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Segregation in high-resolution residential mobility network

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Abstract

We present a study on residential segregation, utilizing high-resolution data from the Danish population registry. Our network-based approach employs a modified version of the Infomap community detection algorithm, which takes into account high-order flow with memory and the gravity law as a null model. To compare with the communities, we generate representative samples by randomly selecting addresses within a community's spatial convex hull. Our findings demonstrate that these overlapping communities exhibit greater homogeneity in socio-economic indicators compared to traditional administrative units. This suggests that the community-based administrative units are more suitable for designing public policy.

Extended Abstract

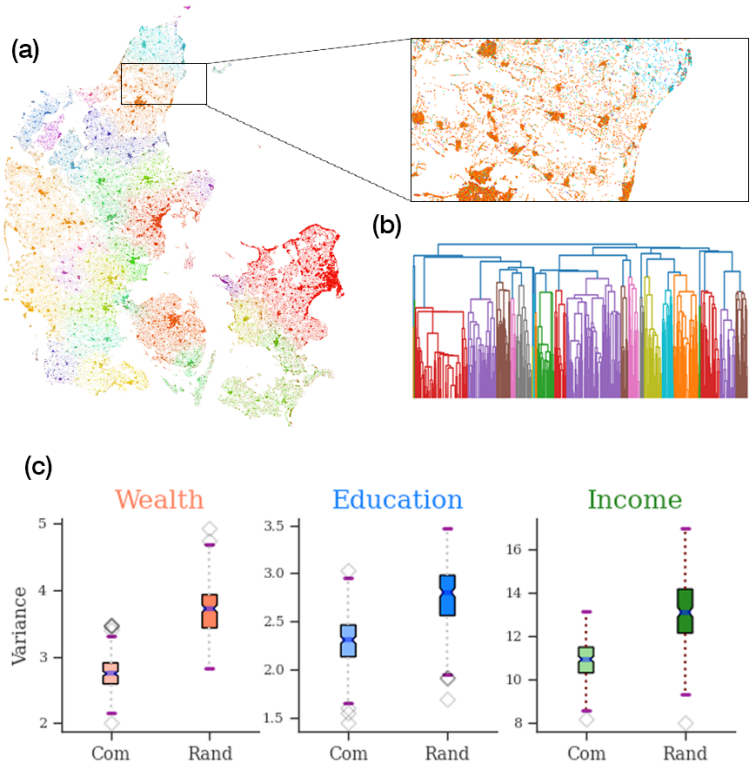

Figure 1: (a) Addresses in Denmark colored according to their community (second level of the hierarchy), (b) dendrogram of the communities , (c) variance of the communities (com) and the randomly selected control groups (rand) for three socio-economic indicators.

Data

The network used in this study is built from the Danish population registry, which is a rich data source containing information on every residential move in Denmark since 1968. Each node in the network corresponds to an address, and an edge represents the number of individuals who have moved from one address to another over time. The network is temporal and weighted. In addition, the data contains individual-level information on socioeconomic characteristics such as wealth, income, and educational background, which we use to explore the patterns of segregation and homophily in the communities identified in the network.

Methods

Community detection

To identify communities in the network, we employ a modified version of the Infomap algorithm that considers high-order flow with memory [2]. This approach allows us to identify communities based on patterns of movement and interaction, rather than relying on administrative units or other predefined spatial units. The algorithm incorporates a null model that takes into account the gravity law, which predicts that the probability of a move between two locations is proportional to their size and inversely proportional to their distance. By favoring communities with moves that are unexpected according to the gravity law, the algorithm is able to identify communities that are more homogeneous than would be expected by chance. Furthermore, the community detection algorithm takes into account individual trajectories, using a sparse Markov chain on the complete trajectories of 10 million individuals to detect communities.

Representative samples

To generate representative samples of the communities, we use a bootstrapping approach in which we randomly select the same number of addresses within the convex hull formed by the geolocation of addresses within a community. This approach allows us to consider the local variation of socioeconomic indicators such as property prices, education levels, and incomes, which are known to vary across neighborhoods.

Result

Our analysis reveals overlapping communities that exhibit greater homogeneity in various socioeconomic indicators (wealth, income, education) compared to bootstrapped representative samples. The communities identified in the network are more homogeneous than the bootstrapped representative samples, enabling us to capture segregation and communities that are more meaningful than the conventional contiguous administrative units. Our findings suggest that the newly designed spatial units divide the population into more homogeneous groups than traditional administrative units, providing a more suitable framework for designing public policies aimed at reducing segregation and promoting socioeconomic equality. These results have important implications for policymakers and social scientists interested in understanding the underlying processes that shape the spatial organization of human populations. [1]

References

[1] David R. James and Karl E. Taeuber. Measures of segregation. *Sociological Methodology*, 15:1–32, 1985.

[2] Martin Rosvall and Carl T. Bergstrom. Maps of random walks on complex networks reveal community structure. *Proceedings of the National Academy of Sciences*, 105(4):1118–1123, 2008.