

Multiscale patterns of migration flows in Austria: regionalization, administrative barriers, and urban-rural divides

Thomas Robiglio^{1,2}, Martina Contisciani^{1,2}, Márton Karsai^{2,3}, Tiago P. Peixoto^{1,2}

¹Inverse Complexity Lab, IT:U Interdisciplinary Transformation University Austria, Linz, Austria

²Department of Network and Data Science, Central European University, Vienna, Austria

³National Laboratory for Health Security, HUN-REN Alfréd Rényi Institute of Mathematics, Budapest, Hungary



W|W|T|F

Austrian internal migration network

High-granularity administrative data from Austria's federal statistics office.

MIGRATION $\equiv$ **CHANGE OF MAIN ADDRESS**

- Node i : municipality ($N = 2093$).
- *Directed and weighted* edge x_{ij} : relocations ($E \sim 70k$).
- Years 2002-2021, aggregated annually.

Gravity model

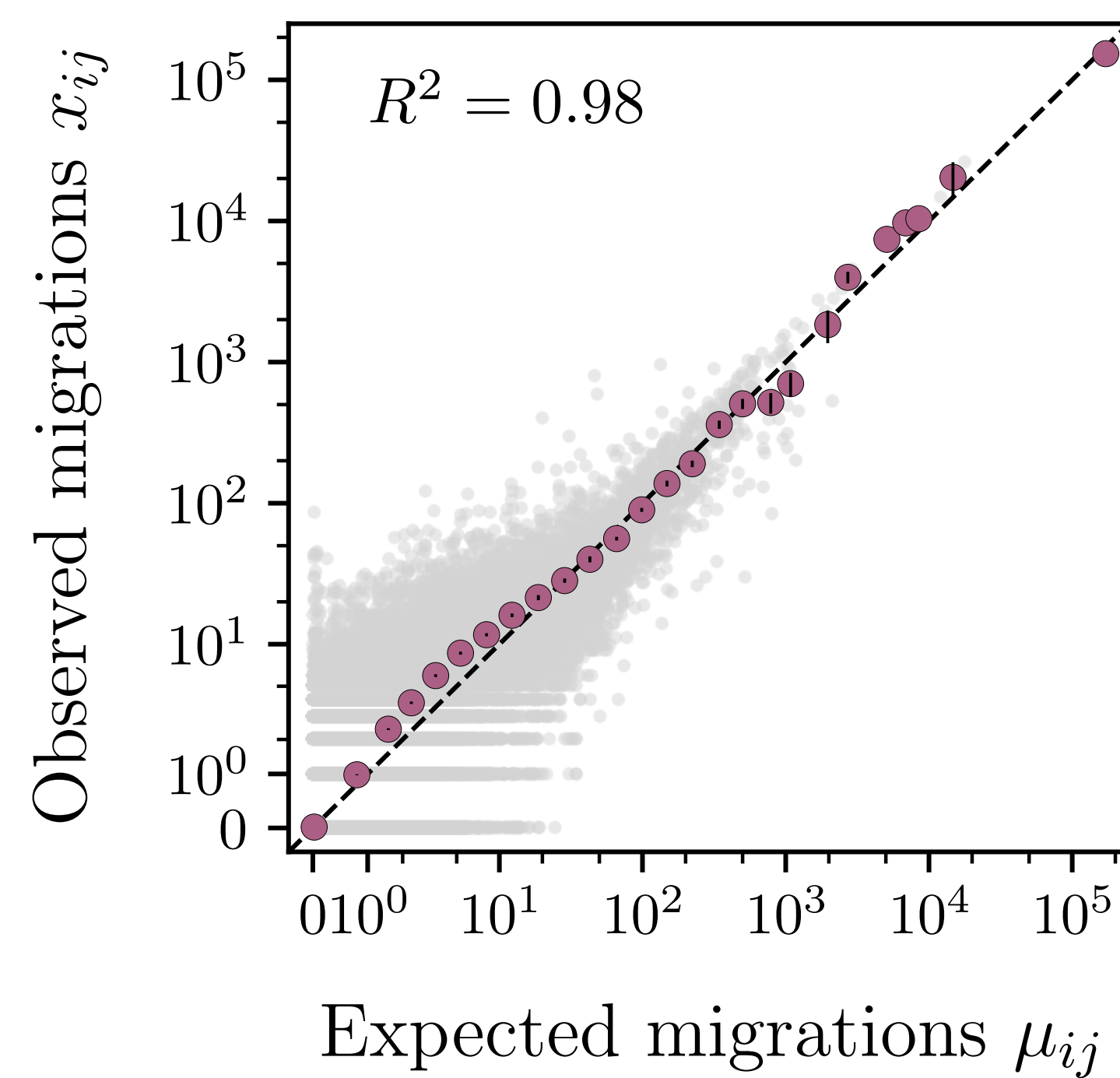
Most commonly used ansatz to model collective flows between locations.

The rate of movements between two locations increases with the product of their populations and decays with their distance:

$$\langle x_{ij} \rangle = \mu_{ij} = K \frac{(p_i p_j)^\alpha}{d_{ij}^\beta}$$

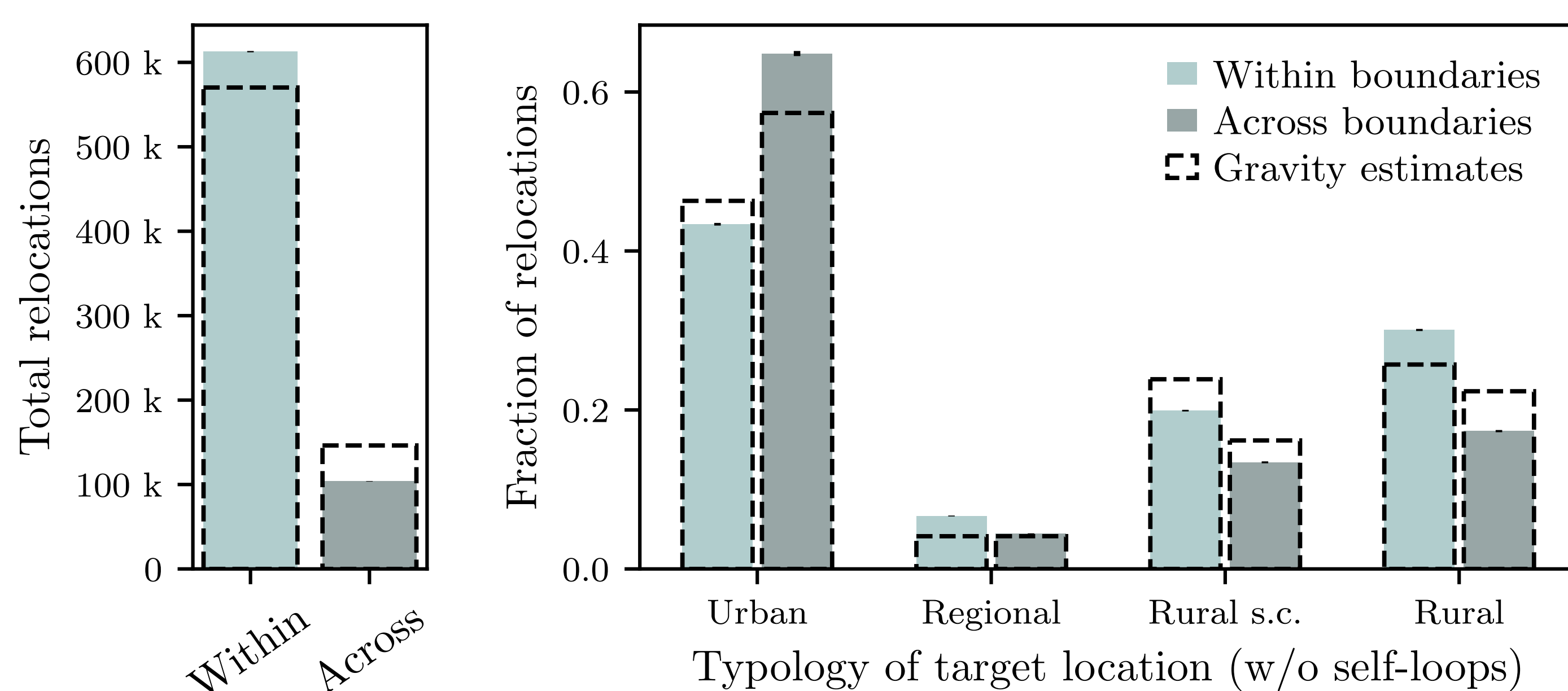
Assuming **distinguishability**:

$$P(x|K, \alpha, \beta) = \prod_{ij} \frac{\mu_{ij}^{x_{ij}} e^{-\mu_{ij}}}{x_{ij}!}$$



Effective global description, but hides discrepancies in relation to geographical and socio-demographic information!

Migration volumes in relation to federal states



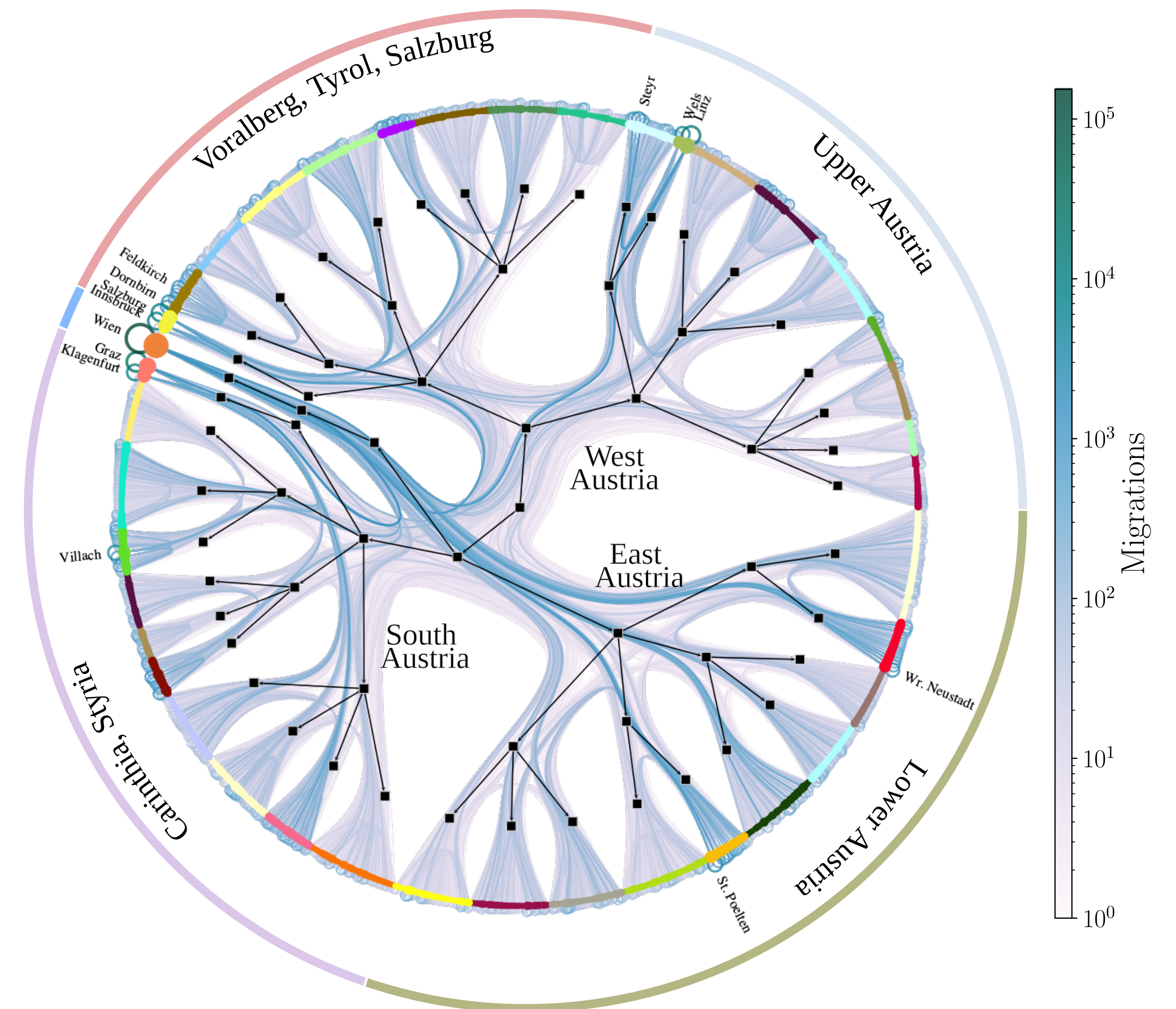
Weighted stochastic block models

Given a partition b of the municipalities in B groups, the migrations between two locations are sampled only according to their group memberships:

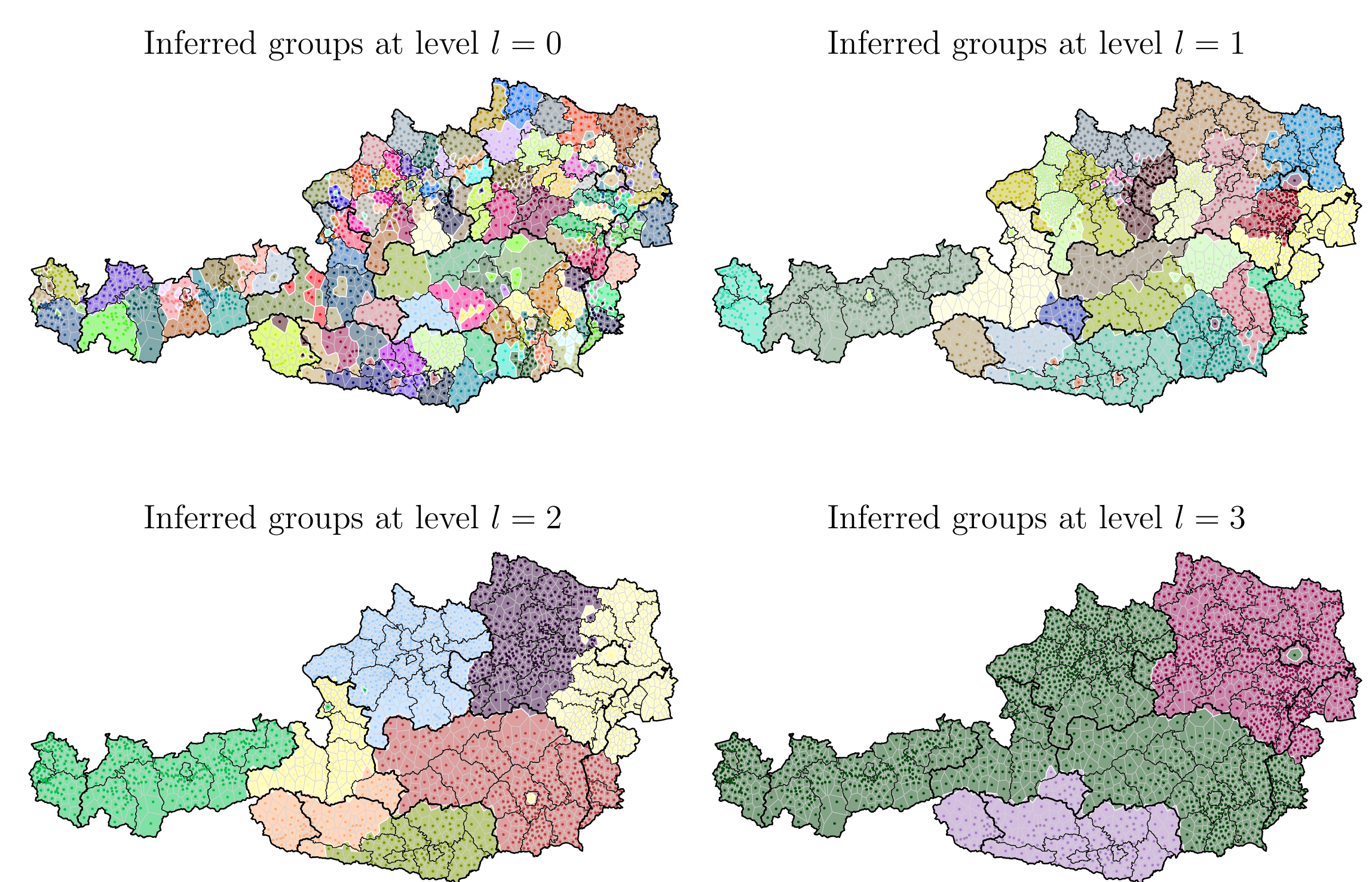
$$P(x|\theta, b) = \prod_{ij} P(x_{ij}|\theta_{b_i, b_j})$$

- $P(x_{ij}|\theta_{b_i, b_j})$ is a kernel distribution, conditioned only on the groups.
- Nonparametric method: B is inferred from data.
- Hierarchical partition, allowing for a **multiscale analysis**.

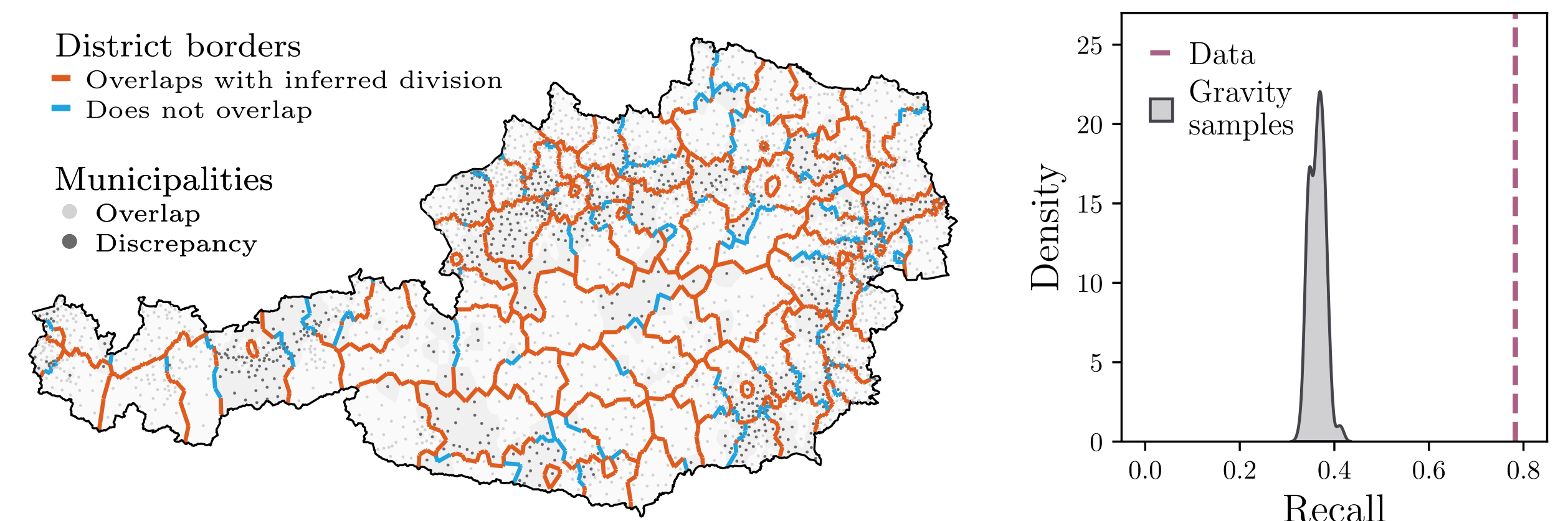
Inferred hierarchical partition



- Significant regionalization at multiple geographical scales.
- **Prominent effect of administrative boundaries at district and state levels.**
- Urban-rural divide that is more accentuated than would be expected according to a gravity ansatz



The administrative boundaries are recovered by the inferred partition but **not** by the gravity model:



Main takeaways

- Migration flows in Austria are driven by **more than gravity**.
- Nonparametric inferential clustering reveals effects of: (i) strong regionalization, (ii) **administrative boundaries** (iii) urban-rural divide, based only of the migration counts, the model is agnostic to geographical, economic, etc. information.
- Patterns are consistent across over 20 years.