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Urban Growth and Demographic Dynamics in Southern Europe: Toward a New Statistical Approach to Regional Science

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Abstract: Metropolitan growth in Europe has resulted in drastic changes of urban forms, socio-spatial structures and land-use patterns due to sequential processes of urbanization, suburbanization and re-urbanization. To assess latent shifts from mono-centric models towards more disarticulated and decentralized settlement configurations, the present study evaluates spatio-temporal patterns of growth between the 1920s and the 2010s in three Mediterranean cities with different structure and functions (Barcelona: compact and moderately polycentric; Rome: dispersed, medium-density; Athens: mono-centric, hyper-compact). To identify and characterize long-term urban transformations, an original approach was illustrated in this study, based on a multivariate analysis of 13 indicators resulting from descriptive statistics and linear regression modeling the relationship between population density and distance from inner cities. The empirical results of this study indicate that Barcelona, Rome and Athens have experienced different urbanization cycles, characterized by a (more or less) concentrated distribution of population along urban gradients. Despite similarities in demographic dynamics and planning practices, these processes have determined (i) a mostly centralized growth in Barcelona, (ii) a relatively dispersed and discontinuous spatial structure in Rome, and (iii) a steep decline of population density with the distance from downtown Athens. Compact urban expansion, population decline and urban de-concentration were finally assessed using the analytical approach proposed in this study.

Keywords: urban growth; density-distance curve; indicators; Mediterranean Europe

1. Introduction

Metropolitan regions worldwide have undergone a progressive transition from urban densification to spatial configurations characterized by settlement scattering around inner cities [1–3]. Besides the rising housing demand caused by internal and international immigration, evolving economic functions and social structures have driven the release of peripheral land for urban development outside cities [4–6]. Impacts of settlement scattering go beyond the respective urban boundaries, reducing a regional system's resilience to external shocks and the overall response to multi-level developmental policy [7–9]. Exurban development is defined a discontinuous, low-density expansion into fringe land, emphasizing dependency on private mobility, soil consumption, and depolarized economic structures. This development path was common in the United States, and was observed more recently in the European continent [10–12], where sparse residential, commercial and service settlements characterize

peri-urban landscapes [13]. Metropolitan areas in Europe have undergone changes in both structure and functions reflecting sequential cycles of compact and dispersed urbanization [14–16].

The inherent differences in urbanization patterns and processes across countries make the identification of spatio-temporal dynamics of urban change progressively more difficult when considering the effects and consequences of exurban development [17–20]. Based on the intrinsic nature of societies and economic systems, recent transformations from mono-centric to polycentric structures have attracted rising attention among the social sciences [21–24]. The identification of mono-centric and polycentric patterns of growth has benefited from a broad range of approaches derived from different disciplines [5,25–27]. Being an explicit target of the European Spatial Development Perspective [28], polycentrism in Europe has influenced forms of human settlements and socio-spatial structures altering the short- and medium-term dynamics of economic activity [29–32].

Until the early 1990s, large metropolitan areas in Mediterranean Europe have been frequently considered as regions with structurally compact urban forms and functionally monocentric spatial organizations [33–35]. Leontidou [36] highlighted similarities in the individual trajectories of urban growth, leading to convergent socio-spatial profiles and homogeneous economic structures [37]. Population expansion fuelled by internal and international immigration, a more consolidated urban tradition, rising class segregation, real estate speculation, planning deregulation and restricted participation to public decisions on land use, have been identified as key dimensions associated with settlement densification and population concentration in southern Europe [38–41]. Based on these findings, large Mediterranean cities have usually been grouped into a homogeneous class of cities distinct from (i) the 'affluent city' prototypes of the United States and of north-western/central Europe; (ii) the centralized urban system typical of eastern Europe; and (iii) the rapidly-growing agglomerations of emerging countries [42–45].

Exurban development has become a widespread pattern of growth in Mediterranean Europe [1,17,46–51]. In this region, recent studies have demonstrated that some cities are progressively shifting towards polycentrism associated with less compact forms of settlement leading to scattered urban growth [52–54]. Exurban development was both a cause and consequence of social polarization, inherent transformations of regional economic structures, infrastructure expansion, rising volatility in amenity-driven and tourism-related real estate markets [31,55,56]. Leapfrogging development further away from fringe land, ribbon sprawl along highways, sparse residential settlements in rural areas, are forms of exurban development typically observed in Mediterranean Europe [7]. Given the implications of discontinuous urbanization patterns and processes in regional sustainability and socioeconomic resilience, recent studies have focused on the intimate relationship between spatial configurations and specific background conditions, including planning, economic performance and social issues [57–59]. Such approaches may benefit from a comparative analysis of long-term urban trajectories, considering together the outcomes of sequential phases of urbanization, suburbanization and re-urbanization. In this regard, new approaches identifying morphological and/or functional specificities in urban development paths from local-scale and/or regional-scale analysis are particularly welcome.

The present study contributes to this issue by verifying if a convergent (or divergent) path of urban development was occurring in representative cities of southern Europe. A long-term analysis (1920–2010) of changes in the spatial distribution of population density along urban gradients was run for three Mediterranean cities (Barcelona, Spain; Rome, Italy; Athens, Greece) using the results of descriptive statistics and regression models with the aim to derive indicators of metropolitan growth whose variation over time was investigated by way of multivariate techniques. Our study implements and enriches the logical framework presented in Couch et al. [7], proposing 13 original indicators of urban growth from an integrated, local-scale analysis of the relationship between population density and the distance from the inner city based on descriptive statistics and regression models.The indicators adopted in this study were selected to quantify population concentration (or dispersion) and to assess territorial transformations underlying distinctive forms of urban expansion (compact, dense, branched,

dispersed, multi-centric). The long time period analyzed in this study covers a large part of the last century, encompassing a complete urbanization cycle representative of different socioeconomic contexts in southern Europe. According to Salvati et al. [60], processes of urban expansion in Barcelona, Rome and Athens are considered illustrative of multiple and distinctive socioeconomic dynamics, typically characterizing hyper-compact, mono-centric models (such as Athens), medium-density and discontinuous configurations (such as in Rome), and moderately polycentric and dense metropolitan organizations (such as in Barcelona).

2. Methodology

2.1. Theoretical Framework

Integrating morphological and functional issues, a permanent assessment of exurban development presents inherent difficulties and needs a better integration of theoretical assumptions and empirical findings [61]. While exurban development was frequently defined as an increasingly articulated spatial process, simple indicators and, more rarely, multi-domain indexes have been proposed to measure urban expansion at different spatial scales [62], from local (i.e., neighborhoods and urban districts) to regional (e.g., metropolitan regions) levels. Couch et al. [7] proposed a simplified methodology assessing urbanization patterns and processes, under the assumption that centralized urban growth occurs when the population living in urban conurbations increases, while a more diffused urban expansion occurs when the percentage of the population living in inner cities declines relative to the total population resident in the conurbation [63].

Reflecting agglomeration factors, centralized urban growth and exurban development have been studied using an ideal-typical model with population density showing a (more or less) negative slope as we move away from central cities [64,65]. According to Salvati et al. [63], changes in population density at different distances from the inner city reflect—and are distorted by—a variety of territorial factors [66–68]. Couch et al. [7] argue that density gradients become progressively less steep in cases of exurban development. Nevertheless, the inherent spatial variability of sprawl's outcomes across Europe outlines the importance of place-specific and regional-based socioeconomic forces shaping urban expansion [69]. Changes over time in population density along relevant geographical gradients remain a common indicator of urban growth and metropolitan scattering, and was only occasionally integrated with quantitative information assessing settlement distribution, urban form and business concentration [29,70,71].

Analysis of changes in density gradients contributes to distinguish settlement densification from scattering [63]. Under the assumption that different patterns and processes of urban growth determine specific changes in the steepness of the density gradient, metropolitan regions may evolve through sequential phases of 'compact growth' and 'sprawl', whose assessment requires conceptually articulated and spatially explicit approaches, grounded on the use of multidimensional techniques [10,11,72]. By comparing a multi-domain set of indicators derived from descriptive statistics and a regression model's outcomes, the methodology proposed in this study is specifically oriented to distinguish the characteristic 'footprint' of any process of urban growth, overcoming limitations of more traditional, linear and non-linear approaches.

2.2. The Study Area

The three investigated areas cover the metropolitan regions of Barcelona (Spain), Rome (Italy) and Athens (Greece) which represent—together with Istanbul, Marseille and Naples—the largest cities in coastal Mediterranean Europe. A sufficiently large area surrounding each city was selected as a reference spatial domain when defining long-term changes in population distribution. Each spatial domain was chosen by aggregating local districts (i.e., municipalities) with administrative boundaries as stable as possible within the study period [63]. We considered administrative boundaries instead of other territorial classifications with the objective of analyzing comparatively changes in

population density for the whole study period. The administrative boundaries selected in this study correspond to the NUTS-3 and NUTS-5 levels of the nomenclature adopted by the European Territorial Statistics (prefecture/province and municipal levels). Technical details and maps illustrating the study areas were provided in Salvati et al. [63]. The study period covers a large part of the last century characterized by a complex urban cycle with sequential demographic waves that reflect distinct expansion models: (i) compact development of inner cities; (ii) high-density settlement growth on fringe land; (iii) medium-density expansion of the areas surrounding the core city and re-densification of urban voids; and (iv) discontinuous and low-density expansion of peri-urban areas [16].

The province of Barcelona includes Barcelona's metropolitan area (defined according to the Law No. 31/2010) and encompasses a total of 311 municipalities extending to 7725 km^2 of Spanish land. Although built-up areas occupy an important (and increasing) part of the region, the majority of the province's area still consists of semi-natural and natural land-cover types [17]. The economic structure of the region is characterized by service activities with high value added. Barcelona maintains an important industrial base specialized in metallurgical, chemical and pharmaceutical sectors [43].

Rome's province (now entitled as the 'metropolitan area of Rome' on the basis of the nomenclature enforced in law in 2009) extends to 5355 km^2 of land and administers a total of 121 municipalities covering a heterogeneous territory, with mixed impervious and semi-natural areas contrasting the compact historical centre of Rome, where the most important economic functions are located [73]. Traditionally, the city provides services related to the public administration and thrives on retail trade and tourism thanks to its invaluable cultural heritage. Interestingly, Rome has never been an industrial city, except for the presence of small-sized enterprises and the recent development of a few spaces for high-tech industry [16].

Athens' region extends to nearly 3000 km^2 of land in mainland Greece administered by 114 municipalities (following the official definition provided by the 'Kapodistrias' act of local administrations). The region mostly consists of mountains bordering the urban conurbation of Athens that occupies a relatively flat area. Athens' economy is largely oriented around sectors such as finance, banking, insurance and real estate. The main economic activities are located in the municipalities of Athens and Piraeus [59]. The 2004 Olympic Games had a major impact on the development of the city in terms of investment and infrastructure [9,49,74].

2.3. Statistical Data

All data used in this study were obtained from the National Census of Population and Households carried out approximately every 10 years along the investigated time period (1920–2011) in Barcelona, Rome and Athens by the respective National Statistical Authorities (Istituto Nacional de Estadistica: INE in Spain, Istituto Nazionale di Statistica: Istat in Italy and National Statistical Service of Greece: ELSTAT). The investigated years were 1920 (or 1921), 1950 (or 1951), 1960 (or 1961), 1970 (or 1971), 1980 (or 1981), 1990 (or 1991), 2000 (or 2001) and 2010 (or 2011) due to a slightly different census timing in the three countries.

2.4. Analysis of Spatial Unit

Administrative boundaries of municipalities and local communities have been used largely as elementary units in the analysis of landscape, land-use, population and socioeconomic transformations in both urban and suburban areas [29,70,75]. Despite criticism about their relevance as geographical domains suitable to identify homogeneous demographic dynamics, administrative domains allow a rather detailed analysis of change in population density for long study periods because of the high availability of census data over time [50]. Long-term population data at municipal scale allows cross-country and within-region reliable comparisons, and full integration with external data sources producing socioeconomic information relevant to urban studies and interpretable by policy-makers, planners and non-technical users. In this regard, municipalities are the local authorities defining land zoning, building volume, settlement size and shape as well as land taxation regime [49,76,77],

and represent a relevant domain for spatial planning [72]. Based on these premises, municipalities were considered the elementary analysis' domain in the three countries. Because of the exceptional dimension of Rome's municipality, this area was subdivided into 115 districts reflecting (i) the historical inner city (22 districts); (ii) consolidated urban districts (35) around the Aurelian Wall (constructed by the ancient Romans); (iii) traditional suburbs developed in the aftermath of World War II (6); and (iv) the remaining areas (mixed urban settlements and cropland) more recently developed around the external ring road (52).

2.5. Data and Variables

Population density was derived from elementary data of resident population aggregated at municipal scale and collected in the framework of the General Census of Population carried out in each country by representative statistical authorities once for decade, from the early 1920s to the early 2010s. Data were analyzed consistently for Barcelona, Rome and Athens with the aim to explore changes over time in the spatial distribution of resident population across each metropolitan region. The average distance of each elementary domain (i.e., municipality) to a central place in each city (i.e., Placa de Catalunya in Barcelona, Piazza Barberini in Rome and Platia Syndagmatos in Athens) was calculated using the municipal centroid by computation with the ArcGIS 'Spatial Analyst' tool (ESRI, Inc., Redwoods, CA, USA). Central places were selected as close as possible to the main tourism attractions, thus representing the economic and social 'heart' of each city.

2.6. Statistical Analysis

A three-step analytical framework was implemented in this study with the final objective to identify similarities and differences in the long-term expansion of three urban models in southern Europe (Barcelona: compact, polycentric, Rome: dense and dispersed, Athens: hyper-compact and mono-centric). The framework introduces original indicators derived from the outcomes of descriptive statistics and regression analysis with the aim of assessing multiple aspects of urban expansion. Metropolitan transformations were finally assessed through a multivariate analysis depicting long-term trajectories of growth and change in each city. Statistical analysis was run using STATISTICA (release 7) and PAST (release 1) softwares.

2.7. Descriptive Statistics

Population density was taken as a key variable widely in the analysis of urban development and settlement encroachment [29,70]. A descriptive analysis of population data based on descriptive metrics was carried out to investigate the progressive expansion of the three metropolitan regions considered in the present study. According to Salvati et al. [60], metrics adopted here quantify concentration (or dispersion) of regional population and human settlements towards progressive scattering driven by residential suburbanization and de-localization of economic activities in sub-central locations. These metrics elaborate a municipal-scale series of demographic data for each census year and metropolitan region by computing 9 measures of central tendency, dispersion, skewness and deviation from normality in the spatial distribution of population density (inhabitants per km^2). Measures include the following metrics: (i) arithmetic average (hereafter 'Avg'); (ii) ratio of median density to average density ('Med'); (iii) harmonic mean ('Har'); (iv) coefficient of variation ('CVm'); (v–vi) 25th and 75th percentile of the statistical distribution of population density across municipalities in each study area; (vii) kurtosis ('Kur'); (viii) skewness ('Asy'); and (ix) ratio of the absolute range (max–mix) of population density across municipalities to the mean population density ('Nor').

2.8. Regression Analysis

Spatial variability in demographic density along urban gradients was considered a proxy of long-term metropolitan expansion. As proposed in earlier studies [63], a regression model was run

to clarify the relationship between population density and the distance from a central city in each metropolitan region [70] according to the linear form:

$$\log(Y) = \alpha + \beta \log(X) + \mathbf{e} \tag{1}$$

where Y is population density (inhabitants/km^2), X is the distance from downtown (km), α and β are the regression coefficients (respectively intercept and slope), and $\mathbf{e}$ is the regression error. Regressions were estimated separately for each time point, using adjusted R^2 as a measure of the model's goodness of fit. Statistical significance of regression coefficients (based on computation of a *t*-statistic testing for significant coefficients at $p < 0.001$) was considered an additional criterion for a model's selection. According to Salvati et al. [63], a descriptive analysis of change over time in regression coefficients allows profiling individual paths of long-term urban development. Under the hypothesis that increasing values of intercept coupled with stable or decreasing values of slope indicate 'compact and dense growth', Couch et al. [7] discriminated different urbanization waves over a sufficiently long time interval. The same rationale was applied to the three case studies to clarify the spatial dynamics of population density along the urban gradient in Barcelona, Rome and Athens. Stable or declining α coefficients coupled with increasing β coefficients indicate 'exurban development'. In these regards, 4 metrics were derived from the regression's results, separately for each census year and metropolitan region: (x) adjusted R^2 ('aR2') (xi) regression intercept ('Int'), (xii) regression slope ('Slo') and (xiii) Durbin–Watson test of serial autocorrelation ('DWt').

2.9. Indicators of Urban Growth

The 13 measures illustrated in Sections 2.7 and 2.8 (9 and 4 derived, respectively, from descriptive statistics and regression models) were adopted as indicators of long-term urban growth at the metropolitan scale separately for the three cities under investigation. Diachronic indicators derived from a statistical analysis of secondary data are particularly effective when examining latent patterns and processes of urban expansion over a sufficiently long time horizon [60]. Indicators from (i) to (ix) are aimed at assessing concentration (or dispersion) of resident population in response to a progressive scattering of human settlements driven by suburbanization processes and de-localization of economic activities in sub-central locations [45]. Indicators from (x) to (xiii) provide a comprehensive investigation of the spatial variability in population density along urban gradients, considered a proxy of long-term metropolitan expansion [63].

2.10. Principal Component Analysis

A principal component analysis (PCA) was run on a data matrix composed of the values of the 13 indicators mentioned above (9 and 4 indicators, respectively, derived from descriptive statistics and regression analysis, see Section 2.9) calculated for each of the 8 time points investigated in this study from the early 1920s to the early 2010s. Results of the PCA contribute to outline (apparent and latent) changes over time in the spatial distribution of resident population as a base to understand long-term metropolitan transformations from a restricted number of (unobservable) components (more or less) associated to the input variables [63]. Components with eigenvalue > 1 were selected and analyzed using both loadings (evaluating the correlation between each variable and component) and scores (estimating the contribution of each time point (years) to individual components satisfying the eigenvalue's threshold). Plots aggregating component loadings and scores on the same factorial plane (i.e., biplot) were analyzed separately for each metropolitan region in order to identify similarities and differences in long-term urban expansion [78]. A line has been designed to connect the points that represent the location of the different years studied in the factorial plane.

3. Results

Table 1 reports the outcomes of the regression models carried out separately for each city and year. For all cities, models' goodness of fit increased substantially over time. For Barcelona, the adjusted R^2 of model regressions increased continuously from 0.24 (1920) to 0.51 (2010) with a Durbin–Watson test close to 2 over the entire time period, indicating the absence of serial correlation in the time series. Regression intercept increased progressively from 3.39 (1920) to 6.19 (2010), outlining rapid, centralized and spatially-homogeneous urban growth. Regression slope decreased at a similar pace from -1.02 (1920) to -2.54 (2010), indicating a progressive strengthening of the population density gap along Barcelona's metropolitan gradient.

Table 1. Regression models (log-log) for each city with population density as dependent variable and the distance from the respective inner city as predictor by year.

| Year	Intercept	Slope	Adj-R^2	D-W Test
		Barcelona		
1920	3.39(0.17)	−1.02(0.10)	0.24	2.03
1950	3.87(0.18)	−1.29(0.11)	0.30	2.01
1960	4.28(0.20)	−1.52(0.12)	0.33	2.02
1970	5.05(0.22)	−1.98(0.14)	0.40	2.05
1980	5.54(0.24)	−2.27(0.15)	0.43	2.01
1990	5.78(0.24)	−2.40(0.15)	0.47	1.98
2000	6.02(0.23)	−2.49(0.14)	0.50	1.99
2010	6.19(0.23)	−2.54(0.14)	0.51	1.99
		Rome		
1921	2.35(0.10)	−1.62(0.08)	0.70	1.10
1951	2.46(0.10)	−1.68(0.08)	0.66	0.95
1961	2.57(0.10)	−1.69(0.08)	0.67	1.03
1971	2.56(0.11)	−1.66(0.08)	0.63	1.14
1981	2.60(0.11)	−1.62(0.08)	0.62	1.31
1991	2.58(0.10)	−1.56(0.08)	0.61	1.38
2001	2.54(0.10)	−1.51(0.08)	0.59	1.42
2011	2.59(0.10)	−1.45(0.08)	0.60	1.54
		Athens		
1920	2.77(0.21)	−1.06(0.18)	0.22	1.90
1951	4.51(0.20)	−2.03(0.17)	0.55	1.99
1961	5.52(0.16)	−2.64(0.14)	0.75	2.03
1971	5.85(0.16)	−2.80(0.13)	0.79	2.02
1981	5.92(0.15)	−2.72(0.13)	0.79	1.99
1991	5.84(0.14)	−2.54(0.12)	0.79	1.85
2001	5.76(0.14)	−2.39(0.12)	0.78	1.75
2011	5.76(0.14)	−2.36(0.12)	0.77	1.71

Regression coefficients are all significant at $p < 0.01$.

For Rome, adjusted R^2 decreased moderately from 0.7 (1920) to 0.6 (2010) with a Durbin–Watson test diverging slightly from 2 in the first decades of the time period and approaching 1.5 in the last decades, indicating a weak serial correlation in the time series. Regression intercept increased up to 1981 (from 2.35 to 2.6) and decreased moderately in subsequent decades. Regression slope was relatively stable around -1.6 in the first temporal period reaching a peak (-1.69) in 1961 and becoming progressively less steep in the subsequent decades up to -1.45 (2011).

For Athens, adjusted R^2 increased up to 1991 (0.79) decreasing slightly in 2001 and 2011. The Durbin–Watson test increased over time approaching 2 in a time period between 1951 and 1981 and decreasing moderately in subsequent decades. The regression intercept increased from 2.77 (1920) to 5.92 (1981) and decreased slowly afterwards (up to 5.76 in 2011). This trend indicates

moderate urban concentration up to 1981 and a more de-centralized growth in the following three decades. Regression slope followed the same pattern, reaching a peak in 1971 (-2.8), a time reflecting the highest population concentration in Athens and Piraeus. Exurban development corresponded to a progressive lowering of the population density gap along the Athens' metropolitan gradient.

　　A principal component analysis was run with the final objective of identifying specific patterns of growth in the three cities. The first two components were selected for all cities, extracting a different proportion of variance for Barcelona, Rome and Athens. For Barcelona, a specific pattern of growth encompassing the time interval between 1920 and 1980 was illustrated along component 1 (76.2%). The recent phase of urban expansion between 1980 and 2010 was mostly associated to component 2 (16.7%), being independent from variables related to component 1 (Figure 1).
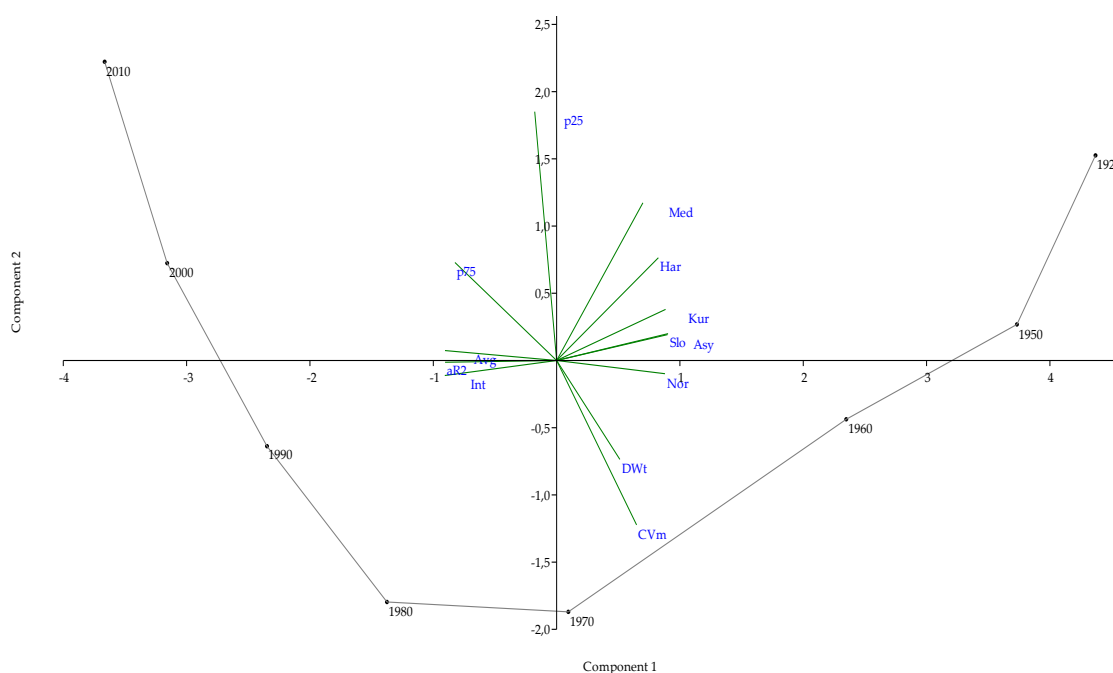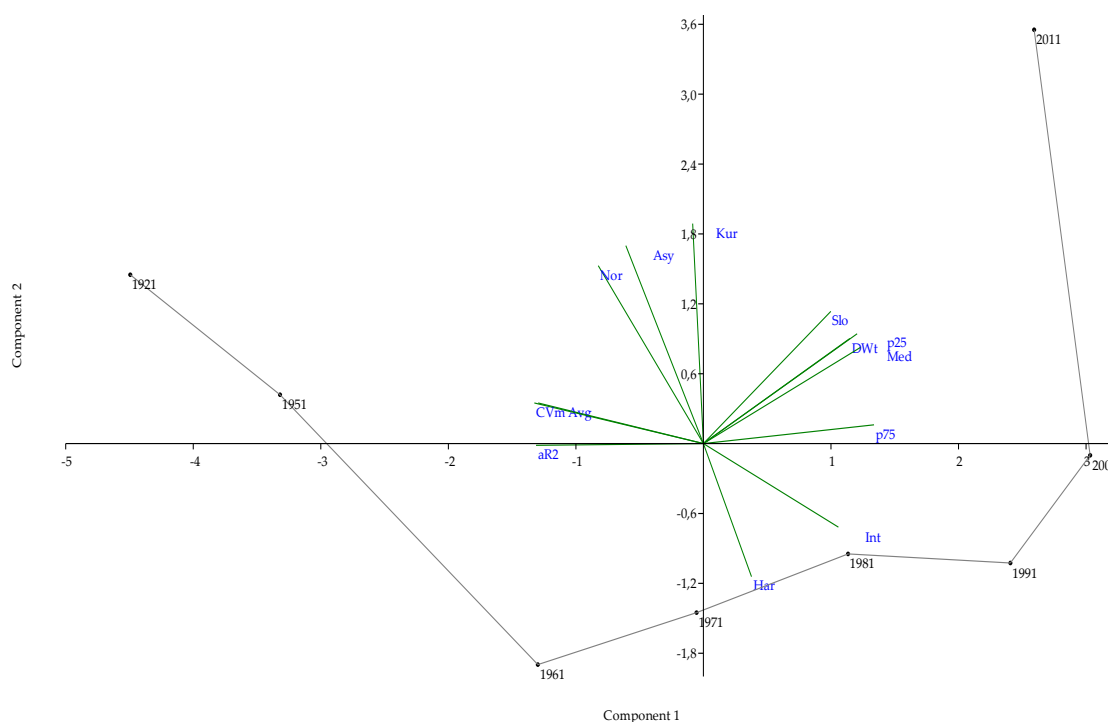

Figure 1. Principal component analysis (PCA) exploring variation over time in basic indicators of urban growth in Barcelona.

　　Principal components discriminated indicators derived from regression analysis (mostly associated to component 1) from indicators derived from descriptive statistics (mostly associated to component 2). More specifically, the regression intercept and the model's goodness of fit (adjusted R^2) received negative loadings to component 1, being in turn correlated with average population density; regression slope was positively associated with component 1, together with spatial variability, asymmetry and kurtosis in population density along the urban gradient (Nor, Asy, Kur). Component 2 discriminated variables indicating areas with low (or medium-low) population density (p25)—which increased largely over time due to suburbanization processes—from variables associated with population density variability (CVm) or indicating non-linear relationships between population density and distance from inner cities (DWt). Taken together, the graphical inspection of the component biplot indicates two cycles of urban expansion for Barcelona, the former encompassing a temporal interval from 1920 to 1970 and the latter extending between 1980 and 2010. The 1970s was classified as a transitional decade with intermediate characteristics between the two cycles.

　　Components 1 and 2 identified a specific pattern of growth observed between 1920 and 1961 in Rome (Figure 2). An intermediate phase of growth between 1961 and 1991 was specifically associated with component 1 (61.4%). The most recent phase of urban expansion between 1991 and 2011 was associated with component 2 (24.8%). The model's goodness of fit (adjusted-R^2),

average population density and variability over space were negatively associated with component 1. An indicator assessing areas with moderate/high population density (p75)—progressively decreasing over time—was associated positively with component 1. Component 2 discriminated indicators of variability, kurtosis and asymmetry (Nor, Asy, Kur) in the spatial distribution of population density from indicators assessing (more or less) evident deviations from normality in the same variable. Taken together, the graphical inspection of component biplot indicates three cycles of urban expansion for Rome, the first being characterized by a spatially-heterogeneous de-concentration of inner cities (1920–1961), the second grounded on centralized growth processes (1961–1991), and the third associated with increasing entropy, fragmentation and spatial heterogeneity in population density at a local scale (1991–2011).

Figure 2. Principal component analysis exploring variation over time in basic indicators of urban growth in Rome.

Component 1 (79%) illustrated a specific pattern of growth observed between 1920 and 1961 in Athens. A specific turning point corresponding with a transitional urban phase was identified in the 1960s (Figure 3). The most recent phase of urban expansion covering a relatively long time period between 1971 and 2011 was associated with component 2 (19.8%). The model's goodness of fit (adjusted R^2) and regression intercept increased along component 1 characterizing the first urban cycle described above. A rising population density (Avg), increasing regression slopes (Slo) and a reduced deviation from normality (Med) characterized the last phase of the Athens' urban cycle, receiving the highest loadings to component 2.
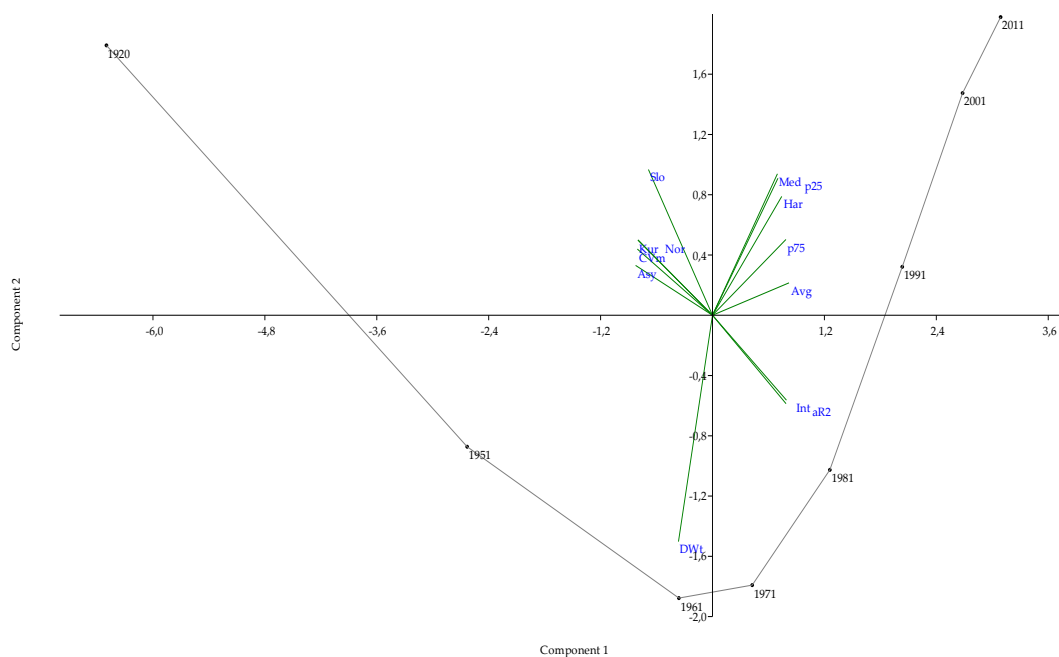
Figure 3. Principal component analysis exploring variation over time in basic indicators of urban growth in Athens.

4. Discussion

A diachronic analysis of population dynamics along transforming urban gradients may advance understanding of (more or less) complex processes of metropolitan expansion and the related socioeconomic change in advanced countries [8,24,39,43,47]. An extensive analysis of the spatial distribution of population over a sufficiently long time interval also contributes to regional studies with new indicators identifying urban cycles and profiling distinctive transformations along sequential waves of metropolitan growth and decline [64,65]. This approach, grounded on a multi-step statistical analysis and producing original indicators of urban expansion, was specifically applied to three metropolitan regions in Mediterranean Europe to verify timing of urban growth and when (and to what extent) compact and dense expansion was being replaced by more scattered models of urban growth [6]. According to the spatial distribution of population density, the analysis has identified a period of dense urban growth followed by (more or less) moderate population de-concentration over the last century. Urban complexity reflects multiple demographic phases, informal city expansion and chaotic spatial planning accompanied by inherent transformations in the socioeconomic structure [17,34,35,56,71].

Taken as an original approach to urban analysis, rapidity of change characterizing distinct growth waves in the three cities was assessed using the analytical tools proposed in this study [50] and outline cycles of urbanization–suburbanization with different timing in Barcelona, Rome and Athens. Compact urban expansion, inner cities' population decline and urban de-concentration were effectively characterized over time and space using the approach proposed in this study. More specifically, the empirical results of this work allowed identification of heterogeneous phases of urban densification and dispersion encompassing the large part of the last century (1920–1970), and a more recent tendency toward urban scattering that reflects a (more or less pronounced) spatial rebalancing across metropolitan regions. Population densities grew in the studied cities up to late 1970s because of multiple socioeconomic forces acting at both regional and local scales (e.g., late industrialization, concentration of traditional and more advanced services in central cities, rural–urban migration, high fertility trends, social housing policies). In that period, concentration and compactness were the main patterns of growth throughout the Mediterranean region [49]. However, this trend underwent a significant—albeit spatially differentiated—change in the following

years. According to Salvati et al. [63], urban trajectories over the time lapse 1980–2010 were dependent on the specific demographic phase (growth, stability, decline) experienced in each region and the spatial pattern of densification vs. de-population observed at local scale, thus making assessment of exurban development a place-specific issue in southern Europe. The empirical results of this study outline diverging growth paths for Barcelona, Rome and Athens, possibly driven by newly emerging, place-specific factors shaping urban transformations (e.g., the different impact of mega-events—Olympic Games in Barcelona (1992) and Athens (2004) and 2000 Jubilee in Rome—in the expansion of the three cities [16]).

In this regard, the outcomes of individual regression models analyzing the population–distance relationship evidence relevant changes in both regression slopes and intercepts, passing from large increases to milder increases (or even decreases) first in Rome (since 1981 for both slope and intercept) and then in Athens (since 1981 for slope, since 1991 for intercept), in contrast with a continuous trend for both regression coefficients in Barcelona. In the last two decades, distinctive growth paths outline consolidation of more entropic and spatially-fragmented socioeconomic transformations in Mediterranean Europe [45]. A progressive de-concentration of population was observed in Athens, following late suburbanization and settlement sprawl in more remote places, especially observed in the early- and mid-2000s [59]. A more centralized growth was observed in Barcelona, with population recovery in inner cities over 2001–2011, after a moderate decline observed in the previous decades [44]. Positioning in-between these two cities, Rome experienced a less linear growth path [16] with a substantial decline in regression slopes (indicating a less steep urban gradient) and a moderate reduction of regression intercepts (indicating a more decentralized urban expansion). Results diverging slightly from this consolidated trend were observed in the last study year (2011).

Intended as a relevant topic in socioeconomic disciplines and spatial planning, urban sprawl is an example of the uneven transformations of advanced regions that require integrated and multi-disciplinary land-management strategies [1,79–81]. For instance, sprawl-driven land take has become central in the European research and policy agenda [13]. Focusing on uneven changes in the spatial distribution of resident populations, the comparative analysis of indicators developed in this study are demonstrated to be a useful tool for monitoring sprawl [82]. The main advantage of this simplified approach is the easy application to variables assessing multiple domains of investigation (population, employment, business density, land use). According to Salvati et al. [63], a comparative analysis of exurban development in representative cities of southern Europe based on mixed regression and multivariate exploratory approaches revealed the multifaceted dimensions of urban sprawl, being intimately connected with sequential urban waves mixing development of new intermediate (and low-) density settlements and self-contained development of newly built-up areas [2,31,33]. In these regards, a complex stratification of immediate and underlying factors was demonstrated to be the ultimate driver of exurban development, influencing population density gradients and the vertical profile of cities [66]. Based on the results of this study, a urban containment strategy promoting medium-density, semi-compact and moderately centralized growth seems to be effective against sprawl, reconciling the functional outcomes of different urban cycles and the underlying socioeconomic context [58,76,77,83]. The most recent crisis has indirectly contributed to urban containment, depressing building activity [59] and re-directing metropolitan expansion toward more compact and land-saving settlements in already urbanized areas [57].

While describing past and present trends in urban expansion at both local and regional scale, identification of specific paths of metropolitan development over a sufficiently long time interval contributes to infer latent characteristics of future development [84]. By adopting a comparative approach applied to cities with different socioeconomic traits and territorial aspects [85], the logical framework presented in this study sheds more light also on the spatial uncertainty and temporal volatility of metropolitan growth. With this approach, the importance of land availability and other factors containing metropolitan expansion (green belts, protected areas, land property and tenure) can be better investigated when determining long-term urban trajectories using spatially-explicit

approaches. For instance, Geographically Weighted Regression may satisfactorily contribute to this analysis' issue [86], controlling for non-stationary population density over space and better linking distance from inner cities to both urban form and socioeconomic structures [87]. Such approaches are also suitable to compare the statistical performance and knowledge content of spatially-implicit indicators related to population density—as the indicators proposed in this study—and spatially-explicit indicators of landscape fragmentation [88] in relation to urban land-use [89]. Approaches specifically referring to fractal analysis [90] or simulation models extensively used in quantitative investigation of present and future urban growth based on e.g., cellular automata [91] are particularly suitable in this direction of study. A comparison of the outcomes of such methodologies with the specific approach illustrated in this study deserves further investigation.

5. Conclusions

The original contribution of this study was to derive new indicators of urban growth from the results of statistical models analyzing the relationship between population density and the distance from the inner city. By highlighting the complex interplay between population dynamics and metropolitan spatial structure in three Mediterranean cities, our study contributes to analysis of long-term urban transformations profiling morphological/functional traits and identifying individual trajectories of growth at the same time. The outcomes of this study represent a relevant knowledge base informing spatial planning and promoting urban strategies rethinking contemporary urbanization, rebalancing objectives of economic competitiveness and socio-ecological sustainability toward more inclusive and land-saving cities [92–94].

Especially in metropolitan regions with an evident urban gradient, it is suggested that spatial planning rethinks contemporary urbanization, putting together economic competitiveness and socio-ecological sustainability toward socially cohesive and morphologically continuous cities [22]. Specific territorial characteristics—such as restricted land availability due to physical constraints, i.e., topography, a factor common to Barcelona, Rome and Athens—should be finally considered in any strategy of urban containment [49,51,52]. Complex causes and consequences of sprawl make the most traditional models investigating the distribution of population and land-use along urban gradients hardly applicable to rapidly evolving cities. The integration of exploratory data analysis and econometric techniques overcame the intimate complexity of Mediterranean urban gradients, revealing peculiar socioeconomic contexts and specific form–function relationships at local scale.

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References

1. Antrop, M. Changing patterns in the urbanized countryside of Western Europe. *Landsc. Ecol.* **2000**, *15*, 257–270. [CrossRef]
2. Schneider, A.; Woodcock, C.E. Compact, dispersed, fragmented, extensive? A comparison of urban growth in twenty-five global cities using remotely sensed data, pattern metrics and census information. *Urban Stud.* **2008**, *45*, 659–692. [CrossRef]
3. Hall, P. Looking backward, looking forward: The city region of the Mid-21st Century. *Reg. Stud. 2009 436*, 803–817. [CrossRef]
4. Camagni, R. The economic role and spatial contradictions of global city-regions: The functional, cognitive, and evolutionary context. In *Global City-Regions: Trends, Theory, Policy*; Hall, P., Ed.; Oxford University Press: Oxford, UK, 2001; pp. 96–118.
5. Johnson, M.P. Environmental impacts of urban sprawl: A survey of the literature and proposed research agenda. *Environ. Plan. A* **2001**, *33*, 717–735. [CrossRef]

6.　Neuman, M. The compact city fallacy. *J. Plan. Educ. Res.* **2005**, *25*, 11–26. [CrossRef]

7.　Couch, C.; Petschel-held, G.; Leontidou, L. Urban sprawl. In *Europe: Landscapes, Land-Use Change and Policy*; Blackwell: London, UK, 2007.

8.　Ward, K. Toward a comparative (re)turn in urban studies? Some reflections. *Urban Geogr.* **2008**, *29*, 405–410. [CrossRef]

9.　Colantoni, A.; Grigoriadis, E.; Sateriano, A.; Venanzoni, G.; Salvati, L. Cities as selective land predators? A Lesson on Urban Growth, (Un)effective planning and Sprawl Containment. *Sci. Total Environ.* **2016**, *545*, 329–339. [CrossRef] [PubMed]

10.　Millward, H. Evolution of population densities: Five Canadian cities, 1971–2001. *Urban Geogr.* **2008**, *29*, 616–638. [CrossRef]

11.　Feng, J.; Wang, F.; Zhou, Y. The spatial restructuring of population in metropolitan Beijing: Toward polycentricity in the post-reform ERA. *Urban Geogr.* **2009**, *30*, 779–802. [CrossRef]

12.　Cuadrado-Ciuraneta, S.; Durà-Guimerà, A.; Salvati, L. Not only tourism: Unravelling suburbanization, second-home expansion and "rural" sprawl in Catalonia, Spain. *Urban Geogr.* **2017**, *38*, 66–89. [CrossRef]

13.　Ludlow, D. *Urban Sprawl in Europe: The Ignored Challenge*; EEA Report No. 10; European Environment Agency: Copenhagen, Denmark, 2006.

14.　Richardson, H.W.; Chang-Hee, C.B. *Urban Sprawl in Western Europe and the United States*; Ashgate: London, UK, 2004.

15.　Plata-Rocha, W.; Gómez-Delgado, M.; Bosque-Sendra, J. Simulating urban growth scenarios using GIS and multicriteria analysis techniques: A case study of the Madrid region, Spain. *Environ. Plan. B Plan. Des.* **2011**, *38*, 1012–1031. [CrossRef]

16.　Di Feliciantonio, C.; Salvati, L. 'Southern' alternatives of urban diffusion: Investigating settlement characteristics and socioeconomic patterns in three Mediterranean regions. *Tijdschr. Econ. Soc. Geogr.* **2015**, *106*, 453–470. [CrossRef]

17.　Paul, V.; Tonts, M. Containing urban sprawl: Trends in land use and spatial planning in the Metropolitan region of Barcelona. *J. Environ. Manag.* **2005**, *48*, 7–35. [CrossRef]

18.　Terzi, F.; Bolen, F. Urban sprawl measurement of Istanbul. *Eur. Plan. Stud.* **2009**, *17*, 1559–1570. [CrossRef]

19.　Sarvestani, M.S.; Latif Ibrahim, A.; Kanaroglou, P. Three decades of urban growth in the city of Shiraz, Iran: A remote sensing and geographical information systems application. *Cities* **2011**, *28*, 320–329. [CrossRef]

20.　Kazemzadeh-Zow, A.; Zanganeh Shahraki, S.; Salvati, L.; Neisani Samani, N. A Spatial Zoning Approach to Calibrate and Validate Urban Growth Models. *Int. J. Geogr. Inf. Sci.* **2017**, *31*, 763–782. [CrossRef]

21.　Cooke, P.; Gomez Uranga, M.; Etxebarria, G. Regional innovation systems: Institutional and organisational dimensions. *Res. Policy* **1997**, *26*, 475–491. [CrossRef]

22.　Faludi, A.K.F. Polycentric territorial cohesion policy. *Town Plan. Rev.* **2005**, *76*, 107–118. [CrossRef]

23.　Cowell, M. Polycentric regions: Comparing complementarity and institutional governance in the San Francisco Bay area, the Randstad and Emilia-Romagna. *Urban Stud.* **2010**, *47*, 945–965. [CrossRef]

24.　Ward, K. Towards a relational comparative approach to the study of cities. *Prog. Hum. Geogr.* **2010**, *34*, 471–487. [CrossRef]

25.　Jaeger, J.A.G.; Bertiller, R.; Schwick, C.; Cavens, D.; Kienast, F. Urban permeation of landscapes and sprawl per capita: New measures of urban sprawl. *Ecol. Indic.* **2010**, *10*, 427–441. [CrossRef]

26.　Hasse, J.E.; Lathrop, R.G. Land resource impact indicators of urban sprawl. *Appl. Geogr.* **2003**, *23*, 159–175. [CrossRef]

27.　Colantoni, A.; Mavrakis, A.; Sorgi, T.; Salvati, L. Towards a 'polycentric' landscape? Reconnecting fragments into an integrated network of coastal forests in Rome. *Rend. Lincei Sci. Fis. Nat.* **2015**, *26*, 615–624. [CrossRef]

28.　European Spatial Planning Observation Network (ESPON). *Making Europe Open and Poly-Centric. Vision and Scenarios for the European Territory Towards 2050*; European Union: Luxembourg, 2014.

29.　Tsai, Y. Quantifying urban form: Compactness versus sprawl. *Urban Stud.* **2005**, *42*, 141–161. [CrossRef]

30.　Torrens, P.M. Simulating sprawl. *Ann. Assn. Am. Geogr.* **2006**, *96*, 248–275. [CrossRef]

31.　Schwarz, N. Urban form revisited: Selecting indicators for characterising European cities. *Landsc. Urban Plan.* **2010**, *96*, 29–47. [CrossRef]

32.　Zambon, I.; Serra, P.; Sauri, D.; Carlucci, M.; Salvati, L. Beyond the 'Mediterranean City': Socioeconomic Disparities and Urban Sprawl in three Southern European Cities. *Geogr. Ann. B* **2017**, *99*, 319–337. [CrossRef]

33. Kasanko, M.; Barredo, J.I.; Lavalle, C.; McCormick, N.; Demicheli, L.; Sagris, V.; Brezger, A. Are European Cities Becoming Dispersed? A Comparative Analysis of Fifteen European Urban Areas. *Landsc. Urban Plan.* **2006**, *77*, 111–130. [CrossRef]

34. Longhi, C.; Musolesi, A. European cities in the process of economic integration: Towards structural convergence. *Ann. Reg. Sci.* **2007**, *41*, 333–351. [CrossRef]

35. Turok, I.; Mykhnenko, V. The trajectories of European cities, 1960–2005. *Cities* **2007**, *24*, 165–182. [CrossRef]

36. Leontidou, L. Repolarization in the Mediterranean: Spanish and Greek cities in neoliberal Europe. *Eur. Plan. Stud.* **1995**, *3*, 155–172. [CrossRef]

37. Leontidou, L. *The Mediterranean City in Transition*; Cambridge University Press: Cambridge, UK, 1990.

38. Leontidou, L. Alternatives to modernism in (Southern) urban theory: Exploring in-between spaces. *Int. J. Urban Reg. Res.* **1996**, *20*, 180–197. [CrossRef]

39. Kourliouros, E. Planning industrial location in Greater Athens: The interaction between deindustrialization and anti-industrialism during the 1980s. *Eur. Plan. Stud.* **1997**, *5*, 435–460. [CrossRef]

40. Ioannidis, C.; Psaltis, C.; Potsiou, C. Towards a strategy for control of suburban informal buildings through automatic change detection. *Comput. Environ. Urban* **2009**, *33*, 64–74. [CrossRef]

41. Leontidou, L. Postmodernism and the City: Mediterranean versions. *Urban Stud.* **1993**, *30*, 949–965. [CrossRef]

42. Gospodini, A. Portraying, classifying and understanding the emerging landscapes in the post-industrial city. *Cities* **2006**, *23*, 311–330. [CrossRef]

43. Kirby, A. Homage to Barcelona. *Cities* **2004**, *21*, 183–186. [CrossRef]

44. Dura-Guimera, A. Population deconcentration and social restructuring in Barcelona, a European Mediterranean city. *Cities* **2003**, *20*, 387–394. [CrossRef]

45. Carlucci, M.; Grigoriadis, E.; Rontos, K.; Salvati, L. Revisiting an Hegemonic Concept: Long-term 'Mediterranean Urbanization' in between city re-polarization and metropolitan decline. *Appl. Spat. Anal. Policy* **2017**, *10*, 347–362. [CrossRef]

46. Economidou, E. The Attic landscape throughout the centuries and its human degradation. *Landsc. Urban Plan.* **1993**, *24*, 33–37. [CrossRef]

47. Muñoz, F. Lock living: Urban sprawl in Mediterranean cities. *Cities* **2003**, *20*, 381–385. [CrossRef]

48. Catalàn, B.; Sauri, D.; Serra, P. Urban sprawl in the Mediterranean? Patterns of growth and change in the Barcelona metropolitan region 1993-2000. *Landsc. Urban Plan.* **2008**, *85*, 174–184.

49. Chorianopoulos, I.; Pagonis, T.; Koukoulas, S.; Drymoniti, S. Planning, competitiveness and sprawl in the Mediterranean city: The case of Athens. *Cities* **2010**, *27*, 249–259. [CrossRef]

50. Salvati, L.; Serra, P. Estimating rapidity of change in complex urban systems: A multidimensional, local-scale approach. *Geogr. Anal.* **2016**, *48*, 132–156. [CrossRef]

51. Zambon, I.; Benedetti, A.; Ferrara, C.; Salvati, L. Soil Matters? A Multivariate Analysis of Socioeconomic Constraints to Urban Expansion in Mediterranean Europe. *Ecol. Econ.* **2018**, *146*, 173–183. [CrossRef]

52. Ceccarelli, T.; Bajocco, S.; Perini, L.; Salvati, L. Urbanisation and Land Take of High Quality Agricultural Soils—Exploring Long-term Land Use Changes and Land Capability in Northern Italy. *Int. J. Environ. Res.* **2014**, *8*, 181–192.

53. Altieri, L.; Cocchi, D.; Pezzi, G.; Scott, E.M.; Ventrucci, M. Urban sprawl scatterplots for Urban Morphological Zones data. *Ecol. Indic.* **2014**, *36*, 315–323. [CrossRef]

54. Ferrara, A.; Salvati, L.; Sabbi, A.; Colantoni, A. Urbanization, Soil Quality and Rural Areas: Towards a Spatial Mismatch? *Sci. Total Environ.* **2014**, *478*, 116–122. [CrossRef] [PubMed]

55. Leontidou, L.; Afouxenidis, A.; Kourliouros, E.; Marmaras, E. Infrastructure-related urban sprawl: Mega-events and hybrid peri-urban landscapes in southern Europe. In *Urban Sprawl in Europe: Landscapes, Land-Use Change and Policy*; Couch, C., Petschel-Held, G., Leontidou, L., Eds.; Blackwell: Oxford, UK, 2007; pp. 71–101.

56. Maloutas, T. Segregation, social polarization and immigration in Athens during the 1990s: Theoretical expectations and contextual difference. *Int. J. Urban Reg. Res.* **2007**, *31*, 733–758. [CrossRef]

57. Zitti, M.; Ferrara, C.; Perini, L.; Carlucci, M.; Salvati, L. Long-term Urban Growth and Land-use Efficiency in Southern Europe: Implications for Sustainable Land Management. *Sustainability* **2015**, *7*, 3359–3385. [CrossRef]

58. Serra, P.; Vera, A.; Tulla, A.F.; Salvati, L. Beyond urban-rural dichotomy: Exploring socioeconomic and land-use processes of change in Spain (1991–2011). *Appl. Geogr.* **2014**, *55*, 71–81. [CrossRef]

59. Rontos, K.; Grigoriadis, S.; Sateriano, A.; Syrmali, M.; Vavouras, I.; Salvati, L. Lost in Protest, Found in Segregation: Divided Cities in the Light of the 2015 'Oki' Referendum in Greece. *City Cult. Soc.* **2016**, *7*, 139–148. [CrossRef]

60. Salvati, L.; Venanzoni, G.; Carlucci, M. Urban growth and polycentric settlements: An exploratory analysis of socioeconomic and demographic indicators in Emilia Romagna, Italy. *Ital. J. Appl. Stat.* **2016**, *26*, 167–178.

61. Clark, C. Urban population density. *J. R. Stat. Soc.* **1951**, *114*, 490–496.

62. Alperovich, G. An empirical study of population density gradients and their determinants. *J. Reg. Sci.* **1983**, *2*, 529–540. [CrossRef]

63. Salvati, L.; Gargiulo, V.; Rontos, K.; Sabbi, A. Latent Exurban Development: City Expansion Along the Rural-To-Urban Gradient in Growing and Declining Regions of Southern Europe. *Urban Geogr.* **2013**, *34*, 376–394. [CrossRef]

64. Duvernoy, I.; Zambon, I.; Sateriano, A.; Salvati, L. Pictures from the Other Side of the Fringe: Urban Growth and Peri-urban Agriculture in a Post-industrial City (Toulouse, France). *J. Rural Stud.* **2018**, *57*, 25–35. [CrossRef]

65. Pili, S.; Grigoriadis, E.; Carlucci, M.; Clemente, M.; Salvati, L. Towards Sustainable Growth? A Multi-criteria Assessment of (Changing) Urban Forms. *Ecol. Indic.* **2017**, *76*, 71–80. [CrossRef]

66. Bruegmann, R. *Sprawl: A Compact History*; University of Chicago Press: Chicago, IL, USA, 2005.

67. Bonifazi, C.; Heins, F. Testing the differential urbanisation model for Italy. *Tijdschr. Econ. Soc. Geogr.* **2003**, *94*, 23–37. [CrossRef]

68. Haase, D.; Nuissl, H. The urban-to-rural gradient of land use change and impervious cover: A long-term trajectory for the city of Leipzig. *J. Land Use Chang.* **2011**, *5*, 123–141. [CrossRef]

69. Munafò, M.; Salvati, L.; Zitti, M. Estimating soil sealing at country scale—Italy as a case study. *Ecol. Indic.* **2013**, *26*, 36–43. [CrossRef]

70. Muñiz, I.; Galindo, A.; Angel Garcia, M. Cubic spline population density functions and satellite city delimitation: The case of Barcelona. *Urban Stud.* **2003**, *40*, 1303–1321. [CrossRef]

71. Weber, C.; Puissant, A. Urbanisation pressure and modeling of urban growth: Example of the Tunis Metropolitan Area. *Remote Sens. Environ.* **2003**, *86*, 341–352. [CrossRef]

72. Guérois, M.; Pumain, D. Built-up encroachment and the urban field: A comparison of forty European cities. *Environ. Plan. A* **2008**, *40*, 2186–2203. [CrossRef]

73. Salvati, L. Urban expansion and high-quality soil consumption—An inevitable spiral? *Cities* **2013**, *31*, 349–356. [CrossRef]

74. Delladetsima, P.M. The emerging property development pattern in Greece and its impact on spatial development. *Eur. Urban Reg. Stud.* **2006**, *13*, 245–278. [CrossRef]

75. Salvati, L.; Carlucci, M. The economic and environmental performances of rural districts in Italy: Are competitiveness and sustainability compatible targets? *Ecol. Econ.* **2011**, *70*, 2446–2453. [CrossRef]

76. Giannakourou, G. Transforming spatial planning policy in Mediterranean countries: Europeanization and domestic change. *Eur. Plan. Stud.* **2005**, *13*, 319–331. [CrossRef]

77. Gospodini, A. Post-industrial trajectories of Mediterranean European cities: The case of post-Olympics Athens. *Urban Stud.* **2009**, *46*, 1157–1186. [CrossRef]

78. Ferrara, A.; Salvati, L.; Sateriano, A.; Nolè, A. Performance Evaluation and Costs Assessment of a Key Indicator System to Monitor Desertification Vulnerability. *Ecol. Indic.* **2012**, *23*, 123–129. [CrossRef]

79. Aguilar, A.G. Peri-urbanization, illegal settlements and environmental impact in Mexico City. *Cities* **2008**, *25*, 133–145. [CrossRef]

80. Alberti, M. Maintaining ecological integrity and sustaining ecosystem function in urban areas. *Curr. Opin. Environ. Sustain.* **2010**, *2*, 178–184. [CrossRef]

81. Schwarz, N.; Haase, D.; Seppelt, R. Omnipresent sprawl? A review of urban simulation models with respect to urban shrinkage. *Environ. Plan. B* **2010**, *37*, 265–283. [CrossRef]

82. McGregor, D.; Simon, D.; Thompson, D. *The Peri-Urban Interface: Approaches to Sustainable Natural and Human Resource Use*; Earthscan: London, UK, 2006.

83. Costa, F.; Noble, A.G.; Pendleton, G. Evolving planning systems in Madrid, Rome, and Athens. *Geojournal* **1991**, *24*, 293–303. [CrossRef]

84. Salvati, L.; Gemmiti, R.; Perini, L. Land degradation and the Mediterranean urban areas: An unexplored link with planning? *Area* **2012**, *44*, 317–325. [CrossRef]

85. Biasi, R.; Colantoni, A.; Ferrara, C.; Ranalli, F.; Salvati, L. In-between Sprawl and Fires: Long-term Forest Expansion and Settlement Dynamics at the Wildland-Urban Interface in Rome, Italy. *Int. J. Sustain. Dev. World Ecol.* **2015**, *22*, 467–475. [CrossRef]

86. Fotheringham, A.; Charlton, M.; Brunsdon, C. Geographically weighted regression: A natural evolution of the expansion method for spatial data analysis. *Environ. Plan. A* **1998**, *30*, 1905–1927. [CrossRef]

87. Fotheringham, A.; Brunsdon, C.; Charlton, M. *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*; Wiley: Chichester, UK, 2006.

88. Corona, P.; Ascoli, D.; Barbati, A.; Bovio, G.; Colangelo, G.; Elia, M.; Lovreglio, R. Integrated forest management to prevent wildfires under Mediterranean environments. *Ann. Silvicul. Res.* **2015**, *39*, 1–22.

89. Salvati, L. Agro-forest landscape and the 'fringe' city: A multivariate assessment of land-use changes in a sprawling region and implications for planning. *Sci. Total Environ.* **2014**, *490*, 715–723. [CrossRef] [PubMed]

90. Batty, M.; Longley, P.A. *Fractal Cities: A Geometry of Form and Function*; Academic Press: London, UK, 1994.

91. White, R.; Engelen, G. Cellular automata and fractal urban form: A cellular modelling approach to the evolution of urban land-use patterns. *Environ. Plan. A* **1993**, *25*, 1175–1199. [CrossRef]

92. Bengston, D.N.; Youn, Y.C. Urban containment policies and the protection of natural areas: The case of Seoul's greenbelt. *Ecol. Soc.* **2006**, *11*, 3–11. [CrossRef]

93. Gomes, E.; Banos, A.; Abrantes, P.; Rocha, J. Assessing the Effect of Spatial Proximity on Urban Growth. *Sustainability* **2018**, *10*, 1308. [CrossRef]

94. Hayek, U.W.; Jaeger, J.A.G.; Schwick, C.; Jarne, A.; Schuler, M. Measuring and assessing urban sprawl: What are the remaining options for future settlement development in Switzerland for 2030? *Appl. Spat. Anal. Policy* **2011**, *4*, 249–279. [CrossRef]