ERC GeoDiverCity

Confidence in the future of cities and regions

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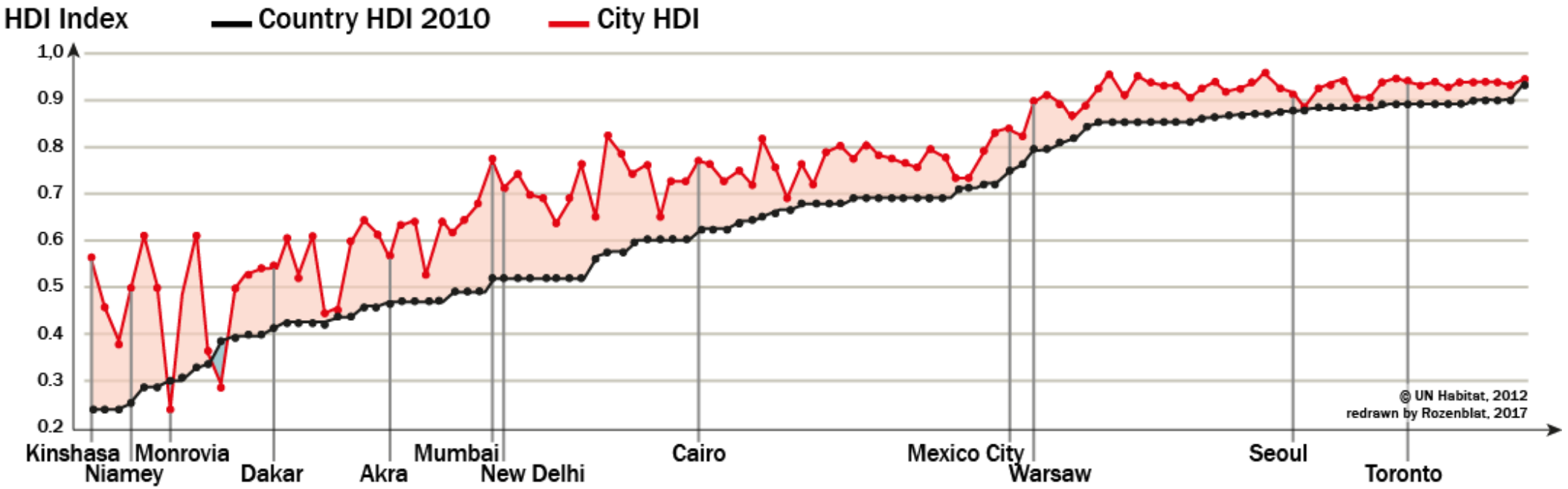
Human development indices of cities still > the value in their country



[Source: Habitat, 2015]

Values of cities and systems of cities

Different expressions of value attached to cities:

- attractivity: densities 10 to 1000 x > rural world
- monetary value: urban land and real estate values 10 x > those of surrounding coutryside
- capitalisation: accumulations of wealth up to those of country states or large firms
- adaptability: cities and systems of cities are societal adaptors (creating and diffusing political, social, technological, cultural… innovations)
- resilience(sustainability): systems of cities since Antiquity, persistency of many urban locations

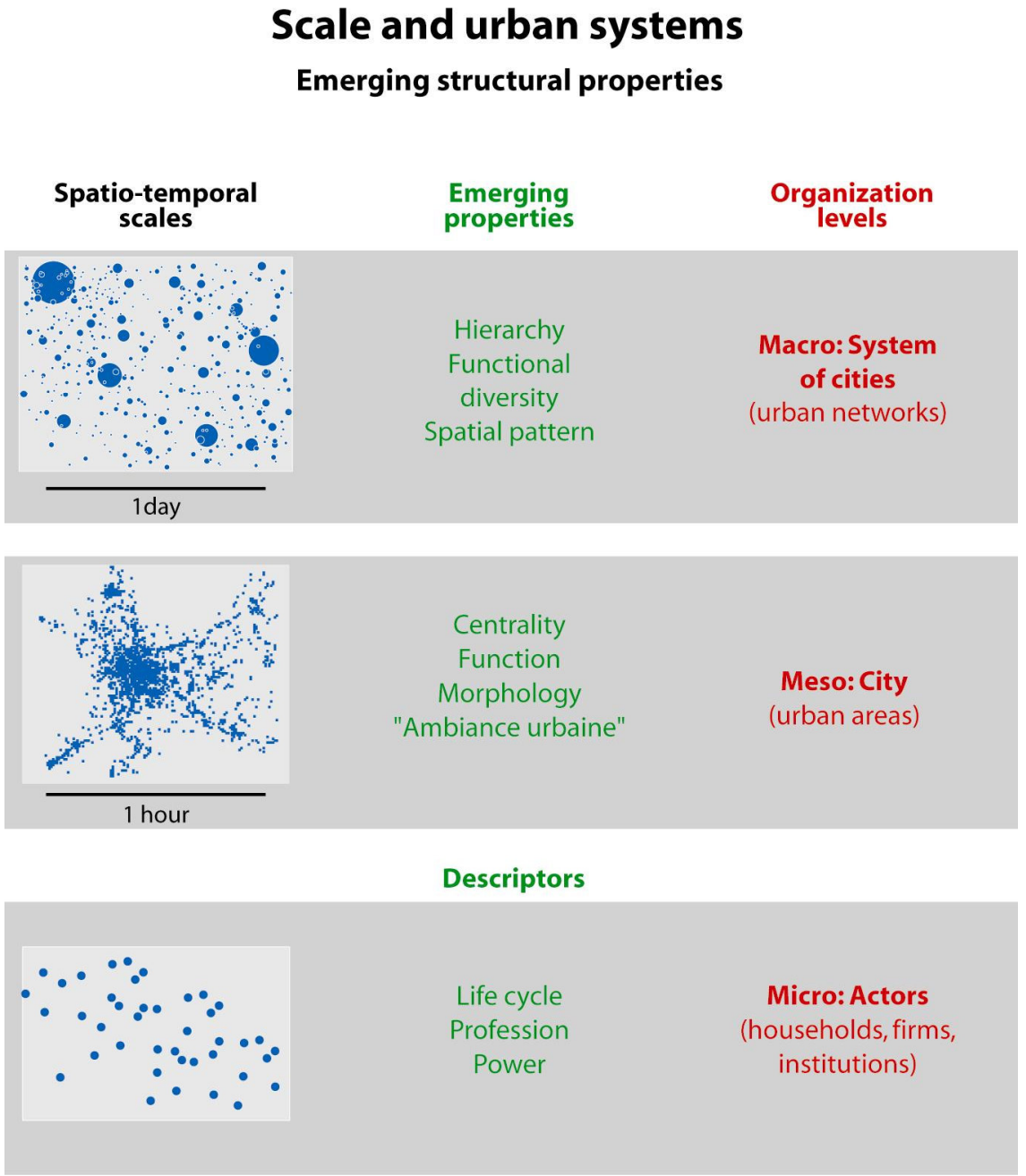
➔ an invention partly directed and partly self-organised of human and societal collective intelligence

Recent challenges for urban systems

- Climatic change → ecological transition: are cities the best places to invent massive adaptive strategies ?
- Pandemics and teleworking → migrations back toward small and medium towns?
- Communication technologies → toward redispersion of human activities?

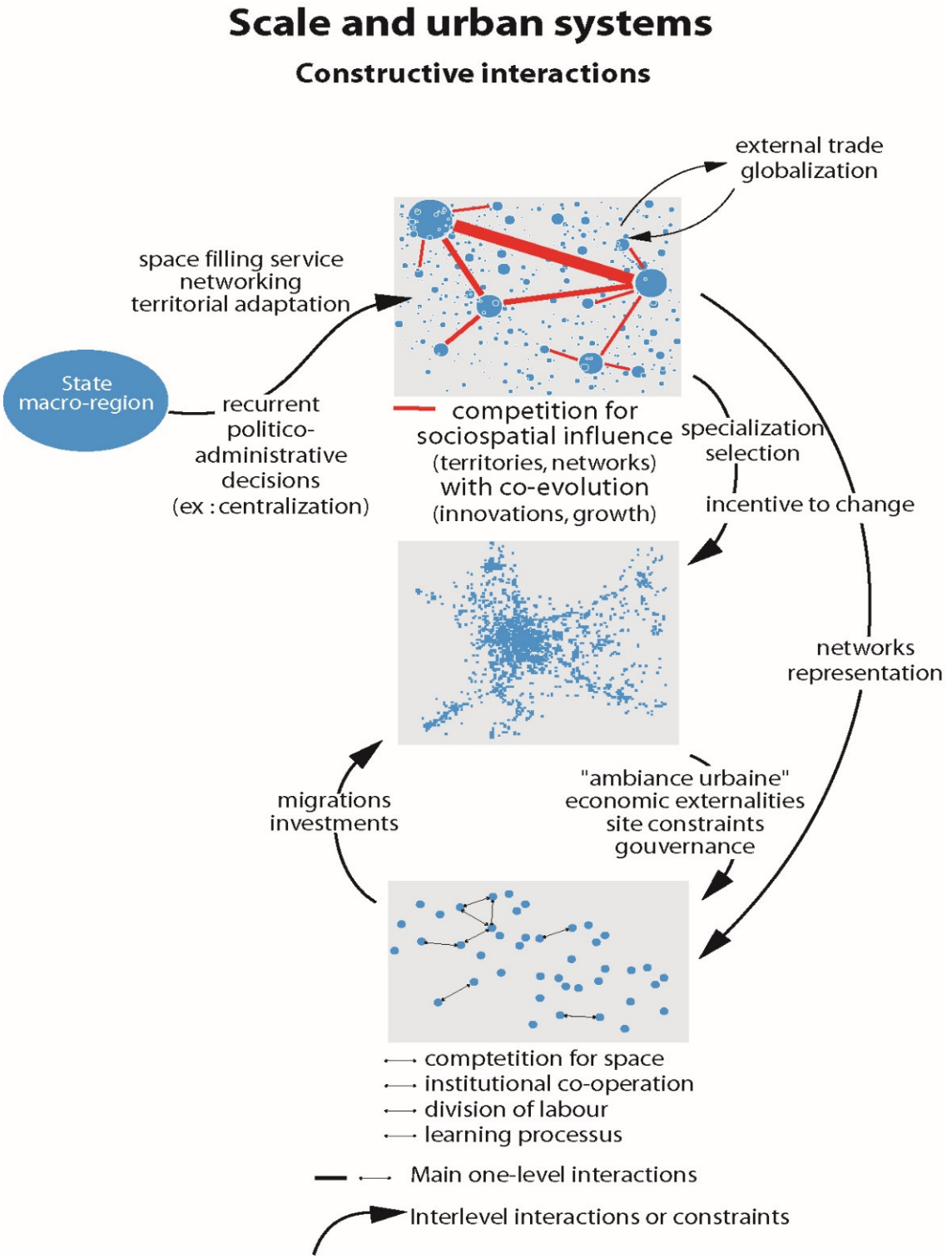
Geographical ontology for urban systems

Two levels: Cities and Systems of cities



[Pumain D. Hierarchy in natural and social sciences, Springer, 2006]

Adaptive multi-levels interactions ➔ cities' co-evolution



[Pumain (ed), 2006 Hierarchy in Natural and Social Sciences, Springer]

What is known about urban growth?

- Apparent direct causes : intentions/actions from urban actors (policies, locational strategies from firms, residential migrations…)
- But statistical observation (thousands of cities, over centuries) : each city has a probability of growing similar to other cities belonging to the same territorial system

= « distributed growth » on the long run with many local and temporal fluctuations

Statistical formalization

Gibrat's model

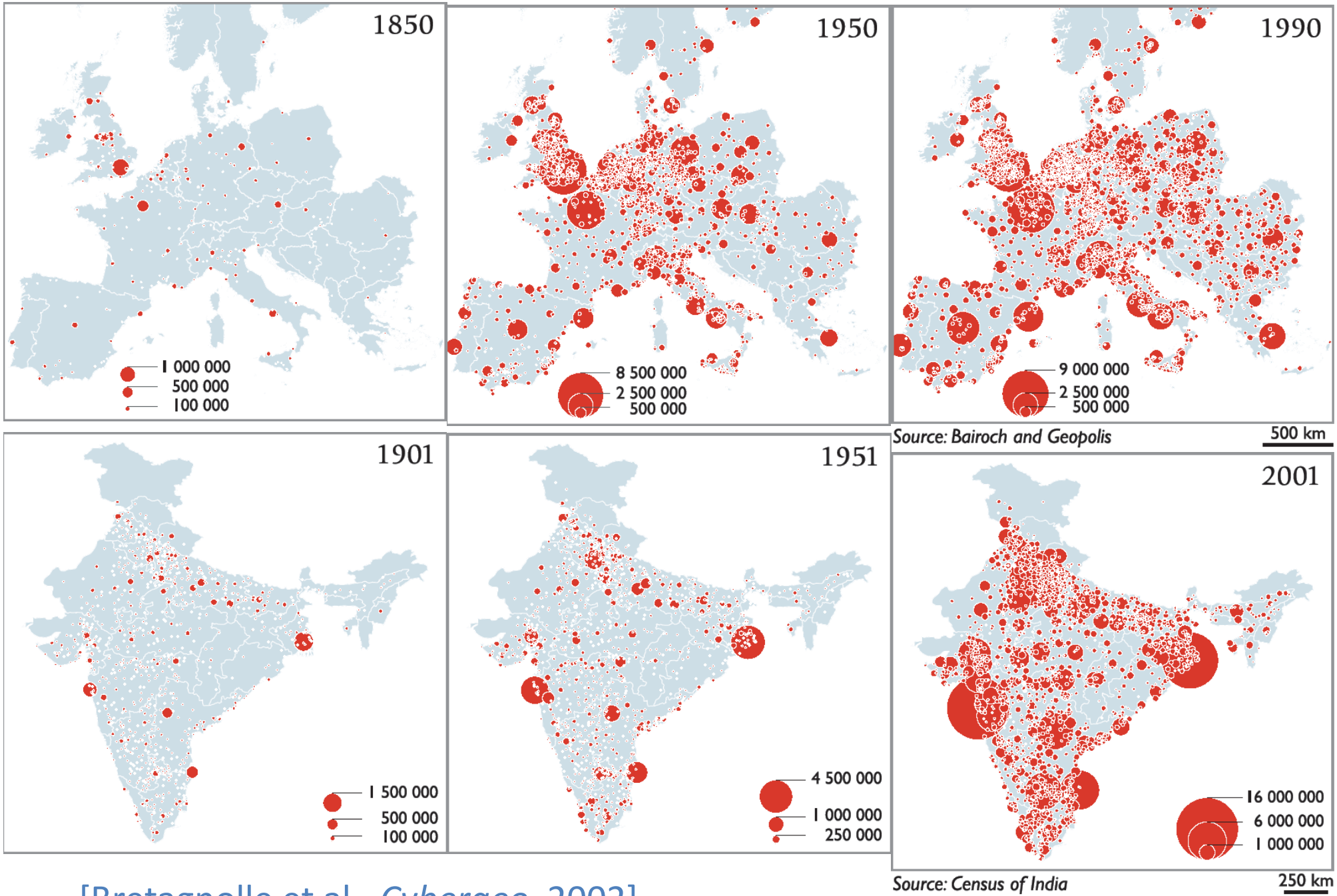
« proportional » (i.e. multiplicative) growth = growth rates are equiprobable ∀ city size and not correlated with previous rate

Good fit ➔ double gain in explaining:

- Persistency of urban spatial patterns and hierarchies
- The statistical shape of urban sizes distribution (Zipf's law or lognormal ≈ H. Simon ≠ P. Krugman) as generated from growth process through innovation adoption

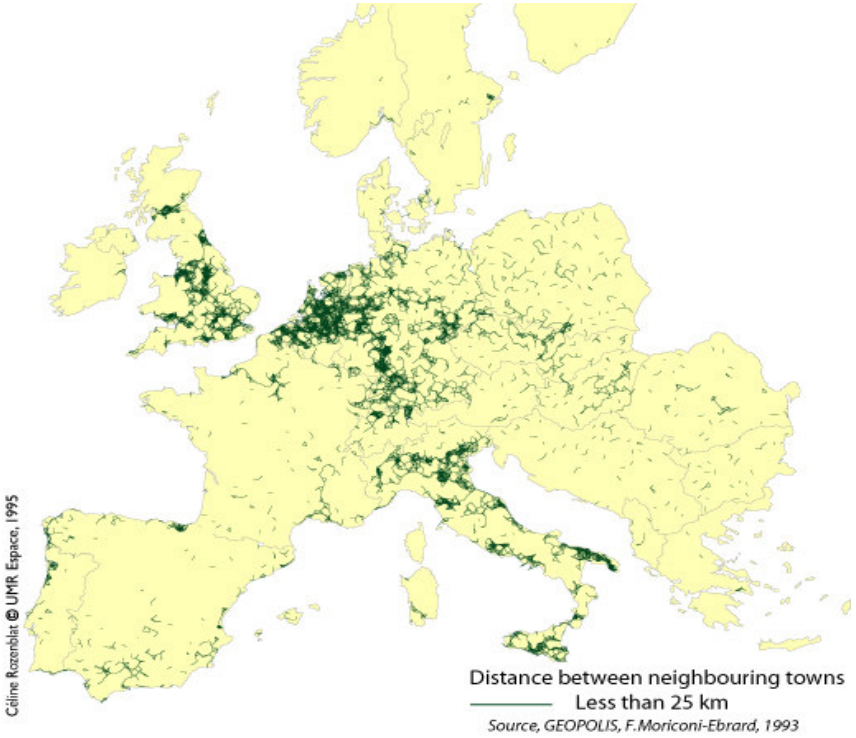
[Gibrat, 1931, Robson, 1973, Pumain, 1982]

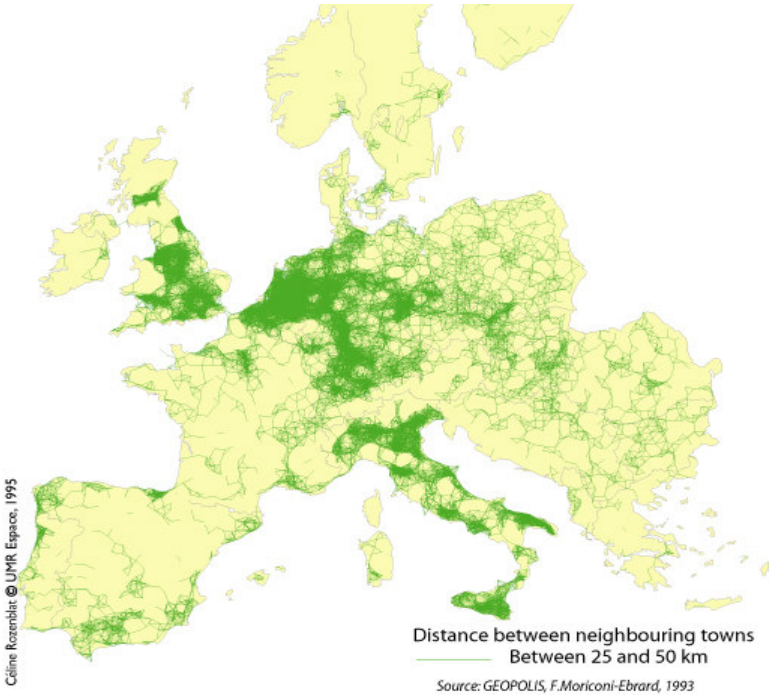
Urban systems Europe and India

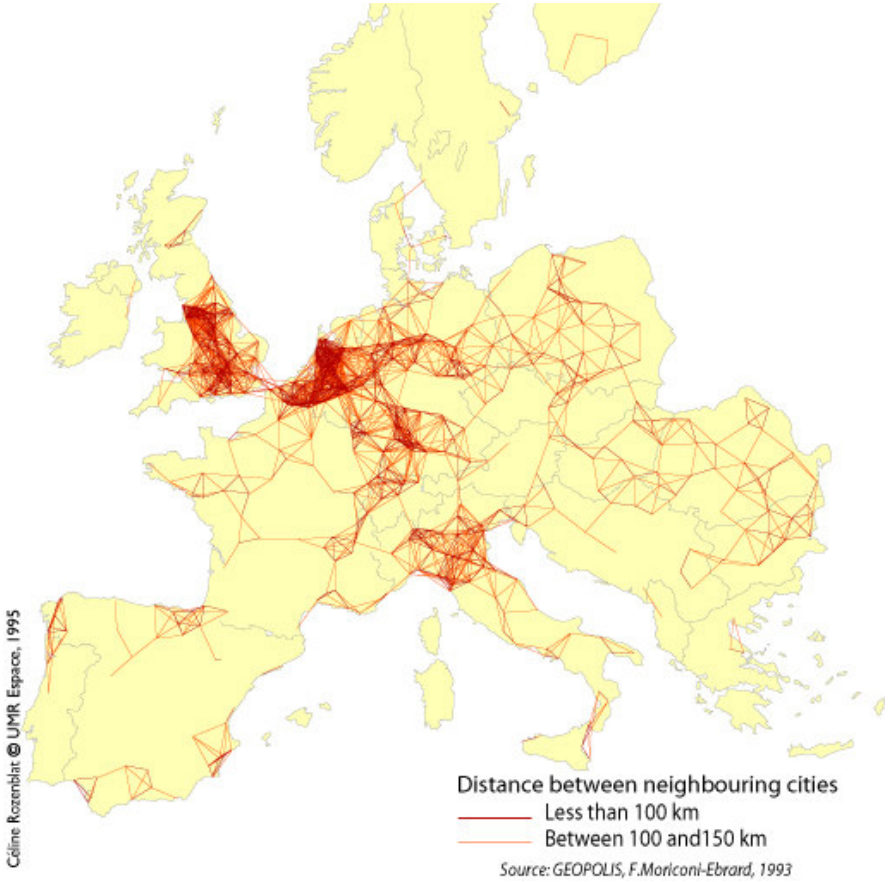


[Bretagnolle et al., *Cybergeo*, 2002]

Robustness of three settlement styles in Europe



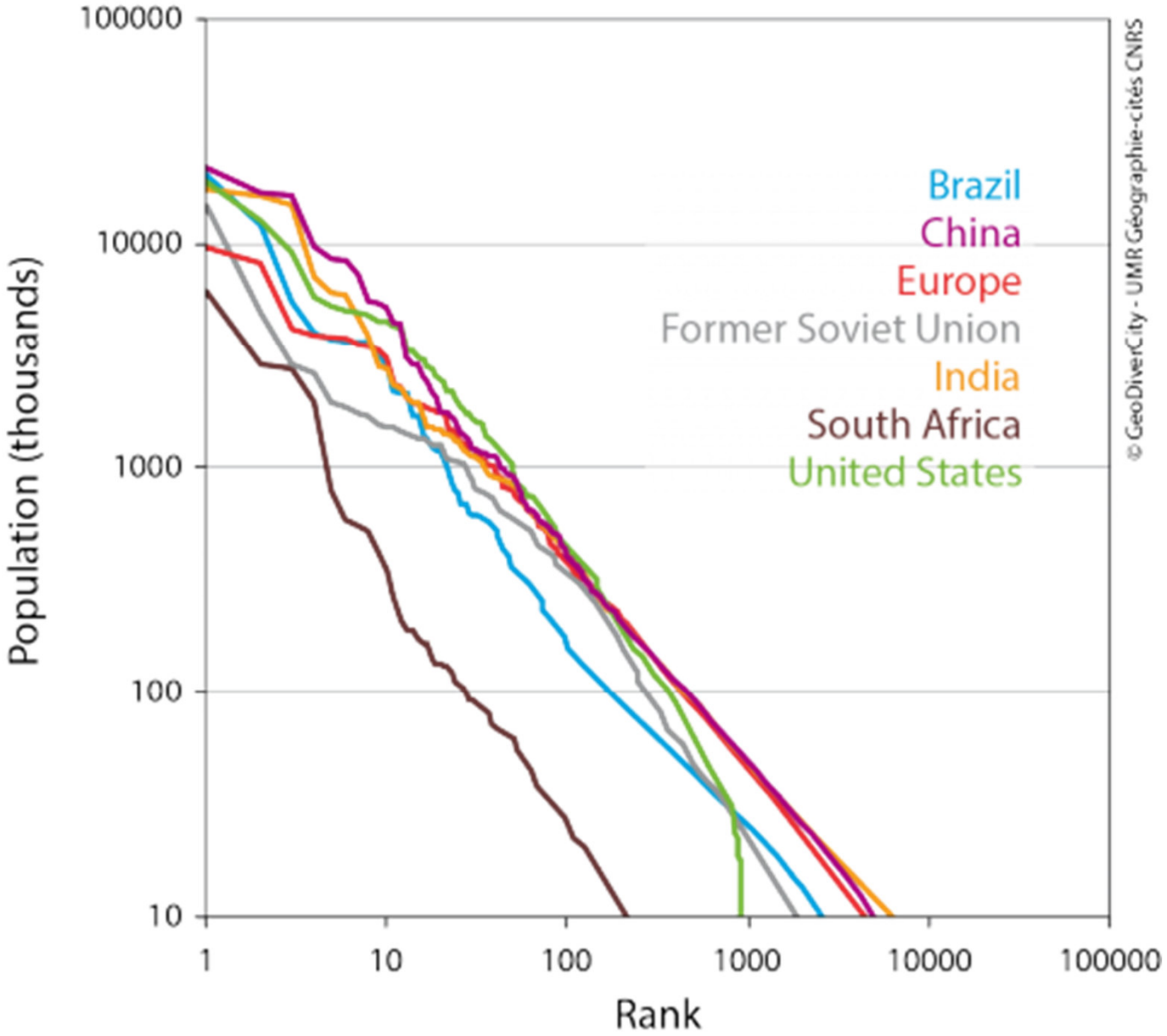




[Céline Rozenblat, Mappemonde,1995]

Zipf's law for 7 systems of cities

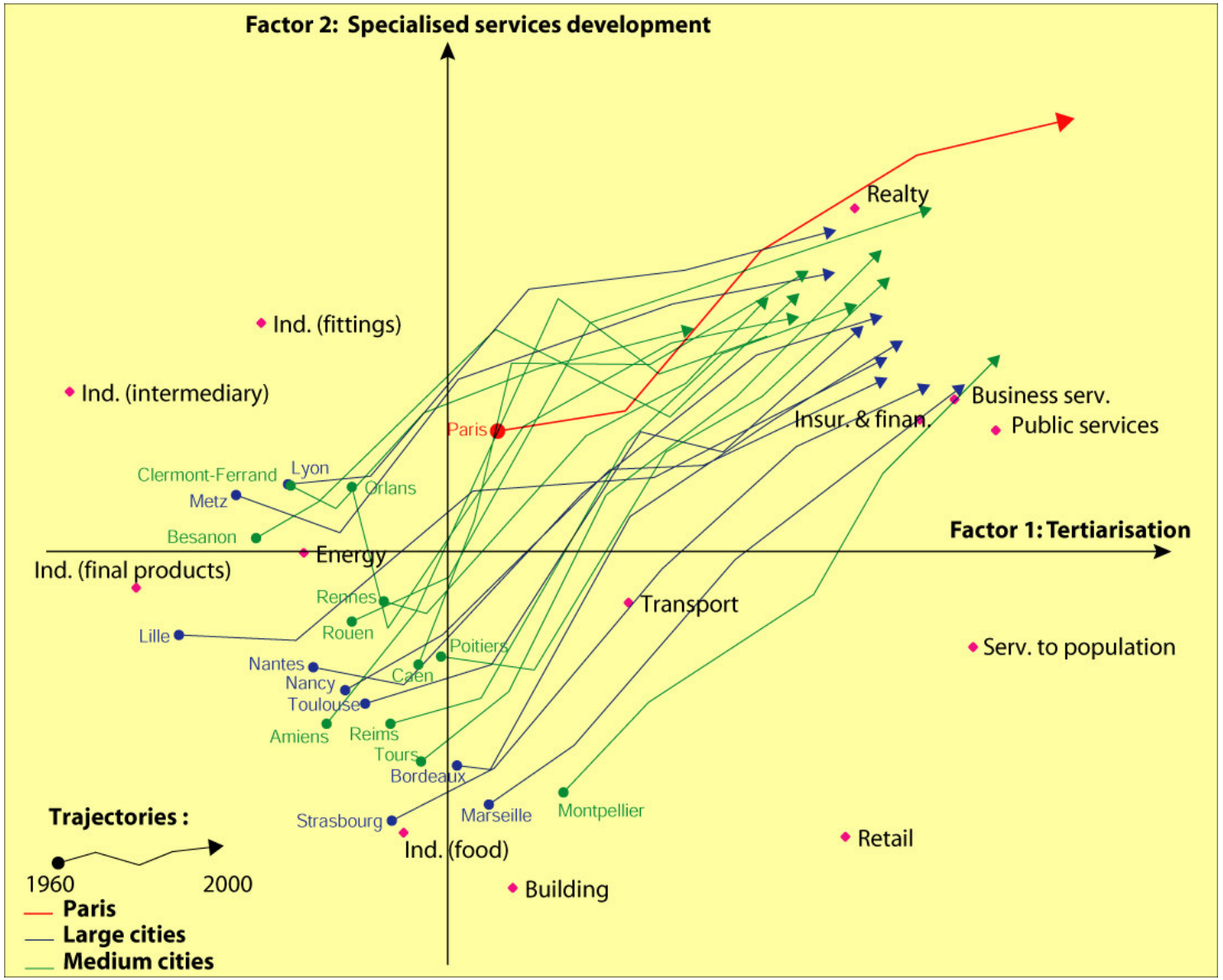
Zipf's law:
Urban sizes continuum over more than 4 orders of magnitude
(10^3 à 10^7 inhab.)



[GeoDiverCity, Pumain et al. *Cybergeo* 2015]

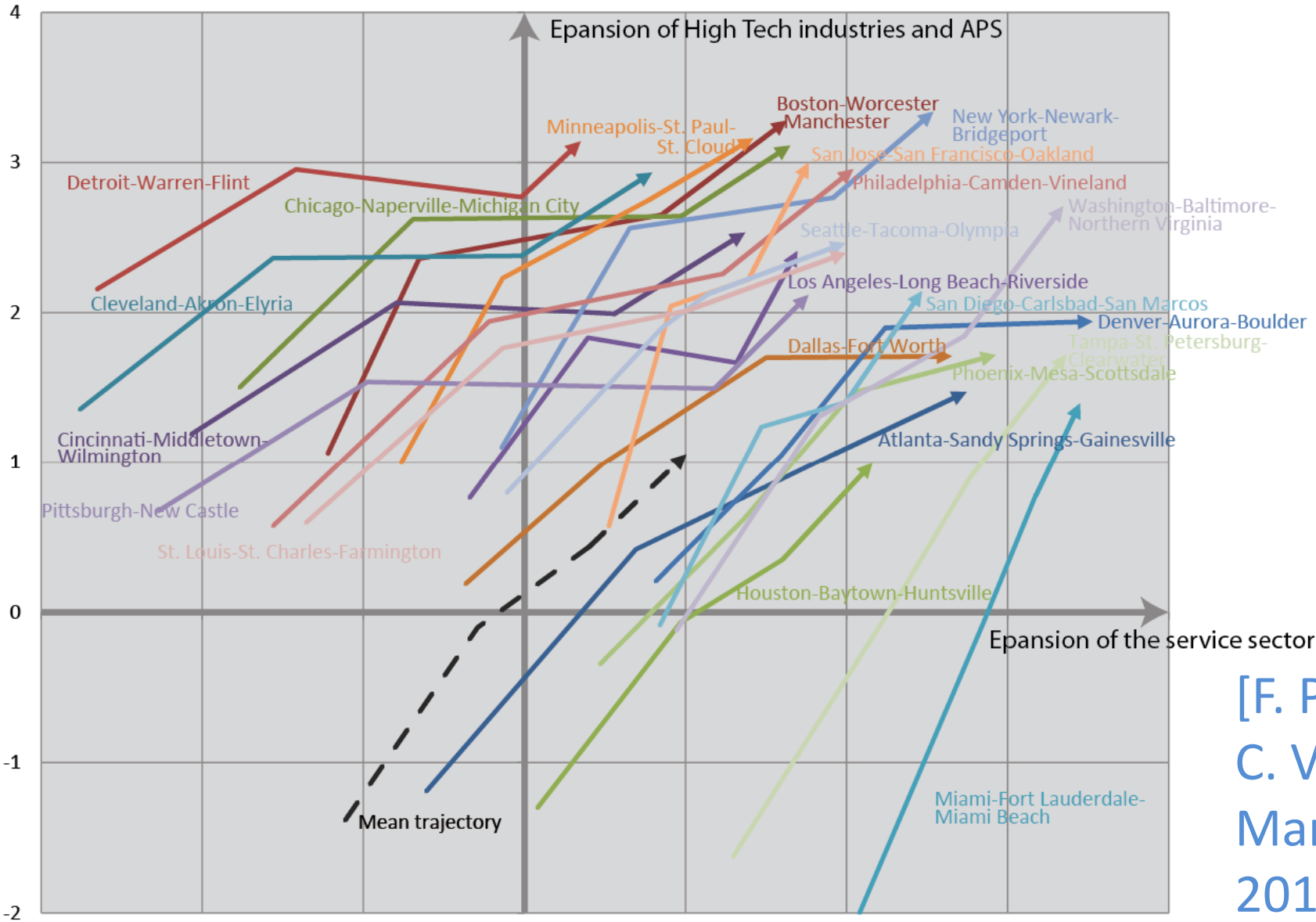
Qualitative socio-economic co-evolution = propagation of societal innovation

PCA on French cities' economic profiles 1960-2000



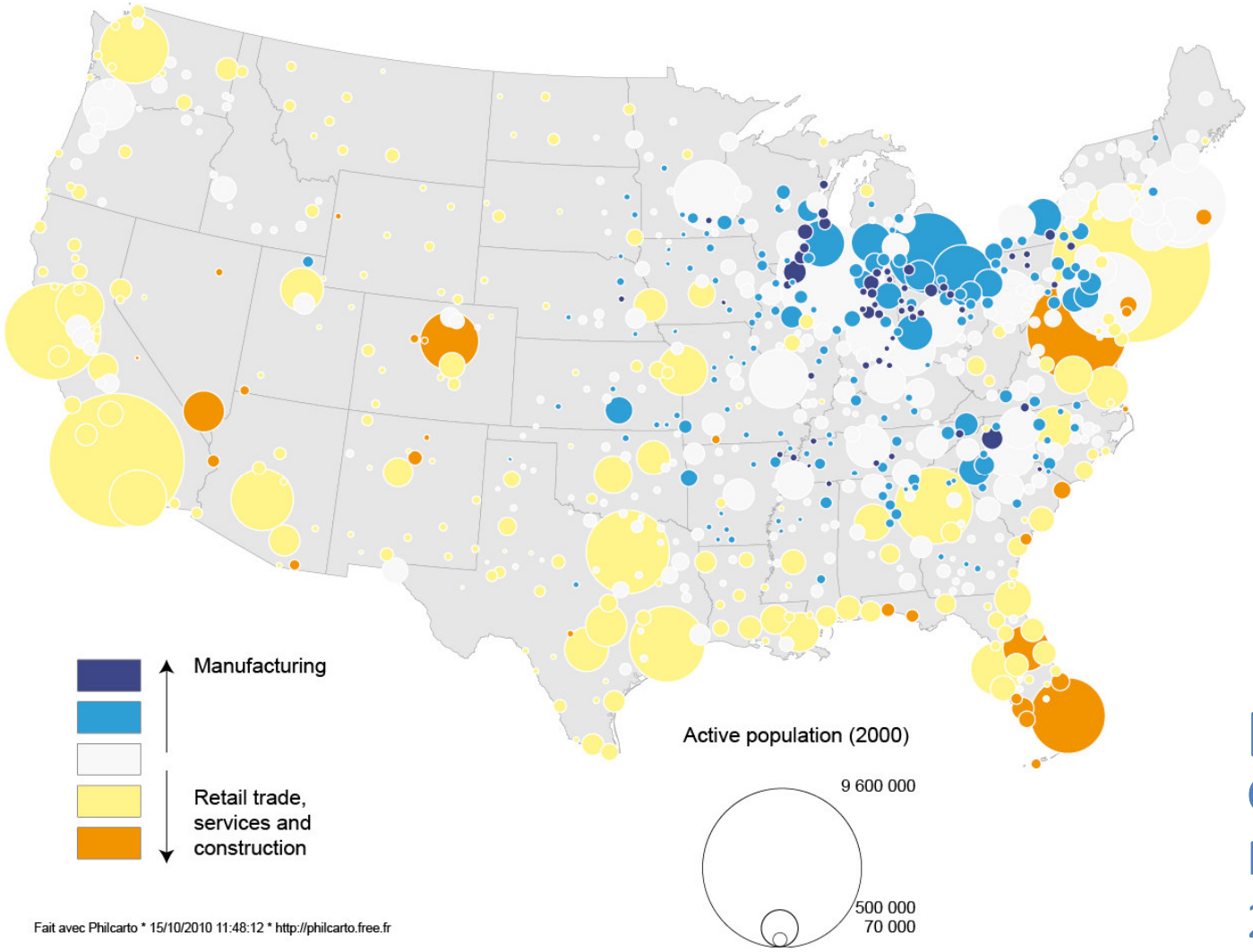
[F. Paulus, 2003]

Co-evolution US cities >2 M inhab.



[F. Paulus C. Vacchiani-Marcuzzo, 2011]

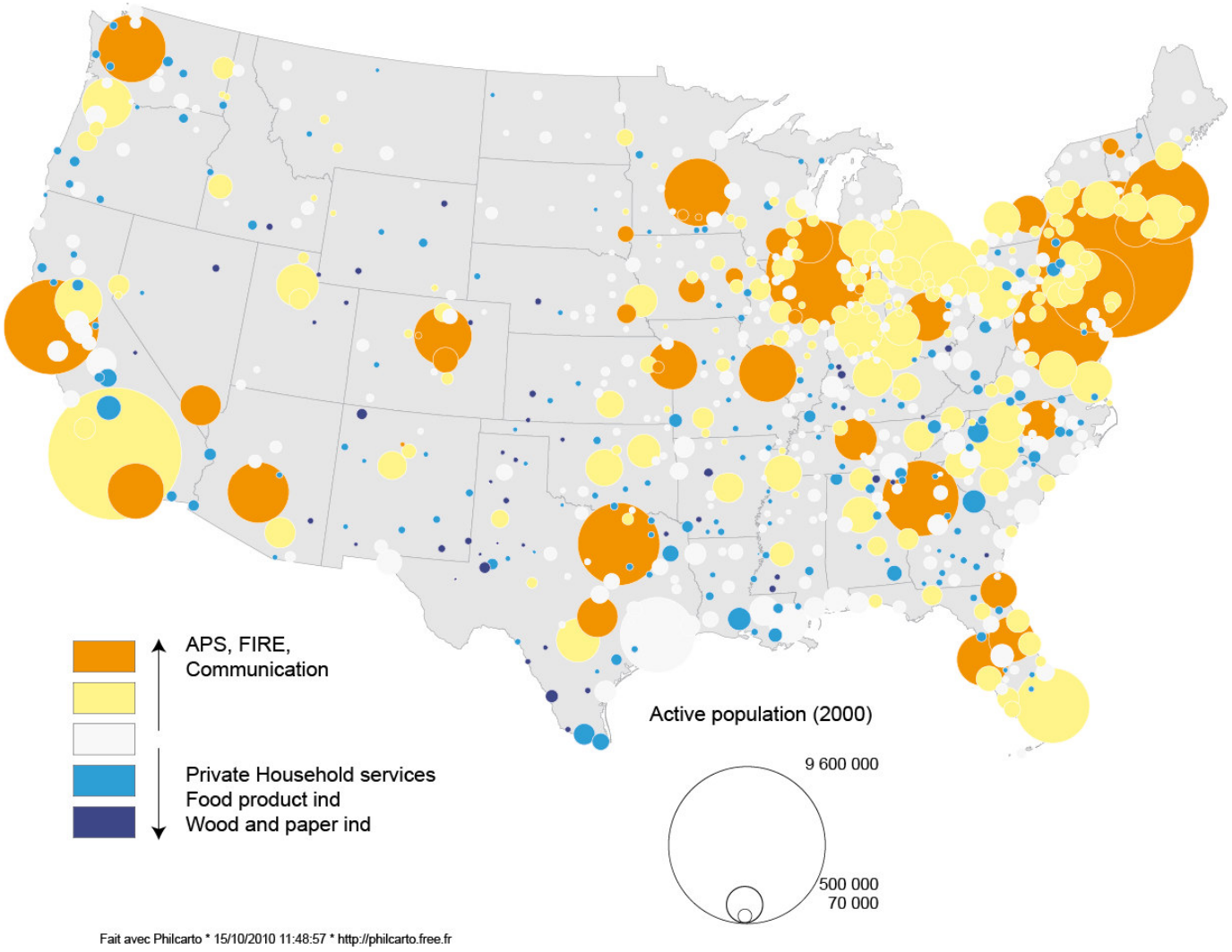
Major economic differentiation of US cities =trace of innovation wave 19th century



1st factor of PCA= manufacturing/ services (differentiation at regional scale)

[F. Paulus C. Vacchiani-Marcuzzo, 2011]

Second economic differentiation
= trace of recent economic cycles



2d factor of PCA
= new/old
services
(hierarchical diffusion)

[F. Paulus
C. Vacchiani-Marcuzzo, 2011]

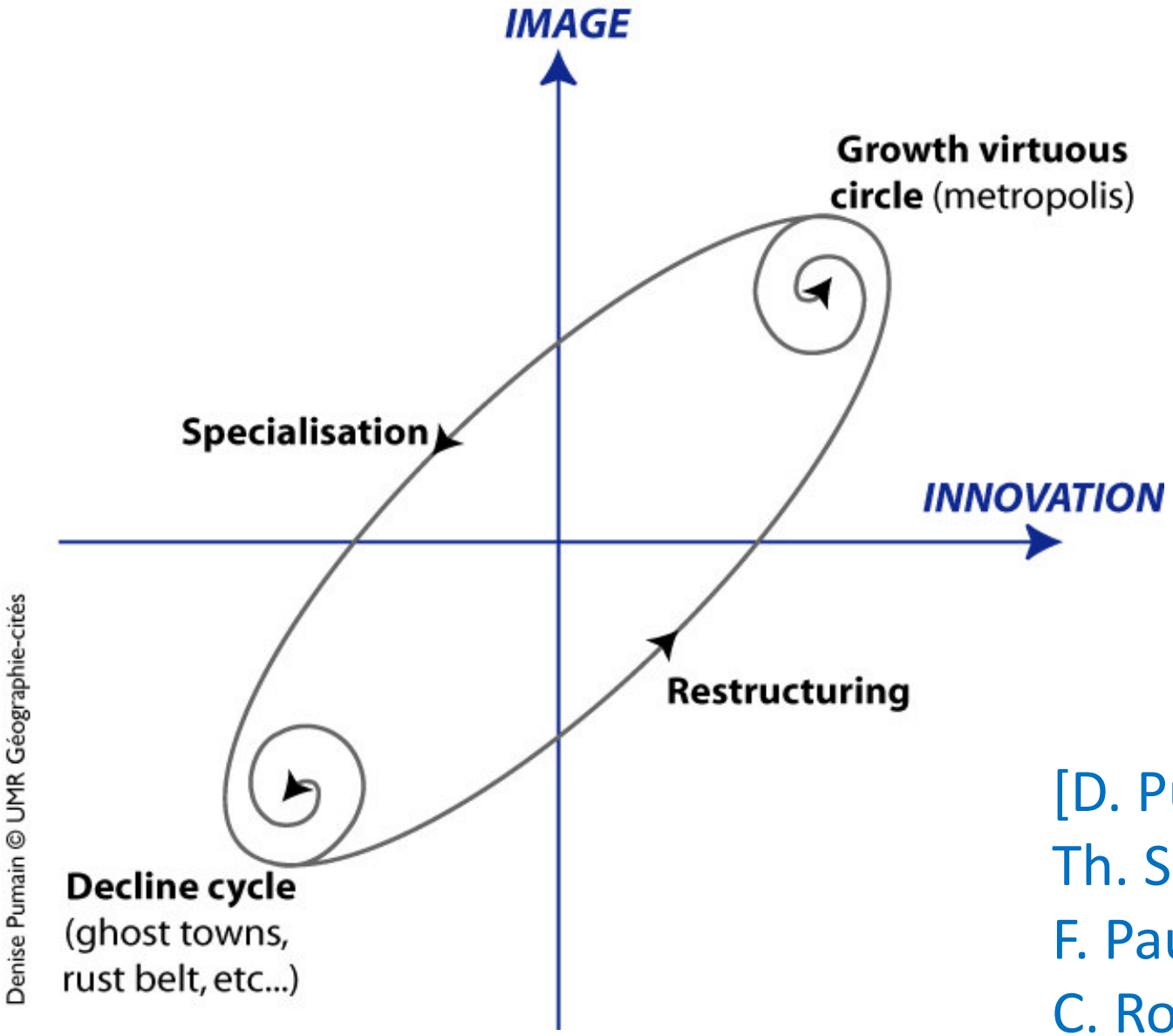
Another progress in explanation

Size unequalities and qualitative socio-economic differences beyween cities are traces of their co-evolution (= interactive adaptation with feedbacks to the innovations they create)

Are now explained :

- systematic observed deviations / Gibrat's statistical model
- emerging properties of systems of cities (hierarchy and functional diversity)
- bifurcations of individual urban trajectories

Innovation as key factor of urban adaptive process



[D. Pumain
Th. Saint-Julien
F. Paulus
C. Rozenblat]

A small town in Tuscany…

San Miniato where the story starts (July 1982)

Transformations through space and time
(NATO Advanced Studies Institute, Dan Griffith)

Participants (San Miniato, 1982)

R.J. Bennett, Cesare Bertuglia, H. Bottcher, Roberto Camagni, William Clark, Leslie Curry, Dimitrios Dendrinos, Lidia Diappi, Dan Griffith, Günter Haag, Richard Haining, Giorgio Leonardi, Silvana Lombardo, Bernard Marchand, Peter Nijkamp, Silvia Occelli, Jean Paelinck, Giorgio Papageorgiou, Denise Pumain, Giovanni Rabino, B. Ralston, Aura Reggiani, Lena Sanders, C. Schonebeck, Eric Sheppard, Michael Sonis, …..and many others…

Presentation by Günter Haag « A dynamic model for the non linear migration of human population » (from the book: W. Weidlich and G. Haag: *Quantitative Sociology. Concepts and Models for the dynamics of interacting populations*. Springer series in synergetics, vol. 14, 1983.

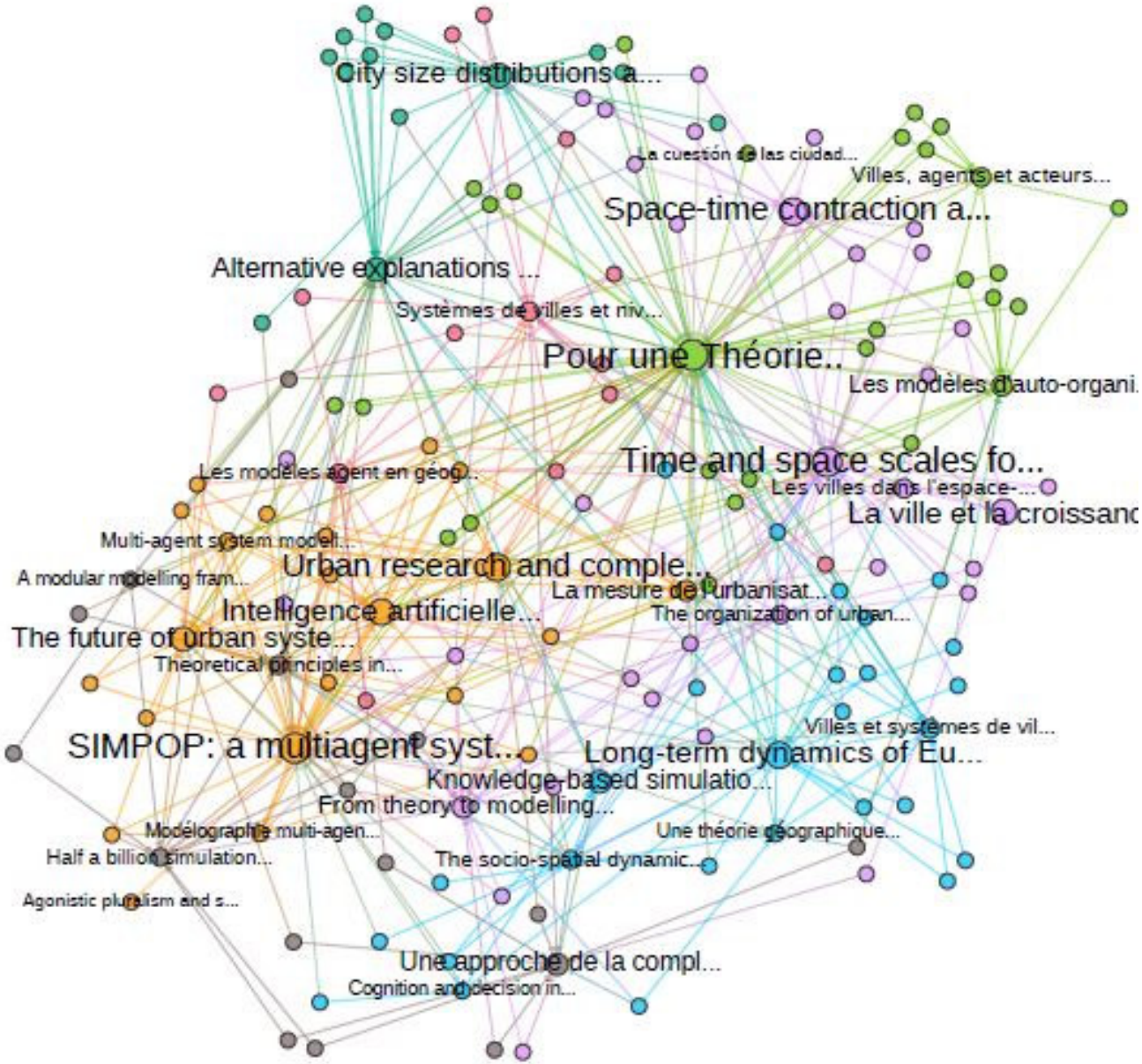


Fig. 1. Citation Network of main publications of Evolutive Urban Theory. The network is constructed the following way: starting from the two seminal publications [15] and [21], we get citing publications, filter conditionally to one of the main contributors, get again citing publications and filter. Nodes are publications ($|V| = 155$), the size corresponding to eigenvector centrality, and edges are directed citation links ($|E| = 449$). Colors are communities obtained with Louvain clustering algorithm (7 communities, modularity 0.39).

[Raimbault 2018]

Hybridating geographical knowledge with simulation models of complex systems

- Self organization : simulation models using systems of non linear differential equations :

➔Prigogine, P. Allen, M. Sanglier

➔Master equation: G. Haag and W. Weidlich

- Computation models with multi-agents systems

Reconstructing urban trajectories with multi-agents systems

- Reconstructing past urban trajectories within their historical and geographical context is a first necessary step for testing the relevance of our theoretical explanation

- = a condition for ensuring the quality of projections estimating future relative positions of cities within inter-urban competition, thus for adjusting intelligent urban policies.

SIMPOP: a multi-agents system

First application of MAS in geography !

Bura, Guérin-Pace, Mathian, Pumain, Sanders, Multi-agent systems and the dynamics of a settlement system. *Geographical Analysis*, 1996, 2, 161-178

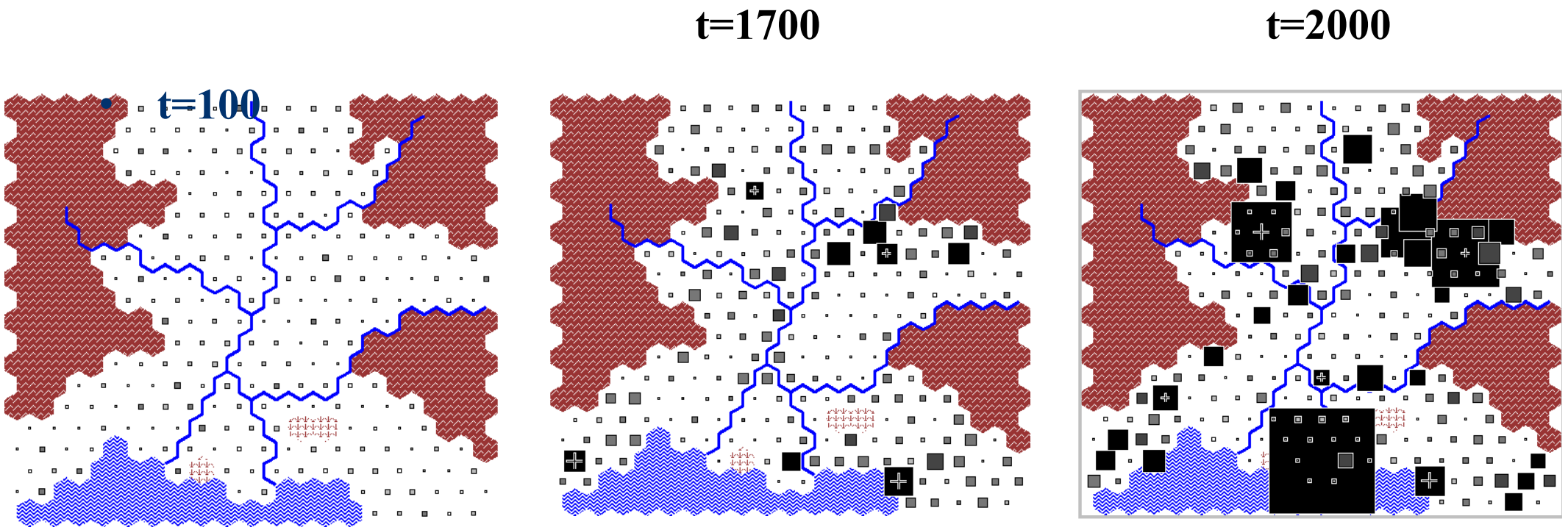
Main results:

- No emergence if no spatial interactions
- Emergence of a polycentric hierarchised system of cities even if homogeneous initial conditions
- A renewed innovation flow is necessary for maintaining structural properties of the system of cities

Pending questions: which validity of estimated parameters?

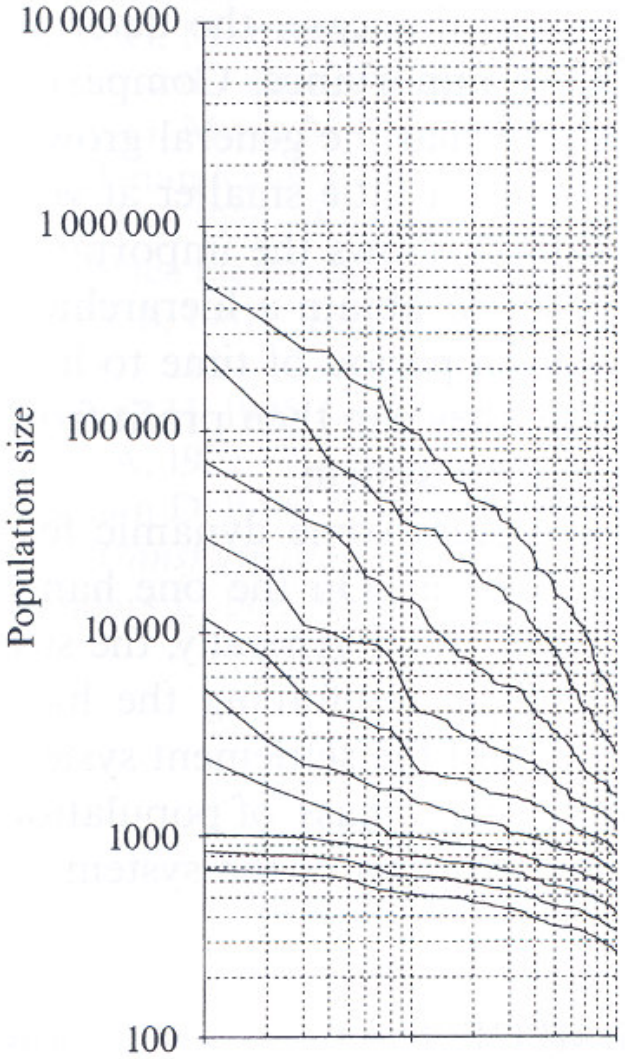
Conditions are sufficient , are they necessary?

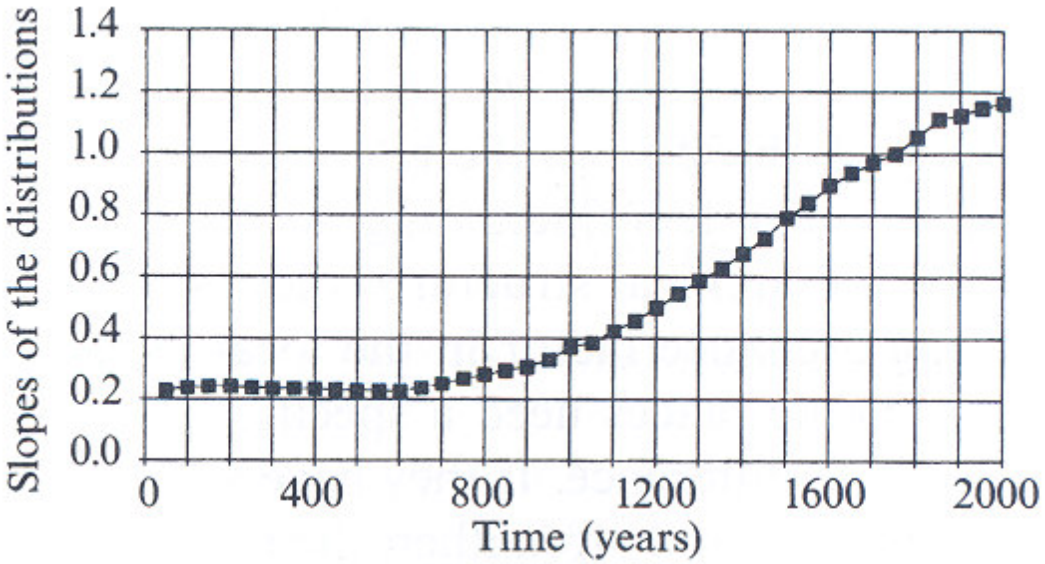
The SIMPOP model: emergence of a polycentric system of cities



Starting from a rather regular distribution of settlements, a system of cities emerges, with a strong hierarchical and spatial organization :[Bura, Guérin-Pace, Mathian, Pumain, Sanders, 1996, 1997]

Emerging hierarchical differentiation of the settlement system (rank-size distribution)





t = 2000

t = 1600

t = 0

[Source: SIMPOP model, Sanders et al.1997]

Originality of SIMPOP2 Model

- Scale: national or continental integrated urban systems, long term
- Cities are agents : collective, immobile, heterogenous, evolving entities
- Main attributes: location, resources (labour force, capital), functions (10 types)
- Three levels: individual (firm or mayor, for scenarios), cities (local governance), national or multinational (global governance)
- Rules : stylised facts from comparative study of the observed evolution of integrated urban systems

Two types of modelling teams

- 1995-2010 : 3 PhD students in computing from 3 different labs Ferber, Drogoul, Giavitto/Hutzler help geographers (S. Bura, B. Glisse, T. Louail)

➔ Three models each in a different langage (Smalltalk, Swarm, C++…), not reusable

Institutional event : ERC adv. grant GeoDiverCity

- 2010-2015: real daily team work between 4 computer scientists (Reuillon, Leclaire, Chapron, Cherel) and PhD in geography and geomatics (C. Schmitt, C. Cottineau, S. Rey-Coyrehourcq, E. Swerts, A. Ignazzi, S. Baffi, O. Finance)

➔ Models on systems of cities in Europe, USA, BRICS with OpenMOLE platform (evolutionary algorithms and distributed computing)

Urban trajectories to reconstruct

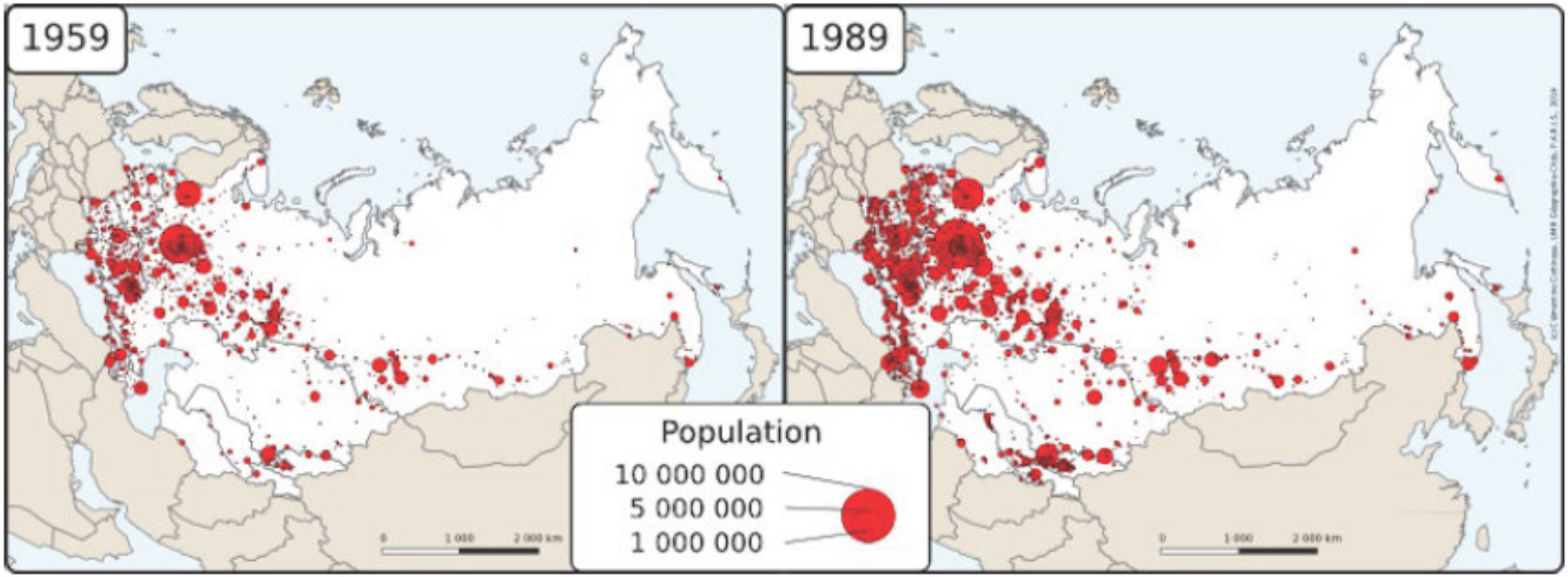
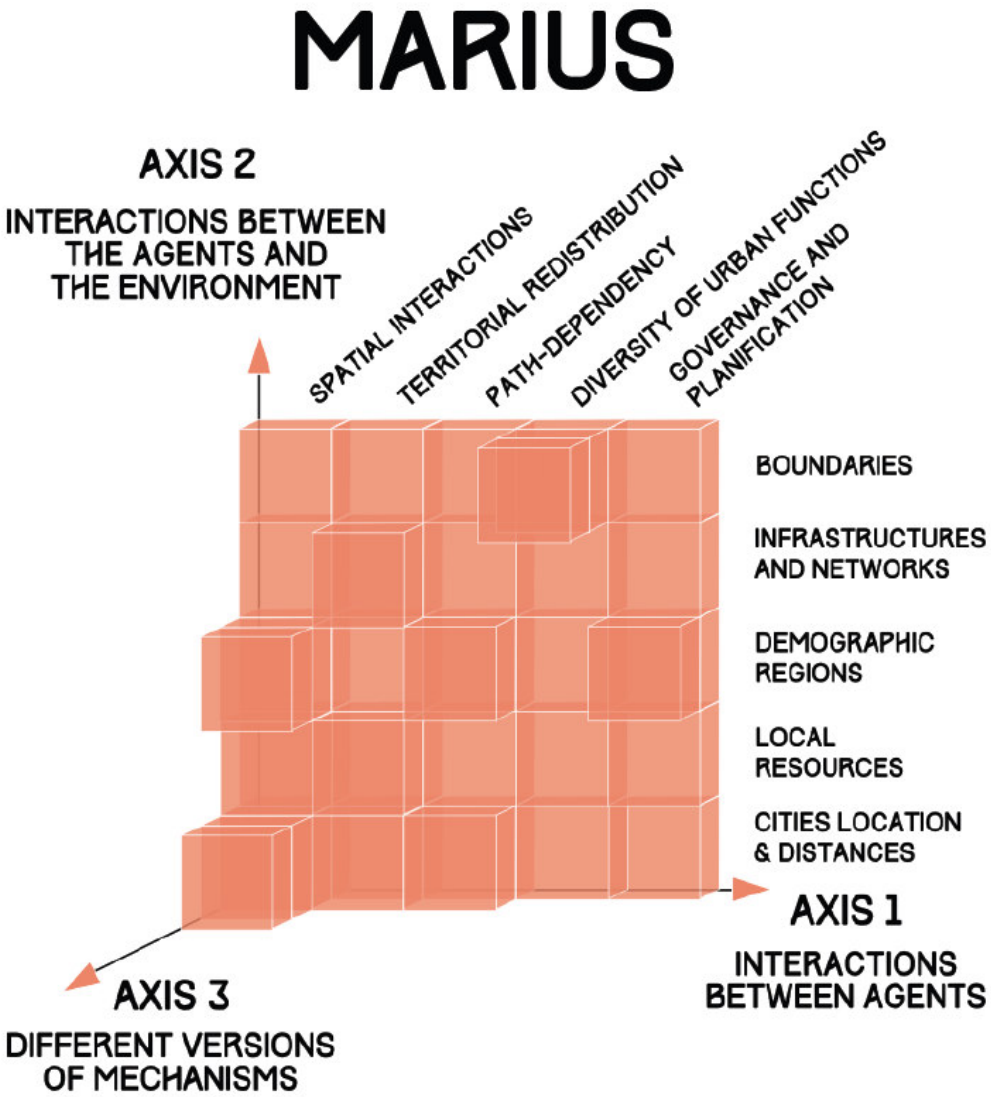


Figure 2. Empirical spatial and hierarchical distribution of cities in the post-Soviet space
source: DARIUS, 2014

[Cottineau et al., 2015, JASS]

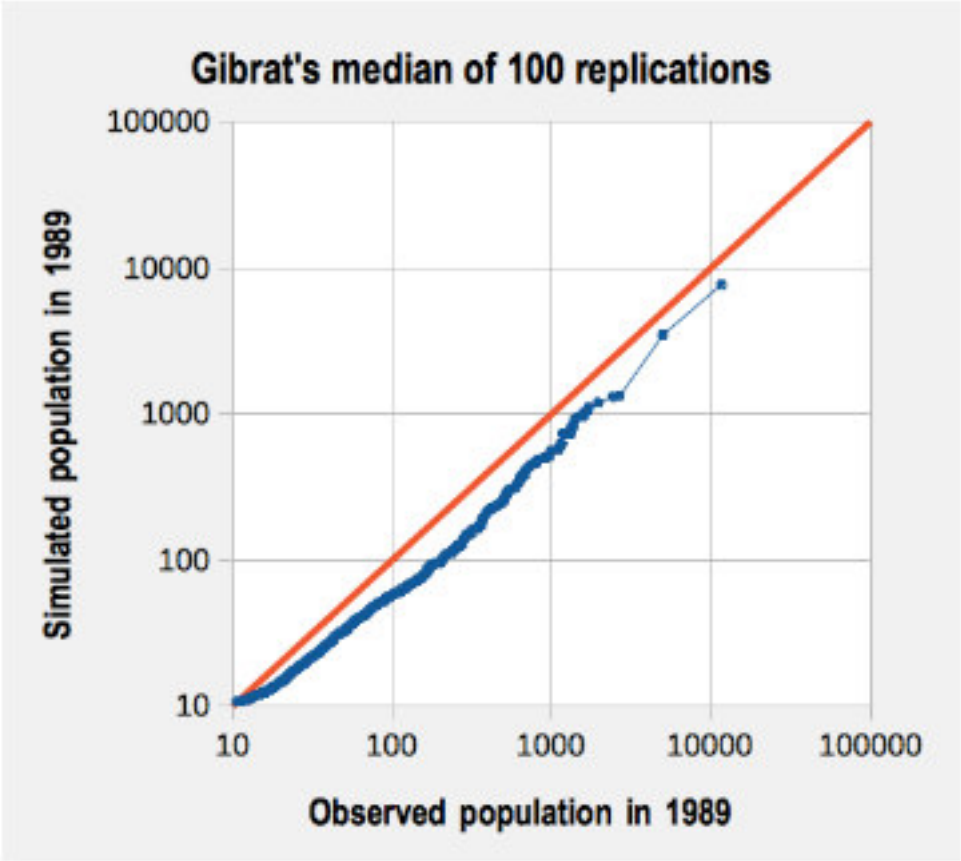
New modelling method: building multi-models



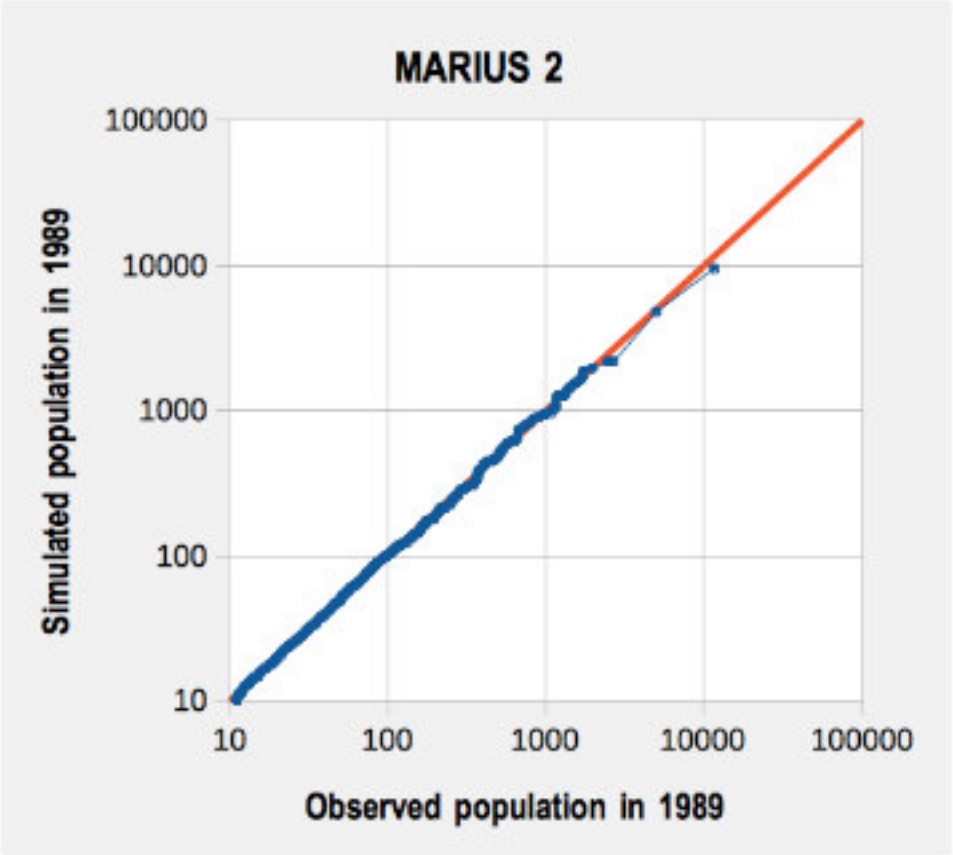
[Cottineau, Chapron, 2015]

Networking boosts urban growth: model with interaction fits better than random growth

Gibrat's model



model with interactions



[Cottineau, 2014]

Further advances in explanation

- No counter-urbanisation (≠ Berry, 1976), increasing hierarchisation > Gibrat' model prediction

(Bretagnolle, Pumain, Rozenblat, 1997, *Cybergeo*, 61, Bretagnolle, Mathian, Pumain, Rozenblat 2000, *Cybergeo* 131, Bretagnolle, Paulus, Pumain 2002, *Cybergeo*, 219)

➔ « metropolisation » and « simplification from below of urban hierarchies (cf. « shrinking cities »)

- « Global cities since Middle Age » (Bretagnolle, Pumain, 2010, *Urban Studies*)

Toward providing proofs in social sciences

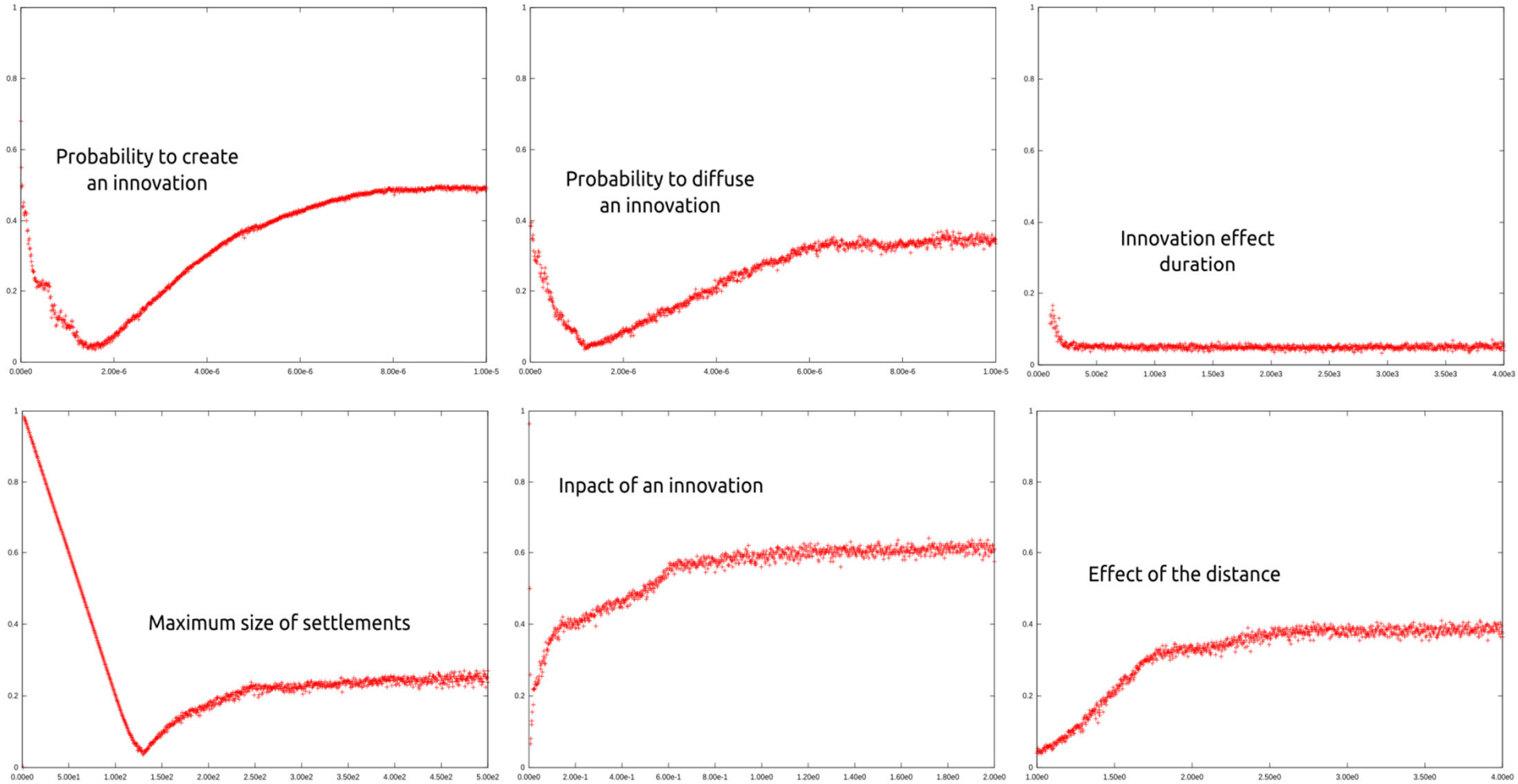
With SimpopLocal model (Clara Schmitt & Sébastien Rey-Coyrehourcq) and simulation platform OpenMole (Romain Reuillon, Mathieu Leclaire)

➔ Proof: hypotheses are sufficient…and necessary!

➔ Schmitt C., Rey-Coyrehourcq S., Reuillon R., Pumain D., 2015, Half a billion simulations, Evolutionary algorithms and distributed computing for calibrating the SimpopLocal geographical model, *Environment and Planning B, 42, 2,300-315.*

- Calibration profile: Romain Reuillon

Best solutions in parameter space (SimpopLocal model)



[Schmitt, Reuillon, 2014: Calibration profile method]

Embedded dynamic trends

- Driving forces of urban growth are not demography, but economy
- Transnational firms mainly invest in large metropolises central areas
- Financial groups in construction favor sprawl around largest cities in developing countries
- Urban residents favor well equipped centers (airports, universities, job diversity)
- More shrinking cities in lower part of urban hierarchies

Urban systems=territorial intelligence

- Cities and systems of cities are the best (resilient) tool invented by societies for managing their environment through pervasive, creative and proactive adaptation.
- They adapt to evolving institutional and technological conditions that they create for using and multiplying resources and improving the quality of living space and urban life

Three stages in the evolution of urban systems (series of Simpop models)

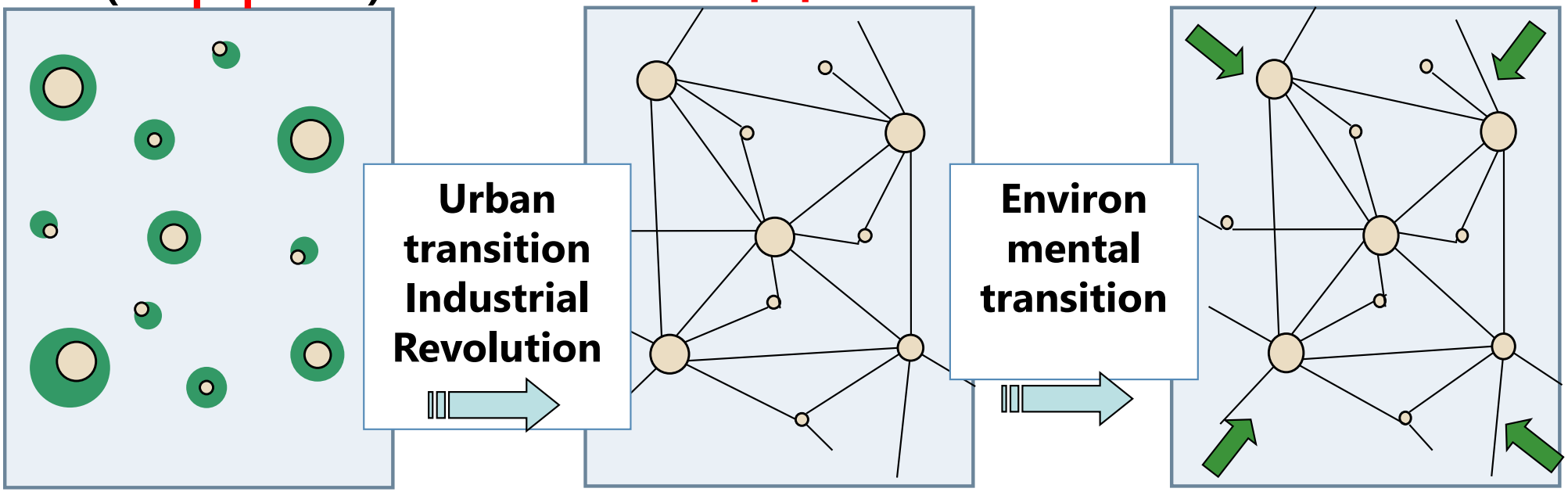
1- Agrarian economy
Local resources
(SimpopLocal)

Urban transition Industrial Revolution

2- Market economy
Network returns
(SimpopNet)

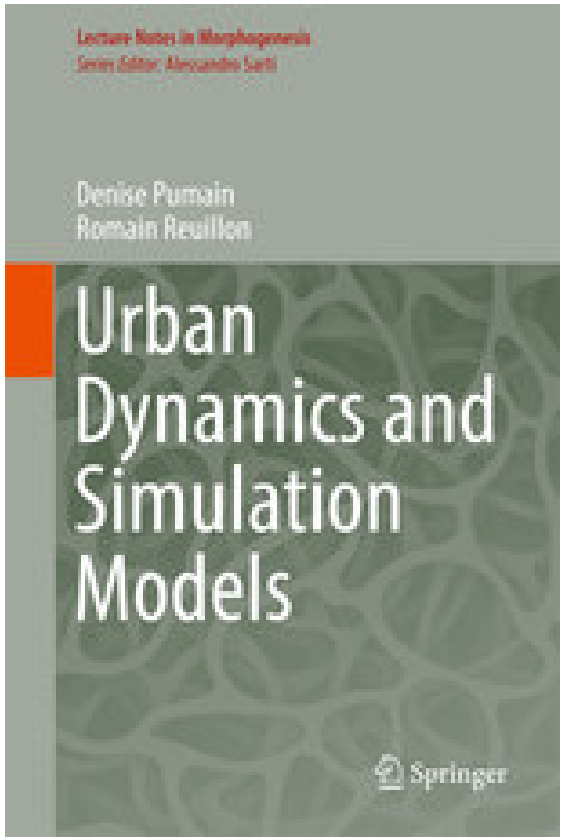
Environ mental transition

3- Knowledge economy
Environmental intelligence
(SimpopClim)

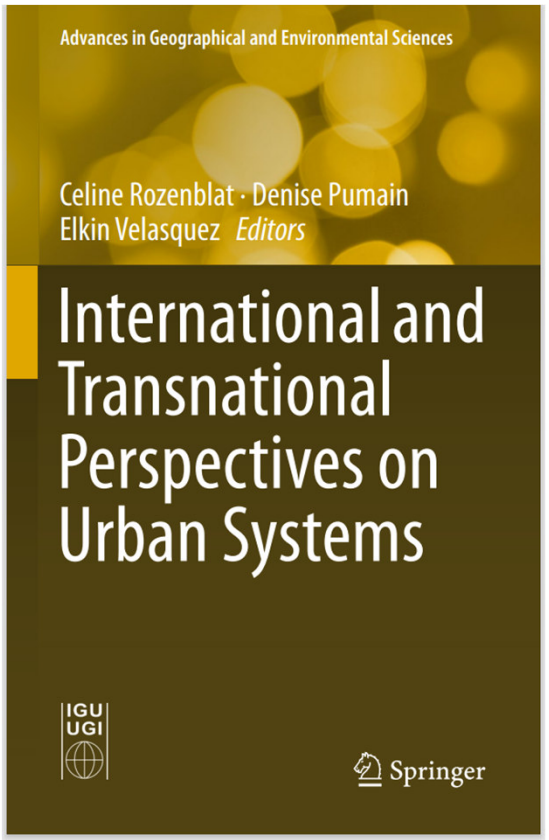


SIMPOP models: France Guérin-Pace, Lena Sanders, Hélène Mathian with Stéphane Bura, Benoît Glisse, Thomas Louail (and Jacques Ferber, Alexis Drogoul, Jean-Louis Giavitto, Guillaume Hutzler). Anne Bretagnolle, Clara Schmitt, Sébastien Rey, Clémentine Cottineau, Elfie Swerts, Céline Vacchiani-Marcuzzo (with Romain Reuillon, Mathieu Leclaire, Paul Chapron, Guillaume Cherel)

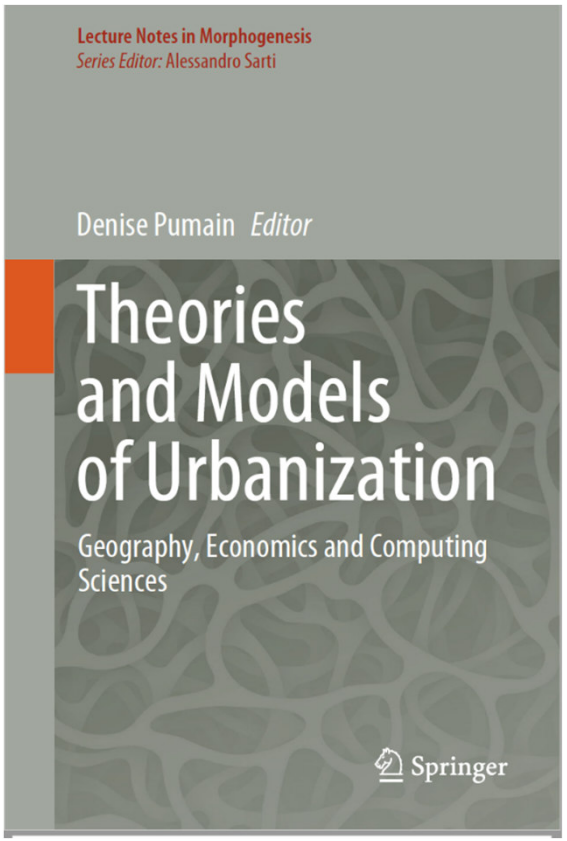
Thank you for your attention!



2017



2018



2020