Structural Segregation: Assessing the impact of South African Apartheid on Underlying Dynamics of Interactions between Networks and Territories

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Technical artefacts sublimating human madness
Relations between Network and Territories: complex co-evolutive processes [Bretagnolle, 2009]

→ How can these interactions be shaped and leveraged as a socio-economic domination tool?

**Research Objective:** Using a new population and railway network database on long time span for South Africa [Baffi, 2016], investigate potential effects of historical events (apartheid segregation laws) on structural properties of the system.
Interactions between Networks and Territories in South Africa

_De-structuring effects of the segregation laws [Baffi, 2016]_
Evolution of Network measures: anomalous trend rupture in centralities
Connectivity to the railway network: a specific relationship between urban hierarchy and centrality
Accessibility Patterns

Distorted co-evolution between cities and the railway network
Spatio-temporal causalities

Use of a generic method to identify causalities in spatio-temporal data [Raimbault, 2017b], in the sense of Granger causalities

→ Estimation of lagged correlations on spatially filtered data, maximising lag if exists (filtering correlations if significant with $p < 0.1$ for a Fisher test) gives propagation lag and sense of the causality

→ Spatial aggregation by station; work with data returns at the first order
Stationarity scales

**Optimal estimation time window and spatial range for accessibility**
Causality Patterns

Clear inversion of the sense of Granger causality suggests a structural segregation effect of the apartheid laws.

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**Introduction**

**Discussion**

**Methods and Results**
**Discussion**

**Implications**

→ Existence of a *Structural Segregation*, in the sense of an impact of policies on second-order dynamics of the system

→ Co-evolutive processes becoming de-structuring, the rail being used as a tool of power

**Developments**

→ Relations with more precise socio-economic variables, direct segregation patterns, housing market, power relations and socio-economic activities [Migozzi, 2010]

→ Method of statistical instrumentation using beginning/end of apartheid as an exogenous independent shock [Angrist et al., 1996]
Converging evidences and complementary approaches to unveil particular cases of co-evolutive dynamics

Crucial aspect of both empirical and theoretical domains, and of concrete fieldwork surveys to fully interpret numerical analyses

- Code et data available at
  https://github.com/JusteRaimbault/CityNetwork/tree/master/Models/SpatioTempCausality/SudAfrica
Reserve Slides
Apartheid policy

- Deshumanized colored populations and exploitation as a crucial economic resource, to sustain economic prosperity of Afrikaners population
- Planned spatial division at different scales: specific autonomous regions called bantustans
- Residential constraints depending on employment status and ethnic origin
- Railway network designed to optimize commuting for mines workers
- High level of induced migrations: up to 2.1 millions daily commutes in 1984
Defining co-evolution

No clear definition of co-evolution in the literature: [Bretagnolle, 2009] distinguishes “reciprocal adaptation” where a sense of causality can clearly be identified, from co-evolutive regimes

[Raimbault, 2017b] identifies multiple causality regimes in a simple strongly coupled growth model → to be put in perspective with a theoretical definition of co-evolution based on the conjunction of Morphogenesis and the Evolutive Urban Theory, summarised by [Raimbault, 2017a]
Database

- Consistent ontologies for metropolitan areas
- Precisely geocoded stations and rail network (with dates of opening and closing) from historical maps and secondary sources
- Growth rates and correlations computed on connected cities
$P_i$ populations, $d_{ij}$ network distance matrix, accessibility is given for $i$ by

$$Z_i = w_i \sum_j w_j \exp(-d_{ij}/d_0)$$

with $d_0$ decay parameters and weights $w_i$ are $1/N$ or $P_i/\sum_j P_j$ depending on weighting scheme.


