SPATIAL DYNAMICS OF INTRA-EUROPEAN OUTWARD FDI: ANALYSIS AT THE REGIONAL LEVEL⌖

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ABSTRACT

As the process of European economic integration is in full swing, European regions have been experiencing a period of unprecedented change, being transformed into integral parts of the European economic space. Yet, the scarcity of data on economic flows at the regional level (i.e., interregional data) acts as a deterrent to the end of the thorough understanding of the spatial dynamics and externalities that are generated and / or reproduced. Hence, several important questions regarding the dynamics of the European economic integration process remain unsolved, for both scholars and policy makers. The paper offers a new understanding of the interrelations among regional economies in Europe, examining the spatial dynamics of intra-European outward foreign direct investment (FDI) across European NUTS-2 regions and over the period 2010-2018 (i.e., from the beginnings of the economic crisis to the outbreak of the COVID-19 pandemic). To this end, the paper integrates a Poisson Pseudo-Maximum Likelihood (PPML) gravity framework with spatial Markov chain analysis. Particularly, using high-dimensional fixed effects, the paper recovers region-specific outward FDI capacity (i.e., exporter fixed effects) and assesses both its spatial clustering and its mobility across relative performance states. Moving beyond static views of regional attractiveness, the paper models transitions across four pooled performance states and conditions them on local neighborhood regimes, thus capturing how spatial context shapes persistence, upgrading and downgrading. The results of the paper point to pronounced spatial dependence: regions embedded in high-performing neighborhoods display markedly higher state persistence, while upward mobility does not differ systematically across neighborhood regimes. These findings underscore the role of spatial context in shaping regional FDI trajectories and motivate place-based investment and cohesion policies that account for persistent neighborhood regimes. For the needs of the analysis, the paper utilizes a novel origin-destination (O-D) matrix for intra-European FDI flows at the regional level.

Keywords: *European regions, FDI, PPML gravity, spatial Markov chain analysis*

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1. INTRODUCTION

Europe is gradually moving from a "space of States" to a "State of spaces" and from a "space of places'' to a "space of flows''. In a nutshell, the pure essence of the European economic integration process is the gradual "thinning" and "melting" of (the artificial) border impediments. As the process of European economic integration is in full swing, European territories have been experiencing a period of unprecedented change, being transformed into integral parts of the European economic space (Brülhart et al., 2004; Petrakos et al., 2005; Crescenzi et al., 2014). Yet, although economic integration has greatly enhanced the mobility of products, people, and money, this does not imply the ubiquity of economic activity. In fact, such "stickiness" may even reinforce spatial externalities (Kemeny, 2011). Thus, it becomes apparent why geography "matters" so much (Gertler, 2003).

The emerging European reality necessitates the thorough understanding of the spatial dynamics that are generated and / or reproduced within the framework of the European economic integration process. Apparently, access to (high-quality) data is a necessary condition for undertaking the required analyses and deriving the corresponding conclusions on the interrelations among European regions. Unfortunately, data on flows is scarce and, in most cases, only at the national level. Thus, due to this limitation, important issues regarding the success and the impact of the European economic integration process and policies remain unexplored and unsolved, for both scholars and policymakers. This is an important drawback, especially in the light of the global mega-trends that are currently taking place.

The paper offers a new understanding of the interrelations among regional economies in Europe, examining the spatial dynamics of intra-European outward foreign direct investment (FDI) across European NUTS-2 regions and over the period 2010-2018 (i.e., from the beginnings of the economic crisis to the outbreak of the COVID-19 pandemic). To this end, the paper integrates a Poisson Pseudo-Maximum Likelihood (PPML) gravity framework with spatial Markov chain analysis. Particularly, using high-dimensional fixed effects, the paper recovers region-specific outward FDI capacity (i.e., exporter fixed effects) and assesses both its spatial clustering and its mobility across relative performance states. Moving beyond static views of regional attractiveness, the paper models transitions across four pooled performance states and conditions them on local neighborhood regimes, thus capturing how spatial context shapes persistence, upgrading and downgrading.

The contribution of the paper is threefold. First, the paper provides a dynamic perspective on regional FDI performance in Europe by analyzing transitions across relative investment states rather than static levels. Second, the paper explicitly incorporates spatial dependence into the analysis, showing how neighboring regions' performance alters transition probabilities and persistence patterns. Third, by integrating gravity-based exporter capacity measures with spatial Markov analysis, the paper bridges two strands of the literature - FDI gravity modeling and spatial distribution dynamics - that are rarely combined.

The findings of the paper reveal strong spatial conditioning in FDI dynamics. Regions surrounded by high-performing neighbors are more likely to remain in higher FDI performance states; spatial conditioning operates primarily through regime-specific persistence rather than through systematically higher upward mobility. Conversely, regions embedded in low-performing neighborhoods exhibit stronger persistence in lower states. These results underscore the importance of spatial context and suggest that regional investment trajectories are shaped not only by internal characteristics but also by the broader spatial environment.

The current section of the paper is introductory. The next section describes the data and outlines the construction of the regional FDI performance measures. The third section presents the methodological framework, combining gravity-based estimation with spatial Markov chain analysis. The penultimate section performs the empirical analysis and discusses empirical results. The last section concludes with implications for regional development and place-based investment policy.

2. DATA

2.1. Utilization of region-to-region origin-destination matrices

FDI is "an investment involving a long-term relationship and reflecting a lasting interest and control by a foreign direct investor (i.e., an entity resident in one economy) in an FDI enterprise (i.e., an enterprise resident in an economy other than that of the foreign direct investor)" (OECD, 2008: 17; IMF, 2009: 100). A foreign direct investor may be an individual (or a group of individuals), an enterprise (public or private; incorporated or unincorporated) (or a group of enterprises), and a government. The rule of at least 10% ownership of the ordinary shares (or, in a broader sense, the control of at least 10% of the shareholders' voting power) defines the foreign direct investor. This is the established dividing line between direct investment and portfolio investment (i.e., in the form of shareholdings) (Wacker, 2013). Thus, an FDI enterprise is an enterprise in which a foreign direct investor controls at least a 10% share of the shareholders' voting power.

The paper utilizes region-to-region (R2R) origin-destination (O-D) matrices compiled for the needs of the ESPON IRiE (Interregional Relations in Europe) project (cf. Adamakou et al., 2024; Tsiapa et al., 2025). The compilation was based on the aggregation of firm-level data obtained from AMADEUS database (see https://amadeus.bvdinfo.com for details). The analysis is conducted at the NUTS-2 regional level, which provides an appropriate balance between spatial detail and data availability for cross-country FDI analysis in Europe. NUTS-2 regions correspond closely to functional economic areas in terms of production structures, labor markets, and policy implementation, making them particularly suitable for examining spatial regimes and regional investment dynamics (European Commission, 2017).

In the present paper, and under an expansive theorization, the term "FDI" refers not only to interregional international flows but also to interregional intranational flows and to intraregional flows. For the sake of simplicity, it has to be underscored that the term "FDI" is used throughout the text. The shareholders' funds unit of measurement is selected to perform the analysis. This unit represents the difference between assets and liabilities (i.e., the not-yet-compilated debt obligations for funding that used to create assets). The shareholders' funds unit of measurement refers to the amount of equity in a company, which belongs to the shareholders. In other words, the shareholders' funds unit of measurement yields an approximation of how much the shareholders would receive if a business were to liquidate.

2.2. Choice of benchmark years

The empirical analysis is based on three benchmark years: 2010, 2013, and 2018. The choice of these specific years is deliberate and reflects both substantive economic considerations and methodological requirements related to the analysis of spatial dynamics. Taken together, the selected benchmark years define two economically meaningful transition periods – 2010-2013 and 2013-2018 – spanning nearly a decade of post-crisis adjustment. This temporal design allows the analysis to focus on structural changes and long-run spatial dynamics, rather than short-run volatility.

The paper utilizes year-specific O-D matrices over harmonized NUTS-2 regional sets (2010: N=230; 2013: N=236; 2018: N=244), yielding N^2 directed dyads prior to final cleaning and model estimation. Exporter fixed effects are recovered from a PPML gravity specification with exporter and importer fixed effects; the estimation retains the subset of exporter regions for which fixed effects are identified in the final estimation sample (2010: 226 exporters; 2013: 232 exporters; 2018: 239 exporters). For the spatial Markov mobility analysis, the paper imposes a balanced panel of 226 NUTS-2 regions observed in all benchmark years, discretizes exporter performance into four states, using pooled cut-offs, and estimates regime-conditioned transition probabilities by splitting regions into low- and high-lag regimes defined by the contemporaneous spatial lag of exporter performance. At this point, it has to be clarified that a small number of regions appearing in the O-D matrices are not retained in the final PPML estimation sample and therefore do not yield identified exporter fixed effects; this is driven by standard sample restrictions and identification in two-way fixed-effects PPML after final cleaning.

2.3. Relevance for spatial Markov analysis

The use of discrete benchmark years is particularly well aligned with the spatial Markov chain framework employed in the paper. Spatial Markov models are designed to analyze transitions across states over distinct time intervals, rather than year-to-year fluctuations. The chosen intervals correspond to well-defined macroeconomic phases, facilitating the identification of persistent spatial regimes and neighborhood effects (Rey and Montouri, 1999; Rey, 2001).

By focusing on these benchmark transitions, the analysis emphasizes path dependence and spatial conditioning in regional FDI performance. This approach strengthens the interpretability of the estimated transition probabilities and avoids conflating long-run spatial dynamics with temporary investment noise.

2.4. Spatial neighborhood definition, spatial weights matrix, Global Moran's I and LISA on exporter fixed effects

Spatial dependence is modelled using a contiguity-based spatial weights matrix defined on NUTS-2 regional polygons. The paper relies on a stable NUTS-2 GIS geometry as the spatial reference and construct neighborhood relations after projecting polygons to Lambert Azimuthal Equal Area (LAEA) Europe EPSG:3035 (i.e., the European Terrestrial Reference System 1989). Neighborhoods are defined by queen contiguity (shared border or vertex) and converted into a row-standardized weights object (style 'W'), so that for each region with at least one neighbor $\sum_j w_{ij} = 1$. A snap tolerance of 1 km is used to mitigate minor boundary-gap artefacts. To accommodate isolated regions, Exploratory Spatial Data Analysis (ESDA) computations are implemented with zero.policy = TRUE, so that no-neighbor observations are retained but contribute a zero spatial lag.

The paper assesses spatial autocorrelation in outward FDI capacity by computing Global Moran's I and Local Moran statistics on exporter fixed effects extracted from the PPML gravity model. Let FE_i denote exporter fixed effects and $z_i = \frac{FE_i - \bar{FE}}{s_{FE}}$ its standardized value. The spatial lag is computed as $(Wz)_i = \sum_j w_{ij} z_j$. LISA cluster typologies (i.e., High-High, Low-Low, High-Low, Low-High) are obtained by combining the sign of z_i with the sign of $(Wz)_i$, and local significance is evaluated at $\alpha = 0.05$.

2.5. Spatial neighborhood definition, spatial weights matrix, Global Moran's I and LISA on exporter fixed effects

To analyze the distributional dynamics of regional outward FDI performance, the paper classifies regions into four ordered relative-performance states based on the exporter fixed effects $\hat{\alpha}_{it}$ obtained from the PPML gravity model. Following standard Markov-chain approaches to regional mobility and convergence (Rey and Montouri, 1999; Rey, 2001), this distribution-based classification focuses on relative positioning rather than absolute levels. To ensure strict temporal comparability, states are defined using common pooled quartile cutoffs computed over the combined 2010-2018 distribution of $\hat{\alpha}_{it}$. This pooled-threshold design allows the mass of regions in each state to vary over time, while "upgrading" and "downgrading" are interpreted as movements across fixed multi-year benchmarks rather than within-year quartile re-ranking. The pooled quartile scheme therefore provides a transparent and consistent performance scale for studying persistence and mobility across the distribution, abstracting from year-specific shifts in aggregate investment conditions.

To study persistence and mobility in outward FDI capacity, the paper constructs a spatial Markov framework using the four pre-defined performance states. Because the year-specific PPML estimations identify exporter fixed effects for 226 (2010), 232 (2013) and 239 (2018) regions, the spatial Markov analysis is conducted on the balanced subset of 226 regions observed in all benchmark years. For mobility analysis, the paper imposes a balanced panel of

226 NUTS-2 regions observed in all benchmark years (2010, 2013, 2018) and computes transition matrices for 2010→2013 and 2013→2018 periods. The paper then conditions transitions into the neighborhood context by defining regime-specific Markov chains. Specifically, for each region i the paper computes the spatial lag of exporter fixed effects in the base year, as $(WFE)_i = \sum_j w_{ij}\, FE_j$, and classifies regions into Low-lag versus High-lag regimes using a median split, ensuring balanced regime sizes. Conditional transition matrices are estimated separately within each regime for each period, allowing to assess whether mobility patterns differ systematically depending on the surrounding spatial context. As a robustness check, the paper redefines neighborhood regimes using the contemporaneous (2013) spatial lag and re-estimates the 2013→2018 conditional transitions to verify that results are not sensitive to the baseline year used to construct regimes.

2.6. Spatial regimes and neighborhood conditioning

To account for spatial interdependence in regional FDI dynamics, the analysis extends the standard Markov framework by conditioning transition probabilities on the performance of neighboring regions, following the spatial Markov approach introduced by Rey (2001). This extension allows the identification of spatial regimes, defined by the relative FDI performance of a region's local neighborhood.

For each region, a spatially lagged indicator is constructed as the contemporaneous spatial lag of exporter fixed effects, $\tilde{x}_{it} = \sum_j w_{ij}\, \hat{\alpha}_{jt}$. Regions are classified into neighbourhood regimes (low-lag vs high-lag) using a median split of $\tilde{x}_{it}$. This classification captures the spatial context in which regional FDI transitions occur, without imposing parametric assumptions on the nature of spatial spillovers.

Conditioning transition probabilities on neighborhood regimes enables the analysis to assess whether regional mobility differs systematically across spatial contexts. In particular, it allows for testing whether regions embedded in high-performing neighborhoods exhibit greater upward mobility or persistence, and whether regions surrounded by low-performing neighbors face higher risks of stagnation or downgrading. For the Markov analysis, quantile thresholds are fixed using pooled exporter fixed effects across all benchmark years. By explicitly incorporating spatial regimes into the Markov framework, the analysis moves beyond a-spatial transition dynamics and provides a structured way to evaluate the role of spatial embeddedness and neighborhood effects in shaping long-run regional FDI trajectories.

3. METHODOLOGY

3.1. Gravity framework for bilateral FDI flows

Gravity models provide the standard empirical framework for analyzing bilateral trade and investment flows. Following the theoretical foundations laid out by Anderson (1979) and Anderson and van Wincoop (2003), and their extension to FDI by Helpman et al. (2004) and Head and Mayer (2014), bilateral FDI flows are assumed to depend on origin-specific characteristics, destination-specific characteristics, and bilateral frictions.

Let FDI_{ijt} denote the flow of foreign direct investment from origin region i to destination region j at time t. The gravity representation can be written as $FDI_{ijt} = \exp\ (\alpha_i^t + \delta_j^t + Z_{ij}'\beta) \cdot \varepsilon_{ijt}$, where α_i^t and δ_j^t capture time-specific origin and destination effects often interpreted as multilateral resistance terms, and Z_{ij} includes bilateral variables reflecting geographic, institutional, and historical frictions between regions i and j. This formulation is consistent with modern structural gravity models, in which exporter and importer fixed effects absorb all region-specific determinants of outward and inward investment capacity, respectively (Anderson and van Wincoop, 2003; Head and Mayer, 2014).

3.2. Estimation using PPML

The gravity model is estimated using the Poisson Pseudo-Maximum Likelihood (PPML) estimator, following Silva and Tenreyro (2006). The conditional mean of FDI flows is specified as: $\mathbb{E}[FDI_{ijt} \mid X_{ijt}] = \exp\ (\alpha_i^t + \delta_j^t + Z_{ij}'\beta)$. PPML has become the benchmark estimator for gravity models as it delivers consistent estimates in the presence of heteroskedasticity and naturally accommodates zero flows without requiring log-linearization (Silva and Tenreyro, 2006; Head and Mayer, 2014). High-dimensional fixed effects are included to fully control for multilateral resistance and unobserved regional heterogeneity.

The estimated exporter fixed effects $\hat{\alpha}_{it}$ summarize each region's relative outward FDI performance at time t, conditional on bilateral frictions and importer fixed effects, and should be interpreted as reduced-form measures embedding both origin-specific characteristics and multilateral resistance components.

3.3. Construction of relative performance steps

For each benchmark year t∈{2010,2013,2018}, regions are ranked according to $\hat{\alpha}_i^t$ and classified into $K = 4$ performance states using fixed pooled quartile cutoffs computed over the combined 2010-2018 distribution of $\hat{\alpha}_i^t$.

Let $S_{it} \in \{1, \dots, K\}$ denote the state occupied by region i at time t, where higher values correspond to higher relative outward FDI performance. This discretization focuses the analysis on distributional position and mobility, rather than absolute investment levels.

3.4. Markov and spatial Markov dynamics

Regional mobility is first analyzed using a first-order Markov chain: $p_{rs} = \Pr\,(S_{i,t+1} = s \mid S_{it} = r)$, where p_{rs} denotes the probability of transitioning from state r to state $s$between benchmark periods.

Following Rey (2001), transition probabilities are then conditioned on the spatial context of each region. Let W denote a spatial weights matrix and define the neighborhood signal: $\tilde{x}_{it} = \sum_j w_{ij}\, \hat{\alpha}_{jt}$. Conditional transition probabilities are given by: $p_{rs}^{(k)} = \Pr\,(S_{i,t+1} = s \mid S_{it} = r, \tilde{x}_{it} \in k)$, where k indexes neighborhood regimes $k \in \{\text{low}, \text{high}\}$. This spatial extension allows the identification of spatially contingent persistence and mobility patterns in regional FDI performance.

3.5. Canonical justification of exported fixed effects

Following the canonical gravity framework (Anderson, 1979; Anderson and van Wincoop, 2003), bilateral FDI flows are modeled in multiplicative form as a function of origin-specific characteristics, destination-specific characteristics, and bilateral frictions. In empirical applications, exporter and importer fixed effects absorb all origin- and destination-specific determinants of investment flows and provide empirical counterparts to multilateral resistance terms (Feenstra, 2004; Head and Mayer, 2014). A key methodological implication of this framework is that gravity equations should be estimated in levels rather than in log-linearized form. As demonstrated by Santos Silva and Tenreyro (2006), log-linear estimation leads to inconsistent parameter estimates in the presence of heteroskedasticity and zero flows, whereas PPML estimation yields consistent estimates of the conditional mean even when fixed effects are included. Subsequent work has firmly established PPML with high-dimensional fixed effects as the benchmark estimator for gravity models (Martínez-Zarzoso, 2013). Within this setting, the estimated exporter fixed effects summarize origin-specific determinants of outward FDI performance, conditional on controlling for bilateral frictions and destination fixed effects within the PPML gravity framework and should be interpreted as reduced-form indicators embedding both origin characteristics and multilateral resistance components. A growing literature exploits this property by interpreting exporter components as summary indicators of outward economic or investment performance, rather than as causal structural parameters (Redding and Venables, 2004; Egger and Pfaffermayr, 2011).

Importantly, the analysis does not rely on the absolute magnitude of exporter fixed effects across time. Instead, it focuses on regions' relative position within the cross-sectional distribution in each benchmark year. This relative interpretation avoids comparability issues across periods and aligns naturally with distribution dynamics approaches (Rey and Montouri, 1999; Rey, 2001). Accordingly, exporter fixed effects are interpreted conservatively as indicators of relative outward FDI performance, capturing the combined effect of all origin-specific factors influencing investment flows, without imposing a causal interpretation or decomposing these effects into individual drivers. This approach is consistent with the use of estimated components as performance indices in Markov and spatial Markov analyses of mobility and persistence (Bickenbach and Bode, 2003). By combining PPML-based gravity estimates with spatial exploratory analysis and spatial Markov chains, the paper examines how regional FDI performance evolves over time and how this evolution is conditioned by spatial context, while remaining fully consistent with the theoretical and econometric foundations of the gravity literature.

4. EMPIRICAL ANALYSIS

4.1. Gravity structure of FDI flows: Validating the baseline

The paper estimates a baseline structural gravity model for bilateral FDI flows across European NUTS-2 regions using PPML with high-dimensional exporter and importer fixed effects. Bilateral distance enters as the main geographic friction. Table 1 reports the distance coefficient for each benchmark year (2010, 2013, 2018), with inference based on two-way clustered standard errors at the exporter and importer levels (and heteroskedasticity-robust standard errors as a benchmark).

Across all three years, the distance elasticity is negative and statistically significant: −0.846 (2010), −0.812 (2013), and −0.955 (2018). This pattern indicates a persistent negative association between distance and bilateral FDI flows, conditional on exporter and importer fixed effects. Model fit is stable across years, with adjusted pseudo-R^2 between 0.73 and 0.78 (0.762 in 2010; 0.733 in 2013; 0.778 in 2018). The sample size increases from 48,376 dyads in 2010 to 54,265 in 2018, reflecting wider regional coverage and a denser set of observed interactions after data harmonization. Exporter and importer fixed effects absorb time-specific origin and destination heterogeneity in FDI flows. In this setting, the estimated exporter effects provide reduced-form summaries of each region's outward FDI performance relative to other regions, conditional on distance and importer effects. Given the stability of the baseline gravity specification across benchmark years, these exporter components offer a consistent basis for the subsequent spatial analysis of outward FDI capacity.

Table 1: PPML structural gravity (Exporter & Importer FE), 2010-2018

	2010	2013	2018
ln_dist	−0.846***	−0.812***	−0.955***
(SE, 2-way clustered: coun_o & coun_d)	(0.113)	(0.133)	(0.151)
(SE, heteroskedasticity-robust)	(0.064)	(0.095)	(0.087)
Observations (N)	48,376	51,052	54,265
Exporter FE	226	232	239
Importer FE	215	221	228
Adj. Pseudo R^2	0.762	0.733	0.778
Log-Likelihood	-1.682×10^{11}	-2.410×10^{11}	-3.572×10^{11}
BIC	3.364×10^{11}	4.821×10^{11}	7.144×10^{11}
Squared Cor.	0.631	0.398	0.607

Notes: PPML estimates with exporter and importer fixed effects. Two-way clustered standard errors (exporter and importer) are reported in parentheses; heteroskedasticity-robust standard errors are reported as a benchmark. *** $p < 0.001$.

4.2. Spatial dependence and clustering of regional outward FDI performance

The paper next assess whether regional outward FDI performance exhibits systematic spatial dependence. Table 2 reports global Moran's I statistics computed on exporter fixed effects derived from the PPML gravity models for the benchmark years 2010, 2013, and 2018. The results reveal strong and highly significant positive spatial autocorrelation in all three years. In 2010, the Moran's I statistic equals 0.318 ($p < 0.001$), indicating that regions with high outward FDI capacity tend to be geographically proximate to other high-performing regions, while low-performing regions similarly cluster in space. This pattern becomes slightly more pronounced in 2013, when Moran's I rises to 0.330, suggesting an intensification of spatial dependence during the post-crisis period. By 2018, the Moran's I statistic remains virtually unchanged at 0.318, pointing to a remarkable stability of spatial clustering over time.

Table 2: Global spatial autocorrelation of regional outward FDI performance (Exporter fixed effects from PPML gravity models)

Year	Moran's I	Expected I	Variance	z-statistic
2010	0.318***	−0.0048	0.00247	6.50
2013	0.330***	−0.0047	0.00243	6.78
2018	0.318***	−0.0045	0.00233	6.70

Notes: Moran's I statistics are computed on exporter fixed effects obtained from PPML gravity models of bilateral regional FDI flows. Spatial weights are based on contiguity relationships. Regions without contiguous neighbors are retained using a zero-neighbor policy. Inference is based on randomization with a one-sided alternative hypothesis of positive spatial autocorrelation. *** $p < 0.001$.

The persistence of Moran's I across the three benchmark years implies that spatial dependence in outward FDI performance is not driven by short-term fluctuations in investment activity, but rather reflects a structural and deeply rooted spatial organization of regional investment capacity in Europe. Despite changes in aggregate FDI volumes and bilateral linkages, regions consistently remain embedded in high- or low-performing neighborhoods. These findings provide a crucial bridge between the gravity results and the subsequent local and dynamic spatial analyses. While the gravity models establish substantial heterogeneity in regional outward FDI capacity, the global Moran's I statistics demonstrate that this heterogeneity is systematically structured in space. This motivates the use of Local

Indicators of Spatial Association (LISA) to identify specific regional cores and peripheries underpinning the global pattern, and sets the stage for the spatial Markov analysis, where mobility across performance states is explicitly conditioned on neighborhood regimes.

Building on the evidence of strong global spatial dependence, the paper examines the local structure of regional outward FDI performance using LISA. Table 3 summarizes the distribution of regions across local spatial regimes for the benchmark years 2010, 2013, and 2018. Two features stand out. First, the number of regions belonging to statistically significant High-High and Low-Low clusters is relatively small compared to the total sample, yet remarkably stable over time. High-High clusters account for 12 regions in 2010, 11 in 2013, and increase to 14 by 2018, while Low-Low clusters comprise between 20 and 22 regions throughout the period. In contrast, the vast majority of regions remain locally non-significant, indicating that spatial polarization is driven by a limited but persistent set of regional cores and peripheries. Second, the composition of these clusters reveals a clear and economically meaningful core-periphery structure. High-High clusters are consistently concentrated in Central and Northern Europe, with a stable core encompassing Swiss regions (Zürich, Zentralschweiz, Nordwestschweiz, Ostschweiz, Ticino) and Southern German regions (Karlsruhe, Tübingen, Unterfranken, Schwaben, Freiburg), complemented by Östra Mellansverige. By 2018, this core expands to include Irish regions (Southern; Northern and Western), signaling the emergence of new outward-oriented FDI hubs at the European periphery. Conversely, Low-Low clusters are predominantly located in Central, Eastern, and Southeastern Europe, including regions in Bulgaria, Romania, Hungary, and Poland, as well as several Greek regions (e.g. Central Macedonia, Thessaly, Epirus, Western Greece). The persistence of these Low-Low clusters across all three benchmark years highlights the spatial entrenchment of weak outward FDI performance and points to strong neighborhood effects that reinforce regional disadvantage.

Spatial outliers (High-Low and Low-High) are rare in all years, suggesting limited instances of regions whose outward FDI performance diverges sharply from that of their neighbors. This further supports the interpretation of outward FDI capacity as a spatially embedded regional capability, rather than a purely idiosyncratic outcome. Taken together, the LISA results complement the global Moran's I evidence by showing that spatial dependence in outward FDI performance manifests through a small number of persistent high-performing cores and low-performing peripheries.

Table 3: Local spatial clustering of regional outward FDI performance (LISA on exporter FE)

Year	High-High	Low-Low	High-Low	Low-High	Not significant	N
2010	12 (5.3%)	20 (8.8%)	3 (1.3%)	2 (0.9%)	189 (83.6%)	226
2013	11 (4.7%)	22 (9.5%)	1 (0.4%)	2 (0.9%)	196 (84.5%)	232
2018	14 (5.9%)	21 (8.8%)	1 (0.4%)	1 (0.4%)	202 (84.5%)	239

Notes: LISA clusters are computed on exporter fixed effects obtained from PPML gravity models of bilateral regional FDI flows. Spatial weights are based on contiguity relationships; regions without neighbors are retained under a zero-neighbor policy. "Not significant" denotes locations not passing the chosen local significance threshold. The number of regions varies by year due to data availability and consistency checks. Spatial diagnostics are reported for the available sample in each year, whereas spatial Markov transitions are estimated on the balanced intersection sample (N = 226).

Across all benchmark years, statistically significant High-High and Low-Low clusters account for a small but persistent subset of regions, while the majority of regions remain locally non-significant. High-High clusters range from 11 to 14 regions, whereas Low-Low clusters remain broadly stable between 20 and 22 regions, indicating a durable core-periphery structure. Spatial outliers (High-Low and Low-High) are rare in all years, suggesting limited instances of regions whose outward FDI performance diverges markedly from that of their neighbours. This scarcity of outliers reinforces the interpretation that outward FDI capacity is spatially embedded and shaped by neighborhood effects rather than idiosyncratic shocks. Overall, the LISA counts complement the global Moran's I results by showing that spatial dependence manifests through persistent local clusters rather than widespread local instability. This evidence motivates the visual inspection of local patterns through LISA maps and provides the appropriate bridge to the subsequent spatial Markov analysis, where transitions across performance states are examined conditional on neighborhood regimes.

4.3. Spatial Markov dynamics of regional outward FDI performance

The dynamic evolution of regional outward FDI performance is analyzed using spatial Markov transition matrices that explicitly allow for state dependence while conditioning on local neighborhood regimes. Regions are assigned to four performance states using common pooled quartile cutoffs of exporter fixed effects computed over the combined 2010-2018 distribution, thereby ensuring strict comparability across time while allowing the share of regions in each state to vary by year. Transitions are then estimated on a balanced panel of 226 NUTS-2 regions for the subperiods 2010-2013 and 2013-2018. The estimated spatial Markov transitions indicate strong persistence at the top of the distribution, with very limited downward mobility once regions enter the highest outward-FDI performance state, pointing to a highly stable top tier over the sample period. Under the pooled-threshold design, the relatively high incidence of upward transitions in 2013-2018 should be interpreted as movement across fixed multi-year benchmarks-capturing both potential shifts in aggregate outward-FDI performance and changes in relative positioning-so “upgrading” refers to crossing pooled cutoffs rather than to within-year quartile re-ranking.

Table 4 reports marked differences in mobility patterns across periods and neighborhood regimes. During the 2010-2013 period, outward FDI performance is characterized by very high persistence, with 93.8% of regions in low-lag neighborhoods and 95.6% in high-lag neighborhoods remaining in the same performance state. Mobility is limited and largely asymmetric, as upward transitions are infrequent and downward movements are rare. This pattern is consistent with strong state dependence and path persistence, in line with the spatial Markov evidence reported in the regional convergence literature (Rey, 2001; Bickenbach and Bode, 2003). In contrast, a substantially different dynamic emerges in the 2013-2018 period. Persistence declines sharply to approximately 45-48%, while upward mobility becomes the dominant transition mechanism, accounting for more than half of all transitions in both neighborhood regimes. Notably, downward mobility is virtually absent, indicating a generalized upgrading of outward FDI performance across the regional distribution. This shift suggests a structural change in regional FDI dynamics, whereby regions increasingly move towards higher exporter capacity states rather than oscillating within or reverting to lower performance classes.

Neighborhood conditioning plays a systematic, albeit moderate, role in shaping these dynamics. Regions embedded in high-lag environments consistently display slightly higher persistence and marginally lower downward mobility compared to regions in low-lag neighbourhoods. This finding is indicative of positive spatial spillovers, whereby proximity to high-performing neighbors reinforces regional outward FDI capacity. Such conditioning effects are consistent with spatial diffusion mechanisms documented in earlier spatial Markov applications (Rey, 2001). Overall, the spatial Markov results provide dynamic confirmation of the core-periphery structure identified in the static LISA analysis. While strong persistence characterizes the early subperiod, the post-2013 phase is marked by pronounced upward mobility, suggesting that neighborhood effects interact with broader macroeconomic and institutional forces to reshape regional outward FDI trajectories. These findings underscore the importance of accounting for spatial dependence when analyzing the evolution of regional internationalization patterns and complement the corresponding static evidence.

Table 4: Spatial Markov mobility of regional outward FDI performance (Exporter fixed effects from PPML gravity models; 4-state pooled quartiles)

Period	Neighbourhood Regime	N	Persistence	Upward mobility	Downward mobility
2010-2013	Low-lag	113	0.938	0.035	0.027
2010-2013	High-lag	113	0.956	0.035	0.009
2013-2018	Low-lag	113	0.451	0.549	0.000
2013-2018	High-lag	113	0.478	0.522	0.000

Notes: States are defined using common pooled quartile cutoffs of exporter fixed effects (1 = lowest, 4 = highest). Spatial regimes are based on a median split of the contemporaneous spatial lag of exporter fixed effects. Persistence denotes the share of regions remaining in the same state; upward (downward) mobility denotes transitions to higher (lower) states.

5. CONCLUSIONS

Throughout the analysis, exporter fixed effects derived from the PPML gravity framework are interpreted as measures of relative outward FDI performance, capturing persistent cross-regional differences in the capacity to generate outward investment flows, conditional on controlling for bilateral frictions and destination fixed effects within the gravity specification, and reflecting the combined influence of origin-specific characteristics and multilateral resistance components. The paper examines the spatial structure and dynamics of regional outward FDI performance in Europe over the period 2010-2018. By combining gravity-based exporter fixed effects estimated through PPML with spatial exploratory tools and spatial Markov transition analysis, the paper provides an integrated assessment of both the static and dynamic dimensions of regional outward FDI capacity. The empirical strategy is designed to maximize internal consistency across methods by using pooled performance states and neighborhood-based spatial regimes, while transition-based estimates are computed on the balanced intersection sample of regions observed in all benchmark years.

The analysis yielded three main findings. First, outward FDI performance exhibits a clear and persistent core-periphery spatial structure. Global and local indicators of spatial association reveal statistically significant clustering of high-performing regions in Central Europe, alongside persistent low-performing clusters in parts of Southern, Central, and Eastern Europe. These spatial patterns are stable across benchmark years, indicating that regional outward FDI capacity is not randomly distributed in space but embedded in geographically coherent regimes. Second, strong state dependence and path persistence are identified, particularly during the early subperiod. Spatial Markov results for 2010-2013 show very high persistence across performance states, with limited mobility and only marginal transitions across the distribution. This pattern is consistent with the presence of structural rigidities and reinforces the interpretation of outward FDI performance as a cumulative and path-dependent process. Third, a marked shift in regional dynamics is observed after 2013. During the 2013-2018 period, persistence declines sharply and upward mobility becomes the dominant transition mechanism, while downward movements are virtually absent. This transition toward higher performance states is observed across neighborhood regimes, though regions embedded in high-performing spatial environments display slightly stronger persistence. These results point to an interaction between broader macroeconomic or institutional changes and local spatial spillovers, reshaping regional outward FDI trajectories in a non-uniform but spatially conditioned manner.

Taken together, the findings underscore the importance of spatial conditioning in the evolution of regional internationalization. Outward FDI performance is shown to depend not only on region-specific characteristics captured by exporter fixed effects, but also on the performance of neighboring regions and the spatial regimes in which regions are embedded. Ignoring such spatial interdependencies risks overlooking key mechanisms through which regional advantages are reinforced or eroded over time. The findings of the paper carry implications for both research and policy. From a research perspective, the findings support the use of integrated frameworks that link gravity-based measures with spatial and distributional dynamics, moving beyond static representations of regional performance. Future work could extend this approach by incorporating sectoral heterogeneity, firm-level dynamics, or endogenous network formation mechanisms. From a policy standpoint, the findings suggest that place-based investment and internationalization strategies should account for spatial context and neighborhood effects, as interventions targeting individual regions may have limited impact if surrounding spatial regimes remain unchanged.

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