

# Skill Resilience — 4EU

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

**D2.1 – Indicators for transition pathways**



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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
COVID-19	Coronavirus pandemic
DTRI	Digital Transition Resilience Index
EQI	European Quality of Government Index
EU	European Union
EV	Electric Vehicle
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
GFCF	Gross Fixed Capital Formation
GHG	Greenhouse Gas
GTRI	Green Transition Resilience Index
HRST	Human Resources in Science and Technology
ICT	Information and Communication Technologies
JRC	Joint Research Centre (European Commission)
KIS	Knowledge-Intensive Services
LQ	Location Quotient
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
SECI	Socio-Economic Change Index
WP	Work Package
z-score	Standardised value expressed in standard deviation units relative to the mean

## Glossary

Term	Definition used or meaning in the Acronym project	Reference or source for the definition if applicable
Digital transition resilience	The capacity of regions to sustain and adapt digital infrastructure, usage, and innovation in response to technological change, supporting long-term economic and labour-market adjustment	
Green transition resilience	The capacity of regions to manage decarbonisation pressures and environmental change while sustaining economic activity and labour-market stability through structural adaptation and investment.	
Socio-Economic Change Index	A composite indicator capturing medium-term regional adjustment dynamics across economic structure, labour markets, investment, and innovation-related performance	

## Executive Summary

This deliverable develops and applies a macro-level framework to assess how European regions prepare for and implement the green and digital transitions under different structural, socio-economic, and governance conditions. Rather than treating the twin transition as a uniform or purely technological process, we adopt an evolutionary resilience perspective, emphasising that transition outcomes depend on inherited economic structures, medium-term adjustment dynamics, and institutional context.

The analysis focuses on NUTS 2 regions across the EU, Norway, and Switzerland over the period 2014–2020, reflecting the latest interval for which harmonised NUTS 2 time series are available across all green, digital, socio-economic, and governance indicators, ensuring cross-domain comparability and robust estimation of medium-term dynamics, while avoiding post-2020 structural breaks associated with the COVID-19 and energy shock. It integrates level-based indicators capturing transition conditions at specific points in time with slope-based indicators capturing the direction and pace of medium-term change. Green and digital transitions are analysed separately through dedicated composite indices - the Green Transition Resilience Index (GTRI) and the Digital Transition Resilience Index (DTRI) - and then examined jointly to identify patterns of alignment, asymmetry, and lock-in. Socio-economic restructuring dynamics are summarised through the Socio-Economic Change Index (SECI), while governance quality is incorporated as a contextual factor using the European Quality of Government Index (EQI).

Several main findings emerge from the analysis.

First, both green and digital transition conditions display strong spatial differentiation and persistence over time. Regions with favourable initial positions tend to retain their relative advantage, while regions starting from weaker positions often remain constrained. Movement within the European distribution is generally gradual rather than convergent, pointing to the role of path dependence and cumulative processes in shaping transition capacity.

Second, green and digital transitions follow partially distinct spatial logics. Green transition resilience is strongly shaped by inherited production structures and sectoral exposure, with green infrastructure acting as a key differentiating factor at the upper end of the distribution. Digital transition resilience, by contrast, is more tightly constrained by digital access and, in particular, digital use. Regions with weak digital use remain persistently disadvantaged even where infrastructure gaps are less pronounced, suggesting higher entry barriers and stronger cumulative effects in the digital domain.

Third, the dynamic analysis reveals that relative catch-up is possible but uneven. Several regions in Central and Eastern Europe display above-average transition dynamics - particularly for the green transition and, in some cases, for digital access and use - despite weaker initial conditions. At the same time, many regions in Northern and Western Europe exhibit greater inertia, reflecting consolidation rather than decline. These patterns underline the importance of distinguishing between transition positions and transition trajectories.

Fourth, crossing transition positioning with socio-economic dynamics reveals widespread divergence. While a subset of regions combines favourable green or digital transition positioning with strong socio-economic adjustment, a large share displays decoupled patterns. In several cases, relatively favourable green positioning coexists with weaker recent socio-economic dynamics, while in others, above-average socio-economic dynamics are not mirrored in comparable transition positioning. Importantly, green transition appears more closely related to

socio-economic characteristics, whereas digital transition aligns more systematically with governance quality. Regions combining favourable digital positioning and socio-economic dynamics tend to exhibit higher EQI values, while socio-economic momentum alone is less consistently associated with digital outcomes. Overall, this points to differentiated conditioning of green and digital transitions across regions.

Taken together, the findings challenge assumptions of automatic convergence and highlight the risks of dominant one-size-fits-all transition strategies. The twin transition unfolds through differentiated pathways shaped by structural exposure, adjustment dynamics, and governance capacity. From a policy perspective, this underscores the need for place-sensitive approaches that recognise sequencing effects, address structural bottlenecks, and align transition investments with labour-market dynamics and institutional capacity. The framework developed in this deliverable provides a macro-level foundation for linking transition contexts to skills demand, labour-market adjustment, and social resilience, and directly informs subsequent project work on micro-level outcomes and policy design.

## Table of Contents

<b>1</b>	<b>Introduction .....</b>	<b>11</b>
1.1	Purpose of the document .....	12
1.2	Intended readership .....	13
1.3	Structure of the document .....	13
1.4	Relationship with other deliverables .....	13
<b>2</b>	<b>Methodology, methods, and data .....</b>	<b>15</b>
2.1	Analytical approach and resilience perspective .....	15
2.2	Data sources, spatial coverage, and time frame .....	15
2.3	Construction of level-based indices (initial transition conditions).....	16
2.4	Construction of dynamic (slope-based) indices .....	18
	To capture transition resilience trajectories, dynamic indices are constructed using region-specific linear trends estimated for each indicator over the analysis period:.....	18
2.5	Socio-Economic Change Index (SECI) and Governance context.....	18
2.6	Twin Transition mapping.....	19
2.7	Summary.....	20
<b>3</b>	<b>Results .....</b>	<b>21</b>
3.1	Green Transition Resilience Index in 2014 & 2020 .....	21
3.2	Green transition resilience dynamics .....	24
3.3	Digital transition resilience index in 2014 & 2020.....	25
3.4	Digital Transition Resilience dynamics .....	28
3.5	Twin transition spatial patterns: balance, asymmetry, and lock-in.....	29
3.6	Green transition & socio-economic dynamics: alignment and decoupling.....	32
3.7	Digital transition & socio-economic dynamics: alignment and decoupling.....	34
3.8	Governance as a conditioning factor -EQI .....	36
<b>4</b>	<b>Conclusions .....</b>	<b>42</b>
4.1	Main results and interpretations.....	42
4.2	Limitations and future work.....	44
<b>5</b>	<b>References .....</b>	<b>45</b>
	<b>Annex 1: Green Transition Resilience Index (GTRI): subdimensions and indicators – candidate indicators .....</b>	<b>48</b>
	<b>Annex 2: Digital Transition Resilience Index (DTRI): subdimensions and indicators – candidate indicators .....</b>	<b>49</b>
	<b>Annex 3: Socio-Economic Change Index subdimensions and indicators – candidate indicators.....</b>	<b>49</b>
	<b>Annex 4: Socio-Economic Change Index subdimensions and indicators – retained indicators</b>	<b>50</b>
	<b>Annex 5: GTRI 2014– dimensions: decarbonisation pressure-left ; structural sensitivity – middle ; green infrastructure – right) .....</b>	<b>51</b>

<b>Annex 6: GTRI 2020 – dimensions: decarbonisation pressure-left ; structural sensitivity – middle ; green infrastructure – right) .....</b>	<b>52</b>
<b>Annex 7: GTRI (dynamics) – dimensions: decarbonisation pressure-left ; structural sensitivity – middle ; green infrastructure – right) .....</b>	<b>53</b>
<b>Annex 8: DTRI 2014 – dimensions (digital infrastructure -left ; digital access – middle ; digital use – right) .....</b>	<b>54</b>
<b>Annex 9: DTRI 2020 – dimensions (digital infrastructure -left ; digital access – middle ; digital use – right) .....</b>	<b>55</b>
<b>Annex 10: DTRI (dynamics)– dimensions (digital infrastructure -left ; digital access – middle ; digital use – right).....</b>	<b>56</b>
<b>Annex 2: The Consortium .....</b>	<b>57</b>
<b>Annex 3: Project Summary .....</b>	<b>58</b>

## List of Figures

Figure 1 – Green Transition Resilience Index (GTRI), 2014(left) and 2020 (right) (z-scores) .....	22
Figure 2 – Green Transition Resilience Index (dynamics – slope-based) : Z-score.....	25
Figure 3 –Digital Transition Resilience Index (GTRI), 2014(left) and 2020 (right) (z-scores) .....	27
Figure 4 - Digital Transition Resilience Index (dynamics: slope-based) : Z-score.....	28
Figure 5 – Twin Transition (2020) : quadrant classification.....	30
Figure 6 – Twin Transition (dynamics: slope-based) : quadrant classification .....	31
Figure 7 – Green Transition Resilience and Socio-Economic Dynamics (GTRI × SECI classification) .....	33
Figure 8 - Scatter plot : GTRI and socio-economic dynamics .....	34
Figure 9 - Digital Transition Resilience and Socio-Economic Dynamics (DTRI × SECI classification) .....	35
Figure 10 - Scatter plot: DTRI and socio-economic dynamics .....	36
Figure 11 - Green Transition Resilience and Governance Capacity (GTRI × EQI classification) .....	37
Figure 12 – Digital Transition Resilience and Governance Capacity (DTRI × EQI classification) .....	38
Figure 13 - Scatter plot: (EQI) across GTRI–Socio-Economic Configurations .....	39
Figure 14 - Scatter plot: EQI across DTRI–Socio-Economic Configurations.....	40

## List of Tables

Table 1 - Green Transition Resilience Index (GTRI): subdimensions and indicators – retained indicators.....	17
Table 2 – Digital Transition Resilience Index (DTRI): subdimensions and indicators – retained indicators.....	18
Table 3 – Green Transition Resilience Index (GTRI) by dimension for 2014 – statistics.....	23
Table 4 - Green Transition Resilience Index (GTRI) by dimension for 2020 – statistics.....	23
Table 5: Green Transition Resilience Index (GTRI) by dimension (dynamics : slope-based) – statistics.....	24
Table 6: Digital Transition Resilience Index (DTRI) by dimension for 2014 – statistics .....	26
Table 7: Digital Transition Resilience Index (DTRI) by dimension for 2020 – statistics.....	26

Table 8: Digital Transition Resilience Index (DTRI) by dimension (dynamics : slope-based) – statistics..... 29

## 1 Introduction

Across Europe, regions are having to deal with the interconnected pressures of the green and digital transition. These transformations are not isolated technological shifts, but systemic processes that require key adjustments in socio-economic structures, labour markets, and infrastructure systems, while simultaneously relying on governance systems capable of coordinating long-term transformation. While both transitions are widely recognised as central to Europe’s competitiveness and sustainability objectives (European Commission, 2022a), regions differ in their ability to absorb transition-related pressures, reorient development paths, and sustain socio-economic stability during periods of structural and demographic change.

The twin transition poses distinct yet interrelated challenges. The green transition exposes regions to sectoral and climatic vulnerabilities associated with emission-intensive production and energy systems, industrial specialisation, and exposure to environmental risk (Alves et al., 2018; European Commission, 2020, 2022b; Rodríguez-Pose & Bartalucci, 2023, 2024). The digital transition, by contrast, centres on access to digital infrastructure, patterns of digital use, and the structural presence of digital and knowledge-intensive services and activities (Apostol & Hernández-Rodríguez, 2025; European Commission, 2025). Regional resilience to the twin transition therefore does not depend on strength in a single domain: regions may exhibit advanced green capacities while lagging digitally, or vice versa, resulting in uneven, and in some cases potentially fragile, transition pathways (Binz, Coenen, Murphy, & Truffer, 2020).

These challenges echo longstanding debates on regional adaptability and evolutionary resilience, which emphasise that regional responses to structural change are shaped by pre-existing socio-economic configurations, innovation capacity, and institutional capacities (Boschma, 2015; Rodríguez-Pose, 2020; Simmie & Martin, 2010). The transition towards decarbonisation and digitalisation generates uneven spatial pressures, as regions with more diversified economies, stronger innovation ecosystems, and higher-quality institutions tend to cope more effectively with transition-related shocks and adjustment costs (Álvarez, Barbero, Orea, & Rodríguez-Pose, 2023; Rodríguez-Pose, 2013; Rodríguez-Pose, 2020). At the same time, governance quality and political stability affect the legitimacy and continuity of transition policies, reinforcing evidence that institutional capacity and trust are central to sustaining long-term transformation (Rodríguez-Pose & Ganau, 2022; Rodríguez-Pose, You, & Teirlinck, 2025)

Recent research further highlights that regional resilience emerges from the interaction between structural economic configurations and transition-specific capacities such as technological diffusion, degrees of carbon lock-in, and mobility system readiness, which jointly shape regions’ ability to absorb and reorient transition pressures. These factors shape not only how regions respond to shocks, but also how they reposition themselves within ongoing processes of structural change (Boschma, 2015; Martin & Sunley, 2015; Rizzi, Graziano, & Dallara, 2018; Simmie & Martin, 2010). Building on this literature, we focus on the macro-level determinants of resilience, examining how green and digital transition context, structural economic dynamics, and governance conditions jointly shape regional trajectories in the twin transition. By integrating data on initial transition conditions and dynamic structural change, the framework developed here seeks to explain why some regions advance steadily, while others progress unevenly or become more vulnerable over time.

Capturing these differences requires an analytical perspective that goes beyond indicators of transition outcomes or technological diffusion alone. We therefore zoom into the structural conditions and transition-relevant capacities that shape how regions engage with, and adapt to, the green and digital transitions. Within this framework, resilience is understood as a

multidimensional and evolving configuration of economic structure, sectoral sensitivity, transition-related infrastructure and technological capacity, climate-related exposure, and innovation potential, rather than as something that can be captured through a single dimension.

Thus, throughout the report, we understand resilience in an evolutionary sense, referring to the capacity of regions to absorb transition-related pressures, adapt their green and digital structures, and sustain development trajectories over time rather than to return to a pre-transition equilibrium. Therefore, we do not measure preparedness or vulnerability in isolation, but aim to capture how inherited structures, transition-related capacities, and medium-term adjustment dynamics jointly shape regions' ability to drive and sustain green and digital transformation. In this sense, resilience is conceptualised as a dynamic and path-dependent process, distinct from static notions of readiness or exposure.

Accordingly, we adopt an evolutionary twin-transition resilience perspective, linking transition trajectories with socio-economic dynamics and governance quality. Rather than ranking regions along a single performance axis, it identifies distinct transition pathways that reflect how green and digital change unfolds and becomes embedded or constrained within wider processes of socio-economic transformation and governance quality.

## **1.1 Purpose of the document**

The purpose of this document is to provide a systematic, macro-level assessment of how European regions handle the green and digital transitions under different structural, socio-economic, and institutional environments. Building on an evolutionary resilience perspective (Boschma, 2015; Folke et al., 2010; Simmie & Martin, 2010), the report moves beyond static comparisons of transition outcomes to examine how initial transition conditions and dynamic change trajectories interact to shape regional pathways in the twin transition.

The framework defines the relevant dimensions, indicators, and composite indices used to analyse macro-level resilience trajectories across European regions between 2014 and 2020. By integrating composite measures of green and digital transition conditions with indicators of socio-economic dynamics and institutional quality, the report seeks to explain why some regions appear to race ahead, while others progress unevenly or are left behind over time.

In doing so, the document aims to:

- I. identify inequalities in the green and digital transition contexts across European regions;
- II. assess how these conditions relate to underlying socio-economic dynamics and governance conditions;
- III. provide a basis for more place-sensitive interpretations of the twin transition.

The findings support EU-level policy debates on cohesion, resilience, and the territorial impacts of climate and digital strategies by examining how regional labour markets respond to the twin transition, how technological and sustainability transformations reshape skills demand across regions, and how reskilling and upskilling pathways can reduce spatially uneven labour-market mismatches.

## 1.2 Intended readership

This document is intended for readers with an interest in the territorial dimensions of the green and digital transitions and in the analysis of regional economic and labour-market change in Europe. It is primarily addressed to policy analysts, researchers, and practitioners working at European, national, and regional levels who require a structured analytical framework to examine how regions respond to transition-related pressures affecting employment, skills demand, and sectoral structures.

The report is designed to be relevant for users involved in the analysis and monitoring of cohesion, climate, digital, and labour-market policies, as well as for those concerned with longer-term structural adjustment. By providing comparable indicators and a dynamic perspective on transition trajectories, the analysis supports evidence-based interpretation of how different regions experience and adapt to the twin transition.

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 transition-related structural conditions and dynamics across European regions.

## 1.3 Structure of the document

The report is organised into the following sections:

- the conceptual and methodological framing of macro-resilience;
- the definition and operationalisation of indicator domains;
- the construction of composite indices;
- the identification of regional transition pathways;
- conclusions and next steps.

## 1.4 Relationship with other deliverables

This document contributes to the macro-level analysis of the project and is designed to support and connect with several other work packages. In particular, it complements the transition matrix developed in WP1. While WP1 identifies how regions and sectors are positioned in terms of green and digital skills and employment, this report provides the macro-level framework needed to interpret why these positions differ.

The analysis also provides an input to WP2.2, which focuses on social and labour-market resilience at the micro level. By identifying differentiated macro-level transition contexts within different socio-economic dynamics and governance capacities, the report helps explain the broader conditions under which skills demand, labour-market adjustment, and social vulnerability are likely to vary across regions.

Additionally, it informs subsequent work in WP3 and WP4, which focus on skills, occupations, and labour-market adjustment in the context of the twin transition. By identifying different resilience contexts and trajectories, this report helps frame the broader economic and labour-market environments within which green and digital employment shifts and skills-related changes take place.

Specifically, the regional typologies identified in this report act as a sampling frame for WP3. By categorising regions into distinct resilience profiles (e.g., 'Locked-in' vs. 'Balanced'), D2.1 enables

WP3 to select representative case studies. This ensures that the subsequent qualitative analysis of skills mismatches covers a diverse range of structural contexts, rather than focusing solely on high-performing regions.

More broadly, the framework and indicators developed here contribute to the project's integrated analytical architecture by linking outcome-oriented mapping (WP1) with process-oriented explanations (WP2), and by informing later synthesis and policy-oriented work packages. In this way, the report supports cross-WP coherence by ensuring that analyses of skills, labour markets, and policy responses are grounded in a coherent understanding of regional transition trajectories and underlying structural conditions.

## **2 Methodology, methods, and data**

### **2.1 Analytical approach and resilience perspective**

The analysis adopts an evolutionary resilience perspective, conceptualising regional economies as systems exposed to environmental and technological pressures associated with the twin transition. Within this perspective, resilience is understood as the capacity of regions to adjust, reconfigure, and redirect economic structures over time in response to transition-related pressures, rather than as the ability to return to a prior equilibrium (Martin, 2012; Boschma, 2015). Rather than treating resilience as a static condition or evaluating transition outcomes against predefined benchmarks, we focus on transition trajectories. We distinguish between structural transition conditions, captured through standardised indicator levels at specific points in time, and adjustment dynamics, captured through trend-based measures estimated over the study period. This distinction reflects the insight that regions may reach similar observed positions through different and potentially uneven or path-dependent adjustment processes (Boschma and Martin, 2010; Martin and Sunley, 2015).

This perspective is particularly relevant in the context of the twin transition, where environmental and technological change interacts with existing production structures and labour-market configurations. Socio-economic characteristics and governance conditions are also considered as contextual factors that shape the conditions under which resilience unfolds, without being treated as primary drivers of transition outcomes. By combining static indicators with trend-based measures of change, the analysis captures not only where regions stand at given points in time, but also the pace and stability of their adjustment trajectories.

Building on this perspective, the empirical strategy operationalises resilience in the green and digital transitions through a set of standardised indicators capturing structural transition conditions, trend-based dynamics, and selected contextual socio-economic and governance characteristics.

### **2.2 Data sources, spatial coverage, and time frame**

The analysis is conducted at the NUTS 2 level, which provides an appropriate balance between policy relevance, data availability, and sensitivity to territorial heterogeneity. A comprehensive review of European regional datasets was undertaken, drawing primarily on Eurostat, ARDECO, OECD, and Joint Research Centre (JRC) sources. Indicators were retained only where sufficient temporal continuity and spatial coverage were available across EU Member States, as well as Norway and Switzerland, following established practices in European regional analysis (OECD and Joint Research Centre - European Commission 2008; Eurostat, 2025). Indicators that did not meet minimum requirements in terms of time coverage or regional availability were excluded.

The retained indicators were subsequently grouped into analytical domains reflecting the green transition, the digital transition, and the broader socio-economic context relevant for regional labour-market adjustment and structural change. Institutional context was captured separately using the European Quality of Government Index (EQI), which was treated as a standalone contextual indicator rather than integrated into a composite governance dimension.

The final indicator set was designed to support a dual analytical objective: capturing structural transition conditions at given points in time and capturing resilience dynamics through trend-

based measures, allowing medium-term transition trajectories to be analysed rather than relying solely on static snapshots.

The analysis covers the period 2014 to 2020, reflecting the longest interval for which sufficiently consistent regional time series are available across most indicators. This period captures medium-term transition dynamics prior to the disruptions associated with the COVID-19 pandemic, providing a stable basis for analysing structural transition conditions and resilience trajectories.

All indicators were harmonised to a consistent regional framework based on the NUTS 2021 classification to ensure spatial and temporal comparability over the study period. Where regional boundaries changed over time, standard population-weighted and proportionate allocation procedures were applied, in line with Eurostat and OECD guidance on regional data reconstruction, to maintain continuity across successive NUTS versions (OECD and Joint Research Centre - European Commission 2008; Eurostat, 2025a). These adjustments were applied uniformly and do not affect the comparative interpretation of regional transition conditions or trend-based dynamics. For greenhouse gas emissions, regional data at the NUTS 2 level are not available for Norway and Switzerland. In these cases, national emissions data were allocated to NUTS 2 regions using GDP-based weights, reflecting differences in regional economic activity and following approaches commonly adopted in regional environmental accounting, in line with observed relationships between economic output and greenhouse gas emissions (Janssens-Maenhout et al., 2019). This affected around 5% of the regional sample. Similarly, for a limited number of countries, patent data and selected indicators of digital infrastructure and digital use were not available at the NUTS 2 level. In these cases, national values were assigned uniformly to the corresponding NUTS 2 regions. The share of affected observations is higher for these indicators, reflecting well-documented limitations in the territorial disaggregation of digital and innovation statistics across Europe (Eurostat, 2025b), and amounted to around one fifth of region-year observations. While this approach reduces within-country variation for the affected indicators, it ensures completeness of the regional dataset and preserves cross-country comparability, particularly given the subsequent use of standardisation and slope-based, trend-oriented analysis.

### 2.3 Construction of level-based indices (initial transition conditions)

For each analytical domain, level-based indices were constructed to capture relative transition conditions at a given point in time. All indicators were standardised as z-scores across regions for each year of analysis, ensuring cross-regional comparability and eliminating scale differences. Indicator directions were aligned so that higher values consistently represent more favourable transition conditions, while lower values indicate greater structural vulnerability or constraint.

Composite level indices were calculated as the unweighted mean of the standardised indicators, applying equal weighting across components:

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

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

The **Green Transition Resilience Index (GTRI)** integrates three subdimensions:

- a. **Decarbonisation pressure** reflects exposure to carbon-intensive production by combining inverse measures of greenhouse gas intensity in industry, energy, and overall production;
- b. **Structural sensitivity** captures exposure to carbon- and climate-sensitive activities, measured through inverse indicators of the share of gross value added and employment in agriculture and manufacturing.
- c. **Green infrastructure** captures transition-related infrastructure support through indicators of public transport availability, electric vehicle uptake, and green patents per 1 mil population.

*Table 1 - Green Transition Resilience Index (GTRI): subdimensions and indicators – retained indicators*

SUBDIMENSION	ASPECT OF RESILIENCE	INDICATORS	REFERENCES
1. DECARBONISATION PRESSURE	vulnerability from decarbonisation pressures- and resource-intensive activities	GHG intensity(total); industrial emission share; energy-sector emission share;	(Guarascio, Reljic, & Zezza, 2025; McDowall, Reinauer, Fragkos, Miedzinski, & Cronin, 2023; Rodríguez-Pose & Bartalucci, 2023, 2024)
2. STRUCTURAL SENSITIVITY	Exposure of regional production systems to carbon- and climate-sensitive activities	Agriculture employment share; agriculture value added share; manufacturing employment share;	(Bourdin & Perrot, 2025; Rodríguez-Pose & Bartalucci, 2023, 2024)
4. GREEN INFRASTRUCTURE	Transition-supporting infrastructure, mobility systems, and innovation capacity enabling decarbonisation	EV share; number of bus/population; Green patents per 1000000 inhabitants.	(D'Amato et al., 2024; Romero-Goyeneche, Boschma, & Li, 2025; Tao, 2024)

The **Digital Transition Resilience Index (DTRI)** also integrates three subdimensions:

- a. **Digital infrastructure** combines indicators reflecting the economic and innovation base of digital activities, including the share of value added in ICT and non-ICT knowledge-intensive services, investment rates in ICT and non-ICT KIS sectors, and digital patents per 1 million inhabitants;
- b. **Digital access** captures household connectivity and access to digital infrastructure, measured through broadband access and internet availability at home;
- c. **Digital use** reflects the functional adoption of digital technologies by public authorities and individuals, measured through indicators of e-government use, internet banking, and online selling.

Table 2 – Digital Transition Resilience Index (DTRI): subdimensions and indicators – retained indicators

SUBDIMENSION	ASPECT OF RESILIENCE	INDICATORS	REFERENCES
1. DIGITAL INFRASTRUCTURE	Economic and innovation base of digital activities	ICT employment share; ICT value added share; KIS nonICT employment share; KIS nonICT value added share; ICT + AI patents per 100000 inhabitants;	(European Commission, 2021; Ivanová & Grmanová, 2023; Stankovic, Marjanovic, Drezgic, & Popovic, 2021)
2. DIGITAL ACCESS	Household connectivity and access to digital infrastructure	Broadband access (% of households); internet access at home (% of households)	(Burinskienė, Seržantė, Burinskienė, & Seržantė, 2022; European Commission, 2021; Ivanová & Grmanová, 2023; Stankovic et al., 2021; Trusina & Jermolajeva, 2022)
3. DIGITAL USE	Extent of digital adoption and participation by individuals and firms	Internet banking (% of individuals); Submitting forms online (e-government completion); Internet use for selling goods/services;	(Burinskienė et al., 2022; European Commission, 2021; Grinberga-Zalite & Hernik, 2019; Stankovic et al., 2021)

## 2.4 Construction of dynamic (slope-based) indices

To capture transition resilience trajectories, dynamic indices are constructed using region-specific linear trends estimated for each indicator over the analysis period:

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

where :

$X_{r,t}$  represents the value of the indicator for region  $r$  in year  $t$

$\alpha_r$  represents region-specific intercept (constant)

$\beta_r$  represents the slope coefficient (trend over time) for region  $r$ .

$year_t$  represents the year variable

$\varepsilon_{r,t}$  represents the residual term (error)

Estimated slopes were standardised using z-scores and aligned so that positive values reflect favourable transition momentum. Dynamic composite indices for the GTRI and DTRI were calculated as the unweighted mean of the adjusted, standardised slopes, following the same indicator structure as the level-based indices.

This approach allows the analysis to distinguish between regional positions at specific points in time and the underlying pace and direction of change.

## 2.5 Socio-Economic Change Index (SECI) and Governance context

The socio-economic medium-term adjustment dynamics are synthesised through the SECI.

SECI captures four subdimensions (see Annex 5):

- a. **Economic structure and specialisation** captures the structural vulnerability or flexibility of regional production systems, combining indicators of industrial specialisation and knowledge-intensive services specialisation, both measured using location quotients (LQ), together with economic diversification measured using the inverse Herfindahl–Hirschman Index;
- b. **Investment intensity** reflects the capacity of regions to finance and sustain structural change, measured through investment rates for the total economy as well as for industry and knowledge-intensive services;
- c. **Employment dynamics** captures adaptive labour-market resilience and sectoral reallocation processes, measured through net job growth, net employment reallocation between knowledge-intensive and traditional sectors, and employment volatility;
- d. **Efficiency and innovation** reflects productivity and transformative capacity through innovation, measured using labour productivity and number of total patents per 1 million population.

Together, these components reflect the extent to which regional economies are diversified, investment-active, capable of reallocating labour, and able to generate productivity and innovation outcomes relevant for longer-term transition resilience.

Governance conditions are captured using the European Quality of Government Index (EQI), developed by the Quality of Government Institute (QoG), University of Gothenburg. EQI is treated as a contextual indicator, being used to interpret variation in regional transition trajectories and resilience contexts identified through the GTRI and DTRI.

Building on this, level-based measures of the GTRI and DTRI in 2020 are cross-analysed with SECI dynamics using a quadrant-based classification framework. In this classification, regions are considered “above” or “below” average based on whether their index values lie above or below the European mean for the respective dimension. For GTRI and DTRI, “above” indicates relatively stronger green or digital transition conditions in 2020, while “below” indicates comparatively weaker positioning. For SECI dynamics, “above” reflects stronger-than-average socio-economic adjustment momentum over the study period, whereas “below” indicates weaker or lagging adjustment dynamics. Crossing these thresholds yields four analytically distinct contexts, distinguishing regions where green and digital transition positions are supported by socio-economic adjustment dynamics from those where transition outcomes appear decoupled from, or unsupported by, underlying structural change.

Finally, mean and median values of EQI (2021) are calculated for the resulting classes, providing additional contextual insight into the governance conditions associated with different combinations of transition positioning and socio-economic dynamics.

## 2.6 Twin Transition mapping

The twin transition is examined by analysing green and digital transition contexts in parallel, rather than collapsing them into a single index. This approach recognises that the two transitions may advance at different speeds and along different trajectories across regions. Therefore, green and digital transitions are treated as distinct but interrelated processes whose alignment, imbalance, or sequencing varies across regions and over time. Analysing them jointly preserves these differences and avoids masking asymmetric transition pathways.

The empirical strategy therefore considers the GTRI and the DTRI simultaneously, using crossed level-based and trend-based measures. This approach allows regions to be characterised

according to their combined transition position and transition momentum, distinguishing between convergence, divergence, and uneven adjustment trajectories.

To operationalise this joint analysis of green and digital transitions, regions are classified using a quadrant-based framework that crosses the GTRI and the DTRI. Quadrants are defined relative to the European average, such that regions are classified as above or below average along each transition dimension. While mean-based thresholds are sensitive to the underlying distribution and may be influenced by extreme values, their use is deliberate in this context. The European average provides a common, policy-relevant reference point that enables consistent comparison across regions and over time, and aligns with the objective of identifying relative positioning within the overall European transition landscape rather than establishing absolute performance benchmarks

This approach distinguishes four broad twin transition contexts: regions performing above average in both green and digital transitions; regions performing above average in only one of the two dimensions; and regions performing below average in both. The same classification logic is applied to both level-based indices and trend-based measures, allowing the analysis to capture not only combined transition positions at a given point in time, but also relative transition momentum.

The quadrant framework provides a transparent and non-normative way to identify patterns of alignment, decoupling, and cumulative disadvantage between green and digital transitions, while preserving the distinct contribution of each dimension.

## **2.7 Summary**

The analysis applies an evolutionary resilience perspective to examine how European regions have managed the green and digital transitions over the period 2014–2020. It combines NUTS 2 regional data from multiple European sources with a structured indicator framework capturing green, digital, socio-economic, and governance contexts. Indicators are standardised and aggregated into level-based indices reflecting transition conditions at specific points in time, and into slope-based indices capturing medium-term transition dynamics.

Green and digital transitions are operationalised through separate composite indices (GTRI and DTRI), each structured around theoretically grounded subdimensions, while socio-economic adjustment dynamics are summarised through the Socio-Economic Change Index (SECI). Governance quality is incorporated as contextual information using the European Quality of Government Index (EQI). Joint analysis of green and digital transitions is conducted using quadrant-based classifications based on European average thresholds, allowing the identification of alignment, and decoupling between green and digital transitions and underlying socio-economic dynamics. Together, this approach provides a coherent and comparable framework for analysing regional transition trajectories and resilience patterns across Europe.

### 3 Results

This section presents the spatial patterns of green and digital transition resilience using European-relative z-score maps, comparing regional positions at the beginning and end of the observation period (2014 and 2020) and examining dynamic change over time, with classes defined by fixed standard deviation thresholds to ensure comparability across years and dimensions. The analysis focuses on how regions' relative positions within the European distribution evolve, highlighting patterns of persistence, convergence, divergence, and imbalance across transition dimensions.

Rather than evaluating absolute performance or applying fixed benchmarks, all results are interpreted relative to the European distribution. Consistent with evolutionary and place-based perspectives, the emphasis is on relative positioning, joint transition contexts, and transition trajectories, rather than on static typologies or convergence outcomes (Boschma, 2015; Folke et al., 2010; Gunderson, 2012; Simmie & Martin, 2010)

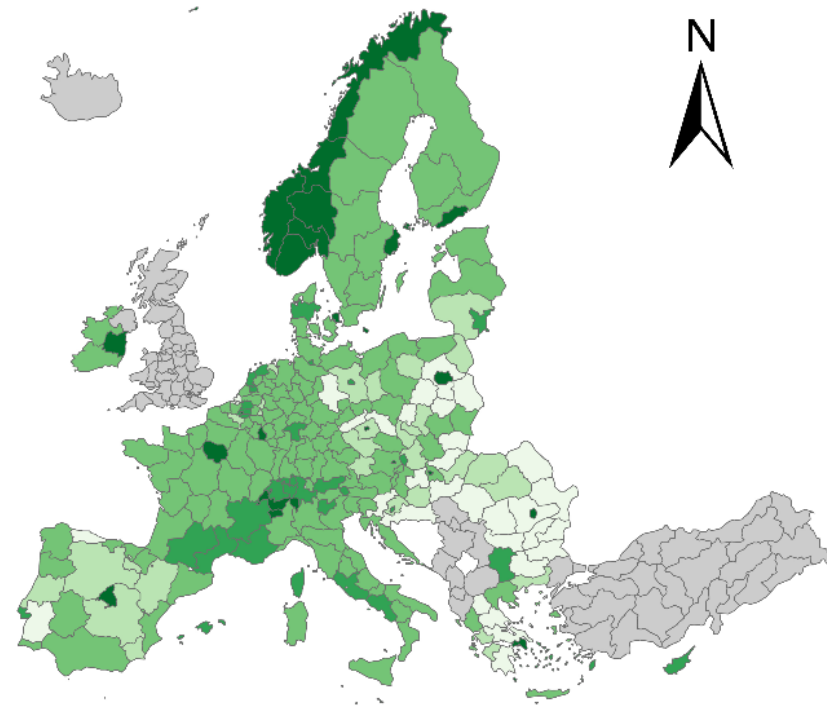
#### 3.1 Green Transition Resilience Index in 2014 & 2020

The level-based GTRI maps show key spatial differences in green transition conditions across Europe between 2014 and 2020. Importantly, because the index is expressed as European-relative z-scores, the results describe how regions are positioned within the European distribution at each point in time, rather than providing an absolute assessment of “performance”. The maps therefore highlight relative strengths and constraints in green transition conditions, and how these positions evolve over the period.

These spatial patterns are underpinned by systematic differences across the three GTRI components - decarbonisation pressure, structural sensitivity, and green infrastructure, which together shape the overall distribution of green transition resilience. In 2014, higher GTRI values were concentrated in a set of Northern and Western European regions, including several capital and metropolitan areas, alongside multiple Norwegian regions. These spatial patterns pointed to a concentration of relatively favourable green transition conditions in regions combining stronger green infrastructure with lower relative exposure to carbon- and climate-sensitive activities.

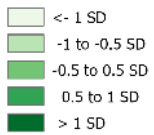
Lower GTRI values in 2014 were more prevalent in parts of Southern and South-Eastern, as well as Central and Eastern Europe. These regions exhibited negative z-scores in both decarbonisation pressure and structural sensitivity dimensions, indicating high exposure to carbon-intensive production structures and climate-sensitive activities. By contrast, green infrastructure in this class was close to the European average, suggesting that green transition resilience positioning at the lower end of the distribution was driven primarily by structural and production-related constraints rather than by infrastructure deficits alone.

Regions clustered around the European mean displayed neutral values in decarbonisation pressure and structural sensitivity dimensions, but negative green infrastructure z-scores. This suggests that for a large share of regions, green transition conditions were constrained less by carbon exposure than by weaker green infrastructure and innovation-related capacities, denoting a structural bottleneck that limits upward movement within the green transition (Rodríguez-Pose & Bartalucci, 2023, 2024).

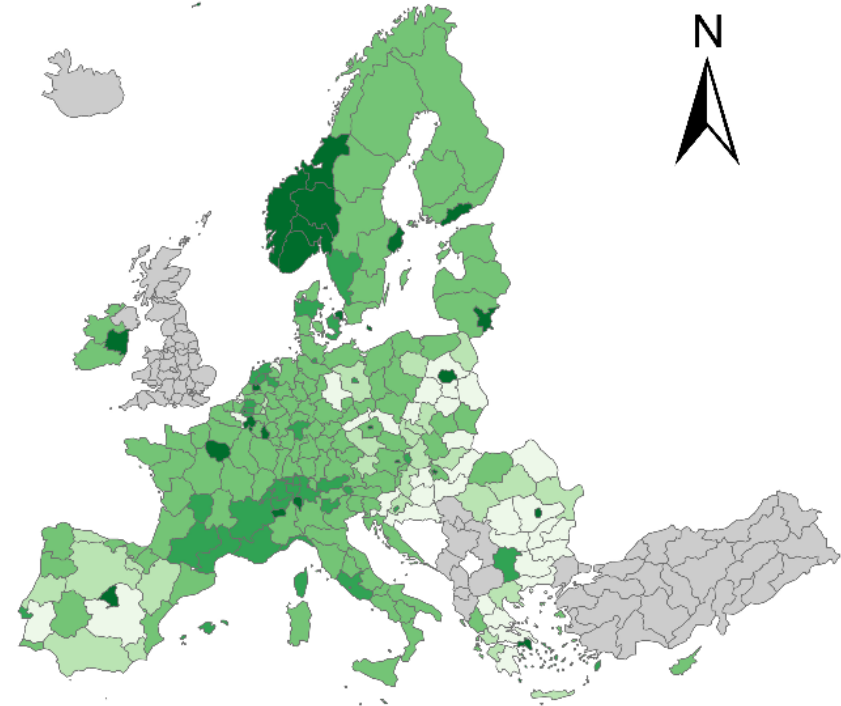
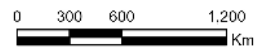


**Legend**

Green Transition Resilience Index (2014)

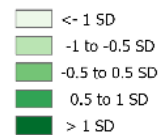


\*Z-scores standardised to mean = 0, SD = 1 across all regions



**Legend**

Green Transition Resilience Index (2020)



\*Z-scores standardised to mean = 0, SD = 1 across all regions

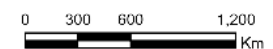


Figure 1 – Green Transition Resilience Index (GTRI), 2014(left) and 2020 (right) (z-scores)

Table 3 – Green Transition Resilience Index (GTRI) by dimension for 2014 – statistics

Class	N	Decarbonisation pressure		Structural sensitivity		Green infrastructure	
		Mean	Median	Mean	Median	Mean	Median
< -1 SD	31	-1.41	-1.16	-1.21	-1.29	0.03	-0.02
-1 to -0.5 SD	28	-0.29	-0.19	-0.57	-0.60	-0.23	-0.25
-0.5 to 0.5 SD	129	0.18	0.28	0.08	0.10	-0.21	-0.30
0.5 to 1 SD	34	0.50	0.56	0.65	0.63	-0.04	-0.08
> 1 SD	27	0.46	0.57	0.80	0.90	1.29	0.49

By 2020, many of these relative positions persisted, indicating a degree of path dependence in green transition conditions over the analysed period. Regions that were positioned above or below the mean in 2014 frequently remained on the same side of the distribution in 2020. At the same time, the comparison highlights selective shifts in relative positioning, with some regions moving closer to or further away from the mean as structural adjustments accumulated over time. As a result, movement within the distribution tended to be gradual and uneven, rather than reflecting broad-based convergence.

Regions in the lowest class again showed strong negative values for decarbonisation pressure and structural sensitivity dimensions, with green infrastructure remaining slightly below average. Similarly, regions in the highest class continued to combine positive scores across all three components, with particularly strong green infrastructure and structural sensitivity dimensions. The persistence of these profiles suggests that relative green transition advantage and disadvantage are not short-term outcomes but reflect deeply embedded structural and infrastructural conditions (Alves et al., 2018; Doukas et al., 2020; Grillitsch & Hansen, 2019; Rodríguez-Pose & Bartalucci, 2023, 2024).

Taken together, the component statistics confirm that green transition resilience across Europe is shaped by a combination of inherited production structures, sectoral exposure, and transition-supporting infrastructure, with green infrastructure emerging as a key differentiating factor at the upper end of the distribution. The coexistence of persistence and reordering suggests that green transition resilience is shaped by both inherited structural conditions and medium-term adaptive processes, in line with evolutionary interpretations of regional transformation (Boschma, 2015; Doukas et al., 2020; Folke et al., 2010).

Table 4 - Green Transition Resilience Index (GTRI) by dimension for 2020 – statistics

Class	N	Decarbonisation pressure		Structural sensitivity		Green infrastructure	
		Mean	Median	Mean	Median	Mean	Median
< -1 SD	33	-1.50	-1.25	-1.09	-1.10	-0.09	-0.10

-1 to -0.5 SD	26	-0.29	-0.15	-0.59	-0.73	-0.24	-0.28
-0.5 to 0.5 SD	126	0.20	0.26	0.06	0.08	-0.19	-0.30
0.5 to 1 SD	37	0.51	0.57	0.60	0.58	-0.05	-0.09
> 1 SD	27	0.49	0.68	0.84	0.91	1.16	0.50

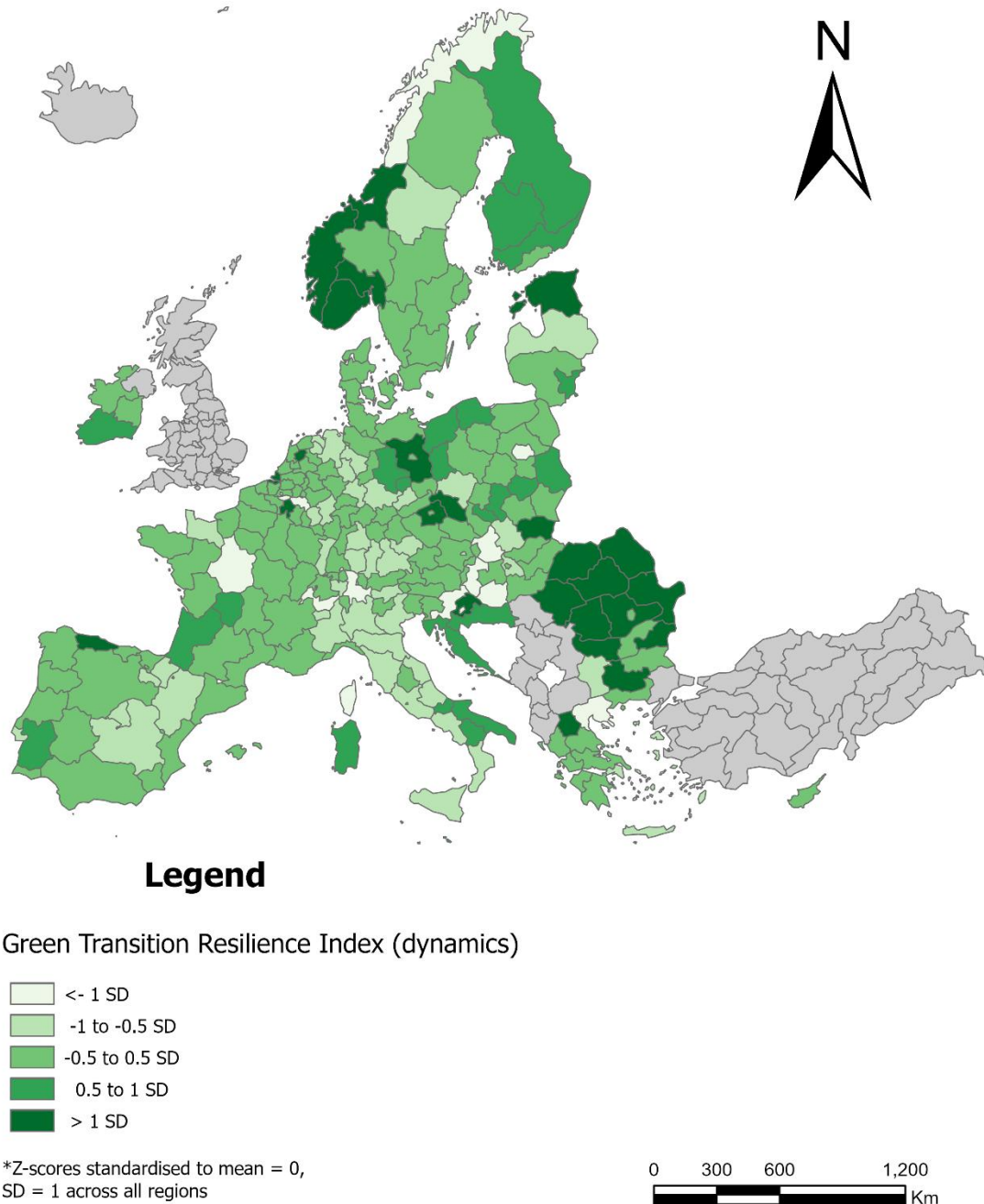
### 3.2 Green transition resilience dynamics

The dynamic GTRI highlights where green transition conditions strengthened or weakened over the study period, relative to the European average pattern of change. In most regions, dynamics remained close to the European average, indicating incremental change rather than sharp shifts. However, several regions stand out for more pronounced upward or downward trajectories. A cluster of positive dynamics is visible across several regions in Central and Eastern Europe, notably in Romania, Bulgaria, and Poland, suggesting catch-up processes linked to investment, structural adjustment, or targeted policy intervention. Component-level statistics indicate that these upward trajectories were typically underpinned by concurrent improvements in decarbonisation capacity and green infrastructure, rather than by change in a single dimension. This suggests that measurable progress in green transition resilience tends to reflect cumulative adjustment across multiple structural channels.

At the same time, the map highlights regions with weaker or declining trajectories over the study period, including several capital and metropolitan regions. In a number of these cases, lower trend values coexisted with relatively strong green transition conditions at the beginning of the period, pointing to slower adjustment or consolidation effects. This pattern resonates with findings from the scholarly literature, which emphasise that adaptive capacity and adjustment trajectories are not solely determined by starting conditions, but are shaped by policy choices, institutional contexts, and the sequencing of structural change (Barbieri et al., 2023; Rodríguez-Pose & Bartalucci, 2023).

*Table 5: Green Transition Resilience Index (GTRI) by dimension (dynamics : slope-based) – statistics*

Class	N	Decarbonisation pressure		Structural sensitivity		Green infrastructure	
		Mean	Median	Mean	Median	Mean	Median
< -1 SD	16	-0.43	-0.37	-0.64	-0.59	-0.73	-0.48
-1 to -0.5 SD	51	-0.37	-0.39	-0.29	-0.32	-0.13	-0.13
-0.5 to 0.5 SD	133	-0.09	-0.16	0.03	-0.01	-0.03	-0.03
0.5 to 1 SD	24	0.47	0.54	0.24	0.21	0.10	0.11
> 1 SD	25	1.05	0.51	0.57	0.42	0.77	0.35



*Figure 2 – Green Transition Resilience Index (dynamics – slope-based) : Z-score*

### 3.3 Digital transition resilience index in 2014 & 2020

The static DTRI provides a snapshot of regional digital transition resilience in 2014 and 2020, revealing persistent spatial inequalities and only limited reordering over time. In both years, a large share of regions clustered around the European mean, indicating that for many territories digital conditions shifted through incremental change rather than step changes. At the upper end of the distribution, strong digital transition conditions remained concentrated in Northern and Western Europe, including multiple Dutch, German regions, and Nordic regions, and a number of capitals. The component profiles further show that “high” digital positioning can be reached through different configurations: in some regions it reflected broadly balanced performance

across digital structure, access, and use, while in others high overall scores were driven mainly by very strong digital access and/or use alongside more average structural conditions.

At the lower end of the distribution, regions exhibited consistently limited digital transition capabilities in both 2014 and 2020. The class averages show that these regions are not only structurally weaker, but are particularly disadvantaged in digital access and, most strongly, in digital use. In both years, mean and median values for digital use are substantially below the European average, and the gap relative to higher-performing classes remains pronounced in 2020. While digital infrastructure deficits are more moderate and, in some cases, closer to the European mean, limited access and especially weak use continue to act as binding constraints on overall digital transition resilience.

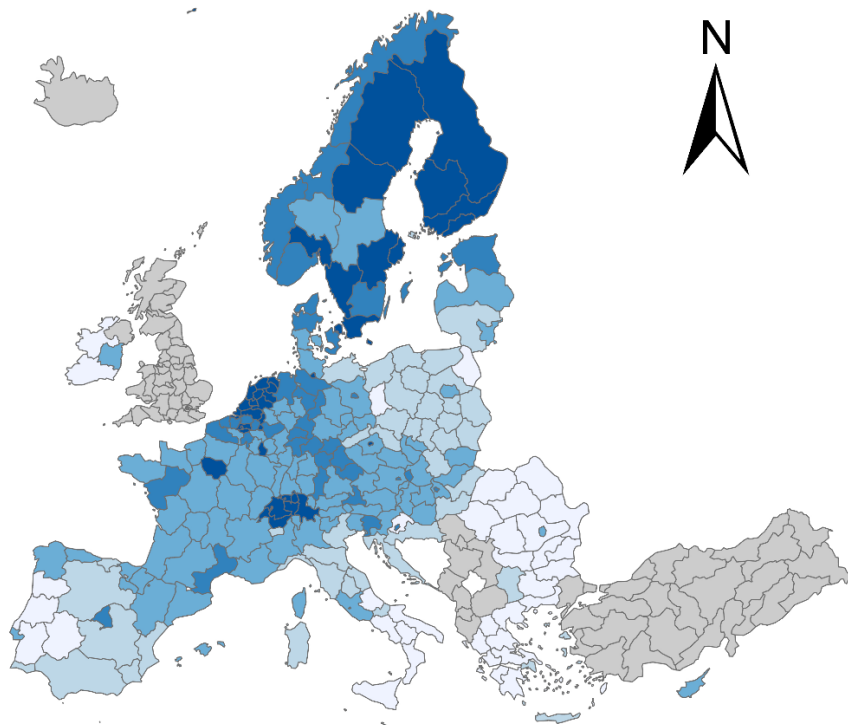
The 2020 snapshot suggests that some regions improved their relative standing, but the overall geography remained shaped by cumulative and path-dependent inequalities rather than broad-based catch-up: regions starting from strong digital conditions largely retained their position, while territories with weaker baselines do not uniformly close the gap. Although the number of regions in the lowest class declines slightly, the average component values suggest persistent relative disadvantages rather than convergence toward the European mean. This is consistent with evidence on the cumulative dynamics of digital development, which tend to reinforce existing regional advantages (Apostol & Hernández-Rodríguez, 2025; European Commission, 2025)

Table 6: Digital Transition Resilience Index (DTRI) by dimension for 2014 – statistics

Class	N	Digital infrastructure		Digital access		Digital use	
		Mean	Median	Mean	Median	Mean	Median
< -1 SD	37	-0.54	-0.47	-0.97	-0.59	-1.17	-1.20
-1 to -0.5 SD	44	-0.43	-0.45	-0.22	-0.26	-0.47	-0.43
-0.5 to 0.5 SD	91	-0.02	-0.04	0.03	0.13	0.08	-0.07
0.5 to 1 SD	39	0.4	0.26	0.38	0.45	0.5	0.44
> 1 SD	38	0.59	0.51	0.71	0.81	1.02	1.09

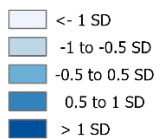
Table 7: Digital Transition Resilience Index (DTRI) by dimension for 2020 – statistics

Class	N	Digital infrastructure		Digital access		Digital use	
		Mean	Median	Mean	Median	Mean	Median
< -1 SD	42	-0.40	-0.39	-1.09	-1.01	-1.13	-1.13
-1 to -0.5 SD	23	-0.45	-0.52	-0.45	-0.25	-0.22	-0.26
-0.5 to 0.5 SD	115	-0.10	-0.08	0.17	0.24	0.07	0.04
0.5 to 1 SD	35	0.4	0.38	0.36	0.53	0.54	0.4
> 1 SD	34	0.66	0.58	0.84	0.92	0.91	1.14

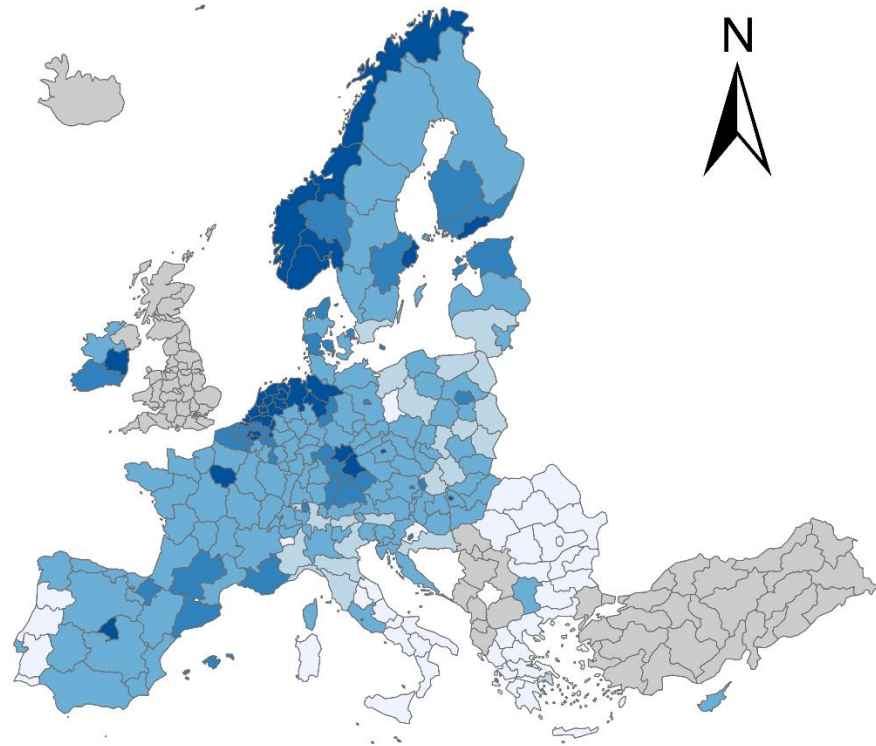
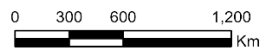


**Legend**

Digital Transition Resilience Index (2014)

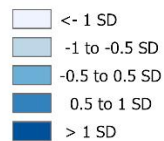


\*Z-scores standardised to mean = 0,  
SD = 1 across all regions



**Legend**

Digital Transition Resilience Index (2020)



\*Z-scores standardised to mean = 0,  
SD = 1 across all regions



Figure 3 – Digital Transition Resilience Index (GTRI), 2014(left) and 2020 (right) (z-scores)

### 3.4 Digital Transition Resilience dynamics

The digital transition resilience dynamics display an uneven spatial pattern. A large share of regions stayed clustered around the European mean, suggesting that for many regions changes have been modest.

Regions with the strongest positive digital dynamics were predominantly found in parts of Central and Eastern Europe, the Iberian Peninsula, and other several peripheral regions. In these cases, relative gains were often driven by rapid improvements in digital access and use, sometimes combined with targeted advances in digital structure. These patterns are consistent with catch-up dynamics, where accelerated uptake and diffusion allow some regions to narrow gaps in specific digital dimensions.

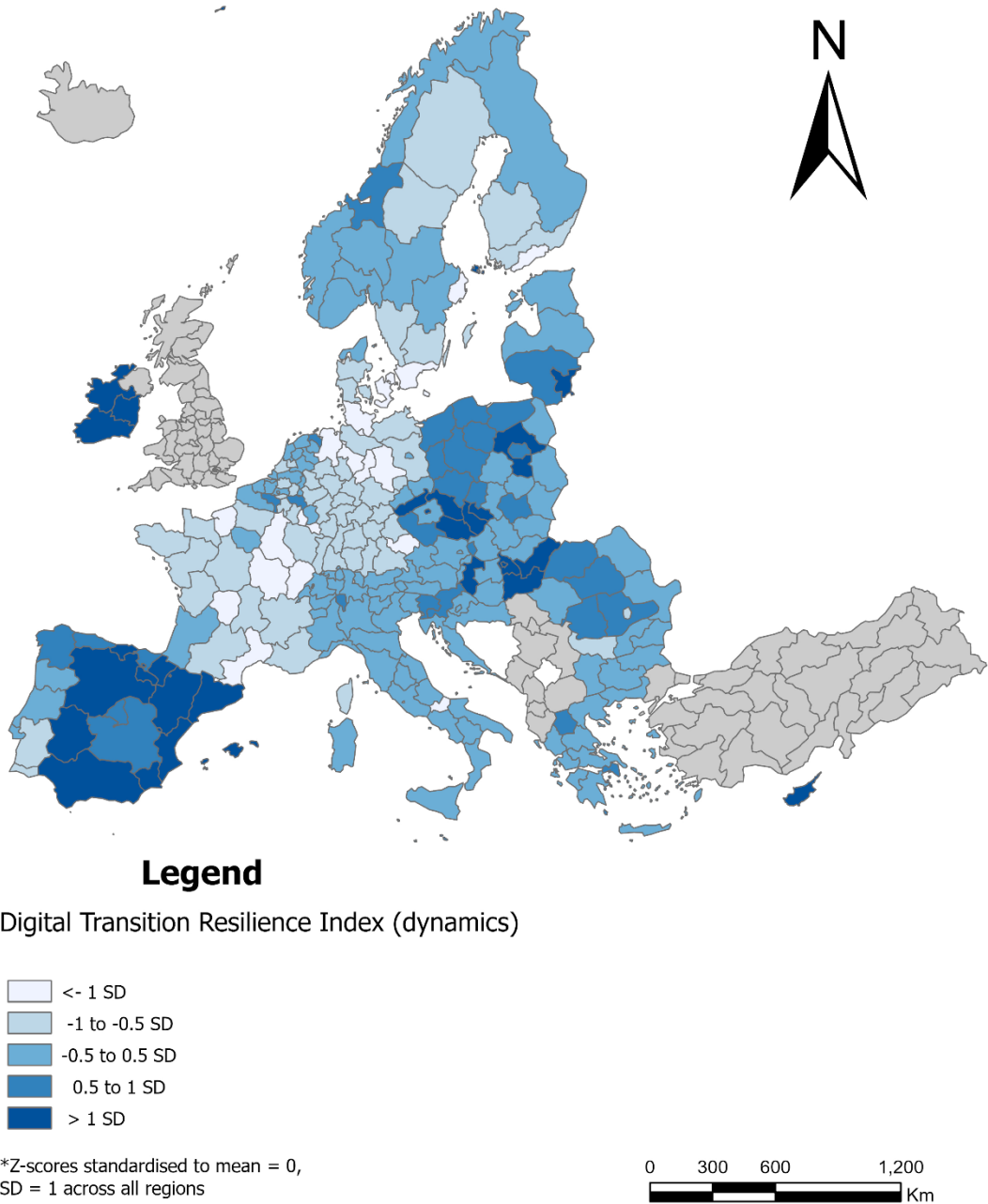


Figure 4 - Digital Transition Resilience Index (dynamics: slope-based) : Z-score

By contrast, several regions in Northern and Western Europe recorded below-average relative dynamics, but in these cases, weaker dynamic scores may reflect consolidation rather than decline, considering their DTRI for 2020.

Taken together, the digital dynamics point to limited convergence across European regions. While relative catch-up is possible, it is uneven and highly selective. The overall geography of digital transition resilience remains strongly influenced by cumulative and path-dependent processes, with existing advantages continuing to shape relative trajectories over time. This pattern is consistent with arguments that digital catch-up faces higher entry barriers than environmental adjustment, particularly in regions lacking strong innovation networks or advanced human capital (Iammarino, Rodríguez-Pose, Storper, & Diemer, 2020).

In fact, compared to green transition dynamics, digital transition dynamics display a more dispersed pattern of relative change across European regions, with a larger proportion of regions located in the extreme classes. This suggests that, in relative terms, green transition dynamics are more evenly distributed across regions, whereas digital transition trajectories are characterised by greater differentiation and polarisation. Indeed, while GTRI dynamics suggest that relative green adjustment is more broadly distributed and supported by incremental change across multiple components, DTRI dynamics are more strongly driven by gains in digital access and use, with weaker-performing regions remaining below the European average despite relatively neutral infrastructure trends. This indicates that digital catch-up is more difficult to achieve and more dependent on cumulative advantages linked to uptake, skills, and effective use rather than physical capacity alone. From a Cohesion Policy perspective, these patterns reinforce the relevance of differentiated, place-based interventions that focus on regions exhibiting persistent divergence from the European average, rather than assuming uniform transition trajectories across territories.

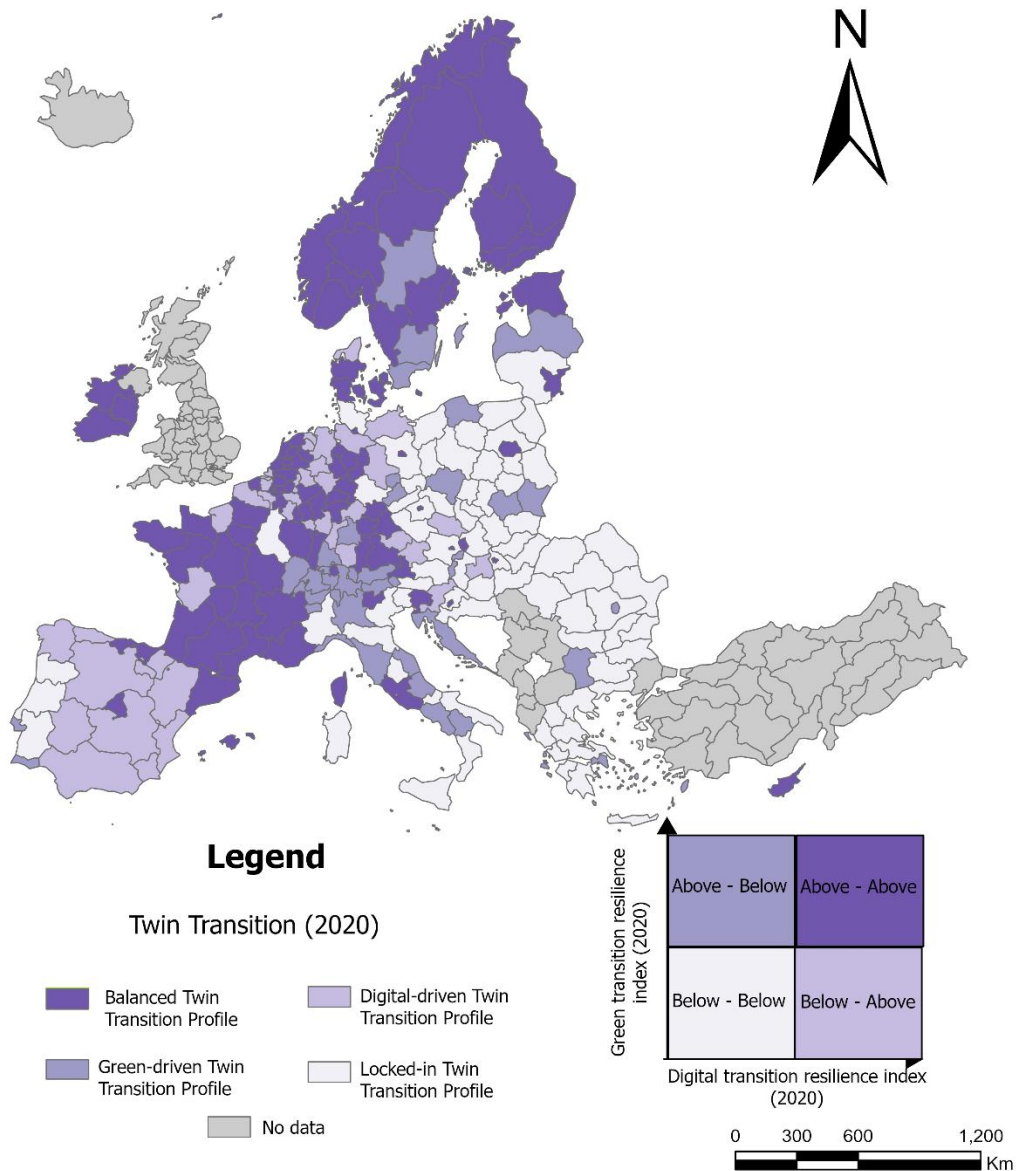
*Table 8: Digital Transition Resilience Index (DTRI) by dimension (dynamics : slope-based) – statistics*

Class	N	Digital infrastructure		Digital access		Digital use	
		Mean	Median	Mean	Median	Mean	Median
< -1 SD	22	-0.17	-0.13	-0.96	-0.87	-0.72	-0.88
-1 to -0.5 SD	57	-0.11	-0.06	-0.53	-0.52	-0.40	-0.47
-0.5 to 0.5 SD	106	-0.02	0.01	-0.02	0.01	-0.04	-0.03
0.5 to 1 SD	32	0.21	0.13	0.58	0.62	0.29	0.39
> 1 SD	32	0.2	0.21	1.16	0.96	1.08	1

### 3.5 Twin transition spatial patterns: balance, asymmetry, and lock-in

The 2020 twin transition classification highlights a differentiated but structured pattern of green–digital resilience across European regions. In this context, balance refers to the internal relationship between green and digital transition conditions within the twin transition, capturing whether the two dimensions evolve symmetrically or diverge within regions. Around 40% of regions fall into the balanced twin transition profile, indicating that green and digital transition conditions are jointly above the European average, co-evolving rather than diverging, reflecting broadly aligned structural conditions. These regions can be interpreted as territories where the twin transition is mutually reinforcing, offering a favourable structural basis for coordinated

climate–digital policy implementation. This is mostly the case for Western, Central and Northern Europe.



*Figure 5 – Twin Transition (2020) : quadrant classification*

At the same time, almost one-third of regions exhibit asymmetric twin transition profiles, split between digital-driven and green-driven configurations. Digital-driven regions are those where digital transition conditions are above the European average while green transition conditions remain below it, whereas green-driven regions display the opposite configuration. In these regions, progress in one transition dimension is not matched by equivalent advancement in the other, indicating partial and potentially fragile transition pathways. This pattern is more frequent in parts of Central- Eastern, and Southern Europe and such asymmetries highlight the risk that sectoral focused or uncoordinated policy interventions may reinforce imbalances rather than support integrated transformation.

Finally, nearly one-third of regions also fall into a locked-in twin transition resilience profile, where both green and digital transition conditions remain below the European average. These territories

face compounded structural constraints across both dimensions, suggesting limited capacity and resources to engage in the twin transition without sustained and targeted support.

Overall, the 2020 snapshot shows that the European Twin Transition landscape is not converging, as numerous regions still experience uneven or constrained twin transition conditions, reinforcing the relevance of differentiated and place-sensitive policy approaches. Moreover, such asymmetries reflect the fact that green and digital transitions operate through partially distinct mechanisms and timescales, even though they are increasingly framed as mutually reinforcing at the policy level (European Commission, 2020). This reinforces the need for territorially sensitive policy approaches that recognise distinct transition starting points and avoid one-size-fits-all strategies in the implementation of the twin transition agenda.

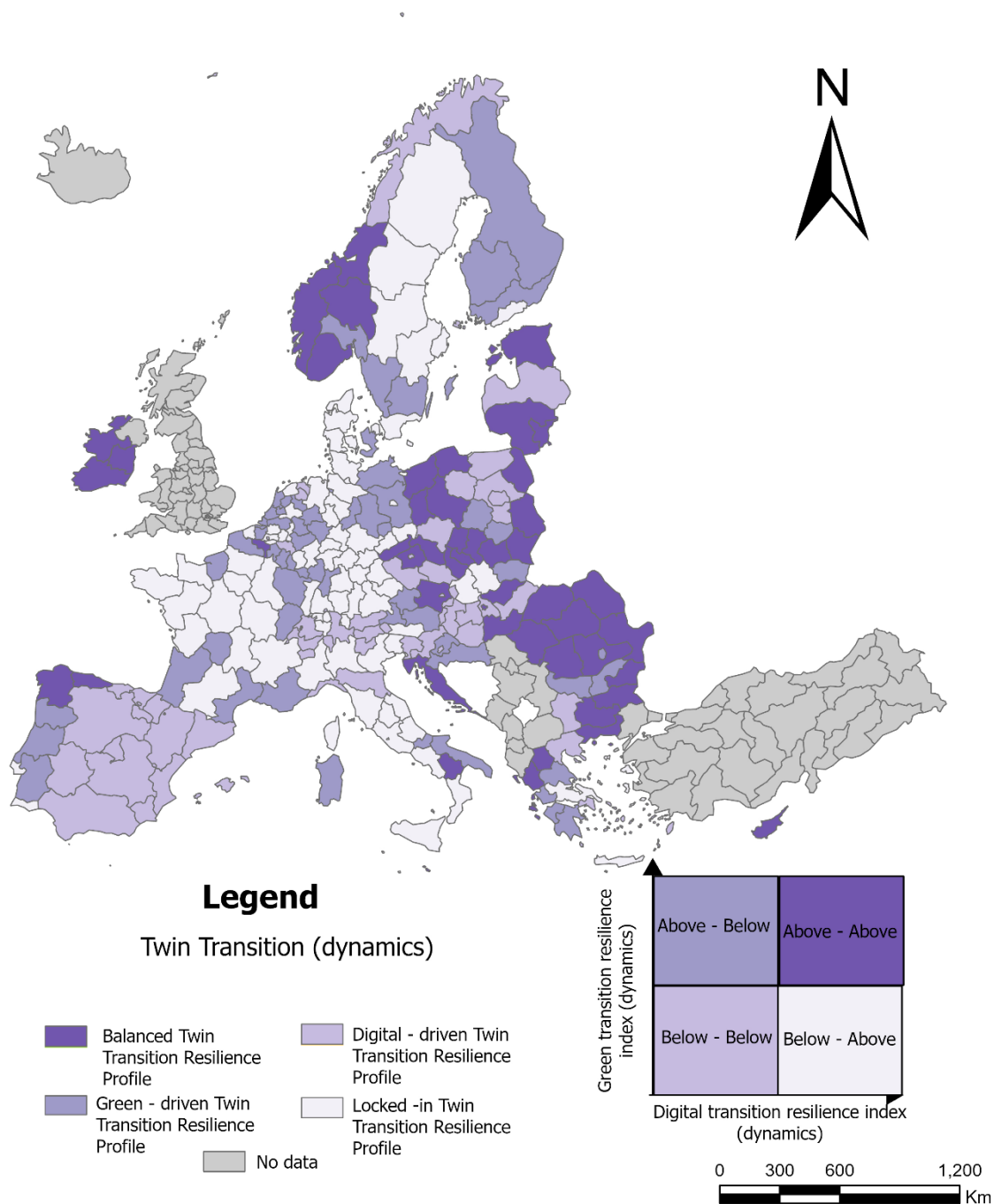


Figure 6 – Twin Transition (dynamics: slope-based) : quadrant classification

The twin transition dynamics map further highlights that regions' current configurations are not always aligned with their adjustment trajectories. Regions with similar positions in 2020 may have followed different paths, while regions with contrasting current positions may exhibit similar dynamics. This reinforces the importance of distinguishing between transition conditions and transition processes, a core insight of evolutionary resilience approaches (Folke et al., 2010; Gunderson, 2012; Simmie & Martin, 2010)

Indeed, several Central and Eastern European regions show above-average dynamics in both green and digital transition, or at least in one of them, highlighting transformative catch-up development. This suggests that several regions starting from less favourable initial positions are nonetheless recording comparatively stronger medium-term adjustment in at least one transition dimension, and in some cases in both. From a cohesion policy perspective, this pattern underscores the importance of supporting transition momentum rather than focusing solely on static levels of transition capacity. Regions exhibiting positive dynamics despite weaker starting conditions represent contexts where targeted investment and institutional support can consolidate emerging trajectories, reduce the risk of renewed divergence, and translate relative catch-up into more durable forms of structural convergence (Diemer, Iammarino, Rodríguez-Pose, & Storper, 2022; European Commission, 2022a).

By contrast, many regions in Northern and Western Europe fall into digital-driven or locked-in profiles. In these cases, twin-transition dynamics appear more inertial: digital momentum is often sustained, but green dynamics are weaker, or both dimensions remain close to the European average without pronounced upward movement. Southern Europe displays a similar pattern of inertia, reflecting limited relative momentum in both dimensions.

Overall, the map suggests that twin-transition dynamics are not simply reproducing the geography of initial conditions. Instead, relative catch-up in parts of Central and Eastern Europe coexists with more stable or consolidating trajectories in large parts of the North and South, underlining the importance of dynamics-based perspectives for understanding how the twin transition is unfolding across Europe.

### **3.6 Green transition & socio-economic dynamics: alignment and decoupling**

Building on the green–digital balance discussed in the previous section, this section examines how green transition resilience relates to broader socio-economic dynamics across regions. The map combining green transition resilience and structural economic dynamics reveals a complex and non-linear relationship between green transition conditions and broader economic restructuring processes. While a substantial share of regions displays reinforcing dynamics, an important proportion also falls into configurations where green transition conditions and socio-economic trajectories diverge or jointly lag behind the European average. Moreover, regions with similar green transition profiles are embedded in different socio-economic contexts, highlighting that green transition resilience does not map straightforwardly onto underlying patterns of socio-economic change. The group of regions where both are reinforcing each other is dominated by capital regions and economically strong territories in Northern and Western Europe, where green transition conditions appear embedded in wider processes of structural adjustment, investment activity, and labour-market dynamism. In these cases, green transition resilience is not an isolated outcome but part of a broader, self-reinforcing development trajectory.

Nevertheless, the map also highlights misalignment between green transition positioning and socio-economic dynamics. A large group of regions exhibits green-driven decoupling, where relatively strong green transition positions coexist with weaker socio-economic dynamics. This

pattern is visible in several advanced metropolitan and industrial regions and suggests that favourable green positioning can be sustained or achieved despite limited recent socio-economic adjustment. Such cases underline that green transition outcomes may reflect accumulated advantages, past investments, or regulatory settings rather than ongoing structural renewal.

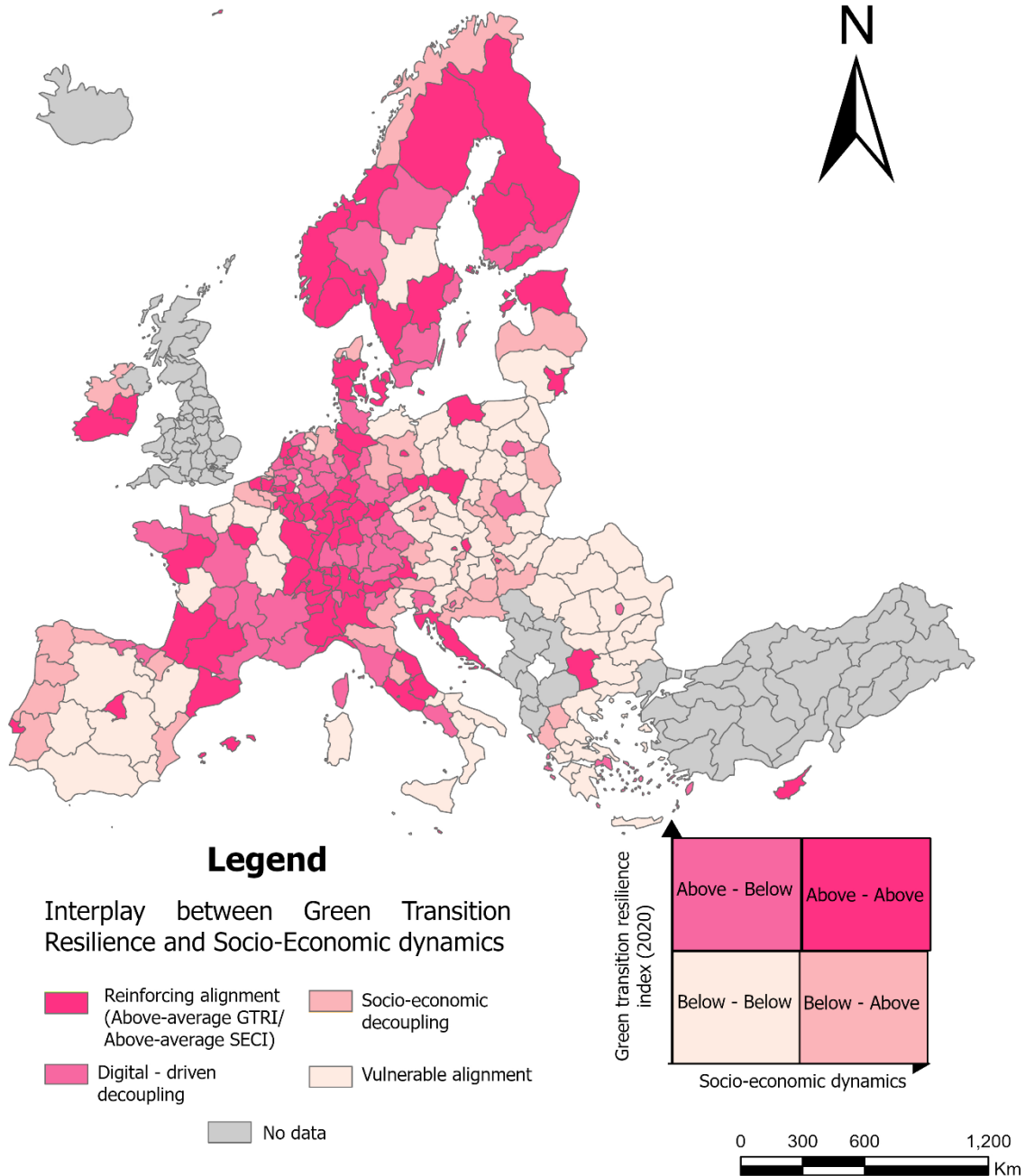


Figure 7 – Green Transition Resilience and Socio-Economic Dynamics (GTRI × SECI classification)

Conversely, another set of regions shows socio-economic decoupling, characterised by above-average socio-economic dynamics but weaker green transition positioning in 2020. These regions, including several in Central and Southern Europe, appear to be undergoing broader economic adjustment without a commensurate strengthening of green transition conditions. This configuration points to potential sequencing effects, where socio-economic restructuring precedes, but does not yet translate into, improved green transition outcomes.

Finally, a large and spatially concentrated group of regions falls into vulnerable alignment, combining below-average green transition resilience with weak socio-economic dynamics. This configuration is particularly prevalent across parts of Central and Eastern Europe and Southern Europe and reflects compounded constraints. Here, weaker green transition conditions are embedded in broader structural and socio-economic challenges, indicating limited capacity to support or absorb transition-related change in the absence of sustained policy intervention (Barbieri et al., 2023; Grillitsch & Hansen, 2019; Rodríguez-Pose & Bartalucci, 2023, 2024).

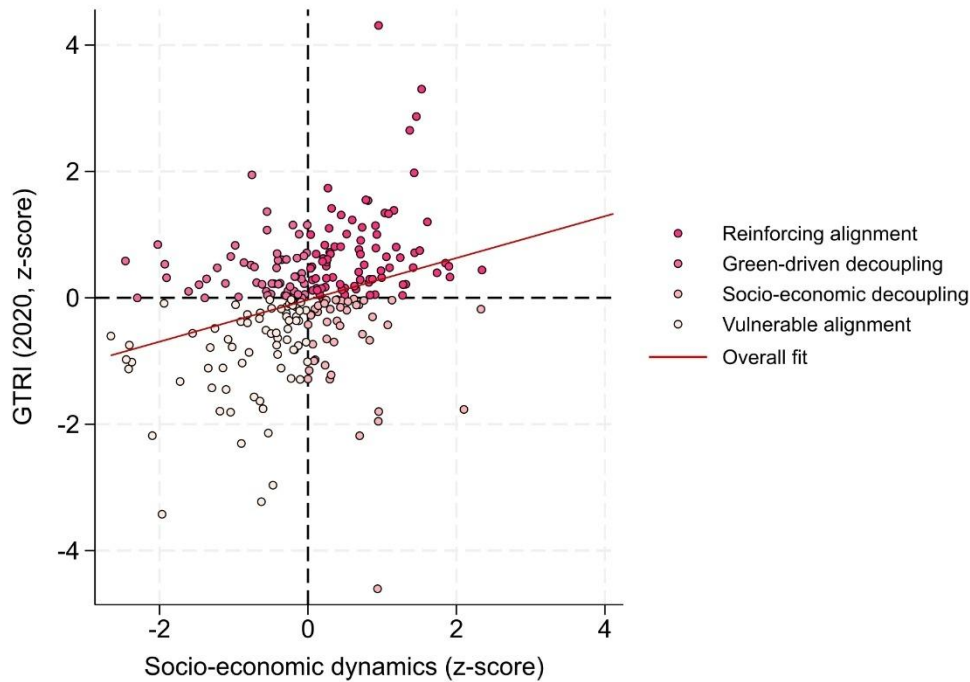


Figure 8 - Scatter plot : GTRI and socio-economic dynamics

Furthermore, the scatter plot confirms that green transition resilience and socio-economic dynamics are only partially aligned across European regions, with a positive but limited association. This pattern highlights that progress in green transition positioning is unevenly coupled with ongoing socio-economic adjustment, resulting in the coexistence of reinforcing trajectories and persistent forms of decoupling. From a policy perspective, this underlines the need for differentiated, place-based approaches: consolidating and scaling up reinforcing dynamics where alignment is already present, while also addressing sequencing gaps and structural bottlenecks in regions where green transition ambitions risk remaining weakly anchored in broader socio-economic change.

### 3.7 Digital transition & socio-economic dynamics: alignment and decoupling

In a similar way to the green transition, the map combining digital transition resilience in 2020 and socio-economic dynamics also highlight heterogeneity in the way digital transition conditions intersect with broader socio-economic dynamics, as in the case of green transition. Approximately one third of regions -spatially concentrated in parts of Northern and Western Europe, including the Nordics, several Dutch and German regions, and a number of capital regions -combine relatively favourable digital transition conditions with socio-economic dynamism, reflecting a closer integration of digital technologies, ICT-related activities, and knowledge-intensive services with productivity growth, investment behaviour, and labour-market

reallocation. A further group of regions from Western Europe display favourable digital conditions but weaker socio-economic adjustment, suggesting that digital infrastructure and adoption do not automatically translate into wider economic restructuring and pointing to limits in spillover.

Conversely, socio-economic decoupling, regions with relatively favourable socio-economic dynamics but weaker digital transition conditions appear in parts of Central and Eastern Europe, suggesting that broader economic or labour-market improvements are not yet also matched by progress in digital capacity.

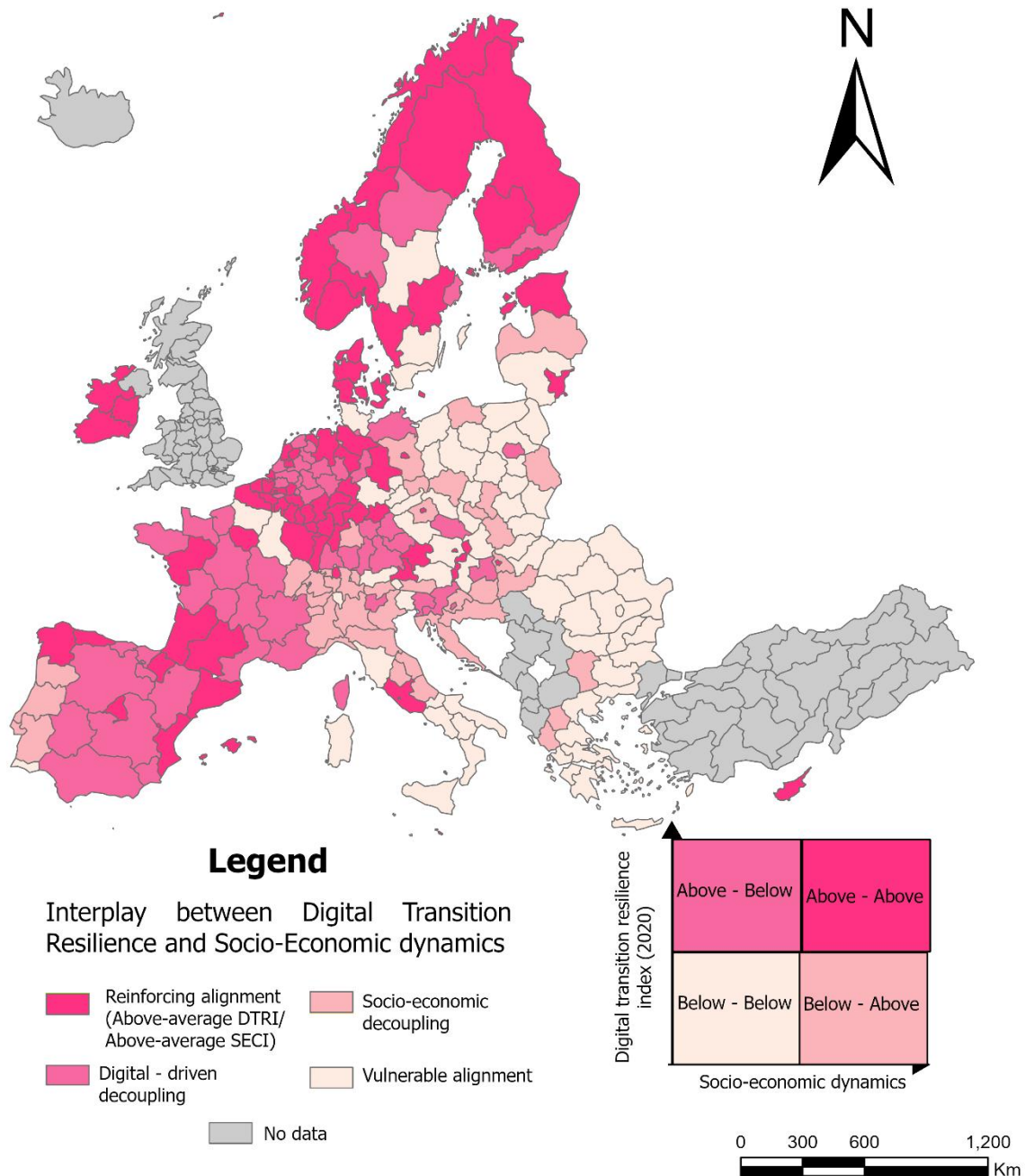


Figure 9 - Digital Transition Resilience and Socio-Economic Dynamics (DTRI × SECI classification)

Finally, there is also an important number of regions which fall into a configuration where both digital transition resilience and socio-economic dynamics are below the European average, being prevalent across large parts of Eastern Europe and in Southern Italy, but also in isolated cases in Northern Italy, France, Germany and Southern Sweden. In these regions, digital transition

challenges are embedded within wider structural constraints, reinforcing cumulative disadvantage.

Overall, the scatter plot shows that digital transition resilience and socio-economic dynamics do not follow a clear or systematic relationship across European regions. Rather than a linear association, the figure points to weak association, indicating that digital transition resilience cannot be read as a direct reflection of contemporary socio-economic change. Instead, it points to weaker and more uneven coupling between digital transition positioning and socio-economic adjustment, with multiple regional pathways observable: in some regions digital transition capacity advances ahead of broader socio-economic change, in others it lags behind, while in a few others the two evolve in parallel. In the context of Cohesion Policy, this underlines the need for integrated and place-based interventions that move beyond digital infrastructure provision alone, and link digital investment with skills development, labour-market inclusion, and complementary policy measures, in order to strengthen the connection between digital transition capacity and broader socio-economic outcomes (Apostol & Hernández-Rodríguez, 2025; European Commission, 2025).

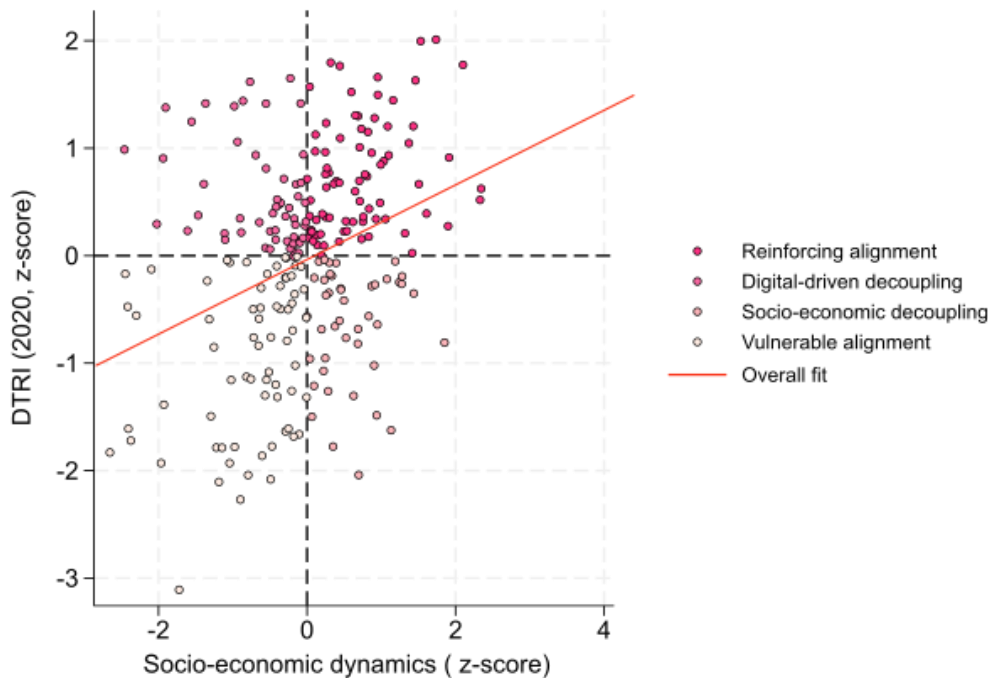


Figure 10 - Scatter plot: DTRI and socio-economic dynamics

### 3.8 Governance as a conditioning factor -EQI

To place the twin transition within the wider institutional environment we first examine the spatial configuration of governance quality (EQI for the year 2021) through bivariate mappings with green and digital transition for 2020. This provides an overview of how institutional quality varies spatially with green and digital transition positioning across regions. Building on this, we then examine EQI across the quadrant classes derived from crossing (i) transition positioning in 2020 (GTRI and DTRI) and (ii) medium-term socio-economic adjustment dynamics. This two-step approach is consistent with the macro-resilience logic of the framework and with evolutionary, place-based perspectives, which emphasise that transition capacity and structural change are mediated by governance capacity rather than being purely socio-economic, technological, or market-driven processes (Boschma, 2015; Rios & Gianmoena, 2020; Simmie & Martin, 2010).

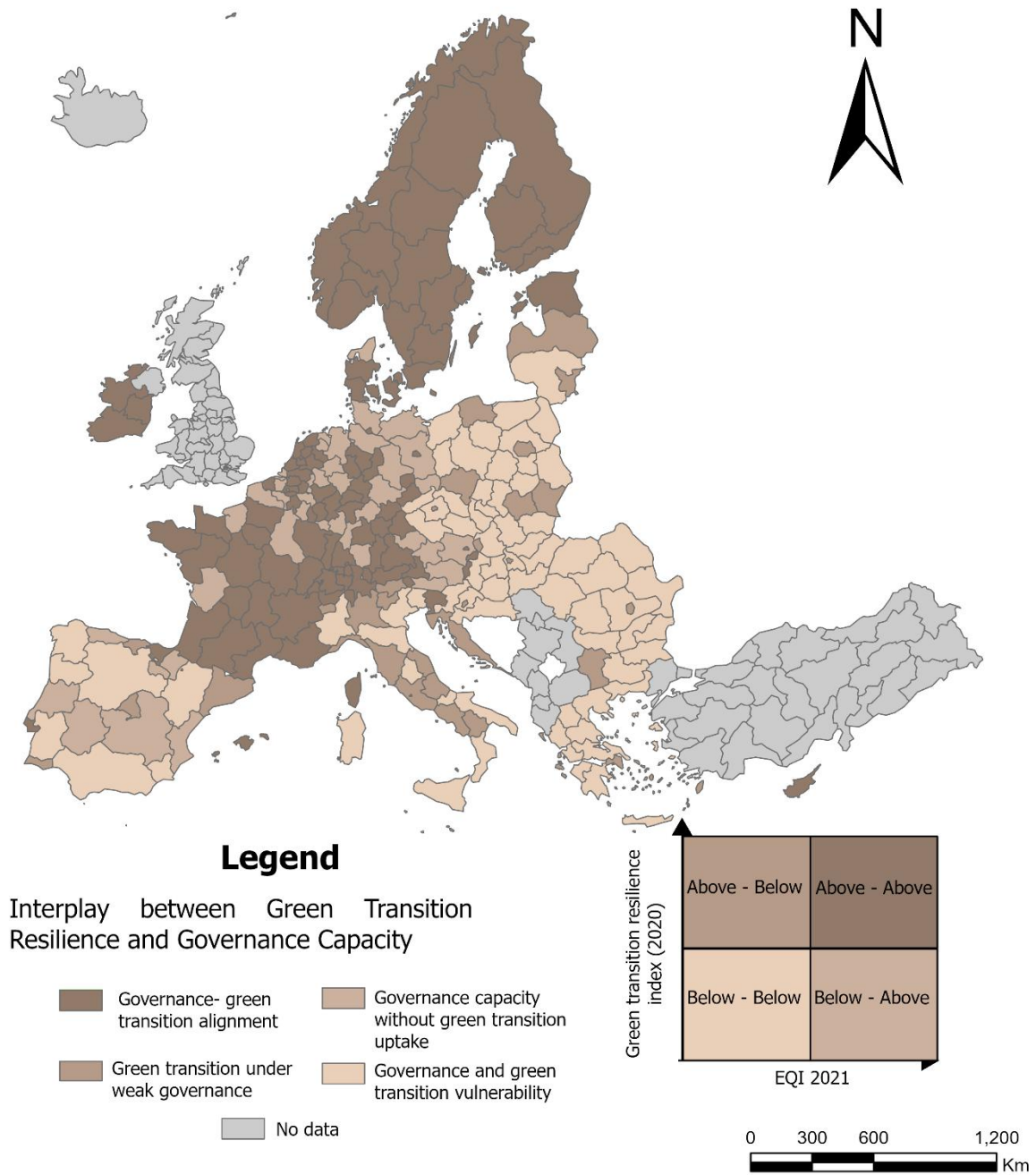
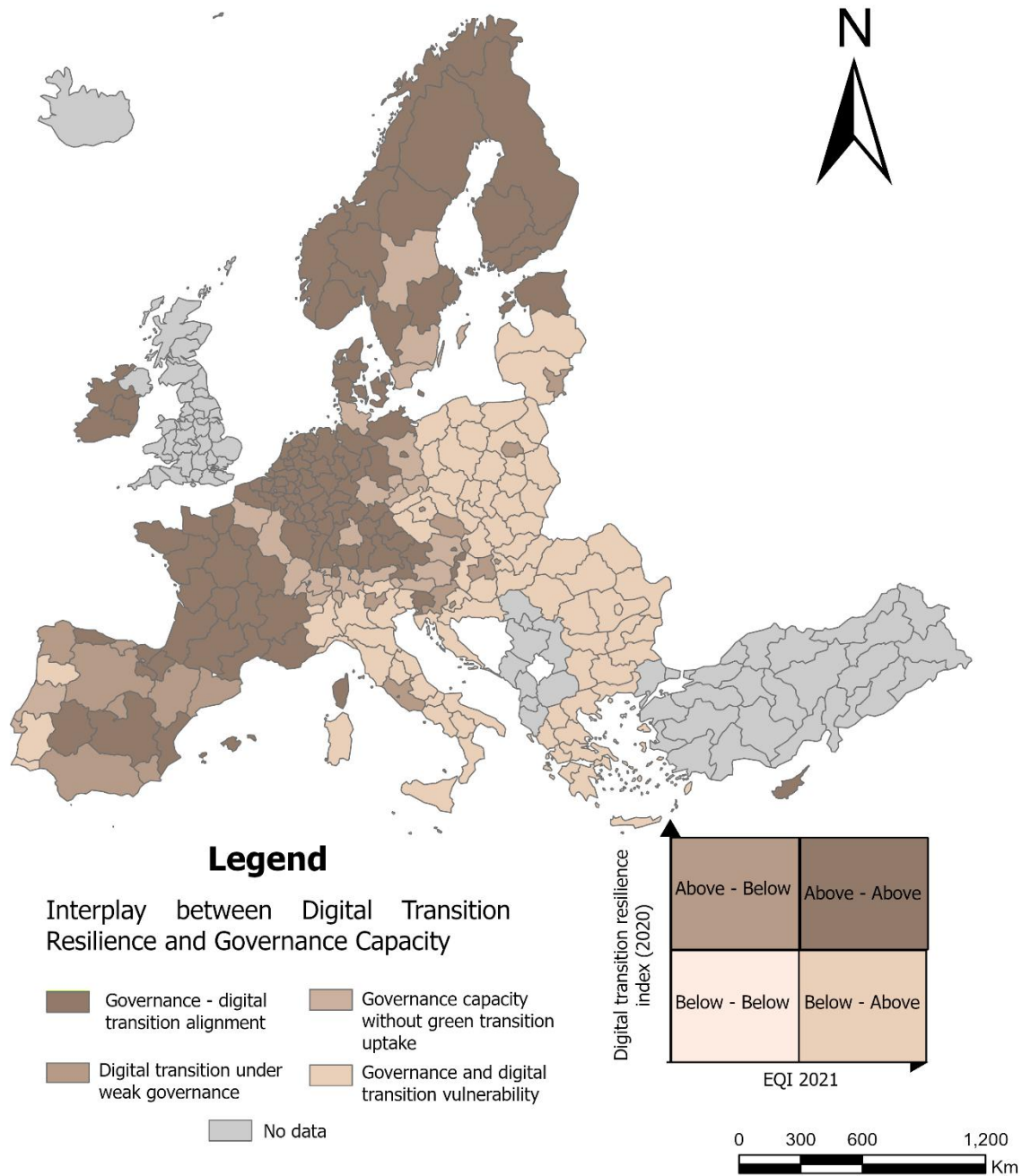


Figure 11 - Green Transition Resilience and Governance Capacity (GTRI × EQI classification)

The map shows a clear spatial stratification across Europe. High green transition positioning combined with high institutional quality is predominantly observed in Northern and Western Europe, including the Nordic countries, much of Germany, France, Benelux, Switzerland, and Austria. By contrast, a large share of Central, Eastern, and Southern European regions cluster in configurations characterised by lower EQI, often combined with weaker green transition positioning. Nevertheless, several regions display relatively strong green transition positioning despite lower institutional quality, particularly in Southern and Eastern Europe, suggesting that while a broad West–East divide is evident, institutional–green transition configurations are far from uniform across Europe.



*Figure 12 – Digital Transition Resilience and Governance Capacity (DTRI × EQI classification)*

The digital transition resilience – governance capacity map reveals a more polarised spatial configuration than the green transition one. Above – average digital transition positioning combined with high institutional quality is spatially concentrated in Northern and Western Europe, including the Nordic countries, Germany, the Benelux states, France, the Netherlands, Ireland, and much of Austria and Switzerland. By contrast, most Central, Eastern, and Southern European regions combine below-average digital transition resilience with lower institutional quality. Moreover, while a limited number of capital and metropolitan regions exhibit relatively strong digital positioning despite lower EQI, the overall pattern points to a pronounced West–East divide with comparatively less internal heterogeneity than observed for the green transition.

Indeed, across both the green and digital classifications, a clear institutional gradient emerges, although a bit more mixed in the case of the green transition. Classes combining above-average transition conditions with above-average SECI dynamics are predominantly associated with higher EQI values in the digital transition, indicating stronger governance contexts where twin transition conditions and socio-economic dynamics reinforce each other. This pattern is consistent with evidence that effective governance supports the coordination of complex structural change, particularly where transition policies require cross-sectoral alignment, long-term investment horizons, and social acceptance (Álvarez et al., 2023; Crescenzi, Di Cataldo, & Rodríguez-Pose, 2016; Farole, Rodríguez-Pose, & Storper, 2011; Rodríguez-Pose, 2013; Rodríguez-Pose & Ketterer, 2020)

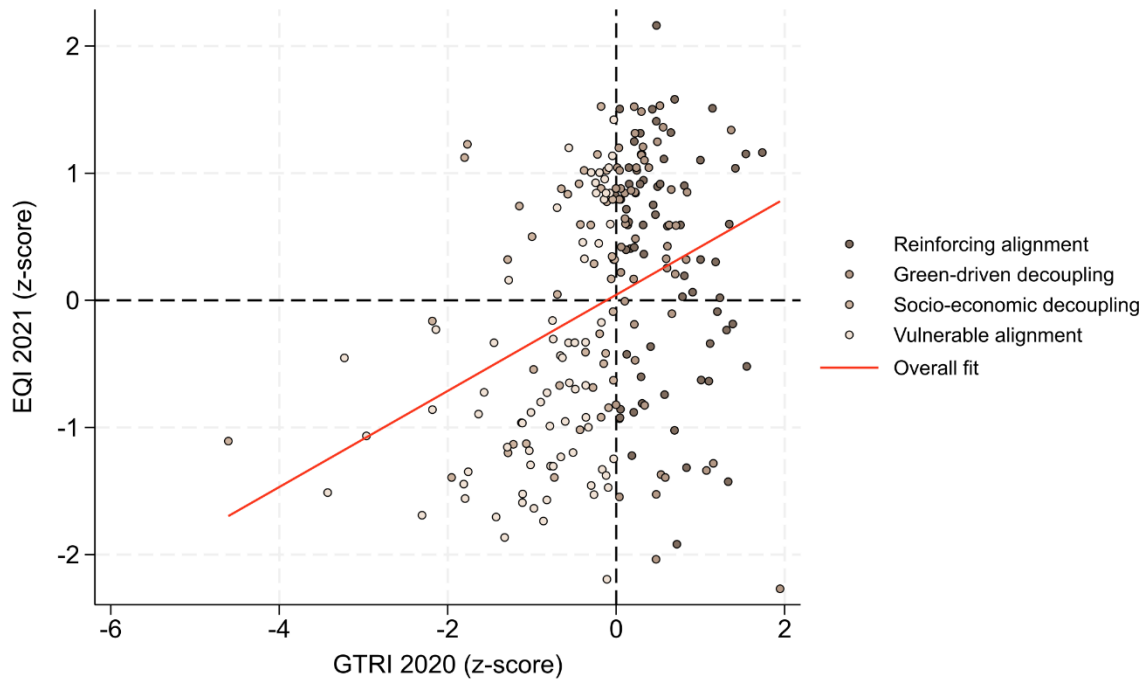


Figure 13 - Scatter plot: (EQI) across GTRI–Socio-Economic Configurations

Indeed, this governance gradient is less pronounced for the green transition, where reinforcing alignment configurations tend to be associated with stronger governance environments, but with a more even spread of EQI values across configurations. This reflects the fact that green transition pressures are more strongly shaped by sectoral composition, legacy energy and industrial structures, and regulatory exposure, which can generate heterogeneous transition outcomes even under similar institutional conditions (Diemer et al., 2022; Doukas et al., 2020; Grillitsch & Hansen, 2019). As a result, governance quality appears to condition green transition pathways in a less linear and more context-dependent manner than in the digital domain, where institutional capacity is more directly tied to coordination, skills, and innovation systems (Antonietti, Burlina, & Rodríguez-Pose, 2025)

Configurations combining below-average transition conditions with below-average SECI dynamics are largely concentrated at lower EQI levels in the digital dimension, reflecting weaker governance quality. This pattern is consistent with evidence that weaker governance capacity and lower institutional trust constrain regions' ability to coordinate complex structural change, absorb transition-related shocks, and sustain long-term policy commitments (Diemer et al.,

2022; Iammarino et al., 2020). In the green dimension, however, vulnerable configurations display greater dispersion in governance quality, with both low and moderate levels of EQI represented.

Nevertheless, overall, the predominance of low EQI values observed across these configurations reinforce longstanding concerns about the cumulative disadvantages faced by regions with weak institutional capacity. In line with the literature on regional lock-in and path dependence, poor governance appears to exacerbate the persistence of unfavourable development trajectories by limiting policy effectiveness, reducing trust, and constraining the mobilisation of collective action in response to structural shocks (Boschma, 2015; Rodríguez-Pose, 2018). The similarity of EQI patterns across both green and digital vulnerable classes further suggests that institutional weakness operates as a cross-cutting constraint on transition resilience, rather than as a domain-specific limitation.

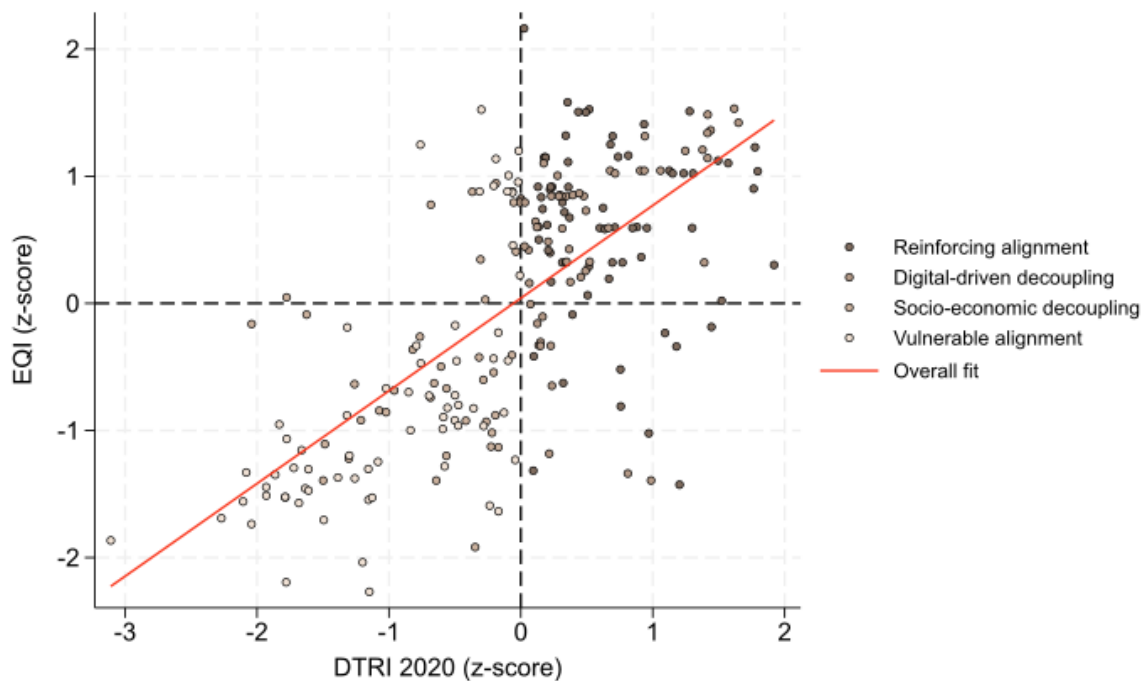


Figure 14 - Scatter plot: EQI across DTRI–Socio-Economic Configurations

However, the EQI profiles also reveal an important asymmetry: decoupling is not necessarily associated with weaker governance when transition positioning is strong. In the green dimension, green-driven decoupling, where above-average GTRI coexists with below-average SECI dynamics, is associated with a wide range of EQI values, including both high- and low-governance contexts. In the digital dimension, by contrast, digital-driven decoupling is more consistently located at moderate to high EQI levels, with substantial overlap with reinforcing alignment configurations. This suggests that strong governance can coexist with limited recent socio-economic adjustment, implying that favourable transition positioning may be sustained through accumulated capacities, policy continuity, and institutional effectiveness even when short to medium-term socio-economic dynamism is weaker. In evolutionary terms, these cases are consistent with path-dependent retention of transition capacity, whereby institutional quality stabilises transition performance despite more inertial socio-economic restructuring dynamics. High median EQI values in these groups further indicate that institutional quality may play a buffering role, supporting the maintenance of transition-related capacities even when broader socio-economic reallocation processes lag behind. This finding resonates with resilience

research emphasising the role of strong governance frameworks in stabilising adjustment trajectories under conditions of structural stress (Rios & Gianmoena, 2020)

Conversely, configurations where SECI dynamics are above average, but transition positioning remains below average appear to also be associated with better higher EQI scores, particularly in the green dimension. This pattern supports a sequencing interpretation in which socio-economic upgrading may be underway and embedded in relatively strong institutional contexts yet does not automatically translate into improved green transition positioning. Indeed, governance capacity emerges as a necessary but non-sufficient condition, shaping but not guaranteeing the conversion of socio-economic momentum into transition capacity. This finding resonates with arguments that socio-economic change, even when supported by relatively strong institutions, may remain weakly aligned with green transition objectives in the absence of targeted policy frameworks and coordinated steering mechanisms (Rodríguez-Pose, 2013; Rodríguez-Pose & Ganau, 2022). By contrast, for the digital domain, such configurations are less prevalent, suggesting that stronger governance is more closely aligned with digital transition capacity. This pattern resonates with arguments that socio-economic change alone does not ensure alignment with new transition paradigms in the absence of institutional frameworks that prioritise and coordinate environmental or digital transformation (Antonietti et al., 2025). Thus, overall, socio-economic dynamism without targeted institutional steering may therefore result in forms of growth that remain weakly connected to twin transition objectives

Taken together, the scatter plots highlight a differentiated relationship between governance quality and transition–socio-economic configurations across the green and digital dimensions. Institutional quality is not considered a direct driver of transition outcomes, but rather a contextual condition shaping how transition pressures interact with underlying socio-economic structures. While governance quality appears to structure digital transition pathways more clearly, its role in the green transition is more heterogeneous and context dependent. In line with evolutionary resilience perspectives, EQI appears to influence whether regions can sustain transition capacities, cope with misalignments between transition demands and socio-economic adjustment, or become locked into persistent vulnerability. This reinforces the importance of integrating institutional considerations into analyses of the twin transition and regional resilience.

## 4 Conclusions

### 4.1 Main results and interpretations

This report set out to examine how European regions differ in their ability to sustain and manage the green and digital transitions. Through a systematic analysis of regional data, combining static transition conditions with dynamic adjustment measures and situating them within a broader socio-economic and governance context, the report moves beyond descriptive analysis by relating transition conditions and dynamics and identifying structured patterns of regional transition pathways, while also providing a foundation for further analytical and policy-oriented work.

Three main conclusions stand out.

First, transition resilience is structurally conditioned and path dependent. Regions do not enter the twin transition from a neutral starting point. Inherited production structures, sectoral specialisation, and infrastructure capacity shape both green and digital transition resilience. As a result, relative advantage and disadvantage tend to persist over time, with only selective reordering within the European distribution. This persistence is more pronounced for the digital transition, where cumulative advantages linked to access, skills, and effective use reinforce existing gaps.

Second, transition capacity and socio-economic change are only partially aligned, with key differences between the green and digital dimensions. While some regions show reinforcing dynamics, where socio-economic restructuring coincides with stronger transition positioning, an important number of regions display various forms of decoupling. In the green dimension, a modest positive association suggests that favourable transition positioning often - but not systematically - coexists with socio-economic dynamism, reflecting the role of accumulated capacities and longer-term adjustment processes. In the digital dimension, by contrast, the relationship with socio-economic dynamics is weaker, pointing to a decoupling between digital transition positioning and socio-economic adjustment in many regions. Taken together, these patterns point to sequencing effects and differentiated regional pathways rather than linear relationships between socio-economic development, and twin transition capacity.

Third, governance quality conditions transition trajectories. High institutional quality is consistently associated with configurations where transition conditions and socio-economic dynamics are aligned. At the same time, governance alone does not guarantee successful transition outcomes: even where governance capacity is relatively strong, socio-economic momentum does not automatically translate into improved transition positioning, especially in the green domain, where sectoral legacies and structural constraints remain influential. By contrast, configurations characterised by weaker governance quality are more frequently associated with vulnerable transition profiles, particularly in the digital dimension, where low EQI is more clearly linked with configurations combining weak transition positioning and limited socio-economic dynamics. In these contexts, institutional limitations are likely to constrain coordination, reduce policy effectiveness, and limit regions' capacity to absorb transition-related shocks.

Overall, the findings reinforce the value of an evolutionary, place-based perspective on the twin transition. Green and digital transformations unfold through different mechanisms and timescales, and their interaction with regional economic structures and institutions produces

diverse and often asymmetric pathways. The analysis suggests that the link between institutional quality and the capacity to implement the twin transition is particularly strong for the digital dimension, where governance conditions appear to structure transition outcomes more clearly than local structural characteristics. By contrast, green transition trajectories are more strongly shaped by place-specific structural conditions, reflecting legacy assets and longer-term patterns of economic specialisation. Recognising these differences is key for designing policies that support not only transition outcomes, but also the capacity of regions and labour markets to sustain twin transition transformation over time.

## 4.2 Limitations and future work

The analytical framework developed in this report is designed to provide a coherent, comparable macro-level perspective on how European regions navigate the green and digital transitions. As with any large-scale territorial analysis, this perspective involves deliberate scope choices that shape interpretation. The analysis is conducted at the NUTS 2 level, which supports comparability and policy relevance but inevitably masks within-region heterogeneity. The results should therefore be read as characterising regional transition contexts and trajectories rather than capturing local adjustment processes.

The framework relies on composite indices that integrate multiple indicators into interpretable dimensions of transition capacity and socio-economic change. This approach enables systematic comparison across regions and over time, while necessarily simplifying complex and context-specific processes. Rather than offering precise rankings, the indices are intended to identify relative positioning, patterns of alignment, and forms of decoupling that are analytically meaningful for understanding transition resilience.

The temporal coverage reflects the longest period for which sufficiently consistent regional data are available across Europe. While this allows the identification of medium-term transition trajectories prior to the COVID-19 shock, it also means that more recent policy responses and acceleration dynamics are not yet fully observable. As longer and more consistent time series become available, the framework can be extended to assess how recent policy interventions interact with existing structural and governance conditions.

Dynamic change is captured through slope-based indicators that focus on medium-term adjustment rather than short-term volatility. This choice aligns with the evolutionary resilience perspective adopted in the report, but it also implies that sudden disruptions or non-linear shifts are not the primary focus of the analysis. Finally, governance quality and socio-economic dynamics are analysed as conditioning factors shaping transition pathways, rather than as causal drivers, supporting interpretation rather than causal attribution.

Taken together, these choices do not limit the usefulness of the report; rather, they define its contribution. The framework offers a structured basis for distinguishing between regions where the twin transition is embedded within broader processes of structural adjustment and those where progress remains partial, uneven, or constrained. By doing so, it provides a macro-level foundation for subsequent project work on labour markets, skills, and social resilience, and for more targeted, place-sensitive policy analysis in later stages of the project.

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## Annex 1: Green Transition Resilience Index (GTRI): subdimensions and indicators – candidate indicators

SUBDIMENSION	ASPECT OF RESILIENCE	INDICATORS
<i>1. DECARBONISATION PRESSURE</i>	vulnerability from decarbonisation pressures- and resource-intensive activities	GHG intensity(total); industrial emission share; energy-sector emission share;
<i>2. STRUCTURAL SENSITIVITY</i>	Exposure of regional production systems to carbon- and climate-sensitive activities	Agriculture employment share; agriculture value added share; manufacturing employment share; industry employment share; industry value added share;
<i>3. ENVIRONMENTAL AND PHYSICAL VULNERABILITY</i>	Sensitivity to climate stress and exposure to physical hazards affecting regional systems	Cooling Degree Days and Heating Degree Days anomalies; Share of built-up area exposed to coastal and river flooding;
<i>4. GREEN INFRASTRUCTURE</i>	Transition-supporting infrastructure, mobility systems, and innovation capacity enabling decarbonisation	EV stocks (passenger, goods, public); EV share; number of bus/population; Green patents per 1000000 inhab.;

## Annex 2: Digital Transition Resilience Index (DTRI): subdimensions and indicators – candidate indicators

SUBDIMENSION	ASPECT OF RESILIENCE	INDICATORS
1. <i>DIGITAL INFRASTRUCTURE</i>	Economic and innovation base of digital activities	ICT employment share; ICT value added share; KIS nonICT employment share; KIS nonICT value added share; ICT + AI patents per 1000000 inhabitants;
2. <i>DIGITAL ACCESS</i>	Household connectivity and access to digital infrastructure	Broadband access (% of households); internet access at home (% of households)
3. <i>DIGITAL USE</i>	Extent of digital adoption and participation by individuals and firms	Frequency of internet access (daily/weekly); Internet banking (% of individuals); Interaction with public authorities (e-government use); Submitting forms online (e-government completion); Online purchases; E-commerce sales and purchases by enterprises; Internet use for selling goods/services; Individuals accessing internet away from home/work
4. <i>BUSINESS DYNAMISM &amp; ENTREPRENEURSHIP</i>	Capacity to renew within the digital economy	ICT labour productivity; KIS nonICT labour productivity; Enterprise births/deaths and net growth (ICT & KIS nonICT sectors)

## Annex 3: Socio-Economic Change Index subdimensions and indicators – candidate indicators

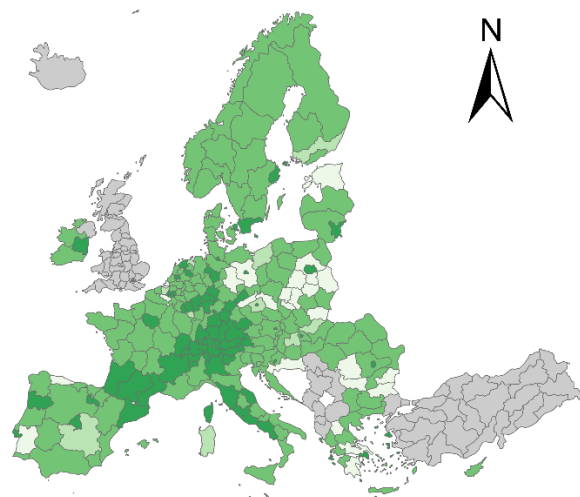
SUBDIMENSION	ASPECT OF RESILIENCE	INDICATORS
1. <i>ECONOMIC STRUCTURE &amp; SPECIALISATION</i>	Structural exposure or flexibility of the production system	Industry specialisation (LQ B–E); KIS specialisation (LQ KIS); Diversification index (1–HHI); Traditional sectors share (A,B–E,F,G–I); Labour productivity (total)
<i>INVESTMENT INTENSITY</i>	Capacity to finance and sustain structural change	Investment rate (total, B–E, KIS); GFCF share in industry (B–E) and KIS

<i>EMPLOYMENT DYNAMICS</i>	Adaptive labour-market resilience and sectoral reallocation	Job creation/destruction/net growth (total); Job creation/destruction/net growth (B–E and KIS); Employment volatility; Net employment reallocation ( $\Delta KIS - \Delta Trad$ )
<i>EFFICIENCY &amp; INNOVATION</i>	Productivity and transformative capacity through innovation	GERD by sector (business, HE, gov.); Researchers share; HRST; Scientists & engineers; Patents per 1000000 inhabit. (all technologies);
<i>BUSINESS DEMOGRAPHY &amp; RENEWAL</i>	Entrepreneurial renewal and structural dynamism of firms	Enterprise births/deaths and net growth (B–E, KIS); Start-up ratios; Enterprise counts

#### **Annex 4: Socio-Economic Change Index subdimensions and indicators – retained indicators**

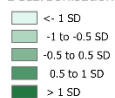
<b>SUBDIMENSION</b>	<b>ASPECT OF RESILIENCE</b>	<b>INDICATORS</b>
<i>ECONOMIC STRUCTURE &amp; SPECIALISATION</i>	Structural vulnerability or flexibility of production systems	Industrial specialisation (LQ B–E) <i>Knowledge-intensive specialisation (LQ KIS)</i> Diversification index
<i>INVESTMENT INTENSITY</i>	Capacity to finance and sustain structural change	Investment rate (total); Investment rate (B–E); Investment rate (KIS) ;
<i>EMPLOYMENT DYNAMICS</i>	Adaptive labour-market resilience and sectoral reallocation	Net job growth (total); Net employment reallocation ( $\Delta KIS - \Delta Trad$ ); Employment volatility
<i>EFFICIENCY &amp; INNOVATION</i>	Productivity and transformative capacity through innovation	Labour productivity; Patents per 100000o inhabit. (all technologies);

## Annex 5: GTRI 2014– dimensions: decarbonisation pressure-left ; structural sensitivity – middle ; green infrastructure – right)

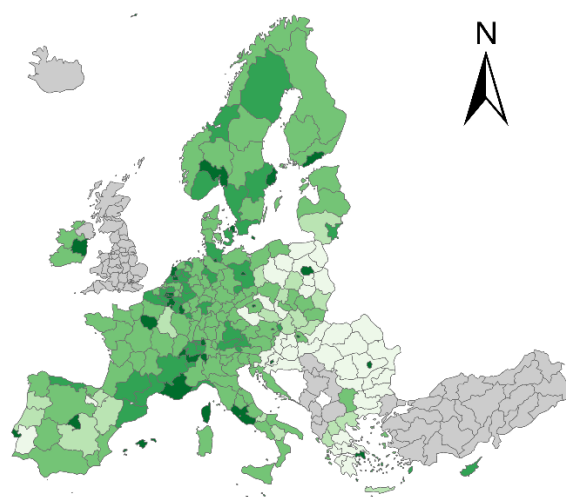


### Legend

Green Transition Resilience Index -  
Decarbonisation pressure dimension (2014)

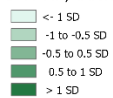


\*Z-scores standardised to mean = 0,  
SD = 1 across all regions

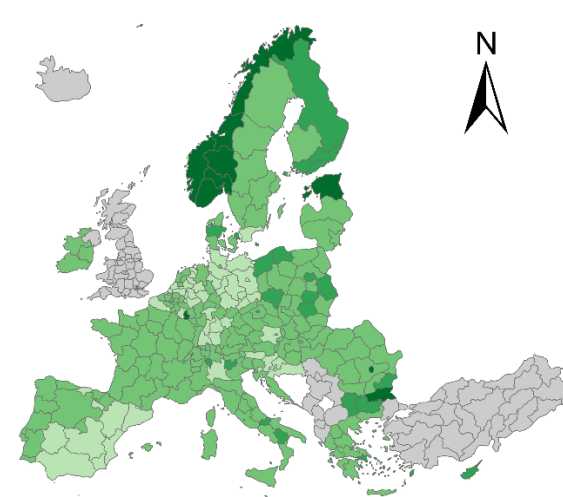


### Legend

Green Transition Resilience Index - Structural  
sensitivity dimension (2014)

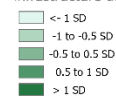


\*Z-scores standardised to mean = 0,  
SD = 1 across all regions

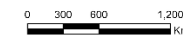


### Legend

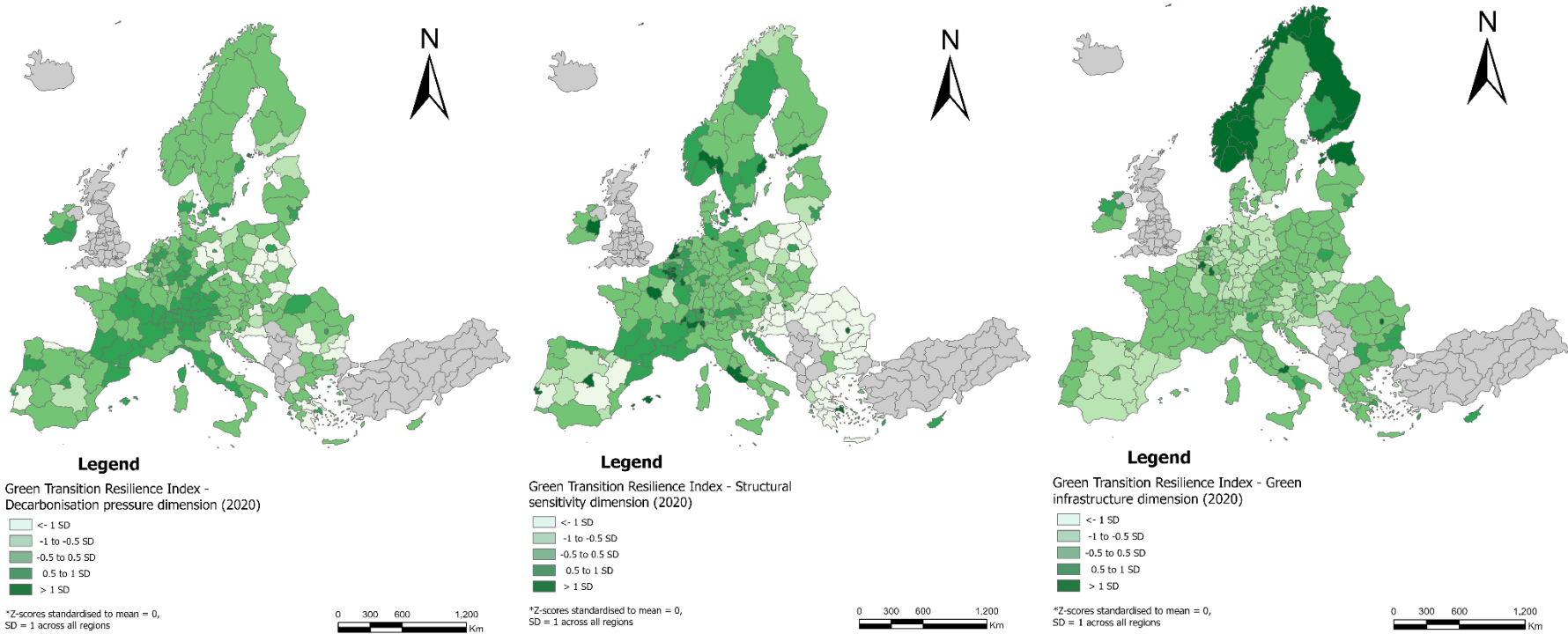
Green Transition Resilience Index - Green  
infrastructure dimension (2014)



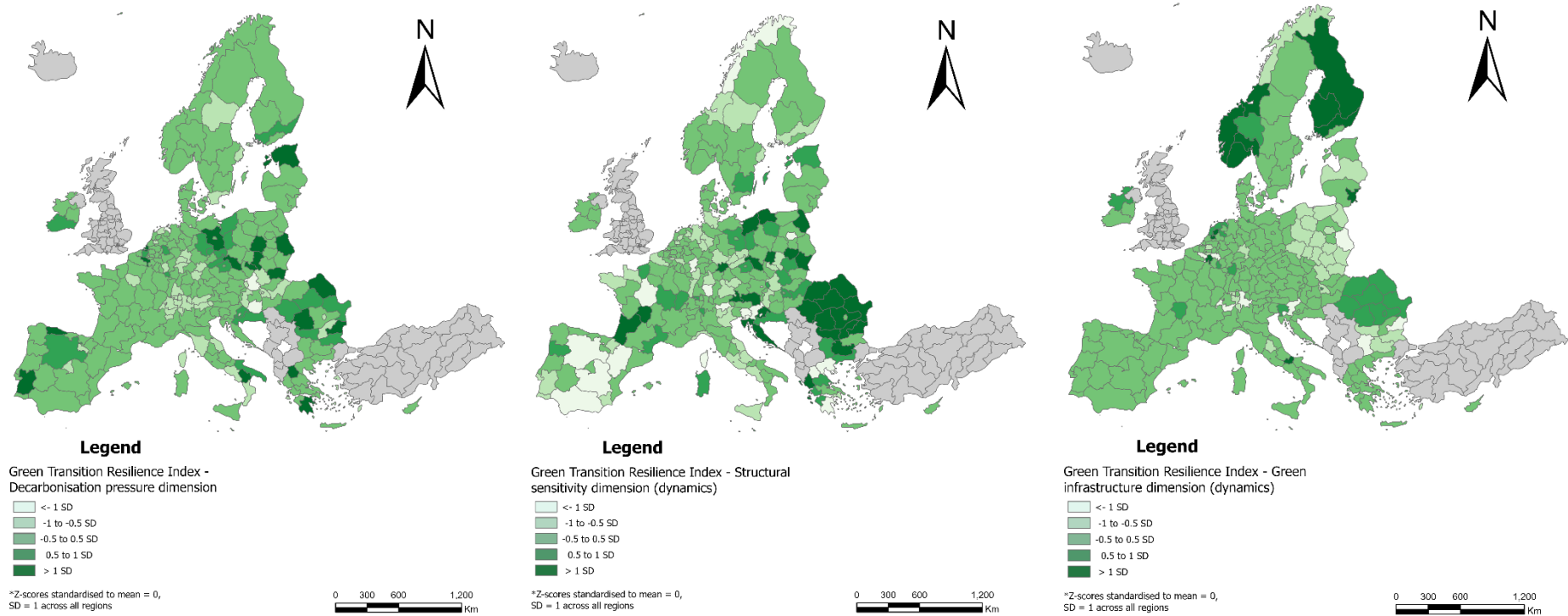
\*Z-scores standardised to mean = 0,  
SD = 1 across all regions



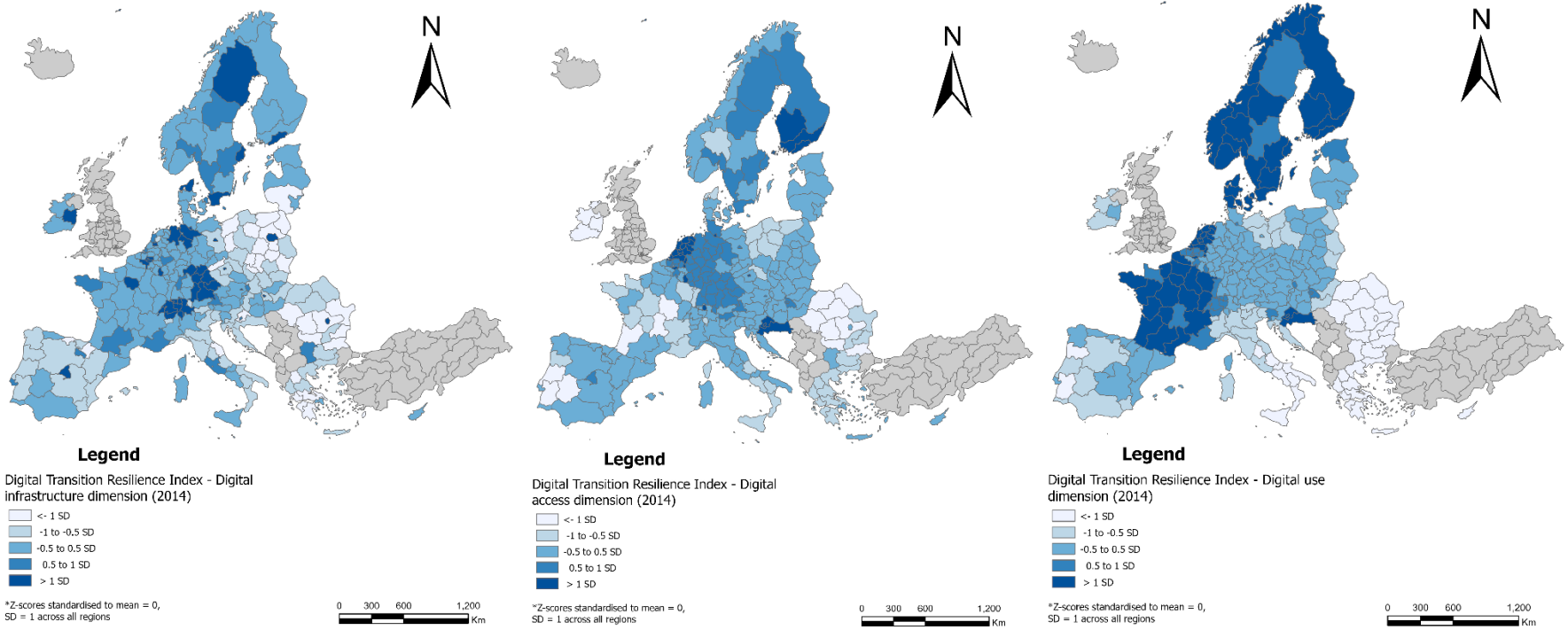
**Annex 6: GTRI 2020 – dimensions: decarbonisation pressure-left ; structural sensitivity – middle ; green infrastructure – right)**



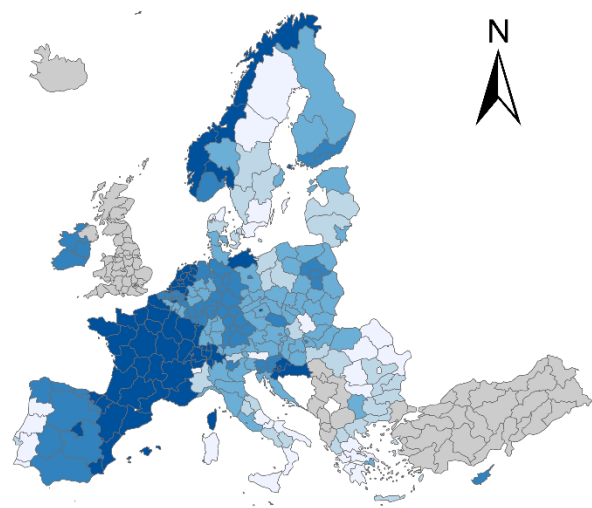
**Annex 7: GTRI (dynamics) – dimensions: decarbonisation pressure-left ; structural sensitivity – middle ; green infrastructure – right)**



**Annex 8: DTRI 2014 – dimensions (digital infrastructure -left ; digital access – middle ; digital use – right)**



**Annex 9: DTRI 2020 – dimensions (digital infrastructure -left ; digital access – middle ; digital use – right)**

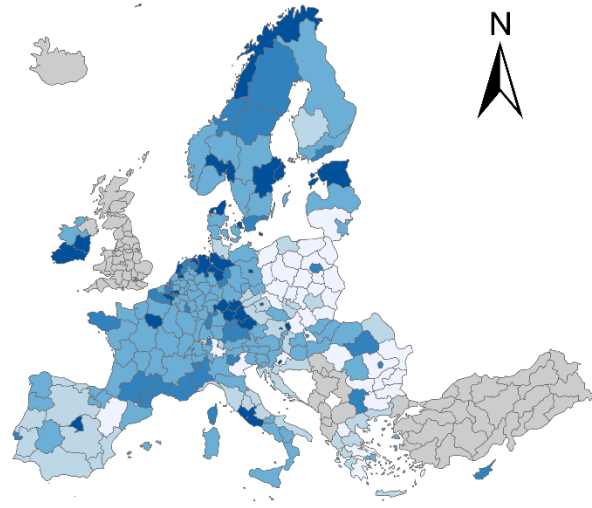


**Legend**

Digital Transition Resilience Index - Digital access dimension (2020)

- < -1 SD
- 1 to -0.5 SD
- 0.5 to 0.5 SD
- 0.5 to 1 SD
- > 1 SD

\*Z-scores standardised to mean = 0, SD = 1 across all regions

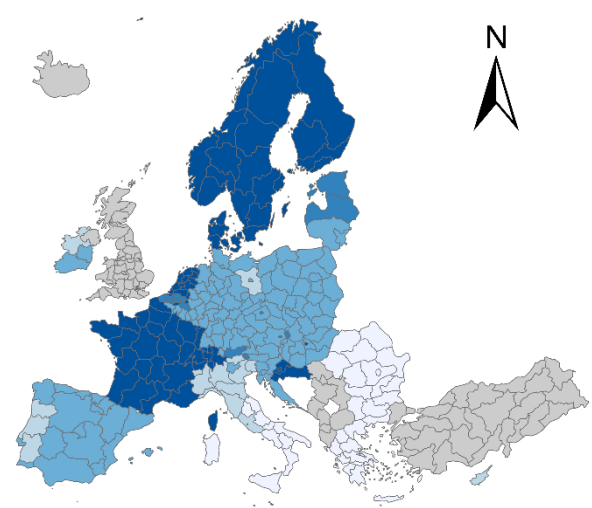


**Legend**

Digital Transition Resilience Index - Digital infrastructure dimension (2020)

- < -1 SD
- 1 to -0.5 SD
- 0.5 to 0.5 SD
- 0.5 to 1 SD
- > 1 SD

\*Z-scores standardised to mean = 0, SD = 1 across all regions

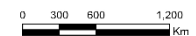


**Legend**

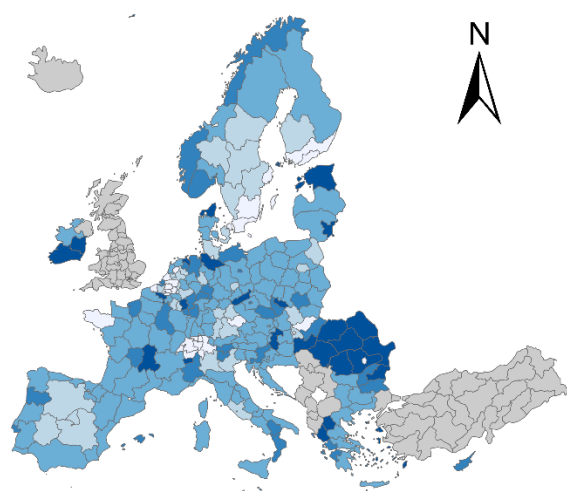
Digital Transition Resilience Index - Digital use dimension (2020)

- < -1 SD
- 1 to -0.5 SD
- 0.5 to 0.5 SD
- 0.5 to 1 SD
- > 1 SD

\*Z-scores standardised to mean = 0, SD = 1 across all regions



**Annex 10: DTRI (dynamics)– dimensions (digital infrastructure -left ; digital access – middle ; digital use – right)**

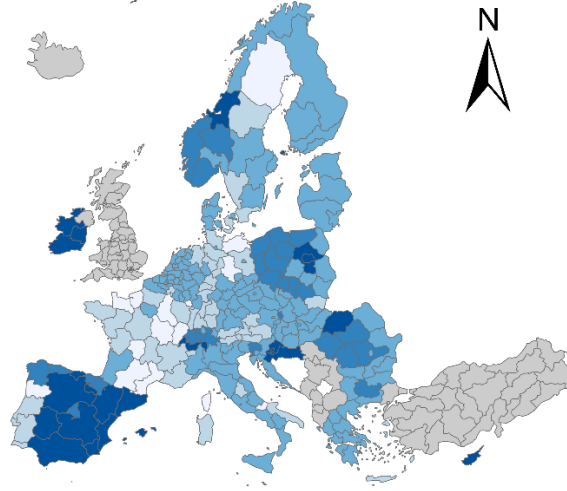


**Legend**

Digital Transition Resilience Index - Digital infrastructure dimension (dynamics)

- < -1 SD
- 1 to -0.5 SD
- 0.5 to 0.5 SD
- 0.5 to 1 SD
- > 1 SD

\*Z-scores standardised to mean = 0, SD = 1 across all regions

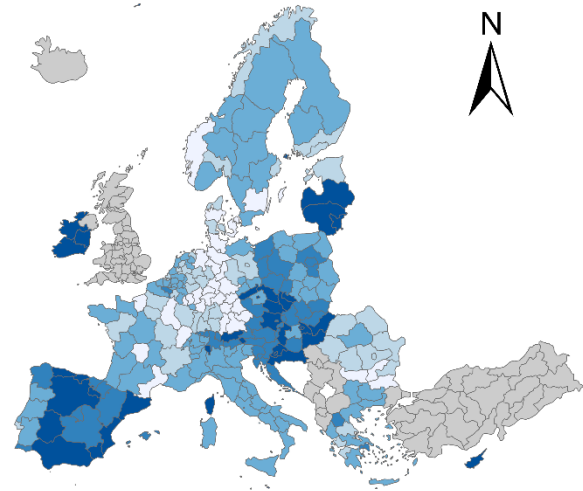


**Legend**

Digital Transition Resilience Index - Digital access dimension (dynamics)

- < -1 SD
- 1 to -0.5 SD
- 0.5 to 0.5 SD
- 0.5 to 1 SD
- > 1 SD

\*Z-scores standardised to mean = 0, SD = 1 across all regions



**Legend**

Digital Transition Resilience Index - Digital use dimension (dynamics)

- < -1 SD
- 1 to -0.5 SD
- 0.5 to 0.5 SD
- 0.5 to 1 SD
- > 1 SD

\*Z-scores standardised to mean = 0, SD = 1 across all regions



## Annex 2: The Consortium

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

## **Annex 3: Project Summary**

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

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

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

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

To achieve this ambition, the SkillResilience4EU consortium unites higher educational institutions (Western Norway University of Applied Sciences, Utrecht University, London School of Economics, University of Warsaw, University of Natural Resources and Life Sciences in Vienna, University of Crete, North-Western Switzerland University of Applied Sciences) one vocational training institute (BFI), one private training organization (Simplon.co) and a local public authority (Municipality of Platania). 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 1<sup>st</sup> January 2025 and will run for 3 years.