A Universal Model of Commuting Networks
Maxime Lenormand

To cite this version:
Maxime Lenormand. A Universal Model of Commuting Networks. Urbannet’13, Satellite Workshop of the European Conference on Complex Systems ECCS’13, 2013, Barcelone, Spain. 10.1371/journal.pone.0045985 . hal-02890635

HAL Id: hal-02890635
https://hal.inrae.fr/hal-02890635
Submitted on 6 Jul 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
A Universal Model of Commuting Networks

Maxime Lenormand, Sylvie Huet, Floriana Gargiulo and Guillaume Deffuant

Urbannet 2013, Barcelona

18th of September, 2013
Motivation

A Universal Model of Commuting Networks
Motivation

Place of residence \rightarrow \text{Place of work}

A \rightarrow B

Place of residence

C

Place of work
Motivation
Motivation
Motivation

Number of out-commuters

- A
- B
- C

5
Motivation

Number of in-commuters

A

B

C

5

2
Motivation
Motivation

Euclidean distances between municipalities

\[ d_{AB} \]
\[ d_{AC} \]
\[ d_{BC} \]
Motivation
Outline

- The Model
- Calibration of $\beta$
- Results
- Comparison with the "radiation model"
Outline

- The Model
- Calibration of $\beta$
- Results
- Comparison with the "radiation model"
The Model

A Universal Model of Commuting Networks

Maxime Lenormand
Urbannet 2013
18th of September, 2013
The Model

A Universal Model of Commuting Networks

Maxime Lenormand

Urbannet 2013

18th of September, 2013
The Model
The Model
The Model

\[ P_{A \to B} \sim 7 \cdot e^{-\beta d_{AB}} \]

\[ P_{A \to C} \sim 0 \cdot e^{-\beta d_{AC}} \]
The Model

\[ P_{A \rightarrow B} \sim 7 \cdot e^{-\beta d_{AB}} \]

\[ P_{A \rightarrow C} \sim 0 \cdot e^{-\beta d_{AC}} \]
A Universal Model of Commuting Networks

The Model

![Diagram of commuting network with nodes A, B, and C, and weights on the edges.]
A Universal Model of Commuting Networks

The Model

![Diagram of commuting network with nodes A, B, and C and labeled edges]

Maxime Lenormand  Urbannet 2013  18th of September, 2013  5 / 22
The Model

A Universal Model of Commuting Networks
The Model
The Model
The Model

A Universal Model of Commuting Networks

Maxime Lenormand

Urbannet 2013

18th of September, 2013
The Model
Outline

- The Model
- Calibration of $\beta$
- Results
- Comparison with the "radiation model"
Calibration of $\beta$

![Graph showing the calibration of $\beta$ with different values: $\beta = 0.14$, $\beta = 0.19$, $\beta = 0.25$. The graph compares observed data with the model predictions.](image)
Calibration of $\beta$

$$D_{KS} = \sup_d \left| F_O(d) - F_S(d) \right|$$

$$CPC = \frac{2 \sum_i \sum_j \min(S_{ij}, O_{ij})}{\sum_i \sum_j O_{ij} + \sum_i \sum_j S_{ij}}$$
Outline

▶ The Model
▶ Calibration of $\beta$
▶ Results
▶ Comparison with the "radiation model"
Results
Datasets

1. Czech Republic - 1 region - municipality - 2001
2. France - 34 regions - municipality - 1999
3. France - 15 regions - canton - 1999
4. France - 1 region - département - 1999
5. Italy - 10 regions - municipality - 2001
6. Italy - 5 regions - provincia - 2001
7. USA - 15 regions - county - 2000
Results

Model evaluation
Results

Estimation of $\beta$

$\beta = 0.3 <S>^{-0.18}$

Lenormand, M., Huet, S., Gargiulo, F., and Deffuant, G. A Universal Model of Commuting Networks. *Plos One*, 2012, .
Results
Estimation of $\beta$

- **Municipality**: $\langle S \rangle \sim 15 \text{Km}^2$
- **Canton**: $\langle S \rangle \sim 150 \text{Km}^2$
- **Department**: $\langle S \rangle \sim 5000 \text{Km}^2$
Results
Estimation of $\beta$
Outline

▶ The Model
▶ Calibration of $\beta$
▶ Results
▶ Comparison with the "radiation model"
Comparison with the "radiation model"

Radiation Model

\[
\langle T_{ij} \rangle = \left( m_i \frac{P_c}{P} \right) \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}
\]

Simini, F., Gonzalez, M. C., Maritan, A., and Barabasi, A.-L. A universal model for mobility and migration patterns. *Nature*, 2012, 484(7392):96-100.
Comparison with the "radiation model"
Comparison with the "radiation model"
Summary

- Model tested on 80 different regions (size and scale).
Summary

- Model tested on 80 different regions (size and scale).
- Estimation of $\beta$ tested on 80 regions.
Summary

- Model tested on 80 different regions (size and scale).
- Estimation of $\beta$ tested on 80 regions.
- Comparison with the "radiation model".
Summary

- Model tested on 80 different regions (size and scale).
- Estimation of $\beta$ tested on 80 regions.
- Comparison with the "radiation model".
- Does it work at urban scale?
Results

A Universal Model of Commuting Networks

\begin{figure}
\centering
\includegraphics[width=\textwidth]{plot.png}
\caption{Relationship between \( \beta \) and \( \langle S \rangle \) (km²) for London and Barcelona.}
\end{figure}

\begin{itemize}
\item London
\item Barcelona
\end{itemize}