

# 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



# Context

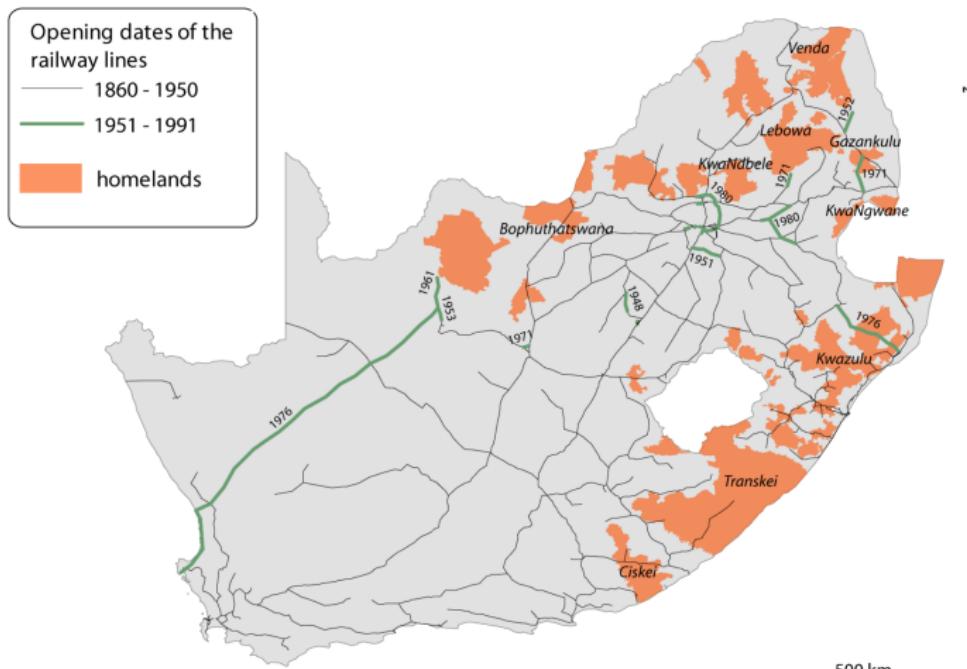
Relations between Network and Territories : complex co-evolutive processes [Bretagnolle, 2009]

→ *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.

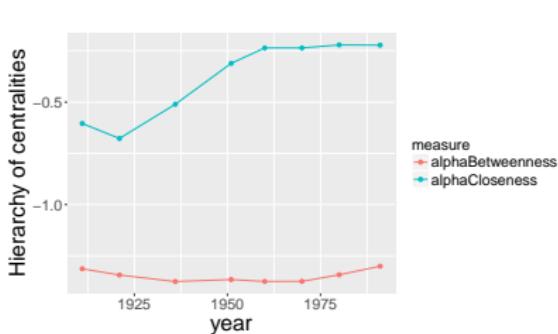
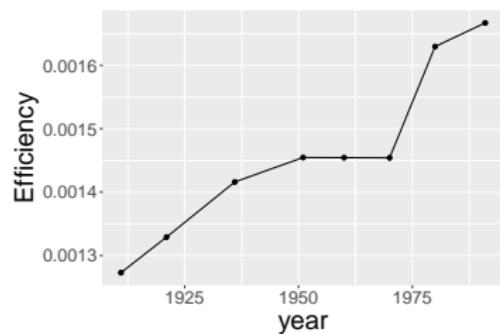
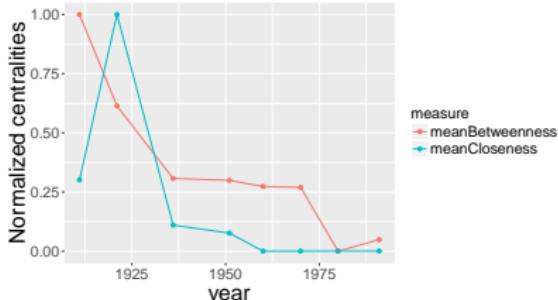
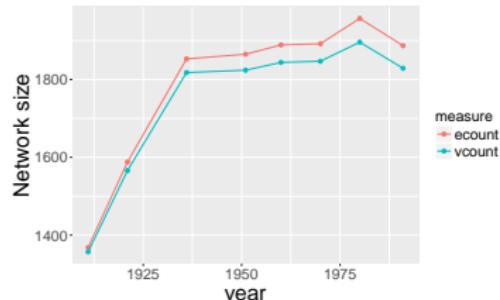
# Interactions between Networks and Territories in South Africa

*De-structuring effects of the segregation laws [Baffi, 2016]*



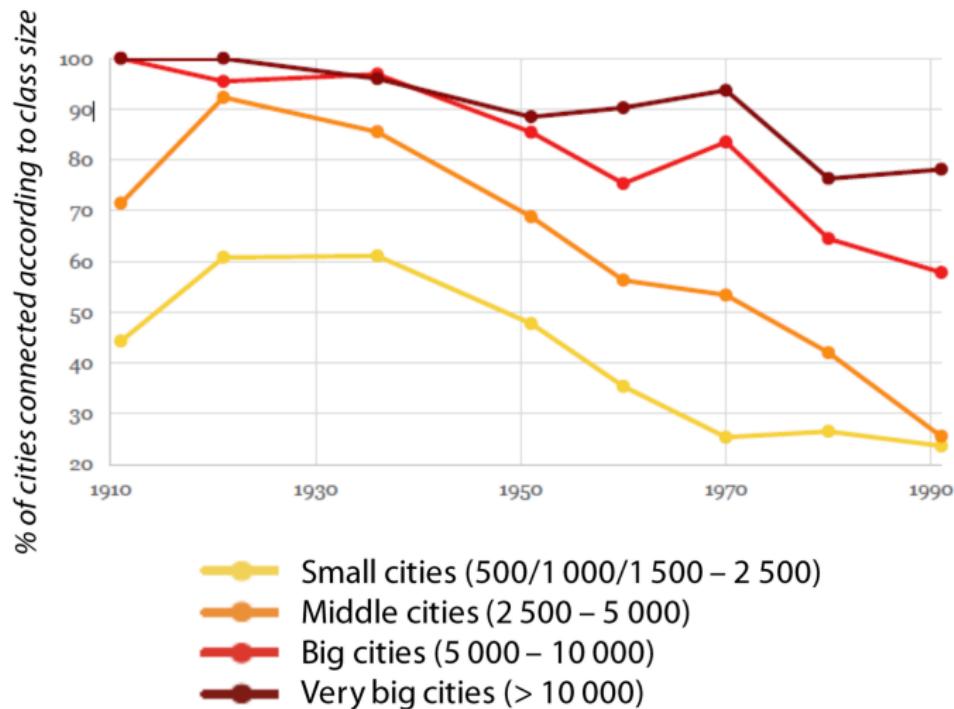
# Network Analysis

*Evolution of Network measures : anomalous trend rupture in centralities*



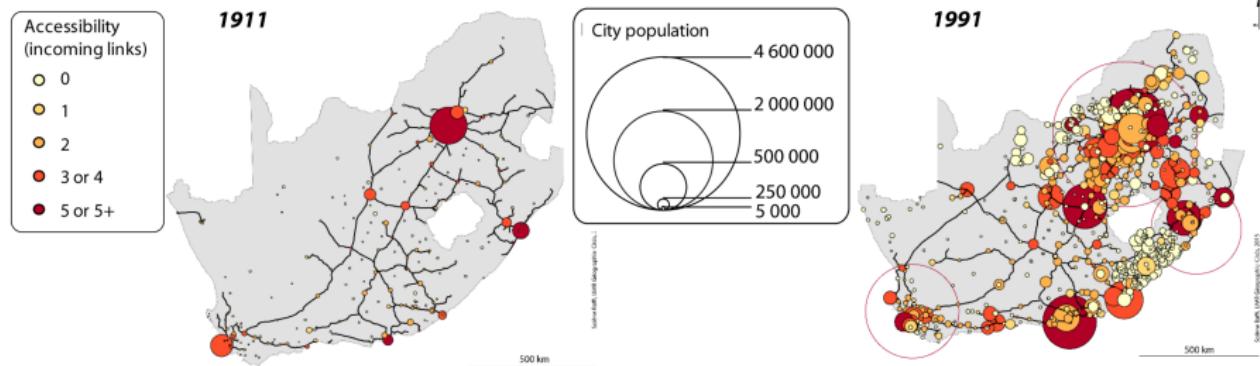
# Network Analysis

*Connectivity to the railway network : a specific relationship between urban hierarchy and centrality*



# Accessibility Patterns

*Distorted co-evolution between cities and the railway network*



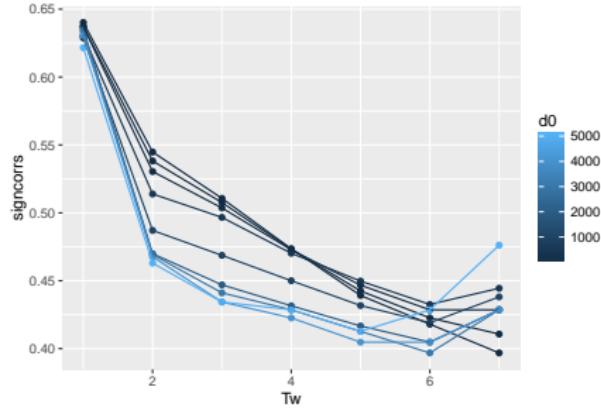
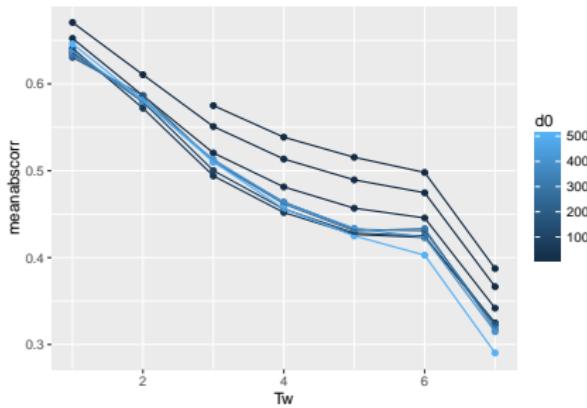
## Spatio-temporal causalities

Use of a generic method to identify causalities in spatio-temporal data [Raimbau 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

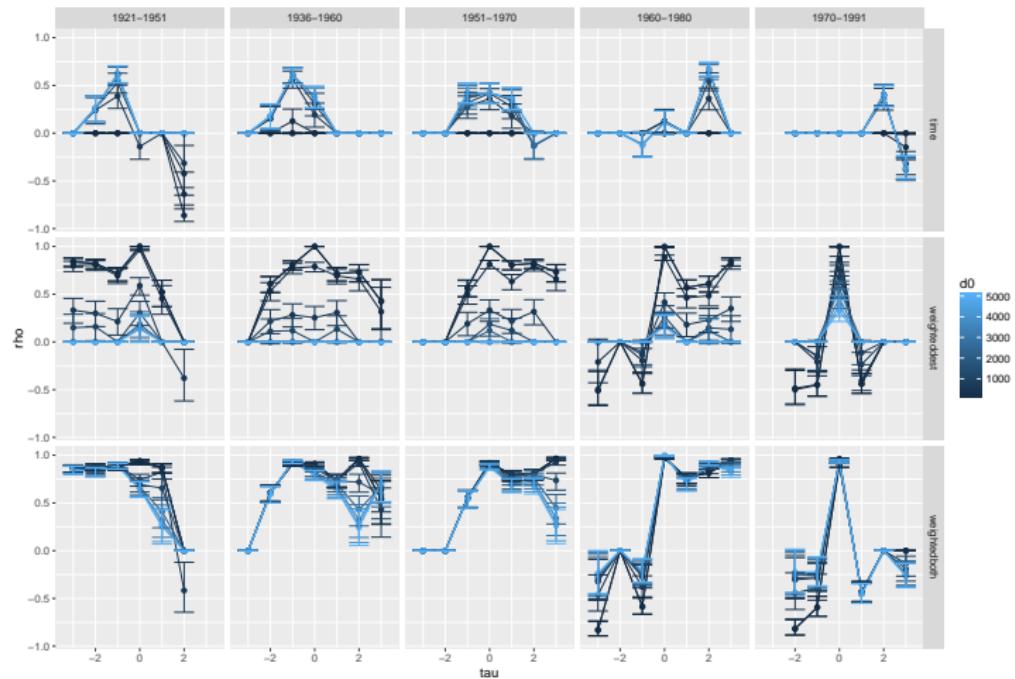
# Stationarity scales

*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*



# 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]

# Conclusion

- 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

## Reserve Slides

# Apartheid policy

- Deshumanized colored populations and exploitation as a crucial economic ressource, to sustain economic prosperity of afrikaners population
- Planned spatial division at different scales : specific autonomous regions called bantoustans
- 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

# Accessibility

$P_i$  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.

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-  Bretagnolle, A. (2009). *Villes et réseaux de transport : des interactions dans la longue durée, France, Europe, États-Unis.* Hdr, Université Panthéon-Sorbonne - Paris I.

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