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The 'niche' city: A multifactor spatial approach to identify local-scale dimensions of urban complexity

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ABSTRACT

Metropolitan systems were constituted by spatial components with different specialization 'niches' based on characteristic attributes (demography, economic structure and performances, socio-spatial patterns, urban morphology, topography, land-use and spatial planning). The present study investigates the multiple dimensions of urban complexity in the light of the 'ecological niche' theory, assessing the spatial structure of a vast ensemble of socioeconomic and territorial indicators that reflect processes of growth and change in contemporary cities. To assess jointly patterns and processes of urban expansion and their impact on recent socioeconomic transformations at the local scale, Athens, the capital of Greece, was taken as a prototype of metropolitan systems with a socioeconomic context evolving under specific form-function relationships. An exploratory framework based on principal component analysis, hierarchical clustering and spatial autocorrelation indexes was used to identify and characterize 8 dimensions that reflect different specialization 'niches' at local scale. Clusters of municipalities were identified according to the dominant socioeconomic dimensions and urban specialization niches. A composite index of urban complexity was finally proposed with the aim to outline latent spatial gradients associated with settlement morphology, social diversification, local development and economic performances. The empirical results of this study contribute to a better understanding of complex urban systems, providing the necessary knowledge base to support implementation of policies for sustainable development of metropolitan regions.

1. Introduction

Recent transformations of contemporary cities have resulted in new economic spaces and creation of social gradients going beyond the traditional urban-rural dichotomy (Neuman and Hull, 2009; Nijkamp and Kourtit, 2013; Zhang et al., 2013; Brenner and Schmid, 2014). At the same time, de-localization of population and economic activities in peri-urban areas have frequently led to urban dispersion, promoting low-density, discontinuous metropolitan expansion (European Environment Agency, 2006; Jacobs-Crisioni et al., 2014; Parr, 2014; Salvati, 2014). While a thorough reading of metropolitan systems based on criteria such as urban hierarchy, population density, linear distances from inner cities or housing regimes brings sometimes to simplified (or even misleading) conclusions about the socioeconomic mechanisms underlying growth and change (van den Berg et al., 1982; Cross, 1990; Derudder et al., 2003; Serra et al., 2014), advantages based on a mix of measurable (e.g. accessibility, economic connectedness, workers' skills, land prices) and intangible inputs (e.g. social diversification, population age, settlement characteristics, environmental quality, topography) remain at the base of competitiveness potential in a number of metropolitan regions (Souliotis, 2013; Di Feliciantonio and Salvati, 2015; Duvernoy et al., 2018). This may reflect increasingly complex patterns and processes of urban expansion (Scott et al., 2013; De Rosa and Salvati, 2016; Cuadrado-Ciuraneta et al., 2017).

Following Berry (1969), complexity is a fabric of heterogeneous constituents that are inseparably associated. In this regard, the aim of a complex approach to urban systems is to bring together different forms of knowledge whose connections have been broken by disjunctive thinking (Brenner and Schmid, 2014). Complex thinking strives to establish the greatest possible number of connections between entities that can be distinguished from one another (Holland, 2006). This general bond between system's elements underlies problems of identification and specification of (apparent or latent) relationships between the whole system and the single parts, and the links that they establish on different scales (Page et al., 2001). The hierarchy between urban scales, from the building to the city, is considered a fundamental aspect of metropolitan complexity (Portugali, 2000), that needs further investigation (Pumain, 2005).

Comprehensive studies in urbanization patterns and processes with the final objective to identify (and assess the importance of) multiple

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dimensions of metropolitan complexity are relatively scarce in advanced countries and especially in Europe (Berry, 2005; Markusen and Schrock, 2006; Nijkamp and Kourtit, 2013). In this regard, empirical research should be oriented to (i) a better interpretation of multiple dimensions of urban complexity focusing on a local scale, (ii) empirical approaches identifying place-specific relationships between patterns and processes of urban expansion and (iii) a more comprehensive evaluation of complex urban systems in the light of sustainable development (Couch et al., 2007). Based on these premises, integrating research over patterns and processes of metropolitan complexity is a relevant task in urban studies (Ceccarelli et al., 2014; Salvati, 2014; Pili et al., 2017).

Metropolitan complexity and the spatial distribution of socioeconomic functions, have been frequently assessed using multidimensional spatial analysis (Baumont et al., 2004; Guillain et al., 2006; Griffith and Wong, 2007). Attempts to investigate the increasing complexity of urban systems through a multivariate analysis of socioeconomic indicators dated back to the 1960s and the 1970s, being the main target of the 'factorial ecology' studies of metropolitan systems (Potter and Coshall, 1986; Portugali, 2000; Holland, 2006). The 'factorial ecology' perspective has provided an empirical base to investigate urban complexity in the light of economic uncertainty, changing social attitudes and modification in political rules (Johnston, 1977). Factor analysis has been used widely to assess specific dimensions of a given metropolitan system, including urban hierarchy, specialization and competition (Markusen and Schrock, 2006), crime determinants (Cahill and Mulligan, 2003), economic deprivation and poverty (Langlois and Kitchen, 2001), institutional and cultural change (Wyly, 1999), and socio-spatial divides (Davies and Murdie, 1991). Despite criticism rooted on the lack of empirical verification and weak theoretical support (Clark et al., 1974), approaches deriving from the 'factorial ecology' thinking – integrated with more innovative visions and technical solutions – have produced articulated frameworks exploring system's dynamics and focusing on the (locally-differentiated) relationship between patterns and processes of urban expansion (Favaro and Pumain, 2011). These approaches fill a gap in urban studies, giving value to the mass of statistical information available at progressively disaggregated spatial levels (e.g. Kazemzadeh-Zow et al., 2017).

Multifactor approaches in urban studies have also benefited from conceptual frameworks derived from classical ecological theory. For example, the 'niche' concept has been largely used when investigating processes of economic specialization, functional diversification or social inequalities (Schlichtman, 2009). Operational approaches identifying urban dimensions and classifying local niches based on 'generalist' or 'specialist' patterns and processes of metropolitan growth contribute to identify urban centers (e.g. administrative units, economic districts or larger territorial contexts) with a given relation between economic, social and environmental factors. This complex interplay is at the base of the relationship between urban patterns and processes varying across space (Serra et al., 2014). The 'niche' concept has been applied to the analysis of specific urban dimensions, including religion and gentrification (Cimino, 2011), post-industrial city development (Schlichtman, 2009), ecological sustainability (Keirstead and Leach, 2008), economic structure, globalization and information technology (Breathnach, 2000), spatial distribution of resident population (Akkerman, 1992), socio-spatial differentiation (Davies and Murdie, 1991), industrial concentration (Carroll, 1985) and environmental constraints to local development (Freeman and Hannan, 1983). Using the niche concept, urban centers characterized by a 'generalist' socioeconomic profile can be discriminated from centers 'specialized' in one or more functional and morphological dimensions (Colantoni et al., 2016), with implications for the analysis of urban complexity and design of policies promoting sustainable development in complex metropolitan systems (Kourtit et al., 2014).

Cities characterized by unbalanced socioeconomic models, governance and planning failures are key examples for the analysis of complex patterns and processes of urban growth (Guillain et al., 2006; Colantoni et al., 2016; Rontos et al., 2016; Duvernoy et al., 2018). In this regard, Mediterranean cities are examples of the variety of forms, economic structures, social forces and territorial factors shaping urban complexity (Salvati and Gargiulo Morelli, 2014; Carlucci et al., 2017; Cuadrado-Ciuraneta et al., 2017). Based on these premises, our study proposes an approach linking a 'factorial ecology' vision with an empirical framework grounded on the 'ecological niche' concept, with the final aims (i) to identify the most relevant socioeconomic dimensions of urban complexity and their relationship with metropolitan expansion in a representative Mediterranean city (Athens, Greece) and (ii) to define an original urban hierarchy based on the ecological concept of 'niche width', i.e. defining 'generalist' or 'specific' patterns of form-function relationships that characterize urban centers with distinct socioeconomic niches. The adopted methodology integrates multivariate techniques with an exploratory spatial data analysis of a large set of socioeconomic indicators varying over time, revealing in this way spatial hierarchies and latent interplays among economic, social and environmental factors at the base of urban complexity (Pumain, 20059. This exploratory framework incorporated sequential statistical techniques contributing to identify non-redundant dimensions of urban complexity, and their linkage with local-scale background contexts, in line with a vision integrating a socioeconomic perspective such as the 'factorial ecology' thinking and the 'niche' concept grounded on the ecological theory.

2. Methodology

2.1. Study area

The study area extends a large part of the administrative region of Attica (Greece) including the Athens' Metropolitan Region (AMR) which encompasses a total surface area of 3000 km^2 consistent with the Urban Atlas (UA) definition of the Athens' Large Urban Zone. Until 2011, the AMR was administered by 114 municipalities (including those in the island of Salamina), responding to one of 4 government prefectures: central Athens (including the inner city and its suburbs), Piraeus (including the inner city and its suburbs), western Attica and eastern Attica. The landscape in the AMR is characterized by rugged topography apart from the plateau occupied by central Athens (Rontos et al., 2016). The Athens' metropolitan region experienced huge population and settlement expansion along the entire study period; population density increased from nearly 2300 inhabitants/km^2 in 1961 to more than 4400 inhabitants/km^2 in 2011, showing a decreasing spatial variability in population density at the same time (Fig. 1). Resident population in the study area increased from 2.03 million people in 1961 to 3.78 million people in 2011. The share of population living in central Athens in total metropolitan population was 31% in 1961 and declined to 18% in 2011. The same pattern was observed for Piraeus' urban pole (decreasing from 19% to 12% over the study period). Conversely, the share of population living in the Greater Athens' area (including urban municipalities of Athens and Piraeus) in total population increased from 41% to 53% over the same time period. In these regards, Colantoni et al. (2016) have identified two cycles in the Athens' recent expansion (compact growth with population densification between 1960 and 1990 and a more scattered and discontinuous growth afterwards). Annual population growth rate declined from 2.8% to 0.7% during the study period, with a slightly increasing variability at the local level, possibly indicating the formation of growing poles outside the central city. These findings indicate that Athens' compact and dense expansion coincided with a transition to tighter relationships between variables, underlying the increased connectedness and redundancy of the system (Salvati and Serra, 2016). A more detailed outlook of the post-war changes in the AMR socioeconomic context can be found in Salvati (2014) and Salvati and Carlucci (2014).

Based on the availability of a homogeneous set of relevant variables,