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**Article**

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Article

# Revisiting the Spatial Cycle: Intra-Regional Development Patterns and Future Population Dynamics in Metropolitan Athens, Greece

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**Abstract:** Being intertwined with economic development, urbanization determines the present and future development path of regions and countries. The intimate relationship between urban expansion and economic development is of particular interest in the case of large regions with complex (and mostly non-linear) socio-demographic dynamics and a relevant primacy in the metropolitan system of a given country. Typical examples of advanced economies with settlement systems characterized by a high degree of city primacy are peripheral and disadvantaged European countries such as Portugal and Greece. For instance, the administrative region of Attica—centered on Athens, the Greek capital city—represents the largest metropolitan area of the country, hosting almost 3.8 million inhabitants in 2021 (36.2% of the Greek population). In this context, this study investigates the internal redistribution of the resident population in metropolitan Athens and the progressive development of satellite cities over a relatively longtime interval, testing the assumptions of the Spatial Cycle Theory (SCT) between 1951 and 2021 and predicting future development paths up to 2051. To investigate past, present, and future intra-regional population trends, we used data released from decadal (1951–2021) censuses and demographic forecasts for the years 2031, 2041, and 2051. Being in line with the SCT, the empirical results of our study document how demographic dynamics of individual centers influence largely—and independently—the long-term development of metropolitan regions, both with policy/planning regulation and in conditions of non-intervention (spontaneous urban growth).



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## 1. Introduction

A growing population in cities is the joint result of natural population growth and (internal and international) immigration to urban areas (Haase et al. 2013). A multitude of socioeconomic drivers and, likely more surprisingly, exogenous shocks that were hardly predicted (e.g., wars, economic recessions, climate crises, pandemics) have influenced such socio-demographic processes (Fielding 1982). Urbanization thus constitutes a complex phenomenon intertwined with long-term development processes characteristic of any country in the world (Findley 1993; Henderson 2003a; Niu et al. 2021). In this perspective, urban expansion should not be regarded as a one-dimensional process (Black and Henderson 2003; Bai et al. 2012; Chen et al. 2014), reflecting long-term population redistribution paths with different intensities and spatial directions across metropolitan regions (e.g., Champion 1989;

Cross 1990; Salvati et al. 2019). They include a relatively fast population growth in urban areas and the subsequent decline of the resident population in the densest settlements (Henderson 2003b; Shaban et al. 2022; Antonoglou and Rontos 2023b). The Spatial Cycle Theory (SCT), initially proposed by Klaassen (1981) and further developed by van de Berg et al. (1982), aims at identifying and explaining sequential development stages of cities in relation to their wider region of influence (namely, metropolitan regions or functional urban areas). Based on SCT assumptions, urban areas are assumed to evolve according to sequential stages, as follows:

- ‘Urbanization’: settlements develop at the expense of the surrounding rural space;
- ‘Suburbanization’: suburban settlements develop at the expense of urban cores;
- ‘Disurbanization’: urban populations decentralized towards satellite centers;
- ‘Reurbanization’: population in central locations start growing again after a long decline.

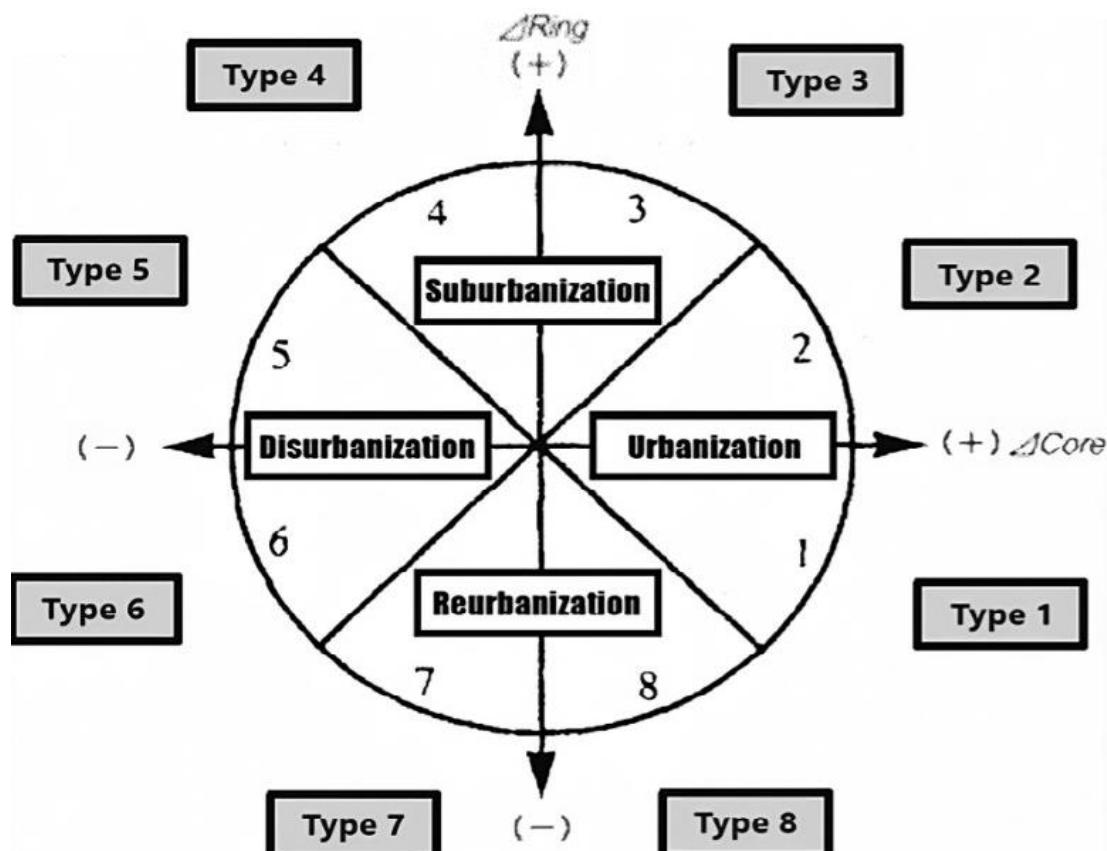
In the first stage, population and economic activities concentrate in central locations, forming dense and compact cities (Angel et al. 2011; Turok and McGranahan 2013; Li et al. 2021). The expansion of secondary and tertiary sectors downtown, alongside the consolidation of the primary sector in peripheral locations, creates the conditions at the base of the first stage of the SCT, namely, ‘urbanization’ (Champion 2000). The promotion and adoption of new economic standards and the attractive force of neighboring cities—in turn shaped by external economies, infrastructure, and institutional factors—may consolidate this development stage (Ji et al. 2020). With the inherent concentration of the population and economic activities downtown, negative external economies begin to swell, and severe traffic congestion occurs, delaying the movement of workers and the smooth trade of finished products (Gross and Ouyang 2021). Lacking free space for the natural expansion of production units, environmental pollution, and generally unfavorable living conditions for resident populations constrain further settlement growth (Kuang et al. 2020).

In order to deal with this unfavorable context, middle- and high-income households move to suburban locations with high environmental quality and favorable living conditions, giving room to the second stage of the SCT, namely, ‘suburbanization’ (Yang and Zhao 2022). Free-standing businesses follow such tendency, especially service businesses, since their executives (or customers) start experiencing a suburban life (Salvati and Sateriano 2015). In other words, they move to a better environment, ensuring improved working conditions and business prestige (Baker et al. 2000). The intrinsic movement of households, businesses, and workers to suburban locations leads to land saturation, worse traffic issues, environmental depletion, and the complete disappearance of traditional agricultural activities along the fringe (Sun and Zhang 2021). On the other hand, households and businesses have left a significant part of core cities almost empty. In the longterm, this development path has two implications, namely, (i) the latent shrinkage of economic activities downtown and (ii) the occupation of abandoned (or free) spaces by illegal activities and social (or ethnic) groups in consolidated (dense) settlements (Chen and Chi 2022). These effects often result in a sort of ‘ghettoization’ of metropolitan centers (Rontos et al. 2016). ‘Suburbanization’ is completed with the appearance of unfavorable conditions in saturated suburbs and the movement of households to new (satellite) cities or new settlements with a high-quality natural environment and more ideal living conditions (Antonoglou and Rontos 2023a).

Satellite cities thus become a key dimension of spatial planning, representing the natural evolution of modern lifestyles and satisfying the needs of a continuously expanding population into even larger metropolitan regions. Satellite cities share key functions with traditional centers, while remaining partially independent (economically and socially) from them, having, at the same time, their own urbanized area and absorbing part of the growth of surrounding cities, as a result of a deteriorated quality of life therein. As the population of satellite cities increases, new settlements at an even greater distance from central locations can be observed, strengthening their role in industry, job markets, and local governance (Evans and Evans 2007). This path is recognized as the third stage of the SCT, namely, ‘disurbanization’.

The theory predicts a fourth stage ('reurbanization'), where urban centers (namely, the core cities) experience a slowdown in population decline, and 'ghettoization' phenomena become less intense (Lever 1993). The possibility of improving housing conditions downtown, where old buildings are demolished and those in better condition are rebuilt, is an important factor in this development path. Consequently, central locations have a new wave of population growth, with declining trends in suburban places. In some cases, this development reflects the reverse movement of households from suburbs to city centers.

Responding effectively to the spatial cycle of cities, urban policies should be formulated accordingly and adjusted dynamically. For instance, decentralization policies can prove ineffective in metropolitan areas undergoing 'disurbanization'. At the same time, urban regeneration policies should take account of the specific stage of the spatial cycle, and development actions should be 'pro-cyclically' adapted to demographic dynamics over large metropolitan regions. The evolution of urban and regional centers, according to the SCT (Kawashima 1986), is presented in Figure 1. Changing population in the core city and in the surrounding suburbs is illustrated, respectively, on the horizontal and vertical axes. In this graph, the cycle is illustrated with sequential waves (from the beginning to the end of the circular development path), considering the stages described above and the intermediate phases inbetween.



$\Delta$ Core : Absolute change in the population of the Center

$\Delta$ Ring : Absolute change in the population of the Suburbs

**Figure 1.** A graphical illustration of the four stages of the Spatial Cycle, and the intermediate development waves (1 to 8), in a given metropolitan region. Source: authors' adaptation of Kawashima (1986) drawings.

- 'Urbanization' appears when the Cartesian Product of the above two quantities is positive ('Type 1'), namely, when urban population increases with a contemporary decline of suburban population (the so-called, 'absolute urbanization'). In the Type 2

development class, the populations of both areas increase, with a slowing growth rate involving urban settlements and an accelerating rate observed in suburban locations (the so-called ‘relative urbanization’).

- ‘Suburbanization’ corresponds to a Type 3 development (the so-called ‘relative suburbanization’), where urban population increases at a slower rate and suburban population increases at an accelerated rate; meanwhile, Type 4 development implies a population decreasing in central locations with uneven suburban growth (the so-called ‘absolute suburbanization’).
- ‘Disurbanization’ occurs when the Cartesian Product of population changes is classified as Type 5 development (the so-called ‘absolute disurbanization’); central settlements continue experiencing an even more accelerated decline, while the suburbs display a slowdown in population growth. Type 6 development (the so-called ‘relative disurbanization’) sees the centers continuing the sharp loss of resident population, with decreasing populations also in the suburbs, for the first time since the beginning of the cycle.
- The wave displaying a moderate regrowth of central locations is detailed in Type 7 development (the so-called ‘relative re-urbanization’), with core cities showing a decelerated population decline and the suburbs evidencing an accelerated decline; Type 8 development (the so-called ‘absolute re-urbanization’), implies a net increase in central populations, and suburbs display a net slowdown of population decline.

Taken together, regional population (core city and suburbs) increases during ‘urbanization’ and ‘suburbanization’, while decreasing in favor of outer satellite settlements during the subsequent stages of ‘disurbanization’ and ‘reurbanization’ (Vining and Kontuly 1978).

With the framework of the SCT, Noordstrom (1981) investigated local-scale urban growth patterns and processes extensively, evidencing demographic changes vis-à-vis sequential developmental stages of a given city. According to the SCT, population, settlements, and economic activities are assumed to be significantly influenced by a mix of regional development and socio-cultural and politic/institutional changes at the local scale (Kontuly and Geyer 2003). Noordstrom also argued that when a society develops, all the activities that affect employment—and, consequently, the spatial structure of populations and settlements—undergo (more or less intense) changes articulated into various stages. Consequently, the effect of environmental conditions and local policies, which constitute the basic drivers of population structure and dynamics in modern societies, can be delineated and interpreted in a broader perspective of regional growth. The impact of policy and planning is also emphasized in light of the SCT (Korcelli 1986).

Based on this assumption, this study implements a spatially explicit interpretation of metropolitan growth and decline over a sufficiently long time interval, considering population change at the local level as an honest measure of regional development paths, taking account of the ‘intensity’ and ‘spatial direction’ dimensions jointly (Geyer and Kontuly 1993). We specifically tested the assumptions of the SCT delineated above, moving from a regional to a local approach that considers together population dynamics at the core, the suburban and satellite locations (Kontuly 1992). Informed by a seminal study of Noordstrom (1981), this local-scale approach incorporates theoretical and empirical evidence from a relatively broad literature of urban geography and applied economics since the late 1980s.

At the local level, we assume urban structure to be basically depending on (i) land, namely, the available space per inhabitant, and (ii) population size, namely, the total number of inhabitants or, better, population density. With this perspective in mind, the empirical analysis of urban development may benefit from the comparative scrutiny of population change over time and space, as available at an appropriate geographical unit from general censuses (Aplerovich 1983; Schwizer 1985; Kawashima 1986). Regardless of the variable’s choice (e.g., Kontuly and Tammaru 2006) or the level of analysis of urban development, a systematic verification of the SCT is achieved by dividing the urban area into distance zones from a central point of the core city and grouping the population residing in the

municipalities (or settlements) falling within these zones, in line with mainstream empirical studies (e.g., [Morelli et al. 2014](#)).

The following analysis's step consists in an explicit examination of population growth (and decline) in aggregated districts within a given time period. This empirical test is grounded on a seminal application by [Noordstrom \(1981\)](#), who divided the city of Gothenburg into communities, grouping them based on their distance from downtown and studying the evolution of population density for these communities over a relatively long-time interval, encompassing 60 years. In the same line of thinking, [Kawashima \(1986\)](#), in a study of the development stages in the Tokyo metropolitan area, classified the city into urban and rural zones—according to their distance from downtown—and analyzed population changes in these zones during nearly 30 years. Stemming from the empirical conclusions of the above-mentioned studies ([Vining and Kontuly 1977](#)), our work is aimed at demonstrating how the highest value of the target variable (population density, in the present case) is observed first at small distances from a central point of the core city and, progressively on subsequent times, moving farther away from downtown.

Taken as a purely mono-centric model of regional growth (as extensively documented in earlier studies), we adopted metropolitan Athens in Central Greece as an appropriate case study when investigating and predicting the inter-urban movement of the resident population over time. Besides Istanbul, Athens—the Greek capital city—is one of the largest and economically powerful centers in the north-eastern Mediterranean arc ([Egidi et al. 2020](#)), having a very complex development path driven by a kaleidoscopic mix of internal factors (demographic dynamics, planning constraints, social forces) and external shocks, which include—but are not limited to—the Turkish–Greek war in the early 1920s, World War II and the consequent civil war in Greece, the intense rural exodus of the 1960s causing internal migration mainly toward Athens, the accession to the European Union in the 1980s, the Olympic decade of the 1990s, the economic decline of the late 2000s, and, finally, the COVID-19 pandemic. Together with census data, our study—likely for the first time in the literature—offers a reasonable perspective of future development paths based on population projections interpreted in light of the Spatial Cycle Theory, taken as an operational contribution to spatial planning and local development policies ([Vinci et al. 2022](#)). Reconnecting past, present, and future population dynamics in a local-scale perspective typical of urban analysis represents the original contribution of this study to regional science.

## 2. Methodology

This study investigates the sequential stages of the spatial cycle in metropolitan Athens (Central Greece) in line with the original formulation by [Klaassen et al. \(1981\)](#) and the extension by [Kawashima \(1986\)](#). The study area was extensively described by [Salvati et al. \(2018\)](#), [Zambon and Salvati \(2019\)](#), [Zambon et al. \(2019\)](#), and [Salvati \(2023\)](#). Metropolitan Athens was divided into a few concentric zones at an increasing distance from downtown (0 to 6 km, 6 to 12 km, 12 to 18 km, 18 to 42 km, 42 to 60 km), considering Constitution Square (Plateia Syntagmatos) as the city center. In cases where a given municipality belonged to two neighboring zones, it was classified to be within the zone where most of its surface area exists.

The evolution over time of the resident population was thus investigated separately in these zones by aggregating municipal data derived from decadal censuses, which allowed for a thorough clarification of spatial cycle timing ([Cecchini et al. 2019](#)). Following earlier studies ([Rontos and Papadaskalopoulos 1994](#); [Rontos et al. 2006](#); [Morelli et al. 2014](#); [Ciaschini et al. 2023](#)), the intra-metropolitan population net balance (growth vs. decline) was calculated on a decadal time interval during the period 1951–2021. Additionally, the total population at the municipal level was projected for the years 2031, 2041, and 2051 using the exponential rate of population growth during the most recent inter-census period (namely, 2011–2021). The method used assumes that population growth is not constant, reflecting an exponential function of time ([Siampos 1993](#)). This approach is taken

to be fully appropriate for population forecasts according to demographic methodologies (e.g., [Papadakis and Tsimpos 2004](#)). More precisely, the econometric specification used is as follows:

$$P_n = (1 + r)^n P_{n-1}$$

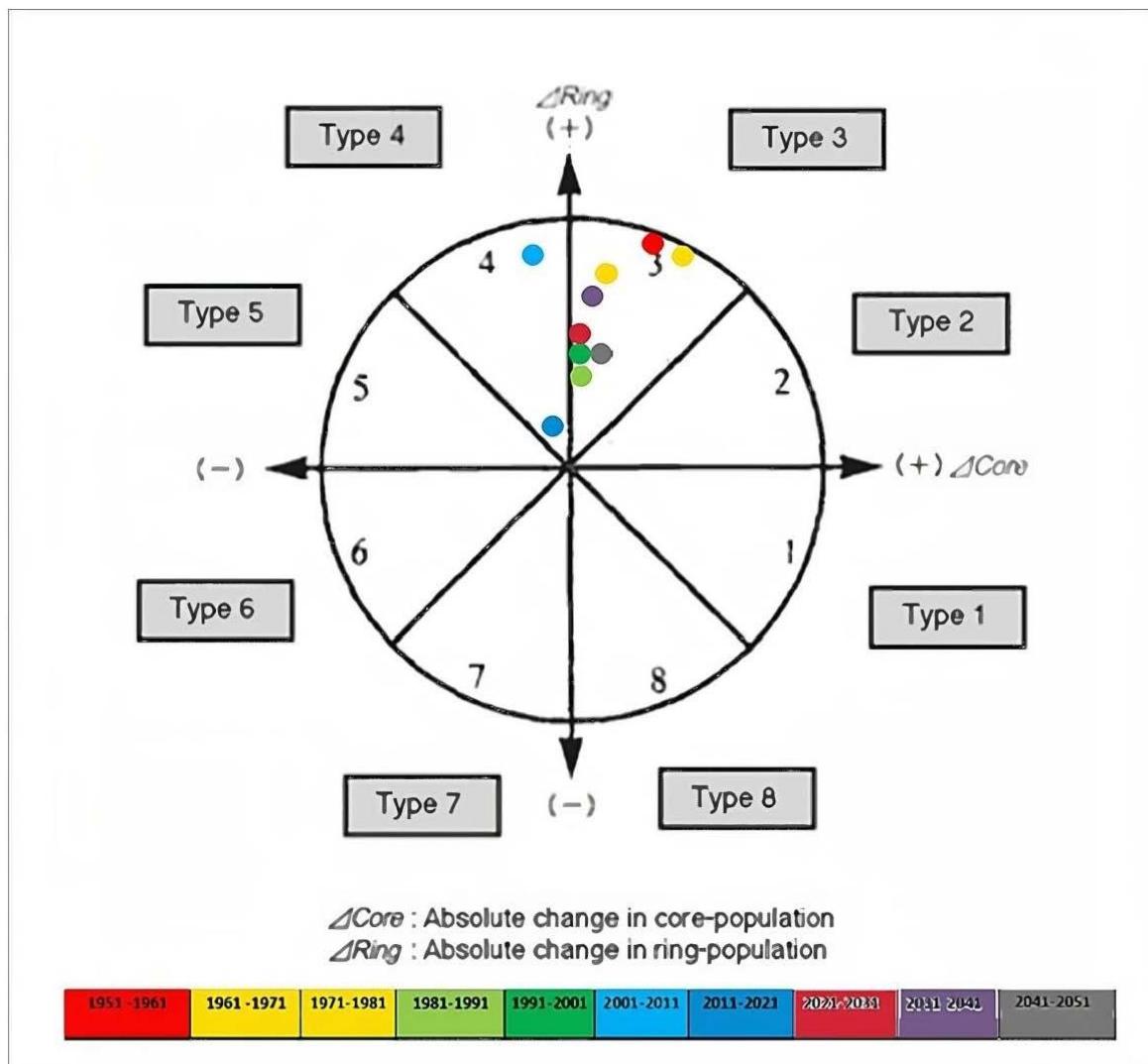
where  $n$  is the time period between  $n - 1$  and  $n$ ,  $r$  is the mean population growth rate between  $n - 1$  and  $n$ ,  $P_n$  is the population to be projected at time  $n$ ,  $P_{n-1}$  is the population at time  $n - 1$ ; and the term  $(1 + r)$  is recalled as the growth multiplier, or common ratio.

Together with metropolitan Athens, the study area included the satellite cities of Thebes (Thiva), Halkida (Chalkida), and Corinth (Korinthos) as a novel contribution to the empirical verification of the SCT in Central Greece. Based on the empirical observation of census data and demographic predictions, this study covers a relatively long time period encompassing exactly one century (1951–2051), intended as a meaningful tool for regional policy and spatial planning in Greece, with implications for similar countries in Europe and outside the old continent. Metropolitan Athens was initially partitioned into sub-areas according to the most recent statistical and administrative system enforced in the country, namely, the wider area of Athens's conurbation (including the municipality of Athens, Piraeus, and the surrounding districts) and the rest of the administrative region of Attica. This spatial division was considered basically appropriate to ensure a full compatibility of population trends over the selected geographical units from 1951 to the present time. Microsoft Excel 2016 spreadsheets, SPSS v.26 statistical package, and GeoDa 1.22.0.4.9 geographical tools were used to process the empirical results of this study.

### 3. Results

Athens's spatial cycle is illustrated in Figure 2 based on long-term population dynamics. As described in the methodological section, the X-axis and the Y-axis of the graph, respectively, measure the absolute change in urban and suburban populations over the studied decades. The points representing the following decades (1951–1961, 1961–1971, 1971–1981, 1981–1991, and 1991–2001) are classified within the third quadrant of the spatial cycle graph, corresponding to a Type 3 development path. This suggests that suburbs around Athens developed continuously between 1951 and 2001. Coherent with a Type 3 development path ('relative suburbanization'), both urban and suburban populations increased. During the subsequent decades (2001–2011 and 2011–2021), the Cartesian Product of the population change in the two regions moved to the fourth class of the spatial cycle. This path reflects a Type 4 development ('absolute suburbanization'), with the downtown population decreasing while the suburban population increasing at an accelerated rate. As a whole (*core plus suburbs*), the region continued growing in terms of population. Finally, based on population forecasts for the decades 2021–2031, 2031–2041, and 2041–2051, the Cartesian Product of the changes marginally returned to the third side of the spatial cycle graph. These results suggest how metropolitan Athens could experience a new wave of Type 3 development in the next years, possibly mixing 'relative suburbanization' with a moderate (demographic) recovery of core cities.

The spatial direction and intensity of suburban development across geographical areas result from the empirical data analyzed in Table 1. Downtown Athens and Piraeus (namely, the city with the largest harbor in Greece) were constantly reducing their share in the total population of the whole area. Their demographic role halved between 1951 (36.3%) and 2021 (18.9%) for Athens, and reduced even three times for Piraeus in the same time interval, from 12.6% to 4.9%. At the same time, Western Attica suburbs showed a significant increase in their population share, which reflects a faster demographic increase in respect of the core city, with the highest rate (17.1%) observed in 1971, the year when the maximum urban concentration was observed ([Salvati 2023](#)).



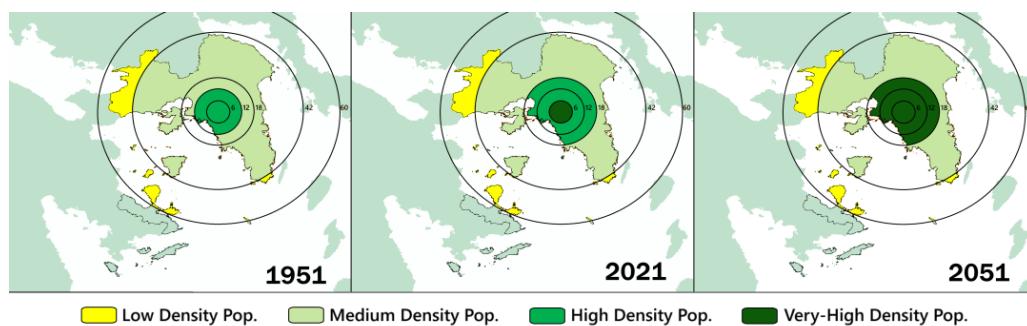
**Figure 2.** Circular diagram of the spatial cycle in metropolitan Athens, 1951–2051. Source: authors' elaboration on population census data (ELSTAT).

Eastern suburbs' population weight in total area increased as well from 5.4% (1951) to 14.9% (2021), highlighting a rapid—and almost continuous—development process. The most remote areas of both Eastern and Western Attica (the so-called 'rest of Attica') also increased their demographic weight since 1991 or 2001. As a novel issue, the satellite cities of Thebes, Halkida, and Corinth (situated outside metropolitan Athens) showed a relative stability in their demographic weight following a moderate stagnation (1961–1991). In other words, the contribution of such satellite cities to population deconcentration in metropolitan Athens was modest or null, likely because of restricted accessibility and less effective transportation services, both public and private (Rontos and Papadaskalopoulos 1994). This may be explained by the insufficient industrialization of satellite cities and their modest tourism specialization, despite the presence of important archeological sites. A systematic classification of the study area by concentric zone using linear distance from downtown Athens allows for delineating local development paths against the dominant regional growth pattern (Figure 3).

**Table 1.** Percent share of resident population in total population by administrative unit (1951–2021).

ADMINISTRATIVE UNITS	YEAR								
	1951	1961	1971	1981	1991	2001	2011	2021	
Capital region	City of Athens (downtown)	36.3	30.7	31.1	26.6	21.5	22.5	19.3	18.9
	Department of Athens, except Athens <sup>1</sup>	8.6	10.0	10.5	11.5	10.9	11.2	10.6	10.5
	City of Piraeus (downtown)	12.6	9.3	6.7	5.9	5.0	5.2	4.8	4.9
	Piraeus Department, except Piraeus <sup>2</sup>	16.8	18.1	17.8	19.5	20.0	19.3	19.0	18.9
	Western Attica District Department <sup>3</sup>	9.5	15.4	17.1	16.9	16.7	14.3	14.3	14.0
Rest of Attica Prefect.	Eastern Attica Department of Transport <sup>4</sup>	5.4	7.1	7.8	10.3	12.6	12.1	14.5	14.9
	Department of Piraeus <sup>5</sup>	1.3	1.1	0.9	0.8	1.1	2.0	2.2	2.0
	Department of Eastern Attica <sup>6</sup>	3.3	3.0	3.0	3.4	6.2	5.9	7.1	7.3
External cities	Department of Western Attica <sup>7</sup>	2.4	2.9	2.6	2.9	2.9	4.3	4.7	4.9
	Thiva, Chalkida, Corinth	3.7	2.9	2.6	2.9	2.9	3.1	3.5	3.6
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: authors' elaboration on population census data (ELSTAT). Notes: <sup>1</sup> Municipalities of Byronos, Galatsiou, Dafni, Zografi, Iliopolis, Kaisariani, Nea Philadelphia, Nea Chalkidonos, Tavros and Ymittos; <sup>2</sup> Municipalities of Agios Dimitrios, Agios Ioannis Rentis, Alimos, Argyroupolis, Voula, Vouliagmeni, Glyfada, Drapetsona, Elliniko, Kallithea, Keratsini, Moschato, Nea Smyrni, Nicea, Palaiofaliro, Perama, and Vari, except Piraeus; <sup>3</sup> Municipalities of Agia Varvara, Agios Anargyros, Aigaleo, Kamatero, Korydallos, Neo Liosion, Peristeri, Petroupoles, and Chaidari; <sup>4</sup> Municipalities of Agia Paraskevi, Amarousi, Vrilissi, Heraklion, Kifissia, Melissi, Metamorfosis, Nea Erythraia, Nea Ionia, Neo Psychiko, Papago, Pefki, Philothei, Chalandri, Cholargo, Psychiko, and Geraka and Communities of Ekali, Lykovrisi, Nea Penteli, and Penteli; <sup>5</sup> Municipalities of Aegina, Salamina, and Hydra (urban and semi-urban areas of over 5000 inhabitants); <sup>6</sup> Municipalities of Aylinos, Acharnon, Keratea, Kropia, Lavreotiki, Marathon, Markopoulou Mesogaia, Nea Makri, Paiania, Pallini, and Spatona—Loutsas and Communities of Agios Stefanos, Artemis (Loutsas), Glykon Neron, and Oropou (urban areas and semi-urban areas over 5000 residents); <sup>7</sup> Municipalities of Aspropyrgos, Vilia, Elefsinos, Erythron, Mandras, Megareon, Ano Liosion, Zephyro, and Fylis and Community of Nea Peramos (urban areas and semi-urban areas with more than 5000 inhabitants).



**Figure 3.** Population density in metropolitan Athens (1951, 2021, 2051) by concentric belts reflecting the linear distance from Plateia Syntagmatos, downtown Athens (km). Source: authors' elaboration on population census data (ELSTAT).

Table 2 shows the evolution of the total population by concentric zone as defined above. The empirical results of this analysis delineate some important conclusions on the evolution of Athens's population.

Additionally, Table 3 displays the rate of population change by concentric zone. A spatial shift in the highest population change rate was initially observed from central zones to peripheral ones. In the zone 0–6 km away from downtown Athens, the highest rate of population change occurred during 1961–1971 (36%). Interestingly, the highest rate of population change occurred one decade earlier (1951–1961) in the zone 6–12 km away from downtown. Conversely, it was observed only during 2001–2011 (57%) for the concentric zone 12–18 km away from downtown. The highest value of change observed in metropolitan Athens's population during 1961–1971 could be justified by intense internal migrations from rural

Greece. However, considering the relative differences instead of absolute differences in a comparative perspective, it was noted how the second belt (6–12 km) grew fastest in the period 1951–1961, while the third belt (12–18 km) grew fastest in the subsequent period 1961–1971 (41%), totalizing a very high demographic increase also during 1971–1981 (40%), 1981–1991 (33%), 1991–2001 (30%), and 2001–2011 (57%). Altogether, these results may confirm the assumptions of Kawashima's SCT.

**Table 2.** Population of metropolitan Athens by concentric zone (km from downtown Athens) for the time period 1951–2051; 'Total' refers to metropolitan Athens.

Zone	Municipality	1951	1961	1971	1981	1991	2001	2011	2021	2031	2041	2051
0 to 6	20	850,435	1,123,027	1,595,901	1,817,059	1,681,767	1,691,532	1,524,167	1,495,483	1,536,981	1,647,730	1,738,579
6 to 12	30	469,713	664,044	870,866	1,081,506	1,169,646	1,263,788	1,387,862	1,383,114	1,520,668	1,711,178	1,877,768
12 to 18	20	77,784	108,838	162,675	241,589	335,012	450,349	704,932	728,439	941,005	1,339,063	1,662,083
18 to 42	46	97,993	113,369	131,619	178,288	244,250	312,791	203,405	199,636	256,810	353,416	434,902
42 to 60	1	4286	4170	3879	4973	6017	5933	8068	7392	10,578	17,000	18,904
Total	117	1,500,211	2,013,448	2,764,940	3,323,415	3,436,692	3,724,393	3,828,434	3,814,064	3,961,586	4,044,785	4,123,847

Source: authors' elaboration on population census data (ELSTAT).

**Table 3.** Rate of population change by concentric belt (km), 1951–2051. The highest rate for each belt is marked in bold. 'Total' refers to metropolitan Athens.

Concentric Belt	1951–1961	1961–1971	1971–1981	1981–1991	1991–2001	2001–2011	2011–2021	2021–2031	2031–2041	2041–2051
0 to 6	28	<b>36</b>	13	−8	1	−10	−2	3	7	6
6 to 12	<b>35</b>	27	22	8	8	10	0	10	13	10
12 to 18	34	<b>41</b>	40	33	30	<b>57</b>	3	29	42	24
18 to 42	15	15	31	<b>32</b>	25	−35	−2	29	38	23
42 to 60	−3	−7	25	19	−1	<b>36</b>	−8	43	61	11
Total	30	<b>32</b>	19	3	8	3	0	4	2	2

Source: authors' elaboration on population census data (ELSTAT).

Nevertheless, it should be noted that the outermost belts of 18 to 42 km and 42 to 60 km show a notable population increase only in the time interval 1981–2011. During the decade 1981–1991, the largest increase in population concentrated in peripheral belts, especially in the 18–42 km zone, which almost equaled the expansion of the previous zone (32%), while it 'tookoff' between 2001 and 2011 in the 42–60 km concentric zone. A possibly unexpected development path was also observed in the 42–60 km distance belt between 2001 and 2011, against a negative population growth in the previous decade (−1%). Population stabilized in the subsequent decade 2011–2021, likely because of economic crisis, the COVID-19 pandemic, geo-political tensions, and inflation rise. However, the intense decrease in the resident population of the 18–42 km belt between 2001 and 2011 (−35%) was hardly explained by the above-mentioned reasons. Although considered with caution, population forecasts indicate a significant growth of the outermost zones, likely stabilizing after 2041.

#### 4. Discussion

Long-term development stages of metropolitan Athens were investigated in this study according with the Spatial Cycle Theory (Klaassen et al. 1981; van de Berg et al. 1982; Kawashima 1986). The main conclusion of this empirical application is that the area experienced a prolonged suburbanization stage, initially assuming the development type of 'relative suburbanization'—which was maintained, almost continuously—during the second half of the 20th century, with the downtown population growth slowing down and an accelerating growth of the suburban population. In the first two decades of the 21st century, the development type of 'absolute suburbanization' emerged and consolidated, with a decreasing downtown population and a moderate increase in the suburban population. Population forecasts finally indicate a new shift toward 'relative suburbanization',

reflecting a moderate recovery of downtown Athens. The demographic and economic recovery of inner Athens can be justified by intrinsic changes in the structure of regional and local productions and activities, mainly leveraged by technological improvement, better accessibility, the growth of high-income sectors (such as finance, research and development, and real estate), and tourism concentration (Rontos and Vavouras 2013).

Information technology, urban sustainability, and new lifestyles (e.g., digital nomads, long-term rental of Airbnb-style housing, changes over time in energy and transport costs) may bring economic activity back to city centers and the surrounding areas. The concentration of foreign immigrants and refugees downtown in Athens is an additional engine of such development paths, considering that, in 2021, the Attica region hosted 45% of the total foreign population in Greece. Migrants settled in downtown Athens because of cheaper housing rents, public transportation, a relatively large opportunity for collective accommodation, social benefits from state agencies or municipalities (e.g., social housing, state pharmacy, public and free medical doctors), and concentration of nationals, forming well-known 'ghettos'—in the districts of Omonia, Metaxourgiou, Pedion ton Areos, and Mavromateon).

According to Mäding (2004), negative externalities have an impact on properties and jeopardize social goals. In the case of Athens, this can be briefly explained as follows: middle-class families leave inner cities and look for suburban districts with single-family houses or more spacious apartments, while minority or even delinquent groups are concentrated in the city center (e.g., 'ghettoization'); meanwhile, population increase, changes in household structure, and higher demand for large housing, resulting from income growth, further expand the supply of more settlements in suburbs (Rontos and Roumeliotou 2009). The spatial expansion of residential areas leads to an ever-increasing demand for built-up space, with important ecological consequences (Rontos et al. 2014). Despite a moderate demographic recovery of inner cities forecasted for the coming decades, the main feature emerging from the analysis is a persistent suburban dynamic over a relatively long time interval. The results of recent censuses may confirm such assumptions, although one would expect a transition to the next stage of the spatial cycle due to the demographic saturation of suburbs. On the basis of such evidence, the Spatial Cycle Theory predicts the emergence of a third stage ('disurbanization'), with the development of progressively remote settlements. As Noordstrom (1981) noted, the vertical profile of Athens's suburbs, with the continuous replacement of single-family houses into multi-story buildings, may document the continuous absorption of an even expanding population. Although the urbanization trend continues at a weaker pace, suburbs continue growing in both population and activities.

Since the early 1990s, the entry of a large number of immigrants into Greece has significantly affected the regional distribution of the total population in the country, especially in metropolitan Athens. In 2001, 324,167 immigrants out of 413,201 (78.5%) settled in urban areas, and 60.6% of them (196,392 immigrants) were concentrated in metropolitan Athens. The same data source reveals that 2764 (94.6%) immigrants who declared themselves as refugees out of 2920 individuals settled in urban areas. The 2011 population census gave the same picture. Of the 329,556 foreigners who settled in Greece in the period 2006–2011, 244,410 (74.2%) were concentrated in urban areas. The redistribution of regional population in response to migration flows was evident from the official statistics concerning Greece. In the last decade, apart from a short break concomitant with the great recession, and especially after 2015, Greece again experienced a significant influx of refugees, mainly through Eastern Aegean islands (Samos, Lesvos) and the Evros region (Turkish boundaries). A significant number of refugees moved to metropolitan Athens, either individually or as organized by the State and Non-Governmental Organizations. A significant part of all the above movements was directed to downtown Athens, but another non-negligible portion of movements involved the surrounding suburbs, depowering the 'ever-green' suburbanization stage.

The concentration of public and private sector services in Athens (Ministries, Deputy Ministries, Headquarters of the Armed Forces, Security Forces, Administrative Services,

Hospitals, Banks) operated competitively with the housing needs of a slightly growing population and contributed to additional movements of residents to the suburbs, in turn eliminating late suburbanization. The result of 'suburbanization' (either absolute or relative) is the persistence of external negative economies (e.g., traffic jams). The lack of space for the expansion of business facilities (especially extensive activities such as storage or distribution of products) appears together with air pollution and unfavorable living conditions (Antonoglou and Rontos 2021).

Moving toward a sub-regional perspective, an intense population growth occurred in both eastern and southern suburbs near the core city, where middle and upper classes settled. However, intense growth was also recorded in less expensive western suburbs, where the working class has systematically settled since the 1950s. Since the early 1990s, the most distant suburbs of Eastern and Western Attica started growing and displayed some trends toward remote development. The satellite cities of Thebes, Corinth, and Halkida, at a distance between 70 and 80 km from Athens, do not seem to attract intense flows from the Greek capital city.

A systematic implementation of the spatial cycle carried out in this study suggested some future directions of empirical research in urban studies and applied economics. A first issue is with regard to the partial lack of geographic comparability in population statistics before and after the First World War in Greece because of intense administrative changes in municipalities and local communities. In such times, extraordinary events—such as the influx of a number of refugees from Asia Minor in 1922 and from rural areas following the civil war of the late 1940s—merit a specific investigation in the context of the SCT, but the available data provide only an aggregate picture that cannot satisfy the information demand of spatially explicit techniques. This lack limits the historical verification of the SCT over two centuries, namely, from the foundation of the modern Greek state around 1830, when Athens settled only 30 thousand inhabitants, after centuries of abandonment and peripheral development under the Turkish domination.

Testing the SCT from the 'foundation' of a city is a particularly meaningful quasi-experiment. Although Athens was one of the most ancient cities in the world, the secular Turkish domination created a breakdown between the historical city dynamics and the modern ones, with this study clearly reflecting only the latter dynamics. The inherent comparability in population data was addressed with separate calculations in the context of this study, as the radical administrative changes that came to Greece with the Kapodistrias and Kallikratis Plan made the aggregate data released within the most recent population censuses as only partly comparable over time and space. Given the recognized usefulness of a spatially explicit analysis, the competent Statistical Authority (ELSTAT, in our case) should operationally address this issue (e.g., Robinson et al. 1993).

Finally, as a continuation of this study, further research could be carried out based on a refined investigation of sequential waves of growth and decline (e.g., Newsham and Rowe 2023). For instance, the results of a multi-way factor analysis taking into account variables such as inflow/outflow of immigrants, births, deaths, health status, life expectancy, and quality-weighted life years, may shed further light on the future development of metropolitan Athens and, for generalization, of many other European cities and regions. The use of Moran's coefficient or other indexes of spatial autocorrelation may refine such kind of analysis. Statistical analysis may specifically shed light on (mostly unresolved) critical issues to be answered, e.g., whether (and when) latent downtown redevelopment trends will lead to a smooth transition toward 're-urbanization' or to a less predictable evolution toward 'disurbanization'.

In this perspective, the evolution of the spatial cycle in metropolitan regions revealed to be particularly important when formulating regional policy, since urban centers have their own dynamics and evolve even in conditions of non-intervention. Despite partial and possibly preliminary, the results of our study indirectly suggest how decentralization policies are partly ineffective in both urban containment and local development leverage, especially during of the third stage of the spatial cycle ('disurbanization'). Similarly,

the fourth stage of the spatial cycle ('reurbanization') may impact the effectiveness of urban regeneration policies. Assuming a long-term development path reflecting intense urbanization, saturation of vacant land, and subsequent decentralization pulses, departures from the traditional assumptions of the SCT contribute to the informed formulation of urban planning strategies and specific regional policy measures.

## 5. Conclusions

Analysis of demographic dynamics between urban and rural areas possibly reflecting the related intra-urban spatial relations (from both social and economic perspectives) is a traditional issue in regional science, affecting the geographical distribution and balance of economic power within countries. Based on the results of the empirical analysis, the study area first experienced a persistent stage of 'relative suburbanization' and, subsequently, an 'absolute suburbanization' stage. Population forecasts delineate a tendency toward relative suburbanization with a modest recovery of the resident population downtown. The demographic role of satellite cities increased moderately, highlighting latent trends of 'disurbanization'. Based on the predictions of the spatial cycle theory, our study constitutes an informative tool for planning the country's regional development and urban policy in a comparative fashion.

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