



# A Universal Model of Commuting Networks

Maxime Lenormand

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# A Universal Model of Commuting Networks

Maxime Lenormand, Sylvie Huet, Floriana Gargiulo and Guillaume Deffuant

Urbannet 2013, Barcelona

*18<sup>th</sup> of September, 2013*

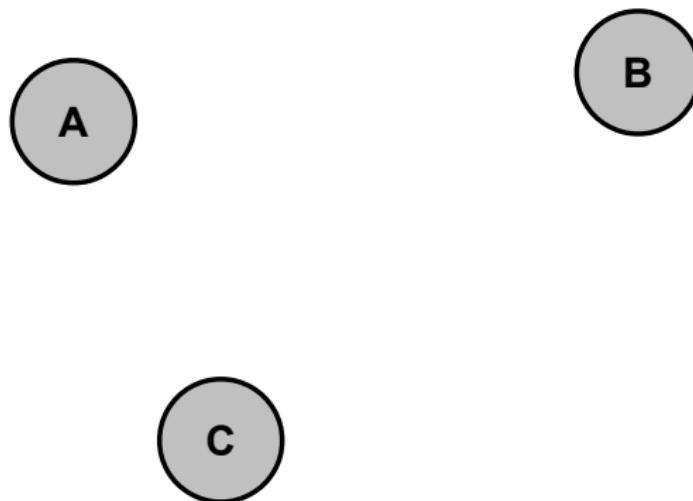


Prototypical Policy Impacts on Multifunctional Activities in rural municipalities

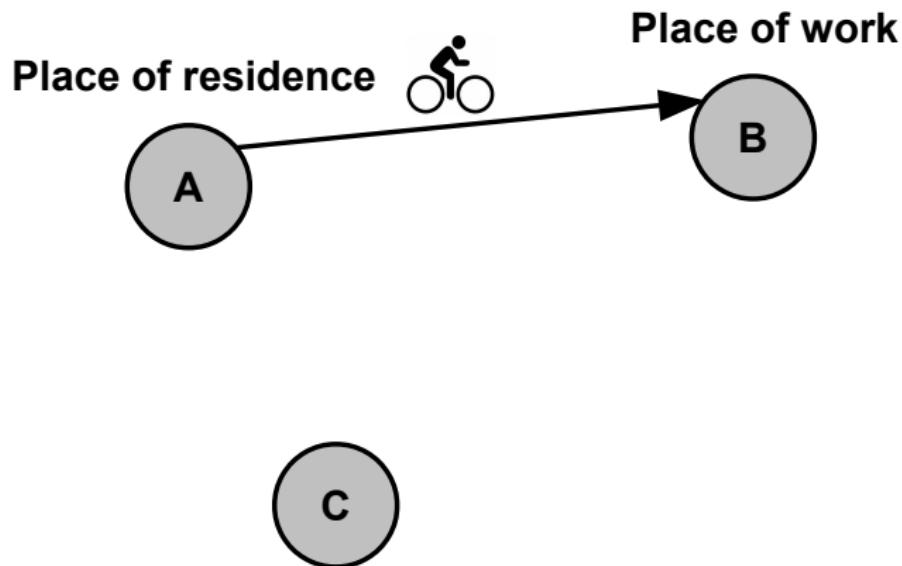
A collaborative project under the  
EU Research Framework Programme



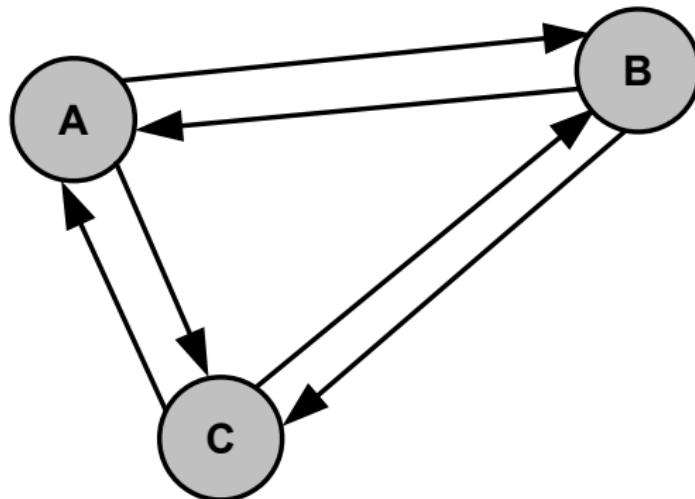
# Motivation



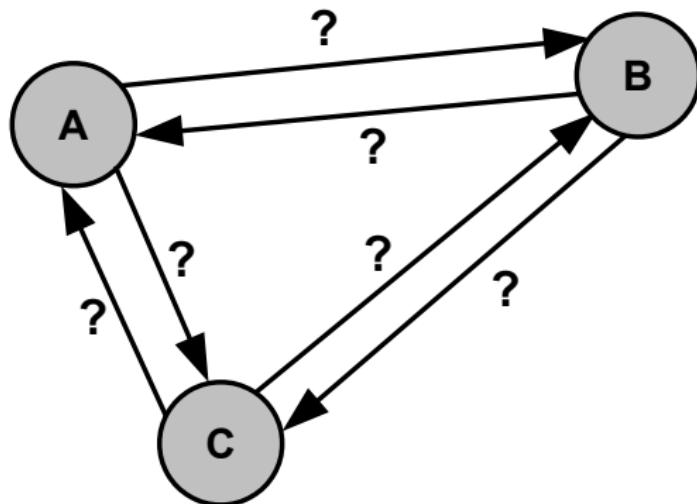
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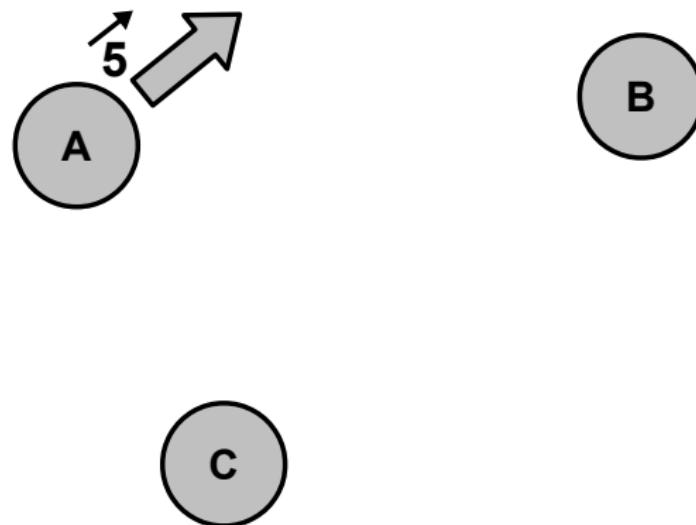


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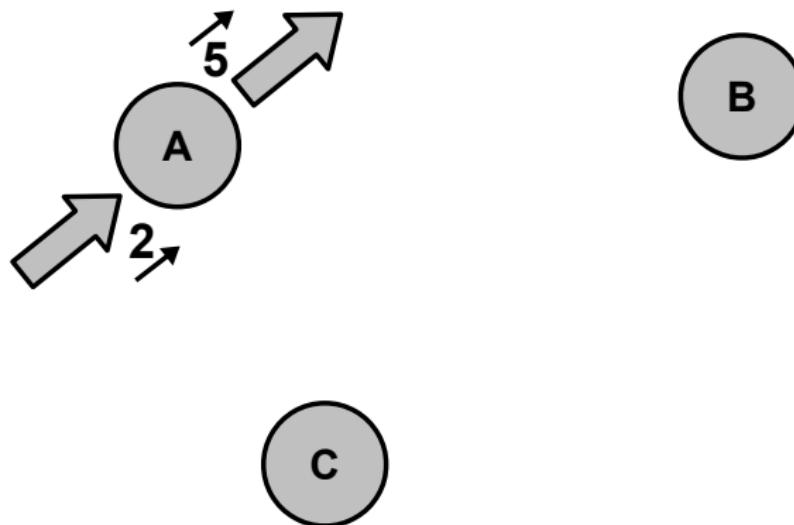
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## Number of out-commuters

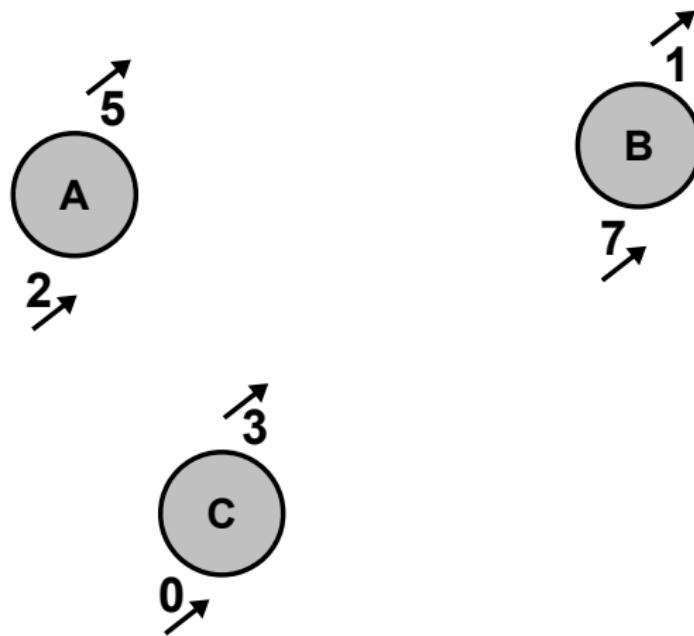


# Motivation

## Number of in-commuters

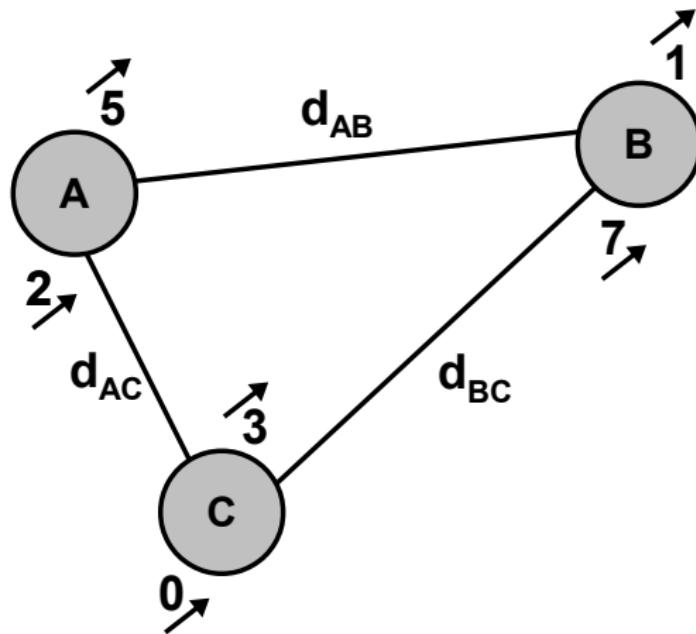


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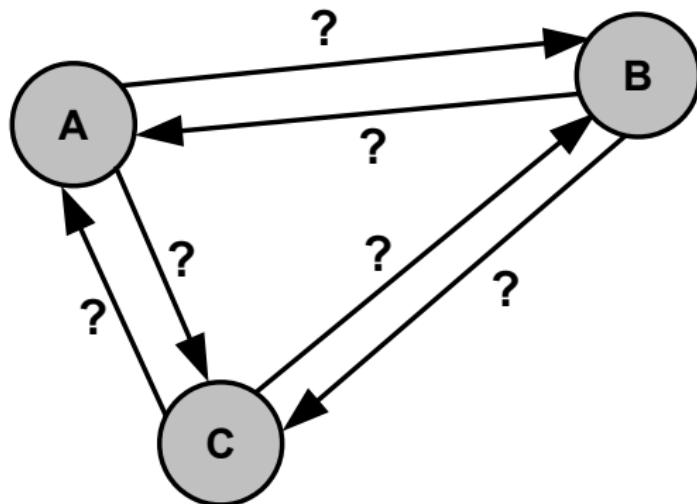


# Motivation

## Euclidean distances between municipalities



# Motivation



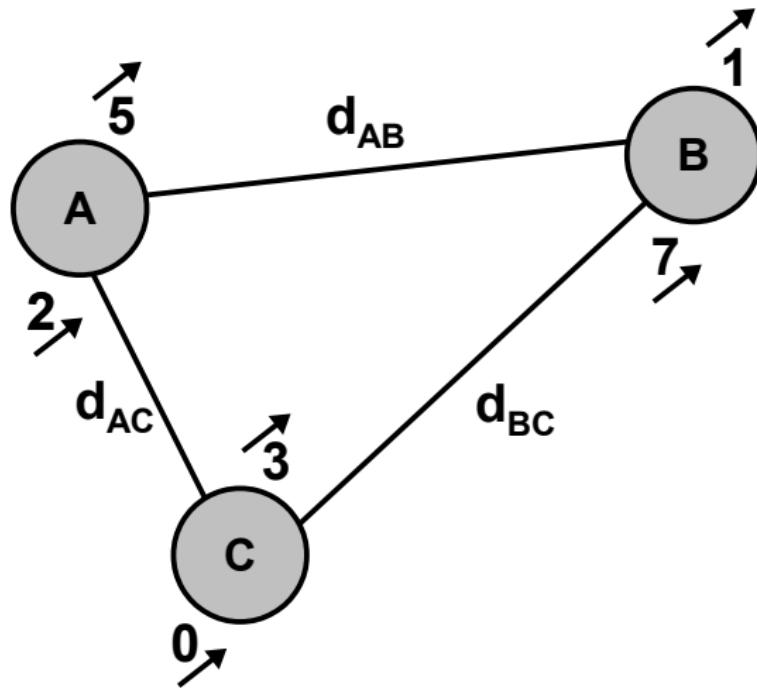
# Outline

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

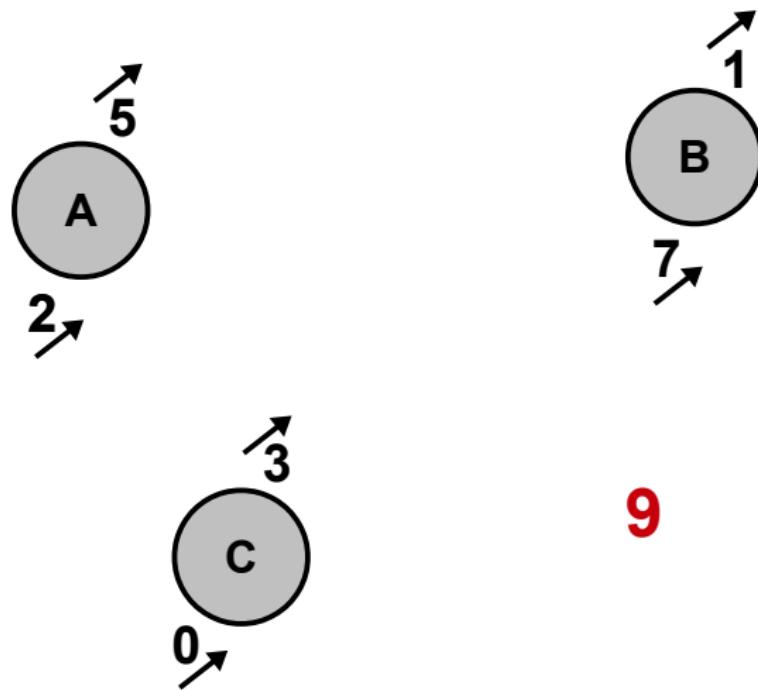
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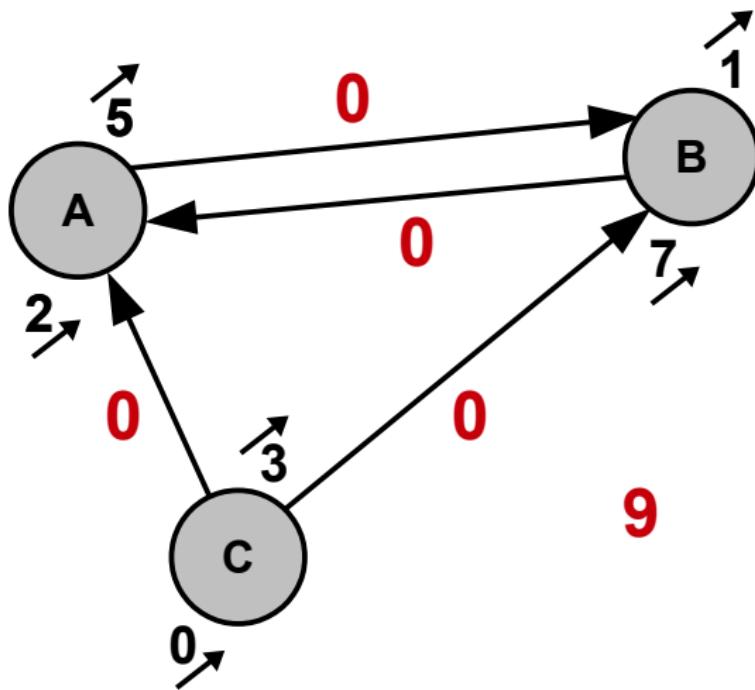
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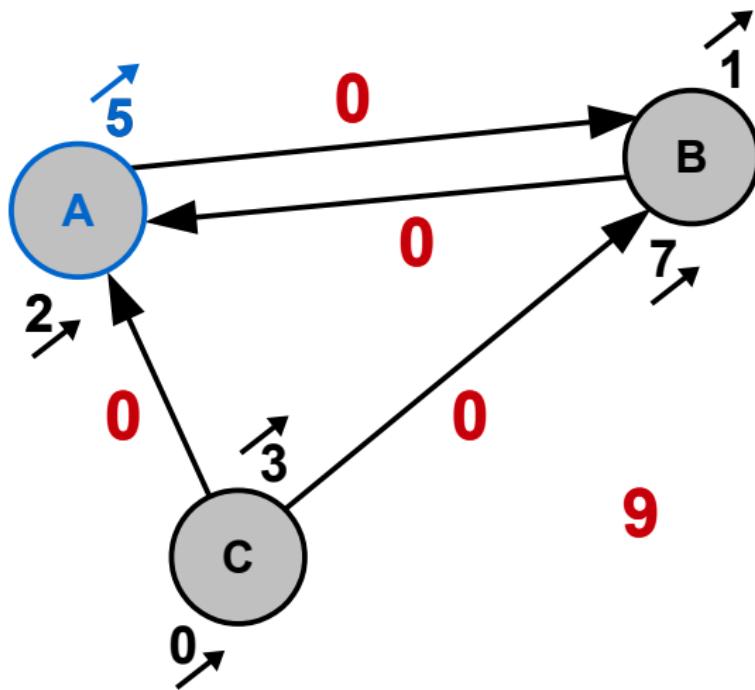
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# The Model



# The Model

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

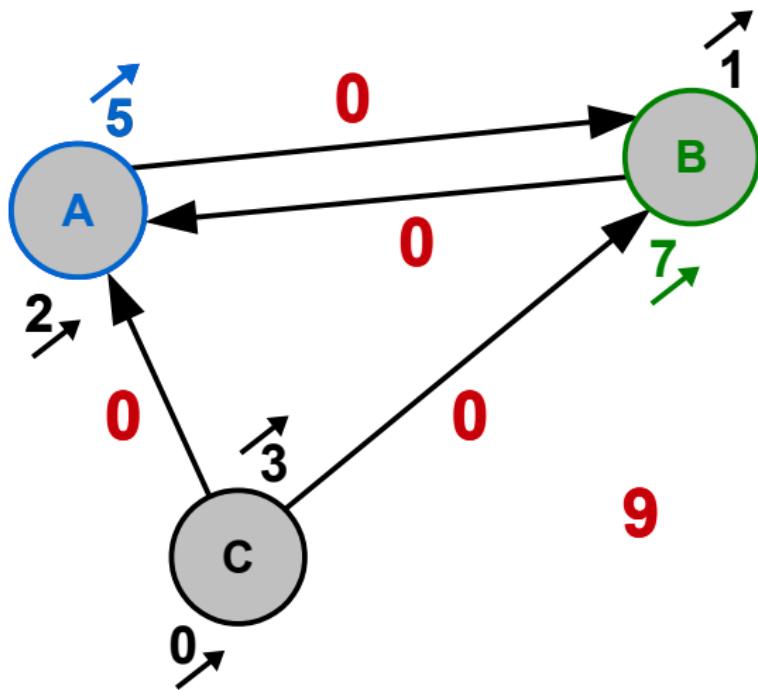
$$P_{A \rightarrow C} \sim 0 \cdot e^{-\beta d_{AC}}$$

# The Model

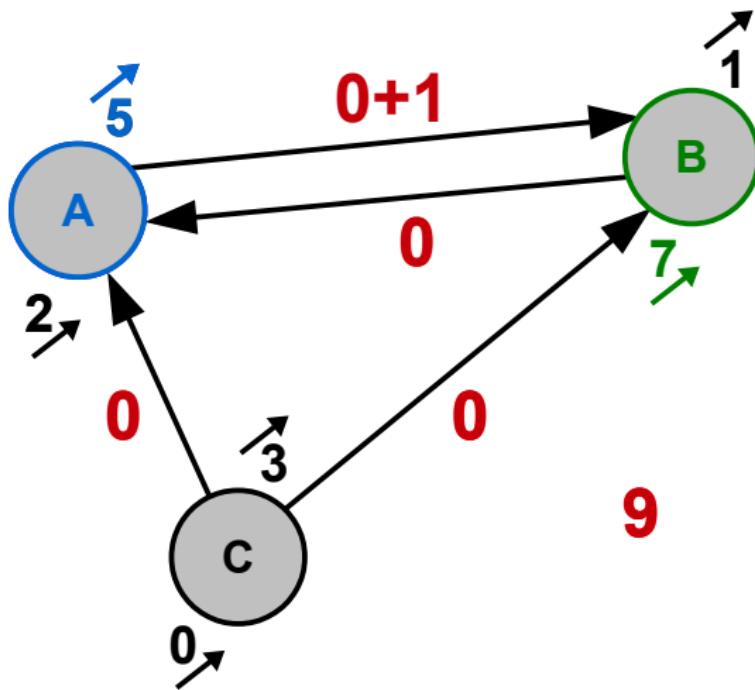
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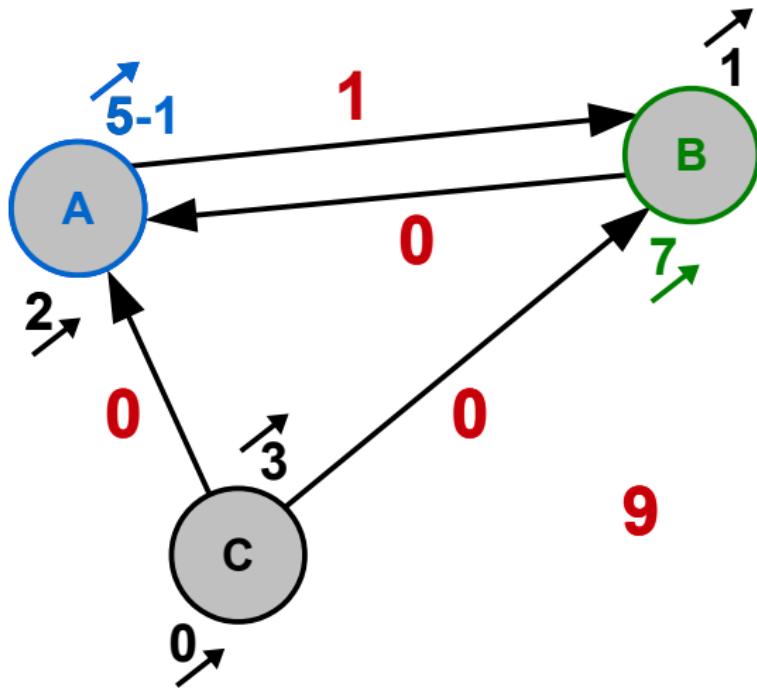
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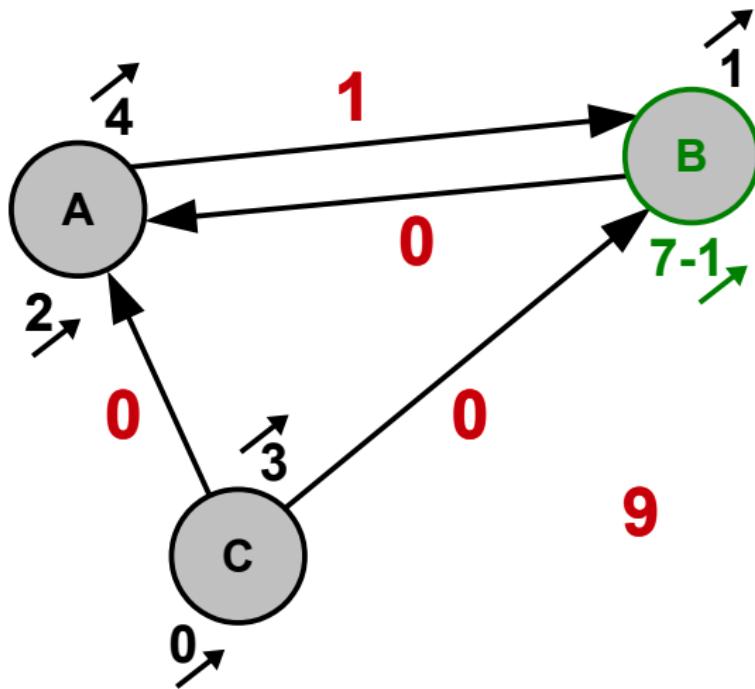
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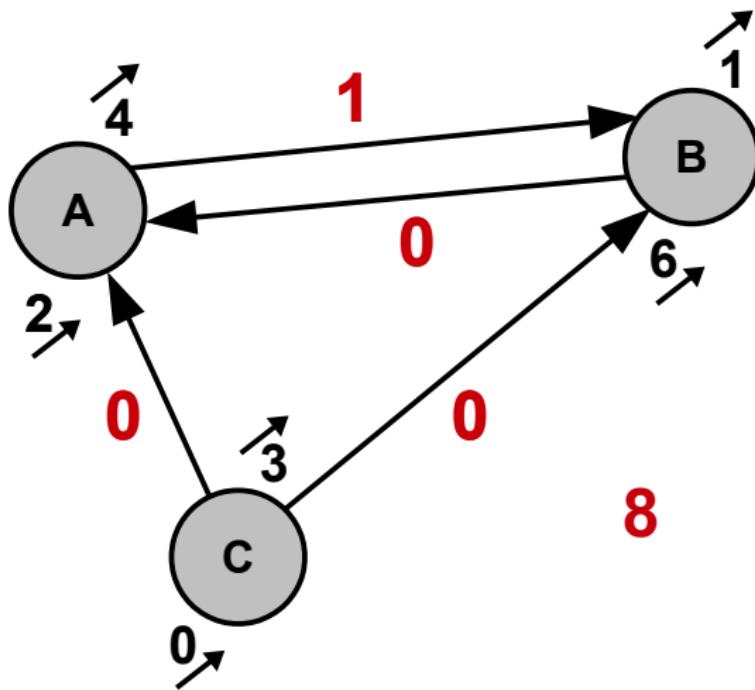
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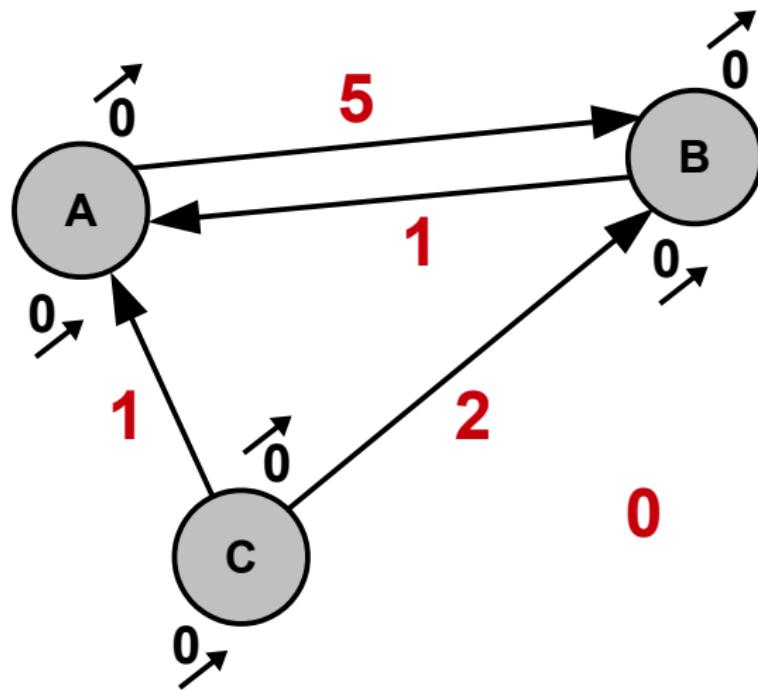
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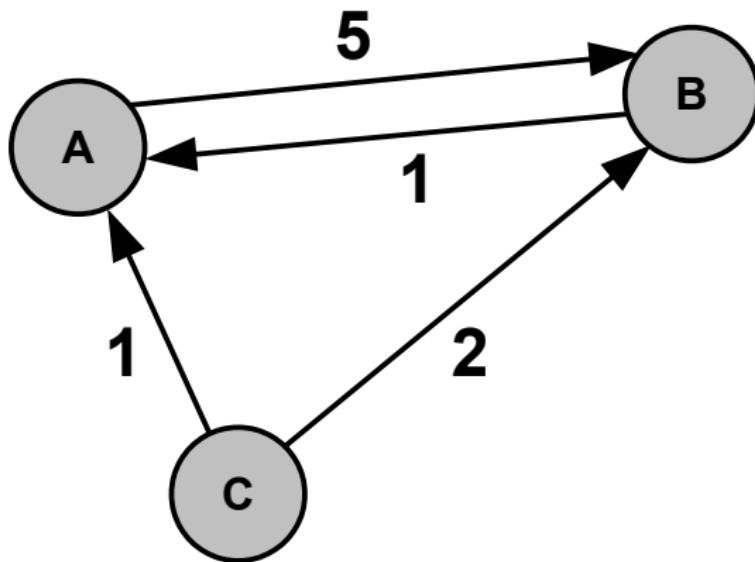
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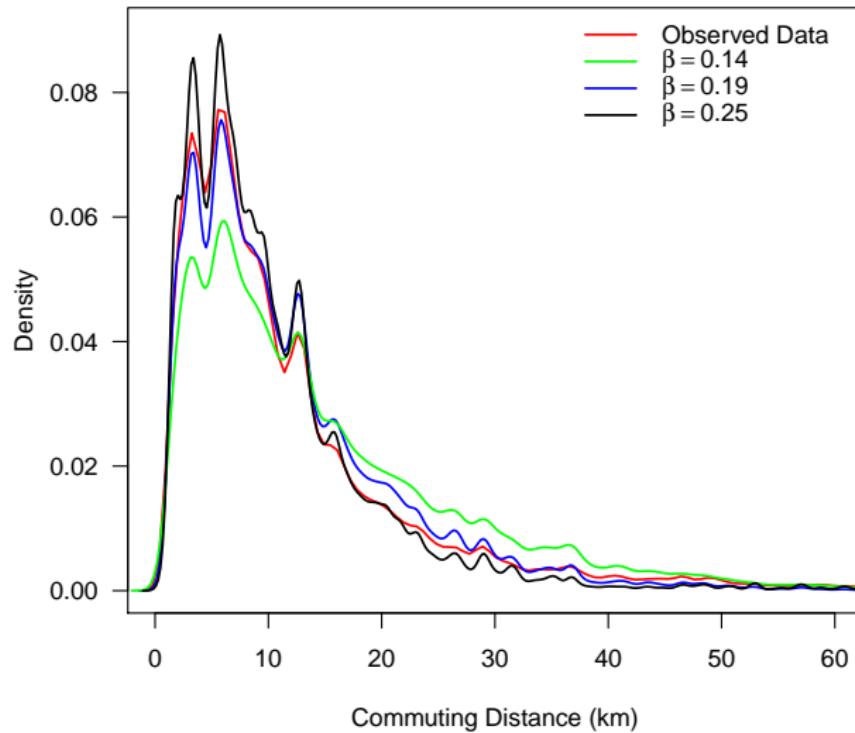
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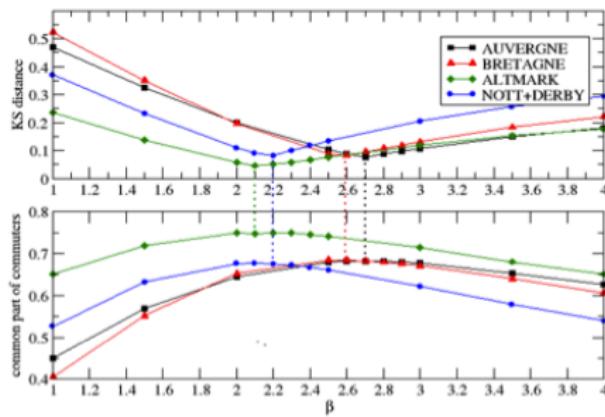
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# Calibration of $\beta$



# Calibration of $\beta$



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

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

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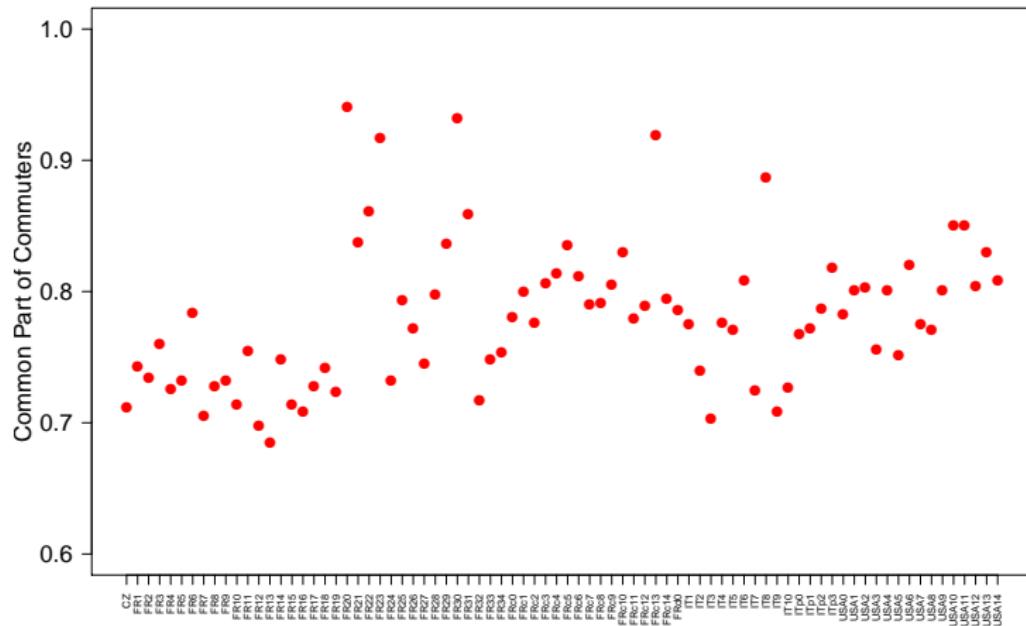
# Results

## 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

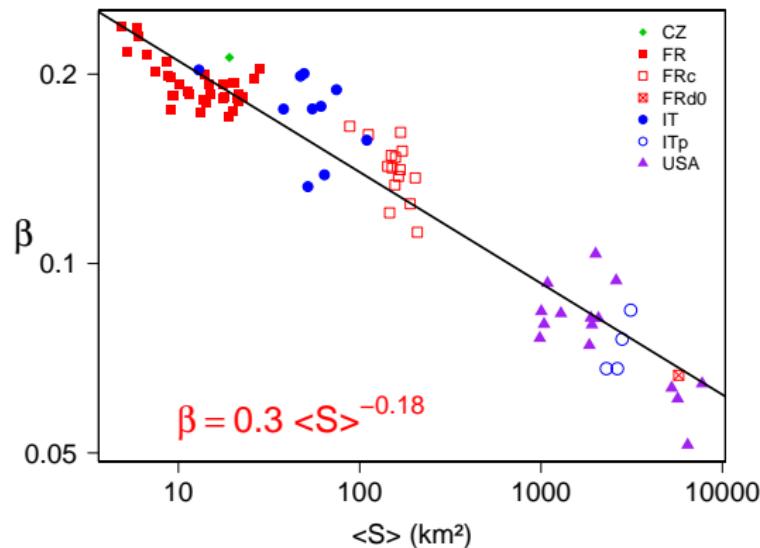
# Results

## Model evaluation



# Results

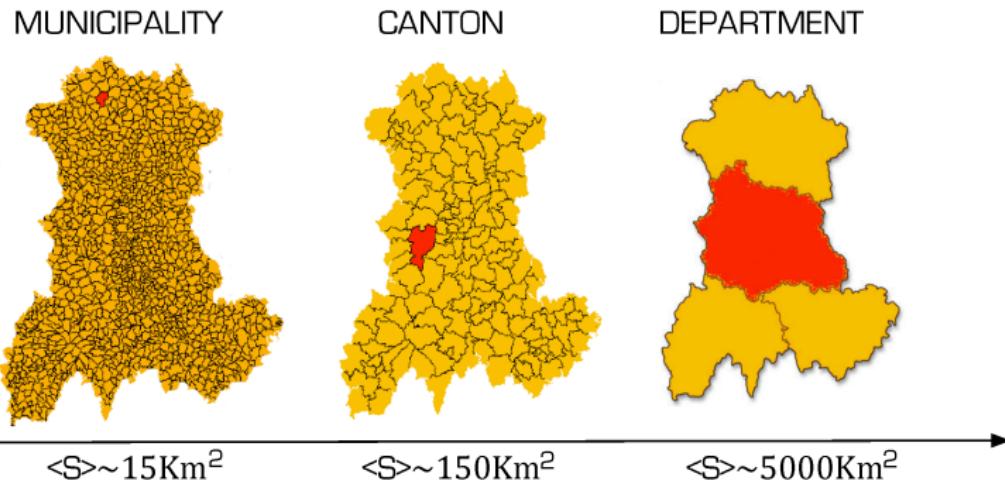
## Estimation of $\beta$



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

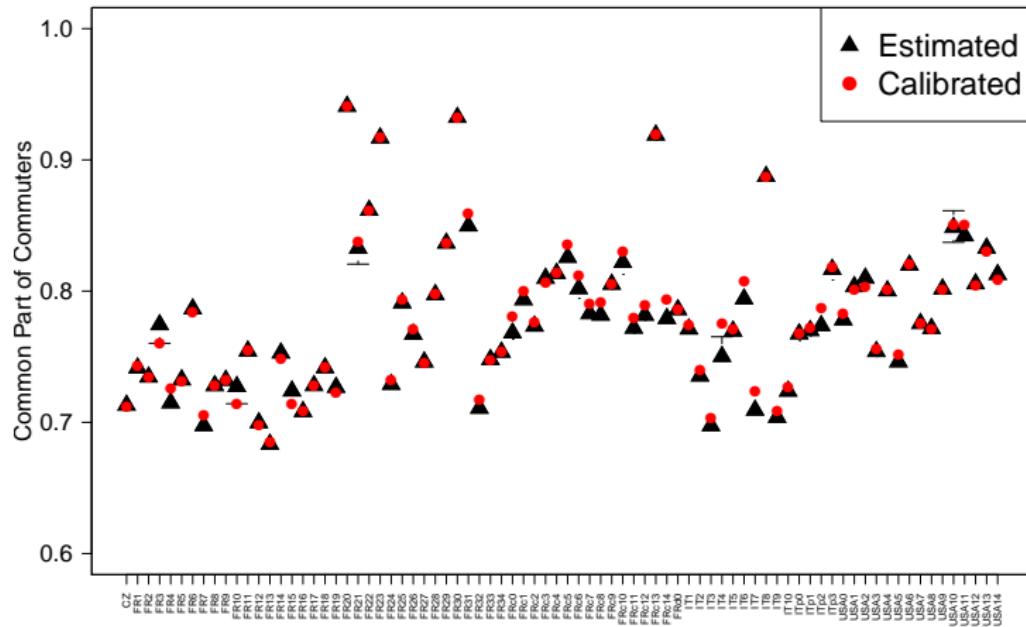
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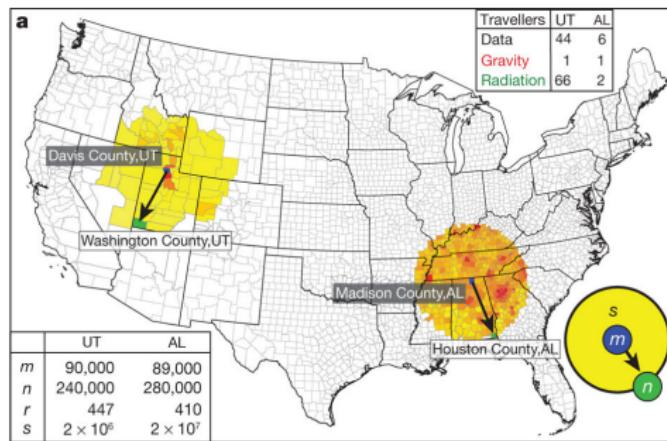
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# Comparison with the "radiation model"

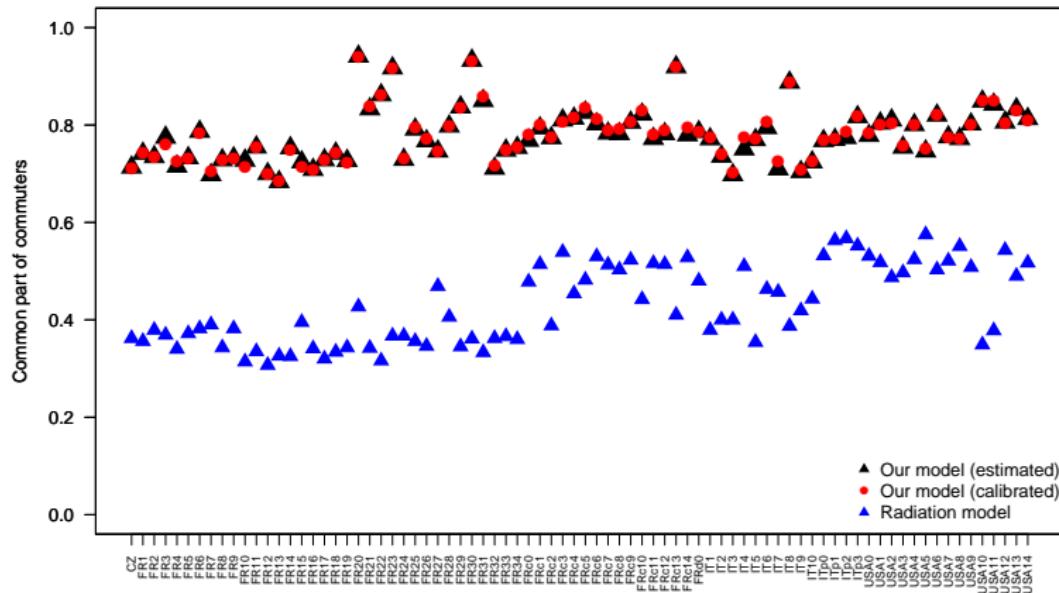
## Radiation Model

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

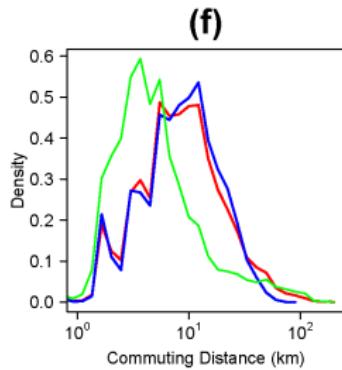
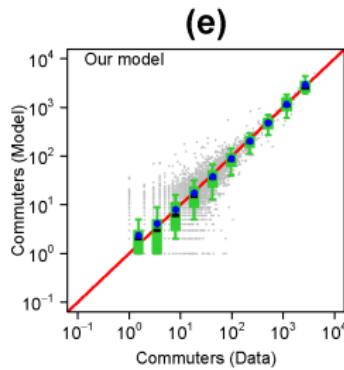
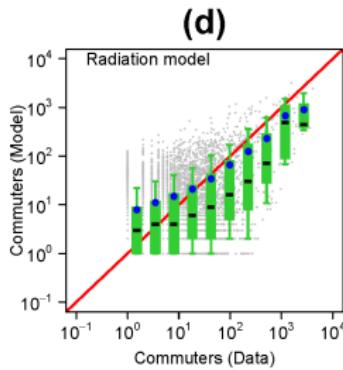
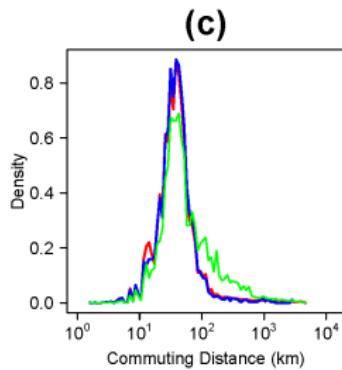
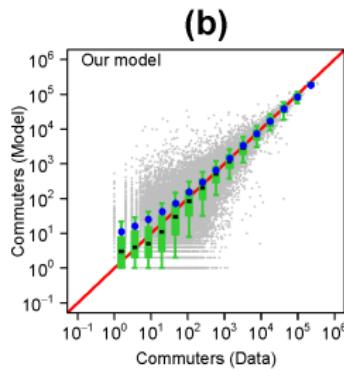
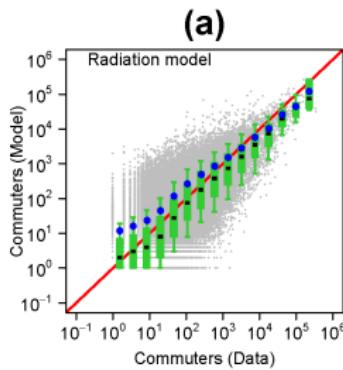


**Simini, F., Gonzalez, M. C., Maritan, A., and Barabasi, A.-L.** A universal model for mobility and migration patterns. *Nature*, 2012, 484(7392):96-100.

# Comparison with the "radiation model"



# Comparison with the "radiation model"



# Summary

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

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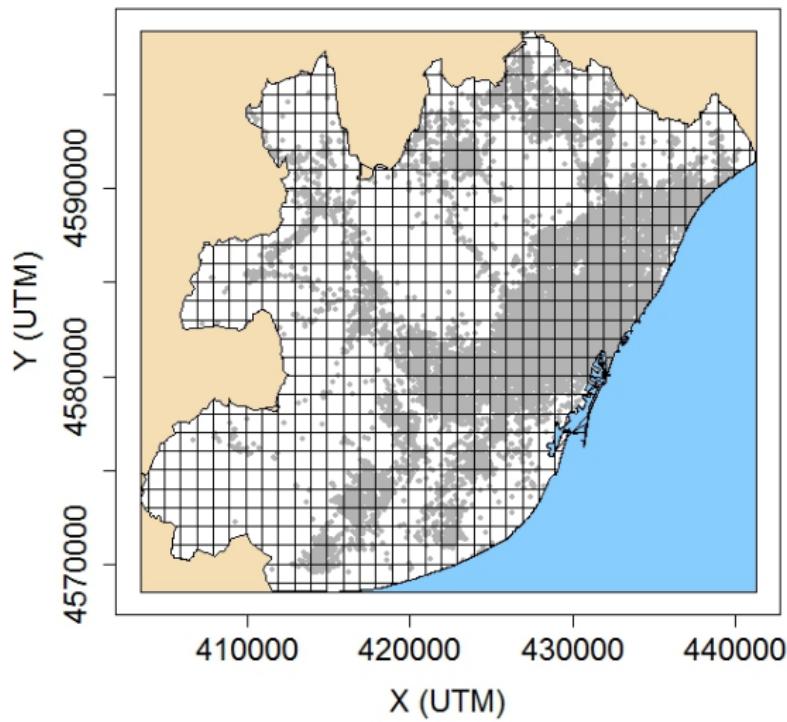
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- Model tested on 80 different regions (size and scale).
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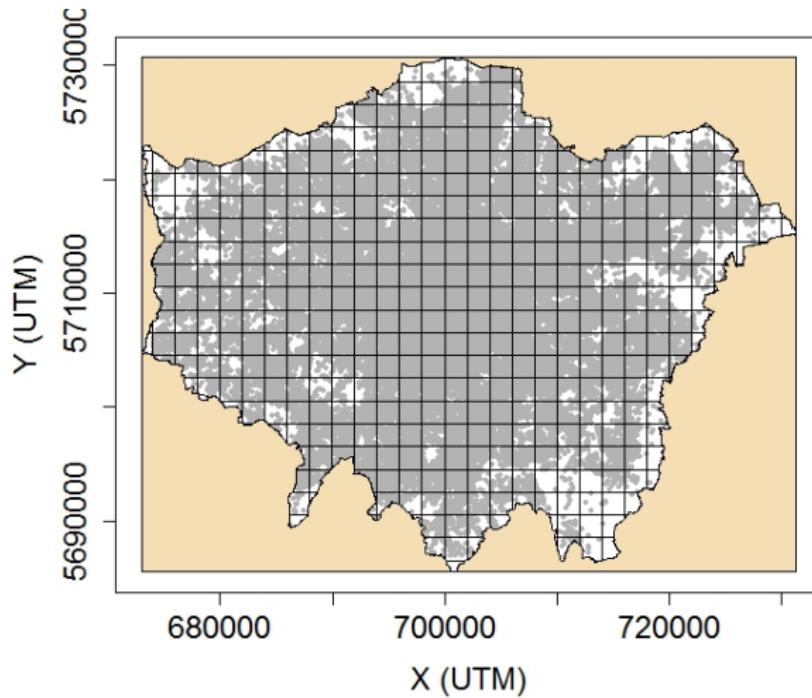
# Summary

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

# Barcelona



## London



# Results

