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Assessing complex route choice models using an abstracted network based on mental representations

Evanthia Kazagli & Michel Bierlaire

Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
École Polytechnique Fédérale de Lausanne

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Agenda

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Route choice modeling

Operational difficulties

- Data
- Choice set
- Structural correlation

Behavioral aspect

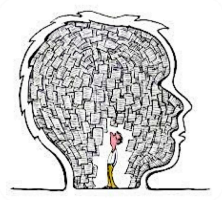
The MRI approach

How can we represent a route in a behaviorally realistic way without increasing the model complexity?

→ Model the strategic decisions of people instead of the *operational* ones.

✓ Mental Representation Item (MRI) → short description of a route

Kazagli, E., Bierlaire, M., and Flötteröd, G. (2016). Revisiting the Route Choice Problem: A Modeling Framework Based on Mental Representations, Journal of Choice Modelling 19:1-23. doi:10.1016/j.jocm.2016.06.001



Objectives

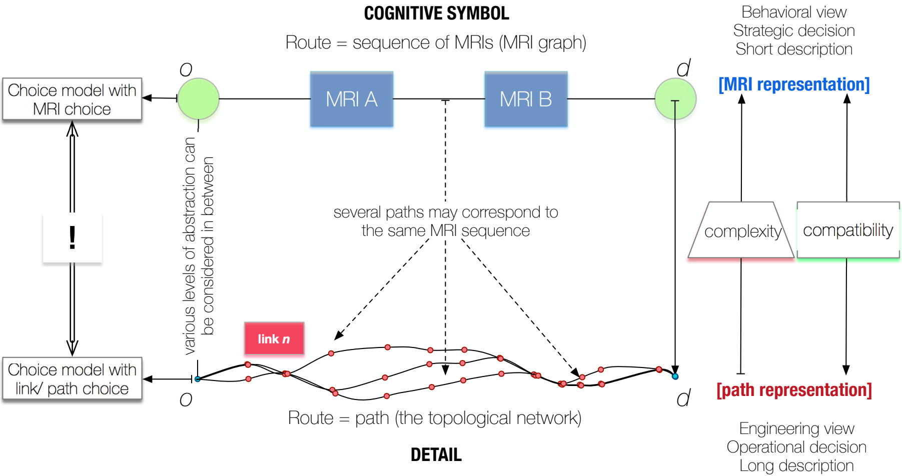
Current work and way forward

Potential of the MRI approach in:

1. simplifying and assessing complex route choice models
   - Recursive logit (RL) [Fosgerau et al., 2013]; [Mai et al., 2015]
   - Error components (EC) [Frejinger and Bierlaire, 2007]
   - Cross-nested logit (CNL) [Vovsha and Bekhor, 1998]; [Lai and Bierlaire, 2015]
2. improving route guidance and map design
   - cognitive limits in "megacities"
   - information provision for navigation in multilayer transportation systems

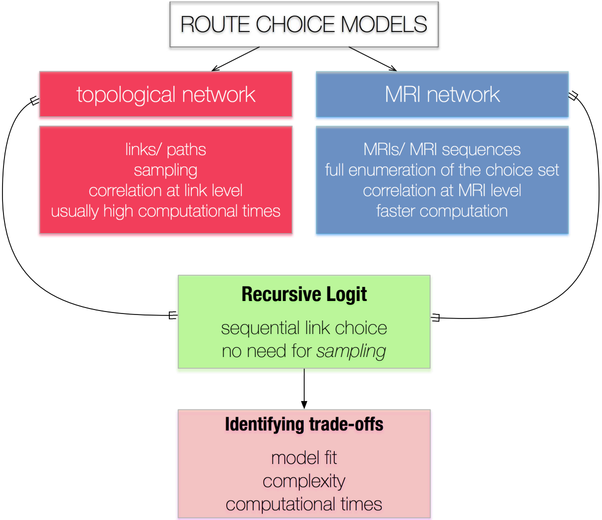
Hierarchical structure and consistency

From MRIs to paths and vice versa



Goal

Specification and estimation using real data



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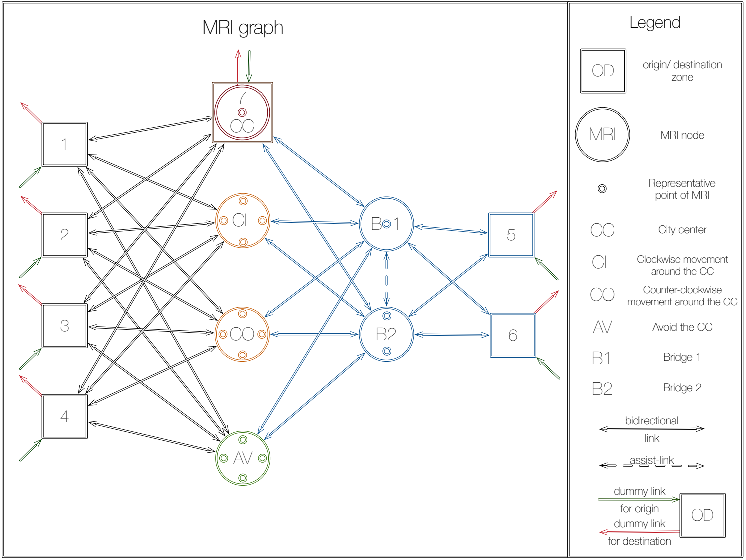
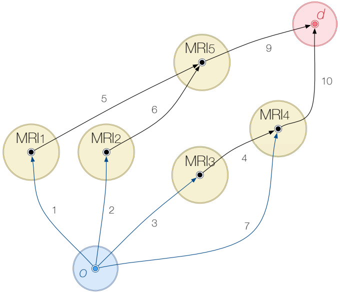
Recap MRI definition

<u>*Conceptual:*</u> *a name and a description;* <u>*Operational:*</u> *a point and a span*

Blueprint of a MRI network for route choice



EC model with MRIs

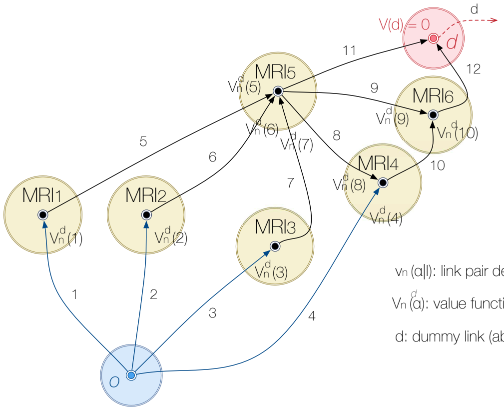


- Each MRI is associated with an error component.
- An alternative i is correlated with alternative j if they use the same MRI.

This is similar to the subnetwork approach proposed by [Frejinger and Bierlaire, 2007], but the MRIs are also the building blocks of the alternatives in the choice set.

RL model on the MRI graph

As soon as the MRI network is defined it is trivial to apply the formulation proposed by [Fosgerau et al., 2013] for the RL model.



$v_n(\alpha|l)$: link pair deterministic utility component

$V_n^d(\alpha)$: value function for the expected downstream utility

d: dummy link (absorbing state)

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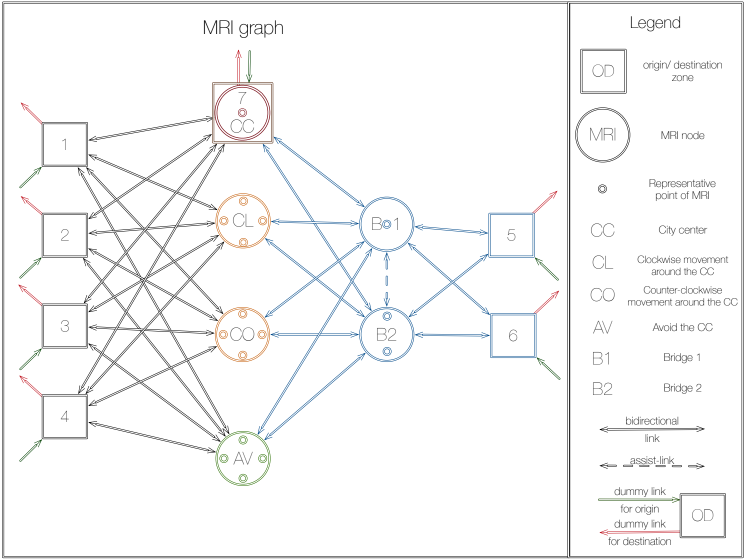
Borlänge dataset

1. GPS data $\rightarrow$ `map-matched trajectories`
2. Borlänge road network:
    1. 3077 nodes and 7459 unidirectional links
    2. Link travel times
3. We identified 6 MRIs.
4. We use a sample of 239 observations.

Borlänge MRI network



Analysis

model type	MRI	path
MNL	✓	–
RL	✓	✓
EC	✓	–

1. Model output
   - Probabilities
   - Elasticities
   - Ratios of parameters
2. Model application
   - Link flows
3. Computational times

Specification table

Parameter name	**Model** 1 **MNL/ RL with** MRIs[1]	**Model** 2 **EC with** MRIs	**Model** 3 **RL with** paths
ASC_{AVOID}	1	1	1
ASC_{CC}	1	1	1
$ASC_{BRIDGE1}$	1	1	1
β_{TIME}	TT[2] (min)	TT (min)	TT (min)
β_{IS}	# intersections	# intersections	# intersections
β_{LT}	# left turns	# left turns	# left turns
ω_{AVOID}	$\times$	$\sim \mathcal{N}(0, \sigma^2_{AVOID})$	$\times$
ω_{CC}	$\times$	$\sim \mathcal{N}(0, \sigma^2_{CC})$	$\times$
$\omega_{BRIDGE1}$	$\times$	$\sim \mathcal{N}(0, \sigma^2_{BRIDGE1})$	$\times$

[1]The RL model is equivalent to the MNL with full choice set for a cycle-free network.
[2]TT: travel time

Estimation results

Parameter name	Model 1: MNL with MRIs Parameter value; (Rob. t-test 0)	Model 2: EC with MRIs Parameter value; (Rob. t-test 0)	Model 3: RL with paths Parameter value; (t-test 0)
ASC_{AVOID}	**1.69**; **(5.51)**	**2.25**; **(5.24)**	**0.087**; **(1.98)**
ASC_{CC}	**-2.07**; **(-3.96)**	**-6.38**; **(-1.11)**	**-0.179**; **(-5.10)**
$ASC_{BRIDGE1}$	**-1.93**; **(-5.01)**	**-4.14**; **(-2.93)**	**0.615**; **(1.61)**
β_{TIME}	**-0.474**; **(-14.94)**	**-0.596**; **(-13.86)**	**-2.420**; **(-14.56)**
β_{IS}	**-0.041**; **(-1.45)**	**-0.115**; **(-3.01)**	**-0.407**; **(-7.64)**
β_{LT}	**-0.076**; **(-1.50)**	**-0.104**; **(-1.58)**	**-0.975**; **(-18.98)**
ω_{AVOID}	-	**2.05**; **(3.46)**	-
ω_{CC}	-	**3.96**; **(1.24)**	-
$\omega_{BRIDGE1}$	-	**4.59**; **(2.17)**	-
Number of observations	239	239	239
Number of parameters	6	9	6
Number of draws	-	1000	-
$\mathcal{L}(0)$	-619.617	-629.983	
$\mathcal{L}(\hat{\beta})$	-193.633	-183.558	1565.49

Ratios of parameters

Model	β_{TIME}	β_{IS}	β_{LT}	β_{IS}/β_{TIME}	β_{LT}/β_{TIME}	β_{IS}/β_{LT}
MNL/ RL	−0.474	−0.041	−0.076	0.086	0.161	0.536
RL (paths)	−2.420	−0.407	−0.975	0.168	0.403	0.418
EC	−0.596	−0.115	−0.104	0.193	0.174	1.106

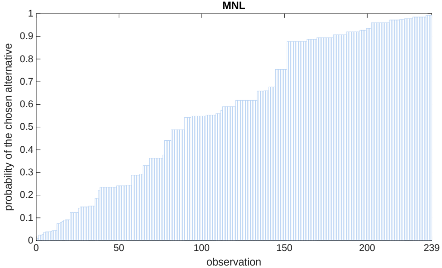
Model	*CC*	*AVOID*	*BRIDGE1*	*AVOID*/ *CC*	*BRIDGE1*/ *CC*	*AVOID*/ *BRIDGE1*
MNL/ RL	−2.070	1.690	−1.930	−0.816	0.932	−0.876
RL (paths)	−0.179	0.087	0.615	−0.487	−3.440	0.142
EC	−6.380	2.250	−4.140	−0.353	0.649	−0.543

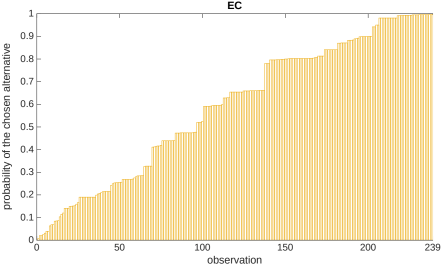
Model	β_{TIME}	*CC*	*AV*	*BRIDGE1*	*CC*/β_{TIME}	*AV*/β_{TIME}	*BRIDGE1*/β_{TIME}
MNL/ RL	−0.474	−2.070	1.690	−1.930	4.368	−3.565	4.072
RL (paths)	−2.420	−0.179	0.087	0.615	0.074	−0.036	−0.254
EC	−0.596	−6.380	2.250	−4.140	10.705	−3.775	6.946

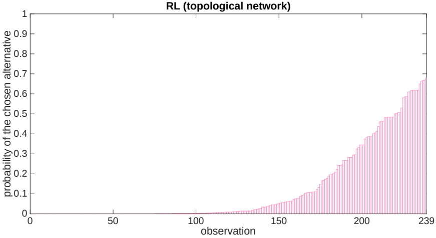
Computational times

Model	MRI representation	path representation
MNL	0 min	–
RL (with ASCs)	0 (2) min	$\sim$ 20 (45) min
EC	$\sim$ 60 min	–

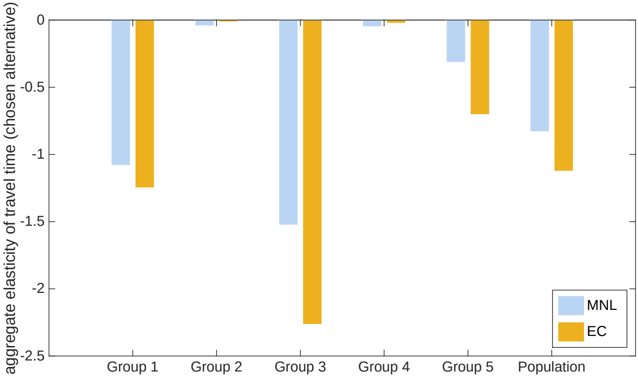
Probability of the chosen alternative





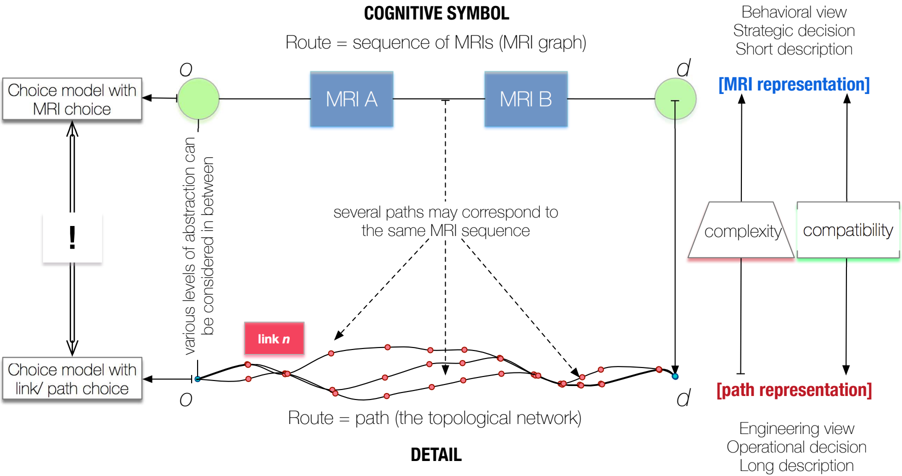


Aggregate elasticity of travel time (chosen alternative)

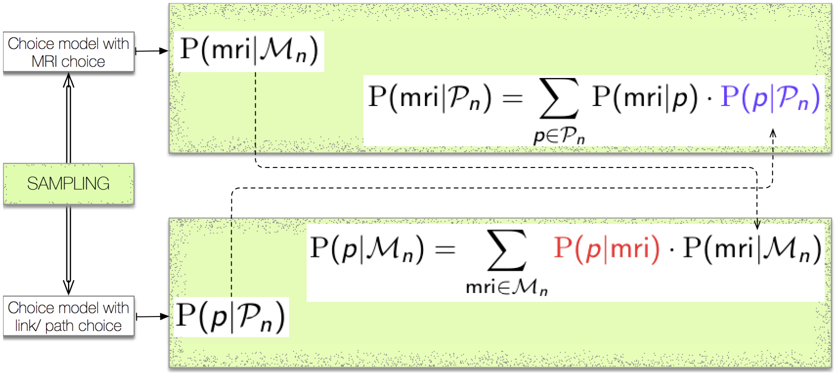


Hierarchical structure and consistency

From MRIs to paths and vice versa



Comparing aggregate and disaggregate output



Agenda

1. Context
2. Route choice with mental representations
3. Analysis
4. Conclusion

Conclusion

- Exploiting behavioral rationale to facilitate the estimation and application of route choice models to large networks.
  1. MNL as a benchmark.
  2. RL: `MRI` approach to reduce the state space.
  3. EC: `MRI` approach to capture perceptual correlation.
  4. CNL: `MRI` approach to reduce the number of nests.
- Aggregate/ disaggregate approach.
  - Can we obtain a similar result?

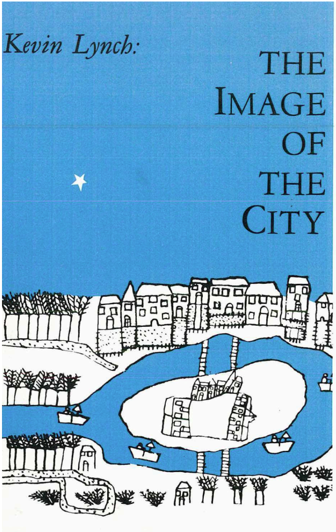
Future work

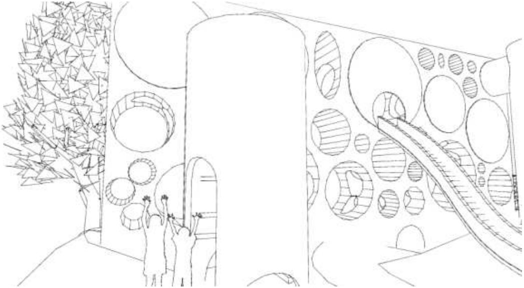
1. Test the MRI approach in a large network and dataset.
   - How complicated it is to define a realistic and operational MRI network for a very big, complex topological network?
2. Relevance for route guidance and map design.
   - [Gallotti et al., 2016] Lost in transportation: Information measures and cognitive limits in multilayer navigation.

Mapping, Beirut-style: how to navigate a city without using any street names.

Jenny Gustafsson in Beirut, for The Guardian (June, 2015)

"It is about learning how a city works. There is usually a very clear order; you just have to understand it. Once you know this, navigation is not hard. ... references and directions like 'nearby', 'opposite' and 'in between', because roads often have no signs. ... creative names like "The Road with the Oak Tree"..."





Thank you!

evanthia.kazagli@epfl.ch

transp-or.epfl.ch

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The MRI network

For a given case study & scope of analysis

1. Define the MRIs and the origin o and destination d zones.
2. For each MRI r creat a node.
3. For each o and d zone determine the centroid s of the zone and create a node corresponding to it.

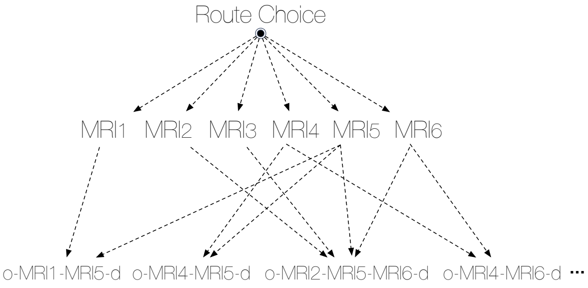
   The number of vertices of the MRI network equals the summation of the number of MRIs $\mathcal{R}$ and zone centroids $\mathcal{S}$.
4. For each pair of nodes in the MRI network create a link (edge) ℓ if the transition from one node to another is allowed.

Recap Definition of alternatives

Following the definition of the `MRI`, a route is defined as:

1. an origin,
2. an ordered sequence of `MRIs` (possibly only one), and
3. a destination.

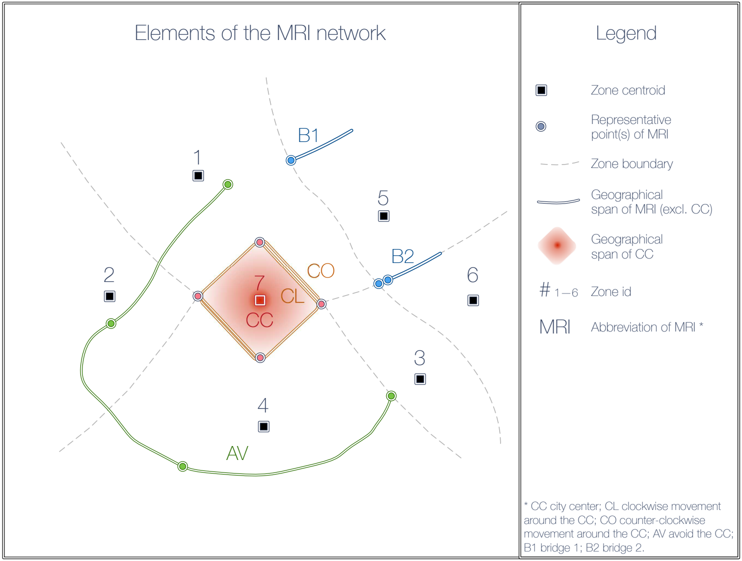
CNL model with MRIs



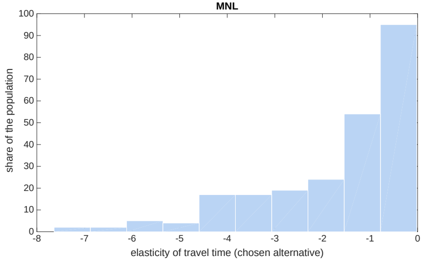
- Each MRI is a nest.
- An alternative i belongs to nest m if MRI m appears in the sequence i.

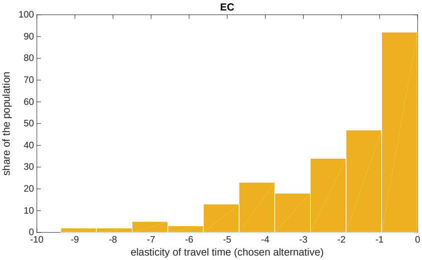
This is similar to [Vovsha and Bekhor, 1998] and [Lai and Bierlaire, 2015], but nests correspond to MRIs instead of links.

Borlänge MRI components

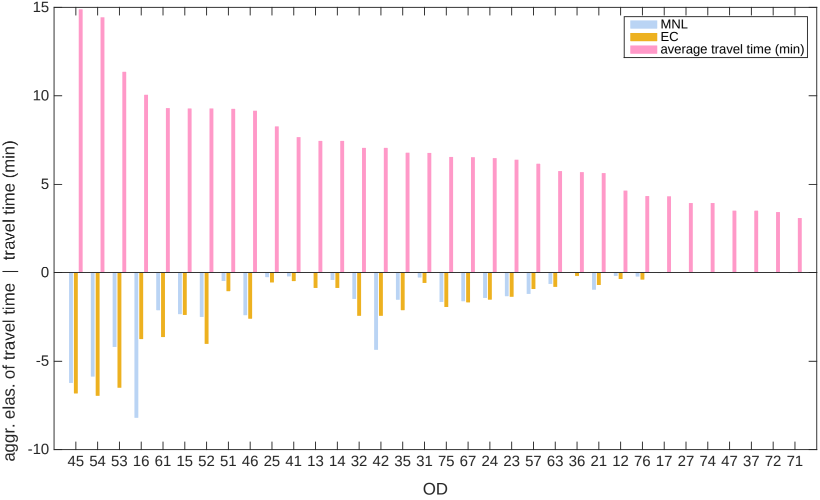


Elasticity of travel time (chosen alternative)





Aggregate elasticity of travel time (chosen alternative)



Québec dataset

1. Smartphone data collection → `more than 20000 GPS trajectories`

✓ Departure times

✓ Trip purposes

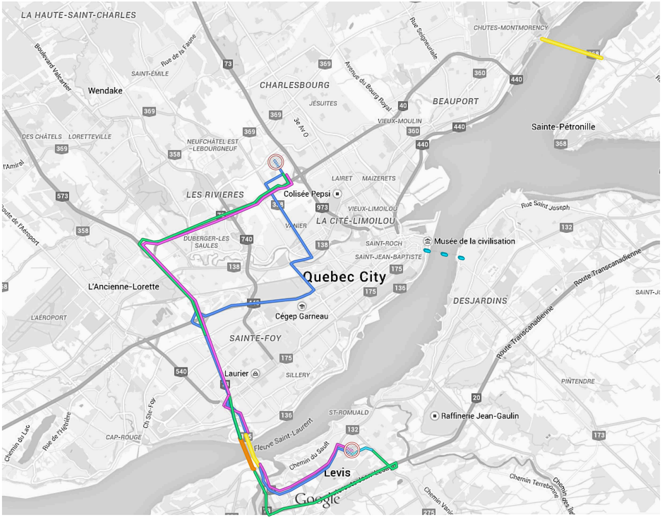
✓ Land use information

2. Quebec road network:

   ∼ 20000 nodes and 40000 unidirectional links

Québec

Autoroutes and bridges



Québec

Bridge vs ferry boat