

6–10 July, 2026, Santiago de Compostela, Spain.

Nonlinear Diffusion and Network Dynamics of Surnames in Galicia

M^a JOSÉ GINZO VILLAMAYOR

Abstract

We investigate the spatial and intergenerational dynamics of surnames in Galicia (Spain) using tools from nonlinear dynamical systems and network-based diffusion models [1, 2, 3]. The study is based on census microdata provided by the Instituto Galego de Estatística [7], including municipality of residence, municipality of birth, age, and surname frequency counts.

We focus on representative surname classes with different historical and linguistic origins: a patronymic surname (e.g., López), a toponymic surname (e.g., Queiruga), and an appellative surname (e.g., Blanco). These categories allow us to explore whether distinct cultural origins correspond to different spatial and dynamical behaviors, following approaches that consider surnames as proxies of population structure [4, 5, 6].

The data are structured into generational cohorts, enabling the construction of a discrete-time dynamical system on a network of municipalities. Let $u_i^{(k)}$ denote the relative frequency of a given surname in municipality i and cohort k . We model its evolution through a nonlinear diffusion process of the form:

$$u^{(k+1)} = u^{(k)} - DLu^{(k)} + f(u^{(k)}),$$

where L is the graph Laplacian derived from spatial adjacency or empirical mobility flows, and f captures local nonlinear effects such as saturation or persistence, in the spirit of classical diffusion models [2, 8].

In parallel, we construct empirical transition matrices based on birthplace–residence flows, allowing us to compare geometric diffusion with observed mobility-driven dynamics. This dual approach enables us to assess the role of spatial structure versus demographic mobility in shaping surname distributions. Preliminary results indicate significant differences between surname types: patronymic surnames tend to exhibit high spatial entropy and uniformization across cohorts, while toponymic surnames retain strong localization patterns. Appellative surnames show intermediate behavior, with evidence of diffusion from rural to urban areas.

This framework provides a novel application of nonlinear dynamical systems to cultural and demographic data, highlighting how inherited social markers such as surnames can be modeled as evolving distributions on spatial networks.

References

- [1] J. D. Murray, *Mathematical Biology I: An Introduction*, Springer, New York, 2002.
- [2] A. Okubo and S. A. Levin, *Diffusion and Ecological Problems: Modern Perspectives*, Springer, New York, 2001.
- [3] M. Newman, *Networks: An Introduction*, Oxford University Press, Oxford, 2010.
- [4] G. W. Lasker, *Surnames and Genetic Structure*, Cambridge University Press, Cambridge, 1985.
- [5] P. Mateos, A review of name-based ethnicity classification methods and their potential in population studies, *Population, Space and Place* **20** (2007), 1–20.
- [6] M. J. Ginzo-Villamayor, *Statistical Techniques in Geolinguistics. Onomastic Modeling*, PhD Thesis, 2022.
- [7] Instituto Galego de Estatística, *Census microdata for Galicia*, Xunta de Galicia, 2011.
- [8] R. A. Fisher, The wave of advance of advantageous genes, *Annals of Eugenics* **7** (1937), 355–369.