against the slope-based dynamics for 2014 to 2024 (z-scores). The near-zero association (R^2 = 0.001) indicates that initial economic conditions did not predict subsequent trajectories over the decade. This is consistent with a growing body of literature that highlight that regional economic disparities within Europe have become self-reinforcing rather than self-correcting, with weaker regions unable to systematically close the gap with stronger ones despite cohesion policy interventions (Durán Laguna, 2024; Iammarino et al., 2019; Rodríguez-Pose, 2018). The absence of convergence means that improvement and deterioration are not determined by where a region starts with structurally weak regions being just as likely to stagnate as to catch up, and structurally strong ones being just as likely to lose momentum as to pull further ahead.

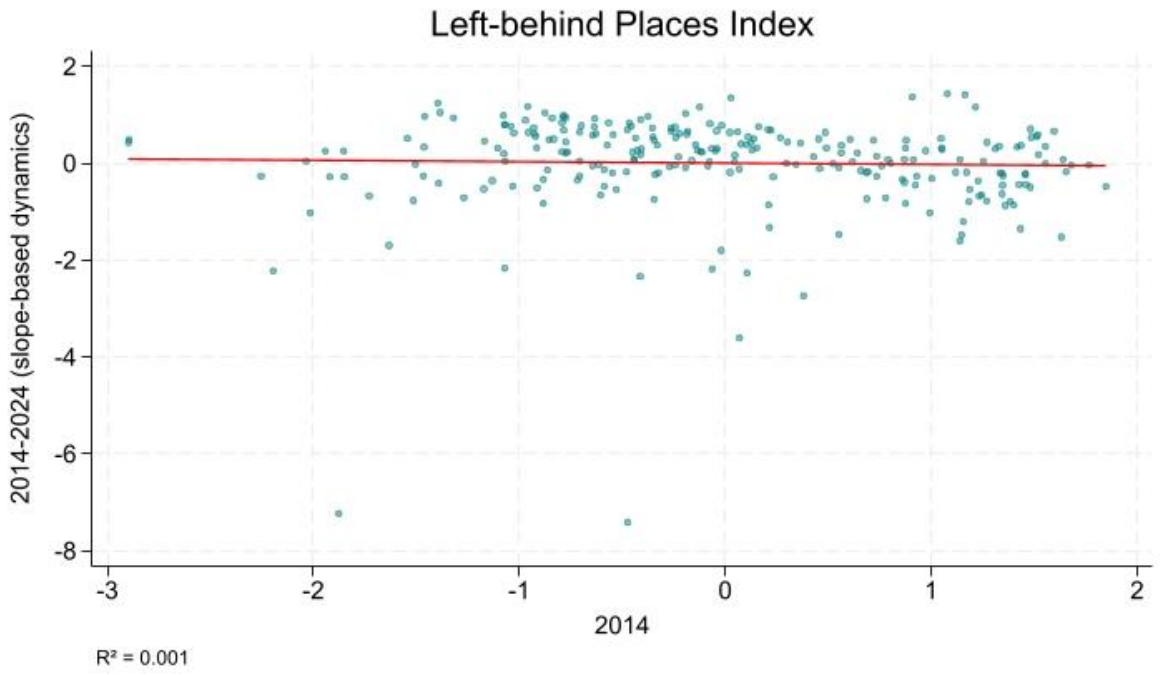


Figure 3 - Scatterplot LBPI (2014 vs 2014-2024)

Figure 4 combines the static and dynamic dimensions of the Left-Behind Places Index into a single quadrant classification. Each region is assigned to one of four categories based on whether its structural position in 2024 is above or below the European average, and whether its trajectory over 2014–2024 has been improving or worsening, relative also to the European average. This produces four distinct profiles: regions with low risk of falling behind (favourable position, improving trajectory), regions at risk of falling behind (favourable position, declining trajectory), catching-up regions (weak position, improving trajectory), and persistently disadvantaged regions (weak position, declining trajectory).

The largest group consists of regions at risk of falling behind. These are regions that currently sit above the European average in economic performance but whose trajectories over the past decade have been weakening. This group covers much of Germany, parts of Scandinavia, Austria, the Netherlands, and northern France, areas that have traditionally formed part of Europe's economic core but where GDP growth and productivity gains have been slowing in relative terms. While these regions are not structurally disadvantaged today, their declining momentum may signal growing vulnerability as the twin transition unfolds.

The second largest group is the persistently disadvantaged category which combines below-average structural conditions with declining trajectories, pointing to long-standing disadvantage. This group includes the traditional European periphery, involving southern Italy, Greece, Romania, and parts of Bulgaria, but it also extends into Western Europe, with several French and Spanish regions where structural weaknesses have remained entrenched during the period of analysis. For these regions, the twin transition risks compounding existing disadvantage rather than opening new pathways to adjustment.

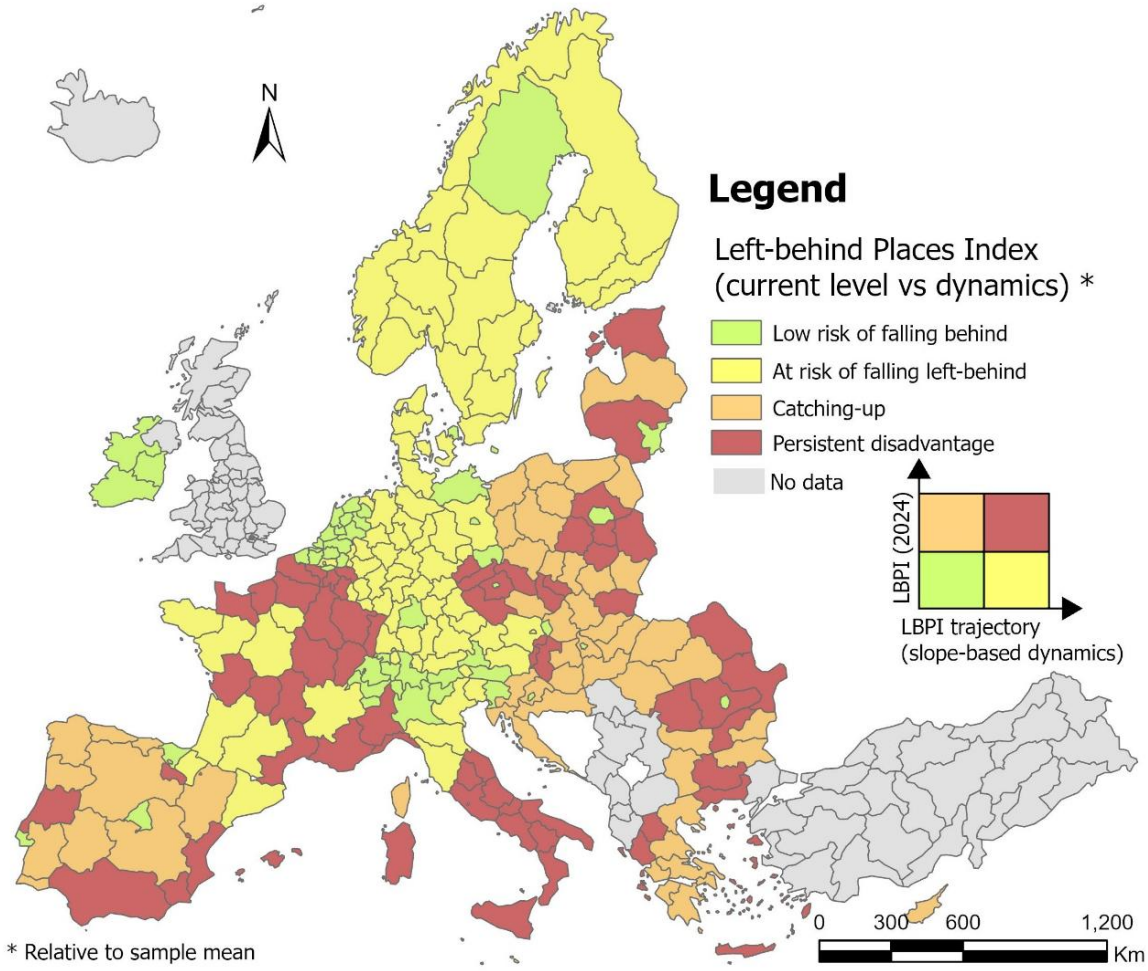


Figure 4 - Left-behind Places Index (current level vs dynamics)

The catching-up group includes regions that remain structurally weak albeit on an improving path. This category is dominated by Central and Eastern European regions (Poland, Hungary, Croatia, Romania and the Baltic states) where rapid economic growth over the past decade has begun to narrow the gap with the European average. Several southern European regions also appear in this group, including parts of Spain, Portugal, and Greece, where recovery from the post-2008 crisis has translated into improving pathways. Nevertheless, whether these regions can sustain their convergence trajectories through the twin transition remains an open question.

Finally, the low-risk category combines favourable structural conditions with improving or stable trajectories. This group includes Switzerland, the Benelux capitals, Ireland, and a number of Nordic and Dutch regions, as well as several Central and Eastern European capital regions that have reached above-average performance levels while maintaining strong economic growth momentum.

Overall, the quadrant map reveals a key geographic pattern. Western Europe is split between a still-favourable core and a growing number of regions showing signs of relative decline. Central and Eastern Europe is likewise divided, between capital regions and a few dynamic hubs that are converging rapidly, and peripheral regions that remain persistently disadvantaged. Finally, Southern Europe presents a mixed but predominantly concerning picture. Most regions fall into either the persistently disadvantaged or catching-up categories, but with structural improvement largely concentrated in major metropolitan areas, with limited evidence of broader convergence across the rest of the territory

3.4 Labour market vulnerability – Opportunity Gap Index (2014 & 2024)

The Opportunity Gaps Index captures labour market vulnerability across population groups, combining five indicators: the unemployment rate; the NEET rate; the share of the population with low educational attainment; the employment rate of older workers (55–64); and the gender employment gap.

Figure 5 presents the spatial distribution of the index in 2014 and 2024. They depict a geography of opportunity that differs across Europe and that is distinct from the gaps and vulnerabilities identified in the Left-Behind Places Index. While structural economic disadvantage follows a broadly east-west gradient, opportunity gaps are more severe along the southern European arc. They stretch from the Iberian Peninsula through southern France, Italy, and Greece, with additional pockets of vulnerability in Romania and Bulgaria.

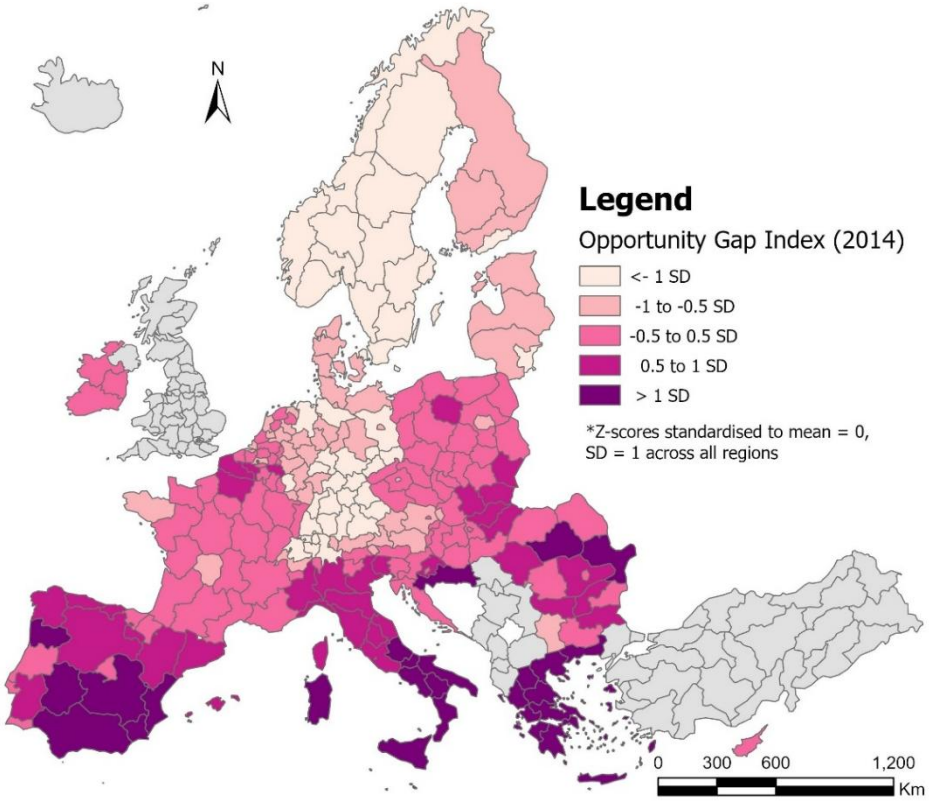
The most vulnerable regions —both at the beginning and at the end of the period— cluster along the southern rim of the EU, involving southern Italy, Greece, southern Spain, and parts of Romania. These regions combine persistently high unemployment, elevated NEET rates, low educational attainment, and large gender employment gaps (European Commission, 2024a).

The most favourable conditions are found across Scandinavia, much of Germany, Switzerland, and parts of the Netherlands and Austria. Regions in this group are characterised by low unemployment, low youth disengagement, high participation of older workers, and narrow gender gaps (Castellano and Rocca, 2019). Several Central and Eastern European capital regions also perform well on this dimension, suggesting strong labour demand in metropolitan economies.

However, between 2014 and 2024, the distribution has shifted. The most favourable class shrank noticeably while the second class expanded, suggesting a compression at the top. Many regions that had the strongest opportunity profiles in 2014 have lost ground, as indicated by their deteriorating scores. At the other end, the most vulnerable group remained broadly stable in size and composition, with southern Italian, Greek, and southern Spanish regions locked-in.

A key feature of the opportunity gaps geography is the distinction it draws within otherwise prosperous countries. Several French regions that appear structurally favourable on the places index, show high opportunity gaps, particularly in the northern part of the country, where industrial declining regions have been shedding opportunities for its inhabitants in recent years. This underscores the value of analysing labour market vulnerability separately from aggregate economic performance, regions can be economically productive yet still harbour a high degree of exclusion. Portugal illustrates a similar dynamic. While the Lisbon region performs close to the European average, the northern and central regions display high opportunity gap scores, driven primarily by very high shares of low educational attainment due to a legacy of historically limited investment in human capital that continues to constrain workforce adaptability(Guichard and Larre, 2006).

The indicator profiles across the five classes confirm that the employment rate is the sharpest differentiator (see Annex 2). The most vulnerable regions show high labour market exclusion of women, young people, and older workers. By contrast, the most favourable regions combine high employment across all demographic groups with low shares of low-skilled workers, suggesting a workforce relatively well positioned to absorb the demands of the twin transition.



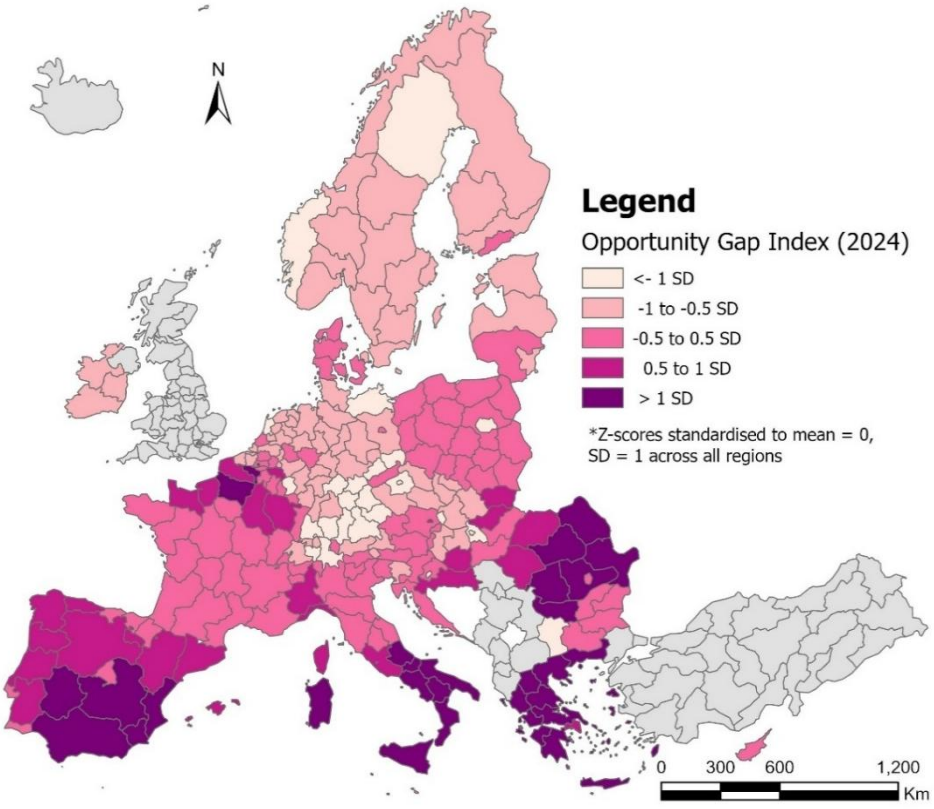


Figure 5 - Opportunity Gap Index 2014 (top) and 2024 (bottom)

3.5 The Opportunity Gap Index – slope-based dynamics (2014 – 2024)

The slope-based dynamics of the Opportunity Gap Index captures how labour market conditions across population groups have evolved over 2014–2024. Indeed, the geography of catching-up and decline on this dimension follows a pattern that is largely the inverse of the places index dynamics. The strongest improvements are concentrated in southern Europe and parts of Central and Eastern Europe, regions that started from the weakest positions. Greek, southern Spanish, and southern Italian regions show sharp declines in unemployment and NEET rates over the decade, reflecting recovery from the post-2008 crisis. Several Croatian, Hungarian, and Polish regions also show strong improvement, driven by tightening labour markets and rising participation rates(European Commission, 2024b).

By contrast, regions with worsening trajectories are concentrated in the traditional heart of Europe: much of Germany, Scandinavia, Austria, Switzerland, and the Netherlands. This deterioration is relative rather than absolute: labour market conditions have not become poor in these regions, but their advantage has narrowed as previously weaker regions have caught up. Rising NEET rates and growing shares of low educational attainment are the most consistent drivers of this pattern, with the gender employment gap showing a more mixed picture.

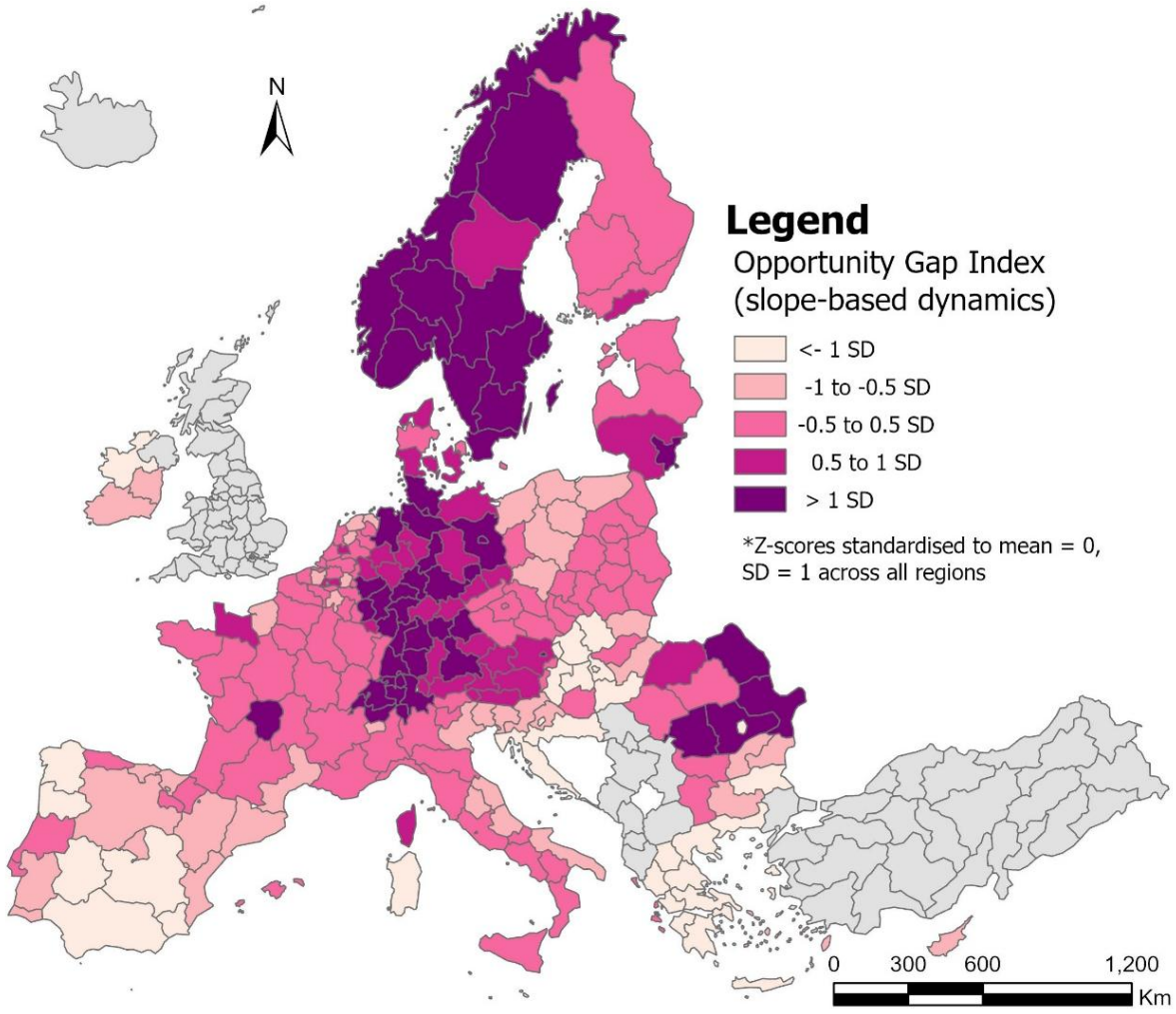


Figure 6 - Opportunity Gap Index (slope-based dynamics 2014 - 2024)

Finally, in terms of indicator profiles, the most rapidly improving regions show broadly consistent gains across all five indicators, suggesting a wide-ranging labour market recovery rather than improvement concentrated in a single dimension (see Annex 2). Among regions with worsening trajectories, the picture is more uneven with indicators such as unemployment and NEET rates remaining relatively stable, while older worker participation and educational composition have deteriorated, pointing to more subtle structural shifts. One exception is the gender employment gap, which shows weaker differentiation across classes than the other four indicators and considerably more variation within each class. Unlike unemployment, NEET rates, educational attainment and older worker participation, which all follow a consistent pattern across the dynamic classification, gender employment trends appear to move more independently of overall labour market trajectories. This points to the value of monitoring this dimension separately rather than assuming it moves in line with aggregate labour market trends.

3.6 The Opportunity Gap Index (levels vs dynamics)

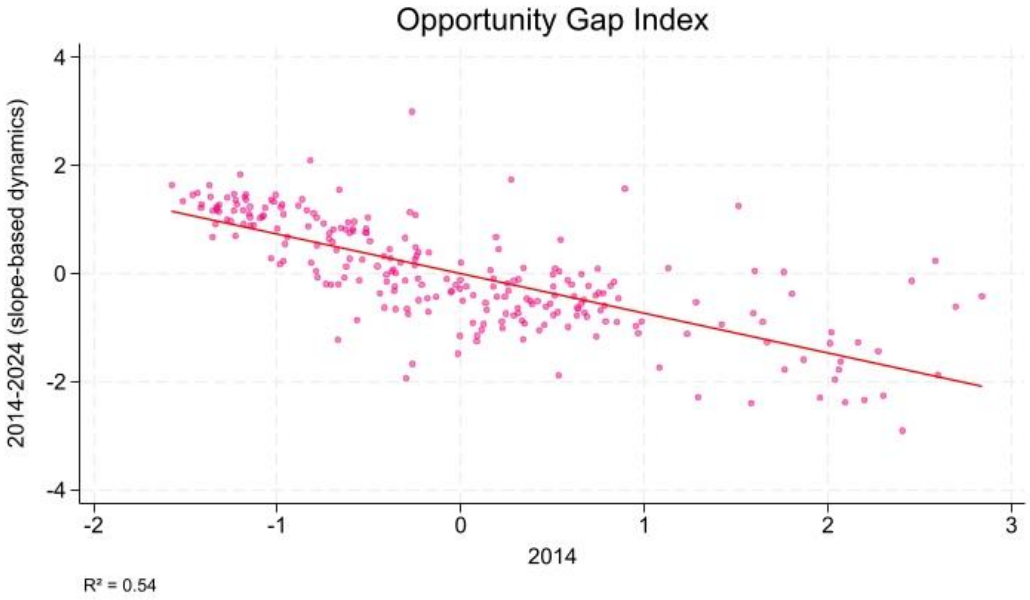


Figure 7 - Scatterplot OGI (2014 vs 2014-2024)

Figure 7 plots the static z-score (2014) against the slope-based dynamic z-score (2014-2024) for the Opportunity Gap Index. The strong negative relationship (R^2 = 0.54) points to convergence: regions with the widest opportunity gaps in 2014 improved the most, while those with initially favourable labour market profiles saw their relative advantage erode. This is consistent with the literature on post-crisis labour market dynamics in southern Europe, where unemployment and NEET rates reached historically high levels and have since declined unevenly, with structural factors continuing to shape the pace and extent of recovery across countries(Caroleo et al., 2020; Eurofund, 2025), and with tightening labour markets across Central and Eastern Europe driven by demographic contraction and outward migration (Astrov and Leitner, 2021). Nevertheless, the relationship accounts for only around half of the observed variation, indicating that convergence has been uneven. A number of initially disadvantaged regions have made limited progress, while several initially well-positioned regions have experienced a more pronounced erosion of their labour market advantage than the aggregate trend would imply.

Figure 8 combines the static and dynamic dimensions into a quadrant classification. Each region is assigned based on whether its structural opportunity gap in 2024 is above or below the

European average, and whether its trajectory over 2014–2024 has been improving or declining relative to the European average.

The largest group by far is regions showing decreasing opportunities, those that currently sit below the European average on opportunity gaps but whose trajectories have been worsening over the past decade. This group includes much of Germany, Scandinavia, Switzerland, Austria, and the Netherlands, reflecting a broad pattern of relative erosion in previously strong labour markets. While these regions are not yet structurally disadvantaged, the direction of change suggests that labour market resilience may be weakening, particularly with respect to youth engagement, older worker retention, and educational composition. In the context of the twin transition, this trajectory may be key, as these are the regions expected to generate and absorb much of the green and digital employment transformation, yet the workforce indicators underpinning their adaptive capacity appear to be quietly deteriorating. If these trends continue, the gap between transition-related labour market demands and the actual condition of the workforce may widen in ways that are not yet visible in structural indicators alone.

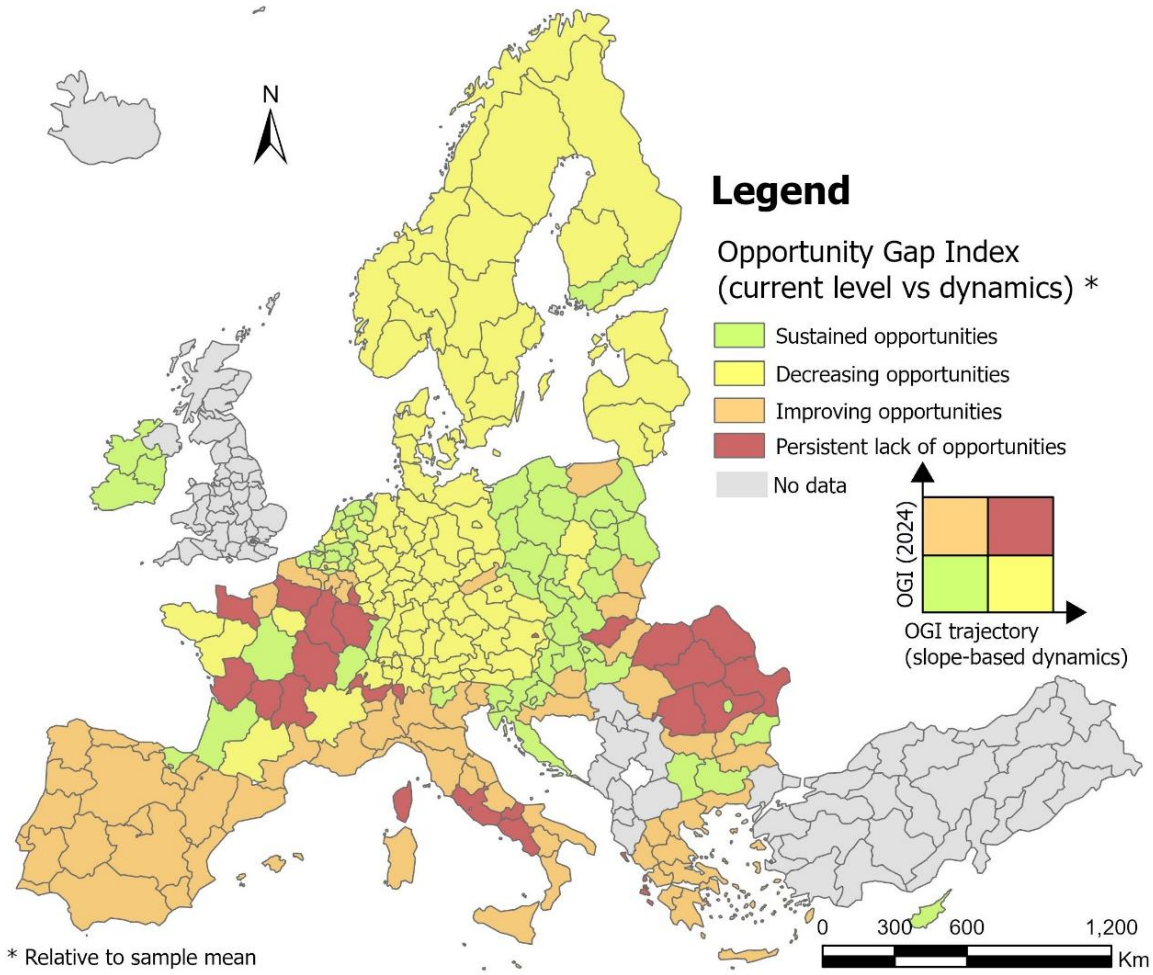


Figure 8 - Opportunity Gap Index (current level vs dynamics)

The second largest group (Improving Opportunities) covers regions that are structurally weak but on an improving trajectory, suggesting that labour market conditions are gradually recovering despite persistently below-average starting positions. This includes most of southern Europe (Spain, Italy, Greece, and Portugal), as well as parts of Central and Eastern Europe. For these regions, the past decade has brought improvement in labour market conditions, though

structural gaps remain wide. Whether this improvement reflects a durable structural shift or a cyclical recovery that may lose momentum as twin transition pressures intensify remains an open question.

The persistent lack of opportunities group is small but geographically clustered. It combines above-average structural opportunity gaps with worsening trajectories. These are regions where conditions are not only weak but continuing to deteriorate. Most of Romania, several French regions, and some French- and Italian-speaking regions in Switzerland fall into this category. The presence of Swiss regions alongside more traditionally disadvantaged areas suggests that persistent labour market vulnerability is not confined to the European periphery. For these regions, the twin transition may compound existing pressures rather than create new opportunities

The Sustained Opportunities group includes many Central and Eastern European regions, particularly from Poland, Hungary, Croatia, and the Baltic states, as well as some Benelux, French, and Nordic regions that have maintained both strong structural positions and positive trajectories.

The opportunity gaps quadrant reveals a pattern that does not closely follow the geography of economic performance. Several regions that score well on the left-behind places index show worsening opportunity gap trajectories, suggesting that good economic conditions do not always translate into better labour market outcomes for all population groups. At the same time, a number of structurally weak regions are making progress on labour market inclusion. These differences point to the value of looking at economic performance and labour market conditions separately, as trends in one do not necessarily reflect trends in the other.

3.7 Transitioning Sectors Index (2014 & 2024)

The Transitioning Sectors Index captures sectoral structure and adjustment capacity through six indicators: structural change indices for a) agriculture and b) manufacturing; c) economic diversification; d) net job growth; e) employment volatility, and f) the share of human resources in science and technology.

Figure 9 presents the spatial distribution in 2014 and 2024 and it highlight that the geography of sectoral vulnerability differs from the other two dimensions. Where economic performance follows a broad east-west gradient and opportunity gaps highlight a southern arc clustering, sectoral adjustment capacity produces a more fragmented map which is shaped less by broad macro-regional patterns than by the specific industrial legacies, agricultural structures, and knowledge-economy development of individual regions.

In 2024, the most favourable conditions were found in regions that have successfully shifted toward diversified, knowledge-intensive economies with limited residual dependence on agriculture or traditional manufacturing. Switzerland, southern Germany, and parts of the Benelux form the core of this group, but it also includes several Central and Eastern European capital regions that have developed strong service and IT sectors over the past decade (Cortinovis and van Oort, 2015; Dijkstra et al., 2023). This group expanded considerably (from 21 to 35 regions) reflecting the growing reach of knowledge-intensive economic structures beyond the traditional European core.

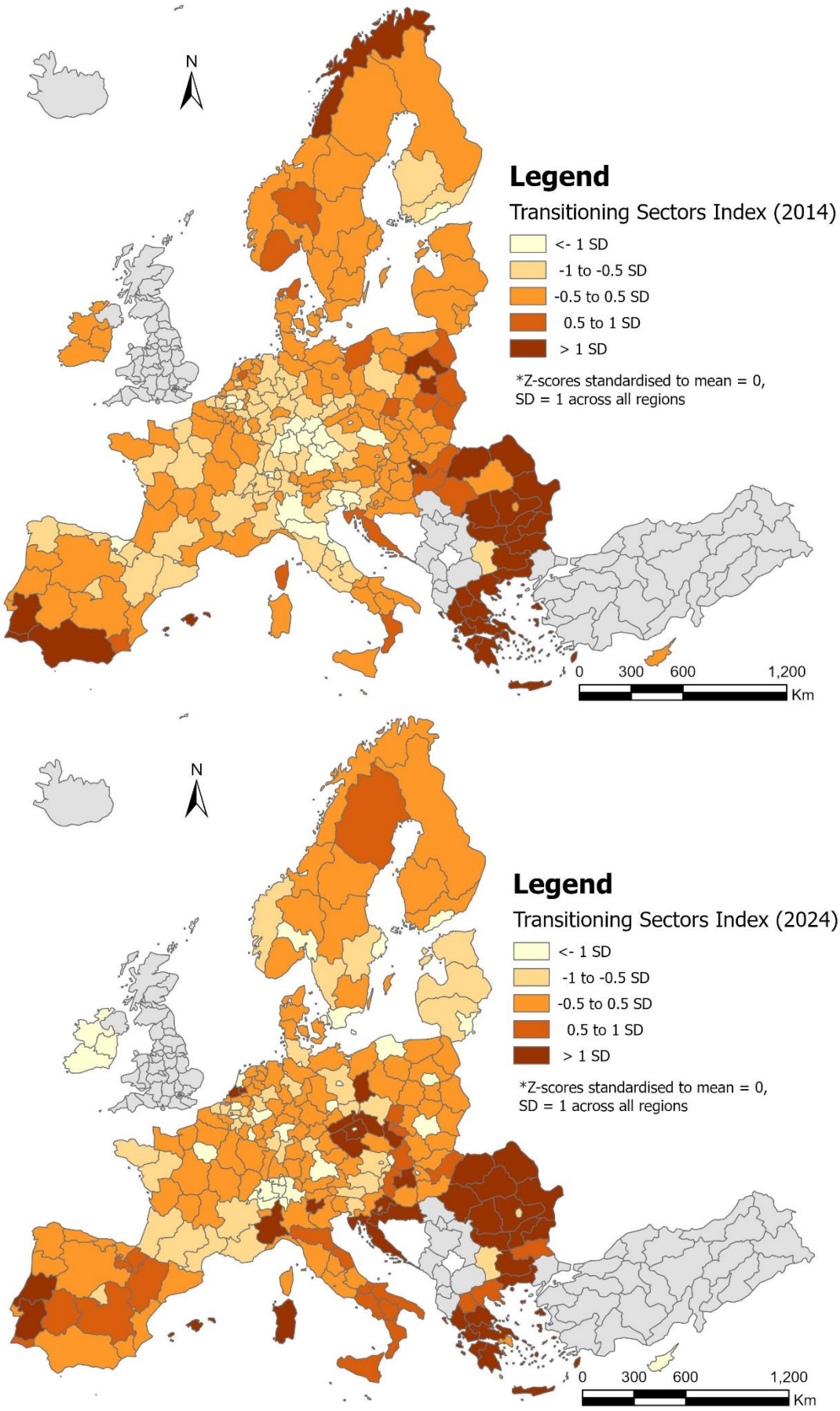


Figure 9 - Transitioning Sectors Index 2014 (top) and 2024 (bottom)

The most vulnerable group also grew, from 32 to 40 regions, signalling that sectoral adjustment pressures are widening rather than narrowing. Greece dominates this class, with regions characterised by high agricultural dependence, limited diversification, and volatile employment. Romania, Bulgaria, and parts of southern Italy are also locked-into this group. But the key development is the entry of new regions into the most vulnerable class by 2024. Several Central European regions with high manufacturing dependence also moved into this group as automation and decarbonisation pressures began to weigh on previously stable industrial structures (Maucorps et al., 2023; McDowall et al., 2023). Parts of Croatia show a similar pattern, and some Dutch regions, where agricultural concentration and employment instability are more pronounced also appear in this category, pointing to pockets of sectoral vulnerability that extend well beyond the traditional European periphery (Heikkonen, et al., 2025).

The simultaneous growth of both extremes is the defining shift of the decade. The result is a more polarised landscape: a growing cluster of diversified, knowledge-rich regions racing ahead, while a widening group of structurally exposed regions, where the capacity to generate or absorb transition-related employment remains weak, continues to lose ground.

In terms of indicators profiles (see Annex 3), the knowledge intensity of the regional workforce, which is captured by the HRST share, emerges as the key differentiator across classes. Regions in the most favourable group have large pools of skilled workers capable of driving innovation and absorbing new technologies; those in the most vulnerable group do not, and this gap has not narrowed over the decade. Employment volatility is the second distinguishing key feature of the most exposed regions, pointing to labour markets already subject to significant structural disruption even before the full weight of twin transition pressures might take hold.

3.8 The Transitioning Sectors Index – slope-based dynamics (2014 – 2024)

The slope-based dynamics Index captures how sectoral structures and adjustment capacity have evolved over 2014–2024. The geography of sectoral change is more fragmented than on the other two dimensions, with improvement concentrated in two distinct types of regions. The first includes regions in Romania, Poland, and the Baltic states, where declining agricultural employment, growing diversification, and expanding knowledge bases have shifted the sectoral profile substantially over the decade. The second includes tourism-dependent economies in Portugal and Greece, where diversification away from narrow sectoral bases has improved the overall adjustment capacity profile (Artelaris et al., 2024; Romão et al., 2016).

At the other end, regions with declining sectoral trajectories are found in parts of northern Italy, several Czech and Hungarian regions in Central and Eastern Europe, and some German, Dutch, and Nordic regions. The drivers vary across these cases. In northern Italy, growing manufacturing concentration and limited expansion of knowledge-intensive employment appear to be the main factors. In several Czech regions, increasing dependence on automotive and traditional manufacturing is raising sectoral exposure at a time when decarbonisation and automation pressures are intensifying. Among German and Nordic regions, the deterioration tends to reflect rising employment volatility and slowing knowledge-intensity growth rather than major shifts in sectoral composition, suggesting that the challenge in these areas is less about structural exposure and more about the pace at which the knowledge base is keeping up with the twin transition demands.

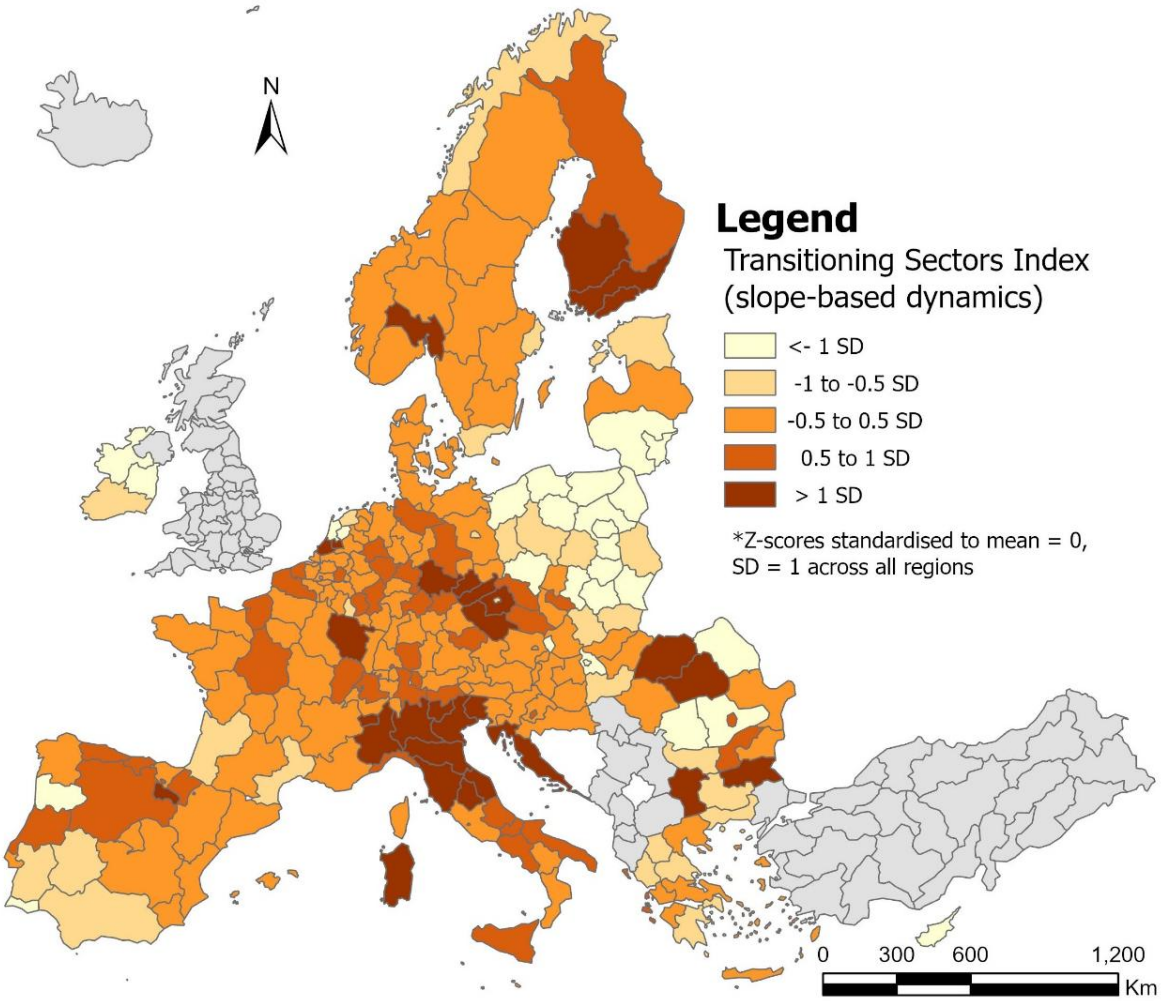


Figure 10 - Transitioning Sectors Index (slope-based dynamics 2014 - 2024)

The indicator profiles are revealing (see Annex 3). Among the most rapidly improving regions, all six indicators tend to move in a favourable direction, with declining traditional sector exposure accompanied by stronger diversification, more stable employment, and growing knowledge intensity. Among the deteriorating group, the pattern is more selective: the HRST share and employment volatility are the strongest drivers, while structural change indicators show more variation. This suggests that in many worsening regions, the problem is less about being stuck in traditional sectors and more about failing to build the knowledge base and employment stability needed to navigate the twin transition.

3.9 The Transitioning Sector Index (levels vs dynamics)

Figure 11 examines the relationship between initial levels in 2014 (z-scores) and subsequent slope-based dynamics for 2014 -2024 (z-scores) for the Transitioning Sectors Index. The moderately negative association (R^2 = 0.21) suggests some convergence in sectoral structures, but substantially weaker than for opportunity gaps. This is consistent with the observation that sectoral transformation tends to be path-dependent and shaped by region-specific factors such as industrial legacy, institutional capacity, access to investment, and proximity to knowledge networks, that do not respond uniformly to broad macroeconomic forces (Boschma, 2015; Hassink, 2010). The wide dispersion around the trend line also reflects that regions with similar starting positions have followed very different sectoral trajectories depending on whether they

managed to diversify, attract knowledge-intensive activity, or remained locked into declining traditional sectors.

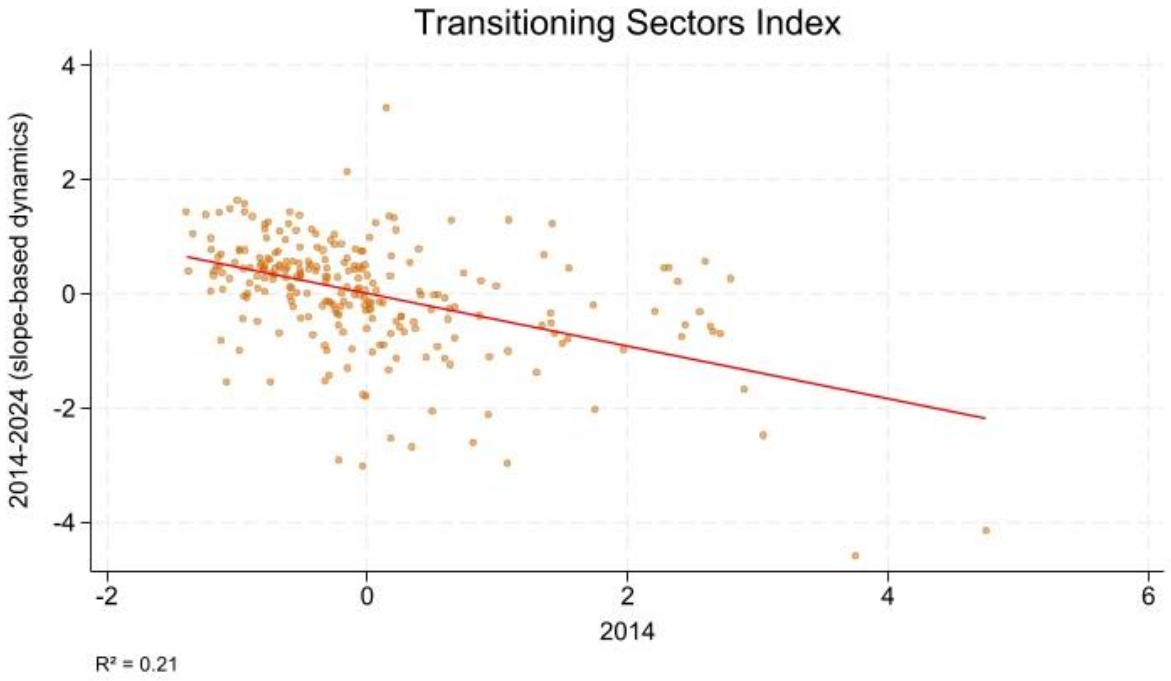


Figure 11 - Scatterplot TSI (2014 vs 2014-2024)

Figure 12 combines the static and dynamic dimensions into a quadrant classification. Each region is assigned based on whether its sectoral structure in 2024 is above or below the European average, and whether its trajectory has been improving or worsening relative to the European average.

Regions facing multiple transitions simultaneously form the largest group, with 69 regions. These regions combine weak sectoral structures and stagnating or worsening trajectories. This is a notably larger group than on either of the other two dimensions, suggesting that sectoral vulnerability is particularly sticky. The group spans a wide range of regions: several Greek regions with entrenched agricultural dependence, Romanian and Bulgarian regions where structural transformation has stalled, but also parts of northern Italy where manufacturing concentration is deepening, several Czech regions where industrial dependence is growing, and some Dutch and German regions where employment volatility and limited knowledge-economy expansion are compounding existing weaknesses (European Commission. European Political Strategy Centre, 2025; Guarascio et al., 2026; Heikkonen et al., 2025; Pavlínek, 2020). The breadth of this group underscores that persistent sectoral vulnerability is not confined to the traditional European periphery.

Regions lacking adaptability are currently well positioned but on a declining trajectory. Much of Germany falls into this category, along with parts of Switzerland, Austria, Scandinavia, and the Benelux. These are regions with historically strong sectoral profiles, diversified economies, stable employment, solid knowledge bases, that are nonetheless seeing their relative advantage erode. For Germany in particular, this pattern may reflect the growing pressures on its manufacturing-heavy economic model as energy costs, decarbonisation requirements, and competitive dynamics reshape the industrial landscape (Tagliapietra and Veugelers, 2020).

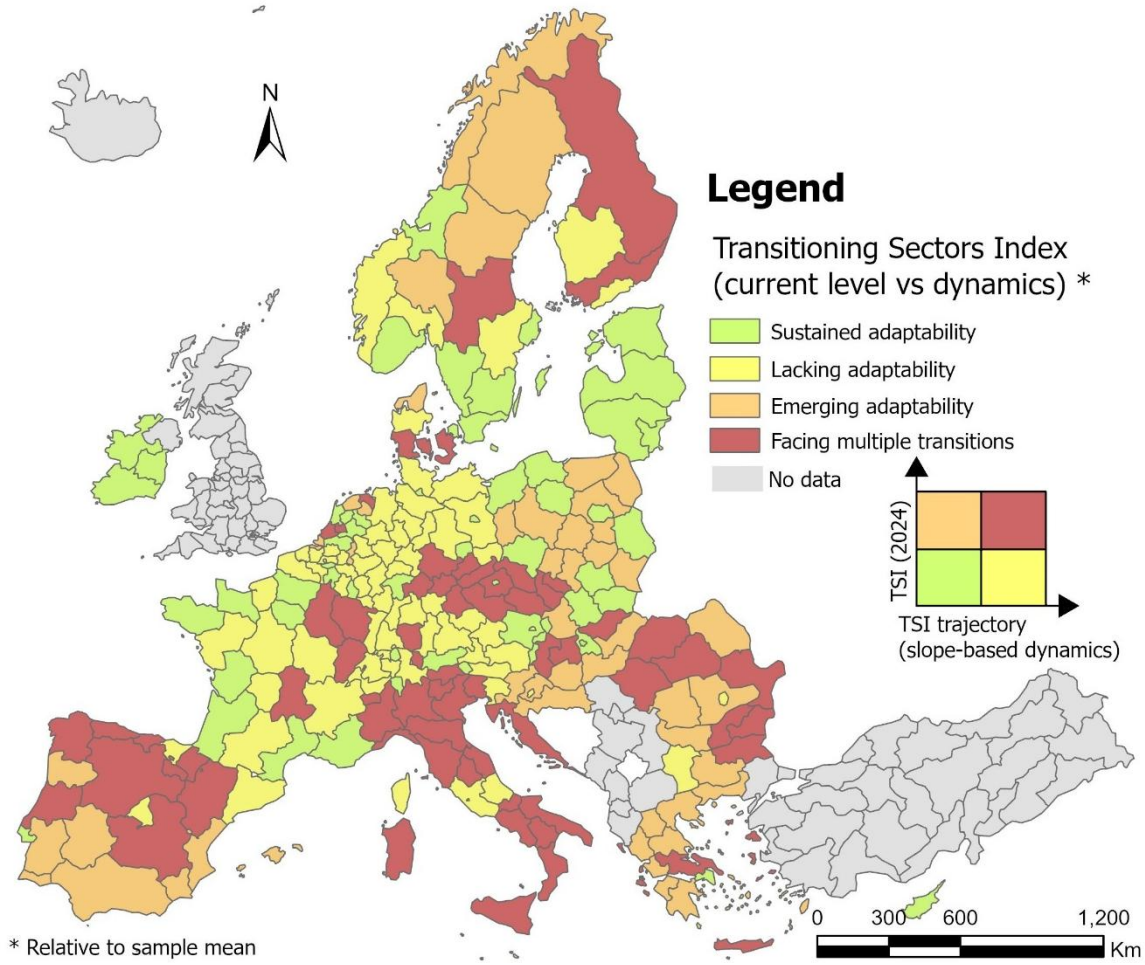


Figure 12 - Transitioning Sectors Index (current level vs dynamics)

The Sustained Adaptability group includes regions that combine strong sectoral profiles with positive trajectories. This group is anchored in Switzerland, parts of Scandinavia, Ireland, and several Central and Eastern European capital regions, as well as several French and German regions that have successfully maintained both diversification and knowledge-intensity growth. The group also includes some Polish and Baltic regions where rapid structural change has pushed them into both structurally strong and dynamically improving positions (Jambor and Gorton, 2025).

Last, the Emerging Adaptability group, structurally weak but improving, includes several southern Spanish and Portuguese regions, parts of Greece, and some Polish and Romanian regions where structural transformation is underway but has not yet lifted the region above the European average. Whether these regions can sustain their improvement through the twin transition depends on whether the knowledge base expands fast enough to absorb the opportunities that structural change creates.

A distinctive feature of the sectoral quadrant map is the degree of polarisation it reveals within individual countries. Germany is split between regions with sustained adaptability profiles (mainly in the south and west) and a large block showing lacking adaptability. Italy is divided between a recovering south and a persistently disadvantaged north which is a reversal of the usual north-south pattern seen on other dimensions, driven here by the concentration of traditional manufacturing in the north. This within-country variation highlights that sectoral adjustment pressures do not respect the broad macro-regional gradients visible on the other two

indices, and that policy responses need to be calibrated to the specific sectoral profile of each region.

3.10 Overall Left-Behind Index (2014 & 2024)

Finally, the overall Left-Behind Index combines the three dimensions —left-behind places, opportunity gaps, and transitioning sectors— into a single composite measure of multidimensional vulnerability. Figure 13 presents the spatial distribution in 2014 and 2024.

The overall index produces a clearer and more stable spatial pattern than any individual dimension because it captures compound disadvantage, namely regions that are simultaneously vulnerable across economic performance, labour market inclusion, and sectoral structure (Martin et al., 2021; Pike et al., 2017).

The composition of the most vulnerable group in 2024 reflects a familiar geography, although the number of regions in this class is 37 down from 46 in 2014. This group is dominated by Greek regions, followed by southern Italian regions where high labour market exclusion combines weak economic output and limited sectoral adaptability. Romania presents one of the highest within-country contrasts, with the entire country outside Bucharest-Ilfov falling into the most vulnerable class. Spain's most structurally disadvantaged regions, concentrated in the south also remain in this group. These regions share a common feature: vulnerability is not confined to a single dimension but spans economic performance, labour market inclusion, and sectoral structure, which may limit their capacity to respond to twin transition-related pressures.

The most favourable group (class 1) consists of 28 regions in 2024, compared to 31 in 2014. Switzerland dominates, followed by Germany. The group also includes several capital regions that perform well across all three dimensions (Stockholm, Copenhagen, Dublin, Prague, Warsaw, Bratislava, and Budapest) reflecting the concentration of diversified, knowledge-intensive economic activity in metropolitan hubs. The presence of Central and Eastern European capitals into this group confirms a pattern visible across all three dimensions: rapid economic growth, tightening labour markets, and expanding knowledge-based services have brought these regions into line with the traditional European core on composite measures of vulnerability.

The intermediate group (class 3) is the largest, expanding from 84 to 94 regions between 2014 and 2024. This group encompasses much of France, central and northern Spain, parts of Italy, the Baltic states, and a range of Central European regions. On aggregate, these regions sit near the European average on all three dimensions, but their individual profiles vary considerably. Some are economically strong but sectorally exposed, while others have narrow opportunity gaps but weak economic output. This heterogeneity means that the twin transition may affect these regions differently depending on which dimension of vulnerability proves most significant in their specific context.

Between 2014 and 2024, the most notable shift is the contraction of the most vulnerable class. The exit of several Polish, Slovak, and Croatian regions from class 5 reflects convergence driven by rising employment, productivity gains, and gradual sectoral diversification thanks to cohesion policy. At the same time, the persistence of Greek, southern Italian, and Romanian regions in this group underscores that convergence has been geographically selective. For these regions, a decade of EU cohesion investment and post-crisis recovery has not been enough to shift their relative position (Durán Laguna, 2024; Egri and Lengyel, 2024; European Commission, 2018b).

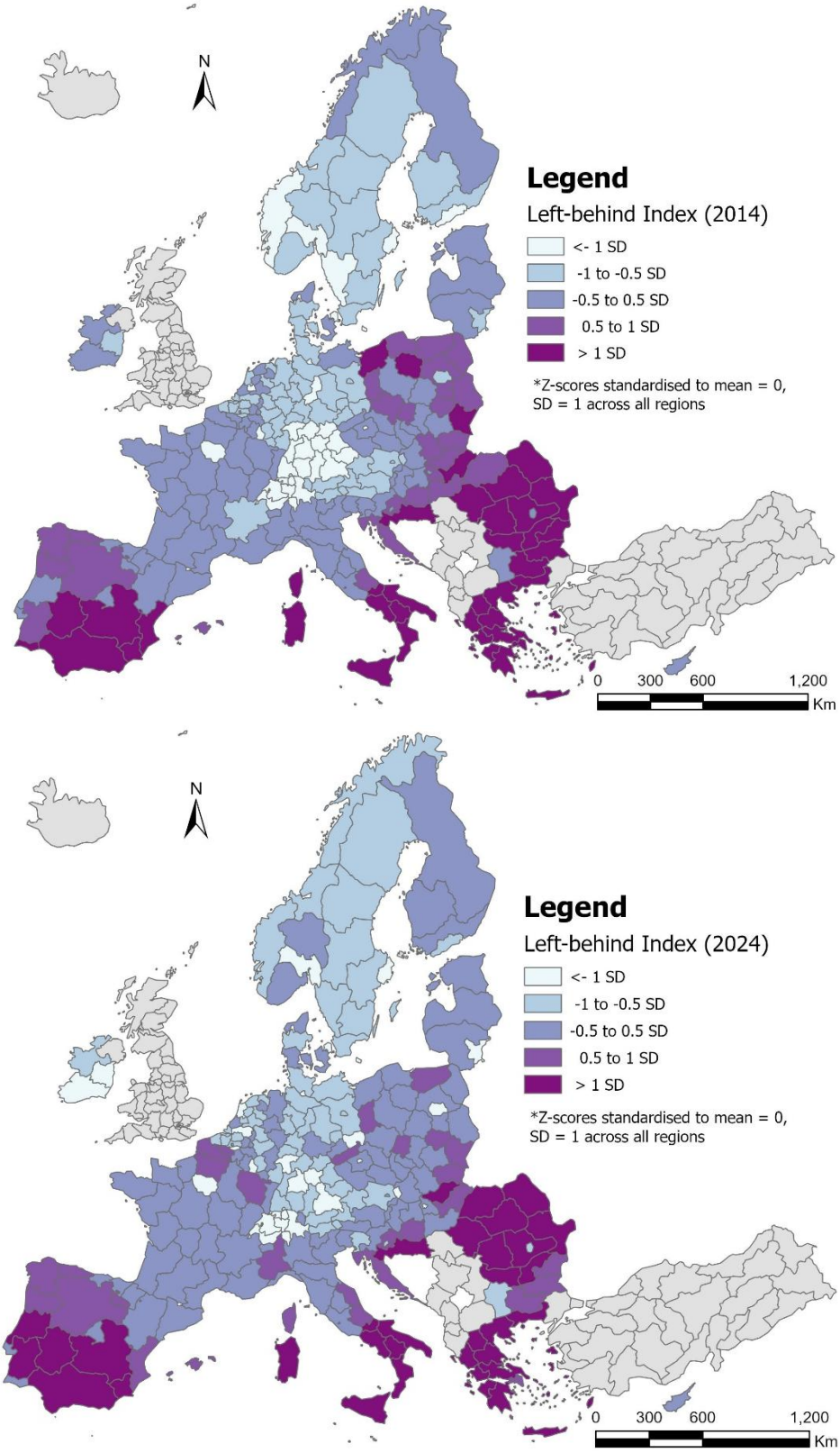


Figure 13 - Left-behind Index 2014 (a) and 2024 (b)

The indicator profiles across the five classes confirm that the overall index captures multidimensional disadvantage (see Annex 4). In the most vulnerable group, all three sub-indices average well above the vulnerability mean, with opportunity gaps showing the widest spread,

suggesting that labour market exclusion is the dimension where the gap between the most and least vulnerable regions is greatest. In the most favourable group, all three sub-indices are well below the mean, with the LBI showing the strongest performance, which is indicating that high economic output is the most consistent feature of the least vulnerable regions, even where opportunity gaps or sectoral profiles are somewhat less favourable.

All in all, the overall index reveals a Europe where compound disadvantage remains concentrated in a well-defined southern and eastern periphery, while compound advantage is anchored in a western and northern core supplemented by a growing number of eastern metropolitan hubs. Between these extremes sits a large and diverse middle ground where the balance of vulnerability and resilience remains uncertain and where the specific pressures and opportunities of the twin transition are likely to determine which regions race ahead and which fall further behind.

3.11 The overall Left-Behind Index – slope-based dynamics (2014 – 2024)

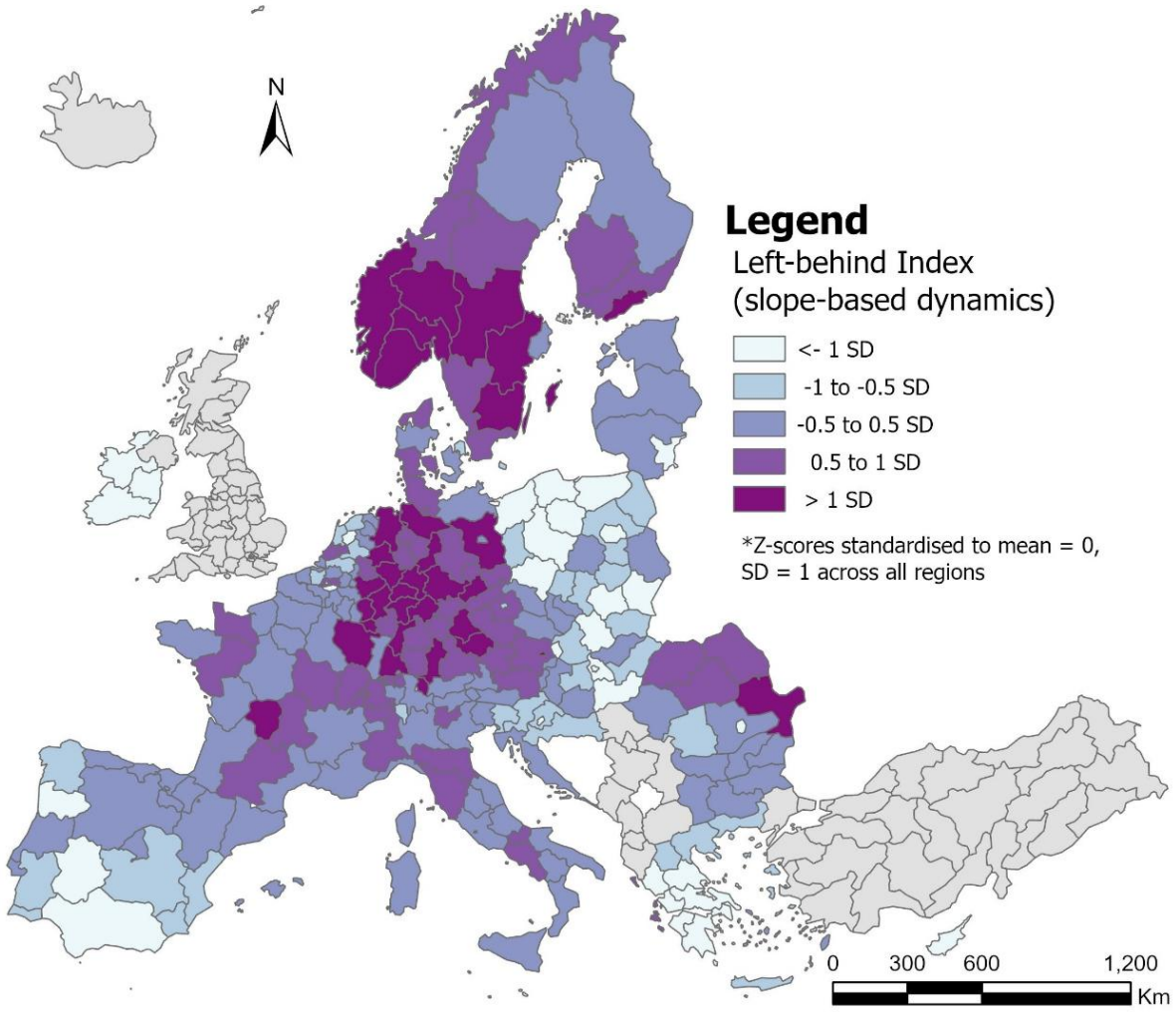


Figure 14 - Left-behind Index (slope-based dynamics 2014 - 2024)

The slope-based dynamics of the overall index combines the trend estimates across all three dimensions to capture how multidimensional vulnerability has been shifting over 2014–2024.
The geography of overall improvement is dominated by Central and Eastern European regions (Poland, Hungary, Croatia, and the Baltic states) where economic performance, labour market

conditions, and sectoral structures have all been moving in a favourable direction over the decade. Several Greek regions also show rapid overall improvement, reflecting deep post-crisis labour market recovery, though starting from very weak structural positions.

Declining overall trajectories are concentrated in the traditional European core. Much of Germany falls into the declining categories, alongside parts of Scandinavia, Austria, Switzerland, and the Netherlands. This is a composite pattern: on the places dimension, slowing GDP and productivity growth; on opportunity gaps, narrowing relative advantage in labour market inclusion; and on the transitioning sectors dimension, rising employment volatility and limited expansion of knowledge-intensive employment. No single dimension dominates, but rather it is the accumulation of low relative weakening across all three that pushes these regions into the deteriorating categories.

The indicator profiles are consistent (see Annex 4). Among the most rapidly improving regions, all three sub-index dynamics move in a favourable direction, pointing to overall convergence. Among the most rapidly deteriorating, all three sub-indices decline, though the opportunity gaps dimension shows the steepest decline on average, suggesting that the erosion of labour market advantage in core European regions is the most pronounced component of their overall trajectory.

3.12 The overall Left-behind Index (levels vs dynamics)

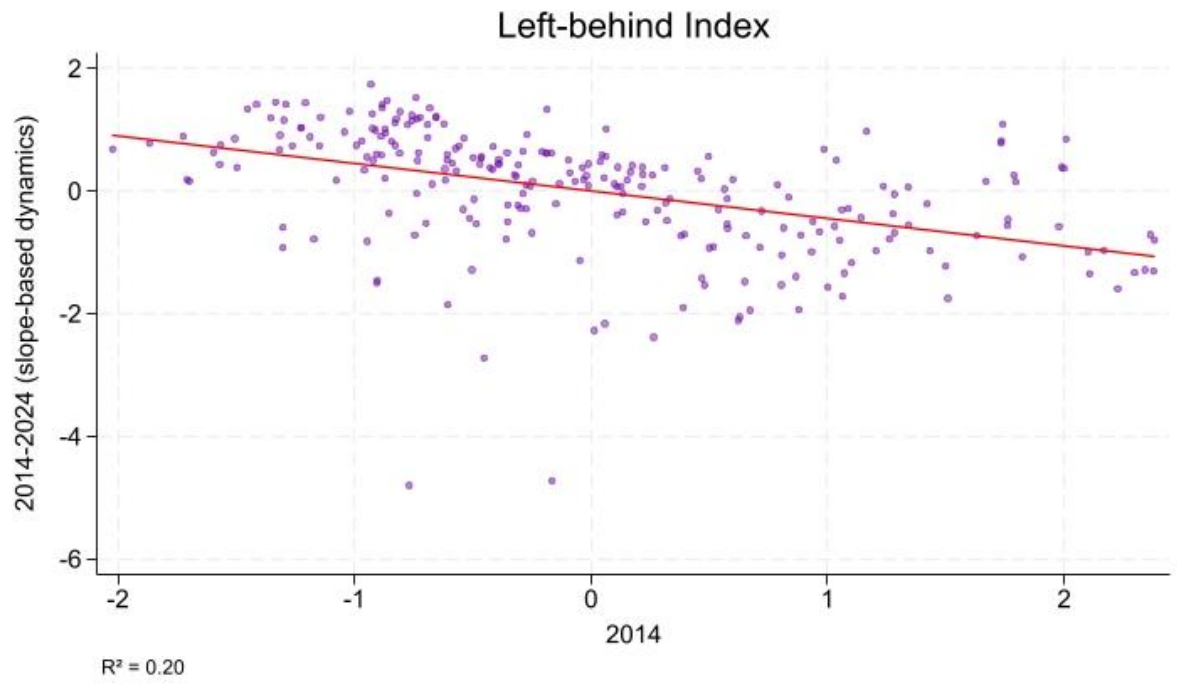


Figure 15 - Scatterplot LBI (2014 vs 2014-2024)

Figure XX presents the static- slope-based dynamic scatterplot for the overall Left-Behind Index. The relationship is moderately negative (R^2 = 0.20), indicating a degree of convergence across European regions - those that were most vulnerable in 2014 have tended to improve, while previously well-positioned regions have seen their relative advantage weaken. However, this aggregate convergence masks very different dynamics across the three dimensions: the places index shows no convergence at all, while opportunity gaps converge strongly and sectoral structures converge moderately. The overall pattern is therefore a composite of distinct and sometimes contrasting dynamics across the three dimensions, and should be interpreted with

caution as aggregate convergence can coexist with persistent or widening gaps on individual dimensions of vulnerability (Iammarino et al., 2019; Rodríguez-Pose, 2018).

Figure 16 presents the quadrant classification of the overall Left-Behind Index, combining the static 2024 position with the 2014–2024 trajectory.

The largest group is regions showing risk of being-left behind. This group covers regions from Germany, Scandinavia, Switzerland, Austria, and the Netherlands which is the traditional European core. The scale of this group is significant: it means that a majority of Europe's most structurally favourable regions are on a weakening trajectory when all three dimensions are considered together. While these regions remain far from structurally disadvantaged, the breadth and consistency of their relative decline across economic performance, labour market conditions, and sectoral adaptability warrants attention in the context of the twin transition.

The Improving left-behind group covers regions that are structurally weak but improving. This includes much of southern Spain, Portugal, Greece, and parts of Central and Eastern Europe where rapid convergence has been narrowing the gap with the European average. For these regions, the central policy question is whether the pace of improvement is sufficient to shift them out of structural disadvantage before the full weight of twin transition pressures takes hold.

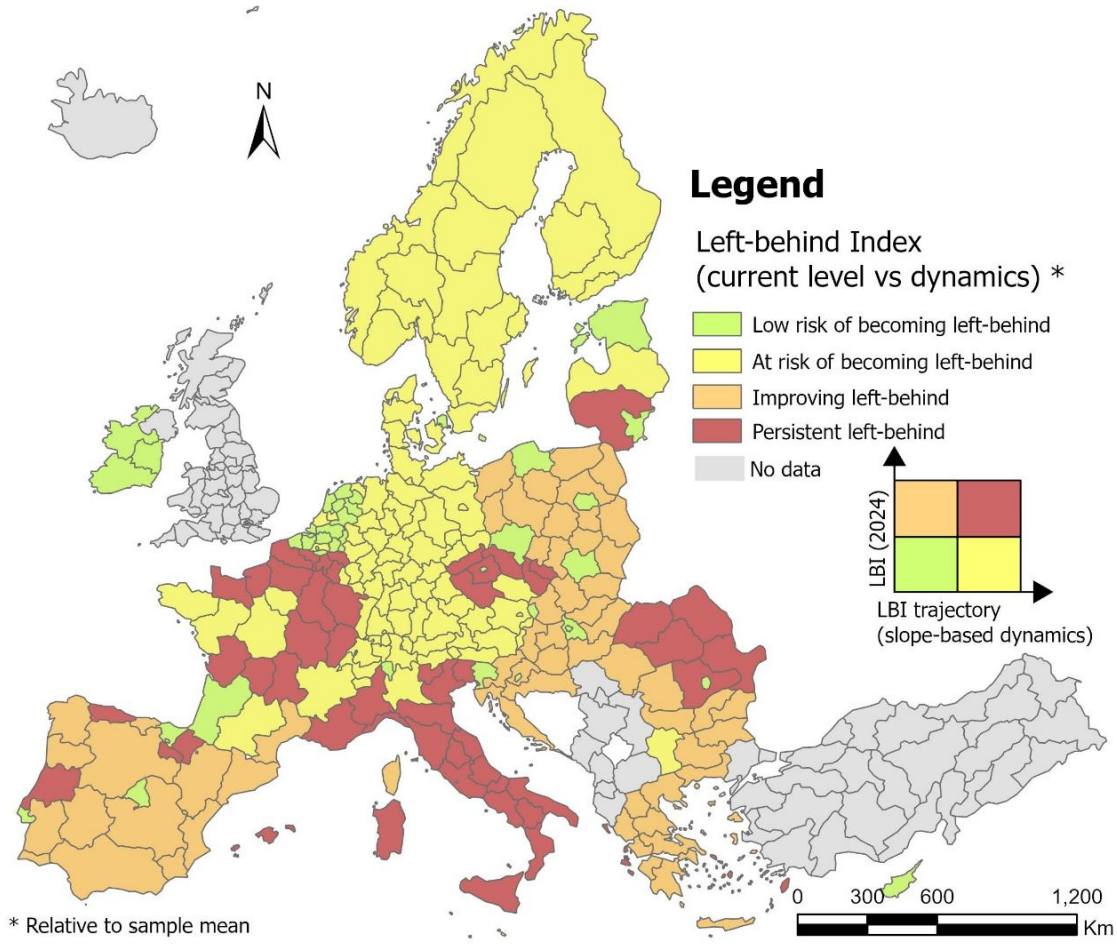


Figure 16 - Left-behind Index (current level vs dynamics)

The persistently left-behind group contains regions that combine above-average vulnerability with declining trajectories across all three dimensions. This is the group of greatest concern from a policy perspective. It includes most of southern Italy, several Romanian and Bulgarian regions, parts of Greece, and a substantial number of French regions where structural weaknesses across economic performance, labour market inclusion, and sectoral structure have not improved over the decade. The group also includes a cluster of Czech regions and several Belgian regions, a finding that underscores the reach of persistent multidimensional disadvantage beyond the traditional European periphery.

The Low risk of becoming left-behind group is the smallest of the groups. It fundamentally includes the Benelux capitals, regions in Ireland, several Central and Eastern European capital regions, and a set of Dutch, Nordic, and Polish regions that have maintained strong positions while continuing to improve. These regions represent the most resilient part of the European landscape being well positioned structurally and moving in the right direction.

Overall, the quadrant map reveals a Europe that is converging and diverging simultaneously. Central and Eastern European regions, particularly metropolitan areas, are closing the gap with the traditional core, which is itself losing relative advantage. Southern Europe is split between improving regions that are gradually narrowing structural gaps and persistently left-behind regions where compound vulnerability shows no sign of easing. The twin transition will play out across this uneven and shifting landscape, and the quadrant classification suggests that the regions most at risk are not only those that are currently most disadvantaged, but also those in the large at risk of becoming left behind group where the erosion of previously strong positions could accelerate if structural adjustment pressures intensify.

3.13 Regional Economic Momentum: A Development Trap Perspective

The preceding sections have identified where regions stand in terms of structural vulnerability across economic performance, labour market inclusion, and sectoral adjustment capacity, and how these conditions have been evolving over 2010–2024. This section introduces a complementary perspective focused on regional economic momentum , namely whether the growth dynamics behind regional economic performance are strengthening or weakening relative to a region's own recent trajectory, its national context, and the European average.

The development trap framework identifies regions where simultaneous deceleration across income, productivity and employment dynamics may signal a structural shift in economic trajectory rather than a temporary cyclical slowdown. In the context of the twin transition, this dimension is relevant: regions that are currently structurally well positioned but showing sustained economic deceleration may face higher difficulties in generating and absorbing transition-related employment opportunities, even where their current structural indicators remain favourable. Conversely, regions that are structurally disadvantaged but showing economic acceleration may retain more adaptive capacity than their LBI scores alone would suggest.

Figure 17 maps the average DTI average score over 2010–2024, with higher values indicating more persistent deceleration across income, productivity and employment relative to multiple benchmarks.

The map shows a geographic pattern that differs from the structural vulnerability distribution identified by the LBI. Regions scoring in the upper classes are concentrated across western and northern Europe. Several German regions fall into this group, with particularly high scores in the Ruhr area, Frankfurt and Hamburg, as do parts of Belgium, France, Spain and the Netherlands. Many of these regions remain structurally well positioned on the LBI being into the emerging vulnerability or low-risk category, but show weakening of growth dynamics relative to their own recent past and European peers across all three economic dimensions. This is consistent with evidence of slowing productivity growth across advanced European economies (Bergeaud et al., 2016) and with the pressures facing manufacturing-intensive regions as decarbonisation and technological change reshape industrial structures (Dauth et al., 2021).

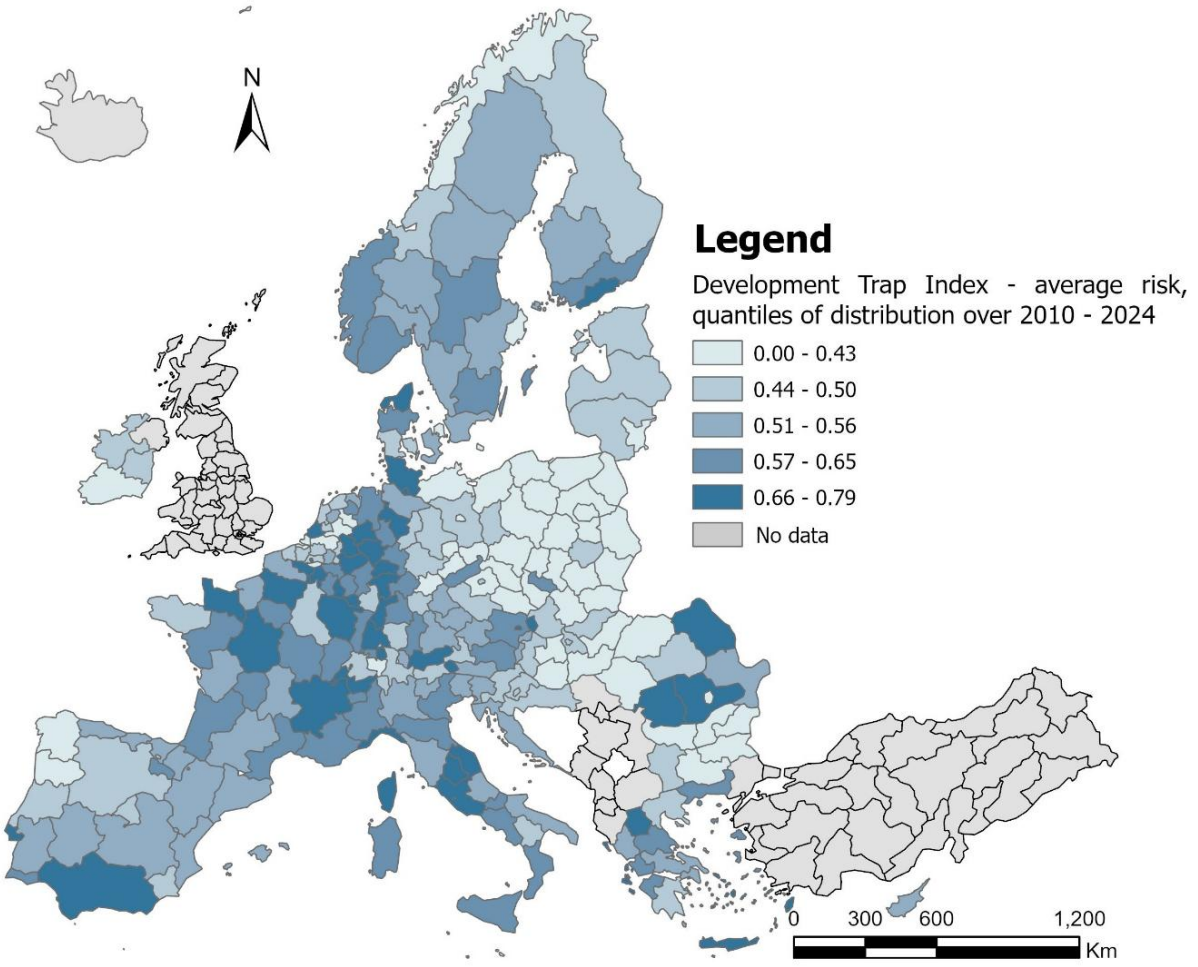


Figure 17 - Development Trap Index - average risk (2010 -2024)

Central and Eastern Europe shows a different pattern. Most Polish, Bulgarian, and Hungarian, regions score in the lower classes, consistent with their catching-up trajectories on the LBI. For these regions, structural convergence on the LBI and positive momentum on the DTI point in the same direction. Bucharest scores in the lowest class, reflecting the strength of the Romanian capital's growth trajectory throughout the period, while also highlighting the diverging dynamics within the country.

Greece and southern Italy score in the middle classes rather than the upper classes reflecting growth acceleration relative to a severely depressed post-crisis baseline even where structural disadvantage on the LBI remains significant. The DTI does not contradict the LBI picture for these

regions but rather adds some nuance, economic dynamics may be somewhat more positive than the structural snapshot alone suggests.

Overall, the DTI and LBI maps together point to two geographically distinct patterns of regional vulnerability. Structural disadvantage, as measured by the LBI, is concentrated in southern and eastern Europe. Weakening economic momentum, as measured by the DTI, is more prevalent in western and northern Europe. These are different dimensions of vulnerability, affecting different sets of regions.

The two patterns overlap most visibly in parts of southern and western Europe and in some eastern European regions outside capital cities, where structural weakness and weakening growth dynamics appear together. Beyond these areas, the two indices frequently diverge, pointing to the value of examining structural conditions and economic momentum separately rather than relying on either measure alone.

4 Conclusions

4.1 Main results

This deliverable has identified left-behind places, population groups, and sectors across European regions in the context of the twin transition, using a multidimensional framework that combines structural conditions with medium-term trajectories. The analysis covers 247 regions across EU27, Norway and Switzerland over the period 2014–2024 and produces a set of composite indices capturing economic performance, labour market vulnerability, and sectoral adjustment capacity.

Several findings stand out across the three dimensions and their combination.

On economic performance, the Left-Behind Places Index confirms a persistent core-periphery structure, with the most disadvantaged regions concentrated in southern Italy, Greece, Romania, Bulgaria, and parts of eastern Poland and Hungary. At the same time, the dynamic dimension reveals an east-west divergence in trajectories that cuts across this structural pattern: Central and Eastern European regions are converging rapidly while many regions in Germany, Austria, Scandinavia and the Netherlands are losing relative ground. This suggests that the geography of future vulnerability may look different from the current structural map.

On labour market inclusion, opportunity gaps follow a southern arc rather than a simple east-west gradient, with key disadvantage concentrated in southern Italy, Greece, southern Spain and parts of Romania. A notable finding is the deterioration of opportunity gap trajectories in much of the western European core, regions that remain structurally strong on labour market indicators but where youth disengagement and older worker participation have been worsening relative to the European average.

On sectoral structure, vulnerability is more fragmented geographically than on the other two dimensions, shaped by industrial legacies and the pace of structural transformation rather than broad macro-regional patterns. The most exposed regions combine high dependence on traditional manufacturing or agriculture with limited diversification and low knowledge bases. A concerning development is the widening of the distribution over the decade - both the most favourable and the most vulnerable groups have grown, suggesting increasing polarisation in sectoral adjustment capacity across European regions.

The overall Left-Behind Index combines these three dimensions into a composite measure of multidimensional vulnerability. The most disadvantaged regions, namely those that score poorly across all three dimensions simultaneously are concentrated in Greece, southern Italy, Romania and southern Spain. The most resilient are anchored in Switzerland, the Benelux capitals, Ireland and a growing set of Central and Eastern European metropolitan areas. Between these extremes, a large and diverse intermediate group covers much of France, Spain, the Baltic states and Central Europe, where the balance of vulnerability and resilience varies considerably across dimensions.

The DTI adds a further dimension to this picture. Persistent deceleration across income, productivity and employment - relative to a region's own recent past, its national context, and the European average - is most prevalent in western and northern Europe, a pattern that diverges markedly from the LBI geography. Many structurally favourable regions show consistently weakening growth dynamics over 2010–2024, while most Central and Eastern European regions show the opposite. In parts of western and southern Europe, structural weakness and weakening

momentum overlap, pointing to a more compound form of vulnerability that neither index alone fully captures.

4.2 Interpretation

Several cross-cutting themes emerge from the analysis.

First, structural conditions and economic dynamics do not always point in the same direction. Some of the most structurally favourable regions in Europe are showing deteriorating trajectories, while some of the most structurally disadvantaged are on improving paths. This underscores the importance of combining static and dynamic measures rather than relying on a snapshot of current conditions to assess where vulnerability is concentrated and where it may be heading.

Second, the twin transition is arriving at a moment of considerable regional differentiation across Europe. Regions with strong structural positions and positive trajectories are well placed to absorb twin transition-related pressures and capture the opportunities associated with green and digital transformation. Regions with structural weaknesses and deteriorating dynamics face a more difficult adjustment, where twin transition pressures may compound existing disadvantage rather than open new pathways. The large group of regions showing emerging vulnerability - structurally favourable but losing momentum - represents a distinct challenge: these regions are not currently left behind but may become so if structural adjustment pressures intensify and are not met with adequate policy responses. The development trap analysis reinforces this finding: several of the same regions identified as emerging vulnerability on the LBI also show persistently weakening economic momentum on the DTI, suggesting that the weakening of their structural advantage may be more advanced than the LBI trajectory alone implies.

Third, vulnerability is multidimensional and the dimensions do not always align. Regions can be economically strong but sectorally exposed, or labour market inclusive but structurally weak on output. This heterogeneity means that the twin transition is likely to affect regions differently depending on which dimension of vulnerability is most consequential in their specific context, and that policy responses calibrated to a single measure of disadvantage may miss important aspects of regional risk.

4.3 Limitations

Several limitations should be kept in mind when interpreting the results. The analysis is conducted at NUTS2 level, which may conceal significant within-region variation, particularly in large or geographically diverse regions. The indicator set is shaped by data availability, and some dimensions of vulnerability relevant to the twin transition could not be fully captured within the available data. The dynamic indices are based on linear trend estimates, which may not fully reflect non-linear change.

A further limitation concerns the population groups that the current index framework can identify. The OGI captures vulnerability across dimensions measurable through standard Eurostat regional labour market statistics such as age, education, and gender. Several groups that may be particularly exposed to the pressures of the twin transition are not separately identifiable in the regional indicators available at NUTS-2 level, including migrants and ethnic minorities, people with disabilities, and unpaid carers. This reflects the broader constraints of harmonised regional administrative data, and points to the value of the focus groups planned in subsequent project tasks, which offer an opportunity to complement the quantitative baseline established here by

surfacing these groups and exploring the specific mechanisms shaping their vulnerability in the context of the twin transition.

4.4 Further work

The findings presented here provide a macro-level empirical baseline for the subsequent analytical work within the project. The vulnerability profiles developed across the three dimensions and their combination offer a spatial and structural reference point for the project's sectoral case studies, focus groups, and policy analysis work. In particular, the identification of regions where multiple forms of disadvantage overlap such as structural weakness and deteriorating trajectories, provide a key basis for prioritising where more qualitative evidence gathering and policy scenario development may be most needed.

However, the analysis also surfaces a set of broader dynamics that deserve further attention. Over the last decade, many trends have moved in an encouraging direction. A considerable number of Central and Eastern European regions have grown rapidly, generated employment, and begun to close the gap with their western counterparts. At the same time, several formerly core regions in Germany, Austria, Scandinavia, and the Netherlands have struggled to maintain their previous dynamism. Taken in isolation, these shifts would suggest a picture of convergence, and single indicators such as changes in GDP per capita or employment rates do indeed point in that direction.

Yet when a broader, multi-dimensional perspective is adopted, the picture is far less reassuring. Disadvantage remains deeply entrenched across Europe, with many of the regions that lagged behind in previous decades continuing to face serious structural challenges. In some cases, this is because core economic indicators have simply not improved. But more often, it is because growth, where it has occurred, has either failed to generate sufficient opportunities for all segments of the population, or because existing economic and industrial structures act as key barriers to the transitions needed to move up. The overlap between weak economic performance, labour-market exclusion, and limited sectoral adaptability in parts of southern and eastern Europe points to a form of compound disadvantage that is unlikely to be resolved by growth alone.

At the same time, the strong performance of certain capital regions, particularly in Central and Eastern Europe, masks profound and growing within-country disparities in advantage and opportunity. The gap between dynamic metropolitan hubs and their surrounding territories is widening in many member states, creating a geography of inequality that is increasingly visible at the sub-national level. Addressing these disparities will be essential if the EU is to overcome the growing political economy challenges linked to rising discontent (Dijkstra et al., 2023; Rodríguez-Pose, 2018) and to build the broad-based prosperity and competitiveness that the twin transition demands.

Future work could also explore the relationship between the vulnerability patterns identified here and specific transition-related labour market outcomes, including skills mismatches, employment reallocation, and the distributional effects of green and digital transformation across different types of regions and population groups. The relationship between development trap dynamics and the LBI vulnerability profiles also merits further investigation. The two frameworks identify partially overlapping but distinct geographies of risk and understanding the

mechanisms through which weakening economic momentum translates or fails to translate into structural disadvantage over time would strengthen the analytical foundation for anticipatory policy.

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Annex 1: Summary statistics for static and dynamic indices - LBPI

Table 1: Left-Behind Places Index - Static indicator profiles by class (2014)

Class	N	GDP p.c. Mean	GDP p.c. SD	Productivity Mean	Productivity SD	Emp. rate Mean	Emp. rate SD
< -1SD	37	-1.663	0.775	-1.423	0.778	-0.901	0.597
-1 to -0.5 SD	43	-0.576	0.412	-0.547	0.273	-0.832	0.385
-0.5 to 0.5 SD	83	0.064	0.384	-0.095	0.544	-0.161	0.512
0.5 to 1 SD	31	0.705	0.252	0.8	0.481	0.465	0.682
> 1 SD	53	1.114	0.315	1.119	0.541	1.285	0.824

Note: Standardised z-scores; higher values = greater vulnerability. N = number of regions.

Table 2: Left-Behind Places Index - Static indicator profiles by class (2024)

Class	N	GDP p.c. Mean	GDP p.c. SD	Productivity Mean	Productivity SD	Emp. rate Mean	Emp. rate SD
< - 1SD	31	-1.939	0.875	-1.498	1.195	-0.761	0.816
-1 to -0.5 SD	49	-0.482	0.368	-0.476	0.435	-0.782	0.455
-0.5 to 0.5 SD	89	0.143	0.402	-0.041	0.509	-0.069	0.547
0.5 to 1 SD	37	0.72	0.245	0.799	0.556	0.304	0.67
> 1 SD	41	1.082	0.277	1.069	0.469	1.386	1.036

Note: Standardised z-scores; higher values = greater vulnerability. N = number of regions.

Table 3: Left-Behind Places Index - Dynamic indicator profiles by class

Class	N	GDP p.c. Mean	GDP p.c. SD	Productivity Mean	Productivity SD	Emp. rate Mean	Emp. rate SD
< - 1SD	20	-1.944	2.104	-1.872	2.337	-1.259	1.302
-1 to -0.5 SD	22	-0.493	0.76	-0.313	0.396	-0.711	0.966
-0.5 to 0.5 SD	133	0.13	0.52	0.061	0.448	-0.086	0.766

0.5 to 1 SD	61	0.397	0.434	0.407	0.364	0.709	0.569
> 1 SD	11	0.752	0.613	1.03	0.997	0.819	1.248

Note: Standardised slope-based z-scores; higher values = worsening trends.

Table 4: Left-Behind Places Index - Quadrant summary statistics

Quadrant	N	Static Mean	Static SD	Dynamic Mean	Dynamic SD
Low risk of falling behind	49	-1.077	0.774	-1.026	1.558
At risk of falling behind	78	-0.583	0.507	0.55	0.313
Catching-up	52	0.814	0.419	-0.501	0.435
Persistent disadvantage	68	0.822	0.608	0.491	0.34

Note: Static = 2024 position; Dynamic = 2014–2024 trend. Higher values = greater vulnerability.

Annex 2: Summary statistics for static and dynamic indices - OGI

Table 5: Opportunity Gaps Index - Static indicator profiles by class (2014)

Cl.	N	Unemp. M	Unemp. SD	NEET M	NEET SD	Educ. M	Educ. SD	Old emp. M	Old emp. SD	Gap M	Gap SD
< - 1SD	43	-0.809	0.327	-1.019	0.212	-0.751	0.319	1.561	0.338	-0.759	0.535
-1 to -0.5 SD	47	-0.59	0.327	-0.699	0.319	-0.538	0.42	0.558	0.564	-0.494	0.613
-0.5 to 0.5 SD	86	-0.191	0.469	-0.086	0.495	-0.215	0.745	-0.423	0.562	-0.007	0.741
0.5 to 1 SD	38	0.495	0.668	0.765	0.629	0.683	0.905	-0.582	0.517	0.205	0.864
> 1 SD	33	1.823	1.043	1.666	0.826	1.519	0.799	-1.057	0.405	1.474	1.014

Note: Standardised z-scores; higher values = greater vulnerability. Older employment (55–64): positive values indicate higher participation (more favourable).

Table 6: Opportunity Gaps Index - Static indicator profiles by class (2024)

Cl.	N	Unemp. M	Unemp. SD	NEET M	NEET SD	Educ. M	Educ. SD	Old emp. M	Old emp. SD	Gap M	Gap SD
< - 1SD	26	-0.948	0.248	-0.943	0.259	-0.784	0.507	1.258	0.522	-0.615	0.549
-1 to -0.5 SD	69	-0.422	0.63	-0.628	0.401	-0.415	0.477	0.807	0.519	-0.504	0.53
-0.5 to 0.5 SD	87	-0.227	0.596	-0.079	0.516	-0.195	0.775	-0.312	0.709	-0.103	0.636
0.5 to 1 SD	29	0.627	0.594	0.563	0.658	0.809	1.102	-0.735	0.697	0.041	0.645
> 1 SD	36	1.537	1.075	1.623	1.115	1.182	1.043	-1.108	0.526	1.625	1.189

Note: Standardised z-scores; higher values = greater vulnerability. Older employment (55–64): positive values indicate higher participation (more favourable).

Table 7: Opportunity Gaps Index - Dynamic indicator profiles by class

Cl.	N	Unemp. M	Unemp. SD	NEET M	NEET SD	Educ. M	Educ. SD	Old emp. M	Old emp. SD	Gap M	Gap SD
< - 1SD	34	-1.485	1.345	-1.253	0.786	-1.083	1.054	-1.173	0.962	-0.39	1.675
-1 to -0.5 SD	44	-0.524	0.586	-0.692	0.532	-0.536	0.619	-0.534	0.767	-0.157	0.727
-0.5 to 0.5 SD	86	0.074	0.496	-0.063	0.768	-0.15	0.598	-0.056	0.696	-0.044	0.771

0.5 to 1 SD	32	0.673	0.333	0.841	0.32	0.767	0.695	0.332	0.446	-0.016	0.589
> 1 SD	51	0.894	0.297	1.011	0.458	0.956	0.743	1.129	0.54	0.48	1.011

Note: Standardised slope-based z-scores; higher values = worsening trends.

Table 8: Opportunity Gaps Index - Quadrant summary statistics

Quadrant	N	Static Mean	Static SD	Dynamic Mean	Dynamic SD
Sustained opportunities	58	-0.556	0.398	-0.636	0.469
Decreasing opportunities	93	-0.691	0.348	0.902	0.464
Improving opportunities	72	0.974	0.795	-0.884	0.694
Persistent lack of opportunities	24	1.1	0.959	0.695	0.734

Note: Static = 2024 position; Dynamic = 2014–2024 trend. Higher values = greater vulnerability.

Annex 3: Summary statistics for static and dynamic indices - TSI

Table 9: Transitioning Sectors Index - Static indicator profiles by class (2014)

Cl.	N	Agr. Mean	Agr. SD	Manuf. Mean	Manuf. SD	Jobs Mean	Jobs SD	Div. Index Mean	Div. Index SD	Emp. Vol. Mean	Emp. Vol SD	HRST Mean	HRST SD
< -1SD	21	0.594	0.159	0.862	0.949	0.581	0.955	0.777	0.605	0.26	0.878	0.592	0.848
-1 to -0.5 SD	67	0.476	0.319	0.198	0.88	0.198	0.462	0.56	0.705	0.35	0.515	0.51	0.735
-0.5 to 0.5 SD	109	0.201	0.491	-0.101	0.929	0.065	0.868	-0.099	0.848	0.077	0.974	0.048	0.901
0.5 to 1 SD	18	-0.691	0.967	-0.116	1.078	-0.027	1.493	-0.359	0.941	-0.429	1.031	-0.608	0.719
> 1 SD	32	-1.684	1.507	-0.57	1.047	-1.001	1.298	-1.143	1.053	-0.925	1.291	-1.277	0.709

Note: Standardised z-scores aligned so higher values = greater vulnerability.

Table 10: Transitioning Sectors Index -Static indicator profiles by class (2024)

Cl.	N	Agr. Mean	Agr. SD	Manuf. Mean	Manuf. SD	Jobs Mean	Jobs SD	Div. Index Mean	Div. Index SD	Emp. Vol. Mean	Emp. Vol SD	HRST Mean	HRST SD
< -1SD	35	0.562	0.302	0.75	0.575	0.219	0.723	0.935	0.81	0.148	0.58	1.375	0.623
-1 to -0.5 SD	39	0.439	0.301	0.252	0.674	0.242	0.732	0.073	0.853	0.345	0.591	0.605	0.382
-0.5 to 0.5 SD	110	0.183	0.61	-0.134	0.862	0.022	0.711	-0.11	0.786	0.166	0.646	-0.039	0.591
0.5 to 1 SD	23	-0.423	0.87	-0.287	1.136	-0.591	1.314	0.255	0.84	-0.104	0.64	-0.78	0.664
> 1 SD	40	-1.179	1.604	-0.37	1.402	-0.15	1.616	-0.732	1.221	-0.861	1.815	-1.238	0.777

Note: Standardised z-scores aligned so higher values = greater vulnerability.

Table 11: Transitioning Sectors Index -Dynamic indicator profiles by class

Cl.	N	Agr. Mean	Agr. SD	Manuf. Mean	Manuf. SD	Jobs Mean	Jobs SD	Div. Index Mean	Div. Index SD	Emp. Vol. Mean	Emp. Vol SD	HRST Mean	HRST SD
< -1SD	28	-1.192	1.748	-0.116	0.873	-1.226	1.25	-1.18	1.271	-0.807	0.974	-1.078	1.007
-1 to -0.5 SD	30	-0.2	0.891	-0.37	1.004	-0.337	0.945	-0.631	1.068	-0.01	1.149	-0.547	1.055
-0.5 to 0.5 SD	119	0.145	0.701	-0.121	0.956	0.154	0.818	0.203	0.696	-0.096	0.828	-0.063	0.799
0.5 to 1 SD	41	0.201	0.589	0.363	0.991	0.39	0.811	0.275	0.668	0.206	0.855	0.534	0.649
> 1 SD	29	0.478	0.775	0.477	1.052	0.35	0.72	0.569	0.962	0.891	0.997	1.11	0.41

Note: Standardised slope-based z-scores; higher values = worsening trends.

Table 12: Transitioning Sectors Index - Quadrant summary statistics

Quadrant	N	Static Mean	Static SD	Dynamic Mean	Dynamic SD
Sustained adaptability	56	-0.953	0.66	-0.811	0.76
Lacking adaptability	71	-0.588	0.387	0.439	0.299
Emerging adaptability	51	0.757	0.711	-0.873	0.987
Facing multiple transitions	69	0.819	0.722	0.851	0.54

Note: Static = 2024 position; Dynamic = 2014–2024 trend. Higher values = greater vulnerability.

Annex 4: Summary statistics for static and dynamic indices - LBI

Table 13: Overall Left-Behind Index - Sub-index profiles by class (2014)

Class	N	LBPI Mean	LBPI SD	OGI Mean	OGI SD	TSI Mean	TSI SD
< - 1SD	31	-1.527	0.559	-1.094	0.327	-0.82	0.334
-1 to -0.5 SD	60	-0.706	0.342	-0.811	0.363	-0.376	0.434
-0.5 to 0.5 SD	84	0.061	0.472	0.033	0.495	-0.324	0.516
0.5 to 1 SD	26	0.962	0.375	0.482	0.412	0.339	0.678
> 1 SD	46	1.295	0.3	1.462	0.809	1.442	1.167

Note: Standardised z-scores of each sub-index; higher values = greater vulnerability.

Table 14: Overall Left-Behind Index - Sub-index profiles by class (2024)

Class	N	LBPI Mean	LBPI SD	OGI Mean	OGI SD	TSI Mean	TSI SD
< - 1SD	28	-1.696	0.731	-0.833	0.513	-1.448	0.561
-1 to -0.5 SD	57	-0.655	0.322	-0.785	0.281	-0.391	0.525
-0.5 to 0.5 SD	94	0.101	0.457	-0.147	0.49	-0.065	0.672
0.5 to 1 SD	31	0.755	0.357	0.536	0.499	0.54	0.668
> 1 SD	37	1.404	0.413	1.763	0.821	1.41	0.671

Note: Standardised z-scores of each sub-index; higher values = greater vulnerability.

Table 15: Overall Left-Behind Index - Dynamic sub-index profiles by class

Class	N	LBPI dyn Mean	LBPI dyn SD	OGI dyn Mean	OGI dyn SD	TSI dyn Mean	TSI dyn SD
< - 1SD	34	-1.415	1.743	-1.184	0.808	-1.204	0.908
-1 to -0.5 SD	37	-0.274	0.651	-0.698	0.848	-0.634	0.953
-0.5 to 0.5 SD	89	0.129	0.463	-0.143	0.597	0.248	0.693
0.5 to 1 SD	52	0.348	0.395	0.705	0.621	0.462	0.968
> 1 SD	35	0.819	0.21	1.203	0.322	0.522	0.414

Note: Standardised slope-based z-scores; higher values = worsening trends.

Table 16: Overall Left-Behind Index - Quadrant summary statistics

Quadrant	N	Static Mean	Static SD	Dynamic Mean	Dynamic SD
Low risk of becoming left-behind	39	-0.845	0.602	-1.22	1.136
At risk of becoming left-behind	93	-0.702	0.425	0.791	0.409
Improving left-behind	62	0.876	0.594	-0.786	0.453
Persistent left-behind	53	0.829	0.837	0.43	0.302

Note: Static = 2024 position; Dynamic = 2014–2024 trend. Higher values = greater vulnerability.

Annex 5: 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 Platanias	https://www.platanias.gr/en/	

Annex 6: 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 inequal 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 Platanias). 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.