Reading Record

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Juste Raimbault

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Reading Record for []

1 Introduction

Synergetics introduced for the study of physical complex systems by Haken around 1984.
TODO : detail Haken approach
→ particular application to systems of cities ; part of a larger corpus of theoretical and quantitative geography developed since ? at Geocites.

2 Linear Reading

Introduction

Particularity of systems of cities : exchange networks and strong interdependencies. "Breakdowns and continuity". Since beginning of 19th, diffusion of social and technical innovations ; stable and auto-reproducing system.
Regularities and fluctuations in such systems. Studied period : 1954-1982.
Concepts of complex systems : non-linearity, centrality of interactions, self-organization far from equilibrium (SOC ?), determinism and stochasticity. Not only conceptual parallelism, but demonstration of application.

2.1 The system of Cities

The city as a spatial entity, coarse-graining at this level. Delimitation of the system ? technical constraints more than theoretical.

2.1.1 City size dynamics

Theories of city growth Classical models ; growth by steps (specialization then diversification) ; agglomeration economies (in both sense, with negative feedbacks)

Evolution of the system of cities More qualitative (geographical ?) approaches : cf. Berry [**?**] ; Pumain. For French Urban System : before 19th, quite independent evolutions (Gibrat ?), later "temporal autocorrelation of growth rates". Thesis of Guerin-Pace : coupling macro (stable, trend) with micro fluctuations.

2.1.2 Cities and cycles

Urban life cycles : more for intra-urban characteristics. At a greater scale : cycles of innovation ; link with role of technical innovations in Schumpeterian theory. Economic cycles have deeply shaped French urban system. rq: product cycles more localized and precise than economic cycles, more complex to analyze.
Combination of two diffusion processes :

- spatial diffusion (core-periphery)
- hierarchical diffusion (schematically, more refined diffusion at different level occurs in reality)

2.1.3 Innovation cycles and evolution of the system of cities

Understanding link between relative growth and diffusion of innovation is complex. Interferences between cycles, spatial and temporal. "Multi-dimensional diffusion analysis".
Various scales can be taken :

- scale of the process
- scale of the firm
- scale of city evolution, innovation as a driver of urban growth

Long-time approach Marchetti technological substitution model : $f \in [0,1]$ fraction of city in urban system, then $\log \frac{f}{1-f} = a \cdot t + b \implies f = \frac{e^{at+b}}{1+e^{at+b}} = \frac{e^{\frac{t-t_0}{\tau}}}{1+e^{\frac{t-t_0}{\tau}}}$. $\rightarrow$ different growth factors for different spatial entities ? fraction is then normalized fraction. PB : assumes stationarity of processes ? or assumed $\tau(t)$ with $\tau \sim_{-\infty} \tau_- > 0$ and $\tau \sim_{\infty} \tau_+ < 0$. [quite strange here]. Idea : Growth/decline cycles.

Short and Middle temporal scales more precise data at these scales. tertiary/secondary substitution, position of agglomeration on a logistic curve. (cf Marchetti model ?).
ex tertiarization french agglos : variety of situations. approach however too general ? (sector, etc particularities). typology by sectors : constant repartition between cities ; homogeneisation ; growth and reinforcment of inequalities.

2.1.4 Dynamical models applied to urban systems evolution [dynamics ?]

Bruxelles, Prigogine and Synergetics, Haken.
particularity of models :

- designed for complex systems ; spatio-temporal
- differential equations : continuity of urban change
- non-linear equations, taking feedbacks into account
- classical assumptions can easily be integrated
- out-of equilibrium, non-unicity of eq. ; "evolve in time" : non-stationarity ?
- qualitative bifurcations possible because of equilibrium multiplicity

With $\mathbf{P}$ populations, $\mathbf{X}$ state variables, μ parameters, most general equation is

$$\frac{\partial \mathbf{P}}{\partial t} = \mathbf{F}(\mu, \mathbf{X}, \mathbf{P})$$

here cross terms between state variables vanish, we have with less generality, $\frac{\partial P_i}{\partial t} = F_i(\mu, \mathbf{X}_i, \mathbf{P})$.
various formulations have been proposed ; models not tractable analytically if take multiplicity of interactions into account.
Noise term ε can be added. example of "deterministic" trend plus noise curve.
Other formulation : Master equation approach, from synergetics.

2.2 Multiscalarity : from individuals to city systems

Emergence of city dynamics from its micro components.
Two visions :

- micro description of behavior
- statistical distribution

what about coupling both ? example of migration process : discriminating character is crucial.

2.2.1 Difficulty of migration models typology

Variety of applications (explanation of behavior, flows distribution, planning, embedding into larger model) ; choice of explanatory variables depends on application ; variety of formalizations (from Markov chains to econometric, log-linear, micro-utility, gravitation, etc) ; different role of time : all these contribute to difficulty of typology.

2.2.2 Individual behavior : micro-geographical models

log-linear models : explain the indicator of move for one household.
Logit and Nested logit models. [// discrete choices]
examples and biblio.

2.2.3 Meso and Macro scales

Meso : flows between entities ; Macro : global organisation of system.

Econometric models explanatory vars ; utility etc : works at an interregional level.

Spatial interaction models : from gravitation to entropy maximization importance of distance for interactions.
Most general gravitation model : $M_{ij} = kP_iP_j \exp\left(-\frac{d_{ij}}{d_0}\right)(1+\alpha c_{ij})$ (or power law instead of exponential), where c_ij captures ratio surfaces / common frontier (to include travel possibility). Rq : thematic based ok, but could fit anything ? pb of equifinality again.
Wilson model, based on entropy maximisation, generalizes gravitation model.
Tobler : not explain migrations but include them accurately.
ex application for France.

More general models Lowry : gravitation plus incomes and unemployment.
Batty 1983 dynamic model of simulation.

2.2.4 Attempts for micro-macro integrations

Different variables ; temporal scales. According to Weidlich, reductionism vs holistic approach - close to autonomy of weak emergence.
Probabilistic interpretation of gravitation model, extension with conditional probas.
Leeds : synthetic population from census data, simulation : too heavy computationnaly [rq : different today ? cf all city systems simulations ?] : top-down approach.
vs bottom-up : use micro-geo data. example of difference between expectations and reality for individuals. Other study : importance of macro factors.
→ various scales, sometimes contradictory results ; logic for each scale and difficulty of explicit link between scales.

2.3 Answers from Synergetics

Interdependance and cooperation between subsystems : auto-organisation.
Typical characteristics of complex systems (recall from dyn. models ?)

- "Hierarchy between scales, each level of aggregation is well defined, perceptible as an entity at a given scale". **RQ : very close to ontological decomposition, furthermore here detailed as "perceptible" → TO BE DETAILED**
- complex interactions, non-linearity between elements at a given level, can influence upper level (RQ : links *between* levels ?)
- Combination of deterministic trends and stochastic fluctuations.
- Possibility of bifurcation because of non-linearity (oscillating or chaotic behaviors) - ex. phase transition.

For city systems : behavior of macro depending on micro constituents ? Weidlich and Haag have first used synergetics to study the evolution of an urban system.

2.3.1 Master Equations system

$\mathbf{n}$ cities populations, $\sum_i n_i(t) = N(t)$, evolution of $\mathbb{P}[\mathbf{n},t]$? Conservation of probas. Master equation : describes dynamics $\frac{\partial \mathbb{P}[\mathbf{n},t]}{\partial t}$.
Integration of migration process : exchanges with external world ; exchanges between cities of the system.
Derivation : proba of jump $\mathbf{n}(t) \rightarrow \mathbf{n}(t+dt)$ at micro level, developed at the first order, so-called "individual transition rate" is derivative ; at level of city "configurational transition rate" - both are linked simply.
→ Master eq. with transition matrix, classic definition.

$$\frac{\partial \mathbb{P}[\mathbf{n},t]}{\partial t} = \sum_{ij} w_{ij}(n'_{ij})\,\mathbb{P}\left[n'_{ij},t\right] - \sum_{ij} w_{ij}(\mathbf{n}\,\mathbb{P}[\mathbf{n},t]$$

2.3.2 From master equation to mean values