

# Scaling of variability measures in hierarchical demographic data

Aleksejus Kononovicius\*, Justas Kvedaravicius

Institute of Theoretical Physics and Astronomy, Vilnius University

✉ [aleksejus.kononovicius@tfai.vu.lt](mailto:aleksejus.kononovicius@tfai.vu.lt)

🔗 [kononovicius.lt](http://kononovicius.lt), [rf.mokslasplius.lt](http://rf.mokslasplius.lt)

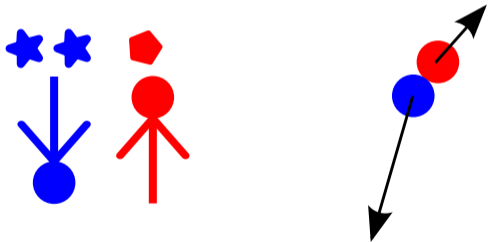




# Motivation

# Historical context

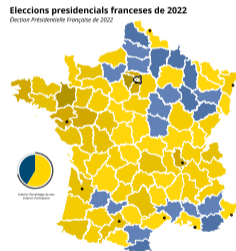
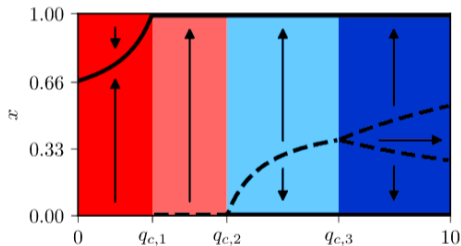
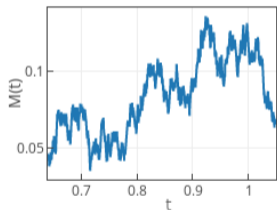
**"The molecules are like so many individuals,  
having the most various states of motion, ..."**  
(L. Boltzmann (1844–1906))



Source: Wiki

# Contemporary sociophysics

Most models are temporal, or explore phase transitions, while the data is (usually) spatial.



Sources: Physics of Risk, Physics of Risk, Wiki (modified)

# (One of) the question(s)

PHYSICAL REVIEW LETTERS

Highlights Recent Accepted Collections Authors Referees Search Press About

Featured in Physics Editors' Suggestion Go Mobile

## Is the Voter Model a Model for Voters?

Juan Fernández-Gracia, Krzysztof Suchecki, José J. Ramasco, Maxi San Miguel, and Víctor M. Eguiluz  
Phys. Rev. Lett. **112**, 158701 – Published 18 April 2014; Erratum Phys. Rev. Lett. **113**, 089903 (2014)

PhysiCS See Focus story: [Voter Model Works for US Elections](#)

Article References Citing Articles (62) Supplemental Material PDF HTML Export Citation

### ABSTRACT

The voter model has been studied extensively as a paradigmatic opinion dynamics model. However, its ability to model real opinion dynamics has not been addressed. We introduce a noisy voter model (accounting for social influence) with recurrent mobility of agents (as a proxy for social context), where the spatial and population diversity are taken as inputs to the model. We show that the dynamics can be described as a noisy diffusive process that contains the proper anisotropic coupling topology given by population and mobility heterogeneity. The model captures statistical features of U.S. presidential elections as the stationary vote-share fluctuations across counties and the long-range spatial correlations that decay logarithmically with the distance. Furthermore, it recovers the behavior of these properties when the geographical space is coarse grained at different scales—from the county level through congressional districts, and up to states. Finally, we analyze the role of the mobility range and the randomness in decision making, which are consistent with the empirical

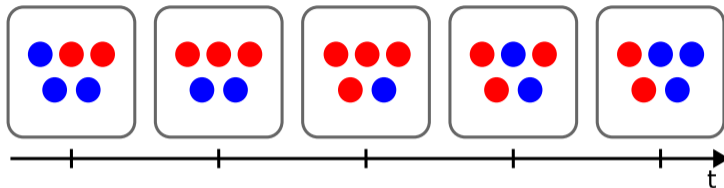
Issue  
Vol. 112, Iss. 15 — 18 April 2014

Reuse & Permissions

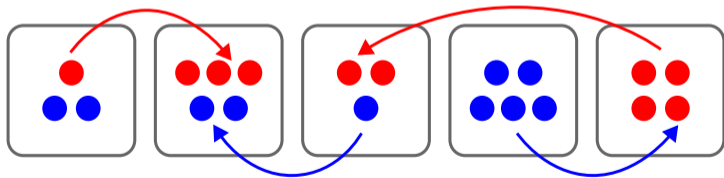
PHYSICAL REVIEW RESEARCH  
A new open access journal

[Fernández-Gracia *et al.* (Phys. Rev. Lett., 2014)]

# The answer seems to be “no”?



**temporal dynamics** is (mostly) equivalent to **spatial rearrangement**





# Exploration

# UK 2011 census data set

nomis

official census and labour market statistics

Office for  
National Statistics

Search...

[Home](#) [Reports](#) [Data Sources](#) [Census](#) [Contact us](#)

[Sign in](#) [Settings](#)

You are here: [home](#) > [Data downloads](#) > [Query](#) > [KS102EW - Age structure](#) > [geography](#) > [select using list](#)

## KS102EW - Age structure [Change dataset](#)

Population : All usual residents  
Unit of measure : Persons

Guide me step-by-step

### Make selections:

**Geography**

[Age](#)

[Percent](#)

[Rural - Urban](#)

### Review selections:

[Summary Of Selections](#)

### Get your data:

[Format / Layout](#)

[Download Data](#)

**Geography** [select using list](#) [map](#) [select areas within](#) [load / save selections](#) [user defined](#)

Postcode or Placename

### Select Using List

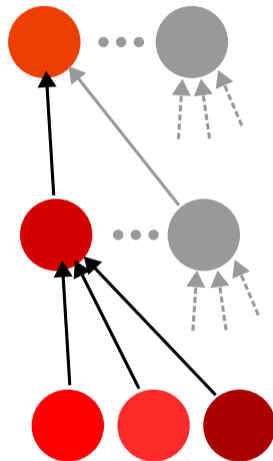
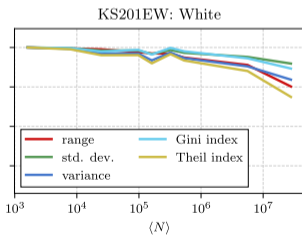
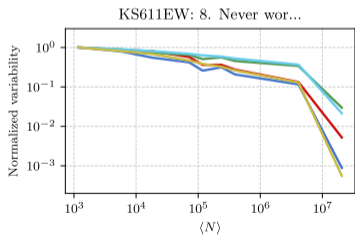
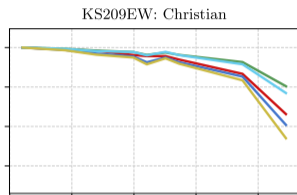
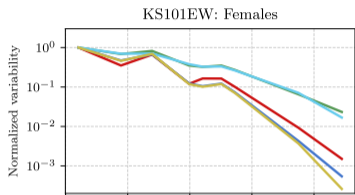
Category selection

#### commonly used

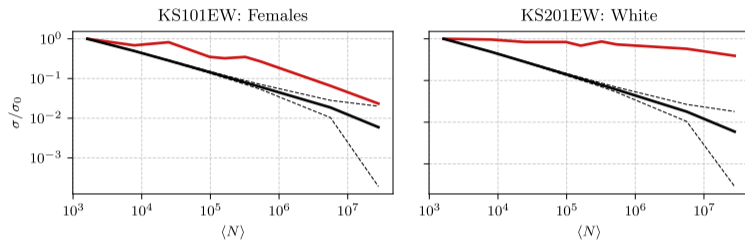
- 2011 output areas
- 2011 super output areas - lower layer
- 2011 super output areas - mid layer
- 2011 wards
- built-up areas
- built-up areas including subdivisions
- countries
- local authorities: county / unitary (prior to April 2015)
- local authorities: district / unitary (prior to April 2015)
- local enterprise partnerships (as of April 2021)



# Analyzing hierarchical demographic data

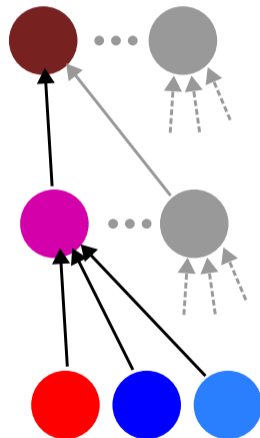


# Null model

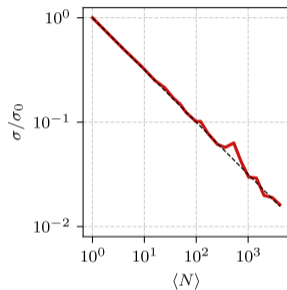
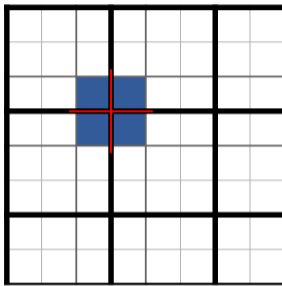
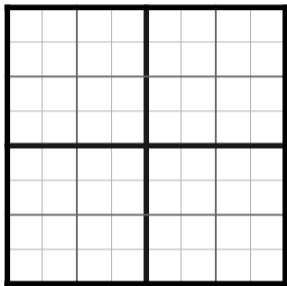


The null model randomizes data at lowest scale by **breaking the spatial relations**, but **keeps data the same**.

For **random data** we would expect  $\sigma \sim N^{-\frac{1}{2}}$ .

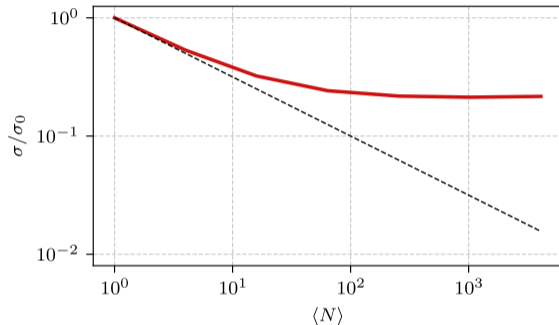
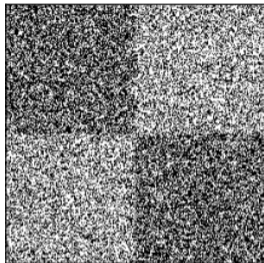


# Non-monotonicity is caused by imperfect hierarchy



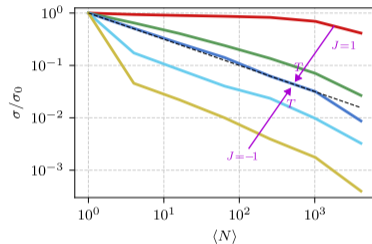
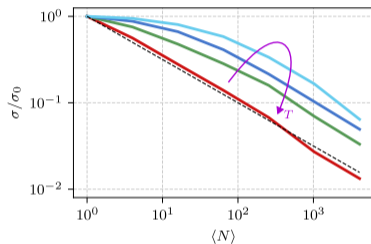
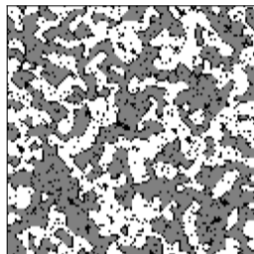
In a perfect hierarchy lowest scale units are always kept “together” (left). In an imperfect hierarchy lowest scale units might be “split” (middle), which generates non-monotonic variability curve (right).

# Modeling segregation using random grid model



Generated random grid with differing occupation densities (left), and the corresponding variability curve (right).

# Modeling segregation using Schelling and Ising models



Variability curves obtained by numerical simulation using Schelling (middle) and Ising (right) models. Different curves correspond to different thresholds (Schelling model) and temperatures (Ising model). State of Schelling model at  $T = 0.5$  (cyan curve) is shown on the left.

# Thank you!

✉ [aleksejus.kononovicius@tfai.vu.lt](mailto:aleksejus.kononovicius@tfai.vu.lt)

🌐 [kononovicius.lt](http://kononovicius.lt), [rf.mokslasplius.lt](http://rf.mokslasplius.lt)

