Investigating the Effects of Activity Space on the Measurement of Segregation using FEATHERS Simulation Data

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1. Introduction

Segregation is a reflection of not only individual preference but also the degree of discrimination and socio-economic inequality in our society. Since an accurate assessment of this multidimensional phenomenon is essential for understanding various social problems and conflicts, the measurement of segregation has been an important research topic in the field of geography and sociology.

The recent advances in computing power and the increasing availability of detailed data on daily travel patterns have, in particular, encouraged the development of various individual-level measures of segregation. For example, Wong and Shaw (2011) incorporated the concept of *activity space* into the exposure index, so it takes into account individual experiences beyond their neighbourhoods. In a similar vein, Farber, Páez, and Morency (2012) demonstrated how the G_i^* statistic and what they termed “relative accessibility deprivation indices” can be used as an individual-level measure of clustering and exposure. While these methods might be able to represent the level of social interaction between population groups more precisely, it is still not clear what their merits and limitations are compared to more traditional, census tract-based indices.

In this extended abstract, we attempt to evaluate the effects of incorporating individual activity spaces into the measure of exposure and isolation. To this end, we employ the activity space-based exposure index developed by Wong and Shaw (2011), but with an adjustment so that the chance of contact between two individuals at a given location is subject to the amount of time they spent together there. This modified index will be applied to a simulated daily travel data set of Seoul, South Korea, and the results will be compared with those from existing methods.

2. Methods

2.1 Tract-based and Surface-based Exposure Indices

The exposure index estimates the probability of encountering different population groups in a specific geographic area, typically a residential neighbourhood. Earlier studies focused on the level of demographic diversity within residential areas, because it is where most people spend the majority of their time and experience a variety of social interactions.

Census tract-based indices assume that one’s neighbourhood is limited to the census areal unit in which the person resides, and that the spatial extent of neighbourhood is identical for all individuals living in the same unit, no matter whether they live close to the edge of the unit, or around the centre of it. More recently developed surface-based measures avoid this rather unrealistic assumption, as they allow constructing a separate neighbourhood at each point of measurement. In Section 3, we will calculate two indices for income groups in Seoul, the traditional exposure index, P^* (Lieberson 1981), and the spatial exposure index, $\widetilde{P}^*$ (Reardon and O'Sullivan 2004), to make comparisons with the activity space-based approach.

The traditional exposure index, P^*, is defined as:

$$P^*_{A\times B} = \sum_{i=1}^{n} \left(\frac{A_i}{A} \times \frac{B_i}{T_i}\right) \tag{1}$$

where n is the number of census tracts, A is the total number of minorities in the study region, and A_i, B_i, and T_i are the population counts of minorities, majorities, and all groups in the unit i.

The spatial exposure index, $\widetilde{P}^*$, can be computed in a similar manner:

$$\tilde{P}^*_{A\times B} = \sum_{i=1}^{n} \left(\frac{A_i}{A} \times \tilde{\pi}_{i,B}\right) \tag{2}$$

where n, A, and A_i are the same as in (1), and $\tilde{\pi}_{i,B}$ represents the proportion of the majority population in the neighbourhood of people located at i.

2.2 Activity Space-based Exposure Index

Suppose that the activity space of an individual i consists of discrete points that represent the exact locations of daily activities. At each j^{th} activity space, we can calculate the likelihood that an individual of group A contacts members of group B and sum them up with weights proportional to the amount of time the person spent at that location:

$$P^*_{i,A\times B} = \sum_{j=1}^{n} \left(\frac{w_{ij}}{W_i} \times \frac{B_{ij}}{T_{ij}}\right) \tag{3}$$

where n is the number of places i visited, w_{ij} is the amount of time the person i stayed at the j^{th} location, and W_i is the total time recorded for i in the data set (i.e., $W_i = \sum w_{ij}$). T_{ij} is the total population of all groups and is defined as:

$$T_{ij} = \frac{1}{w_{ij}} \sum_{k=1}^{m} \tau_{ijk} \tag{4}$$

where τ_{ijk} refers to the amount of time i and k spent together at j (k = 1, 2 … m). Note that (3) is similar to the individual-level analogue of the exposure index presented in Wong and Shaw (2011), but only those who stay at j during the same time frame as i are accounted for the calculation of this measure.

3. Segregation by Income in Seoul

3.1 Data

This study employs an individual trajectory data set that describes daily routines of 21,266 households and 53,002 individuals in the Seoul Metropolitan Area (SMA), South Korea. The daily routine data were obtained from the FEATHERS simulation (Bellemans et al. 2010), which predicts individual schedule based on the relationship between people's socio-economic characteristic and activity-trip behaviour. The data produced from this simulation program encompass various socio-economic attributes for households and their members (e.g., household income, the number of private vehicles in the household, age, gender, and work status of each member, etc.), as well as information on their daily routines. In this extended abstract, we use the household income data to classify the individuals into two groups, low-income group (i.e., < 2,000,000 Korean Won per month) and middle- and upper-income groups (Figure 1), and examines the exposure level between them.

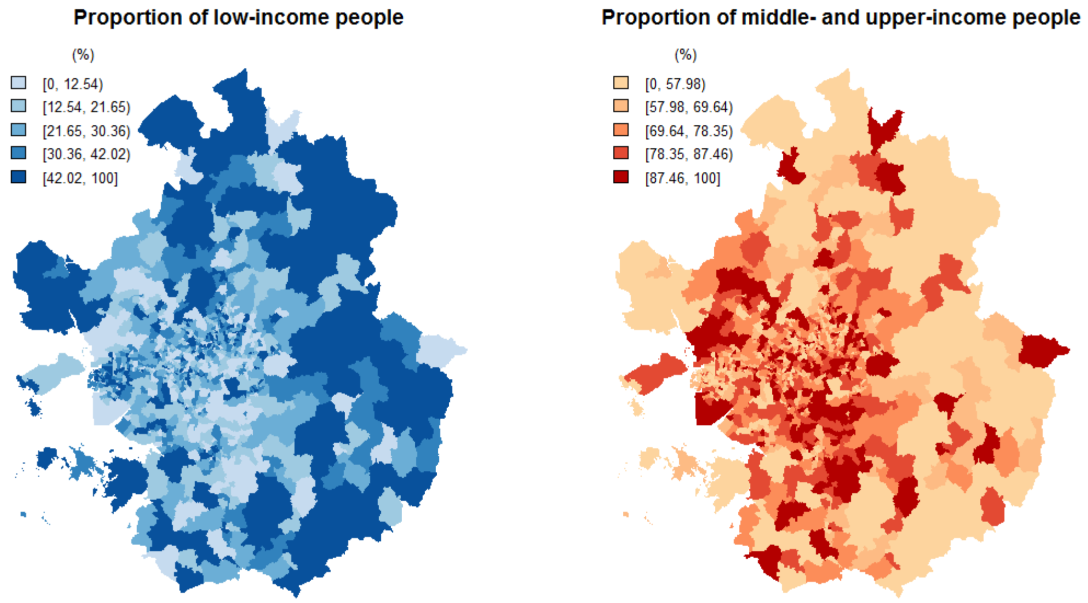

Figure 1. Proportions of low-income people (left) and middle- and upper-income people (right) in the SMA at the census tract level.

3.2 Results

The level of exposure between low-income group (A) and middle- and upper-income groups (B) was measured by three different indices, P^*, $\widetilde{P}^*$, and the activity space-based exposure index, AP^*. It should be noted that the first two measures evaluate the degree of *residential* segregation. As shown in Table 1, P^* and $\widetilde{P}^*$ produced similar figures, but AP^* was considerably higher for both A to B and B to A.

This result is probably because most of the people travelled to the central business district and stayed there during the daytime for work. It would have made a space where people with diverse economic backgrounds are mixed, consequently moderating the degree of segregation (i.e., increases the level of exposure to different income groups). Figure 2 displays that the level of exposure has increased in almost all census tracts compared to Figure 1.

Table 1. The level of exposure between low-income group (A) and middle- and upper-income groups (B), measured by three different indices: P^*, $\widetilde{P}^*$, and AP^*.

Method	A to B	B to A
P^*	0.6583	0.2171
$\widetilde{P}^*$	0.6654	0.2203
AP^*	0.7525	0.2475

4. Discussion

The widespread of GPS-enabled devices and other data collection techniques over the past few decades has led to the availability of micro-level demographic data, and it has permitted

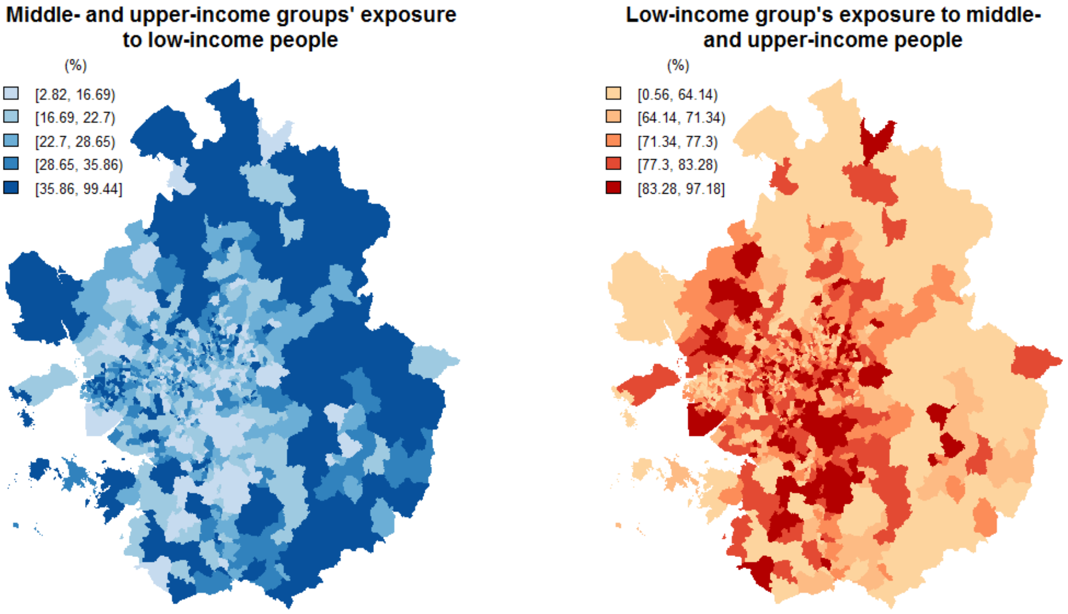

Figure 2. Varying exposure of middle- and upper-income groups to low-income group (left) and the reverse (right) across census tracts.

the development of segregation measures that explicitly consider the spatial extent of individuals' daily activity patterns. Unlike the conventional, tract-based methods, such activity space-based indices do not rely on census areal units as the context of their everyday lives, so this might be able to capture the reality of people's experiences more accurately.

However, this sort of approach should be used with care, because one's activity space consists of many different types of places. Depending on where we are—at home, work, school, café, church, or anywhere in between—we interact with people around us differently. Ideally, for each place, the degree of exposure/isolation should be measured in a different way that reflects the purpose of the visit and the characteristics of the place. However, most, if not all, of the current implementations do not differentiate between places, and this could result in under- or overestimation of the people's actual experiences. As demonstrated in the previous section, the amount of time spent at each location can be used as an indirect indicator of that place's significance, but further research would be needed to develop a more reliable activity space-based exposure index.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 24-02309.

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