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Changes in the residential segregation of immigrants in Sweden from 1990 to 2012: Using a multi-scalar segregation measure that accounts for the modifiable areal unit problem

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ABSTRACT

In this paper, the levels of residential segregation of immigrants in Sweden during the years 1990, 1997, 2005, and 2012 are calculated. This paper applies a novel method for calculating segregation that is multi-scalar and addresses the modifiable areal unit problem (MAUP). The level of segregation is evaluated for each populated location by identifying the population that includes the *k*-nearest neighbours. The share of immigrants in this assessment population is then compared to the share in the reference population that comprises the *K*-nearest neighbours. One of the strengths of this method is the possibility to modify the reference population, thus making it possible to measure the difference in the results due to the size of the reference population. This study demonstrates that the results can considerably differ depending on which reference population is used. Furthermore, this study indicates that using different reference areas can produce completely different trends over time, such as decreasing or increasing segregation. The results demonstrate a general increase in segregation between 1990 and 1997, followed by a more complex pattern from 1997 to 2012. The segregation values are presented for all populated locations in Sweden, and population-weighted means are calculated for the whole of Sweden, in addition to the Stockholm, Malmö, and Gothenburg metropolitan areas.

1. Introduction

Sweden has observed a relatively sharp increase in the number of immigrants in recent decades. Between 1990 and 2012, the number of immigrants in Sweden rose from 9 to 15% of the population and further increased to 17% of the population in 2015 (Statistics Sweden, 2016). In this study, we use a novel method to measure the level of residential segregation of the immigrant population in Sweden during the years 1990, 1997, 2005, and 2012.

In this study, we define residential segregation as the uneven spatial distribution of residency of different population groups. This definition corresponds to the spatial evenness and clustering dimension suggested by Reardon and O'Sullivan (2004), in contrast to their spatial exposure and isolation dimension. Under this definition, measuring residential segregation generally involves comparing the population composition in one area to the overall population composition in a larger area.

1.1. Problems associated with measuring segregation

There are several problems associated with measuring segregation, one being that segregation is multi-scalar (Fowler, 2016; Wright, Ellis, Holloway, & Wong, 2014). In other words, segregation is often present in different amounts at different spatial scales. An area might be segregated at the local level but not at other spatial scales. Segregation is usually measured at one spatial scale, which fails to account for the multi-scalar nature of segregation.

Another problem, which is connected to the multi-scalar nature of segregation, is the modifiable areal unit problem (MAUP). The MAUP refers to the problem that the results from spatial analysis can depend on the delineation of the areal units into which the data are aggregated. In other words, a particular delineation at a specific spatial scale can yield a result that is valid only for that specific delineation. There are two aspects associated with the MAUP: scale and aggregation (Openshaw, 1984). The scale problem refers to the fact that results may be affected by the scale of the areal units. See Nielsen and Hennerdal (2014) for an example of how different scale

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levels of nested administrative units in the Stockholm metropolitan area create different patterns of workplace clusters. The aggregation problem (a.k.a. the zonation effect) indicates that the results may be affected by how the borders between areal units are drawn (Openshaw, 1984).

Hennerdal and Nielsen (2017) demonstrated another aspect of the MAUP that appears when one is calculating the ratio or difference between a value for an aerial unit and the corresponding value for a larger area of reference. Hennerdal and Nielsen called this the part of the MAUP that is related to the area of reference (ref-MAUP). They demonstrated that for segregation and cluster methods for which the area of reference is subject to ref-MAUP, one needs to vary the geographical extent of the area of reference to test how different delineations influence the results. In other words, if one is basing a segregation measure on the ratio of a population in a neighbourhood to that of a larger area, the choice of the larger area will have an effect on the result. See Hennerdal and Nielsen (2017) for a more detailed description of the problems associated with the MAUP and ref-MAUP when measuring segregation.

Multiple studies have addressed some of these problems associated with measuring segregation by adopting a multi-scalar approach. These studies can be categorized into three overall categories, all having in common that segregation is calculated on different spatial scales:

- *Nested spatial units*: calculating segregation on different spatial scales using nested data sets for which, for example, smaller administrative units can be aggregated into larger administrative units.
- *Multiple distance bands*: calculating segregation on different spatial scales using different distance radii.
- *Bespoke neighbourhoods*: calculating segregation on different spatial scales using the *k*-nearest neighbours (k = number of neighbours) calculated for each individual in the study area for multiple values of *k*.

In Table 1, the three different categories are presented with an example study and a list of which of the problems associated with measuring segregation they solve and which problems they do not solve.

What is common to all three categories of methods is that they do not solve the ref-MAUP. One solution to the ref-MAUP was presented by Hennerdal and Nielsen (2017), who further developed the bespoke neighbourhood approach and presented a segregation measure that included multiple area-of-reference scales. The methodology was used to measure levels of segregation of the Hispanic population in different American cities based on the 2010 census data. In our study, the same methodology is used to measure immigrant residential segregation in Sweden.

1.2. Earlier studies measuring ethnic/immigrant residential segregation in Sweden

There have been a number of studies that have measured the residential segregation of immigrants in Sweden using different methodologies, data, and time periods, making comparisons among these studies difficult. Andersson (2000) argues that the basic patterns of segregation were already in place in the 1970s and 1980s, followed by increasing socioeconomic polarization at the beginning of the 1990s, with the foreign-born being over-represented in poorer neighbourhoods. Aldén and Hammarstedt (2016) measured the exposure in the ten-most-populated municipalities in Sweden from 2000 to 2012. Aldén and Hammarstedt (2016) concluded that the proportion of foreign-born neighbours that an individual is exposed to in his or her neighbourhood increased by approximately the same factor as the general increase in the proportion of foreign-born residents in the respective municipality. Thus, the study concluded that ethnic segregation had remained mostly unchanged from 2000 to 2012. Nordström Skans and Åslund (2010) measured ethnic segregation (exposure) in the three Swedish metropolitan areas – Stockholm, Gothenburg, and Malmö – and concluded that ethnic segregation increased between 1985 and 2006 in all three metropolitan areas.

A number of studies that consider segregation on multiple spatial scales using bespoke neighbourhoods calculated with the EquiPop software (Östh, 2014) have recently been conducted. These studies take advantage of coordinate data to create tailored neighbourhoods that circumvent the problems associated with the scale and aggregation aspects of the MAUP. Östh, Amcoff, and Niedomysl (2014) used EquiPop to measure segregation in Stockholm and demonstrated that foreign-born residents became increasingly concentrated in certain neighbourhoods in the Stockholm metropolitan area between 1995 and 2010. Malmberg, Nielsen, Andersson, and Haandrikman (2016) used individualized neighbourhoods ranging in population from 100 to more than 400,000 individuals to calculate the dissimilarity index for the foreign-born population of Sweden during the years 1990, 1997, 2005, and 2012. Malmberg et al. (2016) found that the dissimilarity index decreased for all neighbourhood sizes after 1997, but the variance amongst the neighbourhoods increased.

These earlier quantitative segregation studies in Sweden are affected by several methodological problems. The studies that use administrative units as a proxy for neighbourhoods, usually referred to as small areas for market statistics (SAMS), suffer from different aspects of the MAUP. Additionally, these studies are limited in that they use only one neighbourhood size definition to measure segregation, therefore missing the multi-scalar aspect of segregation. See Amcoff (2016) for a critical review of the use of SAMS. Studies that use multiple bespoke neighbourhoods to compare with a larger area of reference, study segregation at multiple spatial scales but do not address the ref-MAUP because the reference area remains fixed. For example, a neighbourhood is often compared with only the whole of Sweden or the metropolitan area of interest.

1.3. Aim

Because these earlier studies suffer from different types of methodological problems, there is a need to measure the levels of and change in residential segregation of immigrants in Sweden. If the ref-MAUP has an effect, we could expect to find that the levels of segregation differ depending on the choice of reference area.

Table 1
Multi-scalar segregation measurements and the MAUP-related problems that they do and do not solve.

Method	Example of study	Problem solved	Problem not solved
Nested spatial units	(Manley, Johnston, Jones, & Owen, 2015)	Scale MAUP	Aggregation MAUP and Ref-MAUP
Multiple distance bands	(Reardon et al., 2008)	Scale MAUP and Aggregation MAUP	Ref-MAUP
Bespoke neighbourhoods	(Clark, Andersson, Östh, & Malmberg, 2015)	Scale MAUP and Aggregation MAUP	Ref-MAUP