Mapping the integration between Knowledge Domains in Theoretical and Quantitative Geography

Juste Raimbault[1,2,3,4]

11/09/2025

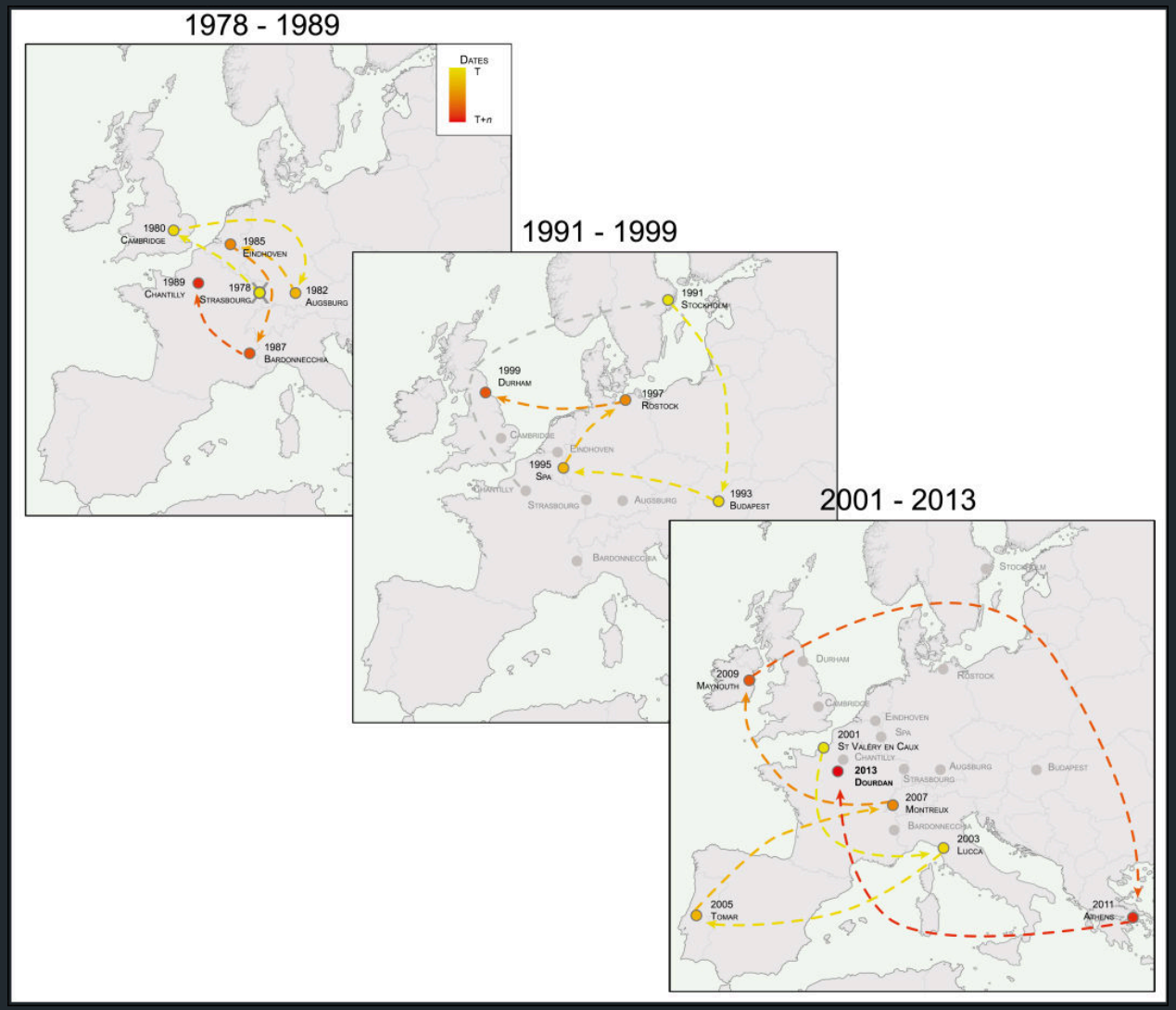
ECTQG 2025

Special Session: Theoretical Geography and the History of Geography

[1]LaSTIG, IGN-ENSG-UGE
[2]CASA, UCL
[3]UPS CNRS 3611 ISC-PIF
[4]UMR CNRS 8504 Géographie-cités

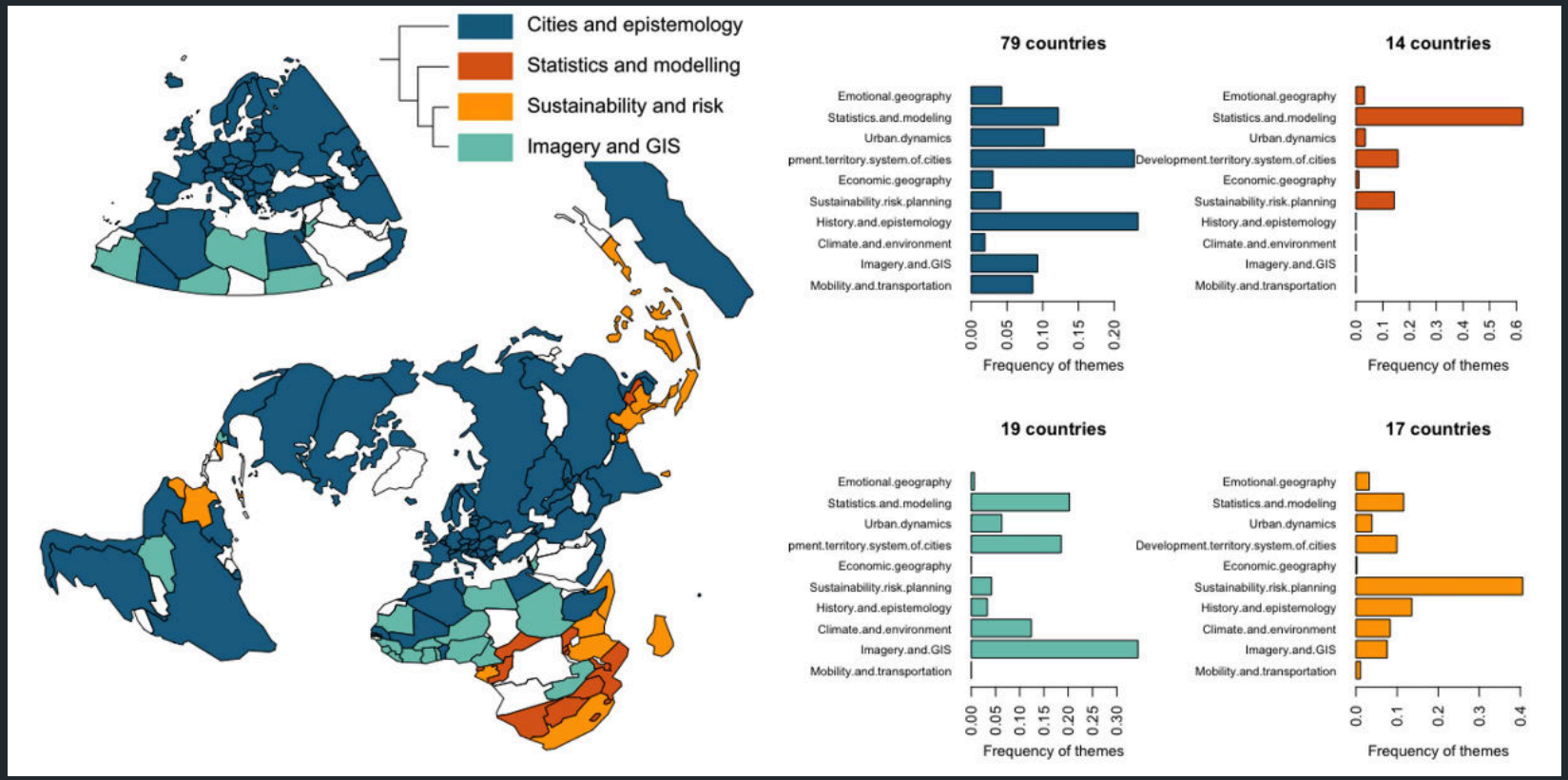
ENSG Géomatique
ÉCOLE NATIONALE DES SCIENCES GÉOGRAPHIQUES

History of ECTQG



Diversity and integration of Theoretical and Quantitative Geography [Cuyala, 2016].

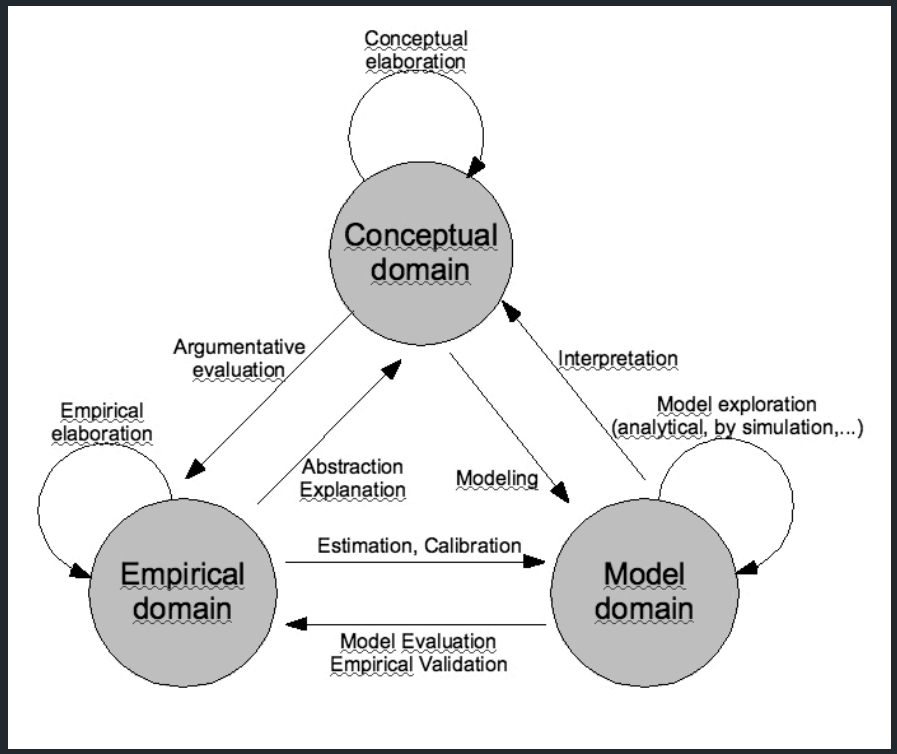
Quantitative epistemology



Spatialised bibliometrics as a tool for a more reflexive and open science: CybergeoNetworks project [Raimbault et al., 2021], continued into OpenJournalScope (currently submitted to FNSO).

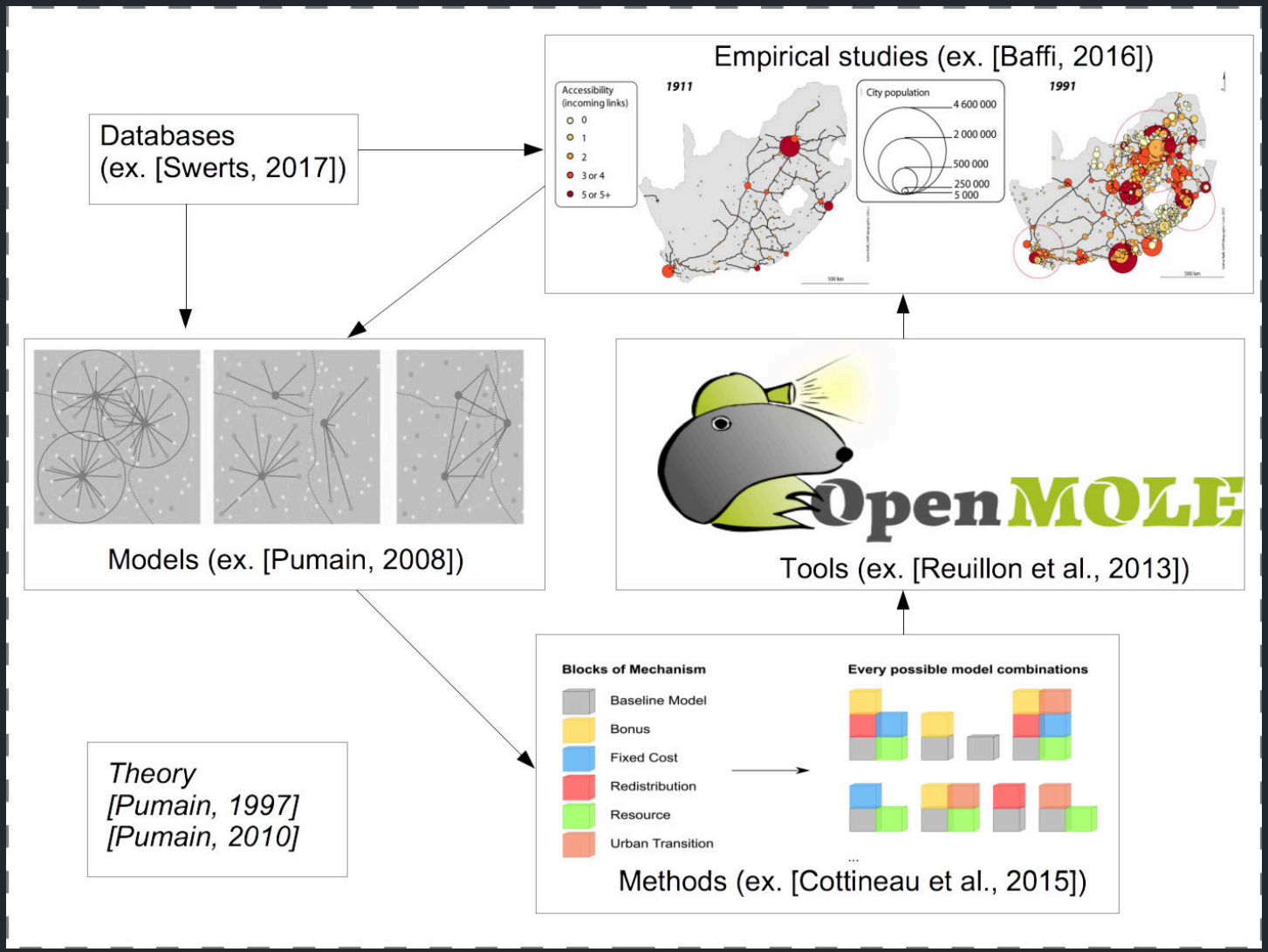
`https://analytics.huma-num.fr/geographie-cites/cybergeonetworks/`

Knowledge domains



(Left) Knowledge framework for agent-based modelling by [Livet et al., 2010]; (Right) Refinement with more Knowledge Domains (KDs) by [Raimbault, 2017a].

KDs in Pumain's Evolutionary Urban Theory



[Raimbault, 2017a]

Research objective

$\rightarrow$ previous work on Pumain's Evolutionary Urban Theory [Pumain, 2018] by [Raimbault, 2017a] suggested an integration of KDs

$\rightarrow$ more general ongoing epistemological research on TQG: [Raimbault, 2017b] (ECTQG 2017), [Raimbault, 2019a] (ECTQG 2019), [Raimbault, 2023] (ECTQG 2023)

Research objective:

Quantify some TQG corpuses in terms of knowledge domains, their use, diversity, and integration.

Data: case studies

Corpus 1: Pumain's evolutionary urban theory [Pumain, 2018], typical of a fruitful TQG approach (discipline: geography).

Corpus 2: studies of Zipf's law for the size of cities, important theme in TQG but studied by various disciplines (economics, regional science, geography, physics), constructed by [Cottineau, 2017].

Data collection: corpus construction

→ start from an initial corpus: [Pumain, 1997] and [Sanders et al., 1997]; 39 papers for Zipf listed by [Cottineau, 2017].

→ reconstruct backward citations networks at depth 2, using the open data collection tools developped by [Raimbault, 2019b]: (16333 nodes and 21775 edges for Ev. Urb. Th.; 99756 nodes and 150611 edges for Zipf).

→ extract core network by removing nodes of low degree (thresholds 3 and 30).

→ corpuses for analysis to be annotated for domains: (1252,4950) Ev. Urb. Th.; (858,8143) Zipf.

Data consolidation: manual annotation

→ manually annotate each paper for its **main** knowledge domain.

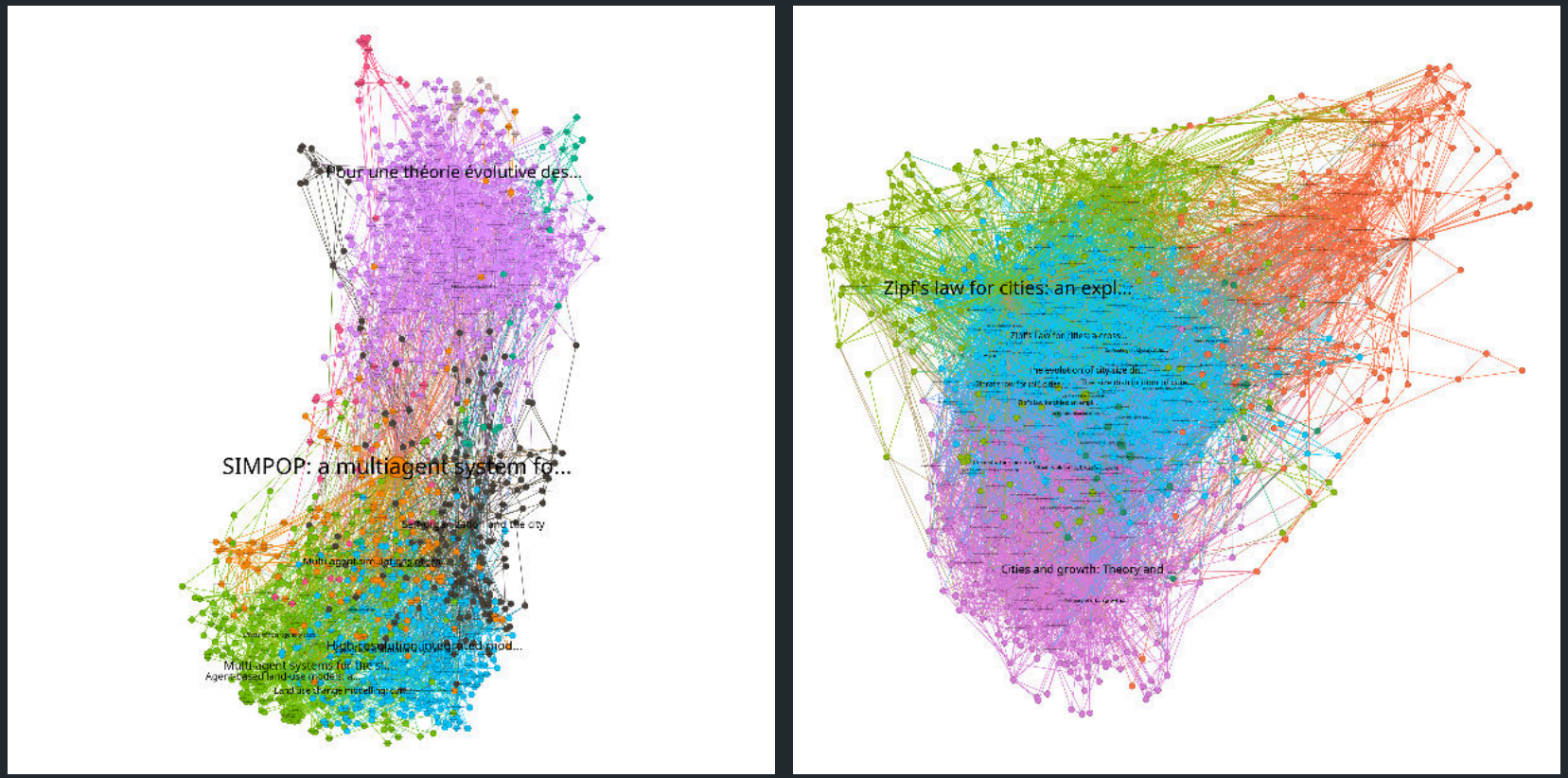
→ reviews and meta-analyses classified as "theory".

→ machine learning approach not relevant with these corpus sizes.

Counts:

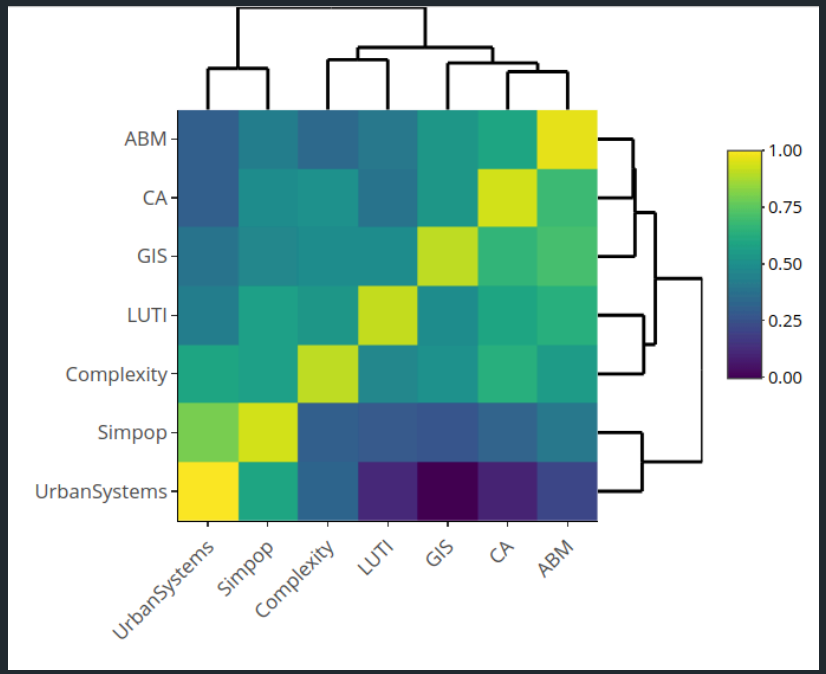
	data	empirical	method	model	theory	tool	NA
EUT	2	208	108	387	456	17	74
Zipf	2	380	41	198	210	0	27

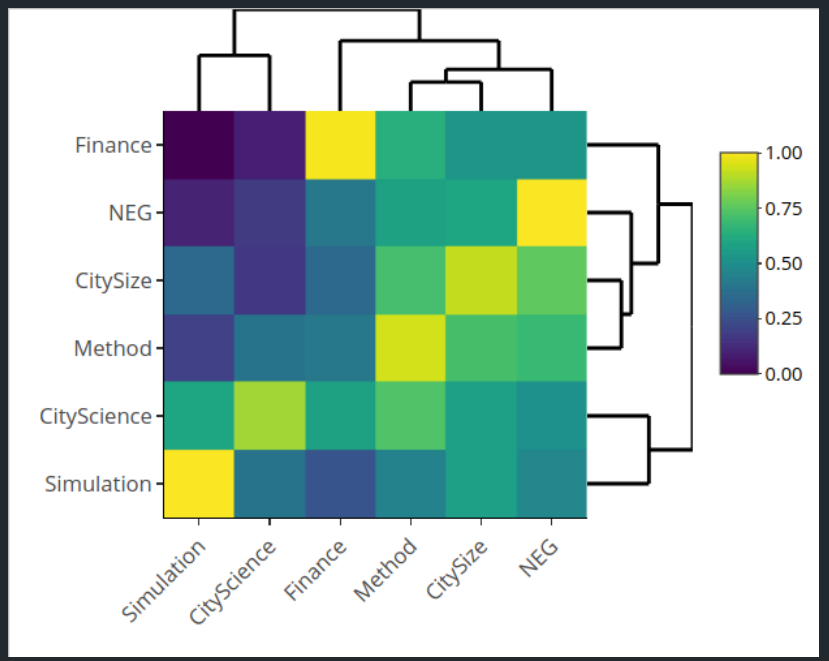
Results: citation networks



(Left) Evolutionary Urban Theory; (Right) Zipf

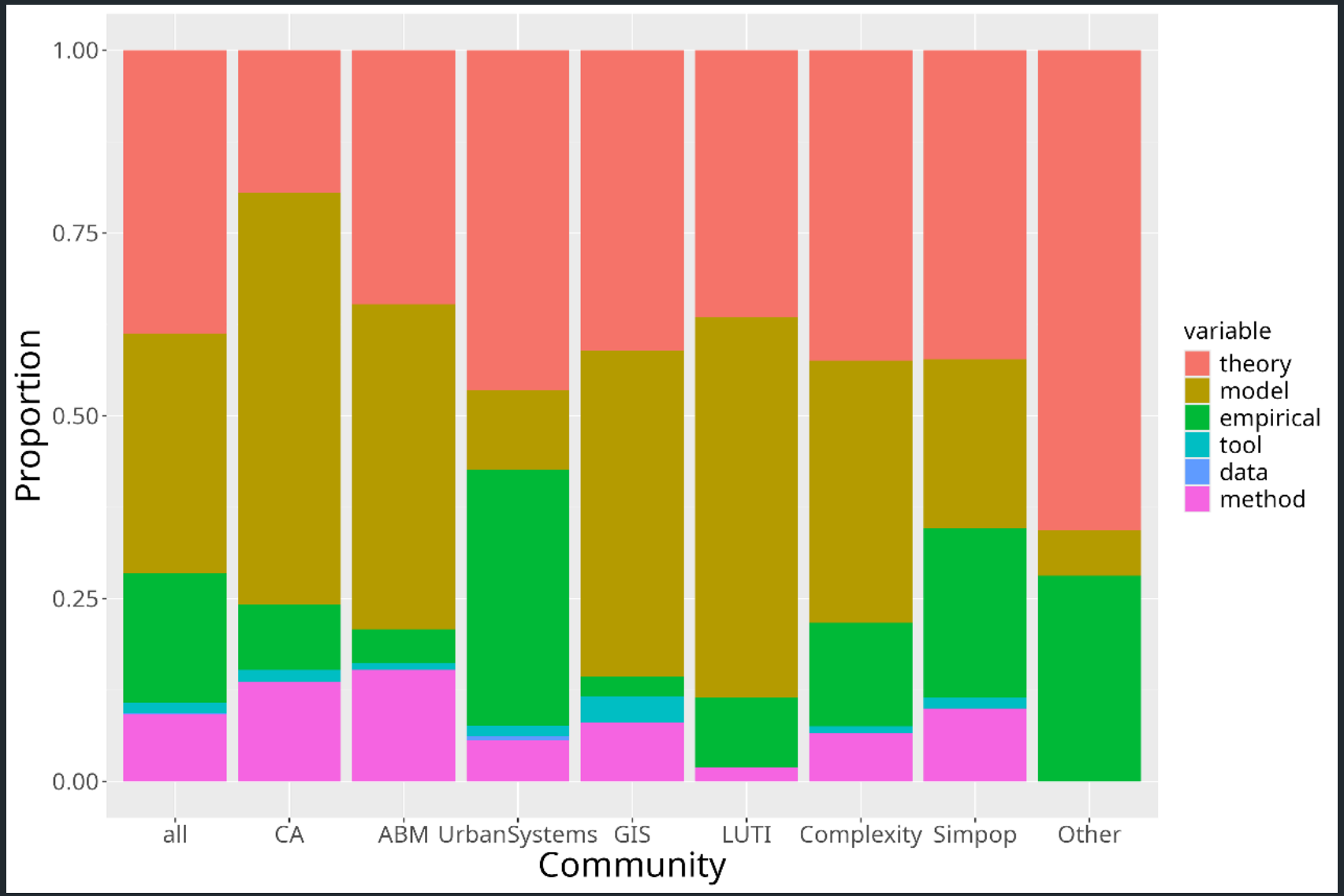
Results:community detection





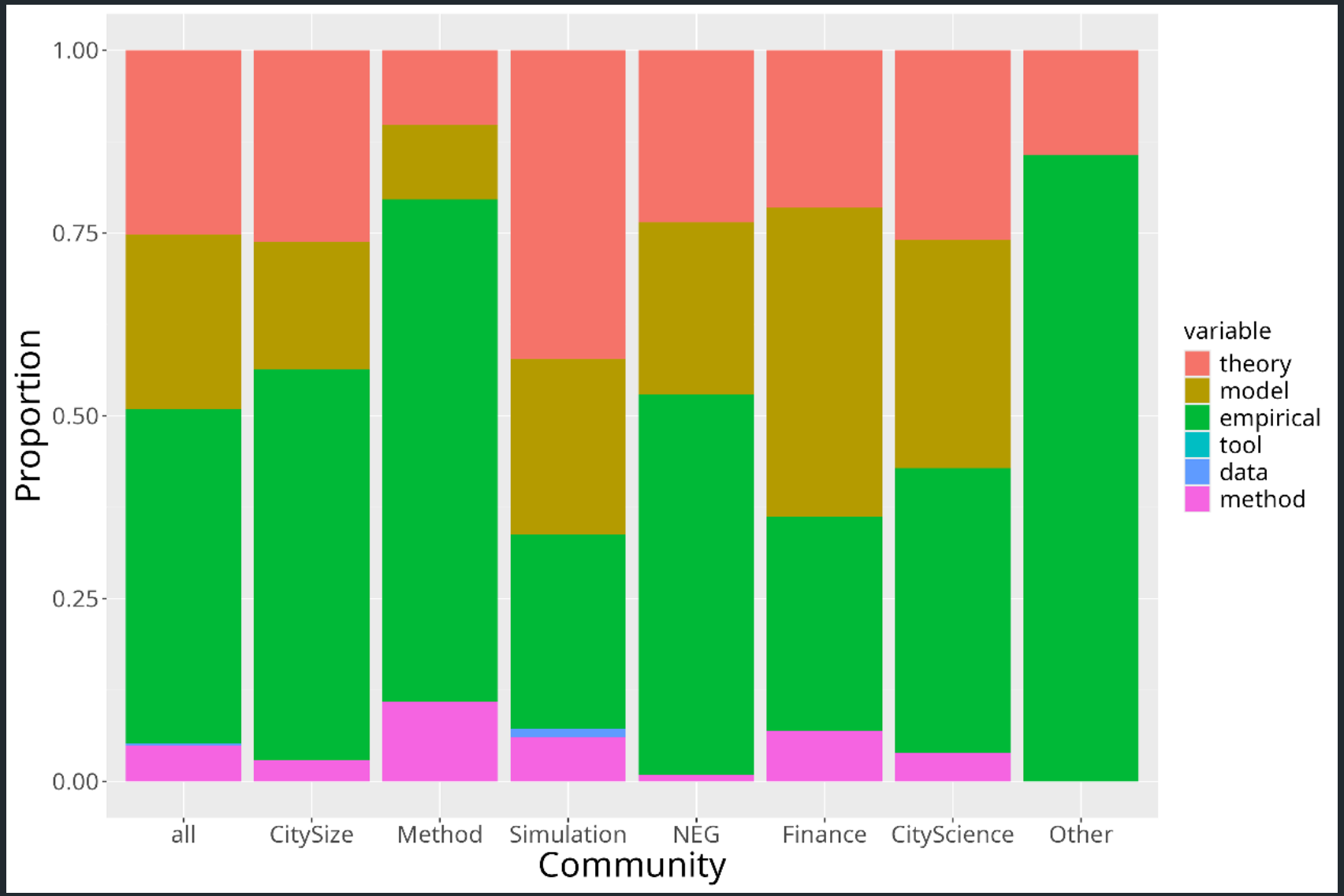
(Left) Evolutionary Urban Theory; (Right) Zipf

Results: KDs composition



Composition of communities by Knowledge Domains for the EUT.

Results: KDs composition



Composition of communities by Knowledge Domains for the Zipf corpus.

Results: diversity

Erfindahl diversity index, computed within each community:

$$d = 1 - \sum_i p_i^2$$

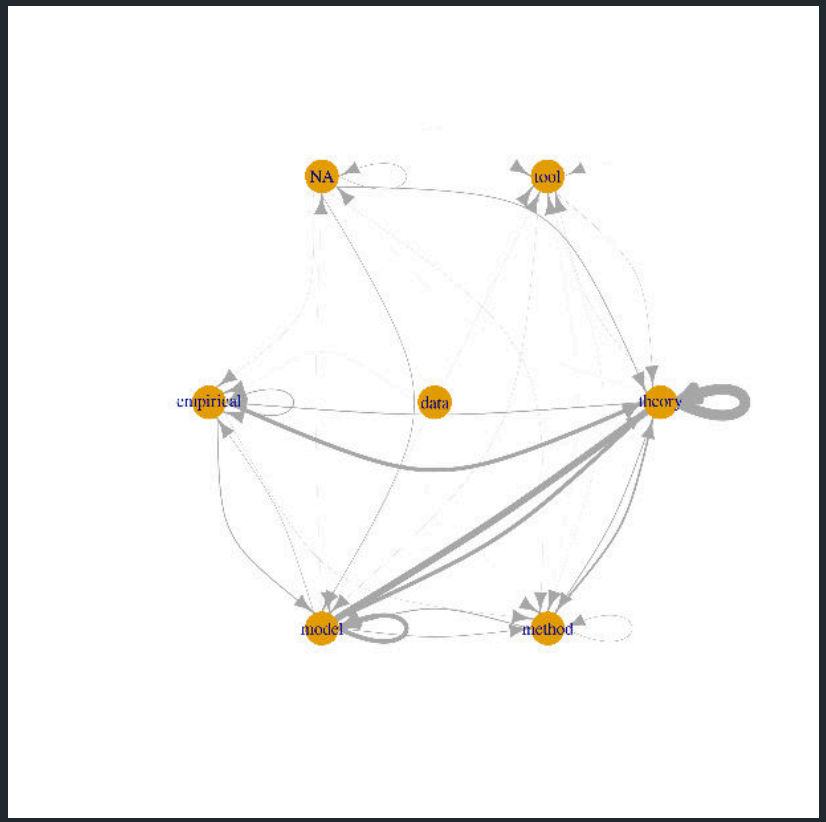
EUT:

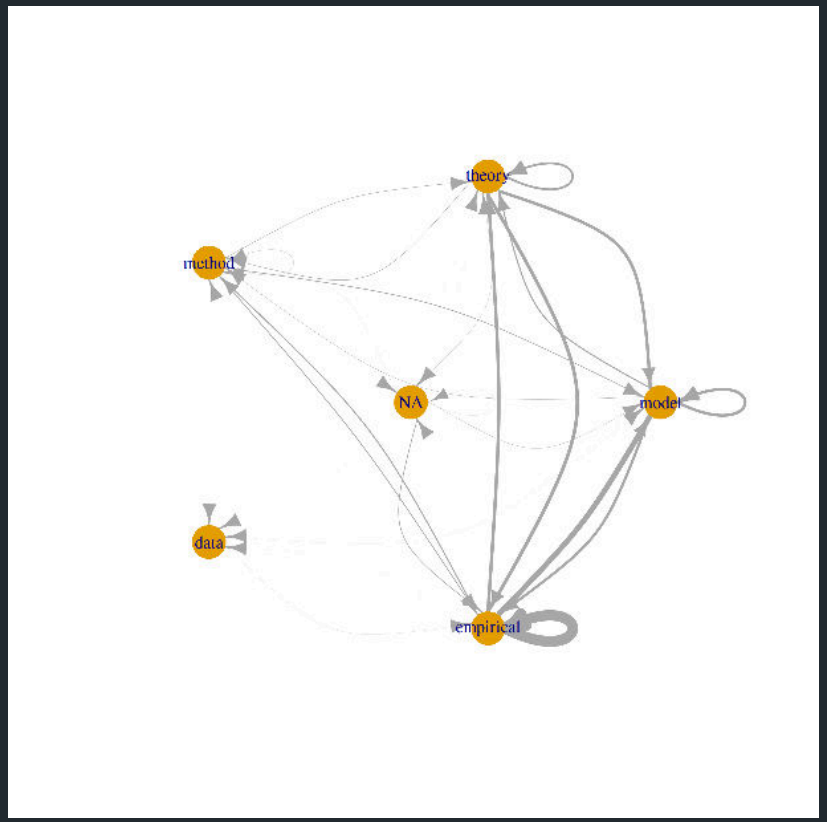
ABM	CA	Complexity	GIS	LUTI	Other	Simpop	UrbSys	all
0.65	0.61	0.66	0.62	0.58	0.48	0.70	0.64	0.70

Zipf:

CityScience	CitySize	Finance	Method	NEG	Other	Simulation	all
0.68	0.61	0.68	0.49	0.61	0.24	0.69	0.66

Results: citation flows between domains





(Left) Evolutionary Urban Theory; (Right) Zipf

Results: modularities

Integration measured by modularity of knowledge domains:

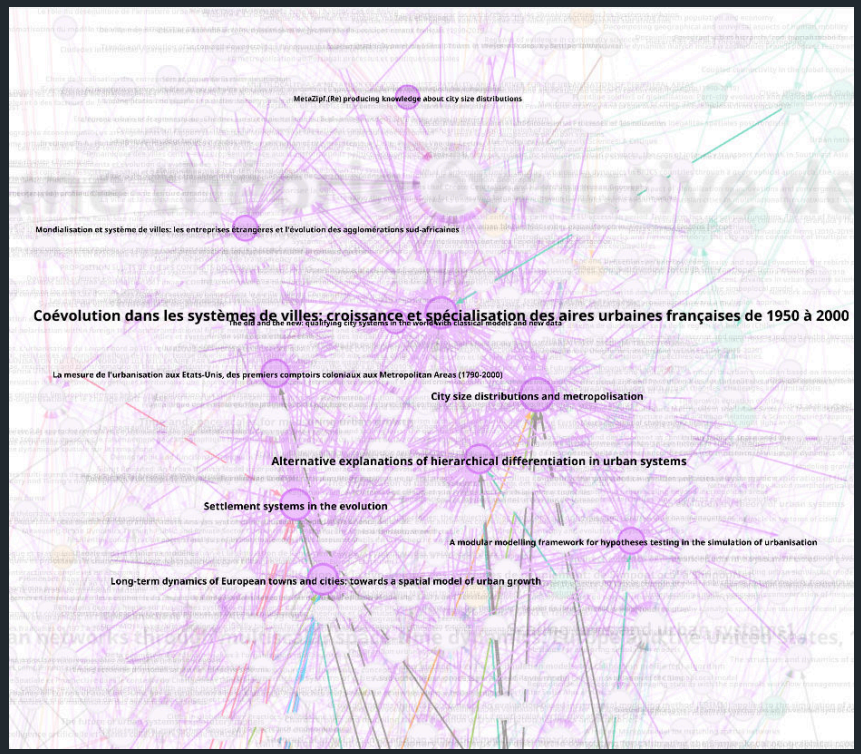
EUT:

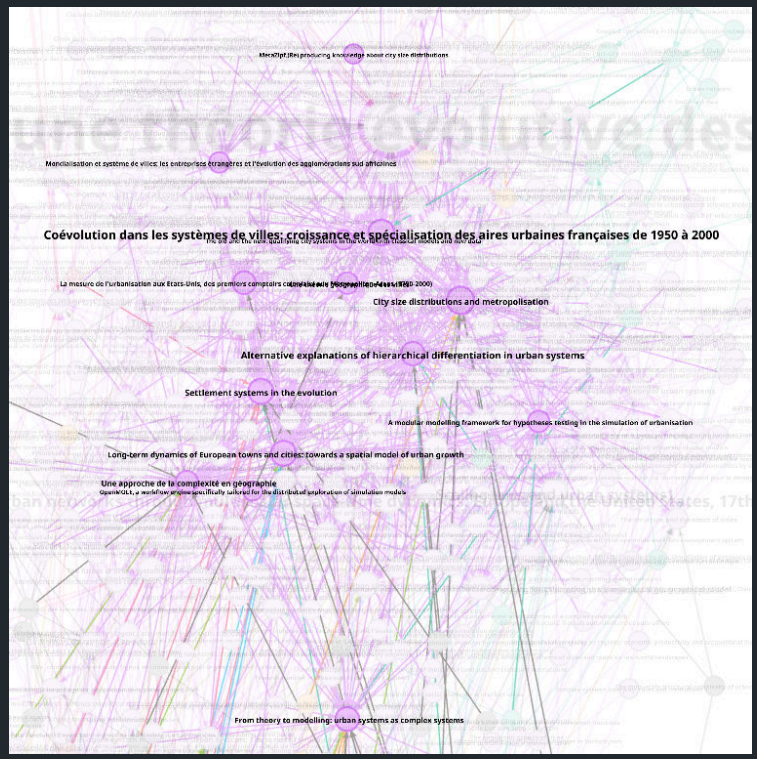
- Optimal communities: 0.496
- Knowledge domains: 0.0723
- Null model (100 bootstrap shuffling): -0.0008 ± 0.0049

Zipf:

- Optimal communities: 0.365
- Knowledge domains: 0.0664
- Null model: -0.0011 ± 0.0041

Results: key papers in the EUT





Papers with a "central" role: tool paper [Reuillon et al., 2013], and "data" paper [Cura et al., 2017].

Perspectives

Contributions:

- First quantitative approach to how knowledge domains interact
- Strong integration (low modularity) but still some structure (vs null model)
- Different interactions for EUT and Zipf

Perspectives:

- Machine learning models trained with the annotated data, for a systematic study of TQG (or more broadly urban science)
- Sensitivity analysis to initial corpuses and annotation noise
- Towards an endogenous construction of Knowledge Domains through functions of literature contributions?
- Similar work in progress on systematic model decomposition and mapping across a corpus

Code and data:

`https://github.com/JusteRaimbault/GeoTheoQuantIntegration`

References i

- Cottineau, C. (2017).
  Metazipf. a dynamic meta-analysis of city size distributions.
  PloS one, 12(8):e0183919.
- Cura, R., Cottineau, C., Swerts, E., Antonio Ignazzi, C., Bretagnolle, A., Vacchiani-Marcuzzo, C., and Pumain, D. (2017).
  The old and the new: qualifying city systems in the world with classical models and new data.
  Geographical Analysis, 49(4):363–386.

References ii

- Cuyala, S. (2016).
  The spatial diffusion of geography: A bibliometric analysis of ectqg conferences (1978-2013).
  Cybergeo: European Journal of Geography.
- Livet, P., Muller, J.-P., Phan, D., and Sanders, L. (2010).
  Ontology, a mediator for agent-based modeling in social science.
  Journal of Artificial Societies and Social Simulation, 13(1):3.
- Pumain, D. (1997).
  Pour une théorie évolutive des villes.
  L'Espace géographique, pages 119–134.

References iii

- Pumain, D. (2018).
  An evolutionary theory of urban systems.
  International and transnational perspectives on urban systems, pages 3–18.
- Raimbault, J. (2017a).
  An applied knowledge framework to study complex systems.
  In *Complex Systems Design & Management*, pages 31–45.

References iv


Raimbault, J. (2017b).
Invisible bridges? scientific landscapes around similar objects studied from economics and geography perspectives.
In *European Colloquium in Theoretical and Quantitative Geography 2017*.


Raimbault, J. (2019a).
A meta-analysis of models for interactions between transportation networks and territories.
In of Socio-economic Research, L. I., editor, *ECTQG 2019 Book of Abstracts, ISBN 978-2-9199594-0-2*, ECTQG 2019

Book of Abstracts, ISBN 978-2-9199594-0-2, Mondorf, Luxembourg.


Raimbault, J. (2019b).
Exploration of an interdisciplinary scientific landscape.
Scientometrics, 119(2):617–641.


Raimbault, J. (2023).
Validation of geosimulation models: a systematic review.
In *European Colloquium on Theoretical and Quantitative Geography 2023*, Braga, Portugal. Universities of Coimbra and Porto.

References vi

Raimbault, J., Chasset, P.-O., Cottineau, C., Commenges, H., Pumain, D., Kosmopoulos, C., and Banos, A. (2021). **Empowering open science with reflexive and spatialised indicators.** *Environment and Planning B: Urban Analytics and City Science*, 48(2):298–313.

Reuillon, R., Leclaire, M., and Rey-Coyrehourcq, S. (2013). **Openmole, a workflow engine specifically tailored for the distributed exploration of simulation models.** *Future Generation Computer Systems*, 29(8):1981–1990.


Sanders, L., Pumain, D., Mathian, H., Guérin-Pace, F., and Bura, S. (1997).
Simpop: a multiagent system for the study of urbanism.
Environment and Planning B: Planning and design, 24(2):287–305.