Rapidity of Change in Population Age Structures: A Local Approach Based on Multiway Factor Analysis

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Abstract: In the light of complex adaptive system thinking, population age structures in Europe have increasingly reflected the interplay between 'fast' and 'slow' socioeconomic dynamics driven by natural population growth and migration. Assuming the importance of demographic dynamics shaping regional growth in recent times, a diachronic analysis of local-scale population age structures was developed for 156 districts of Greece between 1971 and 2011. By using appropriate indicators, the analysis was aimed at demonstrating how 'fast' and 'slow' transitions contribute to socioeconomic change in both urban and rural areas. A comprehensive analysis of change in population age structures between 1971 and 2011 allows identification of latent spatial structures as a result of population re-distribution from urban cores to broader rural regions. Following residential mobility, the empirical results of this study indicate (i) a late phase of urbanization (1971–1981) with population densification and settlement compactness, (i) a rapid suburbanization (1981–1991) consolidating distinctive demographic structures in urban and rural areas, (ii) a mild counter-urbanization (1991–2001) with moderate aging of suburban populations and (iii) a latent re-urbanization (2001–2011) reducing the suburban-urban divide in population age structures. Residential mobility contributed to a more balanced age structure during suburbanization and an increased demographic divide in the subsequent urban waves. A refined analysis of long-term population dynamics in metropolitan regions reflects spatial outcomes and latent aspects of demographic transitions shedding light on the debate over the future development of urban and rural societies in advanced economies.

Keywords: population dynamics; age structure; spatial analysis; rapidity of change; Greece

1. Introduction

In a context of social fragmentation, economic uncertainty, and transforming cultural attitudes and political rules, urban-rural systems have increasingly assumed the role of open systems influenced by non-linear socio-demographic dynamics [1–4]. The relational issue typical of these systems complicates the assessment of such dynamics, since defining the interaction between different levels of a system's organization is a daunting task [5–8]. However, the evolutionary trajectory of regional systems reveals, in some cases, similar patterns reflecting selection, cooperation, imitation, and adaptation to

change [9–12]. In this ambit, local spatial units (e.g., economic agglomerations, provinces, municipalities, homogeneous production districts) are considered an interesting analysis' scale where local institutions are influenced by the collective action of micro-agents [13–15]. The exploratory analysis of complex socio-demographic systems stimulated the emergence of articulated and refined analytical frameworks that explore system's dynamics focusing on macro-level properties resulting from the latent interplay of micro-level agents [16–19]. This approach fills a gap in regional studies, giving more value to statistical information available at aggregate levels.

Assuming that resilience is the ability of a socio-demographic system to tolerate disturbance without shifting to a state governed by different conditions, a refined analysis of the amplitude of changes fueled by post-disturbance recovery dynamics is a key issue when evaluating system's resilience [20–22]. Referring to the intrinsic ability to respond to continuous transformations, recent studies were aimed at re-framing the hegemonic 'resilience' notion within the broader notion of 'complex system stability', considering the multiple ensemble of opportunities that disturbance opens up in terms of new structures and functions [23–25]. In this regard, assessment of resilience in complex systems adapting to new conditions is key for advancing policies of local and regional development [26–28]. Although representing a formally underexplored dimension of local systems' resilience, demography is a key component of socioeconomic processes, expressing local adaptation to new conditions [29–31]. Evaluating the specific contribution of regional demography in socioeconomic resilience provides basic knowledge to develop an informed vision of local system's resilience, as an original contribution to sustainable development in advanced economies [32–34]. In this ambit, population structure by age is a key dimension contributing to system stability, whose change reflect broader demographic transitions shaping local systems' resilience [35,36].

The selection of relevant properties illustrating the evolution of local socio-demographic systems is a key issue in a resilience-oriented, complex system thinking [37,38]. In earlier studies, properties have been sometimes identified with (more or less) simple attributes of local systems. In complex adaptive systems, limiting/controlling factors ('slow' variables) allow the system to move around a predefined regime (i.e., changes state) depending on the changing values of 'fast' variables [39–41]. With this concept in mind, fast and slow variables are a relevant element of a complex system [15]. More specifically, system's rapidity of change depends on the dynamic interplay of fast and slow variables, defined as "the capacity to meet priorities and to achieve goals in a timely manner to contain losses and thwart future disruption" [42]. While rapidity of change in complex systems can be assessed using quantitative (or qualitative) measures, ways of identifying fast and slow variables and measuring rapidity of change have been investigated only partially [43–46].

Involving countries with evident socioeconomic transformations [47–49], Demographic Transitions (DT) from high birth and death rates to low birth and death rates represent non-linear socioeconomic dynamics typical of complex adaptive systems [50]. In Europe, DTs have demonstrated to shape resilience of local systems, reflecting an appropriate example to measure specific properties such as the rapidity of change [51,52]. More specifically, identification of demographic dynamics resulting in specific population structures is key to a comprehensive understanding of local system's response to external shock and recovery [45]. Assuming DT as a multidimensional process of change involving together multifaceted dimensions of population structure and dynamics, the present study hypothesizes that different population distributions by age underlie different responses to external shocks, being reflected in a different rapidity of change of the composing indicators [53–55].

By applying a resilience-oriented, complex systems' thinking to analysis of population age structures in Greece, a European country experiencing late demographic transition compared with Western and Northern counterparts, the present study evaluates, over a sufficiently long time period (1971–2011), (i) the temporal coherency of population structural indicators and (ii) the spatial coherence of population structures in local demographic systems. This analysis delineates homogeneous dynamics (i.e., rapidity of change) with the use of a new metric based on the results of a multiway factor analysis, as a contribution to the explicit measurement of intrinsic properties of complex adaptive systems.

2. Methodology

2.1. Study Area

The present study investigated demographic dynamics over a sufficiently long time period in Greece encompassing four decades, using population data at five census years (1971, 1981, 1991, 2001, 2011). The study area coincides with the Greek national boundaries extending 131.957 km^2 (mainly uplands and mountainous). The metropolitan hierarchy of Greece is centered on the primacy of Athens and Salonika (hosting respectively more than 30% and 10% of Greek population). Demographic trends in Greece have reflected the typical outcomes of a transitional socio-demographic in advanced economies, based on the following evidence: (i) fertility contributed to natural population growth up to the late 1970s (the end of a phase known as the 'baby boom' in Southern Europe); (ii) since the late 1970s, total fertility rates decreased continuously—although with a temporary recovery in the 2000s; (iii) up to the late 1990s, emigration to Northern/Western Europe and North America allowed a dynamic balance in the socioeconomic disparities within the country, maintaining unemployment and rural poverty at a relatively low level; (iv) immigration from developing countries increased substantially since the early 1990s, with rising flows from Albania and Balkan countries, first, and from African, Middle East and Asian countries later; (v) despite a substantial increase in life expectancy, mortality increased slightly in Greece because of ageing, fueling population shrinkage especially in hyper-rural contexts.

2.2. Population Data

Population structure by age in Greece (using 5-years age classes homogeneous over time) was derived from elaboration on comparable micro-datasets derived from national population censuses held in 1971, 1981, 1991, 2001 and 2011 by the Greek Statistical Office (Hellenic Statistical Service, ESYE, today named ELSTAT, Hellenic Statistical Authority) and disseminated by Minnesota Population Center (USA) on behalf of the Integrated Public Use Microdata Series (IPUMS) International initiative (https://international.ipums.org/international/). These data refer to homogeneous geographical boundaries including 156 spatial domains, an intermediate territorial level between NUTS-3 prefectures (n = 51) and LAU-1 municipalities (n = 1034). The geography of these domains allows a satisfactory identification of regional demographic patterns over a sufficiently long time windows, evidencing the importance of urban-rural, coastal-inland and lowland-mountain gradients. More than 50 and 20 domains in the sample corresponded with individual municipalities respectively in the Greater Athens area and in the Salonika prefecture, thus providing a satisfactory detail on population dynamics in the largest metropolitan regions of the country. Even the most rural and depopulation provinces in the country were divided in two spatial partitions, the municipality including the provincial capital town and the rest of the territory.

2.3. Demographic Indicators

A total of 12 demographic indicators were calculated homogeneously from the available dataset (see Section 2.2) at each census year (Table 1). This set includes basic indicators assessing population structure by age (e.g., old age dependency index and structural dependency index) and was supplemented by general indicators of population density and growth rate covering the 156 elementary spatial units described above. Additional structural indicators were derived from computation on the relative share of population by (5-years) age class in total resident population at each census year and spatial domain: this is the case of Pielou evenness J index, a Shannon diversity function standardized to the level of diversification in the population age structure at a given spatial unit [50,51]. This index was recently adopted in socioeconomic studies dealing with e.g., related variety of economic activities, social diversification, and analysis of migrant communities [6–8,47].

Table 1. Basic indicators of population structure by age in Greece, 1971–2011.

Acronym	Indicator	Formulation
Den	Population density	Resident inhabitants/km^2
Gro	Annual population growth rate	(Population(t$_1$)-population(t$_0$))/population(t$_0$))*100/10
Age	Mean population age	Average number of years using 5-years age classes
Eve	Pielou's J evenness index	J = H'/H$_{max}$ (H': Shannon diversity index; H$_{max}$=ln(no.classes))
Agi	Aging index	Population(65+)/Total population
Eld	Elderly index	Population(65+)/Population(0–14)
Dep	Structural dependency index	(Population(65+)+Population(0-14))/Population(15–64)
Dey	Structural dependency of young	Population(0–14)/Population(15–64)
Deo	Structural dependency of elders	Population(65+)/Population(15–64)
Rec	Demographic recovery index	Population(60–64)/Population(15–19)
Str	Structure of active population	Population(40–64)/Population(15–39)
Loa	Children load index	Population(0–4)/Female population(15–49)

2.4. Statistical Analysis

Assuming long-term Greek demographic dynamics as the response of a complex adaptive socioeconomic system, rapidity of change in the population structure by age—taken as a basic property of this system—was investigated using a dynamic multidimensional analysis carried out on 5 data matrices constituted of the 12 demographic indicators (see Table 1) at each spatial unit (156 elementary domains) by year (1971, 1981, 1991, 2001, 2011). More specifically, a Multiway Factor Analysis (MFA) was applied to our case study [56] with the aim to select independent, latent variables (factors) managing data redundancy and serial autocorrelation in a multivariate distribution of observations [57]. This methodology highlights complex structures in higher-order datasets, where data have three (or more) dimensions [58]. Linking different variables with comparable spatio-temporal patterns on a few significant factors, this strategy provides an indirect measure of the extent to which a system's characteristics (i.e., demographic indicators) have substitutes to ensure functioning in the event of a transition or a shock [59]. Being a subjective analysis not grounded on hypothesis testing, the selection of significant factors was based on a priori eigenvalue threshold (eigenvalue > 1). Factor loadings and scores were considered together [60] when defining independent dimensions of demographic transition in Greece. The MFA was supplemented with five supplementary variables (distances from downtown Athens and Salonika, proximity to the sea coast, and two dummies classifying island districts and urban districts. The spatial distribution of factor scores was mapped using a shapefile of spatial units provided by IPUMS International.

MFA results allow an explicit evaluation of the change over time in the position of each unit (demographic indicator) and case (spatial unit) since they are projected into the same factorial plane. This homogeneous representation of the trajectory over time of each spatial unit associated with the intrinsic change of each demographic indicator allows estimation of the rapidity of change in both units and cases along a given time interval [61]. Following Salvati and Serra [56], a multidimensional metric of rapidity of change (R'$_{1-0}$) for both units and cases was calculated as the Euclidean, n-dimensional distance between loadings (or scores) observed at times t$_1$ and t$_0$ (e.g., 1981 *vs* 1971) separately for each indicator or spatial unit according to the following equation:

$$R'_{1-0} = \sqrt{((x_{a,1} - x_{a,0})^2 + (x_{b,1} - x_{2,0})^2 + (x_{...,1} - x_{...,0})^2 + (x_{n,1} - x_{n,0})^2)} \tag{1}$$

where $x_{a,1}$ is the loading on factor a at a given time (1 or 0) and n is the number of factors with eigenvalues > 1. Fast and slow variables and rapidity of change in each spatial unit were thus investigated for two time horizons: (i) short-medium terms (considering each decade separately, i.e., 1971–1981, 1981–1991, 1991–2001, 2001–2011) and (ii) a medium-long term (considering the whole study period, 1971–2011). Specific changes in demographic indicators were regarded as 'fast' (or 'slow'), if the related R' was above (or below) the median value of the overall rapidity of change computed for the respective time interval. Rapidity of change estimated for each spatial unit was mapped by time

window. The average R' metric by time window was finally aggregated in 9 spatial macro-domains representing homogeneous districts along the urban-rural gradient in Greece, as follows; (i) Athens' municipality(downtown), (i) Piraeus' municipality (downtown), (iii) Rest of the Greater Athens' area (with the exception of Athens and Piraeus municipalities), (iv) Rest of Attica (with the exception of the Greater Athens' area), (v) Salonika's municipality (downtown), (vi) Rest of the Greater Salonika's area (with the exception of Salonika's municipality), (vii) Rest of the Salonika prefecture (with the exception of the Greater Salonika's area), (viii) Urban municipalities in the rest of Greece, and (ix) Rural municipalities in the rest of Greece.

3. Results

The age structure of the Greek population was studied by considering 5-year age classes (Figure 1). Population aging was evident for all decades, accelerating in the last time interval (2001–2011). The relative proportion of the young population (0–9 years) decreased progressively, being almost 9% of the total population in 1971 and approaching 5% in 2011. The active population aged 35–44 was relatively stable between 1971 and 2011. In the face of significant structural changes in the Greek population, the percent share of the active population between 25 and 54 years in total population was higher in 2011 than in 1971. An indicator of the population structure (Table 2) confirms the progressive aging of resident population (with a mean age approaching 34 and 42 years, respectively in 1971 and 2011). This trend was linked with the higher life expectancy at birth and adulthood, and with the lower birth rate in recent times compared with the past. The intermediate age classes maintain a relatively stable population, and this entails the consolidation of a substantially balanced population structure in 2011, as the evenness indicator (Pielou J index) clearly indicates.
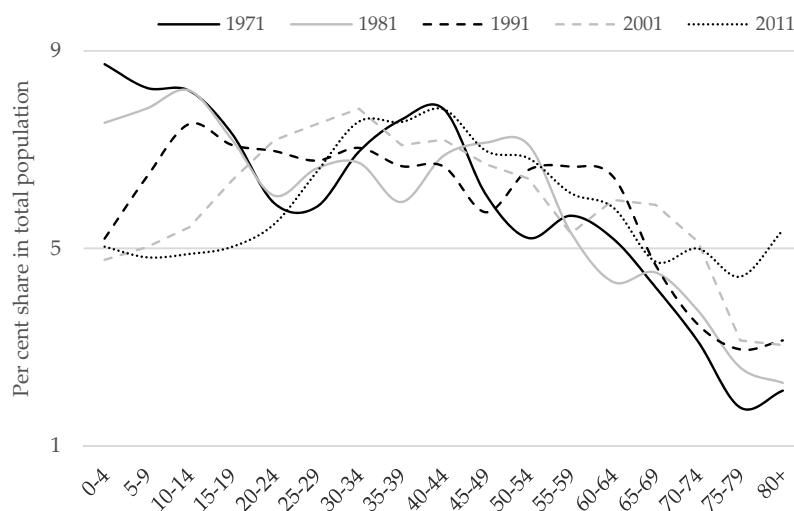
Figure 1. Population structure by age in Greece by census year (percent share of population by age class in total population), 1971–2011.

Table 2. Basic characteristics of population structure by age in Greece, 1971–2011.

Year	Mean Population Age	Shannon H' Diversity	Pielou J Evenness
1971	34.4	2.76	0.98
1981	35.6	2.78	0.98
1991	37.9	2.80	0.99
2001	39.7	2.80	0.99
2011	41.9	2.82	0.99

Within the demographic context traced with the descriptive analysis of the selected demographic indicators, an exploratory multi-temporal analysis was run to estimate the rapidity of change in regional

and local population structures by age in Greece (Table 3). The Multiway Factor Analysis extracted two relevant factors explaining together 67.3% of the overall variability of the five data matrices (one per year). All indicators were related to one of the two axes. Five supplementary variables were used for the geographical characterization of the two axes. Factor 1 accounted for the major proportion of variance (49.1%) and is associated with 9 out of 12 demographic indicators. Indicators of the structure of active population (str), generational turnover (rec), dependence of the elderly (deo), structural dependence (dep), aging (eld and agi), as well as the average age of the population and the J evenness in the distribution of the population by age group were all positively correlated with axis 1. In general, scores took on an inverted U trend over time, reaching a peak in 1991. Population growth rate was the only indicator negatively correlated with axis 1. Considering supplementary variables, Factor 1 discriminated urban districts from the rural ones. Taken together, Factor 1 discriminated against the extent of the progressive aging of the Greek population, which is particularly differentiated between urban and rural areas.

Table 3. Results of a Multiway Factor Analysis (factor's loadings) applied to demographic indicators by census year, 1971–2011 (only relevant factors and significant coefficients were shown).

Indicators	Factor 1					Factor 2				
	1971	1981	1991	2001	2011	1971	1981	1991	2001	2011
Active variables										
Population density						−0.79	−0.79	−0.79	−0.78	−0.76
Annual population growth rate	−0.61	−0.61			−0.61					
Mean population age	0.77	0.95	0.97	0.92	0.84					
Pielou's J evenness index	0.75	0.88	0.90	0.41	0.50					
Aging index	0.85	0.93	0.96	0.96	0.87					
Elderly index	0.76	0.92	0.95	0.90	0.80					
Structural dependency index	0.57	0.69	0.78	0.88	0.83	0.67	0.58	0.41		
Structural dependency of young						0.69	0.71	0.75	0.84	0.83
Structural dependency of elders	0.85	0.91	0.94	0.96	0.86					
Demographic recovery index	0.66	0.78	0.87	0.77	0.61					
Structure of active population	0.82	0.88	0.84	0.75	0.60					
Children load index						0.69	0.58	0.71	0.76	0.70
Supplementary variables										
Distance from Athens								0.46		
Distance from Salonika										
Proximity to the sea coast										
Island district (dummy)										
Urban district (dummy)			−0.76							

Factor 2 explained 18.2% of the overall variance and was associated with 4 demographic indicators: the load of children per woman (loa), the structural dependence of young people (dey), the structural dependence of the population (dep) as well as the density of population (den), the latter displaying a negative correlation. This axis identifies more latent demographic processes, associated with (i) a higher fertility level typical of suburban and rural districts compared to urban ones, (ii) and the progressive balancing of young and adult population segments in urban districts. Factor 2 represents a geographical gradient based on the distance from Athens, highlighting the center-periphery dynamics on a national scale.

The results of a specific analysis of rapidity of change in population structure was proposed in Table 4. Concerning demographic indicators, the greater rapidity of change (R' metric) was observed for the population growth rate in 1981–1991, the J evenness index in 1991–2001, the structural dependence of young people (1971–1981), the generational turnover rate (2001–2011) and the load of children per woman (1981–1991). The mean R' metric for all demographic indicators was comparable over time and slightly higher in the decade 1981–1991 compared to the other time windows. The rapidity of change of regional population structures by age was also studied at a disaggregated spatial level as a metric distinguishing urban and rural districts (Table 5). The highest values of the rapidity of change were observed in urban areas and more specifically in Athens- Piraeus (1971–1981).

**Table 4.** Rapidity of change (R′ metric) of demographic indicators in Greece by time interval.

Indicator	1971–1981	1981–1991	1991–2001	2001–2011
Population density	0.03	0.03	0.02	0.04
Annual population growth rate	0.07	0.51	0.17	0.37
Mean population age	0.22	0.13	0.13	0.09
Pielou's J evenness index	0.14	0.04	0.56	0.33
Aging index	0.08	0.15	0.11	0.11
Elderly index	0.19	0.18	0.19	0.10
Structural dependency index	0.15	0.19	0.15	0.14
Structural dependency of young	0.45	0.11	0.14	0.02
Structural dependency of elders	0.07	0.14	0.11	0.12
Demographic recovery index	0.17	0.11	0.16	0.31
Structure of active population	0.10	0.23	0.10	0.15
Children load index	0.23	0.38	0.22	0.13
Average R′	*0.16*	*0.19*	*0.17*	*0.16*

Table 5. Rapidity of change (R′ metric) of aggregated spatial units in Greece by time interval.

District	1971–1981	1981–1991	1991–2001	2001–2011
Municipality of Athens (downtown)	1.52	0.54	1.30	0.72
Municipality of Piraeus (downtown)	1.26	0.36	0.45	0.82
Rest of the Greater Athens' area	0.89	0.85	0.96	0.90
Rest of Attica	0.82	0.74	0.59	1.17
Municipality of Salonika (downtown)	0.81	0.20	0.51	0.85
Rest of the Greater Salonika area	1.09	1.26	2.39	1.83
Rest of the Salonika prefecture	0.10	0.57	0.91	1.71
Urban municipalities, rest of Greece	1.06	0.84	0.97	0.94
Rural municipalities, rest of Greece	1.27	1.15	1.52	1.09

The rest of the Greater Athens' area showed a comparatively less rapid rate of change with the maximum intensity observed between 1991 and 2001. In the rest of Attica, the peri-urban region of Athens, the fastest changes in population structure have been observed in the last decade of study (2001–2011). In Salonika, the fastest changes have been observed in the Greater Salonika area in the last two decades of study (1991–2001 and 2001–2011), as well as in the rest of the metropolitan area (2001–2011), while structural changes were less rapid in downtown Salonika. The other urban areas in Greece have experienced a substantial stability over time in the R′ metric. Rural areas experienced the fastest change in the 1991-2001 decade. In general, these results highlight how the fastest changes in regional population structures were observed first in urban areas and later on in the surrounding peri-urban and rural areas, highlighting the distinct demographic phases associated with the urban cycle in Greece (urbanization-suburbanization-against-urbanization).

Estimation of the rapidity of change in the age structure of the resident population was carried out in each of the 4 time intervals for all 156 (urban and rural) districts in the country (Figure 2). Structural changes in the population structure by age in 1971–1981 were more rapid in rural areas of the Peloponnese, central Greece and Macedonia. Rapid changes have been also observed in central cities (e.g., Athens, Piraeus, Salonika, Iraklion). This spatial pattern highlights the impact of internal migration on the demographic structure of marginal areas with intense mobility of working age population toward central urban areas. On the contrary, the R′ metric has assumed much lower values in more accessible agricultural areas, in coastal areas and in island districts. In the following decade, the R′ metric assumed the highest values in the rural districts of Western Greece, both coastal and inland, while gradually decreasing in urban areas. This was linked with a process of progressive demographic rebalancing, due to the persistence of socioeconomic conditions favorable to internal migration. Suburban areas exerted the greatest attraction towards young active population, while central urban areas began to experience a temporary demographic shrinkage.
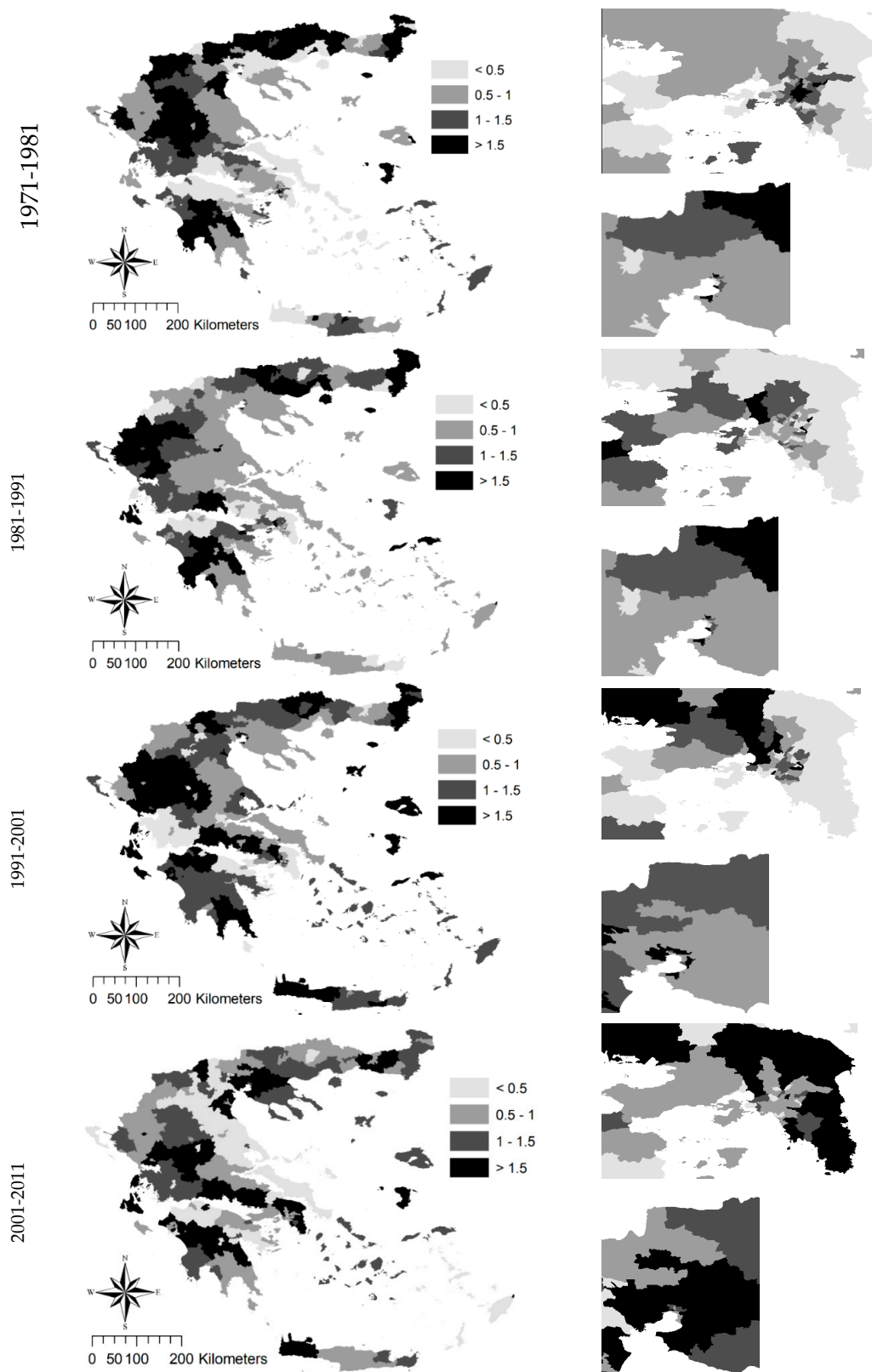
Figure 2. Rapidity of change in demographic indicators by census year, 1971–2011 (for each year's panel, left: Greece; upper right: a zoom on the Athens' metropolitan region; lower right: a zoom on the Salonika's metropolitan region).

In the 1990s, the districts classified with the highest rapidity of change were characterized by a more heterogeneous socio-demographic profile, including coastal areas (Crete, Rhodes, Lesvos, Cyclades, Ionian islands), Laconia and Acaia (tourist regions in the Peloponnese), as well as inland areas of Epirus and Macedonia. In this period, urban areas have lost much of their previous dynamism. In the last decade, the dynamism of the most accessible coastal, island and agricultural areas has consolidated. This process was associated with a much accelerated structural change in the structure of suburban populations both in Attica and in the province of Salonika. In other words, while both urban and rural areas experienced a progressive aging of the population in this decade, the areas that attracted young and working-age population were at a lower density, including both peri-urban regions close to large cities, and more rural regions close to the sea.

4. Discussion

This study highlights how the results of a multivariate exploratory analysis provide a simplified estimate of important properties underlying the spatio-temporal evolutionary path of complex systems. In this case, the age structure of regional populations is considered a complex system subject to a dynamic evolutionary process over time. The evolution of regional demographic systems was therefore described through a characteristic property, the rapidity of change, considered as a multidimensional factor, the estimation of which requires the analysis of a set of indicators that vary over time and space. Multiway Factor Analysis allows a refined analysis of 12 basic indicators, eliminating redundancy and highlighting the information underlying demographic change. The analysis, applied to the structure of the Greek population from 1971 to 2011 in 156 urban and rural districts, identified two characteristic dimensions of the demographic changes in the country, highlighting an overall aging process of the population and a more subtle process of spatial relocation of the young and active population towards central locations. The geographical gradients underlying these transformations highlight how the urban-rural divide was particularly relevant in the first decade of study (1971–1981). The most balanced population structures were observed in central urban areas, with a prevalence of the working age population classes, while in rural areas the youngest and oldest classes were prevalent, also considering the higher fertility rate that has traditionally characterized many rural areas in Greece during that period.

In the last decade (2001–2011), the biggest gap in population structure has been observed between the 'intermediate' areas and the urban (or rural) districts in a more strict sense. The intermediate areas represent initially marginal territories because of low density, but progressively developed thanks to 'soft' growth factors, including quality tourism and agriculture. These territories have more recently undergone intense socioeconomic transformations thanks to improved accessibility, an increase in the non-resident population because of international migration (especially at older ages), and more latent processes of short and medium-range residential mobility [52]. If the demographic changes in the first decade have clearly reflected the final phase of a long process of compact urbanization on a metropolitan scale—associated with the inherent concentration of the population in a few urban areas on a country scale—these transformations have highlighted the underlying processes of suburbanization in the last decade [62]. The two intermediate decades have represented a more mixed period, displaying heterogeneous demographic dynamics over time and space. Such dynamics represented the natural evolution of a center-periphery demographic model based on the dichotomy between Athens (and, in part, Salonika) and the rest of Greece towards a more polycentric and less polarized structure. In this structure, some rural territories have increased their attractiveness for specific segments of the population, mainly young people or adults in working age. The 2000s' economic growth radiating from central urban areas to the most accessible rural districts fueled an intense residential mobility that has sustained this process. The subsequent recession consolidated such spatial patterns leading to a progressive shrinkage of central locations and a counter-urbanization towards the most dynamic rural areas [63].

These dynamics seem to affect only partly the marginal rural areas in Greece that remained linked to more (or less) intense depopulation processes throughout the study period. The progressive decline in the birth rate affecting rural areas, combined with the consolidation of internal migrations, first to urban areas and then to the 'intermediate' areas of the country, stimulated a further demographic decline. In this perspective, the rapidity in the intrinsic change of demographic structures in rural areas was mainly linked to the progressive aging of the population and, secondarily, to the decline in the birth rate, observed especially since 1981. In these regards, the results of our study support the assumption that demographic transformations are linked with a broad spectrum of socioeconomic conditions influencing resilience of local systems [64].

Tourism, local development based on accessibility, infrastructure, construction (second homes) and new decentralized urban functions (universities), are the factors that have most stimulated population growth and structural change towards younger and balanced populations with more fast generational turnover [65]. In this sense, the classic urban-rural polarization model typical of the mono-centric demographic structures in Greece (1971) has been progressively replaced by models oriented toward spatial redistribution of population and deconcentration of economic activities which has had a great impact on local demographic structures by age. Population dynamics have contributed to this transition thanks to, e.g., the inherent polarization of settlements in high-density and low-density areas [66]. Involving socioeconomic dimensions hard to characterize as factors of change, the interplay of population structures and local development requires a more comprehensive analysis in economically advanced countries [67]. A refined investigation of demographic age structures over time and space can be extended to other countries in Southern Europe with the aim to identify common trends, assuming that changes in vital rates are responsible for distinctive paths of population growth (or decline) in this region. A specific study carried out in Northern Spain can provide a vivid example of this rationale [68]. The operational framework proposed here outlines the importance of novel demographic indicators in a broader framework linking changes in population structure with sustainable development [69], social cohesion [70], and socioeconomic resilience of local systems (more or less rapidly) adapting to global change [71].

5. Conclusions

Our study illustrates an exploratory approach based on a Multiway Factor Analysis (MFA) to estimate rapidity of change in regional demographic systems evolving between 1971 and 2011, identifying "fast" and "slow" indicators and country's districts characterized by a different rapidity of change in population structures by age. More specifically, our work proposes an estimation of a multidimensional property of complex adaptive systems (rapidity of change) from the results of a simple multivariate analysis that simultaneously investigates the spatial and temporal variability of the system itself. The rapidity of change represents a particularly relevant conceptual dimension in the theory of complex adaptive systems. From the quantification of the rapidity of change and from the intrinsic capacities of a system to respond to exogenous (more or less) intense shocks, derives the greater (or lesser) ability to predict phase transitions and the evolutionary path in medium-short terms. These results may contribute to design policies addressing system's complexity and promoting resilience of local communities with distinctive socio-demographic profiles.

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