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A commuting generation model requiring only aggregated data

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Prototypical Policy Impacts on Multifunctional Activities in rural municipalities

A collaborative project under the
EU Seventh Framework Programme



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Motivation

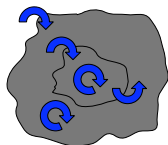
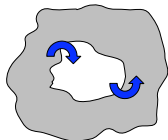
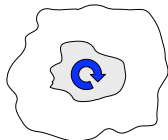
- 
- Studies on traffic and planning infrastructures
(*Ortùzar and Willumsen, 2011*)
 - Diffusion of epidemics
(*Balcan et al., 2009*)
 - Large demographic simulations
(*Huet and Deffuant, 2011*)

Problem description

INPUT: Total out and in-commuters (dark grey line and column)

OUTPUT: Origin-destination region table (light grey table)

Residence \ Work	Work								
	M_1	...	M_j	...	M_n	M_{n+1}	...	M_m	Total
M_1	0	...	R_{1j}	...	R_{1n}	R_{1n+1}	...	R_{1m}	O_1
...
M_i	R_{i1}	...	R_{ij}	...	R_{in}	R_{in+1}	...	R_{im}	O_i
...
M_n	R_{n1}	...	R_{nj}	...	0	R_{nn+1}	...	R_{nm}	O_n
Outside	X	...	X	...	X				
Total	I_1	...	I_j	...	I_n	I_{n+1}	...	I_m	



Summary

- 
- 1 Commuting generation model
 - 2 Exponential law versus power law
 - 3 β estimation for universal calibration

Commuting generation model

Input of the model

- $D = (d_{ij})_{\substack{1 \leq i \leq n \\ 1 \leq j \leq m}}$ the Euclidean distance matrix between the municipalities both in the same region and in the outside.
- $(I_j)_{1 \leq j \leq m}$ the number of in-commuters of the municipality j of the region and outside of it.
- $(O_i)_{1 \leq i \leq n}$ the number of out-commuters of the municipality i of the region only.

Commuting generation model

Algorithm description

For each remaining commuter who has not already found its place of work (while $O_i > 0 \forall 1 \leq i \leq n$), do:

- Select a living municipality i at random among the municipalities where at least one out-commuter remains (such as $O_i \neq 0$)
- Select the working destination j randomly following the probability distribution given by:

$$P_{i \rightarrow j} = \frac{I_j f(d_{ij}, \beta)}{\sum_{k=1}^m I_k f(d_{ik}, \beta)}, \quad \beta > 0.$$

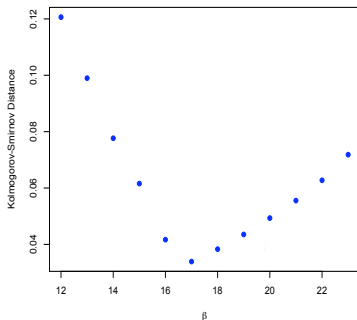
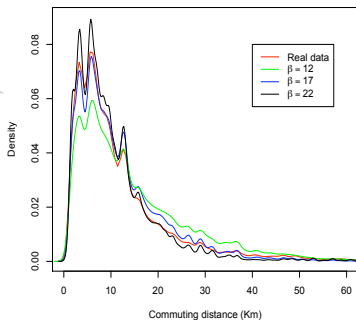
- Update the number of in-commuters of j : $I_j = I_j - 1$
- Update the number of out-commuters of i : $O_i = O_i - 1$

$$f(d_{ij}, \beta) = d_{ij}^{-\beta} \text{ or } e^{-\beta \frac{d_{ij}}{\bar{d}}} \quad 1 \leq i \leq n \text{ and } 1 \leq j \leq m$$


\bar{d} is the average distance between the municipalities of the region

Commuting generation model

Calibration



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 - 2 Exponential law versus power law**
 - 3 β estimation for universal calibration

Exponential law versus power law

Comparison indicators

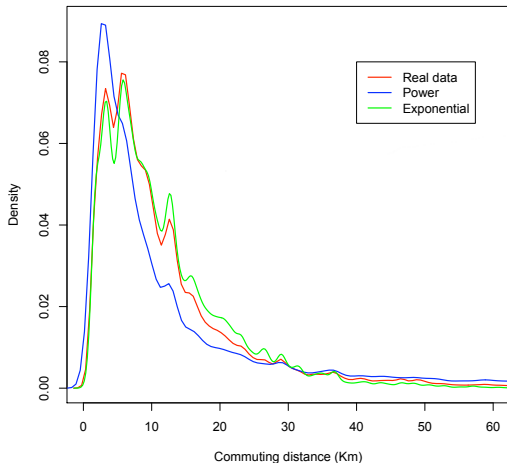
- 1 The commuting distance distribution

- 2
$$CPC_{n \times m}(S, R) = \frac{2NCC_{n \times m}(S, R)}{NC_{n \times m}(R) + NC_{n \times m}(S)}$$

- $NCC_{n \times m}(S, R) = \sum_{i=1}^n \sum_{j=1}^m \left(S_{ij} \mathbb{1}_{(R_{ij} - S_{ij}) \geq 0} + R_{ij} \mathbb{1}_{(R_{ij} - S_{ij}) < 0} \right)$
- $NC_{n \times m}(R) = \sum_{i=1}^n \sum_{j=1}^m R_{ij}$

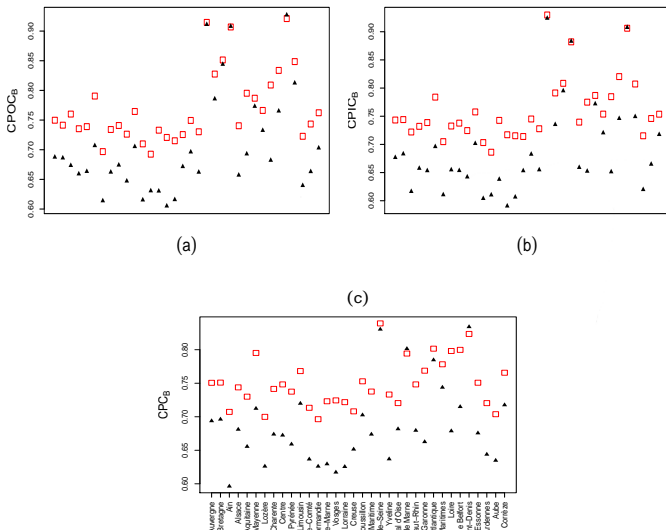
Exponential law versus power law

Commuting distance distribution



Exponential law versus power law

Common part of commuters

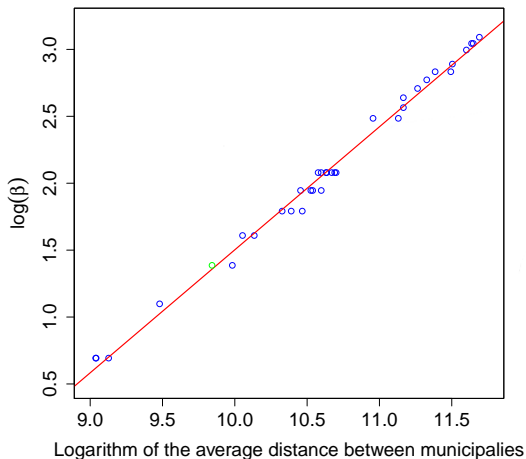


Summary

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β estimation for universal calibration

$$\beta = e^{-7.69\bar{d}} \bar{d}^{0.92}$$



β estimation for universal calibration

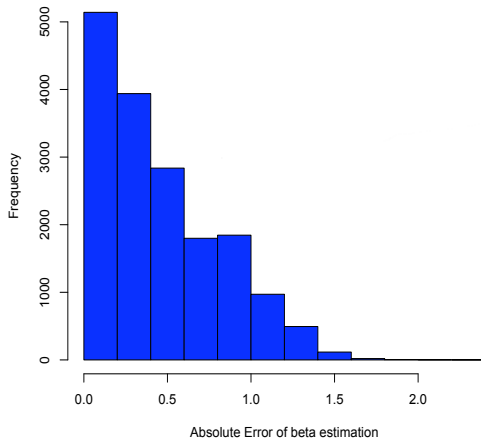
Cross validation

- 
- We draw at random $\frac{2}{3}$ of the 34 observations to build the model.
 - We predict the remaining third with this model.
 - We compute the absolute error between prevision and observation.

⇒ The process is repeated 1,000 times.

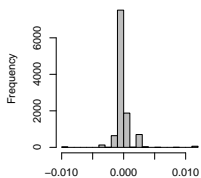
β estimation for universal calibration

Cross validation

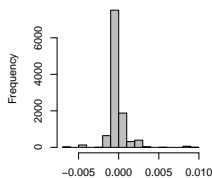


β estimation for universal calibration

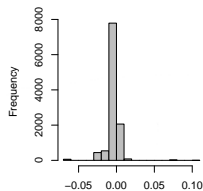
Cross validation



(a)



(b)



(c)

Conclusion and perspective



Conclusion

- Generation model managing with the lack of data
- Universally calibrated
- Tested on 35 case studies

Perspective

- Tested on more case studies
- Include the zero distance (Commuters and non-commuters)