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To cite this article: Luca Salvati (2019) Urban dispersion and economic crisis: empirical evidence from a Mediterranean region, Journal of Environmental Planning and Management, 62:7, 1205-1226, DOI: [10.1080/09640568.2018.1489787](https://doi.org/10.1080/09640568.2018.1489787)

To link to this article: <https://doi.org/10.1080/09640568.2018.1489787>



Published online: 29 Oct 2018.



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## Urban dispersion and economic crisis: empirical evidence from a Mediterranean region

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(Received 25 September 2017; final version received 12 June 2018)

Economic expansions and recessions have had a relevant influence on urbanization patterns, altering building cycles and depressing local housing markets. In regions with declining employment and wealth, the 2007 economic crisis has resulted in urban containment and inherent transformations in metropolitan structures and socioeconomic functions. This study aims at verifying whether urban growth spatial direction and intensity have changed during the 2007 economic crisis in Athens, the capital of Greece, based on a diachronic analysis (1990–2016) of indicators assessing population dynamics, building characteristics and land-use change. Urban growth rate in the study area was the highest over a period of economic expansion spanning from 1990 to 2006, decreasing largely in the subsequent decade, characterized by economic recession. Conversely, dispersed development as a proportion of total urban growth was the lowest during economic expansion, rising after 2007. With economic expansion, discontinuous urban growth concentrated in peri-urban districts. During recession, the same districts experienced a trend towards settlement re-densification, with new sprawled settlements expanding in marginal areas. Taken together, the empirical results of this study suggest that economic recession has promoted a moderate change in spatial direction and intensity of Athens' expansion, with distinct patterns of urban densification and dispersion depending on the specific local context. Our findings bring insights on the debate over post-crisis development of Mediterranean cities, suggesting that – without policy interventions – dispersed settlements will remain the dominant urbanization pattern in heterogeneous and fragmented metropolitan regions.

**Keywords:** indicator system; recession; Southern Europe; urban growth

### 1. Introduction

Economic recessions have deeply influenced patterns and processes of urban growth (Couch, Petschel-Held, and Leontidou 2007), altering building cycles and shaping house and labour markets as a consequence of increased social disparities and polarized distribution of activities (Goldblum and Wong 2000; Winarso and Firman 2002; Pérez 2010; Serra *et al.* 2014; Ren 2015). At the same time, cities and metropolitan regions are significant scales of geography at which to examine the economic, political and social implications of austerity (Souliotis 2013). Empirical evidence on the impact of the most recent economic crisis on urbanization patterns and processes are mixed and usually refer to single variables over a relatively short time period (Garcia 2010;

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Cho, Kim, and Roberts 2011; Fujita 2011; Gkartios 2013; Kane *et al.* 2014; Dijkstra, Garcilazo, and McCann 2015). Recessions have impacted negatively on the demand for new dwellings, with a consequent decline in construction activity and indirect feedback in terms of urban containment (Whitehead and Williams 2011; Kneebone 2013; Kane *et al.* 2014; Kazemzadeh-Zow *et al.* 2017).

Under the assumption that urban form and resource consumption co-evolve dynamically with public finances (Milan and Creutzig 2016), earlier studies have identified significant differences in the rates of population growth and land-use change during economic expansions and recessions, leading to spatially heterogeneous and temporally divergent socioeconomic transformations (Arbaci 2008; Balta and Eke 2011; Barr and Cohen 2014). Empirical findings by Cho *et al.* (2015) indicate that (i) metropolitan growth boundaries attract urban development inside the given boundary during economic expansion while its effectiveness diminishes during a recession, (ii) agricultural zoning works better in restraining new development during economic expansion than stagnation and (iii) land-value taxation increases the incentive for development during recession while higher tax bills do not affect development during expansion. Kane *et al.* (2014) have found a preference for cheaper land and agricultural conversion farther away from metropolitan sub-centres during an economic boom. While zoning remains a proxy for future development, urban trajectories change drastically during stagnation, influencing agricultural conversions and expansion into previously fast-growing areas, while highlighting the depth of impact that the financial environment has on land-use change (Paul and Tonts 2005; Reckien, Eisenack, and Ludeke 2011; Pili *et al.* 2017). At the same time, the work by Cho, Kim, and Roberts (2011) indicates that consumers' marginal willingness to pay for landscape attributes, decreased during the 2007 recession compared to the 2000–2006 real estate boom, probably because of a temporary deterioration in economic conditions (Duvernoy *et al.* 2018). Moreover, Kneebone (2013) demonstrated that the 2007 recession in the United States slowed down the job decentralization (mainly driven by manufacturing and construction industries) that had occurred in the early to mid-2000s. According to Lee (2010), the take-up of sustainable transport modes also appears to have increased during the current recession. Marquet and Miralles-Guasch (2017) showed a trend towards a rationalized use of private modes in favour of an increased use of shorter trips and non-motorized modes in Barcelona.

Based on these premises, Florida (2011) argued that the 2007 crisis may represent a unique opportunity for revisiting contemporary urban models towards sustainability and resilience (Schneider, Kallis, and Martinez-Alier 2010), reinforcing trends towards population and settlement densification, local-scale diversity in land-use and architectural designs, land (brownfield) re-use and building rehabilitation (Garcia 2010). These (formal and informal) responses to urban crisis have demonstrated to be largely heterogeneous over time and space (Salvati, Sateriano, and Grigoriadis 2016). Nuisserl and Rink (2005) argued that processes of urban dispersion have displayed distinctive attributes reflecting specific legislative and political conditions, with changes in these conditions possibly driven by economic stagnation and metropolitan decline. In some cases, returning to city centres materialized in the start of downtown rehabilitation policies coinciding with weak population growth, an acute industrial crisis and new democratic policies in municipal councils (Pérez 2010). In this line of thinking, “the growing recognition of a real estate bubble prompted intense speculation regarding the possibility that the landscape of suburban sprawl might have to be rethought along

lines that would emphasise mass transit and greater density” (McCharty 2012, 185), influencing significantly the most recent patterns and trends of urban expansion.

Distinctive patterns of urban growth over different economic cycles in Europe have become a matter of concern for regional and local planning and claim for specific development strategies (Couch, Petschel-Held, and Leontidou 2007). With a long period of economic expansion, Western Europe, as other wealthy regions in the world, has featured population increase, infrastructural development and semi-compact urban growth. However, at least since the early 1970s, more complex and spatially differentiated patterns towards urban dispersion and polycentric development were increasingly observed in this region (European Environment Agency 2006; Schneider and Woodcock 2008; Angel *et al.* 2011; Pirotte and Madre 2011; Colantoni *et al.* 2015). Compared with western European counterparts, Mediterranean cities experienced late urbanization up to the early 1980s (with dense and partly informal settlement expansion forming mono-centric agglomerations), and more recent suburbanization processes resulting in discontinuous and dispersed urban expansion; empirical evidence for such trends were presented in earlier studies concerning Spain, Italy, Greece and, in part, Portugal (Allen *et al.* 2004; Couch, Petschel-Held, and Leontidou 2007; Colantoni *et al.* 2016; Cuadrado-Ciuraneta, Durà-Guimerà, and Salvati 2017). In these countries, the 2007 recession was typically originated in urban spaces, then becoming a state crisis with consequences for sub-national scales (Donald *et al.* 2014). Being strongly influenced by austerity urbanism and economic shrinkage, recent development paths in Southern European cities have been increasingly shaped by characteristic socioeconomic, demographic, political and cultural factors (Castles and Ferrera 1996; Andreotti *et al.* 2001; De Rosa and Salvati 2016), among which economic polarization (Carlucci *et al.* 2017), class segregation (Rontos *et al.* 2016), immigration (Arapoglou and Sayas 2009) and limited participation in planning decisions (Carlucci *et al.* 2017), were considered key drivers of change.

Since urban dispersion has progressively become a key issue in the European research and policy agenda (European Environment Agency 2006), approaches interpreting the multi-dimensional nature of this process are increasingly required to make regional planning and urban strategies more sustainable and effective (e.g. Salvati 2013). Especially in the Mediterranean region, it was demonstrated that dispersed urban expansion has transformed compact urban areas towards ‘hybrid’ metropolitan models characterized by increased rates of land consumption (Salvati and Gargiulo Morelli 2014). Urban dispersion and population redistribution over larger metropolitan areas have been studied in Europe over vastly different periods of their history by adopting multiple perspectives (e.g. functional, morphological, mixed) and approaches grounded on different indicators and geographical scales of analysis, from local to regional (e.g. Torrens 2006; Balaban 2012; Polyzos and Minetos 2013; Salvati 2013). However, indicators proposed up to now have frequently evaluated partial aspects of construction and housing patterns characteristic of urban dispersion since they often require high-resolution spatial data with restricted availability over long time periods (Balta and Eke 2011; Terando *et al.* 2014; Barrington-Leigh and Millard-Ball 2015).

The use of a multi-temporal set of morphological and demographic indicators allows a timely investigation of the structural complexity typical of metropolitan contexts, allowing for a comprehensive assessment of a city’s forms and socioeconomic conditions over different economic cycles (Arbaci 2008). By integrating information derived from different data sources (as proposed by earlier studies from different socioeconomic contexts, e.g. Catalàn, Saurí, and Serra 2008; Hayek *et al.* 2011; Barr and

Cohen 2014), the present work proposes a diachronic analysis of a multi-domain indicator system aimed at identifying distinct urbanization patterns – with specific focus on dispersed urban growth – during both economic expansion and recession at a disaggregated spatial level (municipalities and/or urban districts). Since urban dispersion has been largely considered a multi-dimensional concept involving societal, economic and demographic dimensions (Tsai 2005), the indicators proposed here are oriented towards a more comprehensive assessment of metropolitan expansion and impacts of economic cycles on urban structures and functions. With empirical evidence of recession impacts on explicit characteristics and directions of urban dispersion being still occasional and restricted to specific contexts in Europe (e.g. Salvati, Sateriano, and Grigoriadis 2016), the present work contributes to this deserving issue by comparing long-term urban cycles in a metropolitan region (Athens, Greece) during sequential expansion and recession waves. The exploratory framework proposed here can be extended to other metropolitan regions experiencing similar development paths in both wealthier and emerging countries (Carlucci *et al.* 2017).

Becoming representative examples of deregulated urban expansion in Europe, Mediterranean cities – and particularly Athens – have been frequently considered a mid-point between metropolitan agglomerations of affluent and emerging countries, reflected in a progressive transition towards zero (or negative) population growth and aging (Catalàn, Saurí, and Serra, 2008; Schneider and Woodcock 2008; Arapoglou and Sayas 2009; Chorianopoulos *et al.* 2010). Results of the study are commented on in the light of recent paths of urban expansion observed on in other countries severely hit by the 2007 economic crisis, discussing the potential implications for the future development of city regions in the Mediterranean region.

## 2. Methods

### 2.1. Study area

The present work focused on the Athens' metropolitan region extending over nearly 3,000 km<sup>2</sup> of Greek land and hosting more than 3.5 million people (Figure 1). The area consists of 30% flat areas (<100 m at sea level) and 40% upland (elevation ranging between 100 and 600 m) belonging to the administrative region of Attica, central Greece, and coinciding with the Athens' Large Urban Zone, as defined in the framework of the 'Urban Atlas' European program. The study area was subdivided in two main districts: (i) the 'Greater Athens' area' encompassing the compact urban area of Athens, Piraeus, Kallithea, Peristeri, Glifada (and other minor centres) and extending over 430 km<sup>2</sup> of land and (ii) the remaining part of the study area (hereafter 'peri-urban Athens', extending over more than 2,600 km<sup>2</sup> of land). Peri-urban Athens includes three lowland districts (Messoghia, Thriasio and Marathon) situated in the immediate surroundings (<20 km) of the Greater Athens' area: Marathon plain is devoted to agriculture, Messoghia plain is characterized by multiple land-use mixing agriculture, sparse residential settlements, manufacturing and service settlements (including the international Airport 'E. Venizelos'), Thriasio plain is a consolidated location for industry and logistics. Mountainous areas extend over less than 30% of the study area and include Parnitha (1,429 m), Pendeli (1,107 m) and Imitos (1,026 m) mountains.

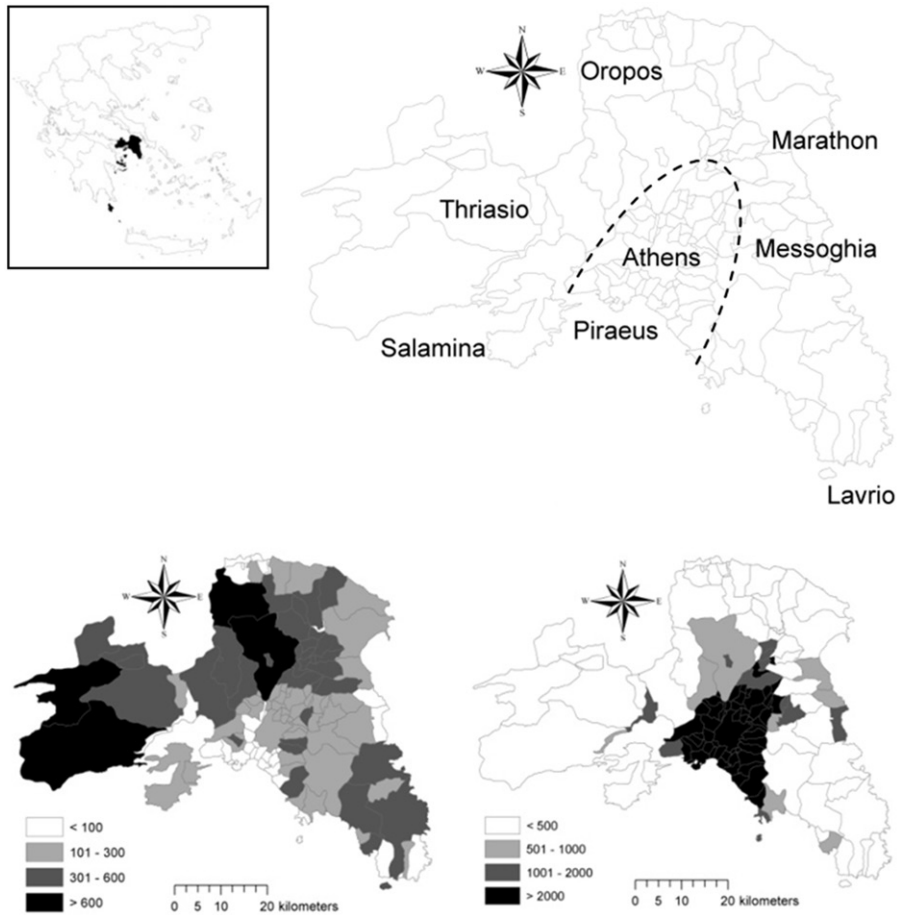


Figure 1. (Upper line) The Athens' metropolitan region with municipal boundaries and selected place names (municipalities inside the inverted-U-dashed line belong to the Greater Athens' area) and (insert left) the position of Attica region in Greece; (lower line) mean elevation (left, m) and population density (right, inhabitants/km<sup>2</sup>) for each municipality in the study area.

## 2.2. Recent economic dynamics in Athens

The Greek capital's development up to the late 1980s was interpreted as a process of 'urbanization without industrialization' (Leontidou 1996), characterized by informal settlements and social diversification that led to a compact and dense urban form (Burgel 2004), shifting to a mixed semi-dense and more discontinuous expansion over the last three decades (Pili *et al.* 2017). Since the early 1950s, the Athens' metropolitan region hosts more than 30% of the Greek population. Growing at around 2% per year, with the population density doubling over the last 60 years (from 630 to 1250 inhabitants/km<sup>2</sup> between 1951 and 2011). After a long period alternating between economic expansion and stagnation (Chorianopoulos *et al.* 2010), Athens experienced a remarkable 'building boom' covering the period from the mid-1990s to the late 2000s (Couch, Petschel-Held, and Leontidou 2007). The announcement of the 2004 Olympics fuelled expansive, state-driven infrastructural policies and a substantial planning deregulation after decades of settlement informality and out-of-plan urbanization

(Leontidou 1996). Regional value added for Attica increased significantly at rates between 4% and 11% between 2000 and 2008 (Table 1), accounting for 45% of Greek value added in 2000 and 48% in 2008. Gaps in per-capita and per-land value added between Attica and the whole of Greece consolidated over time: in 2008, per-capita and per-land value added in Attica were, respectively, 1.34 times and 16.7 times higher than the respective figures for the whole of Greece, although remaining substantially lower than the European averages (Salvati 2016). Subsequently, the impact of the 2008 recession was particularly intense in Attica (Kaika 2012; Souliotis 2013; Chorianopoulos *et al.* 2014), and still persists (Rontos *et al.* 2016). Attica value added decreased continuously at rates between  $-0.6\%$  (2009) and  $-8.6\%$  (2011), with a moderately declining share in Greek value added. Divides in per-capita value added between Attica and the whole of Greece also remained high under economic crisis, while spatial gaps in per-land value added – considered a proxy for urban concentration and economic polarization (Salvati 2016) – decreased moderately over time.

### 2.3. Analysis' spatial unit

The present study proposes a multi-scale analysis of long-term urban expansion based on a multi-domain indicator system derived from statistical data sources and made available at (i) the individual landscape patches (land-use indicators), (ii) the spatial scale of municipalities (building activity indicators) or (iii) the aggregate level of urban districts (i.e. 'Greater Athens' area' and 'peri-urban Athens') and the whole of the study area (population dynamics). As far as municipal units are concerned, they are considered an effective spatial domain when investigating spatio-temporal patterns and drivers of change in urban expansion under sequential economic cycles (e.g. Colantoni *et al.* 2016). In this regard, municipalities in Greece represent a reliable spatial scale easily interpretable by non-technical users and a relevant administrative unit with a

Table 1. Economic dynamics in Attica and Greece, 2000–2015 (percent rate of annual growth in Attica value added, Attica–Greece differentials in per-capita and per-land value added by year (Greece = 1.0), and share of Attica value added in total value added of Greece, by year).

Year	Percent rate of growth	Per-capita value added	Per-land value added	Share in total value added
2000	–	1.263	15.73	0.454
2001	7.5	1.263	15.70	0.453
2002	9.4	1.288	15.99	0.461
2003	9.4	1.283	15.98	0.461
2004	10.1	1.302	16.25	0.469
2005	3.6	1.309	16.36	0.472
2006	10.9	1.327	16.60	0.479
2007	7.4	1.334	16.68	0.481
2008	4.2	1.337	16.71	0.482
2009	$-0.6$	1.356	16.92	0.488
2010	$-4.8$	1.359	16.94	0.489
2011	$-8.6$	1.361	16.90	0.488
2012	$-8.2$	1.359	16.80	0.485
2013	$-5.4$	1.368	16.81	0.485
2014	$-1.8$	1.365	16.69	0.482
2015	$-1.9$	1.362	16.58	0.479



key role in spatial planning, land-use regulation, building volume and settlement size (Chorianopoulos *et al.* 2010). While representing arbitrary domains, administrative boundaries have been used widely in economic, social and demographic analysis, being the minimum spatial domain for a number of pertinent statistical surveys (Salvati 2013). The area was administered by 114 municipalities ('Kapodistrian' definition) until the 2011 Kallikratis Programme's reform of local administration, which reduced the number of local councils to nearly 60. The reform of local administrative units could impact the effectiveness of spatial planning and environmental protection measures in the area, determining further heterogeneity in time-series data and variables collected at this spatial scale (Rontos *et al.* 2016). In the present study, we used both spatial units (i.e. 'Kapodistrias' and 'Kallikratis' municipal structures) based on data availability and spatio-temporal coherence. According to Zambon *et al.* (2017), there are various reasons for using the old municipal structure in this study. The best choice for a detailed analysis of census indicators at the finest possible spatial scale is the 'Kapodistrias' structure. However, since the study concentrated on the effect of economic cycles on urban dynamics before and after 2012, the joint use of 'Kapodistrias' and 'Kallikratis' municipal structures is useful to identify the role of variables such as building activity and land converted to urban use.

#### 2.4. Elementary data and information sources

To investigate the spatio-temporal evolution of urban structures over sequential economic cycles in Athens, variables assessing (i) population dynamics, (ii) building activity and (iii) land-use change were calculated from multiple statistical data sources (Table 1). The related indicators were internally coherent while offering a limited comparability, since they were frequently collected on different spatial and temporal units. Homogenized time-series data for registered population at the prefectural scale in Greece was derived from the national population censuses and demographic register held by the Hellenic Statistical Authority (ELSTAT). The analysis covers a time frame of 25 years between 1992 and 2016. Annual population growth rate (%) was calculated for two partitions of the study area (the 'Greater Athens' area' and the remaining part of the metropolitan region that was regarded as the Athens' peri-urban area).

Indicators assessing basic characteristics of buildings in terms of horizontal and vertical profile by age of construction were derived from the national census of buildings carried out by the Greek National Statistical Authority (ELSTAT) at the municipal scale. Aggregate results of the survey were disseminated on the internet at the web page [www.statistics.gr](http://www.statistics.gr). Specific variables (e.g. number of buildings surrounded by other buildings along the whole perimeter) were made available for two years only (e.g. 2000 and 2010). Additional variables evaluating present and future expansion of urban settlements were derived from the annual questionnaire survey held by ELSTAT in cooperation with local administrative authorities and referring to all issued building permits of any kind and value in Greece. The survey variables include (i) number, (ii) surface and (iii) volume of new constructions. Information was also collected for dwellings and establishments by category of use and the related number of rooms. Data were made available at both district and municipal levels and cover a time interval spanning from 1990 to 2016.



Land-use data were finally derived from three information sources adopting a comparable nomenclature system and different spatial resolutions: (i) high-resolution (1:10,000) maps developed as part of the Copernicus Land Urban Atlas (UA) initiative for 2006 and 2012 identifying 20 land-use classes, (ii) medium-resolution (1:100,000) maps produced as part of the Corine Land Cover (CLC) initiative of the European Environment Agency (EEA) for 1990, 2000, 2006 and 2012, considering 44 land-use classes and (iii) low-resolution (1:250,000) maps realized annually (1992–2015) as part of the ESA GlobCorine initiative.

## 2.5. Data analysis

A total of 17 indicators (see list in Table 2) referring to three thematic domains (population dynamics: 1 indicator; building activity: 9 indicators; land-use changes: 7 indicators) were calculated from elementary data and variables derived from statistical data sources described above (Section 2.2). Following indications provided in earlier studies (Tsai 2005; Torrens 2006; Chorianopoulos *et al.* 2010; Ceccarelli *et al.* 2014; Zambon *et al.* 2018), the indicators selected in this study (population growth, settlement characteristics, building use, land-use change, land consumption, urban densification or dispersion) constitute a comprehensive information system assessing transformations in urban structures at a sufficiently detailed spatial and temporal resolution. Since the relevant source variables were collected at different spatial and temporal units, descriptive statistics were extensively used to illustrate spatial patterns and trends over time in the studied indicators. Specific characteristics of Athens' expansion (1990–2016) were identified using maps derived from a shapefile provided by ELSTAT that illustrates the boundaries of municipalities in the study area.

## 3. Results

### 3.1. Population dynamics

A comparative analysis of annual rates of population growth in the study area and in the whole of Greece shows a substantial alignment with the economic cycle (Figure 2 and Table 1). The highest rates of population growth were observed in the 1990s and declined moderately during the 2000s, with slightly negative values observed since 2011. From the spatial point of view, the highest rates of growth were observed in the Athens' peri-urban region, ranging between 5% in the early 1990s and 2% in the late 1990s; in the same period, the Greater Athens' area totalized growth rates ranging between 1% and 2%. On average, growth rates around 0% and close to 1% were observed during the 2000s, respectively, in the Greater Athens' area and in peri-urban Athens, in line with the rates recorded for the whole of Greece. Population declined in the study area by 1%–2% in the early 2010s; higher (negative) rates were observed in peri-urban Athens than in the Greater Athens' area. Greece as a whole totalized less negative population growth rates during the economic crisis, suggesting that the most evident impact of recession on population dynamics was concentrated in urban agglomerations, particularly in the Athens' metropolitan region. Taken as a measure of urban primacy, the share of resident population in the Athens' metropolitan region to total country population increased to 36.1% up to 2006 and then declined slightly to 35.0% in 2016. The share of peri-urban Athens' population in the total study area population reached a peak in 2011 (15.2%), remaining quite stable in 2016 (15.0%).



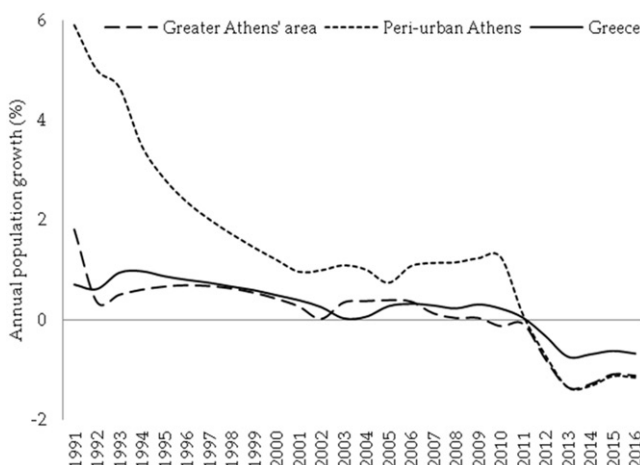


Figure 2. Annual population growth rate (%) in the study area by regional district and year.

The absolute density of population residing in the Greater Athens' area was 60-fold and 45-fold higher than the density of population residing in peri-urban Athens, respectively, in 1990 and 2016. These findings indicate that population concentration in the greater Athens' area declined progressively over the study period.

### 3.2. Building activity

Figure 3 illustrates trends over time in five indicators derived from building permit statistics. Building permits released by municipalities in the study area reached a peak between 2002 and 2006 ( $>4$  building permits/km<sup>2</sup>), in correspondence with the 2004 Olympics, declining markedly since 2007. The average number of floors per authorized building followed a similar trend, with a progressive increase during economic expansion (3.2 floors in 2007) and a substantial decrease afterwards (2.1 floors in the mid-2010s).

Relevant modifications in building activity were reflected in progressive changes in the surface ratio of extensions-to-new-buildings, being relatively low (between 0.1 and 0.3) under economic expansion and increasing drastically up to 1.2 (higher surfaces of building additions than those for new buildings) with recession. The average surface of new buildings was relatively stable at around 600 m<sup>2</sup> in the 1990s and 2000s, declining by nearly 200 m<sup>2</sup> in the mid-2010s. The percentage of small dwellings (1–2 rooms) in total new dwellings was the highest between 2004 and 2010 (around 30%), declining to an average value of 20% in the last 5 years.

A map assessing changes in the vertical profile of buildings in the Athens' metropolitan region (Figure 4) provided indications on time periods characterized by dense settlement expansion for each municipality in the study area. The highest vertical profile of buildings was observed before 2000 in demographically growing municipalities in the north-eastern boundaries of the Greater Athens' area, where most of the Olympic infrastructure is concentrated. Some municipalities in the Piraeus area reached the same condition between 2000 and 2005. The maximum vertical profile was observed after 2006 (or 2010) in the remaining part of the metropolitan region; the most marginal municipalities west, north and east of Athens reached this condition after 2010. These findings document a process of urban densification involving areas

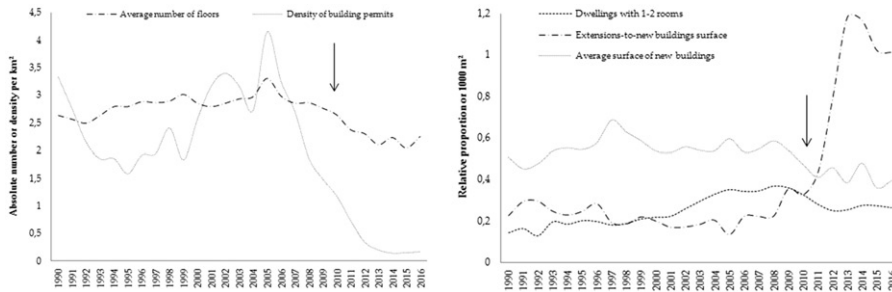


Figure 3. Trends in selected characteristics of building permits released by municipalities in the study area, 1990–2016 (arrows indicate the beginning of the recession wave).

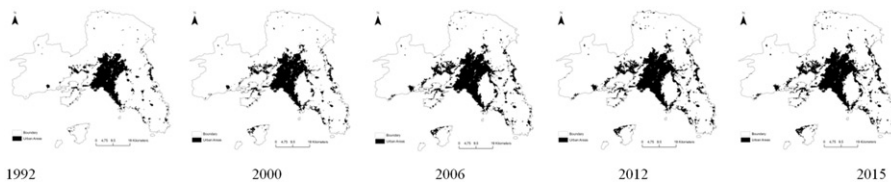


Figure 4. The expansion of Athens' settlements, 1992–2015.

progressively far away from the inner city. Spatial cycles of urban densification started in the late 1990s spreading from central districts to the boundaries of the study area since the late 2000s.

A specific analysis of spatial changes in building use (residential or mixed) was run based on census data (Figure 5). Residential buildings increased in peri-urban municipalities east and north-west of Athens, where an intense settlement dispersion took place at the time of economic expansion. With recession, the share of residential buildings in total building stock increased mostly in peri-urban municipalities south and west of Athens. The increase in mixed-use buildings (integrating residence and services) followed a different spatial pattern evidencing that, during expansion, the stock of buildings with mixed use increased in peri-urban municipalities, possibly demonstrating the strengthening of suburbanization forces in districts already characterized by dispersed settlements. During recession, mixed-use buildings increased only in some peri-urban municipalities. Non-adjacent buildings as a proportion of total building stock were concentrated in suburban locations: three out of four buildings with at least one side not bordering on other buildings were observed in north-western peri-urban districts, only one out of four in central municipalities (Figure 6). Increases in non-adjacent buildings between 2000 and 2010 were scattered over the study area, with peaks observed in some peri-urban municipalities west and north of Athens.

### 3.3. Land-use changes

Athens' expansion at five time points between 1992 and 2015 was illustrated in Figure 7. Built-up areas extended 13% of the investigated area in 1992 and 20% in 2015. The surface area of urban settlements increased at different intensities and spatial directions, reaching a peak between 2000 and 2006 (+2.8% per year) and declining markedly between 2012 and 2015 (+0.9% per year).

Annual land consumption in the study area amounted to 7.7 km<sup>2</sup> in 1990–2000, decreasing to 3.9 km<sup>2</sup> in 2000–2006 and to 1.2 km<sup>2</sup> in 2006–2012 (Table 3). Dispersed

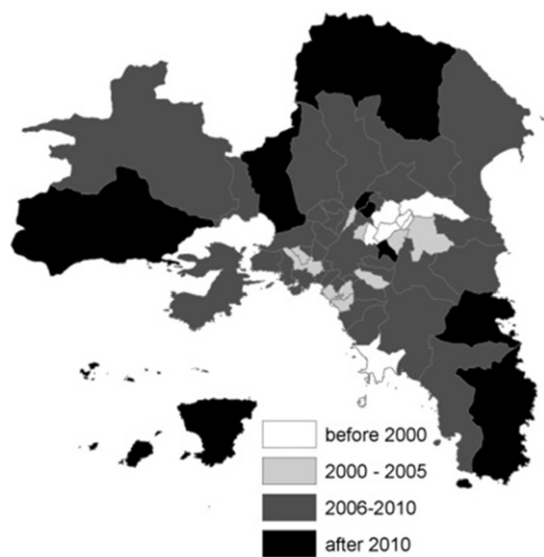


Figure 5. Time interval with the highest recorded building height in the study area.

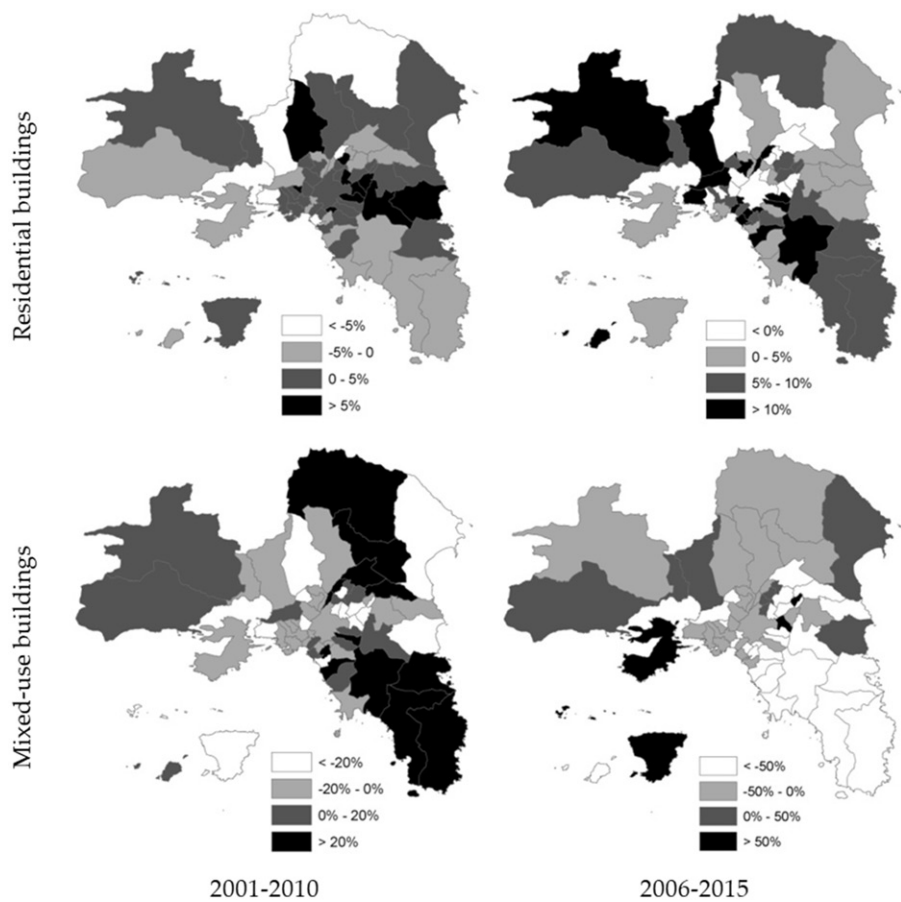


Figure 6. Change (%) over time in the number of buildings by use and time period in the study area.

urban expansion accounted for more than 40% of total urban growth in 1990–2000, decreasing to nearly 20% in 2000–2006 and rising to 37% in 2006–2012. During the study period, cropland converted to urban land-use decreased from 84% to 74% of total new urbanization, with a parallel increase in forests converted to urban use (from 15% to 26%). Low-density built-up areas converted to a more intense urban use (i.e. settlement densification) were only 15% of new urban settlements in 1990–2000, increasing to 36% in 2000–2006 and to 41% in 2006–2012.

Descriptive statistics on non-urban land that is converted to dispersed settlements are presented in Table 4. The surface of urbanized land decreased over time (32, 5 and 3 km<sup>2</sup>, respectively, during 1990–2000, 2000–2006 and 2006–2012). Average size of non-urban land patches converted to dispersed settlements decreased from 100 ha (1990) to 34 ha (2012), with average distance from Athens increasing from 14 km (1990) to 34 km (2012). Complex cultivation was the land use most frequently converted into dispersed settlements during 1990–2000 (87%) and 2000–2006 (68%), representing only 40% of converted land over 2006–2012. In this period, construction sites accounted for 56% of land converted to dispersed settlements. Figure 8 (left) documented that dispersed urban expansion during the study period was characterized by increasing land fragmentation at progressively higher distances from downtown Athens.

Focusing on the most recent time period (2006–2012), Table 5 reports the rate of urban conversion for different land-use types derived from high-resolution land-use

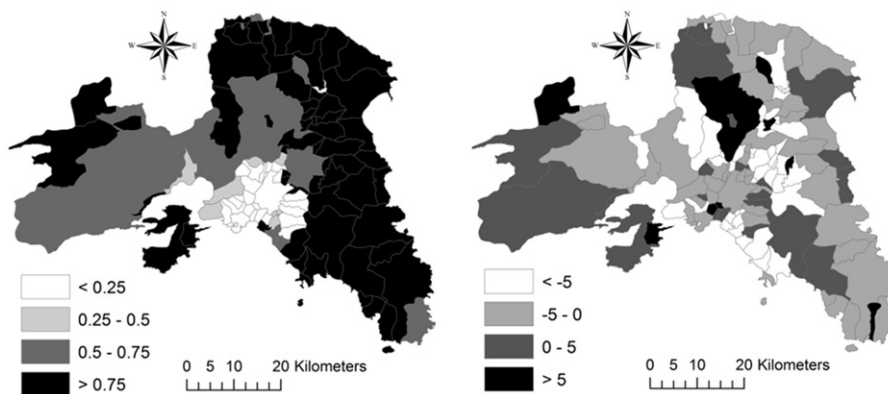


Figure 7. Non-adjacent buildings as a proportion of total building stock in the study area (left: 2000; right: percent change, 2000–2010).

Table 3. Selected indicators of land take in the study area by time period.

Variable	1990–2000	2000–2006	2006–2012
Annual land consumption (km <sup>2</sup> )	7.7	3.9	1.2
Urban area in total area (%)	2.6	0.8	0.2
Urban area in changed area (%)	34.3	31.3	4.5
Cropland to urban area (%)	84.5	84.9	74.3
Forests to urban area (%)	15.1	13.3	25.7
Re-urbanization (%)	15.4	35.7	41.3
Dispersed urban settlements in total urban area (%)	41.6	20.3	36.8
Annual land consumption by dispersed settlements (km <sup>2</sup> )	3.2	0.8	0.5

Table 4. Statistics on land converted to dispersed urban settlements in the study area by time period, 1990–2012.

Pristine land-use class	1990–2000				2000–2006				2006–2012			
	#	Area (%)	Avg area (ha)	Avg dist (km)	#	Area (%)	Avg area (ha)	Avg dist (km)	#	Area (%)	Avg area (ha)	Avg dist (km)
Construction sites	2	6.1	98.1	13.2					4	56.3	38.4	30.0
Olive groves	2	1.2	18.7	19.7								
Pastures									1	3.8	10.5	38.7
Complex cultivation	19	87.4	147.7	10.8	4	67.7	81.0	18.2	3	39.9	36.2	36.7
Mixed agriculture/natural vegetation	2	1.3	20.8	24.7	2	32.3	77.4	13.5				
Coniferous forests	1	0.2	5.5	18.8								
Natural grassland	2	1.8	28.2	9.0								
Sclerophyllous vegetation	4	2.1	16.6	26.2								
Total	32	3,210	100.3	14.5	6	479	79.8	16.6	8	273	34.1	33.6



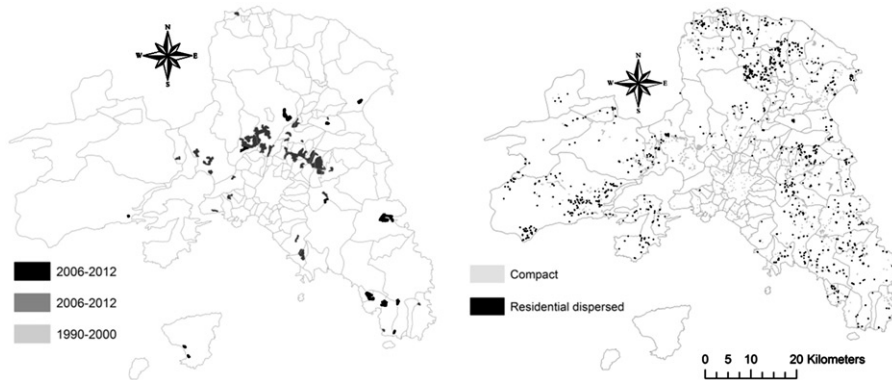


Figure 8. (Left) Dispersed urban expansion in the study area by time interval, 1990–2012; (right) dispersed urban expansion (black) and other types of urban expansion, mainly compact (grey), 2006–2012.

Table 5. Land surface (%) converted to urban use in the study area by class, 2006–2012.

Land-use class	Total converted land	Percent rate of land conversion from			
		Cropland <sup>a</sup>	Forests	Construction sites	Land without current use
Continuous urban fabric (S.L. > 80%)	2.2	0.3	0.0	3.9	7.8
Discontinuous dense urban fabric (S.L.: 50%–80%)	3.2	0.7	0.0	5.7	12.6
Discontinuous medium density urban fabric (S.L.: 30%–50%)	2.2	1.1	0.0	8.5	10.3
Discontinuous low-density urban fabric (S.L.: 10%–30%)	3.0	2.4	7.1	6.0	9.4
Discontinuous very low density urban fabric (S.L. < 10%)	14.4	15.1	30.9	10.0	20.2
Isolated structures	9.5	10.8	43.5	6.5	0.0
Green urban areas	0.3	0.1	0.0	1.9	0.0
Sports and leisure facilities	0.6	0.6	0.0	0.9	0.0
Port areas	0.8	0.5	0.0	3.9	0.0
Airports	2.8	0.6	0.0	19.8	0.0
Roads and associated land	0.8	0.6	0.0	2.3	0.0
Industrial, commercial, public, military and private units	25.9	29.5	0.0	30.5	20.0
Construction sites	18.7	23.9	6.2	0.0	19.6
Mineral extraction and dump sites	8.2	10.9	12.3	0.0	0.0
Land without current use	2.2	2.9	0.0	0.1	0.0

<sup>a</sup>Including semi-natural (non-forest) areas and wetland.

maps. Together with service settlements (26%) and construction sites (19%), discontinuous settlements and isolated building structures accounted together for 24% of total converted land, consuming primarily forests and, at a lesser pace, cropland. Figure 8 (right) outlines the increasingly fragmented expansion of low-density residential settlements in peri-urban Athens, in contrast with the (semi-central) location of the few compact and dense settlements recently developed in the Greater Athens' area.

#### 4. Discussion

Our study proposed an integrated analysis of multiple indicators assessing land-use changes, building activity and population dynamics in a Mediterranean city during the most recent economic crisis (late 2000s–mid-2010s) and in an earlier period of economic expansion (early 1990s–late 2000s), with the aim of verifying whether recession has stimulated (or contained) urban dispersion. Under the hypothesis that economic recession promotes urban re-densification – indirectly containing dispersed metropolitan expansion – building activity, population growth and land-use change were investigated with the aim of identifying distinct spatio-temporal patterns during the study period. Empirical results of this work indicate a moderate – but spatially differentiated – trend towards settlement densification and urban compaction in central districts, with sprawled settlements expanding in peri-urban areas. While outlining a substantial reduction in the rate of urban expansion during economic crisis, dispersed development as a proportion of total urban growth was found higher under recession than under economic expansion, and is concentrated in marginal and remote areas farther away from central cities. Moreover, despite a moderate decline in the average surface of new buildings, the number of large dwellings during recession increased in respect to small dwellings.

Changes in the spatio-temporal distribution of selected morphological and functional indicators provide relevant information on recent trends at both local and regional scales in Athens. With metropolitan growth occurring at different spatial directions and intensity during economic expansion and recession, patterns of urban expansion were largely differentiated, with a progressive reduction in size of dwellings and new surfaces developed for isolated buildings, and a marked decline in resident population. Analysis of morphological indicators confirms a spatial trend towards settlement dispersion in Athens until the late 2000s, with the most relevant changes towards re-densification being observed in the early and mid-2010s in areas growing mostly during the precedent decade. Earlier studies suggest that recessions have traditionally influenced urban cycles, negatively affecting building activity and altering housing and job markets as a consequence of reduced wealth and less investment – both public and private (Firman 2002; Guy and Henneberry 2002; Aalbers 2009). In Athens, public investments in the housing sector decreased drastically and private investments concentrated on more productive land, usually along the cities' outskirts (Chorianopoulos *et al.* 2014). Private capital for infrastructure has been predominant in the city-building process and many interventions have remained spatially uncoordinated because of the lack of planning and construction capital in housing. The activity of relevant institutions in Athens (e.g. the Organization of Attica's Master Plan) was rather marginal in regional planning, and local authorities (e.g. municipalities) had a limited competence in funding urban development due to budget constraints (Salvati and Gargiulo Morelli 2014; Cuadrado-Ciuraneta, Durà-Guimerà, and Salvati 2017; Pili *et al.* 2017). In these regards, the results of our study may enrich the findings

presented by Cho *et al.* (2015, 225), who argued that “in anticipation of a re-emergence of urban sprawl with the recovery of the real estate market, (...) land planners and others concerned with sprawling development should pay more attention to development in sprawl-prone areas during recession periods”.

Impacts of the crisis have been spatially heterogeneous and socially diverse – as clearly demonstrated in Athens (Souliotis 2013; Chorianopoulos *et al.* 2014; Salvati 2016); in these conditions, adaptation strategies depend more on the socioeconomic characteristics of each specific local context (Marquet and Miralles-Guasch 2017). This evidence corroborates a classical interpretation of Athens as a representative example of European Mediterranean cities facing a period of austerity due to shrinking monetary resources, high rates of unemployment and negative effects on metropolitan cohesion, with rising economic inequalities (Hadjimichalis 2011; Kaika 2012; Souliotis 2013). Gkartiou (2013, 161) pointed out the existence of a “crisis counterurbanisation triggered largely by unemployment at origin, rather than pro-rural motivations and idyllic constructions of rurality”. At the same time, Athens remains a distinct case compared with the majority of Italian, Spanish and even Portuguese cities, as far as socioeconomic contexts under crisis are concerned (Salvati, Sateriano, and Grigoriadis 2016).

Building activity in Athens showed relevant differences from what was observed in similar socioeconomic contexts of Mediterranean Europe. Italian and Spanish property markets have experienced a sustained period of growth since the 1990s until 2007–2008, when both markets fell into decline (Taltavull de La Paz and Gabrielli 2015). Spain and Italy have experienced distinct reactions to economic crisis in the respective real estate markets, with place-specific changes in house prices, building characteristics, investment regimes and planning regulations (Jiménez 2009). For instance, the recent crisis in the Spanish urban growth model reveals a particular interaction of globalizing forces with national and local processes (Pérez 2010) featuring specific structures of economic incentives and path-dependent cultural traits (García 2010). Being characterized by marked temporal fluctuations in the construction activity, spatial heterogeneity in settlement form and functions, and variable home ownership regimes at regional and local levels (Castles and Ferrera 1996; Chorianopoulos *et al.* 2010; Salvati, Sateriano, and Grigoriadis 2016), building cycles in Greece – and especially in the Athens’ region – positioned in between what was observed in Spain and Italy (Aalbers 2007). Athens was experiencing a ‘housing bubble’ similar to what was observed in some major Spanish cities in the 2000s, driven by continuous economic development since the mid-1990s and debt-financed public works (infrastructure, services and residence) in the framework of the 2004 Olympics. However, in the subsequent years, recession has progressively altered the regional balance and cohesion with an accumulation regime whose productivity is rapidly tied back – distinguishing from the dominant regime, for example, in Madrid or Barcelona (García 2010; Pérez 2010; Milan and Creutzig 2016; Salvati 2016).

At the same time, population decline in Athens coincided with a lower expansion of dispersed settlements in favour of a more centralized and compact urban growth, confirming recent demographic trends observed for Madrid (Díaz-Pacheco and García-Palomares 2014) and Rome (Salvati, Sateriano, and Grigoriadis 2016). This process may reflect (apparent or subtle) changes in socio-spatial urban structures (Carlucci *et al.* 2017), lower land prices in semi-central areas (Ceccarelli *et al.* 2014), an intense re-organization of economic activities across larger metropolitan areas (Rontos *et al.* 2016) and population re-densification in fringe districts, possibly driven by latent demographic transformations, for example, population ageing, declining family size

and a thorough increase in the number of one-component households (Salvati and Carlucci 2017). Based on these findings, settlement re-densification can be seen as an indirect response to (more or less) rapid modifications in the spatial structure of wealth, land prices, housing regimes and local labour markets driven by the late 2000s economic crisis (Haase *et al.* 2010; Whitehead and Williams 2011; Taltavull de La Paz and Gabrielli 2015). In these regards, the role of central government – often leading to a top-down imposition of density rules and zoning regulations from the national level to the regional and local administrative units (Giannakourou 2005) – should be better explored as far as active policies promoting re-densification processes are concerned.

Taken together, a descriptive analysis of spatio-temporal changes in a joint set of morphological and demographic indicators proved to be particularly meaningful from a policy perspective. Our study demonstrates that a multi-domain indicator system may provide important insight in the analysis of urbanization patterns and processes under economic expansion and recession, with implications for spatial planning (Salvati, Sateriano, and Grigoriadis 2016). A renewed developmental strategy for Mediterranean cities should catch the opportunities derived from a persistent economic crisis (De Rosa and Salvati 2016). While past policies containing urban expansion have revealed largely ineffective in Mediterranean cities (Giannakourou 2005; Chorianopoulos *et al.* 2010; Zitti *et al.* 2015), recession – depressing building activity and the level of investments for infrastructure and real estate developments – may create promising conditions for a new planning strategy that promotes an ‘intermediate-density’ urban model, revisiting both ‘compact and hyper-dense’ models of urban growth dominant up to the 1980s in southern European cities and the most recent trends towards low-density settlements (Chorianopoulos *et al.* 2014; Colantoni *et al.* 2016). However, it was also demonstrated how the recently revised spatial planning approach for Attica has become more ‘favourable’ to investments and market needs, in some instances encouraging – and not regulating – metropolitan growth, and especially discontinuous urban expansion (see, among others, Chorianopoulos *et al.* 2010; Rontos *et al.* 2016; Papageorgiou 2017). These opposite trends may create a particularly complex developmental path reflecting heterogeneous socioeconomic conditions at local scale and consolidating disparities at regional scale (Salvati and Gargiulo Morelli 2014).

In these regards, a better understanding of latent (demographic and economic) trends towards re-densification of central cities represents a pre-requisite for design and application of new and more effective strategies of urban containment in post-crisis cities (Salvati, Sateriano, and Grigoriadis 2016). However, the relationship between re-densification processes and local strategies aimed at reversing urban dispersion was rarely investigated (Salvati 2016). Although decreasing trends in building activity may have important implications for policies targeting urban containment, a shrinking real estate market in Athens was primarily the result of a temporary crisis in local construction markets, without determining structural transformations in urbanization patterns. In other words, without policy interventions, dispersed settlements will remain – even in a post-crisis scenario – the dominant urbanization pattern in heterogeneous and fragmented cities such as Athens.

## 5. Conclusion

Considering the rapid turnaround from expansion to recession, coinciding with the late 2000s, Athens has represented – possibly better than other Mediterranean cities – a

‘metropolitan laboratory’ where testing the impact of economic crisis on recent urbanization patterns, based on the antagonism between crisis-driven austerity urbanism and a spatially uncoordinated town planning oriented towards investment attraction and continuous infrastructural development as a response to crisis. The analysis of statistical indicators performed in this study allows identification of homogeneous phases of urban expansion: (i) a time period spanning from 1990 to the early 2000s, characterized by high (average) surface of new buildings and density of building permits released by local authorities, (ii) a time period spanning from the early 2000s to the late 2000s coinciding with the Olympic decade, characterized by urban concentration reflected in the highest vertical profile of buildings even recorded in the study area and (iii) a post-Olympic transitional period spanning from the late 2000s to 2016 and characterized by recession-driven changes in building activity, with the prevalence of small dwellings in the new built-up dwelling stock and an increasing extensions-to-new-buildings surface ratio. Based on the empirical results of our study, assessing the influence of economic cycles on building activity constitutes a relevant information base contributing to the design of more effective developmental policies and measures for sustainable urban planning under a structural shortage in public budgets. Municipalities revealed to be a meaningful spatial unit when analysing building characteristics and settlement dispersion at a fine geographical scale, making it possible to estimate the effect of land allocation policies and the impact of territorial variables on urban development during expansion and recession. A further investigation on the role of socioeconomic transformations at the base of this pattern is particularly meaningful to gain insight into the post-crisis development path of Mediterranean cities.

### Disclosure statement

No potential conflict of interest was reported by the authors.

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