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THE ECONOMIC URBAN DIVIDE: A DETAILED STUDY OF INCOME INEQUALITY AND SEGREGATION IN DUTCH URBAN AREAS (2011–2022)

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ABSTRACT

Research on segregation and economic inequality is often limited to major capitals and conurbations, neglecting smaller cities. This oversight can lead to public policies based on insights that may not be universally applicable. Leveraging geo-coded register data, this study addresses this problem in the case of the Netherlands by computing income inequality and residential segregation annually in all urban areas from 2011 to 2022. Contrary to most literature, this paper shows that inequality and segregation have remained stable or decreased in most cases. In addition, when looking at how income is distributed among social segments, how segregated they are, and at which geographical scale segregation occurs, we find significant variation between urban areas. More unequal urban areas also tend to be more segregated, but patterns vary, and the same segregation levels can coexist with diverse inequality metrics. Four groups of urban areas are identified through a cluster analysis.

Key words: Inequality; segregation; income; spatial analysis; longitudinal; microdata; the Netherlands

INTRODUCTION

Urban economic segregation is seemingly on the rise. In the last decades, many cities in several countries recorded an increasing divergence in the places of residence of the poor and rich (Musterd *et al.* 2017; Van Ham *et al.* 2021b). This pattern parallels the expanding levels of economic inequality (OECD 2015a). Intuitively, growing economic disparities affect urban space as more affluent neighbourhoods see rising incomes while poorer ones lag behind. In addition, increasing inequality widens the gap in purchasing power between the top and bottom earners so that the former may outbid the latter in seeking the most desirable locations within a city (Watson 2009). Additionally, segregation can further exacerbate inequality by amplifying the differences in opportunities available to individuals depending on the neighbourhood in which they reside (Galster & Sharkey 2017).

Despite these general trends, the extent of inequality and segregation is highly variable across cities. For example, Madrid is twice as segregated as Oslo (Tammaru *et al.* 2020). Research has also shown that levels of inequality and segregation may differ greatly within the same country, such as in the US (Glaeser *et al.* 2009) or China (Monkkonen *et al.* 2017). This not only suggests that it is important to consider the particularities of urban areas

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(e.g. their housing policy; Musterd *et al.* 2017), but also implies that generalisations about the evolution of inequality and segregation cannot be made unless a wide variety of cities, including 'ordinary cities' (Robinson 2013), are analysed. Otherwise, local policies against inequality and segregation designed for various kinds of places would be informed by insights that are only applicable to a handful of global metropolises despite evidence that 'more is different' for urban societies and economies (Cottineau *et al.* 2019; Sarkar 2019).

Worryingly, exhaustive estimations of inequality and segregation that compare different types of urban areas are scarce. With exceptions (see Glaeser *et al.* 2009; Boulant *et al.* 2016), estimations of economic inequality are usually not disaggregated by city and are only provided at the national level. Meanwhile, studies of segregation frequently focus on capital or prominent cities (e.g. Scarpa 2015; Musterd *et al.* 2017; Van Ham *et al.* 2021b). In the Netherlands, much of the research has focused on Amsterdam (Musterd *et al.* 2017; Sleutjes *et al.* 2019; Van Ham *et al.* 2021b; Haandrikman *et al.* 2023). Although some research broadens the scope to other cities in the country (Comandon & Veneri 2021; Veneri *et al.* 2021), it remains limited to a handful of large urban areas. Other cities are often overlooked.

Much of the previous research is also marked by the unavailability of longitudinal and geo-coded microdata. Analyses often rely on decennial census data (Musterd *et al.* 2017; Veneri *et al.* 2021) and sometimes employ occupation and education as imperfect proxies for income (Marcińczak *et al.* 2015; Maloutas 2016; Martínez & Mina 2021). This has hampered the separate study of the segregation of the poor and the rich, despite evidence suggesting that they are distinct phenomena (Reardon & Bischoff 2011). Similarly, it also makes it difficult to assess whether inequality results from the concentration of resources in a small economic elite or is driven by a disproportionate impoverishment of the lower-income segments compared with the rest of the population (Voitchovsky 2005; Cingano 2014). Furthermore, the lack of individual-level and geo-coded income data impedes analyses of segregation at different geographical scales within cities. This matters because cities may appear distinctively segregated depending on the scale used (Fowler 2015). More generally, all these research gaps are worrisome given the considerable threat that inequality and segregation pose to social cohesion (Pettigrew & Tropp 2006; Firebaugh & Schroeder 2009; Bailey *et al.* 2013).

This article offers a detailed examination of economic inequality and segregation for all urban areas of the Netherlands, that is, beyond the most populated cities. Taking advantage of annual, longitudinal and geo-coded microdata, we also consider the different spatial and social patterns that inequality and segregation may take by using indicators suited to the study of ordinal variables and disaggregated to the income percentile unit. The heterogeneity of results is synthesised through a principal component analysis (PCA), which also allows us to classify Dutch urban areas into four groups. In doing so, this paper addresses the following research questions for the 2011–2022 period in all urban areas of the Netherlands:

1. How have the levels of income inequality and income segregation evolved in the Netherlands over the past ten years?
2. How do inequality and segregation differ across the income distribution?
3. On what geographical scale does income segregation occur in different cities?
4. How do cities differ in terms of the patterns and evolution of income inequality and segregation over the past decade?

The next section provides an overview of the existing research on income inequality and urban segregation. The methodology section then describes the data employed in this article and the computations performed to estimate inequality and segregation. In the results section, the findings are presented for the set of Dutch urban areas under study. In the discussion, the results are interpreted, and the conclusion summarises the main implications of the study.

LITERATURE REVIEW

Recent research shows a general increase in the levels of urban economic segregation

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in several parts of the world (Bischoff & Reardon 2014; Scarpa 2015; Musterd *et al.* 2017; Monkkonen *et al.* 2018; Feitosa *et al.* 2021; Fernández-De-Córdova *et al.* 2021; Van Ham *et al.* 2021b). This trend has coincided with the rise of within-country economic inequality due to globalisation, de-regulation combined with de-unionisation, and reduced taxation (Piketty 2014; OECD 2015a). Coupled with the seemingly ubiquitous rise of urban divisions of an economic nature, these circumstances have led to the development of the so-called global segregation thesis (Van Ham *et al.* 2021a). This thesis states that rising residential segregation is fuelled by the general intensification of income and wealth disparities, which then create disparities in purchasing power (Watson 2009; Reardon & Bischoff 2011; Mutgan & Mijs 2023). Additionally, differences in economic growth across geographic areas, shaped by their distinct socio-demographic characteristics (see, *mutatis mutandis*, Krugman 1991), can drive economic segregation without requiring income-based residential sorting. In turn, segregation may also increase inequality, as it amplifies the differences in opportunities among the rich and the poor depending on their neighbourhood of residence (Galster & Sharkey 2017). Consistent with the notion that it is the rich who have more economic resources to act upon their preferences while lower-income groups have more limited choices, evidence from many countries indicates that affluent individuals tend to live more segregated than the poor (Comandon *et al.* 2018).

Notwithstanding these common pattens, the extent of urban economic segregation differs substantially across and within countries (Comandon & Veneri 2021), and income inequality varies across cities (Glaeser *et al.* 2009). Contrary to expectations, increasing income disparities do not always lead to more segregation, as in the case of cities in Egypt (Mohamed & Stanek 2021), Japan (Fujita & Hill 2016), South Africa (Turok *et al.* 2021) or Spain (Domínguez *et al.* 2016). Part of the paradox of observing increased levels of income disparities coupled with decreased urban segregation, or vice versa, may be related to the strong role of city and country contextual factors. For instance, in the 1980s, Amsterdam, Rotterdam and The Hague showed stable degrees of segregation despite growing economic inequality due to the existence of social housing open to middle-income households (Murie & Musterd 1996). In addition, rising inequality may initially produce so-called 'segregation paradoxes' (Sýkora 2007, 2009): as gentrification and suburbanisation bring high-income households into traditionally low-income areas, some extent of social mixing that reduces segregation in the short term may be recorded. Consequently, urban segregation has been theorised in a multi-factor model (Musterd *et al.* 2017), in which economic inequality is the 'sine qua non [but not sufficient] condition for the development of spatial divisions' (Musterd *et al.* 2017, p. 1066).

An additional layer of complexity in understanding urban segregation involves the role of spatial scale. As already discussed by Openshaw (1984), the modifiable areal unit problem (MAUP) implies that any kind of result based on geographic analyses can vary depending on the scale used. As highlighted by Lee *et al.* (2008), the determinants of micro-scale segregation may differ significantly from those of macro-scale segregation. For instance, economic inequality may have a stronger link to micro-scale segregation than to macro-scale segregation if people make residential decisions focusing only on small areas around their home. Similarly, the scale of segregation may vary depending on the polycentric nature of many cities (Kloosterman & Musterd 2001). For example, housing is not necessarily cheaper far away from the city centre if there are different nodes of employment around the city (Osland & Pryce 2012), which entails that micro-scale segregation is more possible in these instances. Fowler (2015) also highlights how spatial measurements address issues like the modifiable areal unit problem (MAUP) but also capture the inherently multi-scale nature of segregation, where no single scale can be considered definitive. It is then not a surprise that recent literature has paid attention to the importance of geographic scale using multiscalar approaches to study segregation

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(Malmberg *et al.* 2014; Jones *et al.* 2015; Östh *et al.* 2015; Costa & De Valk 2018).

More generally, there is relevant research in the field of segregation for the case of the Netherlands. Among other factors, a relatively robust welfare state has been linked to reduced inequality and lower segregation (Musterd & Ostendorf 2012, 2013). Indeed, income inequality in the country, as measured by the Gini coefficient, is among the lowest in the world (25.7 in 2023 according to the World Bank,[1] compared with 29.6 in the EU[2] and 60 at the world level[3]). As mentioned before, local features such as the large share of social housing have been proposed to play a role in alleviating segregation (Musterd & Van Gent 2015; Musterd *et al.* 2017). However, social housing has also been described as undergoing a process of 'residualisation' (Van Gent & Hochstenbach 2020), that is, becoming a service catering exclusively to low-income households in concentrated areas of the city. Analyses of the evolution of segregation in the last years present mixed results: whereas some studies identify a decreasing level of segregation in the Netherlands (Musterd *et al.* 2017), others record an increase at least regarding certain socioeconomic groups (Sleutjes *et al.* 2019). Much of the research has focused on the case of Amsterdam, where economic segregation appears to be low compared with other European cities (Musterd *et al.* 2017; Haandrikman *et al.* 2023) and with ethnic segregation (Sleutjes *et al.* 2019). Simultaneously, the city shows signs of gentrification and touristification, which decrease social mixing in the long term (Boterman & van Gent 2023). In the wider country, economic disparities seem to be on the rise, yet income inequality remains more stable than wealth inequality (Van Bavel & Frankema 2017). However, to the best of our knowledge, a full review of economic inequality and segregation for all urban areas of the Netherlands has not been performed yet. Therefore, much of the specific social and spatial patterns of the income distribution in most Dutch cities remain unexplored.

METHODOLOGY

We estimated the levels of economic inequality and segregation in the Netherlands from 2011 to 2022. Relying on microdata from Statistics Netherlands, we employed longitudinal, annual, and geo-coded information at the 500-by-500-m level for every household registered in the country during the study period. Consequently, this research leverages administrative register data of an almost fully comprehensive nature with no sample bias, providing a more granular data set that complements studies relying on census information (Lobmayer & Wilkinson 2002; Watson 2009; Reardon & Bischoff 2011; Rodríguez 2016).

With this study, we aim to address two main issues in inequality and segregation studies. On the one hand, we analysed all urban areas of the country and not only the most prominent and globally interconnected cities. For comparative purposes, we studied all 35 urban areas identified by the 2015 Functional Urban Areas classification (Dijkstra *et al.* 2019, see Figure 1). Urban areas, not municipalities, were considered because they better match the functional definition of cities regarding transportation, housing, and labour markets

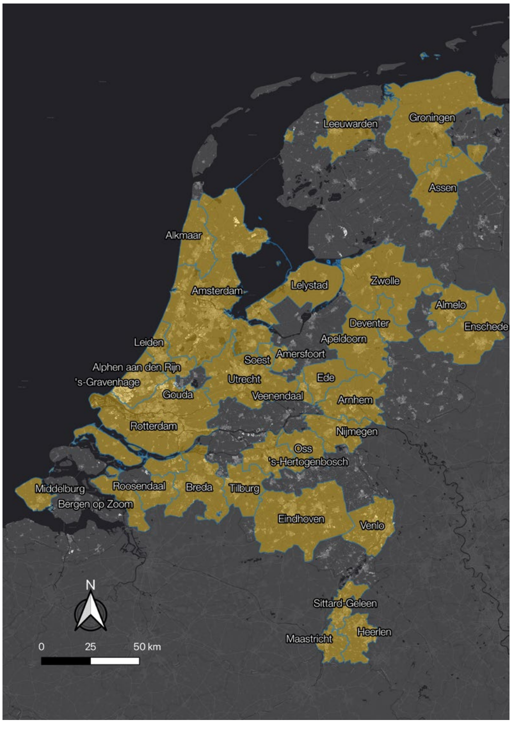

Figure 1. *Urban areas in the Netherlands. Source: Authors' elaboration from OECD's (2024) data and ESRI'S (2024) base map.*

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(Galland *et al.* 2020). All indicators produced for this paper are published in an online database (San Millán 2025), which is open for consultation for further research.

On the other hand, we aim to combine three key elements of segregation measurement which were problematized in previous research: time, space, and the continuous nature of economic segregation variables. As a result, we adopted an axiomatic approach to select our measure of segregation, meaning that it had to fulfil a set of fundamental requirements. First, we chose an indicator with a consistent meaning across time. This enabled us to study a period of 12 years rather than a static moment, providing insights into the evolution of inequality and segregation. This is especially relevant given that inequality seems to produce segregation with a lag (Tammaru *et al.* 2020). Second, we employed a spatial indicator of segregation (Yao et al. 2018). Lastly, we noted that much of the measurements in the field (e.g. Index of Dissimilarity) were initially created to measure racial segregation and, thus, rely on categorical/qualitative divisions of the population (Duncan & Duncan 1955). The sought indicator needed then to be specifically designed for the study of segregation along a continuous variable such as income (see Figure 12 in the Supporting Information Appendix for a comparison between indicators). The indicator that fulfilled all these axioms is Reardon and Bischoff's (2011) spatial version of the Rank-Ordered Information Theory Index (ROITI).

The ROITI is an entropy-based measure of economic segregation. In the context of segregation, entropy refers to the degree of disorder or unevenness in the distribution of different income groups across space. A higher entropy value indicates a more even distribution, while a lower entropy reflects greater clustering or segregation of income groups. Essentially, entropy measures the "uncertainty" about where different income groups are located within a city, which provides a mathematically robust understanding of segregation (Mora & Ruiz-Castillo 2011). In our study, we adapted the ROITI methodology (Reardon & Bischoff 2011) to microdata covering the entire population of the Netherlands.

The ROITI methodology involves a three-step process. Initially, we divide the population of each urban area into percentile groups based on income. We then calculate successive segregation values by dividing the population at each percentile p into two parts: one below percentile p and one above it. For example, Figure 2 presents a case where $p=1$, which shows the segregation between the bottom 1 per cent and the rest of the population in Amsterdam. The calculated segregation value is 0.096, which is higher than the segregation between the bottom 50 per cent and the top 50 per cent (point B: 0.04), but lower than the segregation between the top 1 per cent and the rest (point C: 0.14). Additionally, Figure 3 presents a set of maps illustrating the spatial distribution of the three income groups used

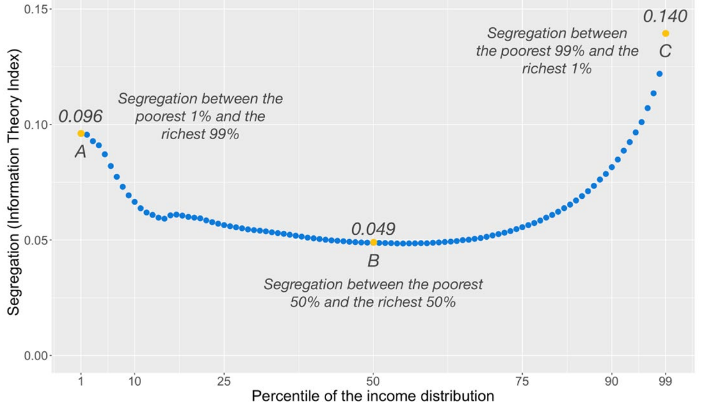

Figure 2. *Information Theory Index at every percentile of Amsterdam in 2022. Source: Authors' elaboration based on CBS microdata.*

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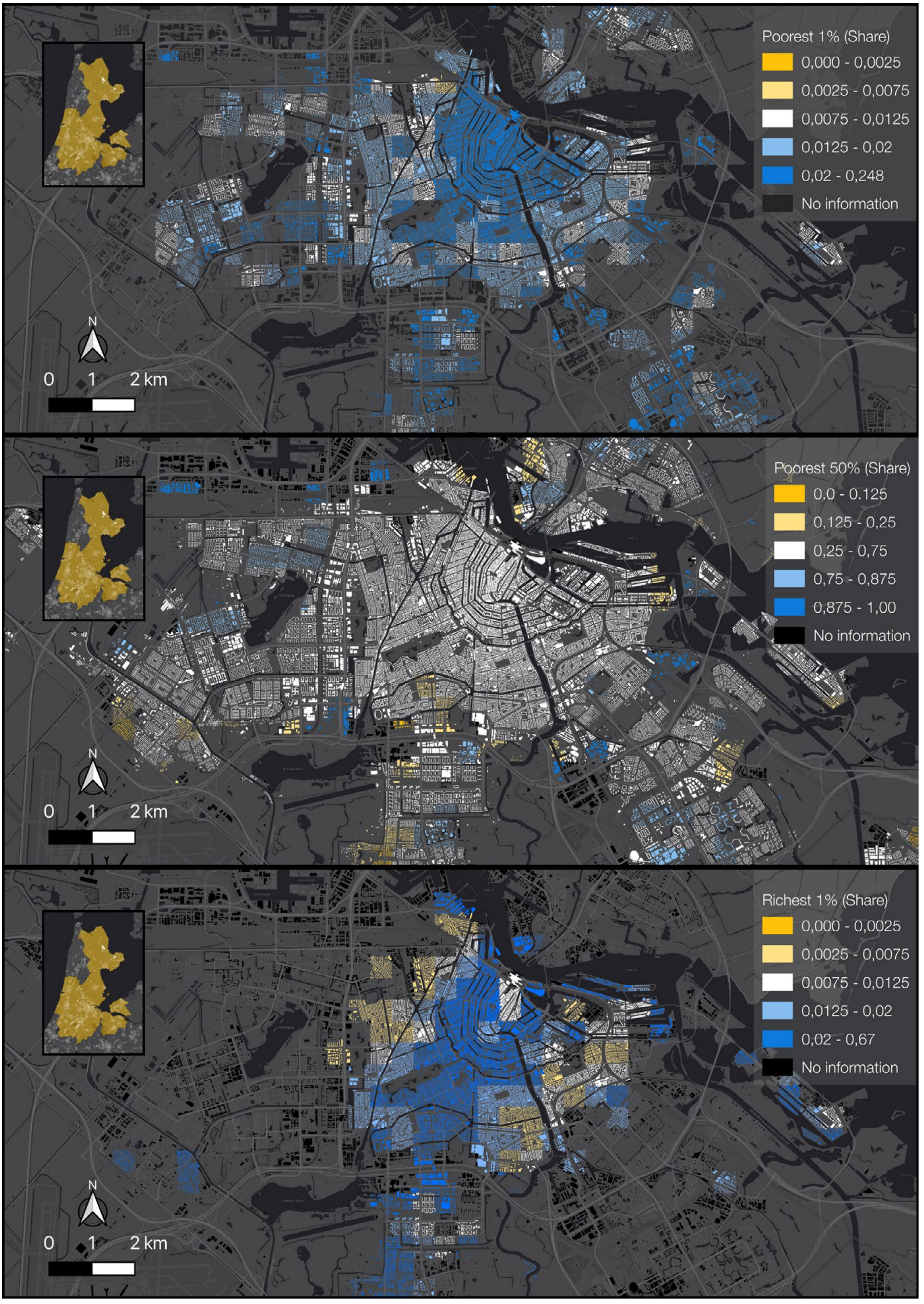

Figure 3. *Spatial distribution of selected income groups in Amsterdam. Source: Authors' elaboration based on CBS microdata and ESRI'S (2024) base map.*

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in the example above, focusing on the central area of Amsterdam. The maps highlight the varying concentrations of the poorest 1 per cent, the poorest 50 per cent, and the richest 1 per cent, revealing that both the richest and poorest segments are notably present in certain central neighbourhoods. This spatial pattern reflects the necessity of analysing income percentiles independently to capture the complexity of economic segregation.This method yields 99 segregation values for each urban area and year. All these estimations form a segregation profile that indicates how separated different income segments (from the very poor to the very rich) are from the rest of the population. This profile of segregation tends to resemble a U shape, with higher segregation at the extremes of the income distribution. Each of these values was obtained by calculating the Information Theory Index (ITI; Theil & Finizza 1971) comparing the population composition of each 500 m x 500 m grid with the overall population composition of the urban area based on the following formula:

$$H(p) = 1 - \sum_{j} \frac{t_j E_j(p)}{TE(p)}$$

where, H is the value of the ITI, p is the percentile used to divide the population into two segments, j is a 500 m × 500 m grid, t_j is the population of grid j, E_j is the entropy of grid j, T is the total population of the urban area, E is the entropy of the entire urban area.

The entropy (E) of each segregation value is determined by the percentile at which the calculation is performed according to the method of Theil and Finizza (1971) and the following formula:

$$E(p) = p\log_2 \frac{1}{p} + (1 - p)\log_2 \frac{1}{1 - p}$$

To construct a general urban index of segregation (the actual ROITI), the 99 ITI values of the profile (Figure 2) were combined using a weight that decreases from the centre of the distribution (50th percentile) to the extremes. This produced the comprehensive value of overall segregation in each urban area, namely, the ROITIs. The ROITI indicator (H^R) was given by the formula:

$$H^R = 2\ln(2) \int_0^1 E(p)\, H(p)\, dp$$

Recent calls in the literature (Lee *et al.* 2015) suggest attaching a measure of uncertainty (i.e. confidence intervals) to segregation indices, mainly when the moment in which information is recorded varies, and when individuals interpret and answer census questions in incoherent ways. This is not the case here as our data comes from tax records: there is no variation in the temporal sampling (tax agencies record personal incomes earned for every day of a year) and income is not self-reported. Likewise, and unlike Reardon and Bischoff (2011), we performed no imputation of values because the register microdata already provided detailed information for the entire population/income distribution.

As noted above, we estimated segregation for every urban area with a spatial measurement. Thus, we created a Kernel decay density distribution around each grid cell used as a local environment employing the *seg* R package (Hong, O'Sullivan & Sadahiro 2014). We calculated four different local environments around every grid cell with four different radiuses following Reardon and Bischoff (2011): 500 m, 1000 m, 2000 m, and 4000 m (see Figure 4), together with a computation with a 0 m radius (i.e. non-spatial) as a robustness check. These four estimations enabled us to obtain different indicators for macro- and micro-scale segregation (Reardon *et al.* 2008). With our smoothing approach, segregation tends to naturally decrease by increasing the radius, as the likelihood of including people with dissimilar incomes in the neighbourhood population rises. This entails that part of the estimated micro-scale segregation may be driven by macro-scale segregation (see Manley *et al.* 2019). However, our method enables the construction of bespoke areas for every grid cell, which better addresses the MAUP problem and can handle segregation based on continuous variables. Moreover, this method permits the calculation of a ratio between segregation estimated at 4000 m and 500 m, which serves as

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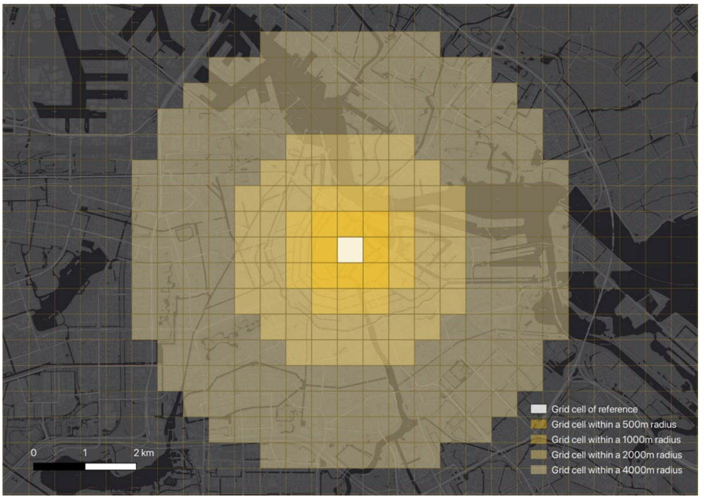

Figure 4. *Sets of radii around the grid cell of reference. Source: Authors' elaboration based on ESRI'S (2024) base map.*

an indicator of the geographic scale of segregation, even if the specific intensity of segregation at a particular scale may reflect patterns from larger scales. Higher values of this ratio mean that segregation occurs at a larger scale (e.g. centre-periphery or large zones), while lower values imply small-scale patterns (e.g. mosaic pattern or small enclaves).

In contrast with the calculation of economic segregation, the computation of income inequality could be simpler as indicators for this element have been historically designed for such a purpose. In short, we computed the aggregate income inequality for every urban area using the Gini coefficient as implemented in the *DescTools* package for R (Andri *et al.* 2023). We also estimated that much of the existing economic disparities are a consequence of the concentration of resources in a small economic elite or whether it results from very poor income segments at the bottom of the distribution (Voitchovsky 2005; Cingano 2014). We then calculated the income share of every income percentile, using the following formula:

$$S_p = \frac{\sum_{(p-1)}^{p} \mathrm{Inc}_{\mathrm{household}}}{\sum \mathrm{Inc}_{\mathrm{household}}}$$

where, S_p is the share of income of a specific percentile group; p is the percentile of the income distribution; $\mathrm{Inc}_{\mathrm{household}}$ is the annual disposable income of a household.

Household income was considered given that households constitute the primary unit of consumption and provide the fittest sense of the disposable income of its members. Income was taken as disposable income adjusted for taxes and household composition (variable INHGESTINKH of INHATAB databases, which refers to the equivalised income). Negative values (mainly due to the complex accounting structure of self-employed individuals) were converted to 0 following OECD standards (OECD 2015b). Missing values (less than 3% of the sample) were eliminated from the analysis.

The computations of inequality and segregation summed up to 294,420 data points (see the online Supporting Information Appendix). Consequently, dimensionality reduction was needed to effectively understand the underlying patterns in the socioeconomic characteristics of the studied urban areas. This is particularly important given that three elements are being analysed simultaneously in this research: time, space, and all different income segments. All above-mentioned data points were used in the PCA. The PCA was conducted for 35 × 12 city-years, scaling variables to unit variance to ensure comparability. Following the PCA, hierarchical clustering was applied to the principal component scores

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to categorise the city-year observations into groups based on their socioeconomic profiles. The optimum number of clusters was selected based on the maximisation of the Silhouette width of every cluster,[4] as measured by the *FactoMineR* R package (Maechler *et al.* 2023).

RESULTS

Evolution of income inequality and segregation – Income inequality remained quite stable from 2011 to 2022. Overall, the mean Gini coefficient of all urban areas only experienced a small reduction, from 0.277 to 0.276. However, we found heterogeneous levels of inequality, with a maximum of 0.325 in Maastricht and a minimum of 0.244 in Heerlen in 2022. As seen in Figure 5, the coefficient's evolution was also quite diverse, with 13 urban areas deviating from the general trend and registering a growth of inequality. Changes in economic inequality were particularly considerable in Lelystad (–0.013), Amsterdam (+0.011) and Maastricht (+0.010).

Similarly, segregation stayed mostly stagnant, as shown in Figure 6 (see Figure 13 in the Supporting Information Appendix for a simultaneous representation of inequality and segregation). The average ROITI value (with a radius of 500 m) only decreased slightly, from 0.066 to 0.065. Still, levels of segregation were diverse, with the most segregated urban area (Groningen, 0.11) being almost four times as segregated as the least segregated one (Gouda, 0.03). Four urban areas experienced considerable declines in segregation: Utrecht (–0.014), Rotterdam (–0.012), Leiden (–0.011) and Amsterdam (–0.010). Conversely, segregation increased in 13 urban areas, but only to a limited extent (less than 0.01 units).

Inequality and segregation across the income distribution – The shape of the income distribution was relatively similar among urban areas and across years. One main exception was that the richest 1 per cent concentrated much larger shares of income in certain urban areas and also became comparatively richer in most of them. As observed in Figure 7, this seems to have occurred at the expense of the income shares of the immediately lower segments (from the 95th to the 99th percentiles). Overall, the 20 largest instances of change in the concentration of income were registered for the top 1 per cent. This is especially the case in Amsterdam, where in 2022, the top 1 per cent concentrated almost eight times (7.89%) the income that it would have recorded if economic resources had been equally distributed among the population (1%). This figure is 2.71 points higher than the FUA average (5.18%) and almost double the value of the FUA where the richest 1 per cent concentrates the least amount of earnings (Assen, 4.03%).

Figure 8 displays the average urban segregation profile in 2022 and its change from 2011. Segregation profiles usually followed the standard U-shaped pattern identified by Reardon and Bischoff (2011) in both 2011 and 2022, meaning that middle-income segments were less segregated from the rest of the population than the rich and the poor. In addition, all but one urban area (Oss) saw an increase in the segregation of the very poor, usually coupled with small reductions in the segregation of the rest of the population and, especially, the most affluent segments. These changes from 2011 altered which groups recorded the highest segregation values. In 2011, 27 out of 35 FUAs recorded the highest ITI values at high percentiles, suggesting that the richest households used to be generally more segregated than the poor in the previous decade. In 2022, this was only the case in a minority (12) of urban areas.

Overall, the levels of segregation at the percentile level in 2022 differed notably across urban areas, ranging from 0.23 (measured at the 5th percentile in Ede) to 0.023 (calculated at the 96th percentile in Gouda). This indicates that between-FUA variation in segregation can be much larger than within-FUA variation (among percentiles) as, for example, the above figures entail that the poorest 5 per cent households in Ede were 10 times more segregated than the richest 5 per cent households in Gouda. Interestingly, a handful of urban areas did not record the expected U-shaped segregation profile. FUAs such as Almelo, Gouda, or Heerlen presented higher levels of segregation for intermediate

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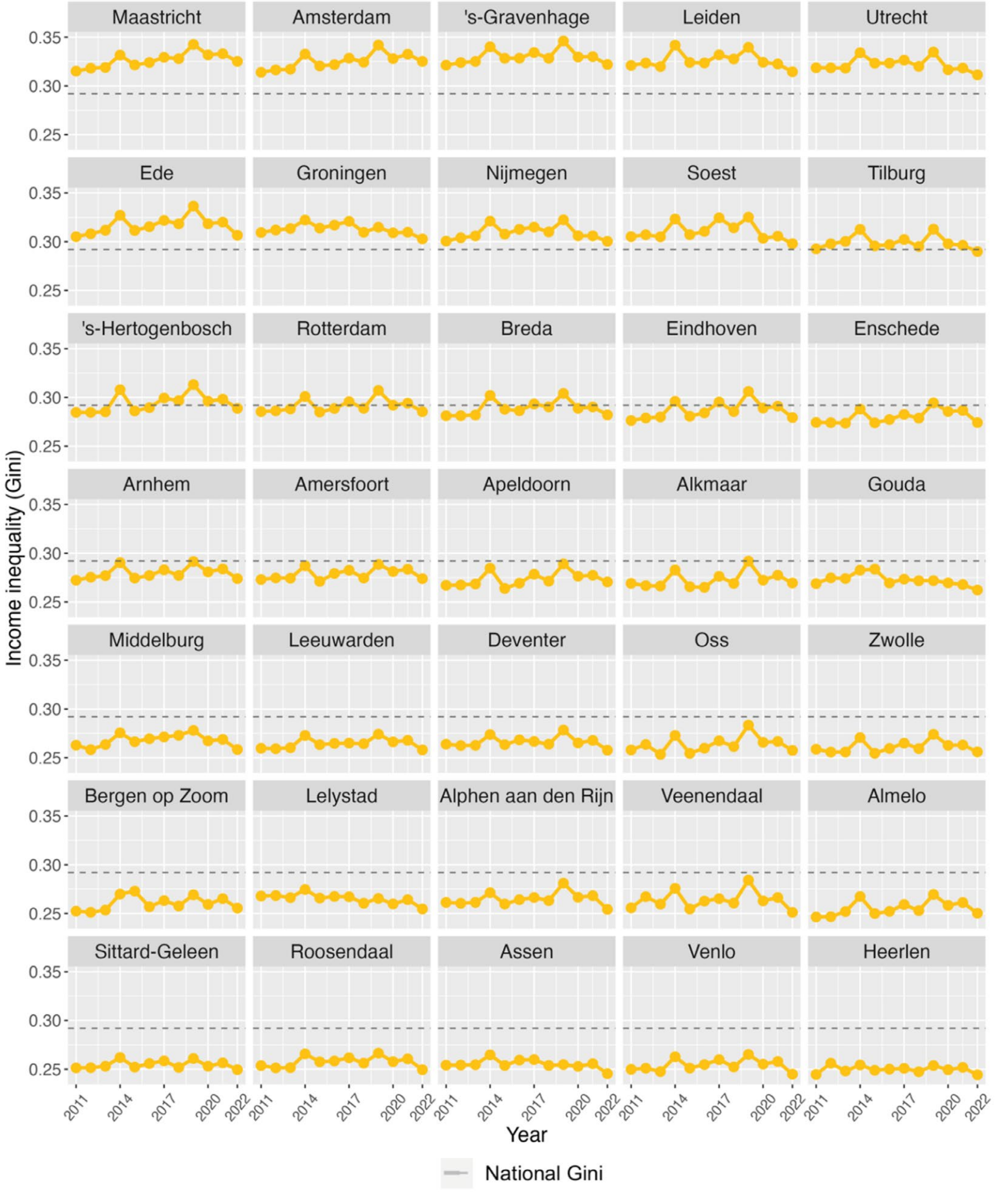

Figure 5. *Evolution of income inequality (2011–2022). Source: Authors' elaboration based on CBS microdata.*

percentiles than adjacent lower or higher percentiles. This result suggests that income segments in the middle of the distribution exhibited unusually high levels of segregation in these particular cities.

Geographical scale of segregation – Segregation occurred mainly through micro-scale patterns. The value of segregation generally shrank as higher radiuses were employed for calculating ITIs and ROITIs. This

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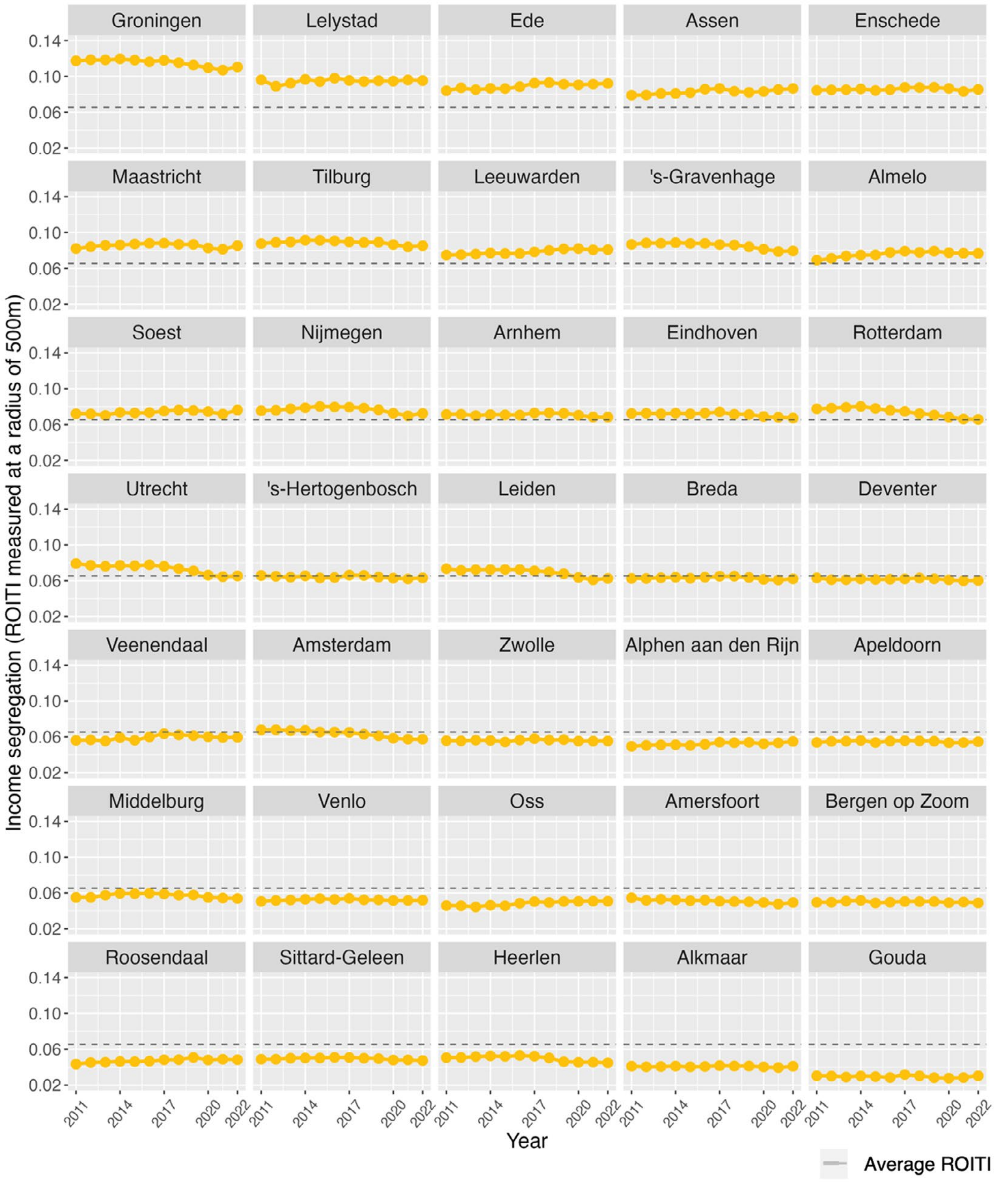

Figure 6. *Evolution of income segregation (2011–2022). Source: Authors' elaboration based on CBS microdata.*

micro-scale of segregation was assessed using the ratio between segregation estimated at 4000 m and 500 m radiuses, where values close to 0 implied mosaic-like patterns. In 2022, the average ratio in all urban areas was 0.18. The scale of segregation remained quite stable over the study period (0.19 in 2011).

However, the scales of segregation showed some variation among urban areas: the 4000 m/500 m ratio ranged from a maximum of 0.383 (Groningen) to a minimum of 0.005 (Gouda) in 2022. This variability was even larger in 2011 when the ratio fluctuated between 0.436 also in Groningen and 0.011 in Gouda. To a

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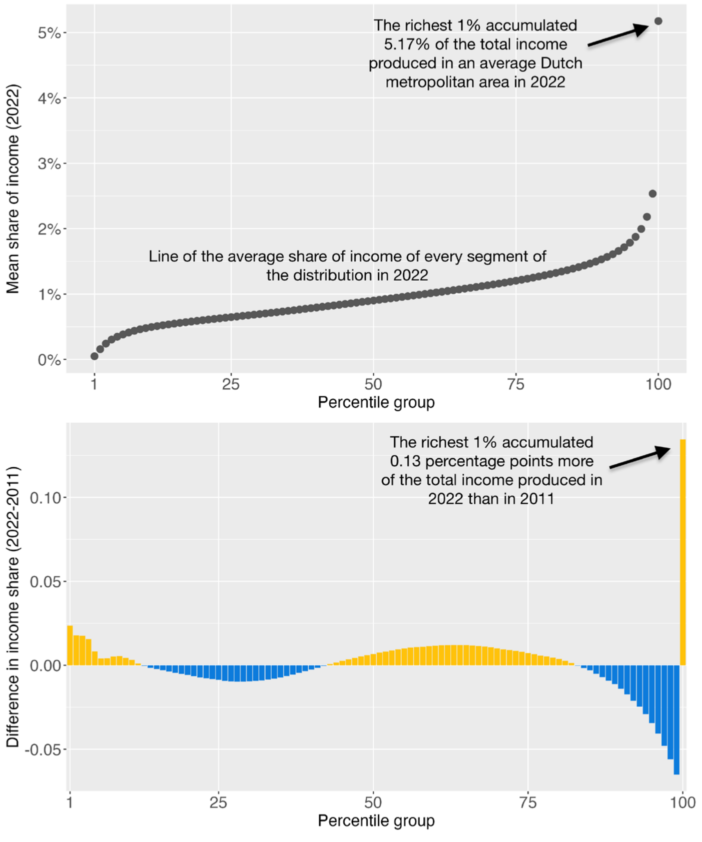

Figure 7. *Average evolution of the income share of every income segment (2011–2022). Source: Authors' elaboration based on CBS microdata.*

certain extent, urban areas showed distinctive spatial patterns of segregation, with some (e.g. Groningen, Rotterdam and Amsterdam) displaying segregation on a considerably larger scale. Interestingly, the scale of segregation was also not uniform for every income segment. As illustrated in Figure 9, the 4000 m/500 m segregation ratio was on average much higher for the poorest households than for the richest. This means that poorer households generally tended to live in large areas where income levels are homogeneous, whereas richer ones were more likely to be clustered in small pockets scattered around the urban space.

General patterns identified through the PCA **and cluster analysis** – The first dimension of the PCA explained almost two-thirds of the empirical variance in the forms of inequality and segregation of Dutch urban areas (Table 1). Only the first two principal components, which explained almost 75 per cent of the total variance, are analysed in this paper. The specific loadings that explain the contribution of each indicator to the principal components (and then serve to understand what the different dimensions mean) are provided in the Supporting Information Appendix.

Figure 10 visualises the results of the principal component analysis (PCA), where Dimension 1 represents an axis of "segregation combined with inequality." This dimension differentiates FUAs with high segregation and high inequality from those with low segregation and low inequality (see the Supporting Information Appendix for the loadings of variables included in the PCA). The strong positive correlations with segregation indices,

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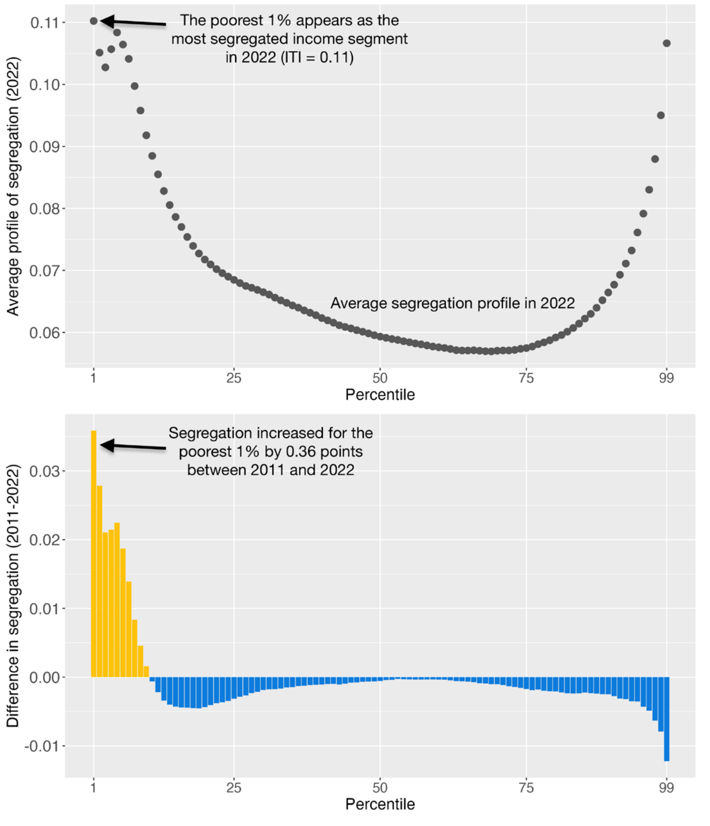

Figure 8. *Average evolution of segregation at every percentile (2011–2022). Source: Authors' elaboration based on CBS microdata.*

particularly the ROITIs measured at various radii, indicate that higher values along this dimension correspond to greater segregation levels. At the same time, its association with the Gini coefficient and the income share of the richest suggests that this axis also reflects economic inequality. Additionally, the 4000 m/500 m segregation ratios have a large loading in this dimension, implying that cities with high inequality and high segregation tend to exhibit macro-scale rather than micro-scale segregation.

A particularly notable finding is that the share of income of the richest 1 per cent (and, to a lesser extent, the richest 2% and 3%) displays weaker correlations compared to other share-of-income variables. This suggests that the economic and residential situation of the very rich differs qualitatively from the rest of the income distribution. Similarly, the segregation values for the highest and lowest percentiles correlate differently with those of the rest of the income distribution, as seen in the horizontal turn of the blue lines around the 10th and 90th percentiles in Figure 10. This result implies that overall segregation is more closely linked to economic inequality than to the segregation of the very rich and, especially, the very poor.

Dimension 2 can be understood as an axis of economic inequality and segregation of particular groups, independent of overall segregation levels. This dimension is influenced by the segregation of the rich and low-middle-income segments, as well as the segregation ratio (macro vs. micro-scale). Interestingly, none of the ROITI variables contribute significantly to this dimension, reinforcing that general segregation levels do not influence this principal component. Instead, this axis distinguishes between urban areas with high macro-scale segregation of the poor, high inequality, and a

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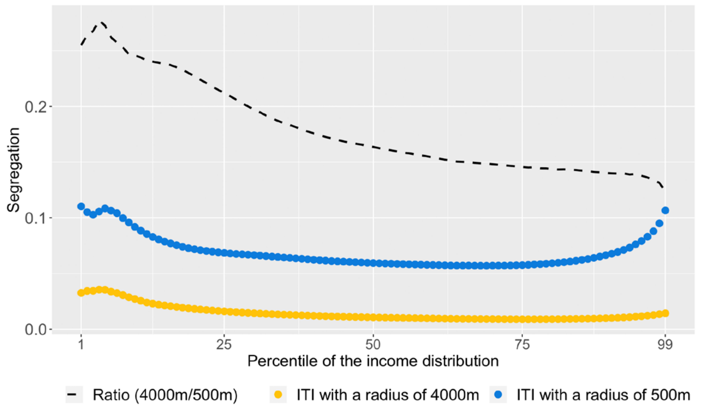

Figure 9. *Scale of segregation at the percentile level (2022). Source: Authors' elaboration based on CBS microdata.*

Table 1. *Share of variability explained by the selected principal components.*

Principal component	Percentage of variance	Cumulative percentage of variance
1	63.00%	63.00%
2	11.30%	74.30%
3	8.43%	82.73%
4	7.36%	90.08%

Source: Authors' elaboration based on CBS microdata.

high share of income concentrated in the top 10 per cent, and urban areas with high micro-scale segregation of the rich, lower inequality, and a high share of income concentrated in the bottom 10 per cent. This distinction suggests that cities with similar overall segregation levels may have very different degrees of economic inequality. Moreover, it highlights that segregation can manifest through different patterns, reinforcing the idea that the segregation of affluence is somewhat independent of the segregation of the very poor.

Based on a comparison of the average Silhouette width of different cuts of a hierarchical clustering according to the scores of these two principal components (average Silhouette width of 0.28), Figure 11 shows the evolution of all FUAs between 2011 and 2022 along the two dimensions. A typology of cities was then extracted from this cluster analysis.

Cluster 1 includes cities with low levels of inequality and segregation. Defined by low scores on Dimension 1 and relatively middle-range scores on Dimension 2, urban areas in this cluster (e.g. Gouda, Alkmaar and Alphen aan den Rijn) registered reduced socio-spatial disparities, with no specific income segments being particularly segregated. Cluster 2, on the contrary, is characterised by higher levels of inequality and segregation. Moreover, some of the FUAs in this cluster (Maastricht and Ede) presented distinctive patterns, such as the low-middle-income segments being particularly poor and segregated. This is evidenced by the larger dispersion in Dimension 2 for Cluster 2.

Cluster 3 contrasts with Cluster 2 in the way income is distributed across the population and across space. Despite registering similar or even higher levels of inequality than in Cluster 2, relatively poor segments of FUAs in Cluster 3 (e.g. Maastricht) tend to be more impoverished and segregated than usual. This suggests that inequality in these areas may be driven by low middle-income segments being comparatively less affluent and more spatially concentrated than their peers in other FUAs. These characteristics can be observed in Figure 11, where the FUAs of Cluster 3 exhibited relatively high values on Dimension 1 and relatively low values on Dimension 2.

Cluster 4 is composed solely of Groningen. This unique positioning, with the highest Dimension 1 value in the whole sample, indicates that Groningen was the most unequal and segregated urban area under study. In

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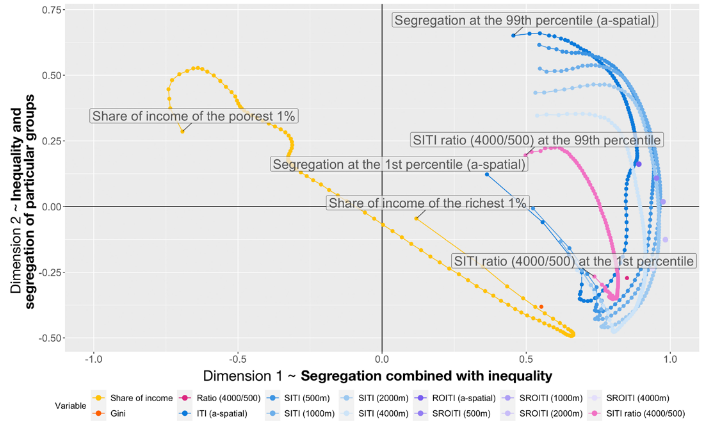

Figure 10. *Projection of the variables in the first two principal components. Source: Authors' elaboration based on CBS microdata.*

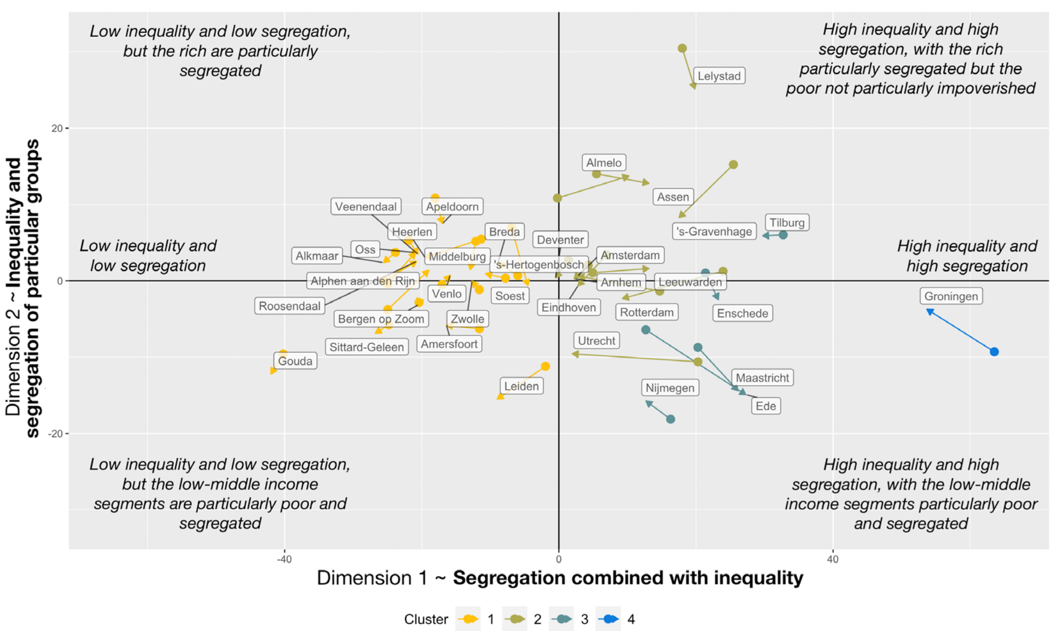

Figure 11. *Evolution of FUAs across the two dimensions from 2011 to 2022 (Only two years are represented in this figure for visual simplification, but clustering was performed on all city-years). Source: Authors' elaboration based on CBS microdata.*

addition, Groningen is defined by a singularly high 4000 m/500 m segregation ratio. This implies that segregation in Groningen occurred more in a large-scale pattern, in contrast with the most frequent mosaic patterns found in other urban areas.

Most urban areas remained similarly unequal and segregated from 2011 to 2022. This manifested in 32 out of 35 FUAs maintaining their cluster classification throughout the 2011–2022 period, demonstrating a significant degree of stability in their socioeconomic and spatial characteristics as captured by the clustering process. However, two urban areas exhibited changes in their cluster memberships (Rotterdam and Utrecht switched

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from Cluster 3 in 2011 to Cluster 2 in 2022), indicating shifts in their socioeconomic landscapes and patterns of segregation and inequality. A review of the implications of this classification and its changes is developed in the discussion section.

DISCUSSION

Evolution and levels of income inequality and segregation – The evidence presented in this paper shows that income inequality and income segregation have remained stable in most urban areas of the Netherlands. Contrary to the global segregation thesis (Van Ham *et al.* 2021a), the average of the Gini and ROITI coefficients of all FUAs remained similar (and even slightly lower) from 2011 to 2022. This suggests that predictions of heightened socio-spatial divisions linked to globalisation, lower taxation, and economic de-regulation may not be universally applicable.

The general stability of inequality and segregation masks considerable differences among urban areas. Regarding inequality, Dutch urban areas presented Gini coefficients that ranged between 0.2 and 0.4. This connects to the finding that within-country city variation may be greater than differences between countries (Comandon & Veneri 2021; Veneri *et al.* 2021). Similarly, segregation varied considerably, with ROITI values between 0.03 and 0.11 points. Overall, these divergent patterns strengthen a relevant contrast: although inequality in most Dutch FUAs appears to be in line with the general continental trends (Piketty & Saez 2014), some FUAs approach the higher levels of inequality typical of American cities (Glaeser *et al.* 2009). Similarly, most Dutch urban areas seem to be as segregated as other cities researched in Europe (Mutgan & Mijs 2023), but some (e.g. Groningen) are close to urban areas in the US (Reardon & Bischoff 2011). Some few urban areas also showed divergent temporal evolutions: inequality increased considerably in Maastricht and Amsterdam and decreased in Lelystad, for example, while four urban areas experienced considerable declines in segregation (Utrecht, Rotterdam, Leiden and Amsterdam).

Some of these atypical cases are especially noteworthy. For instance, medium and small-size urban areas such as Maastricht, Ede, or Groningen record very high levels of inequality and segregation. These places challenge the assumption that economic disparities tend to be higher in more populated cities (Sarkar *et al.* 2018). The anomaly may be driven by the special demographic composition of the three areas, marked by the presence of large universities. A big share of their population is young students attending higher education, who tend to have low incomes due to their lack of participation in the labour market and concentrate in neighbourhoods close to university and/or the city centre. This finding connects with previous research pointing to distinctive urban geographies of college students (Smith & Hubbard 2014).

In addition, the case of Amsterdam reveals a singular situation by which inequality has considerably increased while segregation has clearly decreased. This may be explained by ongoing gentrification (Boterman & van Gent 2023). This process may increase social mix in the short term as more affluent households move into traditionally poorer neighbourhoods but paradoxically increase segregation in the long term when the original inhabitants are fully displaced (Sýkora 2007, 2009). This temporal paradox may be even more important in the case of the Netherlands, as the presence of social housing is likely to enable impoverished individuals to stay in gentrifying areas (Hochstenbach & Arundel 2020). Phenomena of displacement in their early stage may also explain the decreasing levels of segregation in other urban areas of the Randstad where segregation is going down while inequality is going up or stable (Rotterdam, The Hague and Utrecht). Additionally, another factor driving this oddity may be related to local initiatives aiming for social mix. For example, Rotterdam has adopted housing policies that explicitly aimed to reduce the concentration of migration and poverty in specific areas of the city (Uitermark & Duyvendak 2008), even by controversially forbidding registration in certain deprived neighbourhoods to unemployed individuals by the so-called Rotterdam Law (Ouwehand & Doff 2013). More generally,

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any kind of policy particularities of selected urban areas may be driving other apparent anomalies.

Inequality and segregation across the income distribution – Mostly stagnant levels of inequality and segregation were paradoxically coupled with significant changes in the distribution of income across the population and the urban space. First, a concentration of income in the richest 1 per cent was identified for a large sample of cities, especially Amsterdam. This is coherent with Sassen's (1991) 'global city' phenomenon, in which some key urban centres experience a process of social polarisation between highly skilled professionals working in financial and technological sectors and the rest of the population. The fact that smaller, less populated cities of the Netherlands (for instance, Deventer or Venlo) do not experience such a concentration of earnings in the economic elites may be related to dissimilar functional specialisation. While cities such as Amsterdam become world-central and globalised conurbations, other urban areas do not evolve in the same way.

Second, the income segments that experience the strongest residential segregation switched from the rich in 2011 to the poor in 2022. As seen in Figure 8, segregation appears to have generally increased for the least prosperous households while remaining stagnant for the rest. The current situation, in which the lower-income segments are now more segregated than the most affluent groups, diverges from what previous studies have observed (see Comandon *et al.* 2018). It is nonetheless congruous with the process of 'residualisation' of social housing (Van Gent & Hochstenbach 2020). In a country where dwellings managed by nonprofit housing associations are spatially concentrated in specific neighbourhoods (Musterd & Van Gent 2015), restricting access to this form of housing provision to the least affluent strata is very likely to result in an increased segregation of poverty. The aggregate effect of this process is presumably large, as around one third of the population of the Netherlands lives in social housing (Andrews *et al.* 2011). Therefore, public administrations aspiring to reduce spatial divisions must either ensure that dwellings owned by nonprofit associations are equally distributed around the city, or that is open to a wide array of incomes.

The geographic scale of income distribution – Most cities also recorded a decreasing 4000 m/500 m ROITI ratio along the income distribution. This indicates that the rich tend to be clustered in small and homogenous enclaves of affluence, whereas the poor are usually segregated on a larger scale. This diverges from the findings of the study conducted by Reardon and Bischoff (2011) in the US. There, it is precisely the larger incomes that are segregated on higher geographical scales. Such a contradictory result may stem from the suburban history of America, where extensive and low-density territories at the periphery of cities tend to be inhabited by high-income (and white) households. The European urban context is marked by higher population densities and a higher demand for inner-city living among affluent households. This increases the affordability of housing as the fixed cost of land can be spread into a larger amount of dwellings. Eventually, high population density restricts the degree to which the rich can cluster across large territories as economic barriers to exclusionary forms of housing disappear (Rothwell & Massey 2010).

Results also signal that the geographical scale of segregation is larger in some cities (e.g. Groningen or Rotterdam) than in others. We suggest that these results may be driven by an intersection of geographic and economic factors. For example, in Rotterdam, the Maas River serves as a clear physical divide, reinforcing the perception of distinct areas on either side of the city. This geographical barrier has historically shaped the development of the city, with differences in the housing stock, socioeconomic conditions, and phenomena of discrimination across the river. These factors, along with the perception of the two sides as distinct environments, reinforce income and social segregation. This is congruent with literature on physical barriers as catalysers of urban segregation (Ananat 2011; Mitchell & Lee 2014). In the case of

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Groningen, the city stands as the only major urban area in its region, surrounded by much more rural environments. This creates a sharp urban–rural divide, amplifying the scale of segregation as the city contrasts with its rural hinterland – unlike cities in the Randstad, where polycentrism is the norm.

Similarities and differences among FUAs **identified through the** PCA **and cluster analysis** – The PCA reveals that segregation tends to be concomitant with economic inequality. This is patent as a single principal component (Dimension 1), characterised by variables of segregation, inequality, and income (de) concentration in the poorest households, can explain almost two-thirds of the total data variability. In addition, the association is particularly intense when the lower-income segments are particularly impoverished, whereas the top and bottom 5 per cent have their own dynamics (see Figure 10). Overall, the connection between inequality and segregation aligns with empirical studies showing that they are causally linked (see Watson 2009; Reardon & Bischoff 2011; Scarpa 2015; Rodríguez 2016; Mutgan & Mijs 2023).

Nonetheless, the PCA also shows that specific patterns in which inequality and segregation are experienced (e.g. segregation of poverty vs. segregation of affluence) may vary to some extent. The percentage of variability that Dimension 1 cannot explain (one-third) and the presence of a second dimension that accounts for a small yet substantial share of the empirical variability also indicates that similar segregation levels can occur with diverse degrees of inequality.

The identified principal components served to create a four-group typology of urban areas. The main difference among these is related to the level of inequality and segregation, with increasingly unequal and segregated FUAs from Cluster 1 (e.g. Gouda and Breda) to 4 (Groningen). Transitions of an urban area from one cluster to another during the 2011–2022 period are rare. This indicates considerable stability in the socioeconomic and spatial characteristics of FUAs and suggests that changes in economic socio-spatial disparities take time to unravel. However, two cities changed clusters between 2011 and 2022 (Utrecht and Rotterdam). The latter case is particularly interesting because it has become more alike to similar kinds of urban areas in terms of inequality and segregation (e.g. Amsterdam), while being subject to a neoliberal post-industrial urban policy and state-led gentrification (Custers & Willems 2024).

Due to the chosen focus and method of this study, it is not possible to derive any conclusions on causality between inequality and segregation. The degree to which the latter translates into the former (and vice versa) is probably mediated by many factors, which range from racial discrimination to housing policies, and which are not included in this research. Whether the association found between inequality and segregation is driven by omitted variables is an area of analysis that is outside the scope of this paper (for causal studies, see, among others, Watson 2009; Reardon & Bischoff 2011; Scarpa 2015; Rodríguez 2016; Mutgan & Mijs 2023). Furthermore, inequality and segregation are probably related in a two-way causal link (Galster & Sharkey 2017) that this paper cannot disentangle. Second, the urban division of the Netherlands employed does not account for the strong polycentric and interconnected nature of the region where most of the population resides: the Randstad. Consequently, segregation expressed spatially across different yet linked urban areas where residential movements may happen (Janssen *et al.* 2024) is not captured (e.g. moves between Amsterdam and Rotterdam). These methodological choices, however, permit a full examination of segregation disaggregated at the percentile level and enable detailed comparisons across years, cities and countries. As a result, the comprehensive nature of this review of economic and spatial disparities in cities of the Netherlands may come at the cost of capturing some existing interlinks less intensively.

CONCLUSION

This article presented a broad examination of economic inequality and segregation in Dutch

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urban areas. Taking advantage of detailed microdata, we studied the evolution and extent of economic and spatial disparities in the Netherlands between 2011 and 2022, making three main contributions to the literature. First, we estimated indicators of income inequality and segregation on an annual basis and for the entirety of Dutch urban areas. Second, we disaggregated the calculations for every income percentile, enabling a granular analysis of the segregation of affluence and poverty (Reardon & Bischoff 2011) and inter-urban differences in the distribution of income across the social ladder. Lastly, we computed segregation at different geographic scales. This empirical research was thus able to capture three aspects of economic inequality and segregation: their temporal evolution, their distinctive spatial and social patterns, and their different geographical scales.

The paper also made a case for widening urban research beyond capitals and highly populated cities. As shown by these results for the Netherlands, ideas such as the global segregation thesis (Van Ham *et al.* 2021a) may not be applicable to many urban areas outside of the extensively studied global conurbations. This is crucial as most people live in mid-sized cities. Existing assumptions about the universality of the growth of economic inequality and segregation must therefore be challenged and assessed based on detailed data from a variety of urban settings. Echoing Robinson (2013), a focus on 'ordinary cities' is especially needed. In this article, this approach served to build a four-type typology of urban areas and show how levels of inequality and segregation may vary considerably even within the same country, in line with the work of Comandon and Veneri (2021) and Veneri *et al.* (2021). The particularities of every urban area are likely to be involved with the final main conclusion of the paper: inequality and segregation in Dutch cities tend to be concomitant, but not all variations in inequality and segregation in its different forms can be directly explained by each other. As defended by Tonkiss (2020), this suggests as well that inequality and segregation may be partially addressed through policy interventions at the local level.

Consequently, this paper invites researchers to further examine the mechanisms linking inequality and segregation. Models that can quantify and assess the causality linking them are particularly needed for the case of the Netherlands. By identifying considerable heterogeneity in the produced indicators, we also argue for analytically distinguishing between different aspects of inequality and segregation: the segregation of affluence and the segregation of poverty (Reardon & Bischoff 2011), distinct scales of segregation (Reardon *et al.* 2008) and a distinction between elite-driven inequality and the presence of especially poor income segments at the bottom of the distribution (Voitchovsky 2005; Cingano 2014). Additionally, we release all the indicators produced for all urban areas to foster detailed analyses of specific cities in the Netherlands. This can serve to identify best practices and policies that have succeeded in countering two of the main challenges of contemporary societies: inequality and segregation.

Data disclaimer – The results are based on calculations by TU Delft using non-public microdata from Statistics Netherlands.

Endnotes

[1]https://data.worldbank.org/indicator/SI.POV.GINI?locations=NL

[2]https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_income_distribution_and_income_inequality&oldid=528159#Income_inequality

[3]UNU-WIDER, World Income Inequality Database (WIID) Companion dataset (wiidglobal). Version 28 November 2023. https://doi.org/10.35188/UNU-WIDER/WIIDcomp-281123

[4]A 4-group cluster was chosen because it maximises the average Silhouette width in comparison with clustering based on a higher number of groups, while keeping outliers (i.e. Groningen) in separate clusters – in contrast with 2- and 3-group clustering.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web site:

Figure S12. Comparison of segregation estimated using the Dissimilarity Index and the ROITI. *Source*: Authors' elaboration based on CBS microdata.

Figure S13. Evolution of income inequality and segregation in all urban areas (2011–2022). *Source*: Authors' elaboration based on CBS microdata.

Table S2. Loadings of all variables for Principal Component 1 and Principal Component 2 of the PCA. *Source*: Authors' elaboration based on CBS microdata.

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