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SMALL-SCALE SOCIO-ECONOMIC CONDITIONS AND RESIDENTIAL SEGREGATION: EVIDENCE FROM THE MUNICIPALITIES ACROSS THE METROPOLITAN REGION OF ATTICA

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Abstract

Residential segregation gained a new momentum after the turn of the new century. The pace of urbanization that has been observed over the last two decades has been proceeding hand in hand with the increasing residential segregation in large cities and metropolitan areas. The international literature is flourishing with studies on residential segregation. This paper investigates residential segregation trends in the Metropolitan Region of Attica during the period 2004-2019. The analysis is based on a database combining individual household data from the EU-SILC, as well as data from official national sources. The paper applies the Dissimilarity Index for measuring residential segregation trends based on occupation, education and living conditions, before, during and after the economic crisis. We also use the Gini index for comparing income inequality with residential segregation trends. Our analysis shows that between 2004 and 2019, residential segregation intensified between the top and bottom socio-economic groups, whilst an inclusive trend has been recorded between middle-class groups and the other two categories. The results do not suggest any similar patterns between residential segregation and income inequality. The evidence derived from this study is relevant to public policy, inclusive growth and development.

Keywords: residential segregation; social segregation; income inequality; metropolitan areas
JEL Classification: D31, D63, R23, R13

1. Introduction

Cities have been at the epicenter of attention in scientific debate and policy intervention since the turn of the new century. The accelerated pace of urbanization across the globe observed over recent decades resulted in a shift of balance between the urban and the non-urban population. Since the turn of the century, the majority of the global population lives in cities, large metropolises and urban conurbations / agglomerations (OECD 2020).

The increasing pace of urbanization has been accompanied by a growing awareness that the process of urbanization is intertwined with the rise of intraregional socio-spatial inequalities. These could be expressed either in the form of intra-territorial income inequality between the best-off segments of the population and the most deprived individuals and households on the one hand; or interregional/ spatial inequalities between enclaves of prosperous areas with relatively rich inhabitants and amenities, and deprived areas with poor individuals and households and downgraded living conditions, on the other hand. The coincidence of these trends has resulted in a socially and spatially fragmented and unequal environment within cities and metropolitan areas. At this point, socio-spatial analyses in cities regained a new momentum. In the face of the emerging challenges, the nexus between cities and inequality has become a central concern of urbanization.

The vast majority of the literature leans toward the conclusion that socio-spatial inequalities are more pronounced in cities. Income inequalities, residential segregation and social polarization go hand in hand with the pace of urbanization (van Ham et al., 2020). Segregation is perceived in many cases as a spatial expression of rising social polarization (Sassen, 2013). Professionalisation has become a key driver of income inequality, social polarization, and residential segregation (Hamnett,

2021; van Ham et al., 2020, 2021). In several cases, changes in the socio-spatial outcomes of professionalisation are closely related to the social geography of cities, pointing to it as a key mechanism for triggering urban segregation (Azpitarte et al., 2021; van Ham et al., 2021).

Urban segregation can take various forms, encompassing aspects related to different life domains, such as residence, school and work domains (Tammaru et al., 2021). Differences in socioeconomic status (SES) restrict household choices in relation to their location, creating spatial imbalances within urban areas (Nieuwenhuis & Xu, 2021). Residential segregation reflects those uneven distributions of population across space, with evidence suggesting that income inequality not only plays a significant role in their formation, but is also a key outcome (Musterd & Ostendorf, 2013; van Ham et al., 2021).

Even though the literature highlights the complexity of the relationships between these notions, there are few studies that have documented any clearly specified relationship between them (Musterd et al., 2017). In terms of evolution, residential segregation and inequality have, in recent years, increased in European cities, due to the extensive social transformations that they have experienced (Piketty 2014; Tammaru et al., 2017; Alvaredo, 2018). The southern European cities seem to have experienced significant changes in their social geography deriving from professionalisation processes taking place over recent decades (Panori et al., 2019; Maloutas & Botton, 2021). This has led them to experience higher levels of segregation and inequality when compared to northern European cities, which are moderately segregated (Tammaru et al., 2017). Residential segregation in Athens follows a pattern common to southern European cities, characterised by a professionalisation trend of several middle-class areas, residential segregation and the further professionalisation of higher income areas, as well as the deterioration of an extensive portion of the city centre (Maloutas & Botton, 2021).

This paper expands the analysis for the case of Athens, focusing on an extensive area covering the whole Attica region, rather than simply the city center. Moreover, it investigates residential segregation from a multifaceted perspective using three different SES proxies: occupation, education and living conditions. It measures the extent to which each one of these proxies have affected the spatial outcomes of residential segregation during a period of extensive social transformation in the Metropolitan Region of Attica. The corresponding dissimilarity indexes are calculated for each of these SES proxies, making it possible to compare their evolution over the period under investigation. The paper explores the relationship between these residential segregation variables and income inequality within the Metropolitan Region of Attica, measured by the Gini index. It is also the first time that residential segregation in Attica is calculated using a spatial microsimulation model expanding the period of analysis up to 2019, covering a period of 16 years (2004-2019).

The following research questions are addressed:

(1) How does residential segregation in the Metropolitan Region of Attica change with regard to different SES dimensions (occupation, educational attainment and living conditions)?

(2) What is the relationship between residential segregation and income inequalities in the Metropolitan Region of Attica?

The paper is structured as follows. Section 2 provides a detailed presentation of the theoretical framework focusing on the notions of social segregation and income inequality. Section 3 describes our methodological approach providing all the necessary information for the data we used for the empirical analysis, and Section 4 focuses on presenting the main findings in relation to our main research questions. Finally, a general discussion and conclusions are presented in Section 5.

2. Theoretical Framework

2.1. Dimensions of residential segregation

The term segregation refers to the state of setting someone or something apart from others. This means that the criteria we use each time as a basis for segregation define its nature, resulting in different types such as residential, ethnic or gender segregation. Residential segregation encompasses the spatial dimension, as it refers to the uneven distribution of different SES groups in space within an urban area (van Ham et al., 2020). It encompasses the housing preferences of high-income groups living in urban areas who very often choose to reside in attractive parts of the city, such as gentrified inner-city neighbourhoods or the suburbs, being highly segregated from lower-income households (Pastak, 2021; Reardon and Bischoff 2011). Not only does this affect the residential domain, but also broader aspects of everyday life, such as schooling, public space and leisure activities (Boterman et al., 2021; Domina, 2006).

Given that cities can be understood as a collection of sites, each of which refers to different life domains, residential segregation can be seen as an outcome of how these domains interact and affect the location choices of these SES groups (Bernelius & Vilkama, 2019; Tammaru et al., 2021). There is a growing body of literature that investigates the ways in which location choices of different SES groups interact and how various spatial characteristics are very often considered jointly (Oberti & Savina, 2019; Rich et al., 2021). Income and occupation are frequently used as the key dimensions for defining the dichotomous lines between the various SES groups that co-exist within cities (Musterd et al., 2017). Over the last decade, the literature has expanded those boundaries to include dimensions such as education and living conditions as additional proxies for SES which are able to

generate residential segregation (Boterman et al., 2018; Florida & Mellander, 2018). Spatial patterns deriving for each SES group may be similar or may vary between different SES dimensions. For example, residential segregation triggered by educational attainment may indicate patterns similar to residential segregation deriving from different occupational groups (Boterman et al., 2021), whilst the same may not apply when comparing residential segregation outcomes between occupational and living conditions SES groups. Therefore, it is important to consider various dimensions when investigating the spatial outcomes of different SES groups' residential choices.

The literature using occupation as a proxy for SES has shown that residential preferences may vary between types of occupational groups (Boterman et al., 2021). The definition of occupational groups may follow traditional approaches, such as blue-collar and white-collar workers (Oberti, 2020; van Ham et al., 2020; Uesugi, 2021), or more recent ones, such as the "new middle class" (Hall & Barrett, 2018; Grzegorczyk, 2021) and the "creative class" (Florida & Mellander, 2018; Graif, 2018). Patterns referring to employees in traditional sectors usually indicate a preference for the suburbs as we move from blue-collar to white-collar workers, whereas additional findings show that persons working in cultural and creative industries demonstrate a robust urban orientation despite the level of their income (Boterman et al., 2018). This indicates that occupational status may reflect residential choices up to a point after which educational and cultural backgrounds may play a more critical role.

When it comes to the educational dimension, evidence suggests that professionalisation has led to an increased share of high-income workers who are highly educated which affects their spatial distribution across urban areas (van Ham et al., 2021; Domina, 2006). This distribution may begin by introducing an income mix in urban neighbourhoods at its early stages, which gradually becomes a key dimension of residential segregation, increasing the gap between poorly- and highly-educated residents (Maloutas et al., 2019; Boterman et al., 2021). Education seems in many cases to be a more dominant source of social segregation than occupation, indicating a reproduction trend between the various SES classes through increased access to social capital and networks (Otero et al., 2021).

Even though occupational and educational levels can be used as proxies for SES conditions, they do not directly capture the exact household living conditions. The literature has tried to shed light on the relationship between residential segregation and living conditions, indicating that these two notions are highly connected and can be used to explain each other (Farkas et al., 2017; Panori, 2017; Vergou, 2019). More specifically, differences in living conditions can better explain the spatial distribution of the population within a city when compared to income and educational variations (Checa, 2021; Bencardino & Nesticò, 2017).

2.2. Previous research on residential segregation and SES conditions

Residential segregation can be perceived as a type of residential sorting based on income availability, resulting in an uneven spatial distribution of households with diversified socio-economic backgrounds (Oberti & Savina, 2019; Nieuwenhuis et al., 2020). Therefore, there is a close relationship between residential segregation and income inequality. However, there is no clear evidence in the recent literature on the ways in which these two phenomena are connected and whether one acts as a trigger for the other (Tammaru et al., 2015; Musterd et al., 2017).

Literature has shown that variations between residential neighbourhood characteristics trigger diversified socio-economic outcomes (Tammaru et al., 2021). These refer to offering access to experiences covering multiple life domains, such as schools, workplaces and leisure amenities (Holzer 1991; Wrigley 2002; Van Ham & Tammaru, 2016). Hence, inequalities arising through residential segregation can be understood as variations in accessibility and the experiences of individuals living in different areas which depend on spatial characteristics (Hedman & van Ham, 2012). On the other hand, residential segregation can be perceived as a spatial expression of income inequality as various neighbourhoods are not accessible to persons with lower incomes due to higher living expenses, and at the same time persons with higher incomes are not willing to reside in areas with low living standards (Tammaru et al., 2020; Costa & Valk, 2021).

Previous findings suggest that it is essential to consider lags between changes in residential segregation and income inequality, in order to explore their connection, both in time and space (Marcińczak et al., 2015; Wessel, 2016; Musterd et al., 2017). Evidence also suggests that very often segregation tends to be intergenerational, becoming stronger in subsequent generations (Silm et al., 2018). In addition to intergenerational mechanisms, there are spatial channels which connect residential segregation and income inequality. These include aspects referring to the natural changes in the population due to variations in household numbers, as well as mobility between urban regions caused by income changes or a transformation of the geography of the housing market (Tammaru et al., 2020).

Recent studies highlight a rising residential segregation trend between high- and low-income groups in European cities alongside increasing income inequality (Maloutas & Fujita, 2016; Tammaru et al. 2015; Musterd et al. 2017). Availability of new datasets has played an essential role for providing more detailed information on these research questions. Individual data from large-scale surveys have enabled the calculation of DI and GINI indexes at city levels and below, offering a great opportunity to explore the ways in which the social geography of cities changes when compared to city-wide levels of segregation (Ransom, 2000; Tammaru et al. 2020). Evidence deriving from worldwide case studies suggest that the social geography of inequality measured through the GINI

index is changing faster than the dissimilarity indexes referring to city-wide residential segregation (van Ham et al., 2021). However, it is important to further investigate the local conditions in each case, as different patterns arising from the structure of cities may lead to diverse outcomes (Quillian & Lagrange, 2016). For example, in cities like London and New York, high-income groups tend to concentrate around the city centre (Manley, 2021; Zapatka et al., 2021), whilst cases like Cairo and Cape Town are characterized by degraded inner areas (Mohamed & Stanek, 2021; Turok et al., 2021).

2.3. Residential segregation and income inequality

Individual socio-economic characteristics, such as occupation, education and living conditions, play a key role in the evolution and the spatial outcomes of residential segregation. At the same time, these characteristics are also closely related to income distribution, indicating a close link between residential segregation and income inequality. In an attempt to reveal the mechanisms shaping income inequality and segregation, studies indicate that major structural changes, such as deindustrialization and globalization, have also affected income inequality and segregation (Sassen, 2013).

Reardon and Bischoff (2011) stress that income inequality is a key condition for segregation, as, without income inequality, all individuals, and therefore, all neighbourhoods would have the same income distribution. At the same time, Musterd and Ostendorf (2013) highlight the fact that uneven income distribution between households is a key driving force of residential segregation in cities, and vice versa. Relevant studies which attempt to reveal a potential relationship between these two elements have shown that it is difficult to define a one-to-one connection, due to the complex dynamics arising between these phenomena (Tammaru et al., 2015; Musterd et al., 2017).

According to Reardon and Bischoff (2011), three channels can be identified in relation to the processes linking residential segregation and income inequality (Reardon and Bischoff, 2011). First, there are preferences linked to the residents' SES characteristics in a neighborhood that include: income level; educational attainment; and the occupational status of people living in the same area. This of course, relates to the second channel which refers to residential preferences based on more general neighborhood characteristics, such as racial composition, and a third channel related to preferences for local public goods, including social and cultural amenities. Evidence suggests that following those mechanisms, as the top percentile income increases, there is a tendency for these households to concentrate on space (Reardon and Bischoff, 2011).

Summing up, residential segregation in urban areas is increasingly affected by different expressions of socio-economic conditions in addition to income and occupation. Hence, this paper builds on the idea of studying and comparing residential segregation changes along different SES dimensions (occupation, educational attainment and living conditions), forming a multi-dimensional perspective of residential segregation. It also provides an initial investigation of the relationship

between residential segregation and income inequalities in the Metropolitan Region of Attica, which has not yet been investigated, using municipalities as the main geographical level of analysis. In the following section, we present the main data sources and the empirical methods used in this paper to measure and explore residential segregation in terms of occupation, educational attainment, and living conditions.

3. Data and Methodology

3.1. The SimAthens model

With regard to the choice of the data used in this study, we have chosen to use simulated data, instead of census records. The reasons for this choice are twofold. First, we wanted to cover the period under analysis (2004-2019) on a yearly basis, instead of just using the census years as references (2001-2011-2021), to explore whether there were any strong variations due to the 2008 financial economic crisis that severely affected the Metropolitan Region of Attica. Second, the Greek census does not provide all the necessary information for developing a comprehensive calculation of SES conditions at a municipal level for the Metropolitan Region of Attica. This indicates the need to use external data sources such as the European Union Statistics on Income and Living Conditions (EU-SILC) dataset, and to apply novel approaches to estimate the variables identified at the municipal level of analysis.

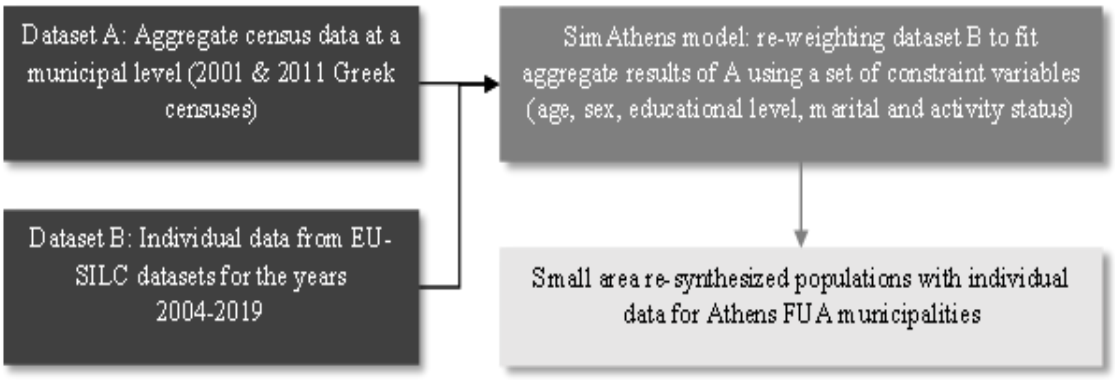
To overcome the abovementioned obstacle, we chose to use the *SimAthens* model which is a static spatial microsimulation model for estimating and analysing small area income and SES condition distribution in the city of Athens (see Panori et al., 2017 for an extended methodological description of the model). The model is based on a static spatial microsimulation approach used to artificially generate data estimating income and other SES characteristics which are not available through the Greek census at the municipal level for Metropolitan Region of Attica.

More specifically, the SimAthens model data generation process uses an iterative proportional fitting (IPF) algorithm to re-weight individual records from the EU-SILC dataset which is aimed at fitting them into specific aggregate small-area descriptions for the 124 Athenian municipalities and communes1. To achieve this, the IPF algorithm uses a set of constraint variables referring to

[1] The analysis is based on the geographical disaggregation that was introduced by the 'I. Kapodistrias' administrative reform L. 2539/1997. Following this reform the metropolitan region of Attica was administratively divided into 124 first tier local government jurisdictions, of which 91 Municipalities and 33 Communes. It is worth noting that the administrative structure of the region of Attica does not exist anymore. Following the so-called 'Kallikratis administrative reform L. 3852/2010, the former 124 Municipalities and Communities of the Region of Attica have been amalgamated

individual demographic and socio-economic characteristics, including gender, age, marital status, activity and educational level. The choice of the constraint variables in the SimAthens model used income and SES conditions as the main target variable which enabled us to directly use the outcomes of this model for our analysis. It is important to note that the validation process of the model has indicated a high-level of goodness-of-fit, both in terms of internal and external validation processes (see Panori et al. (2019) for more details on the validation). A descriptive representation of the methodological approach of the SimAthens model is presented below (Fig.1). The derived dataset includes individual data on income, occupational status, educational level and living conditions for measuring residential segregation and income inequality at the city-wide- level, covering 124 municipalities in the Attica region, forming a broad approach to Athens as a functional urban area, from now on referred to simply as Athens. Fig.2 provides a map of the research area. The paper uses the SimAthens model to cover the period of the last 16 years (2004-2019) for Athens.

Figure 1. Links and connections between different data sources used for the development of the *SimAthens* model



Source: Panori et al., 2017

into 66 Municipalities. Therefore, the analysis of 124 local jurisdictions that is applied in this work is conducted in a more disaggregated level of spatial analysis comparing to an analysis that would be based on the existing first tier of local government jurisdictions today.

Figure 2. Map of Greece highlighting the research area

Source: Authors' elaboration.

3.2. Measures of residential segregation and income inequality

The paper approaches residential segregation in Athens based on three individual dimensions: occupation; education; and living conditions. Income inequality is also calculated. In all cases, the outcomes of the SimAthens model, as described in the previous section, are used to calculate the dimensions of residential segregation at the municipal level for Athens.

Table 1 presents the main individual dimensions used in our analysis. In the first case, we chose to use occupational category as the main variable for measuring residential segregation levels in Athens, using the International Standard Classification of Occupations (ISCO) (ILO, 2012). We classified individuals into three broad occupational groups: (i) top-occup, including managers and professionals (high-skilled white-collar workers); (ii) bottom-occup, including elementary occupations, plant and machine operators and assemblers (low-skilled blue-collar workers); and (iii) middle-occup, including all the other occupations (van Ham et al., 2021). Second, we used the highest level of education attained by each individual as the main variable for capturing residential segregation based on education, following the International Standard Classification of Education (ISCED) (UNESCO, 2012). Three groups are created in this case: (i) top-edu, including persons with at least tertiary education; (ii) middle-edu, including persons with secondary education; and (iii) bottom-edu, encompassing all persons who have attained at most primary education.

To measure segregation based on living conditions, we have used a set of variables that closely relate to housing and neighbourhood deprivation (Atkinson & Marlier, 2010; Guio et al., 2016). In the first case, household deprivation refers to aspects such as leaking roofs, damp

walls/floors/foundations, or rot in window frames or floors, lack of bath or shower in dwelling, lack of indoor flushing toilet for sole use of household, as well as problems with the dwelling being too dark or not having enough light. In addition to this, we have added a set of variables related to the general neighbourhood conditions, including noise from neighbours or from the street, pollution, grime or other problems from the local environment as well as crime, violence or vandalism in the area. All the aforementioned variables are available from the EUSILC dataset which has been used for the analysis. Based on these, we were able to construct three discrete groups: (i) top-living that includes persons living in households with no lack of any of the identified variables; (ii) middle-living that refers to persons living in households lacking a maximum of 2 out of the 7 identified elements; and (iii) bottom-living that refers to persons living in households lacking more than 3 of the 7 identified elements (Guio et al., 2016).

Table 1. Main segregation dimensions for calculating dissimilarity indexes for Athens

Residential Segregation Dimensions			
	Occupation	**Education**	**Living conditions**
Top	Managers and professionals (High-skilled white-collar workers)	Persons with Tertiary education and higher	Persons experiencing no housing deprivation (0 out of 7)
Middle	All intermediate categories	Persons with secondary education	Persons experiencing medium housing deprivation (1 or 2 out of 7)
Bottom	Elementary occupations, plant and machine operators and assemblers (Low-skilled blue-collar workers)	Persons with primary or no education	Persons experiencing increased housing deprivation (3+ out of 7)

Source: van Ham et al., 2021, Guio et al., 2016 and authors' elaboration.

Regarding the residential segregation measurement, we use the Dissimilarity Index (DI) as our main indicator of residential segregation. The Dissimilarity Index can be calculated using (2):

$$DI = \frac{1}{2}\sum_{i=1}^{N}\left|\frac{a_i}{A} - \frac{b_i}{B}\right| \quad (2)$$

Where a_i is the population of group A in the i-th area which is the municipality in our case; A is the total population of group A in the city of Athens; b_i is the population of group B in the i-th municipality; B is the total population of group B in the city of Athens.

The Dissimilarity Index takes values between 0 and 100, indicating the share of a group that needs to relocate in order to ensure a more equal distribution of these groups across space. A value of 0 indicates that there is a common distribution of these two groups across space, whereas 100 shows that the individuals of these groups are located in different municipalities. An increasing (or decreasing) trend of the Dissimilarity Index suggests that there is a gradual increase (or decrease) in segregation between the groups under investigation.

Finally, we use the derived individual income data to calculate the Gini coefficient for measuring annual income inequality in Athens throughout the period under investigation (2004-2019). More specifically, we calculated the Gini index using (1):

$$GINI = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}} \quad (1)$$

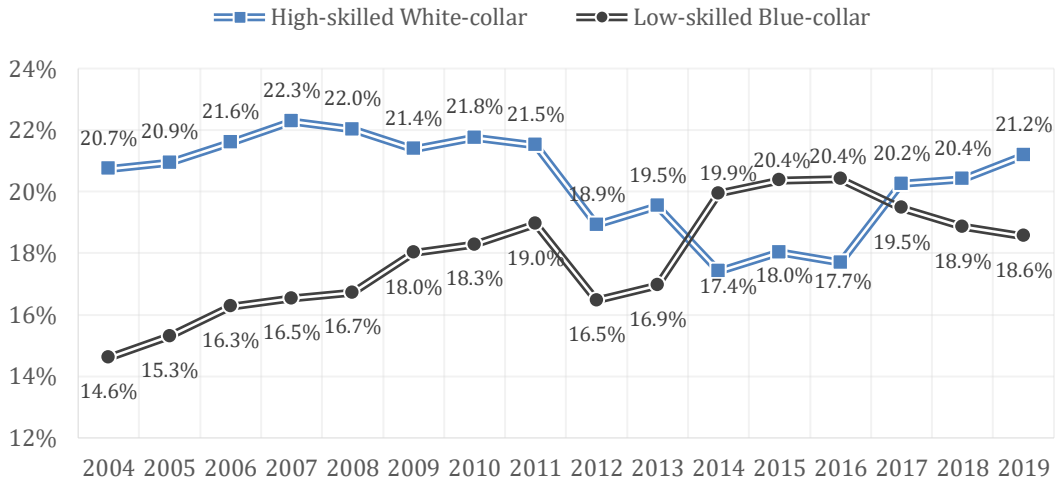
Where x_i and x_j refer to the income of persons i and j respectively, n is the total number of persons in an area and $\bar{x}$ is the average income in this area. The Gini index is a commonly used measurement for income inequality and its values vary between 0 and 100, with 0 representing perfect equality without any income variations between individuals in an area, and 100 representing perfect inequality (Ravallion, 2001). An increase in the Gini coefficient suggests that a higher percentage of income is concentrated in a smaller percentage of persons, resulting in a higher income inequality level.

4. Residential segregation and income inequality in Metropolitan Region of Attica

Athens experienced an interesting shift between high-skilled white-collar and low-skilled blue-collar workers during the period under investigation (Maloutas et al., 2019; Maloutas & Spyrellis, 2019; Maloutas & Botton, 2021). Focusing on the Metropolitan Region of Attica, Fig.2 shows that the city experienced an increasing professionalisation trend until 2008, which gradually shifted, and moved in 2009 and 2014, into a decreasing trend. This decline reversed after 2015, with white-collar worker shares in 2019 having reached their highest levels (21.2%). Regarding the low skilled blue-collar workers, Fig.3 indicates that their share experienced a continuous increase until 2016 with a short decline between 2011 and 2014, and then their share started decreasing after 2016. It is interesting to note that between 2014 and 2016, the share of low-skilled blue-collar workers has been higher (19.9% - 20.4% - 20.4%) compared to the corresponding share of high-skilled white-collar workers (17.4% - 18% - 17.7%).

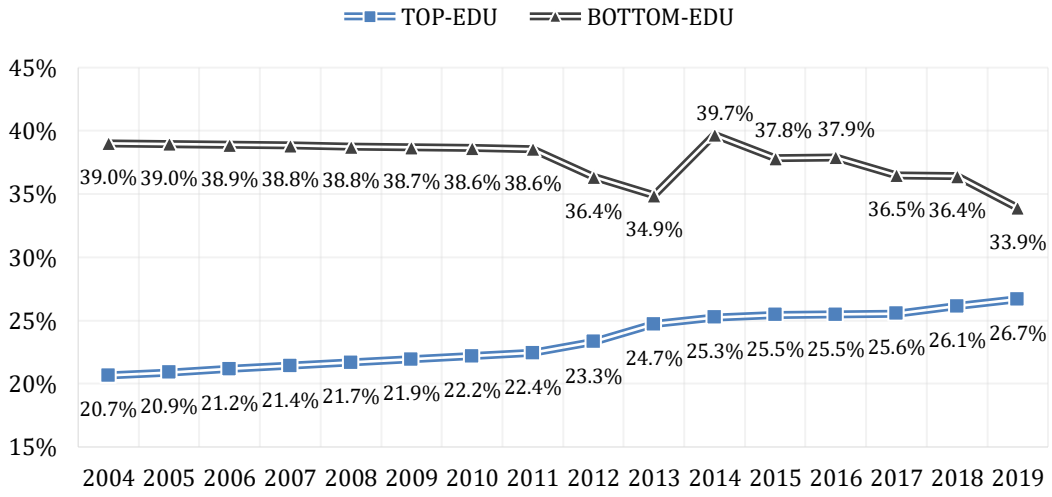
It is important to keep in mind that this study covers the Athens area (124 municipalities) without focusing solely on the metropolitan area of Athens (66 municipalities; see also footnote 1). Therefore, our results may differ when compared to similar analyses for the polarisation and segregation trends focusing on the metropolitan area of Athens (Maloutas & Botton, 2021). Moreover, most of the studies exploring segregation trends in Athens use census data covering the evolution of these trends up until 2011, whilst our approach expands the analysis of this phenomena until 2019, including the recent period of economic crisis.

Figure 3. Evolution of the changing occupational structure in Athens (2004-2019)



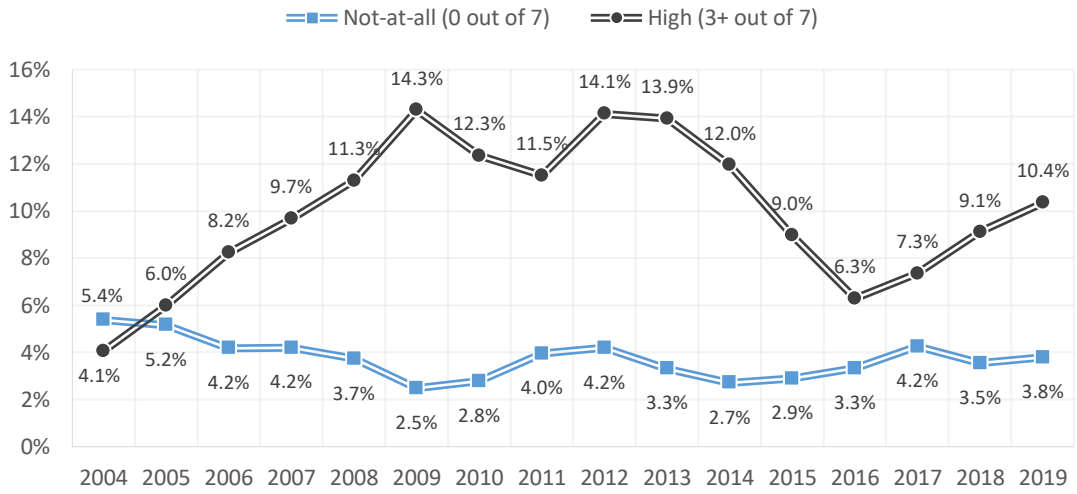
Source: EL.STAT., and authors' calculations.

Figure 4. Evolution of the changing educational structure in Athens (2004-2019).



Source: EL.STAT., and authors' calculations.

Figure 5. Evolution of household living conditions in Athens (2004-2019)



Source: EL.STAT., and authors' calculations.

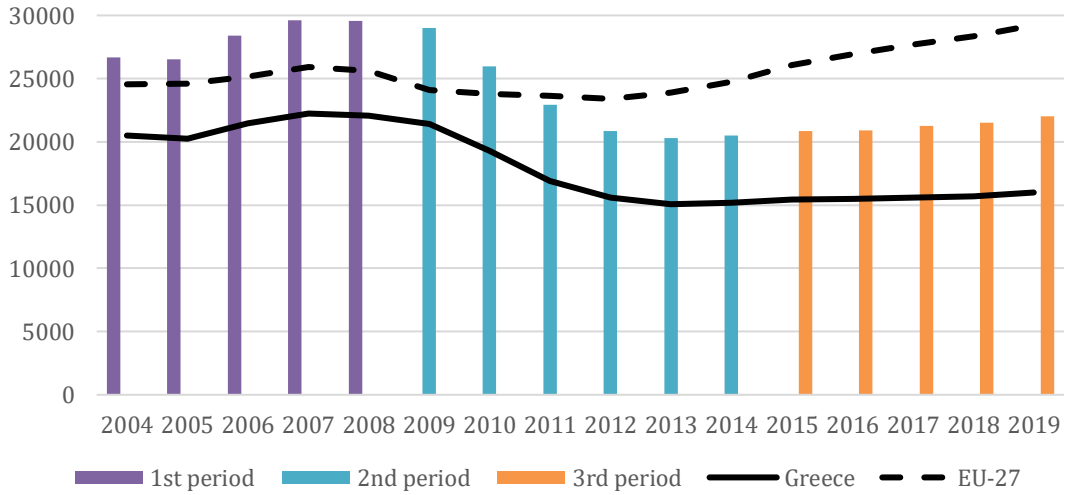
When considering the changing educational structure in Athens, Fig.3 presents the evolution of the top and bottom educational groups. As we can see, there is a gradually increasing trend of persons with tertiary education and higher, starting with 20.7% in 2004 and reaching a peak value of 26.7% in 2019. Fig.4 shows that the share of persons with primary or no education remained stable until 2011 (~38.6%), experiencing a gradual decrease until 2019 when it reached its minimum value (33.9%).

Fig.5 presents the evolution of the living condition levels in Athens for the same period. As we can see, the share of persons with no household deprivation has remained almost stable during the period under investigation, indicating only very small variations. Its highest values refer to the beginning of our time series (5.4% and 5.2% in 2004 and 2005 respectively), whereas its lowest values are seen at the beginning and the end of the economic crisis period (2.5% in 2009 and 2.7% in 2014). At the same time, the evolution of the percentage of persons living in highly deprived households -experiencing lacks in more than 3 out the 7 main variables- also shows a very interesting pattern. It starts with a significant increase during the pre-crisis period (4.1% in 2004 compared to 14.3% in 2009), which is followed by a sharp fall at the beginning of the post-crisis period (2014-2016), but begins increasing again after 2016. During the crisis period (2009-2014), the share of persons living in highly deprived households remained high (~14%).

Fig.3-5 highlighted the main structural changes that Athens has experienced during the overall period we investigated (2004-2019) in relation to the main residential segregation dimensions. Moreover, Fig.6 presents the evolution of Gross Domestic Product per capita at real market prices (RGDPPC) for Athens, compared to Greece and the EU-27 countries, which allows us to get a better picture of the aforementioned structural changes in relation to the broader economic cycle. Based on

these, we can identify three discrete periods: (1) the pre-crisis period (2004-2008) characterised by increasing professionalisation, educational level and deprivation in living conditions; (2) the crisis period (2009-2014) indicating a decline in professionalisation and high levels of deprivation; and (3) the post-crisis period (2015-2019) experiencing a second wave of professionalisation, an initial decrease in deprivation which is reversed after 2016. We will use these three periods to investigate changes in dissimilarity indexes based on the three dimensions for residential segregation.

Figure 6. The evolution of Gross Domestic Product per capita at real market prices (RGDPPC) in Athens, Greece and the EU-27 countries



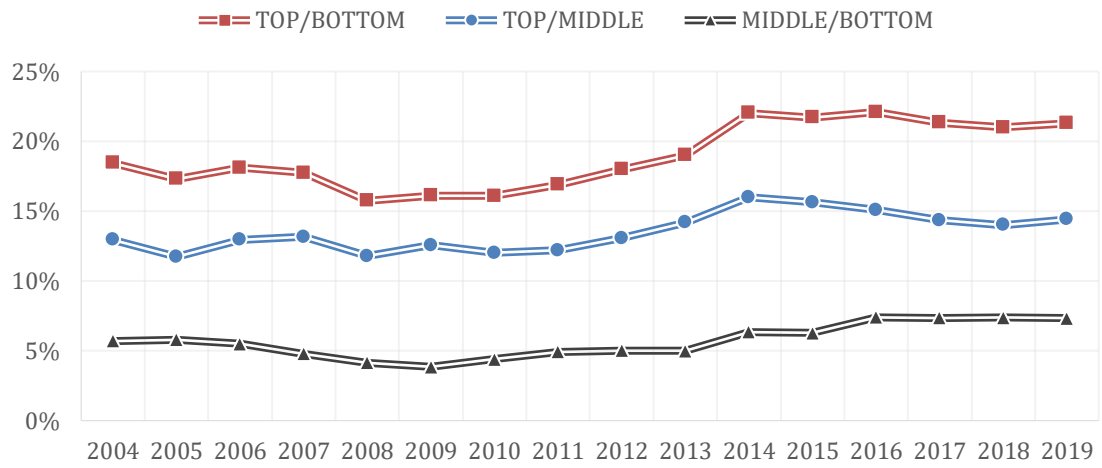
Source: EUROSTAT, nama_10r_2gdp

Starting from the occupational dimension of residential segregation, Fig.7a presents the occupation-related DI evolution throughout the period 2004-2019 for Athens. As we can see, there is an increasing trend in residential segregation for all combinations of DIs. The highest levels of residential segregation based on occupation occur between the top/bottom-occup SES groups, whereas DIs between middle/bottom-occup groups show much lower values. Residential segregation seems to stabilize at its highest values during the post-crisis period (after 2014). Second, when using educational level as the main criterion for residential segregation, Fig.7b shows that there is a diversified pattern between the various SES groups. Residential segregation between the top/bottom-edu groups presents an increasing trend in all three periods, whilst this trend is reversed when looking at the DIs describing the relationship between the top/middle and middle/bottom educational groups. This might be caused because persons belonging to the middle-edu group have been effectively integrated in space, both towards areas previously characterized by low or high educational groups, resulting in lower residential segregation levels. Third, no specific pattern can be recognized in the

case of residential segregation based on the living conditions of individuals. Fig.7c shows that the top/bottom and top/middle DIs indicate similar evolution patterns, but without a continuous trend. Their highest values can be found just before, in the middle and some years after the end of the economic crisis (2007, 2011 and 2017 respectively). Moreover, the results show that the middle/bottom DIs present an overall decreasing trend throughout the period of analysis, with a small 3-year window during the economic crisis period (2009-2012).

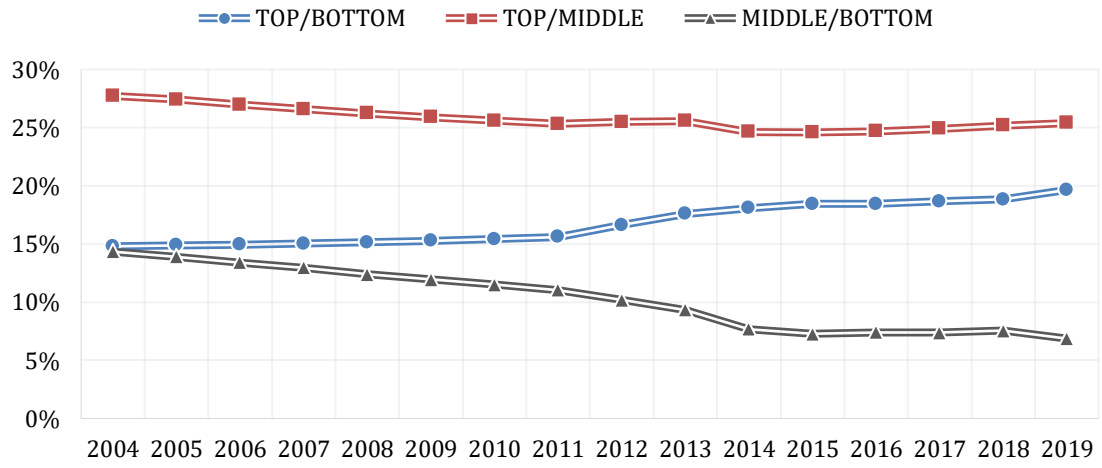
To perform even more direct comparisons between the three periods under investigation, we have calculated the percentage changes of the DIs for all residential segregation dimensions (Fig.8). In all periods, occupational structure has resulted in increased residential segregation between the three SES groups. The highest changes have been recorded between middle and bottom-occup groups during the economic crisis and the post-crises periods, 45% and 38% increase respectively (Fig.8a). When considering changes in residential segregation deriving from changing educational structure, Fig.8b shows that these have resulted in a reduction of spatial fragmentation between the top/middle and the middle/groups. However, it is interesting to note that residential segregation between top- and bottom-educational groups has risen in all three periods. Taking a closer look at the results referring to the living condition dimension, we can see that there is a convergence trend between the middle and bottom-living groups, where DI has declined, whereas the opposite applies when comparing spatial locations of top and middle-living groups (Fig .8c). Even though residential segregation between the top and bottom-living groups dropped during the pre-crisis period, a significant increase took place in the following period, resulting in an overall increase of 10% between 2004 and 2019.

Figure 7a: Occupation-related DI evolution in Athens (2004-2019).



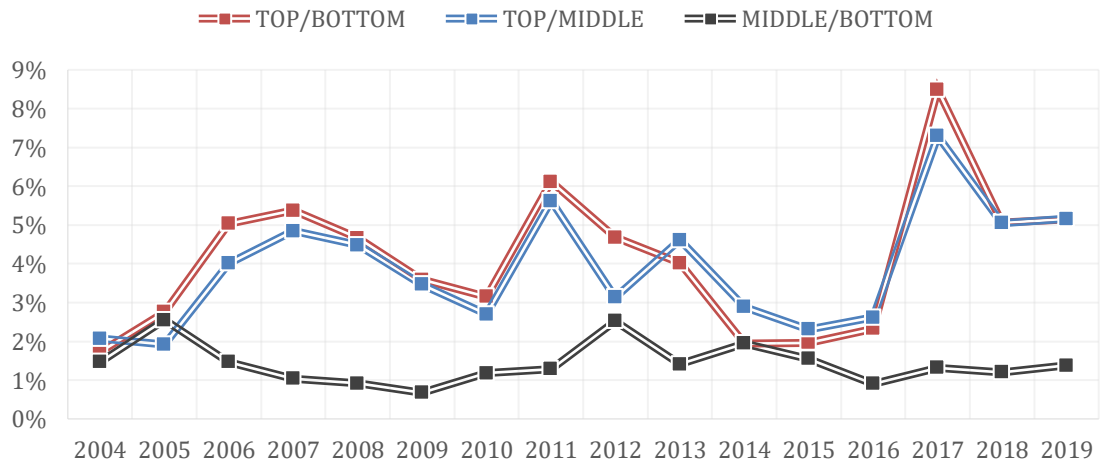
Source: EL.STAT. and authors' calculations

Figure 7b: Education-related DI evolution in Athens (2004-2019).



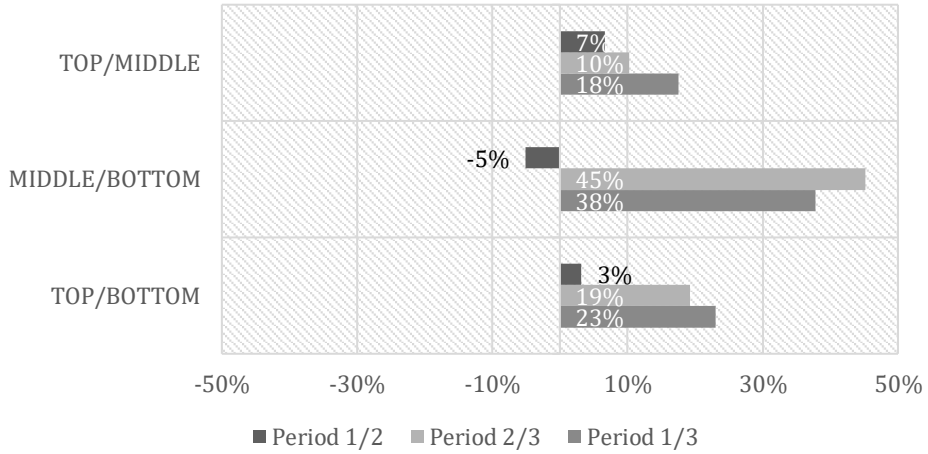
Source: EL.STAT. and authors' calculations

Figure 7c: Living conditions-related DI evolution in Athens (2004-2019).



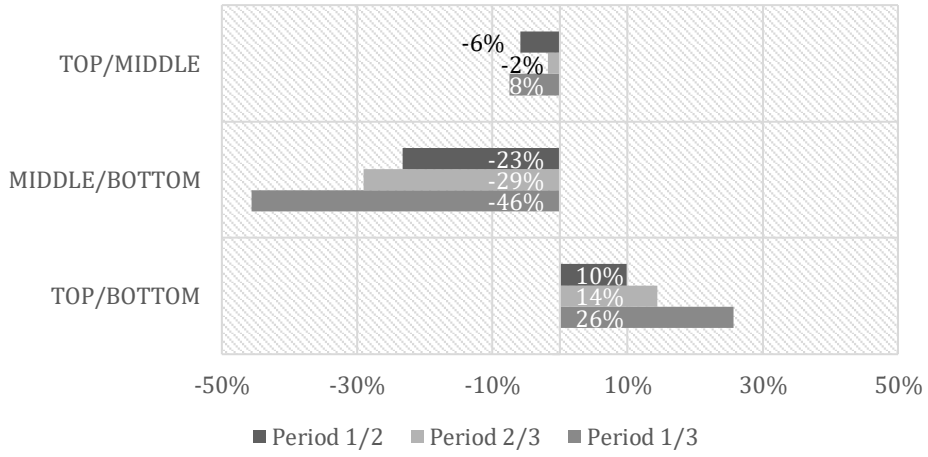
Source: EL.STAT. and authors' calculations

Figure 8a: Occupation-related DI changes (%) in Athens for the three periods.



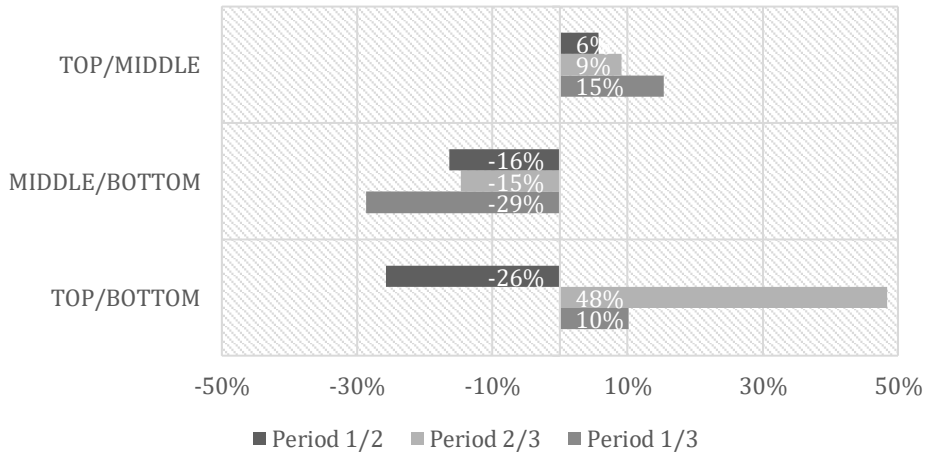
Source: EL.STAT. and authors' calculations

Figure 8b: Education-related DI changes (%) in Athens for the three periods.



Source: EL.STAT. and authors' calculations

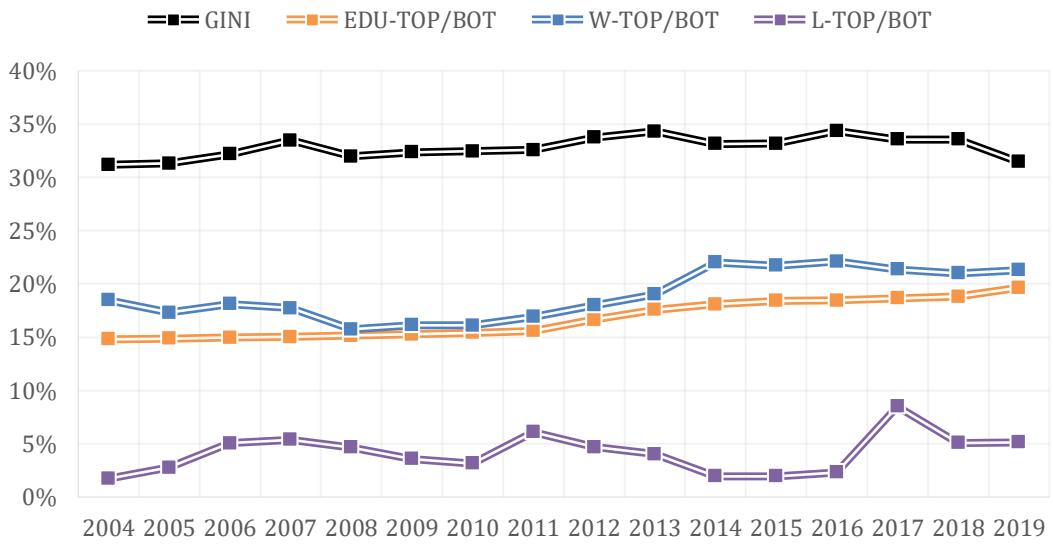
Figure 8c: Living conditions-related DI changes (%) in Athens for the three periods.



Source: EL.STAT. and authors' calculations

After having explored the evolution of segregation in the Athens area, we compare segregation levels with the derived income inequality in this area. Fig.9 depicts the evolution of the Gini coefficient together with the three dimensions of residential segregation, using the DIs for the top/bottom SES-groups in all cases. As we can see, even though the segregation levels experienced a decrease at the beginning of our analysis (2004-2008) and a significant increase during the recession period (2009-2014), income inequality seems to have remained relatively stable between 2004 and 2019 (31.2% and 31.5% respectively at the beginning and the end of this period). Therefore, we cannot identify any similar pattern regarding the evolution of these two measures for the case of Athens using this first descriptive level of analysis.

Figure 9. Gini coefficient and Dissimilarity Index evolution for the metropolitan area of Athens



Source: EL.STAT. and authors' calculations

Moving one step further, we also calculate the correlation between income inequality and the DIs for the top/bottom SES-groups in all cases. Table 2 presents the correlation between all selected variables including their p-values, in order to test for their statistical significance. As we can see, there are no significant correlations between the income inequality measure (GINI) and the DIs used for measuring residential segregation. Again, we cannot identify any statistical relationship between those variables. Thus, we are not able to provide any further insights.

Table 2: Correlation coefficients between income inequality (GINI) and residential segregation dimensions (Dissimilarity indexesw1)

	GINI	DI_EDU-TOP/BOTTOM	DI_W-TOP/BOTTOM	DI_L-TOP/BOTTOM
GINI	1.000			
DI_EDU-TOP/BOTTOM	0.474 (0.064)	1.000		
DI_W-TOP/BOTTOM	0.423 (0.103)	0.880 (0.000)	1.000	
DI_L-TOP/BOTTOM	0.173 (0.523)	0.123 (0.650)	-0.072 (0.792)	1.000

Note: p-values in parentheses

5. Discussion

This paper argues that residential segregation is triggered by various socioeconomic characteristics, including occupation, education and living conditions. In all cases we have seen that residential segregation between top, middle and bottom SES groups increased slightly in the Metropolitan Region of Attica area throughout the period under investigation (2004-2019). However, differences arise between the increasing trends in each case, highlighting the need for further investigation of the effect of each dimension separately. Results suggest that spatial outcomes of occupational and educational variations (top/bottom-occup and top/bottom-edu groups) indicate the highest dissimilarity values, relative to spatial variations in living conditions of SES groups. The lowest DI levels have been recorded in the case of middle/bottom-living SES groups, below 2% in most cases.

This indicates that residential segregation in the case of the Athens area derives primarily from occupational and educational spatial imbalances. This might be due to the structural changes characterized by the professionalization trends that the area experienced over the last few decades (Arapoglou & Sayas, 2009; Maloutas & Spyrellis, 2019; Maloutas & Botton, 2021; Arapoglou et al. 2021). In most cases, we have seen that persons belonging to middle-class SES groups were more effectively integrated into lower SES areas, resulting in a decline of the middle/bottom DIs during the period of our analysis. Middle-class SES groups were also effectively integrated in space in relation to top-SES groups, but only in the case of educational DIs. Residential segregation triggered by occupation and living conditions for these groups indicates an increasing trend in this case. On the contrary, the gap between top- and bottom-SES groups has risen for all dimensions, pointing out the difficulties of bringing those SES groups to live in the same areas.

In the case of occupational-related segregation, industrial clusters may play a significant role for Athens (Karadimitriou et al., 2021). Given that workers tend to choose residential locations based on their distance from work, spatially co-located activities with common characteristics -such as industrial clusters- create a competitive advantage in residential location for their workers (Lin et al., 2017; Giménez-Nadal et al., 2020). At the same time, increased participation in secondary education has been boosted by its mandatory character, and furthermore, the recent economic crisis has triggered a general investment in human capital (Giannakis & Bruggeman, 2017; Panori & Psycharis 2019). Both resulted in a more homogenous educational distribution across space in recent decades due to their effect on income. Finally, the literature reported sharp increases in at-risk-of-poverty rates and material deprivation during the period of economic crisis in Athens for a wide range of socio-economic groups (Panori & Psycharis 2018). This may be a major reason for the significant decrease in residential segregation in the case of living conditions captured by the middle/bottom DIs during the whole period under investigation, whereas changes in residential segregation between top and middle SES groups were very low.

With regard to the relationship between residential segregation and income inequality, evidence suggests that there is no significant correlation between these variables. Previous studies have indicated that there is a relatively steady level of income inequality in Athens (Maloutas & Botton, 2021) which in our case does not seem to be related to residential segregation in the three dimensions explored here. This suggests that for the period under investigation (2004-2019), there is no clear connection between: income inequality deriving from structural path dependence and major social changes taking place in Athens; and its spatial manifestations expressed through residential segregation aspects related to education, work and living conditions. This is in line with the previously identified decreasing trends of social segregation leading to a greater social mix in the spatial dimension (Maloutas & Botton, 2021; Maloutas & Spyrellis, 2019; Maloutas et al., 2019).

It is interesting to note that these findings complement existing studies on the evolution of residential segregation and its relationship with income inequality at an international level. In their study, van Ham et al. (2021) perform an investigation of these interactions at a global level, covering a set of 24 cities across the world. Their findings show that segregation has increased in most cases and is expected to continue rising, which is in line with our findings for Athens. At the same time, their evidence suggests that there is a positive relationship between the level of segregation and the level of inequality. This is not clearly shown in our case for Athens, where we have seen that the increasing trend of residential segregation is accompanied by a relatively stable level of income inequality. This may be an outcome of the structural differences arising between the cases under

investigation, alongside the specificities included in our period of analysis, for example, the 2008 economic crisis.

6. Conclusions and policy recommendations

This study focuses both on exploring the different residential segregation dimensions of Athens for the first time, and on providing a first insight with regards to the relationship between income inequality and residential segregation. It exploits the outcomes of novel methodological approaches related to spatial microsimulation methods that have been previously tested and verified for their validity. It expands the analysis of residential segregation in Athens at the municipal level by measuring it through a living conditions approach, in addition to educational and occupational status.

Results have shown that residential segregation triggered by education indicates the highest values, followed by occupation-related dissimilarity indexes. Living conditions do not seem to trigger high levels of segregation in space. No significant relationships were found for the relationship between residential segregation and income inequality.

The barriers to and the limitations of this research are related mostly to the data generation processes. The SimAthens model was used in this study to overcome the lack of recent official data at a municipal level for Athens, related to occupational structure, educational attainment and living conditions. Even though it performs really well in terms of model fitting (see Panori et al. (2017) for more details), it still refers to simulated data. Evidence coming from the upcoming Greek census for the year 2021 will provide a significant channel for testing our results. However, the census will still lack information on income and living conditions.

There are some interesting policy recommendations that come out from this paper. First, it seems that public policy is necessary in order to ameliorate the increasing inequality in cities and metropolitan areas. Monitoring inequalities is the first critical step in order to enhance our understanding about the evolution, transformations and intensity of this issue. Second, space specific policies do not seem to be sufficient. Increasing interregional and intraregional/interpersonal inequalities require both place-based along with people-centered targeting in order to achieve territorial and social inclusiveness in metropolitan areas. Third, education is a key factor for redressing inequalities. Therefore, educational policy should be regarded as one of the top policy priorities across space and territories. Finally, decreasing inequalities will lessen the degree of resentment/discontent, political turmoil, social unrest in favor of a more cohesive, inclusive and just society, without the bitter feelings of ‘lest behind people’ and ‘left behind areas’ across territories and among citizens (Rodriquez-Pose et al 2023; Pike et al 2023).

Future research could proceed with the examination of the spatial contagion/diffusion of and mortality from Covid-19 across space and within localities in order to explore the interrelation between inequality/segregation on the one hand and diffusion of/ fatality from Covid-19 on the other.

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References

Alvaredo, F. 2018. *The World Inequality Report*. Harvard University Press.

Arapoglou V. Karadimitriou N., Maloutas Th. and Sayas J. 2021. 'Multiple Deprivation in Athens: a legacy of persisting and deepening spatial divisions', GreeSE Paper No. 157, *Hellenic Observatory*, Papers on Greece and Southeast Europe

Arapoglou, V. P., & Sayas, J. 2009. New facets of urban segregation in southern Europe: Gender, migration and social class change in Athens. *European Urban and Regional Studies*, *16*(4), 345-362.

Atkinson, A. B., & Marlier, E. 2010. *Income and living conditions in Europe*. Publications Office of the European Commission.

Azpitarte, F., Alonso-Villar, O., & Hugo-Rojas, F. 2021. Socio-economic groups moving apart: An analysis of recent trends in residential segregation in Australia's main capital cities. *Population, Space and Place*, *27*(3), e2399.

Bencardino, M., & Nesticò, A. 2017. Demographic changes and real estate values. A quantitative model for analyzing the urban-rural linkages. *Sustainability*, *9*(4), 536.

Bernelius, V., & Vilkama, K. 2019. Pupils on the move: School catchment area segregation and residential mobility of urban families. *Urban Studies*, *56*(15), 3095-3116.

Boterman, W. R., Musterd, S., & Manting, D. 2021. Multiple dimensions of residential segregation. The case of the metropolitan area of Amsterdam. *Urban Geography*, *42*(4), 481-506.

Boterman, W. R., Manting, D., & Musterd, S. 2018. Understanding the social geographies of urban regions through the socio-economic and cultural dimension of class. *Population, Space and Place*, *24*(5), e2130.

Checa, J. 2021. Residential Segregation and Living Conditions. An Analysis of Social Inequalities in Catalonia from Four Spatial Perspectives. *Urban Science*, *5*(2), 45.

Costa, R., & de Valk, H. A. 2021. Socio-spatial Disparities in Brussels and its Hinterland. *Urban Socio-Economic Segregation and Income Inequality*, 271.

Domina, T. 2006. Brain drain and brain gain: Rising educational segregation in the United States, 1940–2000. *City & Community*, *5*(4), 387-407.

Farkas, J. Z., Lennert, J., Kovács, A. D., & Kanalas, I. 2017. Impacts and consequences of residential segregation of Roma in urban spaces: Case studies from Hungary. *Urbani Izziv*, *28*(2), 136-148.

Florida, R., & Mellander, C. 2018. The geography of economic segregation. *Social Sciences*, *7*(8), 123.

Giannakis, E., & Bruggeman, A. 2017. Determinants of regional resilience to economic crisis: a European perspective. *European Planning Studies*, *25*(8), 1394-1415.

Giménez-Nadal, J. I., Molina, J. A., & Velilla, J. 2020. Commuting and self-employment in Western Europe. *Journal of Transport Geography*, *88*, 102856.

Graif, C. 2018. Neighborhood diversity and the rise of artist hotspots: Exploring the creative class thesis through a neighborhood change lens. *City & community*, *17*(3), 754-787.

Grzegorczyk, A. 2021. Residential segregation and socio-spatial processes in Marseille. Urban social sustainability challenge. *Bulletin of Geography. Socio-economic Series*, *52*(52), 25-38.

Guio, A. C., Marlier, E., Gordon, D., Fahmy, E., Nandy, S., & Pomati, M. 2016. Improving the measurement of material deprivation at the European Union level. *Journal of European Social Policy*, *26*(3), 219-333.

Hall, T., & Barrett, H. 2018. Housing and residential segregation. In *Urban Geography* (pp. 252-272). Routledge.

Hamnett, C. 2021. The changing social structure of global cities: Professionalisation, proletarianisation or polarisation. *Urban Studies*, *58*(5), 1050-1066.

Hedman, L., & Van Ham, M. 2012. Understanding neighbourhood effects: Selection bias and residential mobility. In *Neighbourhood effects research: New perspectives* (pp. 79-99). Springer, Dordrecht.

Holzer, H. J. 1991. The spatial mismatch hypothesis: What has the evidence shown?. *Urban studies*, *28*(1), 105-122.

International Labour Organization. 2012. *International Standard Classification of Occupations ISCO-08*. International Labour Office, Geneva.

Karadimitriou, N., Maloutas, T., & Arapoglou, V. P. 2021. Multiple Deprivation and Urban Development in Athens, Greece: Spatial Trends and the Role of Access to Housing. *Land*, *10*(3), 290.

Lin, T., Wang, D., & Guan, X. 2017. The built environment, travel attitude, and travel behavior: residential self-selection or residential determination?. *Journal of transport geography*, *65*, 111-122.

Maloutas, T., & Botton, H. 2021. Trends of social polarisation and segregation in Athens (1991–2011). *Social Inclusion*, *9*(2), 117-128.

Maloutas, T., & Spyrellis, S. N. 2019. Segregation trends in Athens: the changing residential distribution of occupational categories during the 2000s. *Regional Studies*.

Maloutas, T., Spyrellis, S. N., & Capella, A. 2019. Residential segregation and educational performance. The case of Athens. *Urban Studies*, *56*(15), 3143-3161.

Maloutas, T., & Fujita, K. 2016. *Residential segregation in comparative perspective: Making sense of contextual diversity*. Routledge.

Marcińczak, S., Tammaru, T., Novák, J., Gentile, M., Kovács, Z., Temelová, J., ... & Szabó, B. 2015. Patterns of socioeconomic segregation in the capital cities of fast-track reforming postsocialist countries. *Annals of the Association of American Geographers*, *105*(1), 183-202.

Manley, D. 2021. Segregation in London: A City of Choices or Structures?. *Urban Socio-Economic Segregation and Income Inequality*, 311.

Mohamed, A. A., & Stanek, D. 2021. Income Inequality, Socio-Economic Status, and Residential Segregation in Greater Cairo: 1986–2006. *Urban Socio-Economic Segregation and Income Inequality*, 49.

Musterd, S., & Ostendorf, W. (Eds.). 2013. *Urban segregation and the welfare state: Inequality and exclusion in western cities*. Routledge.

Musterd, S., Marcińczak, S., Van Ham, M., & Tammaru, T. 2017. Socioeconomic segregation in European capital cities. Increasing separation between poor and rich. *Urban Geography*, *38*(7), 1062-1083.

Nieuwenhuis, J., & Xu, J. 2021. Residential segregation and unequal access to schools. *Social Inclusion*, *9*(2), 142-153.

Oberti, M., & Savina, Y. 2019. Urban and school segregation in Paris: The complexity of contextual effects on school achievement: The case of middle schools in the Paris metropolitan area. *Urban Studies*, *56*(15), 3117-3142.

Oberti, M. 2020. Urban and school segregation in the larger Paris metropolitan area: A complex interweaving with a strong qualitative impact on social cohesion. In *Handbook of Urban Segregation*. Edward Elgar Publishing.

Otero, G., Volker, B., & Rozer, J. 2021. Space and social capital: social contacts in a segregated city. *Urban Geography*, 1-24.

Panori, A., Psycharis, Y., & Ballas, D. 2019. Spatial segregation and migration in the city of Athens: Investigating the evolution of urban socio-spatial immigrant structures. *Population, space and place*, *25*(5), e2209.

Panori, A., Ballas, D., & Psycharis, Y. 2017. SimAthens: A spatial microsimulation approach to the estimation and analysis of small area income distributions and poverty rates in the city of Athens, Greece. *Computers, Environment and Urban Systems*, *63*, 15-25.

Panori, A., & Psycharis, Y. 2019. Exploring the links between education and income inequality at the municipal level in Greece. *Applied Spatial Analysis and Policy*, *12*(1), 101-126.

Panori, A., & Psycharis, Y. 2018. The impact of the economic crisis on poverty and welfare in Athens. *Region et Developpement*, *48*, 23-40.

Panori, A. 2017. A tale of hidden cities. *Region: the journal of ERSA*, *4*(3), 19-38.

Pastak, I. 2021. Gentrification and displacement in postindustrial neighbourhoods of Tallinn. Tartu: University of Tartu Press.

Pike A., Béal V., Cauchi-Duval N., Franklin R., Kinossian N., Lang Th., Leibert T., MacKinnon D., Rousseau M., Royer J, Servillo L., Tomaney J. & Velthuis S. 2023. *'Left behind places': a geographical etymology*, Regional Studies, DOI: 10.1080/00343404.2023.2167972

Piketty, T. 2014. *Capital in the Twenty-First Century*. Cambridge, MA: Belknap.

Quillian, L., & Lagrange, H. 2016. Socioeconomic segregation in large cities in France and the United States. *Demography*, *53*(4), 1051-1084.

Ransom, M. R. 2000. Sampling distributions of segregation indexes. *Sociological Methods & Research*, *28*(4), 454-475.

Ravallion, M. 2001. Growth, inequality and poverty: looking beyond averages. *World development*, *29*(11), 1803-1815.

Reardon, S. F., & Bischoff, K. 2011. Income inequality and income segregation. *American journal of sociology*, *116*(4), 1092-1153.

Rich, P., Candipan, J., & Owens, A. 2021. Segregated neighborhoods, segregated schools: Do charters break a stubborn link?. *Demography*, *58*(2), 471-498.

Rodriguez-Pose A., Terrero-Davila J and Lee N., 2023. Left-behind vs. unequal places: interpersonal inequality, economic decline, and the rise of populism in the US and Europe, *Papers in Evolutionary Economic Geography* (PEEG) 2306, Utrecht University, Department of Human Geography and Spatial Planning, Group Economic GeographySassen, S. (2013). *The global city: New york, london, tokyo*. Princeton University Press.

Silm, S., Ahas, R., & Mooses, V. 2018. Are younger age groups less segregated? Measuring ethnic segregation in activity spaces using mobile phone data. *Journal of Ethnic and Migration Studies*, *44*(11), 1797-1817.

Tammaru, T., Knapp, D., Silm, S., Van Ham, M., & Witlox, F. 2021. Spatial Underpinnings of Social Inequalities: A Vicious Circles of Segregation Approach. *Social Inclusion*, *9*(2), 65-76.

Tammaru, T., Marcin´ Czak, S., Aunap, R., van Ham, M., & Janssen, H. 2020. Relationship between income inequality and residential segregation of socioeconomic groups. *Regional Studies*, *54*(4), 450-461.

Tammaru, T., Marcińczak, S., Aunap, R., & Van Ham, M. 2017. Inequalities and segregation across the long-term economic cycle: An analysis of south and north European cities.

Tammaru, T., Van Ham, M., Marcińczak, S., & Musterd, S. (Eds.). 2015. *Socio-economic segregation in European capital cities: East meets West*. Routledge.

Turok, I., Visagie, J., & Scheba, A. 2021. Social inequality and spatial segregation in Cape Town. *Urban Socio-Economic Segregation and Income Inequality*, 71.

Uesugi, M. 2021. Changes in Occupational Structure and Residential Segregation in Tokyo. *Urban Socio-Economic Segregation and Income Inequality*, 209.

UNESCO Institute for Statistics. 2012. International standard classification of education: ISCED 2011. *Comparative Social Research*, *30*.

van Ham, M., Tammaru, T., Ubarevičienė, R., & Janssen, H. 2021. *Urban socio-economic segregation and income inequality: A global perspective* (p. 523). Springer Nature.

van Ham, M., Uesugi, M., Tammaru, T., Manley, D., & Janssen, H. 2020. *Changing occupational structures and residential segregation in New York*, London and Tokyo. *Nature human behaviour*, *4*(11), 1124-1134.

van Ham, M., & Tammaru, T. 2016. New perspectives on ethnic segregation over time and space. A domains approach. *Urban Geography*, *37*(7), 953-962.

Vergou, P. 2019. Living with difference: Refugee education and school segregation processes in Greece. *Urban Studies*, *56*(15), 3162-3177.

Wessel, T. 2016. Economic segregation in Oslo: polarisation as a contingent outcome. In T. Tammaru, S. Marcińczak, M. van Ham, & S. Musterd (Eds.), *Socioeconomic segregation in European capital cities: East meets West* (pp. 132–155). London: Routledge.

Wrigley, N. 2002. 'Food deserts' in British cities: policy context and research priorities. *Urban studies*, *39*(11), 2029-2040.

Zapatka, K., Mollenkopf, J., & Romalewski, S. 2021. Reordering Occupation, Race, and Place in Metropolitan New York. *Urban Socio-Economic Segregation and Income Inequality*, 407.

Zhang, J. 2004. Growing Silicon Valley on a landscape: an agent-based approach to high-tech industrial clusters. In *Industry and Labor Dynamics: The Agent-Based Computational Economics Approach* (pp. 259-283).