A commuting generation model requiring only aggregated data

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Prototypical Policy Impacts on Multifunctional Activities in rural municipalities
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Motivation

- Studies on traffic and planning infrastructures
  (Ortùzar and Willumsen, 2011)

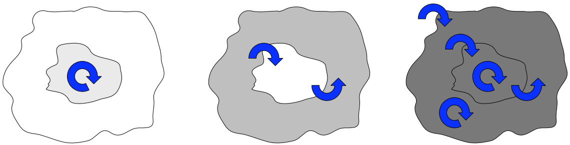
- Diffusion of epidemics
  (Balcan et al., 2009)

- 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)

Work / Residence	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

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

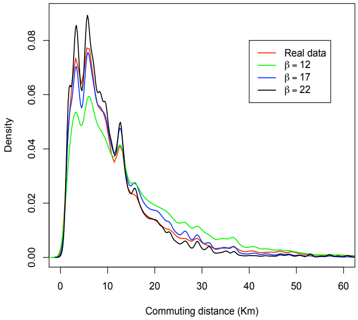
$$P_{i \to j} = \frac{I_j f(d_{ij}, \beta)}{\sum_{k=1}^{m} I_k f(d_{ik}, \beta)}, \quad \beta > 0.$$

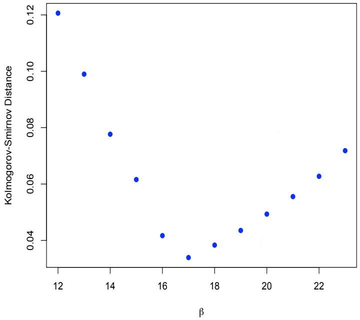
- Update the number of in-commuters of j: $I_j = I_j - 1$
- Update the number of out-commuters of i: $O_i = O_i - 1$

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

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

Commuting generation model
Calibration





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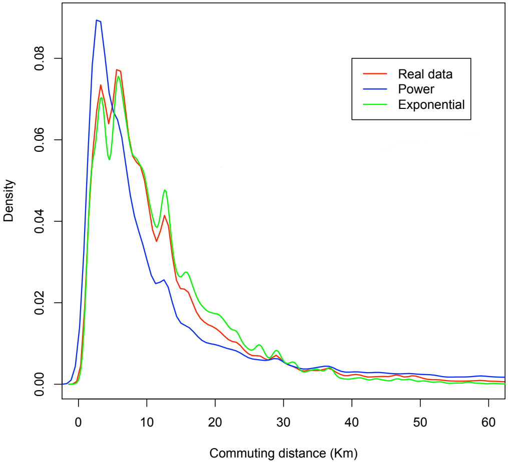
Exponential law versus power law
Comparison indicators

1. The commuting distance distribution
2. $CPC_{n\times m}(S,R) = \frac{2NCC_{n\times m}(S,R)}{NC_{n\times m}(R)+NC_{n\times m}(S)}$
   - $NCC_{n\times m}(S,R) = \sum_{i=1}^{n}\sum_{j=1}^{m}\left(S_{ij}\mathbb{1}_{\left(R_{ij}-S_{ij}\right)\geq 0} + R_{ij}\mathbb{1}_{\left(R_{ij}-S_{ij}\right)<0}\right)$
   - $NC_{n\times m}(R) = \sum_{i=1}^{n}\sum_{j=1}^{m} R_{ij}$

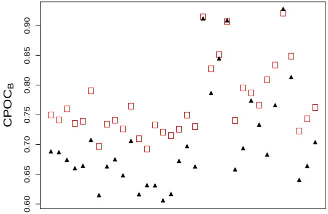
Exponential law versus power law

Commuting distance distribution

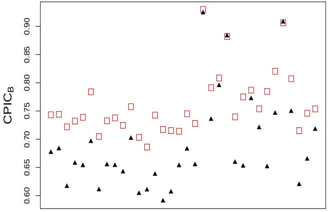


Exponential law versus power law

Common part of commuters

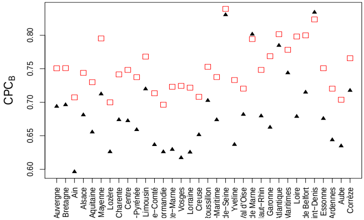


(a)



(b)

(c)



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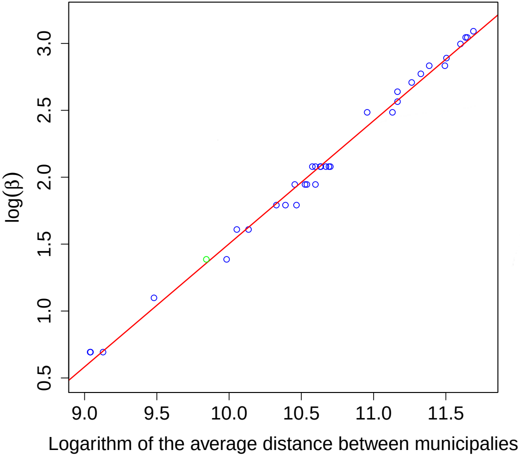
β estimation for universal calibration

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



β estimation for universal calibration

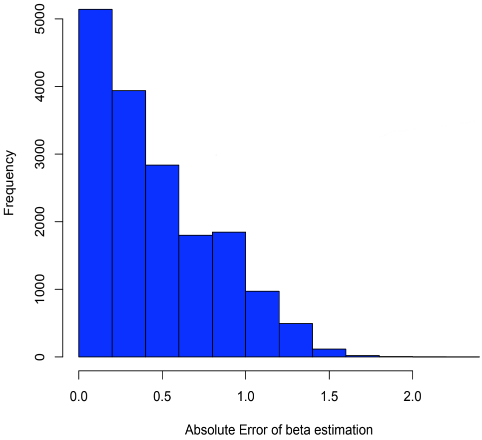
Cross validation

- 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.

$\Longrightarrow$ The process is repeated 1,000 times.

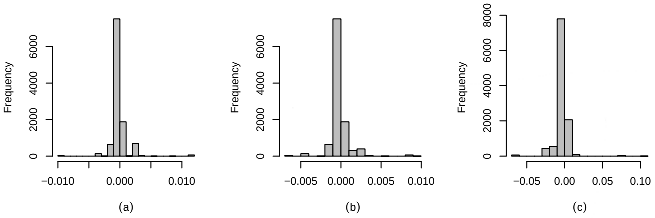
β estimation for universal calibration

Cross validation



β estimation for universal calibration

Cross validation



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)