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Tiit Tammaru[a] , Szymon Marcińczak[b] , Raivo Aunap[c], Maarten van Ham[d] and Heleen Janssen[e]

ABSTRACT
This paper provides new insights into the relationships between income inequality and residential segregation between socioeconomic groups by undertaking a comparative study of European urban regions. In Europe, income inequalities are the lowest in North Europe and the highest in South Europe. In many East European countries, a switch from low inequality to high inequality has taken place. The main findings show that changes in the levels of residential segregation between socioeconomic groups correlate to changes in the levels of income inequality found approximately 10 years earlier, that is, with a time lag.

KEYWORDS
income inequality; socioeconomic segregation; comparative urban studies; South Europe; North Europe; East Europe

INTRODUCTION

Residential segregation between socioeconomic groups in European urban regions has grown in the last decades (Fujita & Maloutas, 2016; Kazepov, 2005; Musterd & Ostendorf, 1998; Tammaru, Marcińczak, van Ham, & Musterd, 2016). By residential segregation between socio-economic groups, we understand an uneven distribution of different occupational or income groups across residential neighbourhoods of an urban region. Income inequality, the uneven distribution of income between people and households, is often considered to be the most critical catalyst for residential segregation between socioeconomic groups (Musterd & Ostendorf, 1998; Quillian & Lagrange, 2016). The residential choices of the top

socioeconomic groups who earn the highest incomes often drive the rise of segregation in urban regions, as they have the most freedom to realize their housing and neighbourhood preferences that are either different or not achievable for other income groups (Harvey, 1985; Hulchansky, 2010; Maloutas, 2016). Contrary to the top socio-economic groups, the bottom socioeconomic groups with the lowest incomes usually have less choice of where to live. In most European urban regions there is a substantial overlap between income inequality and inequality along ethnic lines since many immigrant groups are overrepresented in low-skilled jobs and associated low incomes. The marginalization and spatial concentration of lower income people, often with an ethnic minority background, signals deeply entrenched structural inequality on the

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labour and housing markets (Malmberg, Andersson, & Östh, 2013).

A recent European comparative study shows that similar national levels of income inequality correspond with very different residential segregation levels between the top and bottom socioeconomic groups (for the definition of socioeconomic groups, see below) in European urban regions. The relationship between income inequality and socioeconomic segregation is complex and previous studies (e.g., Musterd, Marcińczak, van Ham, & Tammaru, 2017; Tammaru et al., 2016) and we could not document a one-to-one relationship between the two since this relationship hinges on many factors. Since the 1980s, globalization, restructuring of labour markets and the liberalization of the economy have led to rising income inequality across the globe (Piketty, 2013; World Inequality Report, 2018). Previous studies have suggested that it takes time before a rise in income inequality leads to higher levels of socioeconomic segregation, and therefore it is needed to take into account time lags between changes in the two phenomena (Marcińczak et al., 2015; Musterd et al., 2017; Wessel, 2016).

The aim of this paper is to obtain more insight into the relationship between income inequality and socioeconomic segregation. Although a large volume of studies exists on both income inequalities and residential segregation, their connection is poorly studied, especially in a comparative framework. This paper builds on Tammaru et al. (2016) who compared levels of socioeconomic segregation in 13 European urban regions in 2000 and 2010 and found an increase in segregation in all but one studied city. In this paper, we will explicitly study the link between income inequality and socioeconomic segregation by taking into account time lags between changes in income inequality and changes in segregation between the top and bottom socioeconomic groups. In order to do this, we use a longer time frame measuring income inequality since 1980 and socioeconomic segregation from 1990. We focus the analyses on the urban regions located in North, South and East Europe. The North European countries represent the lowest levels of income inequality in Europe; the South European countries represent the highest levels of income inequality in Europe; and many East European counties, including Estonia and Hungary, have switched from the most equal to most unequal countries in Europe (Statistical Office of the European Communities (EUROSTAT), 2018).

We seek answers to three central research questions:

- What are the differences in socioeconomic segregation in North, South and East Europe?
- Is there a relationship between the change of socioeconomic segregation and change in income inequality 10 years earlier?
- Are there variations in the relationship between income inequality and socioeconomic segregation in North, South and East Europe with different income inequality contexts?

We start the study with the analysis of changes in the Gini index of the countries included since 1980. We then analyze the levels of residential segregation between the top and bottom socioeconomic groups measured by the dissimilarity index at the 1990, 2000 and 2010 census rounds. Finally, we will explore the relationship between the Gini index and the dissimilarity index to obtain more insight into the relationship between income inequality and residential segregation between the top and bottom socioeconomic groups.

The empirical evidence comes from the urban regions of Helsinki (Finland), Oslo (Norway), Stockholm (Sweden) in the North of Europe; from Athens (Greece), Madrid (Spain) and Milan (Italy) in the South of Europe; and from Tallinn (Estonia) and Budapest (Hungary) from the East of Europe. Although the data for the empirical study is[simple, on the one hand, arranging a spatially detailed and comparable data set for a broad set of urban regions from different parts of Europe was a significant challenge and a possible explanation for the fact that very few comparative studies exist so far.

MECHANISMS THAT RELATED INCOME INEQUALITY AND SOCIOECONOMIC SEGREGATION

Fundamentally, the most critical cause of residential segregation between socioeconomic groups is income inequality (Nightingale, 2012; Préteceille, 2016). The income inequality started to grow globally during the 1980s (World Inequality Report, 2018; Piketty, 2013; Sachs, 2012) together with rapid globalization, economic liberalization, marketization and deindustrialization that, combined, shape today's social relations and spatial structures (Marcuse & Van Kempen, 2000; Tammaru et al., 2016). The levels of income inequality were already high in South Europe in 1980, with the Gini index ranging between 30 and 35 in Greece, Italy and Spain in 1980 (Figure 1). The Gini indices were the lowest, around 20, in North Europe and in the formerly socialist countries in East Europe in 1980. In international comparison, the Nordic countries were relatively equal societies and wealthy, while the formerly socialist countries in the East of Europe were relatively equal but poor (Kornai, 1992).

Figure 1 shows the trajectories of the Gini index change since 1980. In North European countries, the Gini indices have steadily but slowly increased between 1980 and 2015 and now hover around 25. In South European countries, the Gini indices decreased in the 1980s but climbed back to the levels of 1980 thereafter. In other words, the differences in income inequalities between North and South Europe have decreased during the last few decades, but income inequality is still considerably higher in the South compared with North Europe. In East European countries, the Gini index increased rapidly in the 1990s to the levels of South Europe. Since then the income inequality in Estonia has remained at the South European levels, but have decreased in Hungary. Across the board and irrespective of the initial levels of income inequality, the most rapid
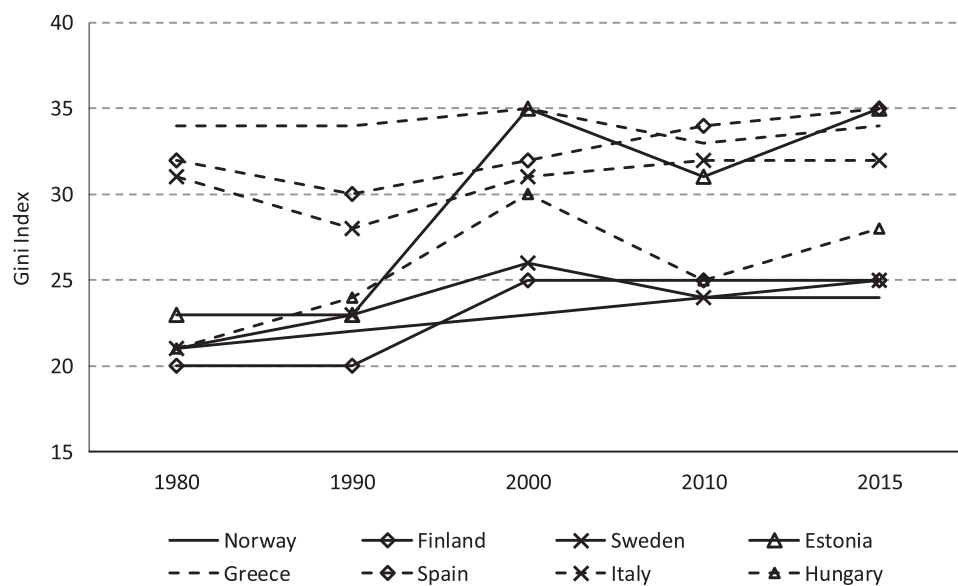
Figure 1. Per capita Gini index in the case study countries, 1980–2015.

changes in the Gini indices took place in the 1990s, allowing it to be analyzed whether this was followed by a rise in residential segregation between top and bottom socioeconomic groups a decade later in the 2000s.

In short, the case study countries provide an interesting mix of income inequality contexts in Europe for analyzing how income inequality may be related to socioeconomic segregation. Although residential segregation between socioeconomic groups is fundamentally related to income inequality, there are several underlying spatial mechanisms that can connect the two: (1) changes in household numbers that affect the distribution of top and bottom socioeconomic groups over the neighbourhoods (population shrinkage or growth, natural change, immigration); (2) residential mobility within the urban regions (people changing residential neighbourhood because their incomes increase or decrease); and (3) the geography of housing and its differentiation, attracting, forcing or constraining the residential mobility of households. The interplay between these factors is complicated, and it takes time, therefore, before a change in the level of income inequality results in changes to the level of residential segregation between the top and bottom socioeconomic groups. Next, the paper will discuss the three mechanisms in greater detail.

Differential change in household numbers across neighbourhoods

Changes in household numbers affect the distribution of top and bottom socioeconomic groups over the neighbourhoods. The extent of immigration is the most important contributory factor here. The transition from a Fordist to a post-Fordist economy and social mobility through education brought along the professionalization of, usually, the native workforce not only in global cities (Sassen, 1991) but also in other major cities (Costa & de Valk, 2018; Marcuse & van Kempen, 2002). The employer demand for low-skilled workers remained as the (low-paid) service sector developed and the number of foreign

immigrants – getting overrepresented in those low-skilled/low-paid jobs – started to grow in both North and South Europe in the 1990s (Castles, de Haas, & Miller, 2013). Although the ethnic dimensions of income inequality have been present in Western Europe with the arrival of guest workers since the 1950s, the professionalization of the native workforce and the residualization of low-skilled jobs to immigrants reinforced the ethnic component of economic inequality (Sassen, 1991), especially in those countries that experienced the second wave of international migrants that started in the 1990s (Castles et al., 2013).

As the incomes of immigrants are, on average, lower compared with natives (EUROSTAT, 2018), their neighbourhood choice is restricted by various constraints such as their lower purchasing power on the housing market, limited number and clustered location of affordable housing in certain parts of the urban region (Arbaci & Malheiros, 2010; Hulchansky, 2010; Malheiros, 2002). The social mix policies that are in place in many European countries have not always been able to stop the growth of levels of residential segregation for various reasons, including ineffective implementation of the policies, failures in policy design or because of conflicting policy aims (Andersson, Bråmå, & Holmqvist, 2010). In this light, Andersson and Kährik (2016) refer to 'eth-class' segregation, a process of double sorting of non-Western immigrants to low-paid jobs and less prestigious neighbourhoods with affordable housing, and natives to high-paid jobs and more prestigious neighbourhoods.

Since residential segregation of ethnic groups is driven by income, by preferences to reside together with co-ethnic, and discrimination, segregation in urban regions with a high share of immigrants can grow more rapidly than income inequality itself (Préteceille, 2016). In short, changes in the population composition of neighbourhoods as a result of foreign immigration and immigrant sorting into low-paid jobs and affordable housing, in particular, are among the primary causes of increased residential segregation between socioeconomic groups (Arbaci, 2007;

Cassiers & Kesteloot, 2012; Musterd et al., 2017). How-ever, other factors may be important as well, for example, the differential fertility of different ethnic and income groups (Finney & Simpson, 2009).

Differential residential mobility of socioeconomic groups

Levels of segregation may also change as a result of the differential residential mobility of top and bottom socioeconomic groups between urban neighbourhoods. In parallel to growing income inequalities, the share of the top socioeconomic groups has increased in many European cities (Butler, Hamnett, & Ramsden, 2008; Hamnett, 1994). Since money buys choice on the housing market (Hulchansky, 2010), the residential mobility of high-income earners affects both the level and the geography of segregation. The increasing demand for higher end housing has led to stark increases of land and housing prices in desirable areas (Préteceille, 2016), and spill over effects to formerly low-income neighbourhoods, pushing up house prices there (Leal & Sorando, 2016). These areas are often adjacent to the already existing high-income neighbourhoods (Préteceille, 2007). However, the most important macro-geographical change in the distribution of socioeconomic groups pertains to the movement of high-income households to the central areas of the city or gentrification of the inner-city neighbourhoods, and the movement of low-income households to the urban margins or suburbanization of poverty (Hochstenbach & Musterd, 2018).

Such changes in the residential relocation of the top and bottom socioeconomic groups will bring along mixing of different income groups in urban neighbourhoods (Marcińczak, Musterd, van Ham, & Tammaru, 2016; Musterd & van Gent, 2016). The segregation paradox refers to this inverse relationship between income inequality and residential segregation: increasing income inequality may bring along lowering levels of residential segregation between socioeconomic groups (Sýkora, 2009). However, ultimately such differential residential mobility patterns of top and bottom socioeconomic groups will lead to higher levels of segregation, for example, when high-income groups colonize the inner city (Leal & Sorando, 2016), and lower income groups retreat to urban fringe, often to the modernist housing estates built in the 1960s–80s (Kavanagh, Lee, & Pryce, 2016; Lelévrier & Melic, 2018; Musterd et al., 2017).

Uneven geography of housing

The geography of housing is an essential factor that attracts, forces or constrains people with different income levels to undertake residential change. Both the extent and speed with which selective residential mobility of top and bottom socioeconomic groups leads to changes in the levels of residential segregation hinges, first, on how uneven is the geography of housing, or how the urban neighbourhoods are planned in terms of their housing mix (Fujita & Maloutas, 2016; Préteceille, 2016). The more spatially clustered the low-cost housing is, the more likely it is that low-income households with little choice

in terms of housing sort into those neighbourhoods, contributing to the rise of the level of residential segregation (Marcińczak et al., 2016). In many North, South and East European urban regions, affordable housing can often be found in the modernist housing estates from the 1960s–70s (Hess et al., 2018). Sweden became world famous with its so-called 'Million Programme': the construction of modernist houses took place on large suburban plots of land, filling them with homogenous housing (Andersson & Bråmå, 2018). Today, the attraction of many of the modernist housing estates has decreased as new and more attractive housing for higher income groups has become available (Andersson & Bråmå, 2018; Wassenberg, 2013).

However, the fortunes of the neighbourhoods may also change with time. According to rent-gap theory (Smith, 1987), the movement of high-income groups to the inner city may be related to the interests of the investor seeking higher profits. Namely, the expected higher profits for attracting high-income earners to low-income neighbourhoods could be attractive for investors, leading to the renovation and new housing construction in such areas. The housing allocation matters, too. If social housing is spatially clustered but available to all income groups, segregation levels change slower. However, what has happened in many European urban regions is a process called the residualization of social housing: market elements have been introduced to better quality social housing, often to balance city budgets (Urban, 2018). The contraction of the social housing segment, in turn, brings along the need to grant access to such housing mainly to the low-income households, driving up levels of segregation, especially when the residualized part of the social housing is spatially concentrated to certain parts of the city (Hochstenbach, 2017; Hoekstra, 2017).

To conclude, although the most important cause for the increase in residential segregation between socioeconomic groups is an increase in income inequality, there is no one-to-one relationship between the two. The spatial mechanisms that link the two relate to changes in the population in urban neighbourhoods, the differential residential mobility of socioeconomic groups and the nature and change of the urban housing stock. These mechanisms take time to show up in changed levels of segregation. Therefore, we will test the hypothesis that income inequality is related to socioeconomic segregation with a time lag in the empirical parts of the paper. By examining the lagged relationship between income inequality and socioeconomic segregation, we hope to document better the relationship between the two compared with previous studies (e.g., Musterd et al., 2017; Tammaru et al., 2016) that measure them at the same time.

DATA AND METHODS

For the analyses of segregation, we used population data for Athens, Budapest, Madrid, Milan, Tallinn, Helsinki, Oslo and Stockholm from the years 1989/1990/1991, 2000/2001 and 2010/2011, or the last three census rounds.

Table 1. Spatial units used in the study.

City	Spatial characteristics used in the study[a]
Athens	About 3.1 million inhabitants lived in the Athens Urban Region in 2011, comprising 58 municipalities on the continental part of the Attiki region. The neighbourhood definition is based on 2.835 urban analysis units (URANU), which are either individual census tracts or groups of census tracts with an average of 1.200 residents. Census tracts are defined by the Greek Statistical Authority (ELSTAT), while the regrouping in URANUs was produced by the project 'Dynamic Management and Mapping of Social Data' conducted by the National Centre for Social Research (EKKE)
Budapest	About 1.7 million people lived in Budapest in 2011. Budapest is divided into 1600 discrete territorial units on the basis of functional and morphological attributes with an average of about 1000 inhabitants
Helsinki	About 1.5 million inhabitants lived in the Helsinki Metropolitan Region in 2011. The definition of neighbourhoods is based on zip code areas. There are 303 zip code areas in Helsinki with an average population size of 4865 people
Madrid	About 6.4 million inhabitants lived in the Madrid Urban Region in 2011. The neighbourhood definition is based on groupings of census tracts since the Census of Population and Housing of 2011 is not representative at a more disaggregated territorial level. Usually, the Spanish Statistical Offices provides data for neighbourhoods with an average size of 20,000. However, it is possible to obtain more detailed data depending on the exact data needed for research. The data asked for the comparative segregation study needed data by International Standard Classification of Occupations (ISCO) which allowed tract groupings with an average of 12,252 residents to be created
Milan	About 1.2 million people lived in the city of Milan and 3.0 million in the province of Milan in 2011. With regard to the spatial units, census tracts, census areas (ACE), districts (*circoscrizioni*), administrative districts (*zone di decentramento*) are available. The average number of people is 219 in census tracts and 14,778 in ACE areas. The findings of trends yield similar results; neighbourhoods units used in the final analysis were census tracts
Oslo	About 1.2 million lived in the Oslo Region in 2011. The neighbourhood definition is based on census tracts with an average population of 594 inhabitants
Stockholm	About 1.2 million people lived in the Stockholm built-up area in 2011. The neighbourhood definition is based on small area market statistics (SAMS) areas. The study includes 655 neighbourhoods with the average size of 2100 people
Tallinn	About 0.5 million inhabitants live in Tallinn urban region. The neighbourhood definition is based on census tracts with an average population of 494 inhabitants

Note: [a]We define cities as a continuous built-up area that forms a common housing market. In other words, the analysis is not confined to administrative city boundaries. However, within this broad definition of a common housing market area, authors of different city reports in *Socioeconomic Segregation in European Capital Cities: East Meets West* (Tammaru, Marcińczak, van Ham, & Musterd, 2016) adapted it to their specific context. We rely on this local expert knowledge in the concrete definition of the city regions.

Sources: The neighbourhood definitions were made for comparative research published in Tammaru et al. (2016). For the more detailed descriptions of the city definitions and spatial units, see Andersson and Kährik (2016), Kovács and Szabó (2016), Leal and Sorando (2016), Maloutas (2016), Petsimeris and Rimoldi (2016), Tammaru et al. (2016), Wessel (2016), and Kauppinen and van Ham (2018).

The data on the levels of segregation were systematically collected and provided by researchers from each urban region under study – partly within the book project 'Socioeconomic Segregation in European Capital Cities' (Tammaru et al., 2016) and partly specifically for the current paper. (We greatly acknowledge the support of all the country teams, without whom this paper would not be possible.) Despite some minor inconsistencies across time and between countries, census years provide the most reliable information on socioeconomic segregation across Europe. Data for Athens, Budapest, Madrid, Milan and Tallinn are based on censuses. Data on Helsinki, Oslo and Stockholm are based on registers. All case study areas are defined as urban regions since residential segregation processes evolve at the level of regional housing markets (cf. Tammaru et al., 2016). The census data used do not include data on income, and the register data used do not include information on occupations.

Although both censuses and registers contain information about education, education is only weakly related to income, while there is a strong correlation between occupation and income (Tammaru et al., 2016). Hence, we measure socioeconomic status using occupational groups in census-based countries and data on income in register-based countries. A note of caution relates to the use of these different variables. An increase in income inequality could in itself increase levels of residential segregation when measured by income. This should not affect segregation measured by using occupational categories, because in this case although professionals earn more and unskilled workers earn less, if all continue to live in the same neighbourhoods, the dissimilarity index does not change. Therefore, rising levels of income inequality might lead to different outcomes in cities where residential segregation is measured by income compared with cities where occupational status is used.

Top and bottom socioeconomic groups are defined as follows. In register-based countries (Finland, Norway, Sweden) we use income quintiles and show levels of segregation between people belonging to the first and fifth

income quintiles. In census-based countries (Estonia, Greece, Hungary, Italy, Spain), we rely on the International Standard Classification of Occupations (ISCO). The ISCO classification refers to those employed at the time of the census. The top socioeconomic group refers to managers and the bottom socioeconomic group to people working in elementary occupations. In Milan, the definitions differ somewhat from the ISCO, but we still use the highest and lowest ranked occupational categories in the analysis. From here on, we will use the terms top and bottom socioeconomic groups or high- and low-income groups interchangeably to denote them. To facilitate comparison, we rely on the data aggregated to small spatial units as available in the data (Table 1).

Comparative research faces several challenges when it comes to the data on spatial units. Different countries have different data policies when it comes to releasing data for small geographical areas and use different aggregation levels of either socio-economic groups or spatial units/neighbourhoods. These obstacles are beyond our control, but we aimed at a high level of comparability and analytical detail within these two sets of limits. We are aware that our research materials on the levels of segregation have some limitations stemming from the different classification of socioeconomic groups and different spatial units. We acknowledge that the levels of segregation might not be directly comparable between the case study urban regions, not to the same extent as in one national context since every country has its own methods for delineating the spatial units of the city. Nonetheless, even if the cross-city comparisons might be moderately biased, we believe that the data at hand are adequate to investigate the relationship between income inequality and segregation in each case city, which is the primary focus of this paper (Table 1).

Although new methods have been proposed to investigate both the global and local patterns of segregation (Johnston, Poulsen, & Forrest, 2010; Marcińczak et al., 2015), this study uses the easily comparable dissimilarity index. The analyses consist of two steps. The first analyzes changes in the levels of socioeconomic segregation between 1989/1990/1991, 2000/2001 and 2010/2011 by means of the dissimilarity index (D) between the top and bottom socioeconomic groups – depending on the data availability, the groups are represented either by the top and bottom quintiles or by managers and people employed in elementary occupations. The D-values range from 0 to 100, indicating the percentage of the group members that need to move to another neighbourhood in order to achieve an even residential distribution to the reference group. Marcińczak et al. (2015) suggest that D-values < 20 can be interpreted as low and those > 40 can be interpreted as high levels of segregation. To add detail to the D-values, we will also analyze differences in the geography of socioeconomic segregation by drawing stylized maps that portray the main patterns of the spatial distribution of the top and bottom socioeconomic groups in each of the case study city.

In the second step, we depict the changes of D-values and Gini indices (G) graphically to understand the

relationship between social inequalities and socioeconomic segregation better. We use the standard Gini index available at EUROSTAT (2018) that characterizes how much the country's wealth distribution deviates from an entirely equal wealth distribution and, when expressed in percentages, 0 indicating complete equality and 100 indicating complete inequality. The Gini index is not available at the city level and is measured at the national level. However, the focus of this study is on the change of income inequality and change in residential segregation that diminishes the problem somewhat. In general, the level of income inequality in capital cities' urban regions is (significantly) higher than the national average (City Monitor, 2018), which means that the increase of income inequality may be higher in the case study urban regions than revealed in the Gini index. We keep this problem in mind when interpreting the findings. Since (1) the rise of social inequalities comes first, followed by the rise in socioeconomic segregation, and (2) the level of segregation can be measured only for census years, we use lagged G-values for 10 years in the analysis. In other words, we match the D-values from 1989/1990/1991, 2000/2001 and 2010/2011 with the G-values from 1980, 1990 and 2000.

RESULTS

Changes in segregation in each case study city

Levels of socioeconomic segregation are not directly comparable between the case study cities because of somewhat different spatial units and different definitions of socioeconomic group. Figure 2 summarizes changes in socioeconomic segregation in each city. In 1989/1990/1991, D-values ranged between 22 and 27 in northern and eastern European urban regions and between 39 and 46 in southern European urban regions. The speed and trajectory of change in segregation varies significantly between cities and between the three census rounds. Tallinn and Stockholm show a very rapid rise in residential segregation between the top and bottom socioeconomic groups between the last two census rounds, and segregation has also risen in Helsinki and Oslo in that period. In Athens, Budapest, Madrid and Milan, the levels of segregation decreased between 1990/1991 and 2000/2001 census rounds, followed by an increase between 2000/2001 and 2010/2011 census rounds. In Madrid, the rise in segregation was especially rapid between 2000/2001 and 2010/2011 with a considerably higher D-value in 2010/2011 than in 1990/1991. In Athens and Milan, the 2010/2011 D-value is lower than in 1990/1991.

The segregation levels in the study urban regions are the outcome of very different and city-specific residential geographies of the top and bottom socioeconomic groups. Figure 3 summarizes the residential segregation patterns comparably. Milan has a historically evolved concentric form that reflects the land-covered canal system that still characterizes today's spatial structure and the socioeconomic geography of the city (Petsimeris & Rimoldi, 2016; Petsimeris, 2018). The high-income groups are overrepresented in the city centre (Figure 3), most notably in the *centro storico*
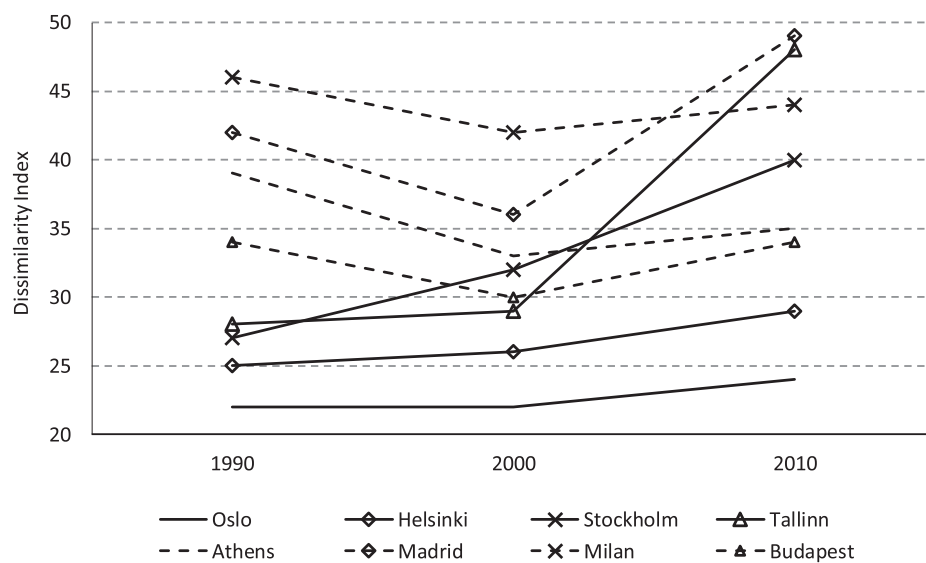
Figure 2. Dissimilarity index in the case study countries, 1990–2010.

neighbourhoods of Brera, Sempione and Guastalla. This housing-wise heterogeneous zone was the main playground for the post-Second World War rapid processes of urbaniz-ation and industrialization of Milan, providing shelter to the working class and immigrants.

The high-income groups are also overrepresented in the city centre of Madrid, in districts such as Centro, Salamanca and Tetuán (Figure 3). The growth of young professionals has been rapid in those historical central neighbourhoods that are undergoing regeneration and gentrification, and the process resembles the colonization of most central parts of the city by high-income groups (Leal & Sorando, 2016). Likewise, wealthier suburban low-density neighbour-hoods are mostly located in the north-western parts of the metropolitan Madrid. The southern parts became subject to large-scale urbanization and industrialization similar to Milan in the post-war decades in Madrid, now housing the working class and immigrants.

Like Madrid, Athens lacks concentric urban zones that characterize Milan, but the wealthier neighbourhoods such as Chalandri, Amarousio and Kifista are located outside the urban core, in the eastern part of the urban region (Figure 3). As the share of high-income groups has expanded, they have spilled over into adjacent areas, rather than contributing to the gentrification of the city centre (Maloutas, 2016). The city centre of Athens is socioeco-nomically mixed, partly because of vertical rather than horizon-tal patterns of socioeconomic segregation, a phenomenon that developed fully with the increase of foreign immigrants in the 1990s who often found a residence in the downgrad-ing private rental sector (Maloutas & Karadimitriou, 2001). Especially, the densification of housing in the central parts of the city has left apartments on the lower floors suffering from both a lack of light and noise. Hence, lower income groups tend to live on the lower floors while higher income groups tend to live on the upper floors (Maloutas, 2016). The wes-tern part of the urban region has a working-class nature, where lower income groups are overrepresented.

Similarly to Athens, the higher income groups are over-represented in the suburban neighbourhoods in Stock-holm, mainly in the north-east parts of the urban region such as Danderyd, Lidingö and Täby (Figure 3). The dis-tinctive feature of Stockholm relates to the large spatially clustered modernist housing estates built between 1950 and 1970 (Andersson & Kährik, 2016). Substantial immi-gration to Sweden has occurred since the 1990s, and immi-grants are strongly overrepresented in those housing estates mainly located in the south-western part of the suburban ring, contributing to the increase of segregation. Neither Helsinki nor Oslo have such vast and spatially concentrated modernist housing estates (Figure 3). However, immi-grants and lower income groups do cluster to this housing segment located on the eastern side of the metro areas in those two urban regions (Kauppinen, 2017; Wessel, 2016). Higher income groups are overrepresented in wes-tern parts in Oslo, expanding from around the royal castle, and on the southern waterfront areas in Helsinki.

The physical geography of the case study urban regions, in combination with the planning zoning regulations implemented in the 19th century, primarily determine the spatial pattern of residential segregation of Budapest by allowing a natural residential separation between the top and bottom socioeconomic groups (Kovács & Szabó, 2016). The first is actively clustered to the villa areas on the Buda hills on the western bank of the River Danube, while the latter are clustered on the eastern side of the river in Pest (Figure 3). The clustering of bottom socioeco-nomic groups is the highest in south-eastern industrial parts of Budapest where sizeable modernist housing estates, as well as the less attractive detached housing areas, can be found. The inner city of Budapest is socioeco-nomically mixed as a result of the gentrification processes that has occurred in the last decades.

In Tallinn, the top socioeconomic groups are increasingly overrepresented along the coastline of the urban region, both in the city centre as well as in the lower density suburban areas
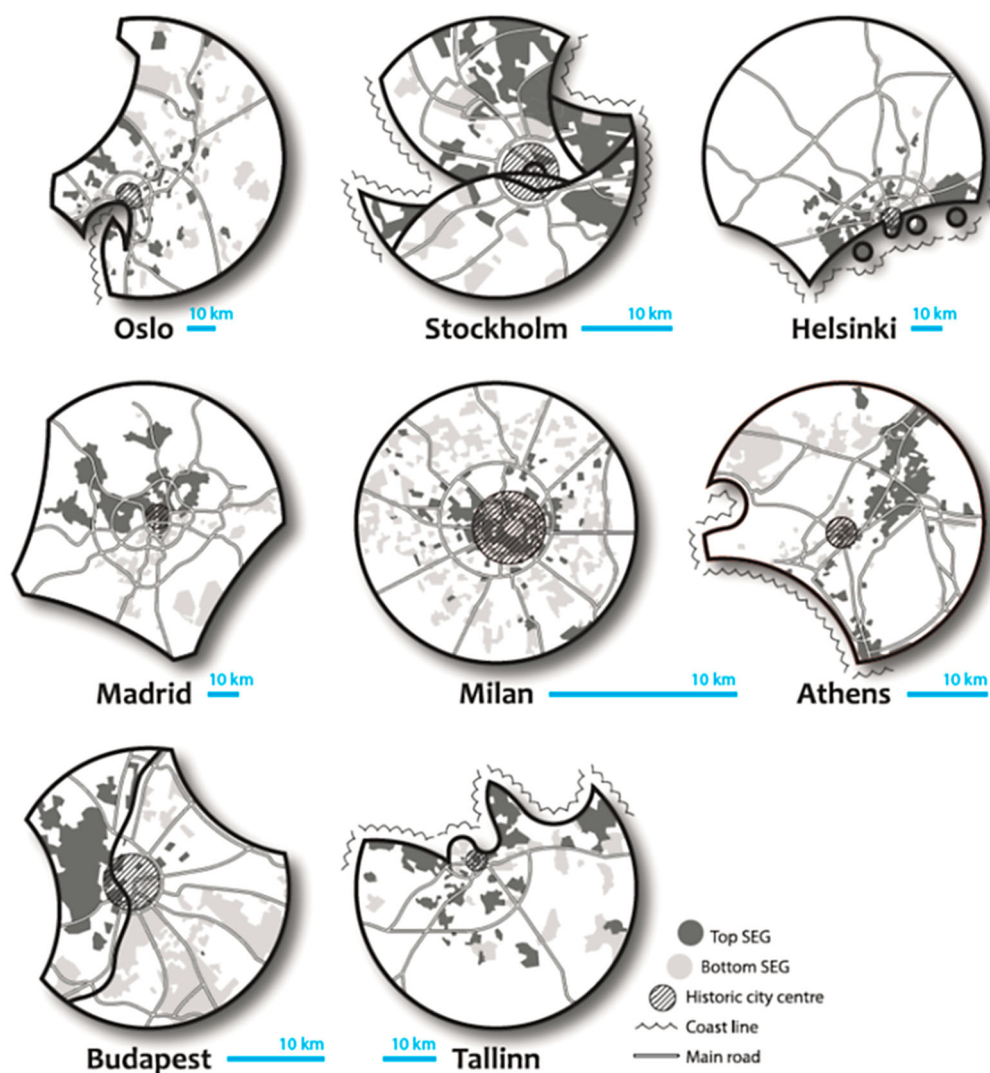
Figure 3. Geographies of the top and bottom socioeconomic groups.

of Kakumäe-Tiskre in the east and Pirita-Viimsi in the west. Gentrifying inner-city neighbourhoods are more socioeconomically mixed, with increasing concentrations of high-income groups in some of them. Tallinn's modernist housing areas are spatially concentrated to certain locations around the inner city, and the bottom socioeconomic groups are increasingly clustering in them as in Stockholm.

Relationship between income inequality and socioeconomic segregation

Since changes in socioeconomic segregation tend to follow changes in income inequalities with a time lag, we will next compare the dissimilarity index (D) with a 10-year lagged Gini index (G). The most general impression we obtain from Figure 4 is a strong correlation between the changes of the two indices. In Oslo, the time lag is the greatest, or 20 years. In other urban regions of northern Europe, an increase in income inequality has led to an increase in socioeconomic segregation 10 years later. In Stockholm, the growth of D is more rapid than the growth of G ten years earlier. This might be due to many reasons: the rise of income inequality in Stockholm may have been more

significant than the national average in Sweden, and both differential housing marketization and immigration of non-Western immigrants have been unusually extensive in Sweden (Andersson & Kährik, 2016; Marcińczak et al., 2016). In all three urban regions, immigrants tend to be overrepresented in the modernist housing estates where the most affordable housing is available.

Income inequality and socioeconomic segregation also correlate in South European urban regions, but the trajectory of change is different than in North European urban regions. In Madrid and Milan, income inequality decreased in the 1980s, and we find that the residential segregation between the top and bottom socioeconomic groups also decreased a decade later, in the 1990s. Residential segregation also decreased in Athens in the 1990s, although the level of income inequality stayed almost unchanged in the 1980s. In addition to income inequalities, the social mobility of a young generation without spatial mobility – very common in South Europe as children stay with their parents for 10 years longer than in North Europe (EURO-STAT, 2018) – can explain the reduction in the levels of residential segregation (cf. Maloutas, 2016). Similar
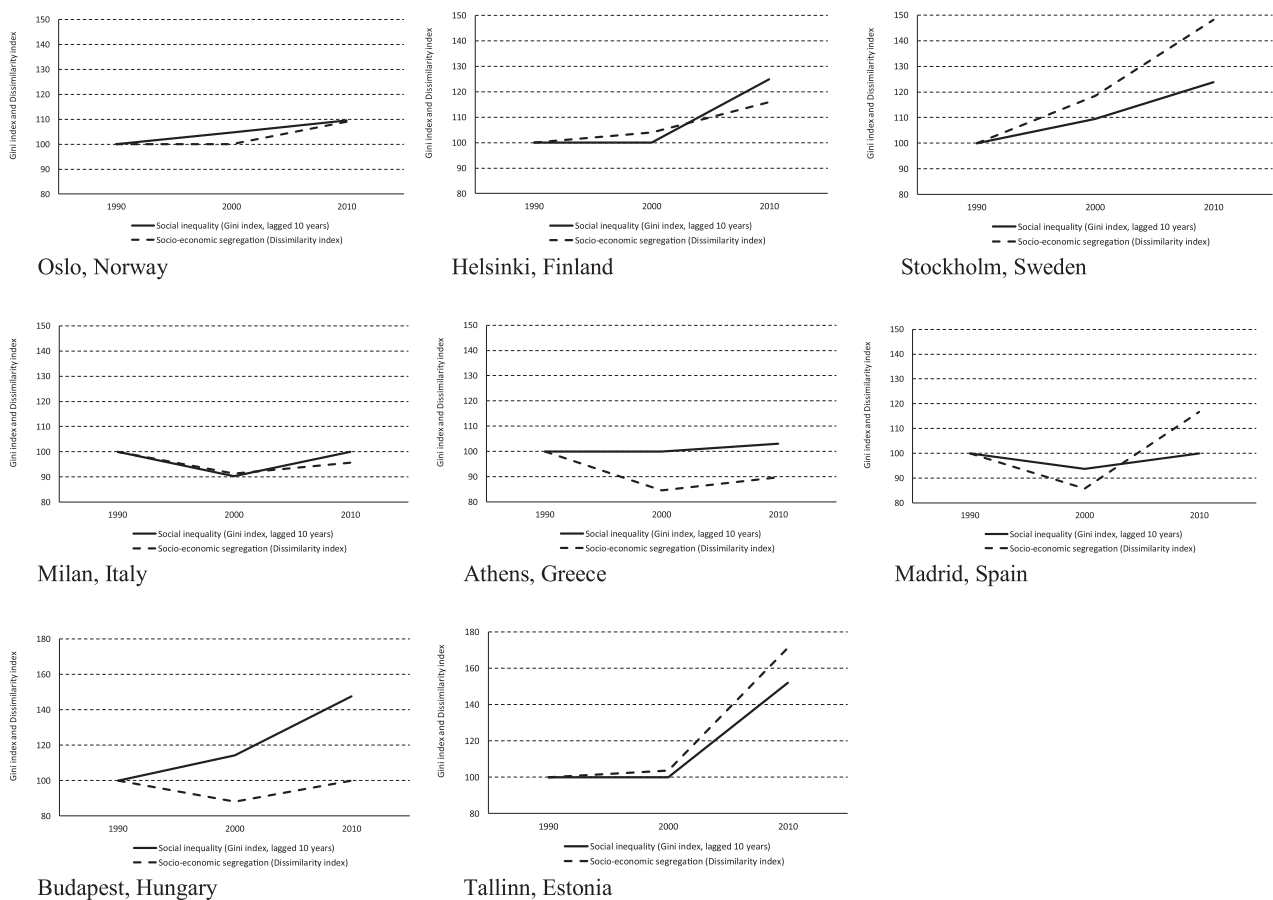
Figure 4. Changes in the dissimilarity index 10 years after changes in the Gini index.

tendencies can be found in Milan a decade later. In Madrid, the situation is the opposite and, like in Stockholm, residential segregation between the top and bottom socioeconomic groups grew more rapidly in the 2000s than would have been predicted from the rise of income inequality a decade earlier. A plausible explanation pertains to the boom of new housing construction in the 2000s (property bubble) that created spatially uneven opportunities for higher income groups to improve their living conditions (cf. Gutiérrez & Domènech, 2017; Leal & Sorando, 2016). And like with Stockholm, it may be that the income inequalities in the Madrid urban region may have grown more rapidly than the national average.

In Budapest, changes in income inequality and socioeconomic segregation are similar to Athens, but more pronounced. The differential marketization of housing in Hungary started already in the 1980s (Kovács & Szabó, 2016), earlier than in Estonia, but it led to lower levels of socioeconomic segregation in the 1990s. Thus, Budapest is an excellent example of the segregation paradox: as the top socioeconomic groups move to low-income neighbourhoods, socioeconomic segregation lowered at times of growing income inequalities. Lowering of segregation was a temporary phenomenon, and the continued growth of income inequalities in the 1990s led to higher levels of segregation in Budapest a decade later, in the 2000s. In Tallinn, the combination of post-Soviet economic growth and very low levels of socioeconomic segregation in the

1980s increased income inequalities rapidly in the 1990s, followed by a rapid increase in socioeconomic segregation 10 years later, in the 2000s.

DISCUSSION AND CONCLUSIONS

This paper has focused on the relationship between income inequality and residential segregation between the top and bottom socioeconomic groups by undertaking a comparative study of North, South and East European urban regions. Socioeconomic segregation hinges strongly on income inequality (Nightingale, 2012; Préteceille, 2016). However, there is no one-to-one relationship between the two since several mechanisms, such as changes in the population in urban neighbourhoods, the differential residential mobility of socioeconomic groups, and the nature and change of the urban housing stock, may intervene. Therefore, we expected to find a time lag between changes in income inequality and residential segregation between socioeconomic groups. This hypothesis was confirmed and we find that there is roughly a decade between change in income inequality and change in residential segregation between the top and bottom socioeconomic groups.

The relationship between income inequality and residential segregation holds both when income inequalities increase and decrease. In North Europe, income inequalities increased, although moderately, from 1980 to 2000, followed by an increase in residential segregation between the

top and bottom socioeconomic groups in the 1990s and 2000s. In South Europe, income inequalities decreased in the 1980s and increased in the 1990s, followed by a decrease in residential segregation in the 1990s and an increase in the 2000s. In East Europe, income inequalities increased in both the 1980s and 1990s, but residential segregation decreased in Budapest in the 1990s, followed by an increase in the 2000s. The temporary lowering of segregation levels in Budapest, when income inequalities increased, can be explained by using the segregation paradox: as high-income households move into low-income neighbourhoods, temporary mixing of socioeconomic groups may occur (Kovács & Szabó, 2016). Although similar mechanisms operate in other cities, we did not detect clear evidence of this paradox elsewhere. However, the same phenomenon was previously observed in Amsterdam (Musterd & van Gent, 2016). Despite differences in the time lags in different cities, the main finding still holds: a change in residential segregation follows a change in income inequality.

If residential segregation is seen as a problem, it is thus important to deal with income inequalities. The case study countries come from Europe where, in a global perspective, income inequalities are low with Gini indices ≤ 35. According to the World Bank's (2018) estimates on income inequality, in most countries outside Europe, Gini indices are > 35. Levels of residential segregation are also higher in most other world regions compared with Europe (Tammaru et al., 2016). Hence, our finding that residential segregation between the top and bottom socioeconomic groups can decrease as income inequalities decrease is most likely of broader relevance for large urban regions around the globe. However, we also need similar analyses for urban regions outside Europe and getting comparable data is a challenge. Since most countries outside Europe are census based rather than register based, occupational groups could be used as a measure of socioeconomic status. Furthermore, since occupational status reflects in housing outcomes, novel geographical information system (GIS)-based methodologies for studying segregation between socioeconomic groups (Fung-Loy & Van Rompaey, 2017) may serve as a useful proxy and help one to understand better the relations between income inequality and residential segregation also in the developing countries of the Global South.

For the relationship between changes in income inequality and residential segregation between the top and bottom socioeconomic groups to emerge, at least one of the three intervening mechanisms – changes in the population in urban neighbourhoods, the differential residential mobility of socioeconomic groups, and the nature and change of the urban housing stock – needs to operate. In this study, we established that change in income inequality affects residential segregation, but the data at hand do not one allow to examine the role of different mechanisms. Hence, future comparative studies are needed that focus on the underlying mechanisms, which in turn would also help one to understand the determinants of the time lag between change in income inequality and change in residential segregation. For example, in Budapest

and Oslo, the time lag was greater than in other case study urban regions. In Budapest, segregation paradox is a plausible explanation. In Oslo, Wessel (2016, p. 152) explains that it may take years before redistributive changes affect the structure of market signals, and when these signals are firmly expressed, there is still a time lag before residential replacements and accretions appear.

To conclude: this paper documents that change in income inequality and change in residential segregation between socioeconomic are related to each other once we introduce a time lag into the analysis: income inequalities change first, followed by a change in residential segregation. This is a significant advancement compared with previous studies (e.g., Musterd et al., 2017; Tammaru et al., 2016) that were not able to document that the two processes are related. However, more studies are needed in different country and urban region contexts, also keeping an eye on the mechanisms that relate change in income inequality to change in residential segregation between socioeconomic groups.

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