Changing Boundaries: Harmonizing Territorial Data for Comparative Subnational Research*

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Abstract

Comparative subnational research typically assumes that territorial units remain stable over time. Yet municipal boundaries change frequently across Europe, creating overlooked challenges for longitudinal comparability, measurement, and causal inference. We develop a methodological framework for identifying, classifying, and tracking changes in subnational territorial units and apply it to harmonized geospatial boundary data covering 35 European countries between 2014 and 2024. Systematically validated against legislative records, the resulting dataset documents 2,070 municipal territorial changes and reveals substantial cross-national variation in patterns of territorial restructuring. We also extend existing typologies of territorial change by incorporating a broader range of territorial transformations observed across European municipalities and introduce LoQoG Dataspace, an open-access spatial harmonization infrastructure that enables the construction of geographically consistent subnational panel datasets across changing administrative boundaries. Together, these contributions provide a foundation for a new generation of comparative subnational research by transforming territorial change from a source of measurement error into an analyzable political phenomenon and a source of identification.

Keywords: municipal spatial change; border change; European municipalities; geospatial approach
JEL: R58, R12, C8

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1 Introduction

A growing number of actors – from scholars and policymakers to businesses and citizens – rely on subnational data to understand socioeconomic and political phenomena (OECD, 2024; UN Statistics Commission, 2020). In academia, the increasing emphasis on causal identification (Imbens, 2024) has further intensified demand for high-quality data below the national level, making comparative subnational research a standard design in political science and related disciplines (Giraudy et al., 2019). This trend is evident in bibliometric data. Using the Web of Science database, we find that the number of publications mentioning municipalities in their title or abstract increased from approximately 1,000 per year in 2000 to nearly 12,000 in 2025.

The growing reliance on subnational data, however, also raises important conceptual and methodological challenges. Subnational political units such as municipalities are not fixed territorial entities. Their boundaries, names, and administrative codes change over time through mergers, splits, and other territorial reorganizations. Yet many researchers implicitly treat these units as temporally stable, an assumption that often does not hold in practice. For example, when the Italian municipality Faedo merged with San Michele all'Adige in 2020, the resulting municipality retained San Michele all'Adige's identifier. As a consequence, longitudinal data show an apparent population increase of more than 20 percent despite no substantive change in the underlying population (see Appendix A for extensive illustrations).

This issue is particularly salient in Europe, where repeated territorial reforms have substantially altered both the number and spatial distribution of municipalities. Through mergers, splits, and other forms of reorganization, municipalities have been dissolved, newly created, and reshaped (Ebinger et al., 2019; Erlingsson et al., 2021; Goerlich and Ruiz, 2018; Klausen, 2026; Steiner et al., 2016; Swianiewicz, 2020, 2021), often generating discontinuities in the administrative units used to measure socioeconomic and political phenomena.

Changes in the boundaries of subnational administrative units alter the territorial basis of statistical indicators. Consequently, panel datasets may inadvertently combine observations that refer to different territorial entities over time, a discrepancy that is often unaccounted for in empirical research. This creates several threats to inference.

First, boundary changes undermine *temporal comparability*. Observations associated with

the same municipality may correspond to substantively different territorial entities before and after reform, introducing measurement error as variables are effectively measured for different territories at different points in time. Since territorial reforms are often driven by political, fiscal, or demographic pressures, this error is unlikely to be random and may therefore bias empirical estimates. Second, boundary changes can produce *misattributed effects* when observed changes reflect territorial restructuring rather than the causal processes under study. Yet territorial reforms are not only a source of inferential challenges; they can also provide powerful opportunities for causal identification. Because exploiting such reforms requires precise information on how territorial units change over time, the lack of systematic longitudinal data has limited their use in comparative research. Consequently, the identification opportunities created by territorial reforms remain underutilized (Cerqua et al., 2026), highlighting the need for systematic longitudinal data on changes in subnational territorial units.

Researchers often attempt to address these problems by restricting analyses to territorially stable municipalities or to periods without boundary changes (Agasisti and Porcelli, 2023; Dahlberg and Johansson, 1998; Roesel, 2017; Schmutz and Verdugo, 2023). While such strategies improve panel consistency, they may also introduce *selection bias* by systematically excluding municipalities most affected by administrative reforms.

Beyond their implications for inference, municipal boundary reforms are also politically consequential processes in their own right. Despite their prevalence, systematic knowledge about the scale and patterns of municipal boundary changes remains limited. This gap is consequential because such reforms are rarely purely technical adjustments; rather, they are embedded in broader political and policy processes, including efforts to strengthen administrative capacity, address fiscal pressures, or improve local service provision. Understanding territorial boundary changes is therefore essential both for the accurate interpretation of longitudinal data and for the analysis of the political and institutional dynamics of subnational governance.

At its core, these challenges reflect the temporal inconsistency of subnational political units. In this article, we introduce Local Quality of Government Dataspace (LoQoG Dataspace), an open-access infrastructure for documenting and harmonizing municipal boundary changes across 35 European countries[1] between 2014 and 2024, thereby enabling researchers to identify

[1]Including the EU, EFTA and the constituent units of the UK.

and account for inconsistencies in longitudinal and cross-national municipal data. The platform is accompanied by online tools that help researchers improve the validity of comparative subnational analyses.

Our approach combines the analysis of official geospatial boundary data with systematic verification of detected changes using legislative acts governing boundary reform. By comparing municipal polygons across years and validating detected changes against relevant legislation, we construct a comprehensive dataset of European municipalities that supports the creation of geographically consistent longitudinal data, reduces measurement error arising from territorial change, and facilitates more credible comparative and causal research designs.

This paper makes four contributions. First, it develops a methodological framework for identifying, classifying, and tracking changes in in subnational territorial units over time. Second, it documents 2,070 municipal boundary changes across 35 European countries between 2014 and 2024, revealing substantial cross-national variation and showing that mergers constitute the dominant form of territorial restructuring. Third, it introduces a publicly available data resource that enables researchers to construct geographically consistent subnational panel datasets and conduct more rigorous longitudinal and comparative analyses. Fourth, it extends the typology of territorial unit changes developed by Goerlich and Ruiz (2018) by incorporating a broader range of territorial transformations observed across European municipalities.

Taken together, these contributions provide researchers with the tools needed to track municipalities consistently over time, construct comparable longitudinal data, and leverage territorial reforms as both an object of study and a source of causal identification.

2 Literature Review

Municipalities change through both geographical modifications to territorial boundaries and non-geographical changes to legal identifiers such as names or registry codes (Goerlich and Ruiz, 2018; Kociuba and Kociuba, 2023). Existing research, however, typically examines only one dimension or form of change within individual-country contexts (Blesse and Baskaran, 2016; Heinisch et al., 2018; Strebel, 2018). Most studies focus on mergers (Allers and Geertsema, 2016; Blom-Hansen et al., 2016; Hansen et al., 2014; Harjunen et al., 2021; Moisio and Uusitalo,

2013; Solvang et al., 2025) or splits (Bačlija Brajnik and Lavtar, 2021; Brink, 2004; Erlingsson et al., 2024; Lysek, 2021; Swianiewicz et al., 2024), while broader analyses of municipal boundary change remain rare (Cerqua et al., 2025; Dobos, 2021; Ebinger et al., 2019; Klausen, 2026; Swianiewicz, 2020, 2021). Moreover, boundary reforms are usually studied through their causes or consequences rather than as a phenomenon requiring systematic conceptualization and measurement (Allers and Geertsema, 2016; Bačlija Brajnik and Lavtar, 2021; Blom-Hansen et al., 2016; Erlingsson et al., 2024; Hansen et al., 2014; Harjunen et al., 2021; Heinisch et al., 2018; Solvang et al., 2025; Strebel, 2018; Swianiewicz, 2020; Swianiewicz et al., 2022, 2024). Existing comparative efforts, most notably Goerlich and Ruiz (2018), provide important foundations for tracking territorial change, but remain geographically and temporally limited (Kociuba and Kociuba, 2023; Pászto et al., 2020). This paper builds on and extends this literature by developing a typology of municipal spatial change and systematically documenting territorial alterations across 35 European countries between 2014 and 2024.

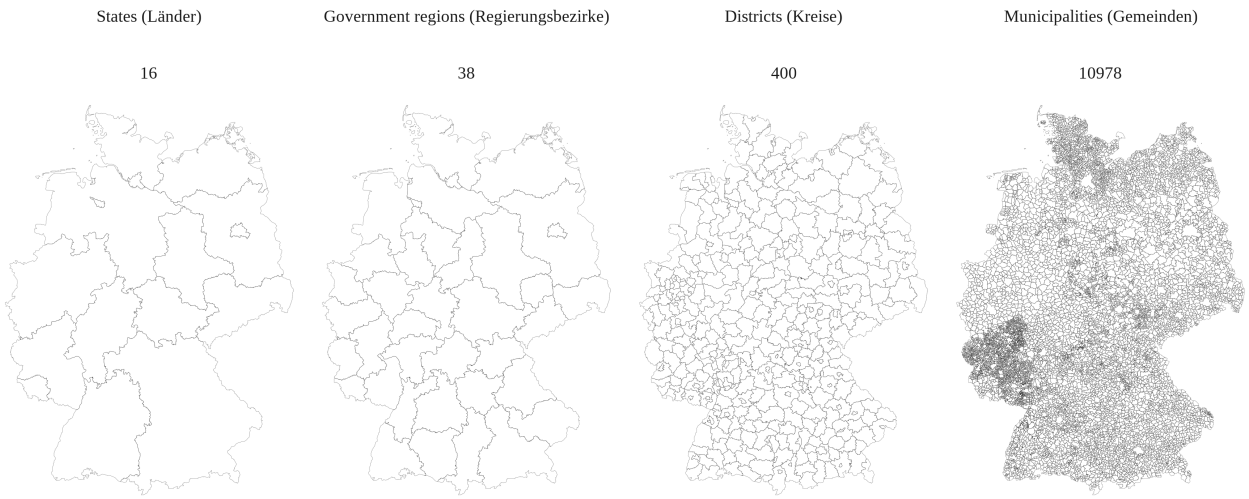
3 Defining the Unit of Analysis

Conceptually, we approach the unit of analysis from the perspective of local self-rule, or local autonomy. We define this as the legally and institutionally grounded capacity of local government units operating within clearly demarcated territories to make binding decisions for local residents and manage resources independently of higher levels of government. The existence of an effective "policy space" (Ladner et al., 2016, 325), in which local governments can design and implement policies, distinguishes local autonomy from mere local administration, where authorities primarily execute policies determined by higher-level governments. Following Lidström (1998), we define a local government as a territorially bounded unit with legislative and executive institutions, authority to make binding decisions for local residents, and a degree of autonomy in managing local affairs and resources.

Although some countries feature multiple tiers of subnational government – as in Germany, where three levels exist (see Figure 1) – we focus on the lowest level within each country's government hierarchy. Across Europe, this level is most commonly referred to as the municipality (Ladner et al., 2016), although country-specific terminology varies (e.g., local authority

in the United Kingdom, *commune* in France and Luxembourg, *Gemeinde* in Germany, or *gmina* in Poland). We therefore adopt municipalities as our unit of analysis, as they constitute the primary institutional arena where local autonomy is exercised and decisions with direct implications for local communities are made.

Figure 1: Subnational Territorial Organization in Germany



4 Method

To systematically identify municipal boundary changes across 35 European countries between 2014 and 2024, we combine automated comparisons of geospatial data over time with manual verification against legislative sources. Following Servigne et al. (2000), we use geometric properties of polygons and computational geometry algorithms (e.g. checks for closure, intersections, and uniqueness) to detect potential boundary changes between t and $t + 1$. We then verify these changes against legal records to ensure that they correspond to formally adopted administrative reforms. Appendix B provides a detailed description of the methodology.

We begin by acquiring geospatial boundary files for consecutive years (t to $t+1$, $t+1$ to $t+2$, etc.) from official sources, including national government agencies, public geoportals, and Eurostat. The data, obtained in different formats (Shapefile, GeoJSON, GML), were harmonized by converting them to GeoPackage format, reprojecting to a common coordinate reference system (EPSG:3035), and encoding in UTF-8. We then applied custom algorithms to compare polygons across years and detect spatial changes, including the disappearance of existing polygons, the emergence of new polygons without linkage to prior units, and changes in the size or configuration of existing polygons.

We subsequently verified each detected spatial change against official legal documentation retrieved from national legal databases and government sources and, where necessary, through correspondence with the relevant authorities (e.g., National Institute of Statistics and Economic Studies (INSEE) and data.gouv.fr in France). This step not only confirmed the validity of observed outcomes but also allowed us to identify the underlying territorial alterations–such as mergers, splits, and dissolutions–that generated these outcomes.

Finally, we constructed a master database documenting the annual status of each municipality: remained unchanged, dissolved, newly created, or reconfigured. Each unit is assigned a unique internal identifier (LoQoG ID), enabling consistent linkage over time. Each Case ID is shared by all municipalities involved in a given event of territorial alteration and follows the *country code–change type–case number–pre/post years* structure. For example, *fr-m-34-2015-2016*, indicating France, a merger, case number 34, and the years before and after the change. We link these identifiers to geospatial polygons, allowing users to trace territorial evolution directly within a GIS environment. The resulting dataset provides harmonized local time series, a legally validated record of boundary changes, and geospatial layers suitable for spatial analysis.

5 The LoQoG Typology of Municipal Spatial Changes

We conceptualize municipal spatial change as a transformation between two time points: one preceding a territorial alteration (t) and one following it ($t+1$). Following Goerlich and Ruiz (2018), we distinguish between observed spatial outcomes and the underlying territorial

alterations that generate them. Unlike that article, however, we systematically attribute all observed spatial changes to specific types of territorial alteration, including previously unidentified forms, thereby avoiding residual categories such as "unspecified disappearance" or "unspecified emergence".

Figure 2 presents the LoQoG typology. The outcomes, shown on the right, are the observed changes in spatial status, captured through the geospatial data analysis: whether municipalities cease to exist, are created,[2] both, or neither. These outcomes are the consequences of underlying territorial alterations, shown on the left, such as mergers, splits, separations, or territorial transfers. Alterations highlighted in dark gray denote types not identified in Goerlich and Ruiz (2018).

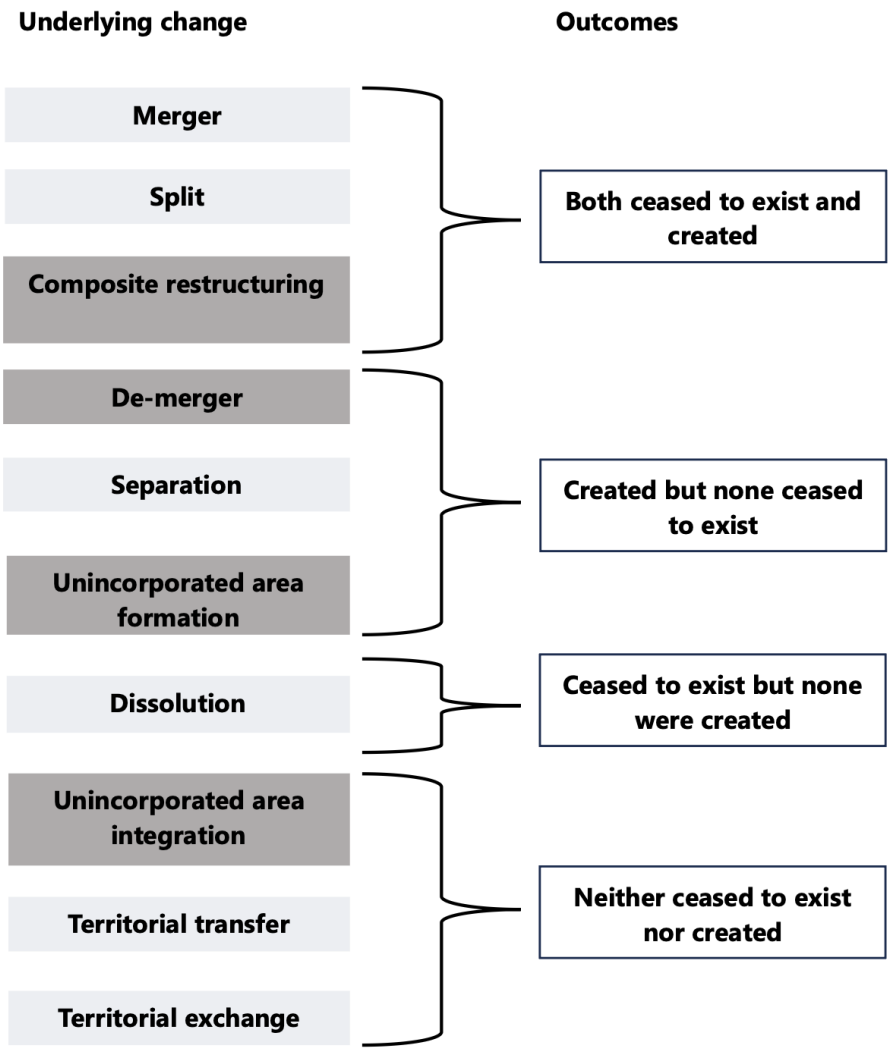
Table 1 summarizes the ten main categories of municipal boundary change identified in our analysis. Appendix C provides further details, including definitions of type of underlying change and their subtypes, graphical illustrations, legislative references, and country examples for each type of territorial alteration.

While mergers represent the most common form of reform in many countries, other types of change–such as territorial transfers or composite restructuring–also occur in several national contexts. Multiple types of territorial alteration may lead to the same spatial outcome; for example, mergers, splits, and composite restructurings all result in units both ceasing to exist and being created.

In addition, we identify three categories of changes to municipal identifiers that occur without spatial change: name changes, identification code (ID) changes, and simultaneous changes in both name and ID. Although these changes do not alter territorial boundaries, they can affect the analysis of municipal-level data, as identifiers are commonly used to link statistical observations over time (see Appendix D for examples). Spatial and identifier changes do not always coincide. Municipalities may undergo boundary alterations without changes to their identifiers, while in other cases identifiers change despite stable territorial boundaries. In some instances, both types of change occur simultaneously, generating obstacles for robust

[2]Creation refers to the establishment of a new administrative entity, legally recognized within the administrative system, with a distinct territory, an officially recognized name, and an organizational structure enabling local governance and elections.

Figure 2: LoQoG Typology of Municipal Spatial Changes



Note: Alterations in dark gray denote types not identified in Goerlich and Ruiz (2018).

Table 1: Types of Underlying Territorial Alterations

Category	*Explanation*
1. Both ceased to exist and created	
Merger	A new municipality formed through the union of two or more pre-existing municipalities.
Split	The territory of a municipality is divided into two or more newly created municipalities, none of which retains the legal or administrative identity of the original unit.
Composite Restructuring	The simultaneous dissolution, merger or territorial transfers of multiple municipalities, whereby entire or partial territories are reorganized into one or more newly created municipalities.
2. Created but none ceased to exist	
De-Merger	The re-establishment of one or more municipalities previously absorbed in a merger, creating new entities whose territories coincide with their pre-merger boundaries.
Separation	A new municipality is formed through the separation of part of the territory from one or more existing municipalities, all of which continue to exist.
Unincorporated Area Formation	A new municipality is formed from territory that was not previously organized as a municipality.
3. Ceased to exist but none were created	
Dissolution	A municipality ceases to exist as a legal-administrative entity and its territory is redistributed among existing municipalities.
4. Neither ceased to exist nor created	
Unincorporated Area Integration	Previously non-municipal territory is incorporated into one or more existing municipalities.
Territorial Transfer	The transfer of part of a municipality's territory to another municipality without reciprocal exchange.
Territorial Exchange	The mutual exchange of territory between municipalities.

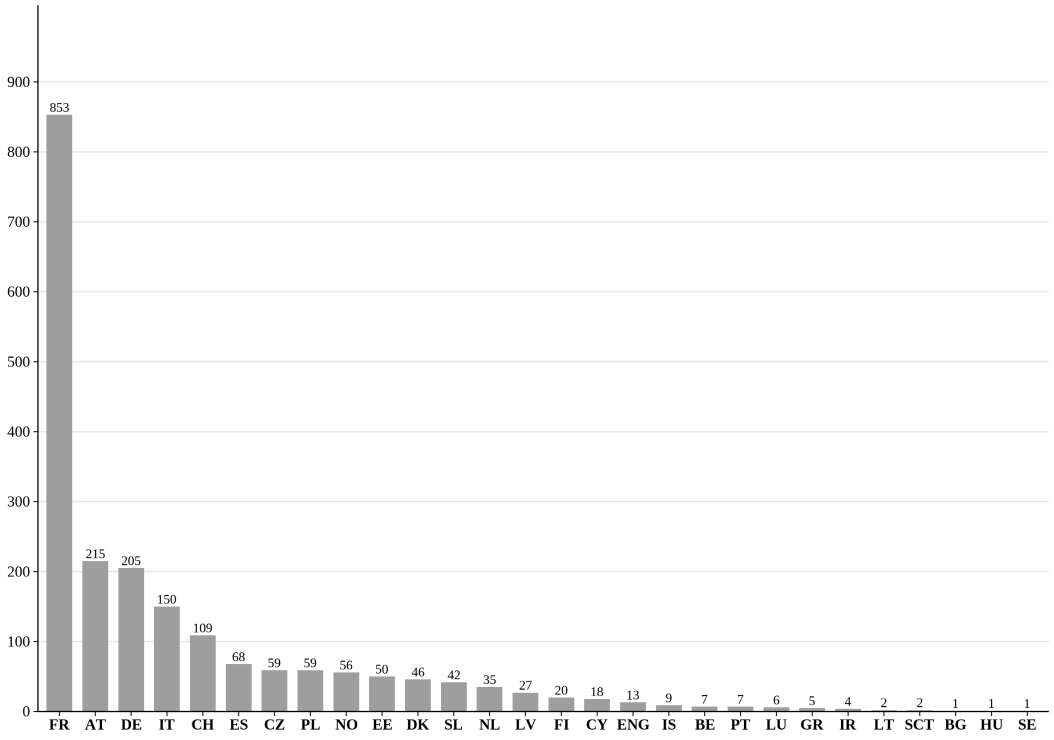
Note: All categories, except dissolution and composite restructuring, include subcategories; territorial transfer and exchange are classified as national or international.

data analysis.[3]

6 Scope and Patterns of Municipal Boundary Changes

Across the 35 European countries in our dataset, we identify 2,070 territorial changes between 2014 and 2024, revealing substantial cross-national variation in both the scope and form of municipal restructuring. These changes are highly concentrated geographically: a small subset of countries accounts for the overwhelming majority of reforms, with France recording by far the largest number of cases (853 since 2015), followed by Austria (215) and Germany (205), while seven countries experienced no municipal boundary changes during the study period (Figure 3).

Figure 3: Municipal Spatial Changes by Country, 2015-2024



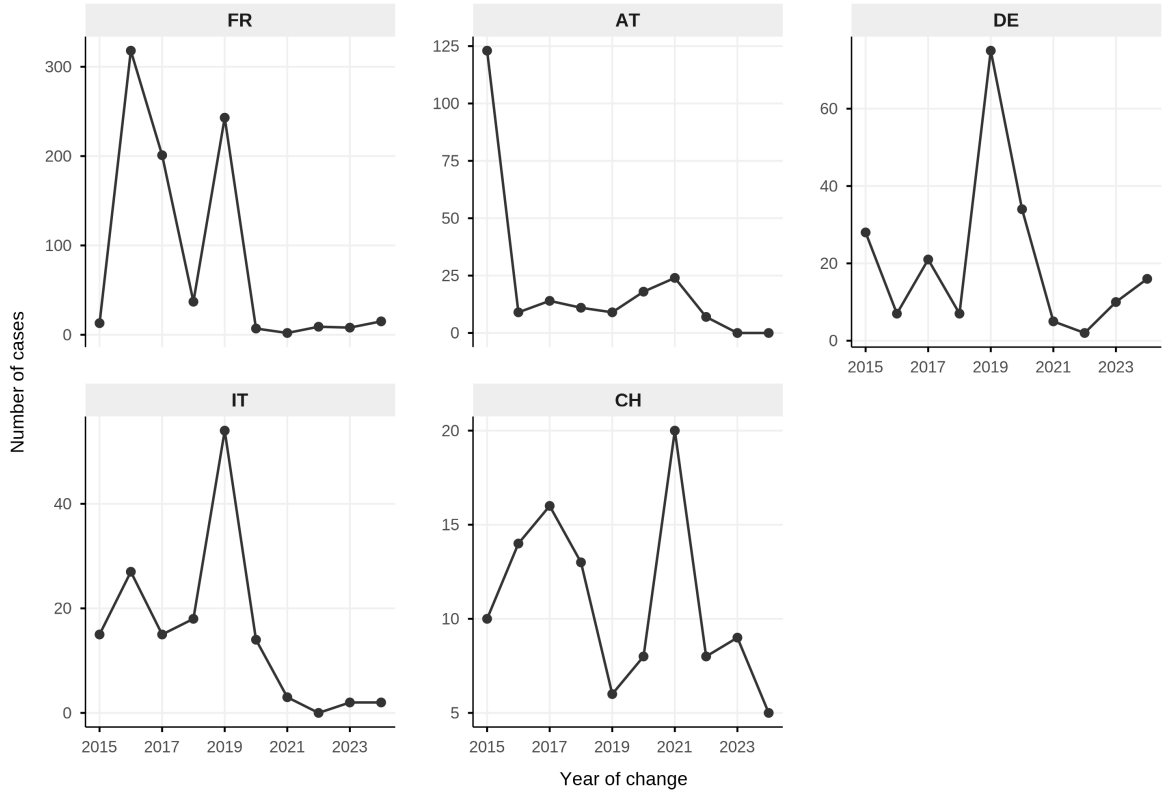
Note: Croatia, Liechtenstein, Malta, Romania, Slovakia, Northern Ireland, and Wales had no changes.

The temporal distribution of these territorial changes further underscores their uneven character. Rather than occurring gradually, reforms tend to cluster in specific years, reflecting

[3]For example, in the case of mergers, four configurations frequently occur: (a) a new name with a new ID, (b) a new name with an inherited ID, (c) an inherited name with a new ID, and (d) an inherited name with an inherited ID. See Appendix D for further detail.

the implementation of discrete, large-scale reform programs. This pattern is particularly visible in countries with the highest reform activity (Figure 4).

Figure 4: Municipal Spatial Changes in the Five Countries with the Highest Number of Changes, 2015–2024



Note: Y-axis scales are adjusted to highlight country-specific temporal trends. FR=France, AT=Austria, DE=Germany, IT=Italy, CH=Switzerland.

In terms of their substantive form, territorial changes are dominated by mergers, which account for 78% of all cases (Figure 5). Other types of alterations—such as territorial transfers and exchanges—occur less frequently, while separations, dissolutions, and more complex restructuring processes are rare. This distribution highlights a strong overall tendency toward municipal consolidation, but also indicates that territorial change encompasses a broader range of institutional adjustments beyond merger-driven reforms.

Despite the scale of these territorial changes, their aggregate impact on the overall number of municipalities remains modest. Across all countries, the total number of municipalities declined by approximately 4% over the decade (Figure 6). Appendix E provides additional descriptive statistics, including the number of municipalities by country and year.

Figure 5: Territorial Alterations by Type, 2015–2024

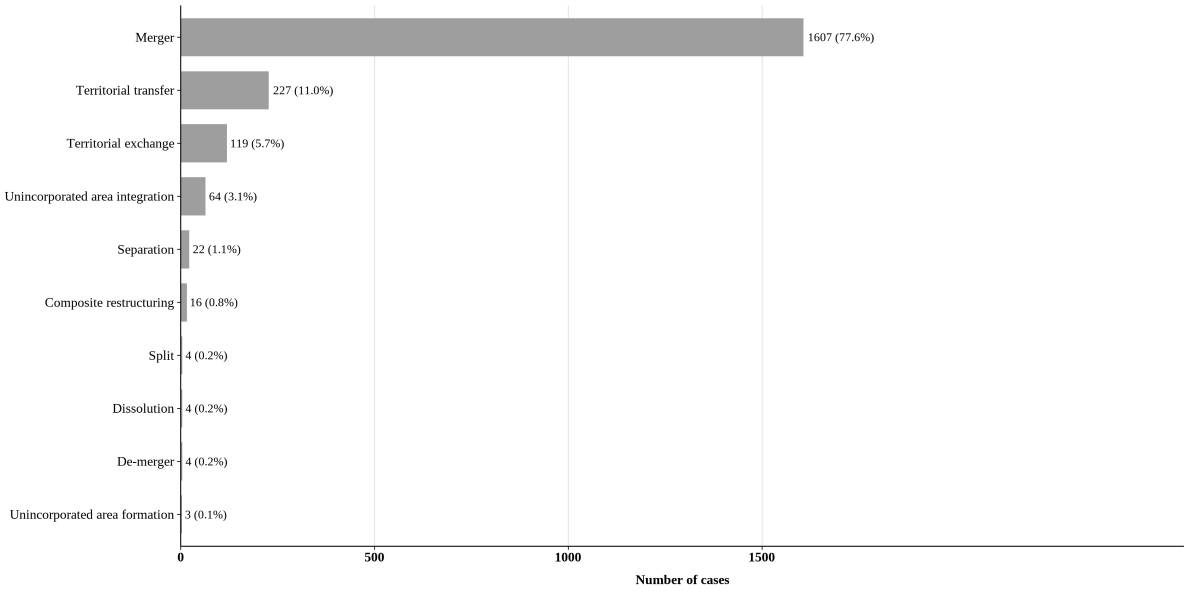
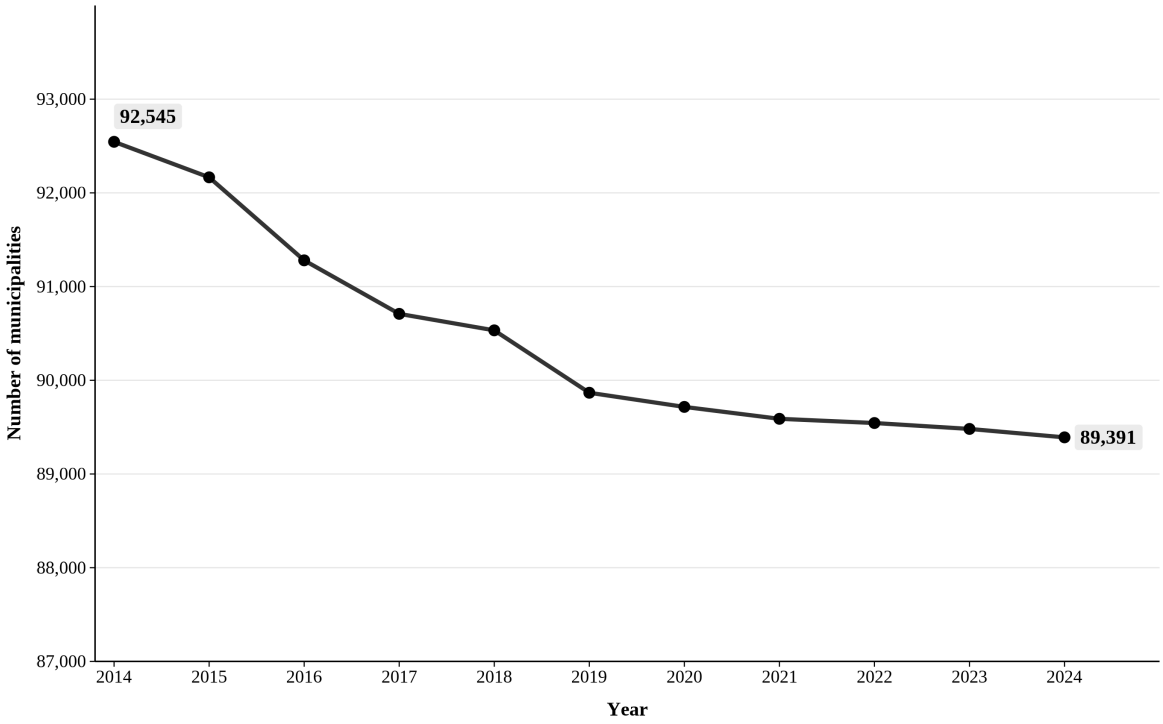


Figure 6: Number of Municipalities across 35 European Countries, 2014–2024



Note: The number of municipalities as of January 1st of each year.

7 Implications for Research

The results demonstrate that municipal boundaries in Europe change more frequently than is often assumed. When such changes are not accounted for, they introduce inconsistencies in longitudinal municipal data, generating measurement error and potentially biasing statistical inference. Indicators derived from shifting territorial units may conflate administrative reorganization with substantive demographic or economic change, thereby complicating both descriptive and causal analysis.

The LoQoG framework addresses this problem by providing i) a methodology for identifying spatial change and ii) a public data infrastructure that accounts for all municipal territorial alterations across 35 European countries between 2014 and 2024. Together, these enable the integration of comparable subnational data and support more rigorous empirical analysis.

The LoQoG methodology relies on longitudinal analysis of geospatial data, combined with systematic verification of detected changes against legislative sources. It explicitly documents boundary discontinuities and links municipalities involved in the same territorial alteration through shared case identifiers. This produces transparent, consistent, and geographically referenced time-series data and supports the reconstruction of geographically consistent spatial units over time. The underlying approach–automated polygon comparison combined with legal validation–is extendable to other contexts where official geospatial and legislative data are available and can be applied iteratively as new data are released.

The LoQoG data infrastructure provides harmonized information on politically relevant subnational units that already account for territorial change. Each unit is assigned a unique identifier (LoQoG ID, which connects all municipalities involved in a given alteration) and links them to corresponding geospatial data and legislative sources. This structure enables researchers to align statistical indicators with their correct geographic context, thereby reducing measurement error and the risk of biased estimates. In addition, it facilitates the integration of existing, often fragmented subnational datasets into a unified framework, thereby improving cross-national comparability and expands opportunities for causal analysis, including designs that rely on precise spatial or administrative discontinuities.

8 Limitations

This study has several limitations that should be considered when interpreting the results. First, our geo-based approach identifies potential municipal boundary changes through comparisons of geospatial boundary files and subsequently verifies these cases using legislative sources. This approach enables the consistent analysis of boundary changes across a large number of countries, including those where comprehensive legislative documentation is difficult to access. However, because legislative documents are not systematically collected as an independent first step, some legally relevant changes may remain undetected.

Second, the analysis relies on official geospatial boundary files that typically represent administrative divisions as of January 1 of each year. In practice, however, municipal reforms often take effect at other points during the calendar year. For example, a major administrative–territorial reform in Latvia that reduced the number of municipalities from 119 to 42 entered into force on July 1, 2021 (Saemia Press Service, 2020). As a result, annual geospatial files may capture either the pre-reform or post-reform configuration, but not both within the same year. Similar timing discrepancies occur elsewhere in Europe, including France, where some municipal mergers take effect mid-year rather than on January 1.

Third, differences in the spatial resolution of municipal boundary files across years may generate false positives when detecting potential boundary changes. Apparent changes may therefore reflect technical inconsistencies in geospatial files rather than genuine administrative reforms. To reduce this risk, all detected cases are manually verified against official legal sources.

Finally, the temporal scope of this study is limited to 2014–2024. While this ten-year interval provides sufficient variation to identify multiple forms of territorial alteration and develop a comprehensive typology, reforms occurring outside this period are not captured. Because boundary changes are detected through year-to-year comparisons of spatial data, some reforms may also become observable with a one-year lag.

This temporal limitation also affects the interpretation of certain categories of boundary change, particularly splits. Some cases recorded as splits may instead reflect reversals of mergers that occurred before the observation period. In such cases, municipalities that re-emerge during

the study period may appear as newly created units even though they existed prior to earlier consolidation reforms. Although this limitation does not affect the identification of boundary changes themselves, it should be considered when interpreting specific change categories within the typology.

9 Conclusion

Municipalities are often treated as stable units in comparative research, yet our analysis demonstrates that they change more frequently than is commonly assumed. This poses an important challenge for scholars working with subnational data, as changes in municipal boundaries can introduce measurement error, undermine the comparability of longitudinal data, and lead to biased estimates. Here, we develop an approach for identifying and accounting for these inconsistencies in longitudinal and cross-national municipal data.

The paper makes four contributions. First, we provide a methodological framework for analyzing territorial unit changes across contexts and over time. Building on evidence from more than 2,000 identified municipal boundary changes, we extend the typology of territorial unit changes developed by Goerlich and Ruiz (2018) by introducing four new types of change and eliminating the residual category "unspecified". Second, we provide new empirical evidence on municipal boundary changes across 35 European countries between 2014 and 2024, showing that territorial restructuring is widespread and varies substantially across countries and over time. Third, we introduce the LoQoG dataset, a new research infrastructure that accounts for spatial changes across European municipalities over a ten-year period and enables the integration of comparable subnational data. Fourth, we provide a framework that supports more rigorous longitudinal and comparative empirical analysis by enabling researchers to track municipalities consistently over time and construct geographically consistent municipal-level panel data.

Beyond these contributions, the paper also opens several avenues for future research. Extending the temporal and geographical scope of the dataset would allow scholars to examine longer-term patterns of territorial restructuring and compare administrative reforms across a broader range of institutional contexts. Future work may also combine the geo-based approach

developed here with additional administrative, electoral, fiscal, or demographic data to improve the comparability and measurement validity of longitudinal subnational research.

An additional promising direction concerns the political origins of municipal boundary changes. While the LoQoG dataset documents how municipal boundaries change, future research could further distinguish between reforms initiated by higher levels of government and those emerging from local initiatives. Such distinctions may be particularly valuable for empirical research designs, as exogenously imposed reforms may provide opportunities for causal inference, while locally initiated changes may themselves constitute important political outcomes.

More broadly, as the use of subnational data continues to expand across the social sciences, ensuring that geographic units are consistently defined over time will remain a central methodological challenge. By documenting municipal boundary changes and providing tools to track them systematically, the LoQoG framework contributes to more reliable longitudinal and cross-national research using municipal-level data and supports more credible comparative and causal inference.

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