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The dual geography of European labour markets: Gendered convergence and spatial polarisation across NUTS 2 regions

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ABSTRACT

This study examines gendered and spatial labour-market convergence across 244 NUTS 2 regions (Nomenclature of Territorial Units for Statistics, level 2) of the present European Union (EU-27) from 1999 to 2024. It combines Phillips-Sul club convergence, conditional β-convergence models, multiple structural-break estimation, dynamic spatial Durbin models and nonparametric distributional dynamics for total, male and female employment and unemployment rates. Trend components emphasise low-frequency adjustment. Full-panel convergence is rejected for all six indicators, while conditional employment catch-up, particularly for women, coexists with persistent regional rankings. Unemployment displays more heterogeneous adjustment and widely separated club trajectories; conditional divergence within some low-unemployment clubs is distinct from the relative disadvantage of the highest-unemployment clubs. Estimated breaks describe changes in conditional relationships without identifying the effects of integration or crises. Spatial models indicate positive spatial dependence in adjustment. Female employment and unemployment exhibit lower seven-year decile-rank mobility than those of their male counterparts. Estimated density peaks remain descriptive because the dip tests do not reject the unimodality assumption. The findings reveal a dual geography of conditional employment catch-up and differentiated unemployment adjustment; they do not establish convergence in gender equality or the gender employment gap. They support place-based, gender-sensitive and spatially coordinated policy assessment, while leaving the effects of specific institutional mechanisms and interventions open to further investigation.

1. Introduction

Regional disparities in labour-market outcomes constitute major barriers to European economic and social cohesion. Persistent regional inequalities have been shown to increase social fragmentation and weaken public trust in European Union (EU) institutions (Rodríguez-Pose et al., 2024). Addressing these regional labour-market disparities through targeted cohesion policies is important for maintaining long-term social and political stability in the EU, as such policies can reduce both financial inequalities and geographic disadvantages (Agkoli, 2024). Employment and unemployment are key economic indicators that reveal how effectively regional economies translate growth into job creation, stable income and broader social participation. Despite decades of integration and cohesion policies, labour market outcomes continue to vary widely across European regions due to entrenched differences in economic structures and institutional capacities (Beyer and Stemmer, 2016; Leško, 2025).

This challenge is particularly important at the NUTS 2 level, which remains the primary scale used for EU cohesion policy and for monitoring territories. This imperative is amplified by the European Pillar of Social Rights Action Plan (European Commission, 2021), which established a 2030 target of a 78% employment rate for the population aged 20–64 years, explicitly tying the achievement of this goal to reducing the gender employment gap. Concurrently, the 9th Cohesion Report (European Commission, 2024) emphasises that while national economies may be converging, substantial sub-national disparities persist, leaving numerous regions entrenched in structural hysteresis and sub-optimal equilibria. The 20–64 employment target is a policy benchmark rather than a directly comparable sample rate since our empirical analysis covers people aged 15 years and over. This spatial stratification indicates that aggregate national progress frequently obscures severe localised stagnation, necessitating highly targeted interventions.

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This heterogeneity provides strong reasons to move beyond conventional global convergence tests. While classical β- and σ-convergence frameworks remain useful as initial diagnostics, analyses conducted for the full sample of regions may obscure differences in adjustment paths, exposure to structural shocks and institutional conditions across European regions (Bathelt et al., 2024; Borseková et al., 2025). Recent evidence highlights nonlinear relationships between institutional quality, innovation capacity and regional development across EU NUTS 2 regions, reinforcing the importance of accounting for regional heterogeneity (Borsekova et al., 2026). Empirical analyses of European regions frequently indicate that regional economies tend to converge towards distinct, group-specific steady states rather than a single, continent-wide equilibrium. In doing so, they often exhibit increasing divergence from other regional convergence clubs. Moreover, the way regions are grouped usually represents long-term structural features rather than short-term cyclical fluctuations (Bartkowska and Riedl, 2012; Borseková et al., 2025; Cuestas et al., 2015). Consequently, the club-convergence framework represents a fundamental methodological shift in modelling labour-market adjustment within a diverse economic space (Obadić et al., 2023). Among available methodologies, the Phillips and Sul (2007, 2009) procedure is particularly suitable because it accommodates time-varying heterogeneity and identifies endogenous groupings without imposing prior classifications.

It is also well-suited for deciphering the complex dynamics of labour-market adjustment in Europe, where convergence, divergence and stagnation often coexist across regions and indicators (Borseková et al., 2025). In a gender-disaggregated setting, this procedure is applied separately to male and female employment and unemployment, allowing determination of whether the same region follows different long-run adjustment paths depending on the labour-market outcome and gender.

A gender-disaggregated perspective makes this methodological shift analytically imperative. In 2024, the EU employment rate for men aged 20–64 years was 80.8%, compared with 70.8% for women, i.e., a gender employment gap of 10.0 percentage points. While this aggregate gap is important for policy design, its spatial distribution provides crucial diagnostic insight: disparities in female employment and unemployment are markedly more pronounced in regions characterised by weaker care infrastructure, narrow sectoral specialisation and persistent conventional gender norms (European Commission, 2025). Consequently, a region may appear resilient in terms of aggregate employment while relying excessively on male job creation in cyclical industrial sectors. The central theoretical argument of this study is that aggregate labour-market measures obscure considerable underlying variation, hiding distinct regional, sectoral and demographic patterns that shape and characterise regional economies.

Gender balance and absolute gender gaps do not necessarily move in parallel, and improvements in overall indicators do not necessarily imply the substantive integration of women into regional labour markets (Borseková et al., 2025). Employment trajectories for men and women are governed by distinct macroeconomic mechanisms: male outcomes are heavily exposed to cyclical contractions in construction, manufacturing and tradable sectors, whereas female outcomes depend more on care responsibilities, service-sector composition, part-time working arrangements and the availability of childcare (Baussola and Mussida, 2017; Nchor and Náplava, 2025). Thus, treating labour markets as gender-neutral misrepresents both the scale and causes of regional convergence, underscoring the need to look beyond aggregate data.

This study aims to establish how regional labour-market convergence differs between employment and unemployment, and between men and women, across 244 NUTS 2 regions of the current EU-27 over 1999–2024. It addresses four research questions. First, do regional outcomes follow a common transition path, or do they form distinct convergence clubs whose composition differs by gender and indicator? Second, how does conditional catch-up vary across outcomes and clubs, and between estimated temporal regimes? Third, how are regional adjustment processes associated with contemporaneous and lagged spatial dependence? Fourth, is conditional catch-up accompanied by changes in regional rankings and the shape of the cross-regional distribution? Together, these questions assess whether a reduction in territorial stratification accompanies conditional catch-up and whether aggregate indicators conceal different male and female trajectories. We use "dual geography" to frame the potentially different regional patterns of employment and unemployment adjustment, with gender differences cutting across both. The analysis examines whether stronger employment catch-up can coexist with more heterogeneous unemployment adjustment and persistent regional rankings, rather than assuming that progress in one outcome implies convergence in the other.

This study makes three core contributions. First, it jointly examines employment and unemployment within the same EU regional panel, disaggregating each indicator by gender to identify differences obscured by aggregate measures. Second, it combines convergence-club identification and conditional catch-up estimates with spatial dependence and regional rank mobility, distinguishing complementary dimensions of adjustment. Third, it examines how these patterns vary across estimated temporal regimes and relates their timing to the context of European integration and crisis.

Methodologically, the study combines five complementary approaches. The Phillips-Sul procedure tests for a common transition path and identifies groups with compatible convergence dynamics; these groups need not be spatially contiguous. Conditional β-convergence models assess catch-up in the full panel and within the identified clubs. Multiple structural-break estimation examines changes in conditional convergence relationships over time. Dynamic spatial Durbin models describe contemporaneous and lagged spatial dependence and decompose estimated impacts into direct and indirect components. Finally, Markov transitions measure mobility between quantile-rank states, while kernel density estimation and dip tests assess distributional shape and unimodality. Using Hodrick-Prescott (HP) trend components focuses the analysis on low-frequency adjustment over a period spanning EU enlargement and successive crises, subject to the filtering and inference limitations discussed in Section 3.

The remainder of the paper is structured as follows. Section 2 reviews the theoretical and empirical literature on regional labour-market convergence, with particular attention to club-convergence studies and the gender dimension. Section 3 details the data and methodology. Section 4 presents the results for aggregate and gender-specific employment and unemployment. Section 5 discusses their academic implications and historical context. Section 6 considers policy implications, and Section 7 concludes.

2. Literature review

2.1. The limitations of global convergence and the imperative for club dynamics

The regional convergence literature uses β- and σ-convergence methods to assess whether less-developed regions catch up with more advanced economies (Zhang, 2025). These approaches have been widely applied to labour markets to examine whether areas with high unemployment or depressed employment participation improve more rapidly than prosperous regions (Rasvanis, 2024). While these methods offer transparency and comparability across economic indicators (Baer-Nawrocka et al., 2026), their application in the highly heterogeneous EU context is severely limited, as they frequently fail to capture institutional diversity, complex spatial interdependencies and the presence of multiple regional equilibria (Quintero-Rojas, 2011).

This limitation profoundly impacts the analysis of European labour markets, where research increasingly recognises that spatial clustering, institutional variation and path-dependent economic development generate distinct regional trajectories rather than a singular continental equilibrium (Unal and Špeciánová, 2023). Labour markets are

inherently spatial; commuter flows, supply-chain linkages and industry agglomerations cross administrative boundaries and generate powerful spillover effects, even across disparate national regulatory frameworks (Overman and Puga, 2002). As a result, localised shocks exhibit substantial spatial contagion, underscoring the critical importance of accounting for contiguous interdependencies. Subsequent research has confirmed that labour-market outcomes are determined by path dependence, sectoral specialisation, human capital endowments, and institutional complementarities that vary systematically across territories (Iammarino et al., 2019; Jurajda and Terrell, 2009; Zhang, 2025). Under these conditions, European labour-market dynamics are better understood not as convergence towards a single equilibrium, but as the coexistence of multiple regionally differentiated steady states. Club-convergence analysis is designed precisely for such an environment, as it identifies endogenous groups of regions that converge internally without necessarily converging to the aggregate sample mean (Phillips and Sul, 2007, 2009).

This methodological aspect is crucial for the current study, as the EU comprises highly divergent regional typologies: some regions are characterised by optimal employment equilibrium, others are entrenched in structural stagnation, and a subset is undergoing transitional adjustments. Relying on aggregate averages to evaluate these diverse groups imposes a statistical mask that fundamentally distorts empirical reality. Specifically, global averages overstate progress by statistically pooling regions moving in diametrically opposed directions, and they understate policy relevance by failing to group territories with similar structural bottlenecks that require specific interventions. Evidence from EU regional studies reinforces this limitation: β-convergence does not invariably imply σ-convergence, and labour-market indicators may simultaneously exhibit convergence, stagnation or divergence across different dimensions (Borseková et al., 2025). Consequently, the club-convergence framework provides a more rigorous and structurally accurate mechanism for mapping regional adjustments, enabling policymakers to target interventions towards the specific sub-optimal equilibria in which regions are operating.

2.2. Empirical trajectories of european labour-market convergence: from aggregate trends to spatial clusters

A substantial body of previous research has examined labour-market convergence in Europe. However, the emphasis has historically been on aggregate unemployment, productivity or broad indicators of regional economic performance rather than on gender-disaggregated outcomes. Earlier studies documented persistent regional labour-market disparities, showing that European integration did not eliminate the territorial clustering of unemployment and employment disadvantage across European regions (Overman and Puga, 2002; Perugini and Signorelli, 2004). Later research refined this perspective, showing that regional unemployment disparities may narrow during certain pre-crisis or expansionary phases while remaining highly persistent overall, characterising convergence as partial, conditional on country- and region-specific dynamics, and spatially uneven (Beyer and Stemmer, 2016; Kónya, 2020).

The club-convergence literature further strengthens this view. Bartkowska and Riedl (2012) showed that European regions tend to cluster into separate convergence clubs rather than progressing along a single, common path. Applying this to labour markets, Cuestas et al. (2015) found that unemployment in Central and Eastern Europe is characterised by convergence-club behaviour rather than a single common convergence path, with distinct country clusters shaped in part by labour-market policy and institutional differences. Maynou et al. (2022) revealed a pattern of spatially uneven youth disengagement, as determined by the rates of young people not in employment, education or training (so-called 'NEETs'), which indicates that a common EU integration and policy context does not translate into homogeneous labour-market realities for young people across regions. More recently, Borseková et al. (2025) demonstrated that EU regional labour market indicators exhibit highly mixed patterns of convergence, divergence, and stagnation. Some indicators exhibit β-convergence, but this does not translate into σ-convergence; instead, regional dispersion either stagnates or increases across several labour-market dimensions. Their findings reinforce the view that one-dimensional convergence narratives are inadequate for describing EU labour markets.

This body of evidence establishes three critical theoretical precedents. *First*, aggregate indicators such as overall employment, unemployment and productivity frequently follow divergent evolutionary paths. *Second*, intra-national spatial stratification remains severe, with proximate regions exhibiting vastly different capacities for economic resilience. *Third*, regional adjustment mechanisms are heavily moderated by structural and spatial preconditions rather than solely by initial endowments. However, a considerable empirical gap remains in the application of advanced frameworks to gender-specific employment and unemployment rates across a common sample of EU NUTS 2 regions.

2.3. The analytical imperative of gender disaggregation: unmasking structural asymmetries

Distinct macroeconomic and institutional mechanisms produce male and female labour-market outcomes. Women's employment is shaped by care responsibilities, family constraints, occupational and sectoral segregation, and part-time work regimes. In contrast, men's employment is heavily exposed to cyclical contractions, because men are disproportionately concentrated in highly cyclical sectors such as construction and manufacturing (Baussola and Mussida, 2017; Nchor and Náplava, 2025). These asymmetries dictate that a uniform regional shock can generate highly divergent dynamic responses by gender, and that a singular regional growth trajectory can yield vastly different levels of labour-market inclusion for men and women.

Despite gradual institutional progress, the convergence of gender outcomes in the EU remains insufficient to meet the 2030 targets, and this shortfall is highly spatially concentrated. According to recent reports from the European Commission and Eurostat, deep structural barriers continue to perpetuate regional inequities. The gap widens further at the NUTS 2 level; the gender employment gap exceeds 31 percentage points in the most disadvantaged NUTS 2 territories of Greece, Southern Italy and Eastern Romania. The Commission's Roadmap for Women's Rights and the new Gender Equality Strategy place economic independence, equal labour-market participation and the removal of structural barriers at the centre of the policy agenda. This is driven not only by equity imperatives but also by the macroeconomic reality that higher, stable female employment is essential to counter demographic decline, ensure fiscal sustainability, and foster inclusive regional growth (European Committee of the Regions, 2025).

The rationale for gender-disaggregated analysis is more specific than a general call for higher-level data disaggregation. First, it distinguishes regional employment and unemployment adjustment for men and women, allowing aggregate patterns to be compared with their gender-specific counterparts. Second, it maps whether male and female outcomes place the same regions in different convergence clubs. Third, it assesses whether mobility between quantile rank states differs by gender. These transitions describe changes in regional rankings rather than movement between Phillips-Sul clubs or individual workers' transitions. Fourth, club-based analysis identifies groups with distinct adjustment trajectories, which can inform a more focused investigation of regional constraints. In this sense, gender disaggregation shifts the analysis from average regional performance towards the differentiated patterns that institutional and sectoral explanations must account for.

Convergence clubs do not arise randomly; they emerge when regions share structural characteristics that dictate similar transition paths, such as industrial composition, demographic profiles, educational structures, urbanisation and institutional quality. More specifically, convergence clubs can be interpreted as groups of regions whose labour-market

trajectories are shaped by similar labour-demand structures, institutional legacies and social constraints over long periods. These conditions may affect how regions respond to shocks and policy interventions (Phillips and Sul, 2009; Borseková et al., 2025). Technological change may further differentiate regional labour-demand structures: evidence from Italian regions shows that digitalisation and platformisation generate selective employment opportunities across occupational groups, contributing to persistent labour-market polarisation (Capello et al., 2025). Regions with stronger human capital endowments, more adaptable workforces, and more competitive labour markets are more likely to follow favourable labour-market convergence trajectories. In contrast, structurally disadvantaged regions are more likely to display stagnation or divergence (Borseková et al., 2025). From a gender perspective, club formation is particularly revealing because women's labour-market outcomes are more strongly shaped by childcare availability, unpaid care burdens, part-time work regimes and gender norms, whereas men's outcomes tend to be more exposed to sectoral composition and cyclical shocks in industry and construction (Baussola and Mussida, 2017; Nchor and Náplava, 2025; European Commission, 2025). Accordingly, the same region or country may appear relatively favourable in aggregate employment terms while still showing stagnation or divergence in female unemployment, gender employment balance or gender pay gaps, potentially leading to different club classifications (Borseková et al., 2025; Nchor and Náplava, 2025).

Gender layers additional complexity onto this process. Female club formation is closely linked to the institutional and social organisation of care, the prevalence of part-time work, and gendered norms regarding labour-market participation (Nchor and Náplava, 2025; Borseková et al., 2025). Because male club formation depends more heavily on manufacturing exposure and cyclical volatility, a single region may exhibit structural proximity to an advanced cluster in male employment while simultaneously lagging in female employment (Baussola and Mussida, 2017; Nchor and Náplava, 2025; Rajni, 2026).

Analysing regional mobility between quantile-ranked states, alongside convergence-club membership, provides information that static rankings alone cannot capture. This dynamic perspective distinguishes conditional catch-up from changes in relative position, helping to identify where persistent regional differences warrant further investigation of institutional and structural constraints.

3. Methodology

Despite considerable methodological progress, three critical gaps remain in the literature, which this research seeks to address. The *first* is spatial granularity. Most research on gender inequality in labour markets still operates at the national level or focuses on country groups rather than on the EU NUTS 2 geography. The *second* gap concerns the choice of the dependent variable. Much of the gender-inequality literature remains centred on the gender pay gap (Nchor and Náplava, 2025), while the regional convergence literature has prioritised aggregate unemployment (Overman and Puga, 2002; Gray, 2004; Tyrowicz and Wójcik, 2010; Ibáñez, 2014; Beyer and Stemmer, 2016; Yiğiteli, 2022; Borseková et al., 2025; Karahasan, 2025), productivity (Meliciani, 2006; Rosiek and Włodarczyk, 2012; Borseková et al., 2025), GDP (Giannini and Martini, 2024; Eriş-Dereli and Pinar, 2025) or broader competitiveness measures. Employment and unemployment, explicitly disaggregated by gender, have not received comparable spatial econometric attention, despite labour-market attachment being the fundamental precondition for wage equality and economic autonomy. This motivates an examination of whether aggregate indicators conceal regional differences relevant to place-sensitive policy assessment. The *third* gap is conceptual and methodological. The previous research has not yet integrated the spatial, gendered and dynamic temporal dimensions of labour-market convergence into a single cohesive framework.

To address these gaps, our analysis examines employment and unemployment rates (y_{rt}) across 244 NUTS-2 regions ($r \in \{1,\ldots,R\}$) in the present EU-27 countries ($c \in \{1,\ldots,C\}$) over the period 1999–2024. We evaluate total, male and female employment (TE, ME, FE) and unemployment (TU, MU, FU) for populations aged 15 years and over. Missing observations in the regional labour-market series were imputed using a structured multi-stage procedure developed by the authors. The complete methodology, original Eurostat data, enriched datasets with imputed values, audit variables and Stata implementation code are publicly available in the Lithuanian National Open Access Research Data Archive (MIDAS) under DOI: https://doi.org/10.18279/MIDAS.554492. Descriptive statistics and panel decomposition measures for all labour-market variables are reported in Supporting material Appendix A1, Table A1, including the overall variation and the between- and within-region components.

Because our convergence framework targets low-frequency structural dynamics, we isolate the long-run trend component (y^{tr}_{rt}) from short-run cyclical fluctuations using an HP filter (Hodrick and Prescott, 1997). Applying an annual smoothing parameter, $\lambda = 400$, emphasises low-frequency movements and reduces cyclical variation in the relative transition paths used for club identification and convergence testing. However, the standard HP filter has faced criticism in the literature; specifically, it can induce spurious cyclical dynamics that lack an underlying basis in the data-generating process, suffer from severe end-point bias and rely on an arbitrary smoothing parameter (Cogley and Nason, 1995; Hamilton, 2018). To assess sensitivity to filtering, we compare the club classifications obtained using the Hamilton regression filter (Hamilton, 2018), the Butterworth high-pass filter (Pollock, 2000) and the Christiano-Fitzgerald random-walk band-pass filter (Christiano and Fitzgerald, 2003). All four filters yield multiple clubs, although their number and regional membership vary (Table A3.2). These comparisons do not eliminate endpoint uncertainty or establish the robustness of every subsequent estimate.

To assess whether European regional labour markets share common long-run stochastic trends, we utilise the Phillips-Sul convergence methodology. Unlike traditional β- and σ-convergence frameworks that assume homogeneous dynamics or strict stationarity (Barro and Sala-i-Martin, 1992; Islam, 1995), the log t test accommodates nonlinear transitional paths and time-varying heterogeneity without imposing deterministic trends or unit-root restrictions (Dufrénot et al., 2012; Corrado et al., 2005). This flexibility is vital for the EU-27 regional data, which are characterised by institutional and structural diversity (Rodríguez-Pose, 1999; Ezcurra et al., 2005). The procedure transforms the data into relative transition parameters:

$$h_{rt} = \frac{y^{tr}_{rt}}{\frac{1}{R}\sum_{r=1}^{R} y^{tr}_{rt}}, \tag{1}$$

which capture the dynamic trajectory of each region relative to the panel average. Convergence is evaluated via the following log t regression:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log(\log t) = a + b\log(t) + u_t, \tag{2}$$

$$\text{with} H_t = \frac{1}{R}\sum_{r=1}^{R}(h_{rt}-1)^2, \tag{3}$$

where H_t denotes the cross-sectional variance. The model is estimated over a truncated window ($r = 0.33$) and the regression is estimated over $t = [rT], [rT]+1,\ldots,T$. Convergence is not rejected at the 5% level when $t_{\hat{b}} > -1.65$; a positive estimate of $\hat{b}$ provides stronger support for convergence. If full-panel convergence is rejected, we deploy a data-driven clustering algorithm. Regions are ranked by their final-period levels to form a core group, to which regions are sequentially added if they meet the log t threshold. To ensure parsimony and avoid over-segmentation, an iterative merging algorithm tests and combines adja-

cent clubs in the ordered classification whose union fulfils the convergence criterion.

Building on these identified clubs, we estimate conditional β-convergence after accounting for region fixed effects, common time effects and country-specific trends. A negative β indicates catch-up conditional on these controls, not necessarily narrowing of observed regional disparities. The baseline specification is:

$$\Delta \ln y_{rt}^{tr} = \alpha_r + \gamma_t + \theta_c t + \beta \ln y_{rt-1}^{tr} + \varepsilon_{rt}, \tag{4}$$

where $\Delta \ln y_{rt}^{tr} = \ln y_{rt}^{tr} - \ln y_{r,t-1}^{tr}$, α_r and γ_t capture region and time fixed effects, and $\theta_c t$ accounts for country-specific long-run structural trends. To address intra-unit persistence and cross-sectional dependence in standard error estimation, we initially use regional-level clustered standard errors to account for intra-unit dependencies, such as labour-market inertia. To address serial and contemporaneous cross-sectional correlation, we introduce a Beck-Katz panel-corrected standard errors (PCSE) estimator (Beck and Katz, 1995) and a Prais-Winsten transformation (Prais and Winsten, 1954) with region-specific AR(1) errors. As an alternative treatment of cross-sectional and serial dependence, we employ Driscoll-Kraay standard errors (Driscoll and Kraay, 1998).

Because European labour markets have absorbed severe structural shocks, ranging from EU enlargements to the Great Recession and the COVID-19 pandemic, the assumption of a temporally stable convergence parameter β may obscure critical regime shifts. To accommodate this, we extend the model to identify multiple unknown structural breaks (Bai and Perron, 1998, 2003; Ditzen et al., 2022, 2025). The dynamic structural-break formulation allows the convergence speed to vary across s regimes:

$$\Delta \ln y_{rt}^{tr} = \alpha_r + \gamma_t + \theta_c t + \sum_{s=1}^{S+1} \beta_s D_{s,t} \ln y_{rt-1}^{tr} + \varepsilon_{rt} \tag{5}$$

where $D_{s,t}$ is a regime indicator equal to 1 if time t falls between breakpoints $T_{s-1}+1$ and T_s. Utilising the unified framework of Ditzen, Karavias and Westerlund, we sequentially test for breaks against the alternative of an increasing number of structural shifts. The specification includes cross-sectional averages of the regressor to account for common components (Pesaran, 2006), while the resulting break dates remain descriptive of changes in conditional relationships rather than causal event effects. Break dates are optimised through dynamic programming to minimise the sum of squared residuals, yielding break dates with confidence intervals and regime-specific β_s parameters with standard errors, describing temporal variation in the estimated relationships within the full panel and individual clubs.

To account for geographical interdependence, we use a dynamic spatial econometric framework. Candidate spatial weight matrices (W) represent distance decay and selected institutional frictions through administrative-border and language-related weights. Centroid distances are calculated within a European projected coordinate system, and the matrices are row-standardised so that spatial lags represent weighted averages of connected regions (Appendix A2, Table A2). These choices encode possible spatial relationships; they do not directly measure commuting, job-search or other transmission channels.

We compare candidate matrices using fixed-effects SDM approximations, with residual sum of squares (RSS)-based pseudo-Akaike and pseudo-Bayesian information criteria. The selected matrix for each indicator is then used to compute Moran (1950), Geary (1954), and the final SDM estimates. This is a proxy comparison of model fit rather than a test that coefficients or impacts are invariant across matrices; spatial estimates are interpreted conditional on the selected W.

We use the SDM to represent dependence in regional adjustment and spatially lagged regressors. The generalised specification is:

$$\Delta \ln y_{rt}^{tr} = \tau \Delta \ln y_{rt-1}^{tr} + \psi W \Delta \ln y_{rt-1}^{tr} + \rho W \Delta \ln y_{rt}^{tr} + \beta \ln y_{rt-1}^{tr} + \varphi W \ln y_{rt-1}^{tr} + \alpha_r + \gamma_t + \theta_c t + \varepsilon_{rt} \tag{6}$$

where ε_{rt} represents a stochastic error term. This specification distinguishes short-run local (τ) and neighbour-driven (ψ) adjustments, contemporaneous spatial spillovers (ρ) and lagged-level associations (β, φ). Static and dynamic models use a quasi-maximum likelihood estimator with region and time fixed effects and country-specific trends (Belotti et al., 2017). The dynamic specification includes temporal and space-time lags, with analytical bias correction; spatial simultaneity is represented in the likelihood. No external instruments are used. Region-clustered standard errors and Monte Carlo impact decompositions provide inference conditional on these assumptions.

To capture the long-run evolution of regional (un)employment disparities, we complement our regression-based analysis with a non-parametric distributional dynamics framework. Following the empirical foundations of regional convergence analysis, this approach utilises Markov transition matrices to quantify intra-distributional mobility alongside KDE to track the cross-sectional shape of the distribution over time (Fingleton and López-Bazo, 2006; López-Bazo et al., 1999; Magrini, 1999; Pittau et al., 2010; Quah, 1996). Because the HP filter suppresses short-term cyclical volatility, standard annual transitions are largely uninformative for detecting structural changes. Therefore, we estimate Markov transition matrices over five- and seven-year intervals to capture medium-term changes in regional rankings (Bickenbach and Bode, 2003; Fingleton and López-Bazo, 2006).

Regions are assigned to discrete states $Q_{rt} \in \{1, \ldots, q\}$, based on their relative ranking within the trend-adjusted log (un)employment distribution (Azzoni and Servo, 2002). We implement a dual-resolution specification to dissect mobility patterns: quintiles (q = 5) isolate macro-level structural mobility across broad segments of the regional hierarchy (Fingleton, 1997; Magrini, 1999; Quah, 1996), while deciles (q = 10) capture fine-grained, incremental micro-mobility and local re-ranking (Pittau et al., 2010). For each transition lag, we compute a $q \times q$ conditional transition probability matrix P, which in turn yields the ergodic distribution π, which is the invariant distribution satisfying $\pi = \pi P, \sum_{j=1}^{q} \pi_j = 1$. This stationary vector describes the limiting rank-state distribution implied by the estimated transition matrix under a time-homogeneous Markov assumption; it is not a forecast of absolute labour-market outcomes. To summarise overall distributional fluidity independent of its localised shape, we compute the Shorrocks mobility index (Shorrocks, 1978):

$$M = \frac{q - \mathrm{tr}(\mathrm{P})}{q - 1} \tag{7}$$

where $tr(P)$ is the trace of the transition matrix.

To examine the cross-regional distribution, we estimate the cross-sectional probability density of regional (un)employment trends via KDE. Densities are evaluated at strategically selected benchmark years ($t \in \{1999, 2004, 2007, 2009, 2012, 2019, 2020, 2022, 2024\}$). The benchmark years provide descriptive snapshots of enlargement, the financial and sovereign debt crises, and recent disruptions. Filtering reduces short-run variation but does not establish the timing or effects of those events. We deploy a Gaussian kernel function to accurately accommodate potential non-symmetric or multimodal features (Silverman, 1986), utilising Silverman's rule-of-thumb bandwidth selector to balance bias and variance in compact support distributions optimally:

$$h = 0.9 \cdot \hat{\sigma} \cdot n^{-\frac{1}{5}} \tag{8}$$

where $\widehat{\sigma}$ is the sample standard deviation, and n is the number of regional observations.

We report WARPing mode counts as descriptive summaries of the estimated density shapes and use the dip test to assess the null hypothesis of unimodality. Density modes and Phillips-Sul convergence clubs measure different features of the data and are not treated as equivalent classifications.

Several limitations qualify the interpretation of this framework. Trend extraction can smooth genuine adjustment and distort endpoints; comparisons across HP, Hamilton, Butterworth, and Christiano-Fitzgerald filters assess sensitivity, but do not eliminate measurement uncertainty. Club numbers and memberships remain, to some point, filter-dependent, and inference for clubs containing very few regions requires particular caution. Uncertainty from trend extraction and data-driven club selection is not fully captured by the reported regression standard errors. Region and year effects, country-specific trends, and clustered, PCSE, and Driscoll-Kraay specifications address selected sources of heterogeneity and dependence but do not establish causal identification or eliminate all finite-sample bias. Break estimation allows convergence relationships to vary over time; correspondence between estimated dates and historical events does not identify those events' effects. Spatial results are conditional on the candidate weight matrices and the selection criterion. Spatial coefficients alone do not identify transmission channels or geographical reach. The analysis, therefore, distinguishes conditional associations from mechanisms suggested by the literature. Finally, Markov transitions measure movement between ranked quantile states, not between Phillips-Sul clubs; their interpretation depends on the chosen partition and horizon. We compare five- and seven-year transitions using quintiles and deciles, and distinguish descriptive density modes from formal evidence: the reported dip tests do not reject unimodality. Taken together, these procedures provide complementary evidence on regional adjustment rather than an independently identified explanation of its institutional causes.

4. Results

4.1. Convergence and club identification

The empirical analysis begins by testing whether European regional labour markets follow a common transition path. The log t results reject full-panel convergence across all six labour-market indicators (Appendix A3, Table A3.1), with full-panel statistics below the −1.65 threshold. For instance, total employment yields a test statistic of −48.92 and total unemployment a statistic of −17.60. These results provide evidence against a common full-panel convergence path over 1999–2024 and motivate the Phillips-Sul club-identification procedure. They indicate persistent heterogeneity within the sampled NUTS 2 regions, without constituting a general rejection of convergence theory or establishing that the identified trajectories are permanent equilibria.

The clustering algorithm identifies differences between aggregate and gender-specific employment trajectories. Total and male employment each form five convergence clubs, whereas female employment forms four (Appendix A3, Table A3.1). Female Employment (FE) Club 1 encompasses 176 regions, indicating a large group with compatible relative transition dynamics. Male employment also has a large initial club, but its regional composition and smaller-club structure differ. The relative transition paths in Appendix A3 (Figs. A3.1-A3.3) further illustrate these distinctions: female employment trajectories are comparatively concentrated around the panel average, particularly in the dominant club, while male employment shows more dispersed paths among the smaller clubs. The aggregate employment classification, therefore, does not reproduce the gender-specific geography of adjustment. Institutional and sectoral differences offer possible explanations for these patterns, but the club-identification procedure does not separately estimate their contributions.

Unemployment displays more widely separated relative transition paths. Total unemployment (TU) forms four clubs, male unemployment (MU) three, and female unemployment (FU) four (Appendix A3, Table A3.1). The average paths in Figure A3.7 show a marked contrast with the comparatively compressed employment trajectories. In particular, the highest-unemployment TU and FU clubs, both labelled Club 1, move further above the panel average, reaching mean relative unemployment levels more than four times the average by 2024. Club 4 exhibits comparatively low unemployment trajectories in both series. These patterns document widening relative differences between clubs; they should be distinguished from the conditional convergence or divergence estimated within each club in Section 4.2. The regional transition paths in Figures A3.4-A3.6 also show substantial heterogeneity within this differentiated geography of unemployment.

The maps in Appendix A3 (Fig. A3.8) show geographical concentrations of club membership, although convergence clubs need not be spatially contiguous. The alternative filters continue to yield multiple convergence clubs, but their number and regional membership vary (Table A3.2). The evidence, therefore, supports heterogeneous trajectories more consistently than any single exact partition. These comparisons assess the sensitivity of the club classification; they do not establish the robustness of every subsequent regression, break estimate or spatial impact. Overall, the club results show that total employment and unemployment indicators conceal differences in the regional adjustment patterns of men and women.

4.2. Conditional beta-convergence

Following the rejection of a common full-panel path, the analysis examines conditional β-convergence within the full panel and identified clubs. The full-panel Wooldridge, Pesaran and modified Wald diagnostics reject their respective null hypotheses at the 5% level, indicating serial correlation, cross-sectional dependence and heteroskedasticity; the strength of the evidence varies across individual clubs (Appendix A4, Table A4.2). Accordingly, Table A4.1 reports regional clustered, PCSE and Driscoll-Kraay/SCC specifications. These provide alternative treatments for dependence and inference while leaving the estimates subject to the limitations discussed in Section 3, particularly for clubs with very few regions.

The conditional employment models show comparatively strong evidence of female catch-up. Female employment has significant negative full-panel coefficients across all three specifications, including −0.0399 under SCC inference ($p < 0.01$). FE Club 1 also has a negative coefficient of −0.0532 under SCC inference ($p < 0.01$), consistent with conditional catch-up within this large group (Appendix A4, Table A4.1). Male employment coefficients are smaller in absolute magnitude and less consistently significant: its full-panel PCSE estimate is −0.0172 and is not statistically significant. For the full panel and FE Club 1, respectively, the SCC coefficients imply annual conditional adjustment speeds of 4.1% and 5.5% and half-lives of 17.0 and 12.7 years. Using annual observations, these are calculated as $\kappa = -\ln(1+\beta), \mathrm{aH} = \ln(2)/\mathrm{kappa}$, assuming constant coefficients and controls. These half-lives indicate gradual adjustment towards conditional regional trajectories, not convergence in observed regional disparities or the gender employment gap.

The reported full-panel unemployment models do not show significant negative coefficients on convergence. Female unemployment has positive coefficients under clustered and PCSE estimation, including 0.1039 under PCSE ($p < 0.01$), but its coefficient is not significant under Driscoll-Kraay inference (Appendix A4, Table A4.1). At the club level, adjustment is heterogeneous. TU Club 2, MU Clubs 1 and 2, and FU Clubs 2 and 3 have significant negative coefficients across the three reported specifications. By contrast, TU Club 4, MU Club 3 and FU Club 4 have significant positive coefficients across these specifications. Figure A3.7 places the latter groups in comparatively low-unemployment trajectories. Their positive coefficients indicate conditional divergence within those groups, rather than demonstrating that

the highest-unemployment clubs are diverging internally. The widening relative disadvantage of high-unemployment clubs is a separate feature of the transition paths. Together, the results support a heterogeneous adjustment to unemployment more clearly than a uniform divergence across all regions and specifications.

4.3. Structural break analysis

The structural-break analysis examines whether conditional convergence relationships vary over time. Appendix A5 reports the sequential tests (Table A5.1), estimated break dates and confidence intervals (Table A5.2), and regime-specific coefficients (Table A5.3). The strength of the break-test evidence differs across indicators and clubs, so the reported regime specifications are interpreted separately. The analysis describes temporal variation in regional adjustment; it does not by itself attribute changes to particular macroeconomic events or establish that their effects are permanent.

The estimated employment break dates differ by gender (Appendix A5, Table A5.2). Total and female employment exhibit breaks in 2005 and 2011, followed by breaks in 2017 and 2016, respectively; male employment exhibits breaks in 2008, 2013 and 2017. These dates indicate changes in conditional relationships; temporal proximity to integration or crisis episodes does not identify the effects of events. Interpretation must also account for the confidence intervals, possible adjustment delays and smoothing of the underlying series. Female employment retains significant negative coefficients in each estimated full-panel regime, including −0.03334 in 2006–2011 and −0.04155 in 2017–2024 (both $p < 0.01$; Table A5.3). This indicates continuing conditional catch-up within those regimes, rather than immunity to crisis. Unemployment has a different and gender-specific break chronology. Total unemployment has estimated breaks in 2005, 2012 and 2020; male unemployment in 2003, 2008, 2011, 2015 and 2021; and female unemployment in 2010 and 2020 (Appendix A5, Table A5.2). The full-panel total-unemployment coefficient changes from an insignificant 0.00296 in 1999–2005 to a significant 0.02559 in 2006–2012 ($p < 0.05$), and then to 0.03729 in 2021–2024 ($p < 0.01$). Female unemployment coefficients are positive throughout the reported regimes, with significant estimates of 0.03509 in 2011–2020 and 0.04320 in 2021–2024 (both $p < 0.05$; Table A5.3). These results indicate periods of conditional divergence in the full-panel unemployment relationships. These changes cannot be attributed to particular crises, nor do they imply uniform responses across regional clubs. Institutional and sectoral explanations are therefore considered as contextual interpretations in Section 5.2.

4.4. Spatial dynamics

The spatial diagnostics show significant geographic dependence in regional labour market outcomes. Moran's I and Geary's c indicate spatial association at both the level and growth rate for all six indicators over the reported 2000–2024 period (Appendix A6, Tables A6.1-A6.3). In 2024, Moran's I is 0.730 for the total employment level and 0.823 for female unemployment. The SDM specifications use candidate weight matrices incorporating distance decay and border-related frictions (Appendix A2, Table A2). The RSS-based pseudo-AIC and pseudo-BIC scores differ only marginally across candidates, providing weak discrimination among plausible weighting schemes. Similar fit does not establish robustness of spillover magnitudes or significance; their sensitivity across alternative matrices remains unquantified. The selected matrix for all three employment indicators is w_lab_exp75_border10. The unemployment selections differ: *w_lab_rook_exp75_border10* for total unemployment, *w_lab_exp75_benelux75* for male unemployment, and *w_lab_exp75_domestic* for female unemployment. These choices define the spatial relationships, conditional on which the subsequent estimates are interpreted.

The full dynamic specifications have lower reported AIC and BIC than the static xsmle specifications for all indicators (Appendix A6, Tables A6.4-A6.6), although differing estimation samples limit direct comparison. Contemporaneous spatial coefficients (ρ) are positive and significant. In the fully dynamic specification, total employment has $\rho = 0.73549$ ($p < 0.01$), while male and female employment have coefficients of 0.70046 and 0.59143, respectively (both $p < 0.01$). These estimates indicate positive spatial dependence in adjustment under the selected common employment matrix. Their magnitudes do not measure the geographical radius of spillovers or establish a particular transmission mechanism. Sectoral composition, commuting and supply-chain connections offer possible interpretations, but the spatial coefficients do not separately identify these channels.

Unemployment likewise exhibits positive spatial dependence in adjustment. In the dynamic models, the temporal coefficient τ is near or above unity, while the space-time coefficient ψ is negative and significant; for total employment, $\psi = -0.74755$ ($p < 0.01$). These coefficients must be interpreted jointly with the other dynamic terms and do not establish a drain of workers or investment towards neighbouring regions. The impact decompositions provide a further distinction: dynamic short-run indirect effects are negative and significant for total, male and female employment, whereas the corresponding unemployment effects are not significant (Appendix A6, Tables A6.4-A6.6). Dynamic long-run direct and indirect effects are estimated with imprecision. The results consequently support interdependent regional adjustment without identifying specific channels of contagion or competition.

4.5. Distributional dynamics

Markov transition matrices and Shorrocks mobility indices describe how regional rankings change over time (Appendix A7, Tables A7.1 and A7.2). At a seven-year horizon with decile states, the male employment index is 0.6885, compared with 0.4887 for female employment. Thus, female employment exhibits less movement between relative-rank states, even though its conditional β-convergence estimates indicate catch-up. These findings describe distinct aspects of adjustment: initially, lower-employment regions may improve conditionally while the regional ordering remains persistent. The indices do not measure individual worker mobility, movement between Phillips-Sul clubs or convergence of the gender employment gap. Institutional differences discussed in the literature offer possible explanations for the persistence, rather than mechanisms identified by the transition matrices.

At the same seven-year decile horizon, unemployment rank mobility is higher than employment rank mobility for both genders. The male unemployment Shorrocks index is 0.7939, compared with 0.6985 for female unemployment, indicating greater persistence in female regional rankings (Appendix A7, Table A7.2). These are summaries of movement across the entire distribution. They do not measure the probability of leaving a particular high-unemployment state, and greater mobility does not necessarily imply improved outcomes because re-ranking may occur in either direction.

The KDEs and WARPing mode counts provide descriptive evidence about distributional shape (Appendix A7, Tables A7.3 and A7.4; Figs. A7.1-A7.7). Total employment has two estimated modes in each reported cross-section from 2007 onwards, and female employment from 2004 onwards; a single mode mostly represents male employment. Unemployment densities display between two and four estimated modes, with female unemployment showing two or three across the benchmark years. However, the dip tests do not reject unimodality in any reported cross-section; all reported p-values exceed 0.25. The multi-peaked estimates are therefore descriptive indications of distributional structure, not formal confirmation of multimodality or distinct structural traps. This qualification does not negate the separately documented differences in regional rank mobility or convergence-club trajectories.

5. Discussion

5.1. Implications for regional convergence and gender inequality

The principal academic implication is that regional labour-market convergence has several empirically distinct dimensions. Rejection of full-panel convergence can coexist with conditional catch-up within a heterogeneous regional system, while catch-up need not produce rapid changes in regional rankings. The coexistence of these patterns calls into question any interpretation of integration based on a single convergence measure. It connects the evidence on differentiated European regional trajectories in Bartkowska and Riedl (2012) and Borseková et al. (2025) with the persistent unemployment disparities examined by Beyer and Stemmer (2016). The contribution here is to examine these dimensions jointly for employment and unemployment, and separately for men and women, within the same regional panel. The results provide evidence against a common transition path over the observation period, rather than a general rejection of convergence theory.

Female employment illustrates why these distinctions matter. Its full-panel conditional coefficient is negative across all three reported specifications, and its largest Phillips-Sul club contains 176 regions. Nevertheless, its rank mobility is lower than male employment mobility: the seven-year decile Shorrocks indices are 0.489 and 0.689, respectively. Conditional catch-up can therefore occur alongside persistent relative ordering. This is consistent with regional differences that continue to shape employment opportunities even as initially lower-employment regions improve conditionally. The gender and regional persistence examined by Baussola and Mussida (2017), and the institutional and sectoral differences discussed in Section 2.3, offer plausible interpretations. However, care provision, occupational segregation and gender norms are not separately identified in the present models. Moreover, convergence within male and female series does not itself establish convergence of the gender employment gap or broader gender equality.

Employment and unemployment also describe different dimensions of adjustment. Employment rates use the population denominator, whereas unemployment rates use the labour force. Changes in participation can therefore permit employment expansion without a proportional decline in unemployment. This accounting distinction helps explain why stronger female employment catch-up and persistent unemployment differentiation need not conflict. It also limits the inference that new jobs necessarily fail to reach previously unemployed women: testing that mechanism would require measures of participation or individual labour-market transitions. In the reported full-panel models, female unemployment does not display robust conditional convergence, but its positive coefficient is not significant under Driscoll-Kraay inference. The evidence consequently supports heterogeneous adjustment more clearly than uniform divergence across all regions and specifications.

The spatial results extend this interpretation by showing that regional adjustment is geographically interdependent, connecting the analysis to Overman and Puga (2002) and the territorial-development perspective of Iammarino et al. (2019). Contemporaneous spatial coefficients are positive, but their magnitudes are not direct estimates of the geographical reach of spillovers or proof of a particular transmission mechanism. Commuting, supply chains and shared institutions are possible explanations rather than measured causal channels. Similarly, lower female rank mobility and persistent differences between club trajectories indicate durable territorial differentiation, whereas the density modes remain descriptive because the dip tests do not reject unimodality. The resulting “dual geography” is best understood as the coexistence of comparatively stronger employment catch-up and more heterogeneous unemployment adjustment, with gender differences in their spatial and distributional patterns.

5.2. European integration and successive crises

European integration provides a relevant setting for the coexistence of catch-up and persistent territorial differentiation. Enlargement expanded opportunities for trade, investment and labour mobility, but regions differed in their capacity to participate in these processes. The Ninth Cohesion Report documents substantial convergence among newer Member States alongside persistent regional disparities, cautioning against equating national catch-up with uniform territorial improvement (European Commission, 2024). The 2005 total and female employment breaks do not estimate enlargement effects, and their timing cannot distinguish trade integration, migration or institutional adjustment from other contemporaneous changes.

The 2008–2009 financial crisis and the subsequent sovereign debt crisis should be distinguished because their transmission mechanisms and policy environments differed. The literature suggests that construction and manufacturing can transmit contractions differently from sectors with higher female employment shares; the 2008 male employment break does not test this mechanism. Subsequent fiscal constraints and uneven recoveries could also interact with regional labour demand and public-service provision. These interpretations are consistent with the gendered persistence discussed by Baussola and Mussida (2017), and with evidence that European employment shifts differed across countries, sectors and occupational groups (Torrejón Pérez et al., 2023). The 2010 female unemployment break likewise cannot be isolated to austerity, demand, or care-related mechanisms. COVID-19 introduced a different combination of restrictions, sectoral disruption, care demands and employment support. Eurofound (2022) reports a broadly gender-neutral aggregate EU employment impact alongside substantial differences across sectors and households, including an unequal distribution of unpaid care. Job-retention schemes also preserved employment relationships in many countries (OECD, 2020). This evidence provides pandemic context; the 2020–2021 unemployment breaks do not estimate COVID-19 effects or establish a common regional response. The faster economic recovery after COVID-19 than after the 2009 recession, documented by the European Commission (2024), further cautions against treating all crises as equivalent. Longer-term demographic and structural change may also shape the trend series, leaving the mechanisms behind the estimated regimes open to further investigation.

6. Policy implications

The evidence against a common regional transition path supports a differentiated approach to cohesion policy. Regions with distinct employment and unemployment trajectories may face different constraints, making aggregate national indicators insufficient for identifying local priorities. Club classifications and gender-specific outcomes can help target further assessment of those constraints, alongside local institutional and sectoral information. Because exact memberships are sensitive to filtering and the models do not estimate policy effects, the classifications should inform policy diagnosis rather than mechanically determine funding eligibility or imply that a single intervention will suit every region within a club.

Policy design should also account explicitly for gender. Stronger conditional female employment catch-up coexists with lower female rank mobility and persistent differences in unemployment, so progress in total employment can conceal uneven opportunities for men and women. The literature discussed in Sections 2 and 5 points to care responsibilities, sectoral composition and institutional arrangements as relevant areas for regional assessment. Depending on the constraints identified locally, priorities may include childcare and care infrastructure, tax-benefit arrangements affecting second earners, access to suitable working arrangements, skills development and industrial resilience. These are policy options informed by the wider evidence, rather than interventions whose effectiveness is estimated in this study.

Their design should reflect local conditions and should not assume that the estimated spatial coefficients establish different geographical policy boundaries for male and female employment.

Employment expansion and unemployment reduction also require separate policy monitoring. Employment rates use the population denominator, whereas unemployment rates use the labour force, so changes in participation can produce different movements in the two indicators. The coexistence of female employment catch-up and heterogeneous adjustment in female unemployment, therefore, motivates further investigation into labour force participation, skills mismatches, and barriers to employment. It does not establish that new jobs systematically fail to reach previously unemployed women. Combining the regional evidence with participation measures and individual labour-market transitions would help identify which groups require support and which active labour-market measures address their constraints.

The spatial results support the consideration of links between neighbouring and economically connected regions when designing interventions. Coordination across functional labour-market areas may be relevant for transport, skills recognition and access to employment. However, the models do not identify the effects of specific investments or demonstrate a cross-border drain of human capital. The break analysis also supports monitoring changes in regional adjustment relationships during periods of economic disruption. As discussed in Section 5.2, enlargement, financial and sovereign-debt crises, and COVID-19 occurred in different sectoral and policy settings, with potentially uneven gender and regional consequences. Crisis preparedness and locally informed support remain relevant policy priorities. However, the estimated dates do not show that every crisis permanently worsened territorial outcomes or that a particular stabilisation instrument would prevent divergence.

7. Conclusions

This study documents heterogeneous employment and unemployment adjustment across 244 NUTS 2 regions of the present EU-27 over 1999–2024. Full-panel convergence is rejected for all six indicators, while conditional employment catch-up, particularly for women, coexists with persistent regional rankings and differentiated unemployment trajectories. The results provide evidence against a common transition path over the observation period. Comparing total, male and female indicators reveals differences in club composition, conditional adjustment and rank mobility that aggregate measures alone do not capture. This gender-specific territorial differentiation is the central contribution; it does not establish convergence in the gender employment gap or broader gender equality.

The five-part framework identifies complementary dimensions of this differentiation. Club analysis documents multiple relative trajectories, while conditional models show clearer employment catch-up than unemployment convergence. Within-club divergence is not confined to the highest-unemployment paths: positive coefficients also occur in comparatively low-unemployment groups. Estimated breaks identify changes in conditional relationships, without identifying the effects of enlargement or crises. Spatial models indicate interdependent adjustment, with imprecise separate long-run direct and indirect effects. Finally, female employment and unemployment exhibit lower seven-year decile-rank mobility than those of their male counterparts. At the same time, the estimated density peaks remain descriptive because the dip tests do not reject unimodality. These distinctions prevent any single measure from standing in for the full pattern of regional convergence.

The resulting dual geography is the coexistence of comparatively stronger employment catch-up and more heterogeneous unemployment adjustment, with gender differences in their spatial and distributional patterns. Improvements in one dimension need not eliminate persistent relative disadvantage in another. This supports place-based, gender-sensitive, and spatially coordinated assessment of European labour market policy. Further research linking regional trajectories to participation, individual transitions and institutional or sectoral conditions could test the mechanisms suggested by the literature and evaluate which interventions improve outcomes. The present findings establish the importance of differentiated regional adjustment while leaving those causal and policy-effectiveness questions open.

CRediT authorship contribution statement

Mindaugas Butkus: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Conceptualization. **Laura Dargenytė-Kacilevičienė:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Data curation. **Kristina Matuzevičiūtė:** Writing – review & editing, Writing – original draft, Resources, Conceptualization. **Dovilė Ruplienė:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Raimonda Valasevičienė:** Writing – original draft, Resources, Formal analysis.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.pirs.2026.100176.

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