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Evaluation of low traffic neighborhoods: the Paris case study

Biao Yin[a], Azise Oumar Diallo[b], Tatiana Seregina[a], Nicolas Coulombel[a]

[a]*LVMT, Ecole des Ponts ParisTech, France*

[b]*LAET, Ecole Nationale des Travaux Publics de l'Etat, France*

Laboratoire Ville Mobilité Transport

École des Ponts ParisTech

Université Gustave Eiffel

Context

Cities face multiple challenges:

- environmental transition: climate change, air quality
- accessibility: recent focus on local accessibility (15-minute city)
- quality of life

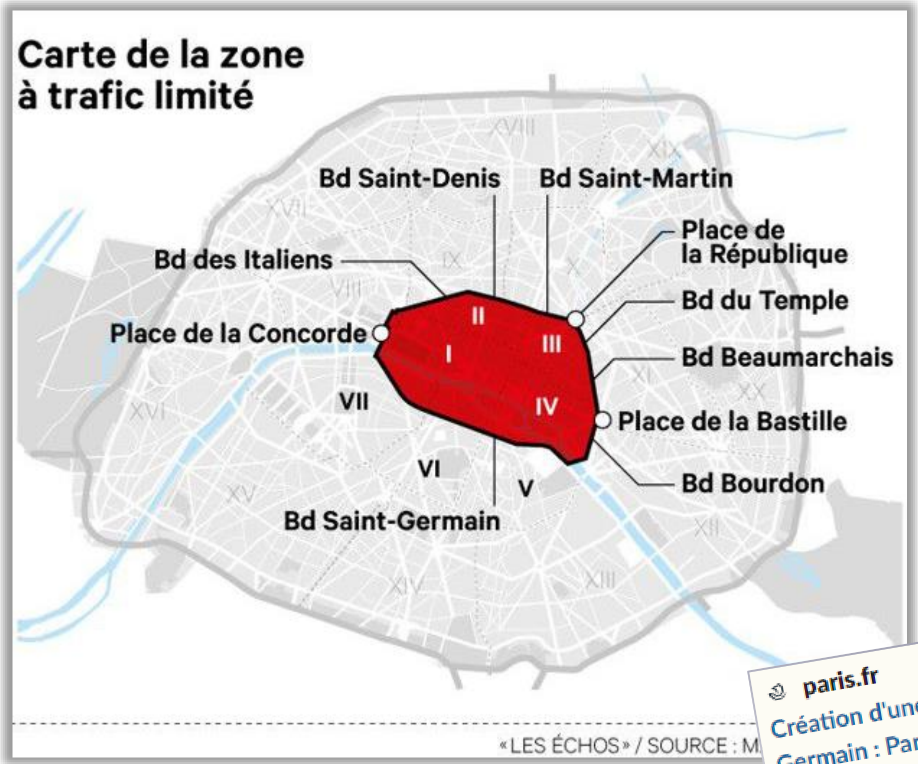
Increasing interest for policies limiting traffic

- low emission zones $\rightarrow$ air quality
- low-traffic neighborhoods $\rightarrow$ local accessibility, air quality, climate change

But possible rebound effects?

The case of Paris

- Contemplated low-traffic neighborhood in 2024



Les Echos

Entreprises | Finance - Marchés | Bourse | Monde | Tech-Médias | Start-up | Politique | Région

Les restrictions de circulation automobile dans le centre de Paris repoussées à 2024

D'abord annoncée pour le premier semestre 2022, l'entrée en vigueur d'une « zone apaisée » dans le centre de Paris interviendra finalement en 2024, a annoncé jeudi la mairie. Mais le préfet de police de Paris, Didier Lallement, a exprimé dans la foulée ses « fortes réserves sur le projet tel qu'envisagé ».

... apaisée » couvrira l'arrondissement de Paris Centre ainsi que le nord du boulevard Saint-Germain jusqu'à la Seine ... la rive gauche. (iStock)

paris.fr

Création d'une zone apaisée Paris Centre - Saint Germain : Paris lance la concertation

Et si on ralentissait ? Et si on se réappropriait la ville ? Et si on libérait l'espace public au profit de ceux qui en ont vraiment besoin ? Pour répondre à ces questions, la Ville de Paris lance une consultation sur l'instauration d'une Zone à trafic limité dans la zone Paris Centre - Saint-Germain.

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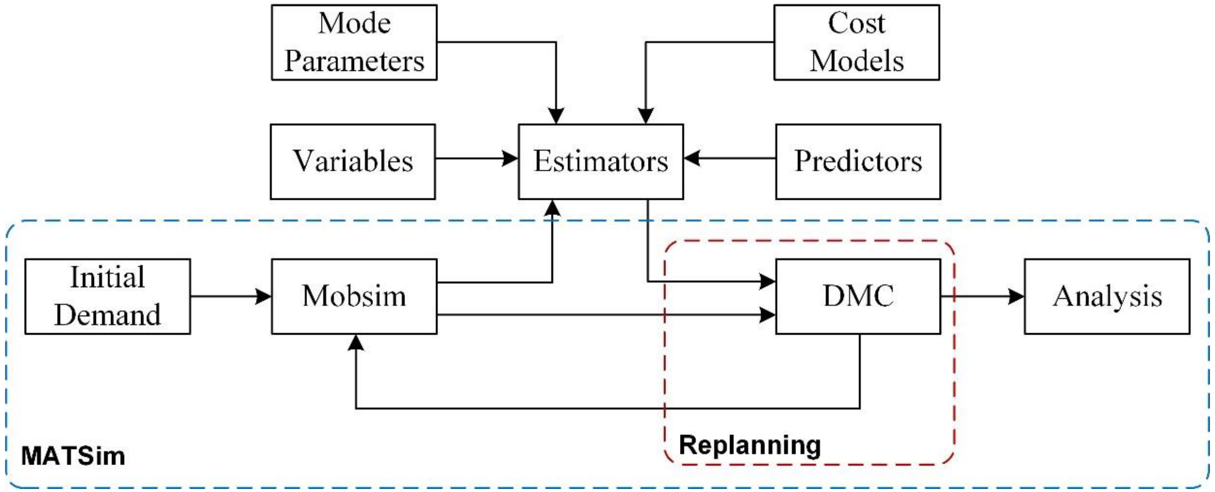
Outline

1. Configuration of intermodality
2. Calibration
3. Paris case study
4. Results
5. Discussion and conclusion

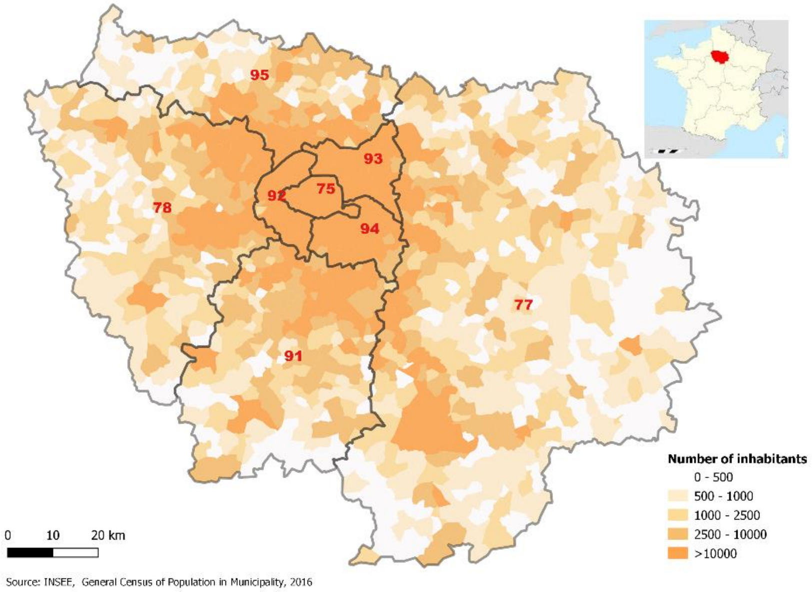
1. Configuration of intermodality

❑ Overview of Eqasim

- A novel **Discrete Mode Choice (DMC)** extension under the MATSim framework
- Pipeline of **synthetic population** generation (**Île-de-France**, Sao-Paulo, Los Angeles, etc)
- Calibrated with 2010 HTS (EGT 2010) in Île-de-France scenario
- Open source: https://github.com/eqasim-org



Coupling DMC module in MATSim (Hörl and Balac, 2021)



Île-de-France (~12 million inhabitants)

1. Configuration of intermodality

❑ Add two forms of intermodalities into Eqasim

Park & Walk

- Activate walk-car-walk trips
  - by setting AccessEgressType.accessEgressModeToLink;
- Compute accessEgressWalkTime within a multi-stage car trip

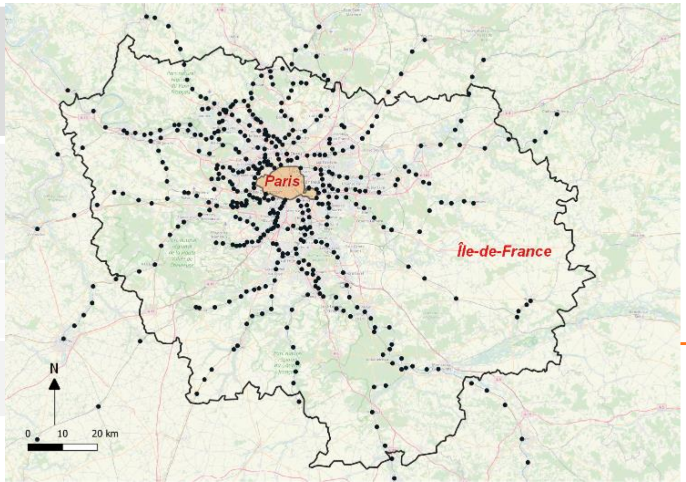
Park & Ride (Car & PT)

- Adapt the P&R module (Diallo's PhD thesis) to Île-de-France scenario
- Create the new routing modes of car_pt and pt_car with a tour constraint
- Implement 500 P&R facilities (outside Paris) in Île-de-France

❑ Our scenarios

Scenario	Walk access/egress for car trips	Parking & Ride (Car & PT) trips
Reference_default (Eqasim)	No	No
Reference	Yes	Yes
Driving restriction zone	Yes	Yes

P&R in Île-de-France



Transport

1. Configuration of intermodality

- DMC utility functions in Île-de-France scenario

$$
\begin{aligned}
u_{\mathrm{car}}(\chi) = \alpha_{\mathrm{car}} & \\
&+ \beta_{\mathrm{travelTime,car}} \cdot \chi_{\mathrm{travelTime,car}} \\
&+ \beta_{\mathrm{travelTime,car}} \cdot \theta_{\mathrm{parkingSearchPenalty}} \\
&+ \beta_{\mathrm{travelTime,walk}} \cdot \theta_{\mathrm{accessEgressWalkTime}} \\
&+ \beta_{\mathrm{cost}} \cdot \left(\frac{\chi_{\mathrm{crowflyDistance}}}{\theta_{\mathrm{averageDistance}}} \right)^{\lambda} \cdot \chi_{\mathrm{cost,car}} \\
&+ \begin{cases} \beta_{\mathrm{inside\_urban,car}} + \beta_{\mathrm{cross\_urban,car}}, & \mathrm{O\&D} \in \mathrm{urban} \\ \beta_{\mathrm{cross\_urban,car}}, & \mathrm{O|D} \in \mathrm{urban} \\ 0, & \text{other} \end{cases}
\end{aligned}
$$

$$
\begin{aligned}
u_{\mathrm{pt}}(\chi) = \alpha_{\mathrm{pt}} & \\
&+ \beta_{\mathrm{numberOfTransfers}} \cdot \chi_{\mathrm{numberOfTransfers}} \\
&+ \beta_{\mathrm{inVehicleTime}} \cdot \chi_{\mathrm{inVehicleTime}} \\
&+ \beta_{\mathrm{transferTime}} \cdot \chi_{\mathrm{transferTime}} \\
&+ \beta_{\mathrm{accessEgressTime}} \cdot \chi_{\mathrm{accessEgressTime}} \\
&+ \beta_{\mathrm{cost}} \cdot \left(\frac{\chi_{\mathrm{crowflyDistance}}}{\theta_{\mathrm{averageDistance}}} \right)^{\lambda} \cdot \chi_{\mathrm{cost,pt}}
\end{aligned}
$$

$$
\begin{aligned}
u_{\mathrm{bike}}(\chi) = \alpha_{\mathrm{bike}} &+ \beta_{\mathrm{travelTime,bike}} \cdot \chi_{\mathrm{travelTime,bike}} \\
&+ \beta_{\mathrm{age,bike}} \cdot \max(0, \quad \alpha_{\mathrm{age}} - 18) \\
&+ \begin{cases} \beta_{\mathrm{inside\_urban,bike}}, & \mathrm{O\&D} \in \mathrm{urban} \\ 0, & \text{other} \end{cases}
\end{aligned}
$$

$$
u_{\mathrm{walk}}(\chi) = \alpha_{\mathrm{walk}} + \beta_{\mathrm{travelTime,walk}} \cdot \chi_{\mathrm{travelTime,walk}}
$$

With intermodality

$$
\begin{aligned}
u'_{\mathrm{car}}(\chi) = \alpha_{\mathrm{car}} & \\
&+ \beta_{\mathrm{travelTime,car}} \cdot \chi_{\mathrm{travelTime,car}} \\
&+ \beta_{\mathrm{travelTime,car}} \cdot \theta_{\mathrm{parkingSearchPenalty}} \\
&+ \beta_{\mathrm{accessEgressWalkTime,car}} \cdot \chi_{\mathrm{accessEgressWalkTime}} \\
&- \exp\left(\log(101) \frac{\chi_{\mathrm{accessEgressWalkTime}}}{\theta_{\mathrm{walkTimeThreshold}}} \right) + 1 \\
&+ \beta_{\mathrm{cost}} \cdot \left(\frac{\chi_{\mathrm{crowflyDistance}}}{\theta_{\mathrm{averageDistance}}} \right)^{\lambda} \cdot \chi_{\mathrm{cost,car}} \\
&+ \begin{cases} \beta_{\mathrm{inside\_urban,car}} + \beta_{\mathrm{cross\_urban,car}}, & \mathrm{O\&D} \in \mathrm{urban} \\ \beta_{\mathrm{cross\_urban,car}}, & \mathrm{O|D} \in \mathrm{urban} \\ 0, & \text{other} \end{cases}
\end{aligned}
$$

$$u'_{\mathrm{pt}}(\chi) = u_{\mathrm{pt}}(\chi)$$

$$u'_{\mathrm{bike}}(\chi) = u_{\mathrm{bike}}(\chi)$$

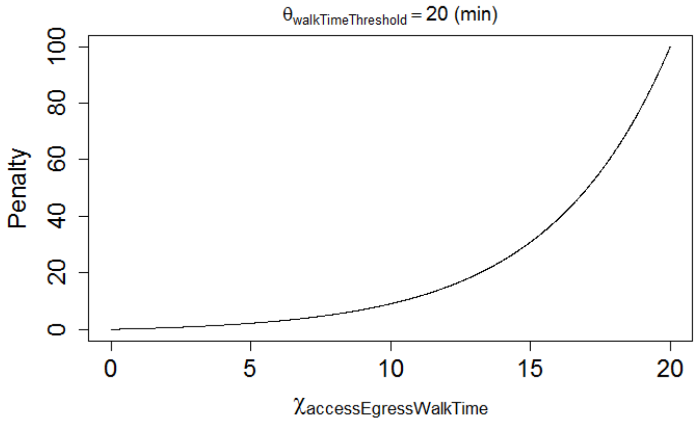
$$u'_{\mathrm{walk}}(\chi) = u_{\mathrm{walk}}(\chi)$$

$$
\begin{aligned}
u'_{\mathrm{car\_pt}}(\chi) &= \alpha_{\mathrm{car\_pt}} \\
&+ u'_{\mathrm{car}}(\chi) - \alpha_{\mathrm{car}} \\
&+ u'_{\mathrm{pt}}(\chi) - \alpha_{\mathrm{pt}}
\end{aligned}
$$

Parameters for calibration

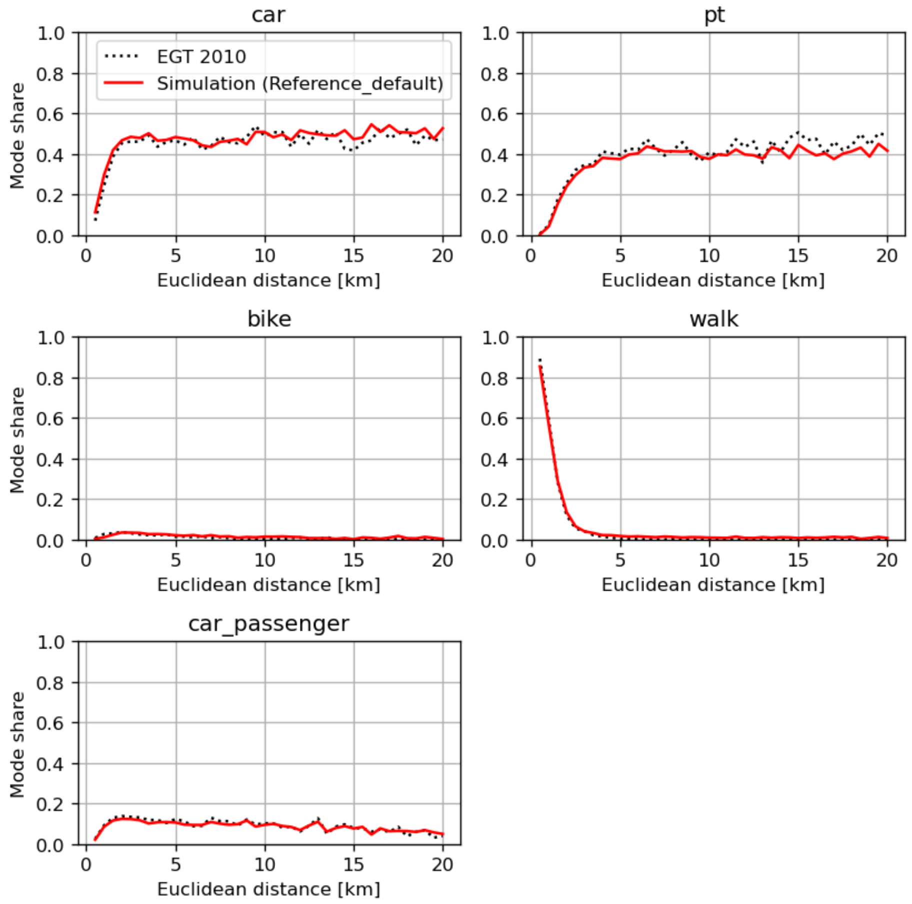
$$\beta_{\mathrm{accessEgressWalkTime,car}} = ?$$

$$\alpha_{\mathrm{car\_pt}} = ?$$



2. Calibration

- The two parameter adjustments (1% population in IDF)

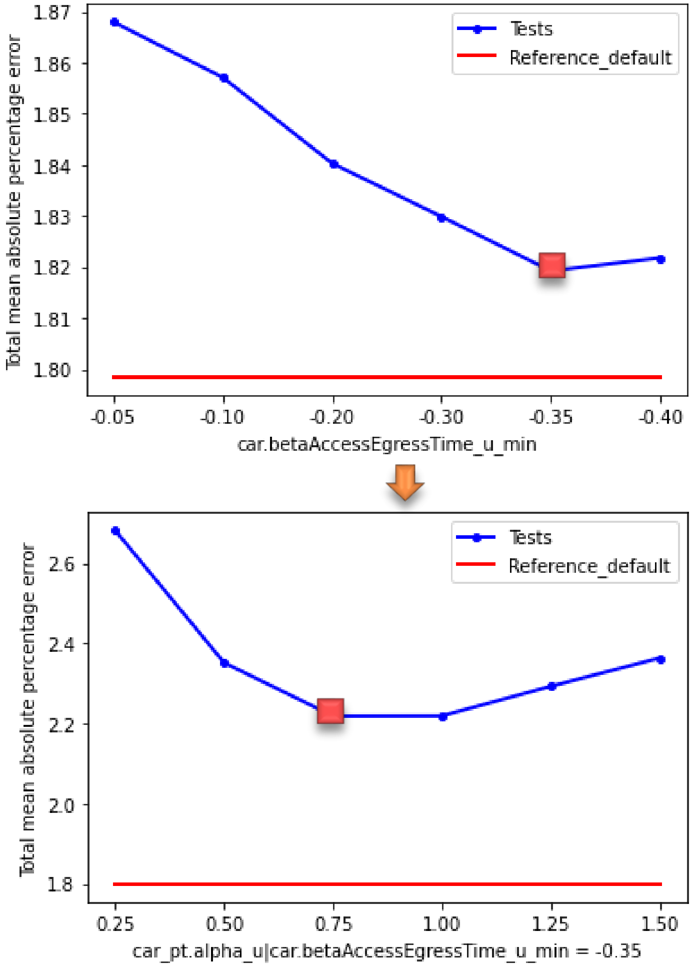


Calibrated modal shares by distance in Île-de-France
(default: without intermodality)

$$\beta_{\text{travelTime,walk}} = -0.15$$
$$(\theta_{\text{accessEgressWalkTime}} = 4)$$

$$\text{MAPE} = \sum_i \sum_j \frac{\left|\text{Sim}_{i,j} - \text{HTS}_{i,j}\right|}{\text{HTS}_{i,j}\left|\text{DC}\right|},$$
$$(i \in \text{M},\ j \in \text{DC})$$

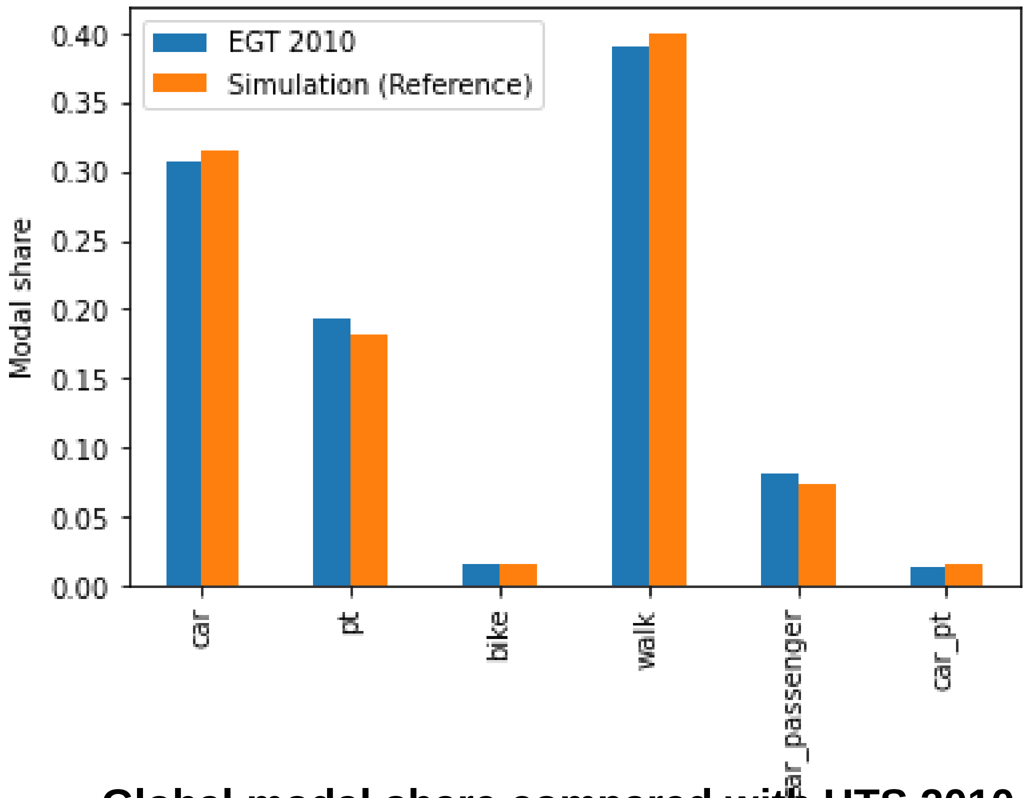
$$\alpha_{\text{car}} + \alpha_{\text{pt}} = 1.35$$
$$(\alpha_{\text{car}} = 1.35,\ \alpha_{\text{pt}} = 0)$$



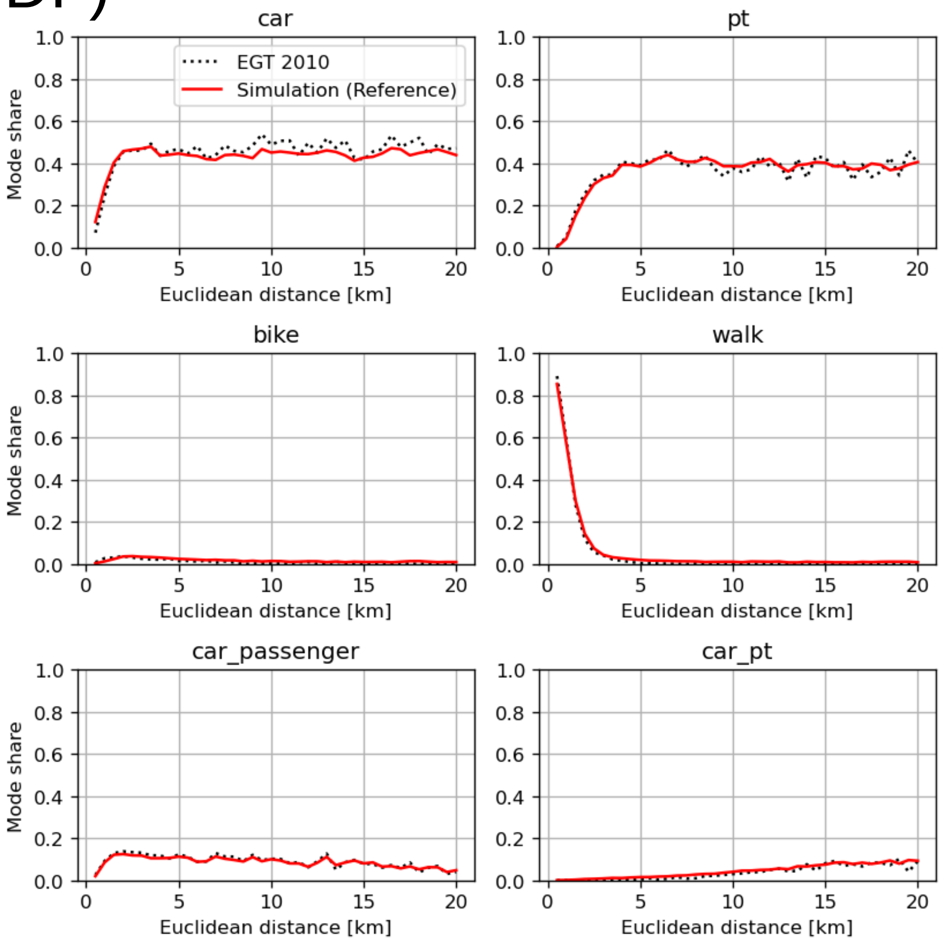
Tests with intermodality

2. Calibration

- Parameter verification (**5%** population in IDF)
  - car.betaAccessEgressWalkTime = **-0.35**
  - car_pt.alpha = **0.75**



Global modal share compared with HTS 2010



Calibrated modal shares by distance in Île-de-France (with intermodality)

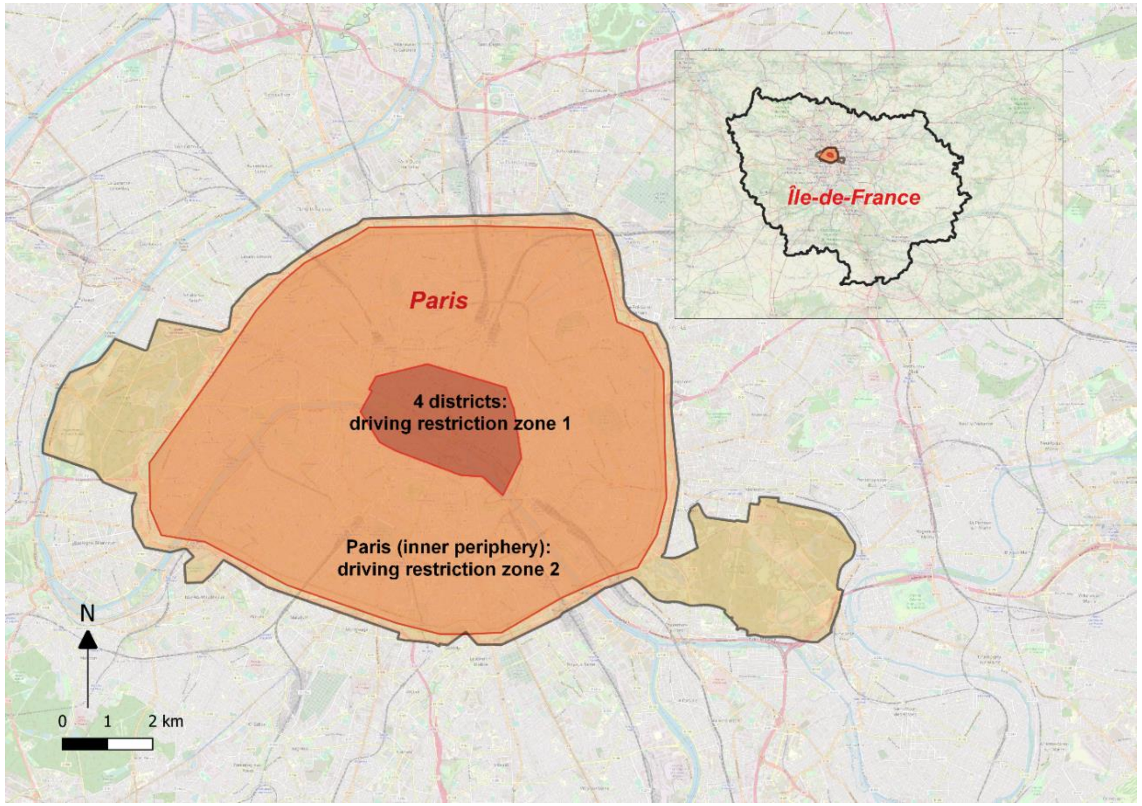
3. Paris case study

Scenario

- Case 1: 4 inner districts
- Case 2: all Paris
- Permission:
  - only residents can drive in the zone
  - vehicle type: only passenger cars

Configuration

- Population file: sub-population = resident / non-resident
- Network file: remove “car” from links in DRZ and add “carInternal” for all links
- Mode availability: replace “car” by “carInternal” for residents
- Set carInternal the same attributes as car (parameters in DMC, routing mode, tour constraint, etc.)

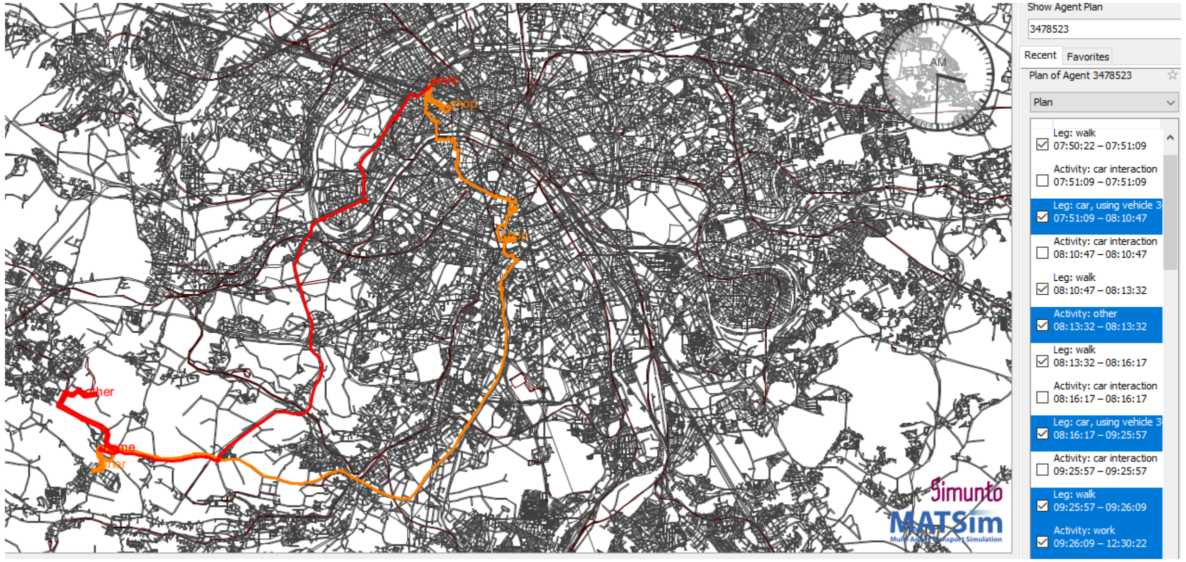


Two cases of driving restriction zone in Paris

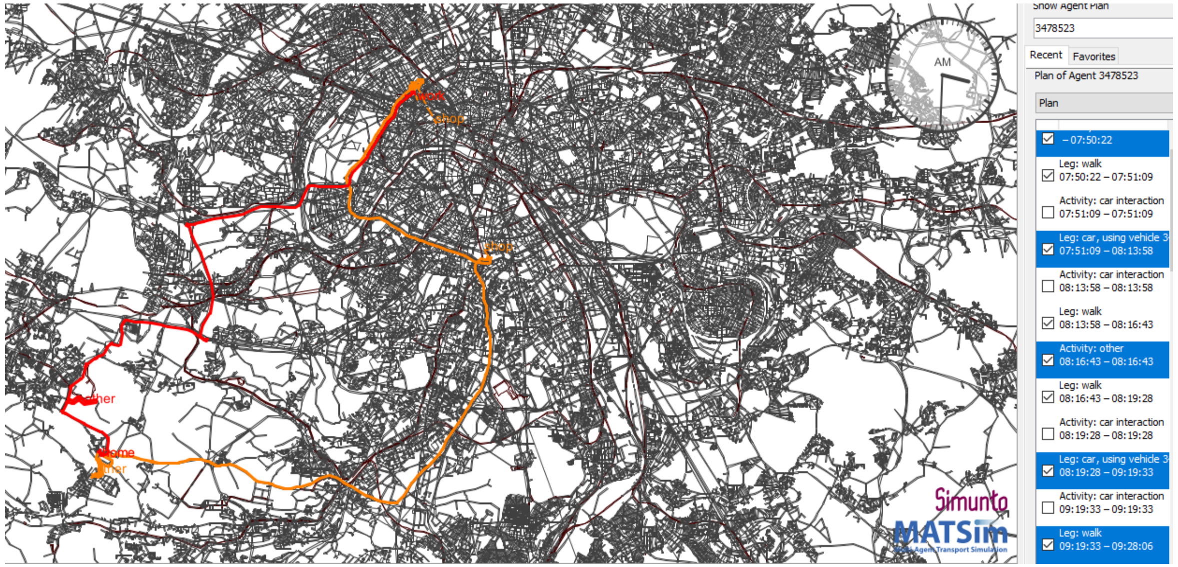
3. Paris case study

- ❑Example of travel behaviors before/after driving restriction zone (DRZ) in Paris

The individual who still uses the car: id = 3478523



Before DRZ (car for work)



After DRZ (car for work)

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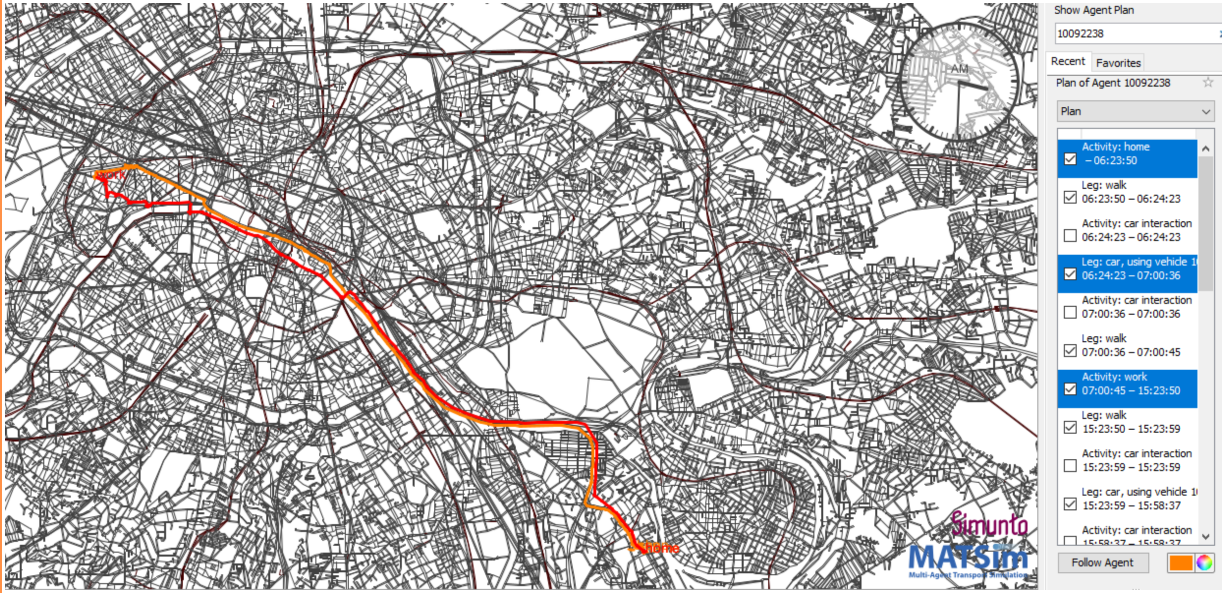
3. Paris case study

- ❑Example of travel behaviors before/after DRZ in Paris

The individual who changes the modes: id = 10092238



Before DRZ (car for work)

After DRZ (car+pt for work)

4. Results

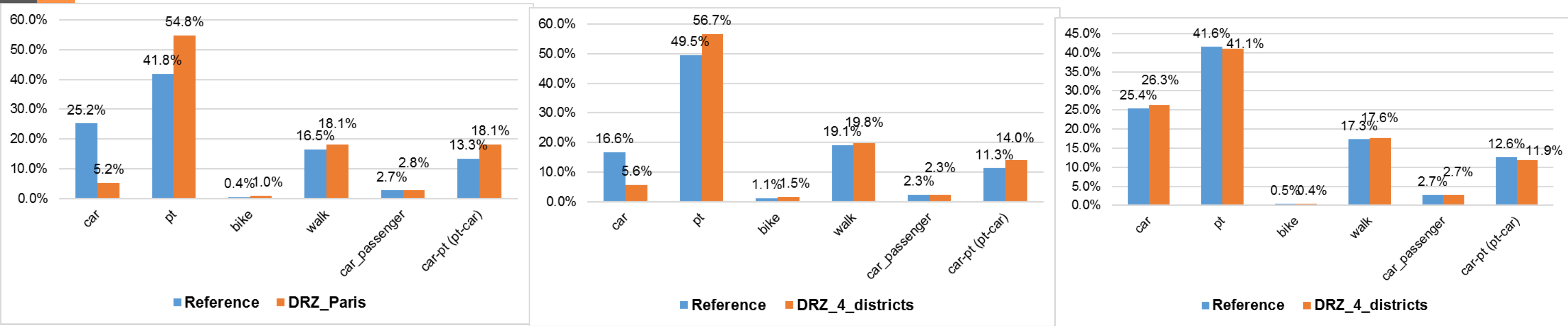
❑ Modal shares

5% population in Île-de-France (~ 2.0 million trips)

	car	pt	bike	walk	car_passenger	car + pt
Reference	31.5%	18.1%	1.5%	40.0%	7.3%	1.56%
DRZ_4_districts	31.3% (+0.1%*)	18.2%	1.5%	40.1%	7.3%	1.50%
DRZ_Paris	27.8% (+2.3%*)	19.0%	1.5%	40.3%	7.3%	1.73%

* DRZ residents' carInternal trips

(a) *(b)* *(c)*

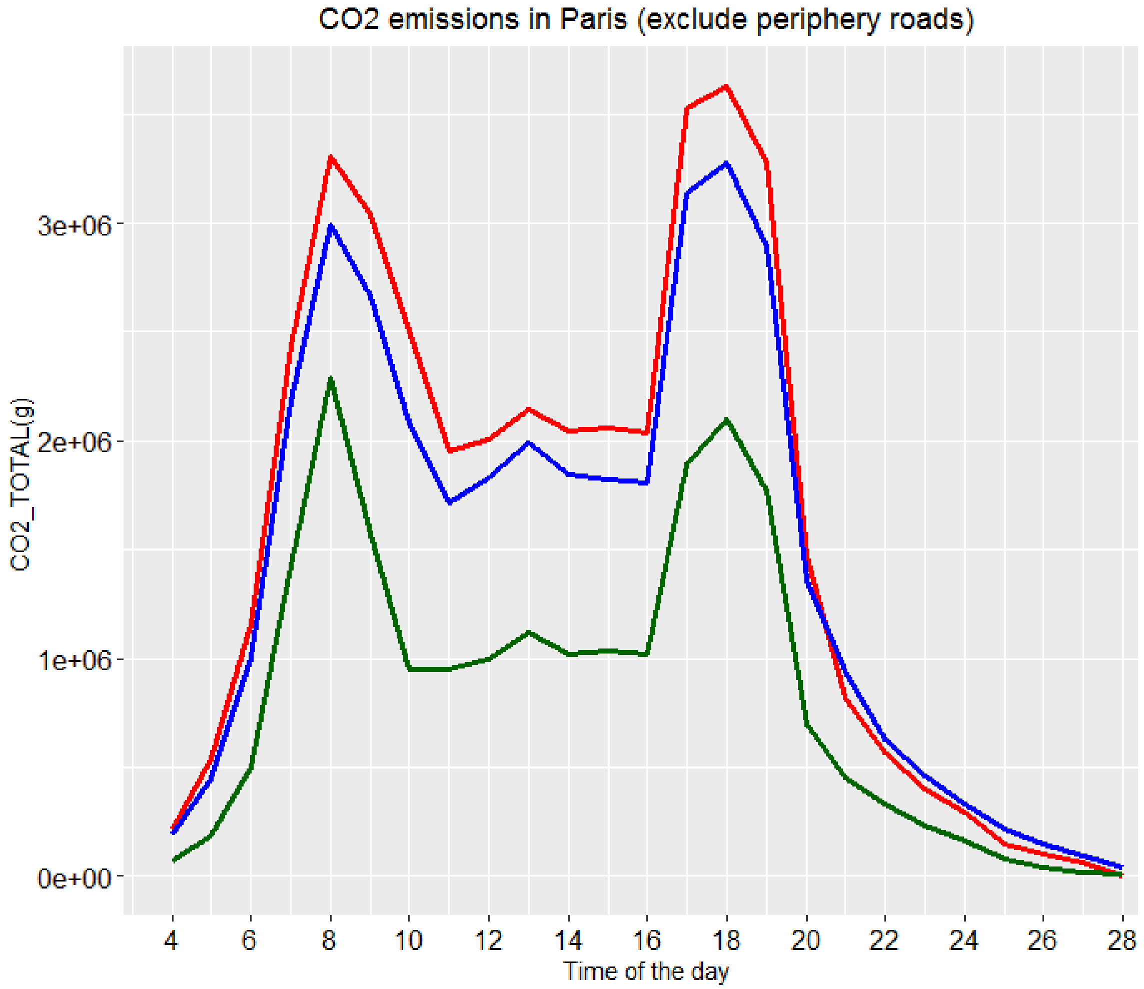


Non-resident commuters with trips associated to (a) Paris (~ 0.1 million trips), (b) 4 districts (~ 17 thousand trips), and (c) between Paris and 4 districts (~ 86 thousand trips)

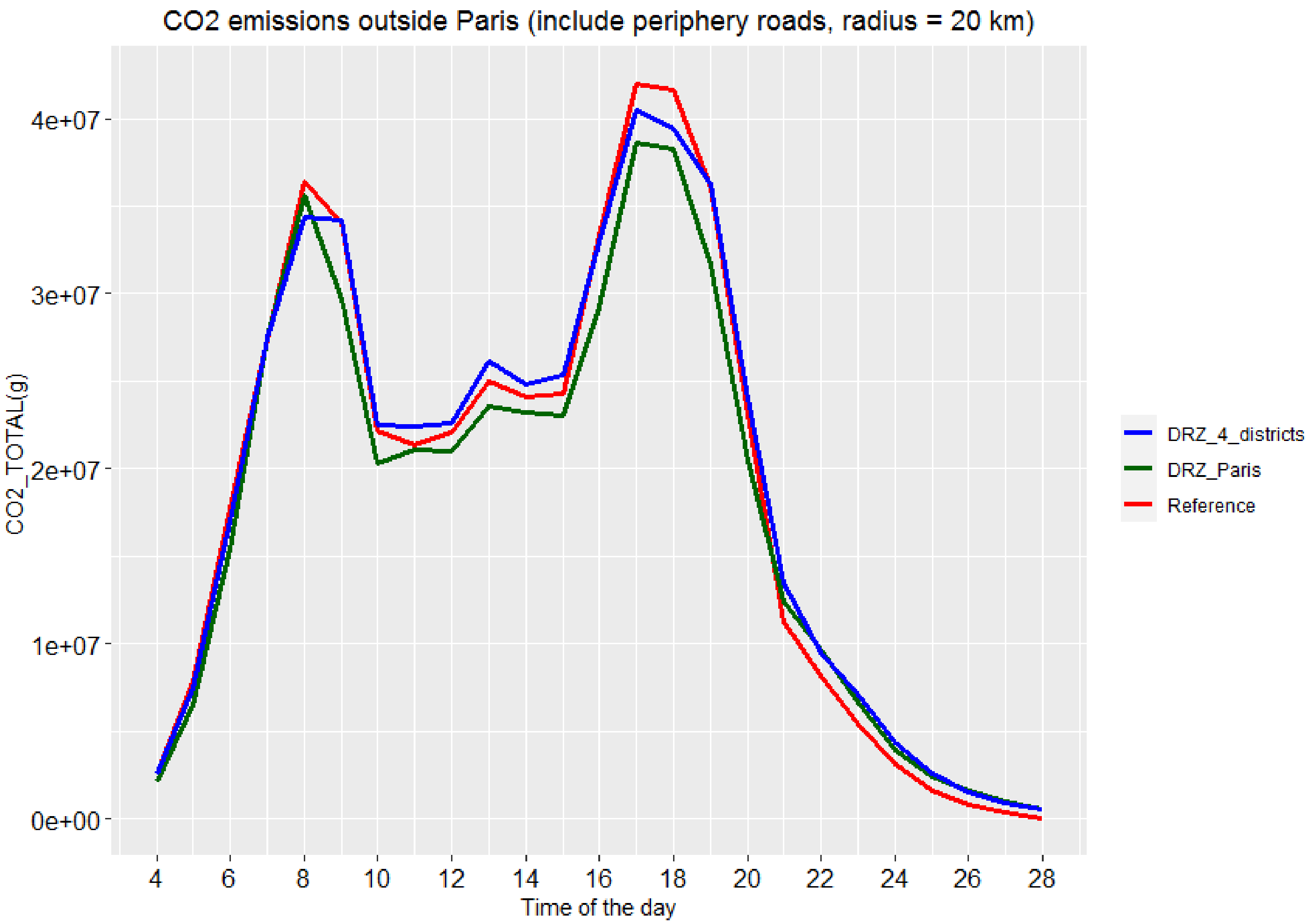
4. Results

- CO_2 emissions (based on HBEFA 4.1)

(a) Inside Paris



(b) Outside Paris



4. Results

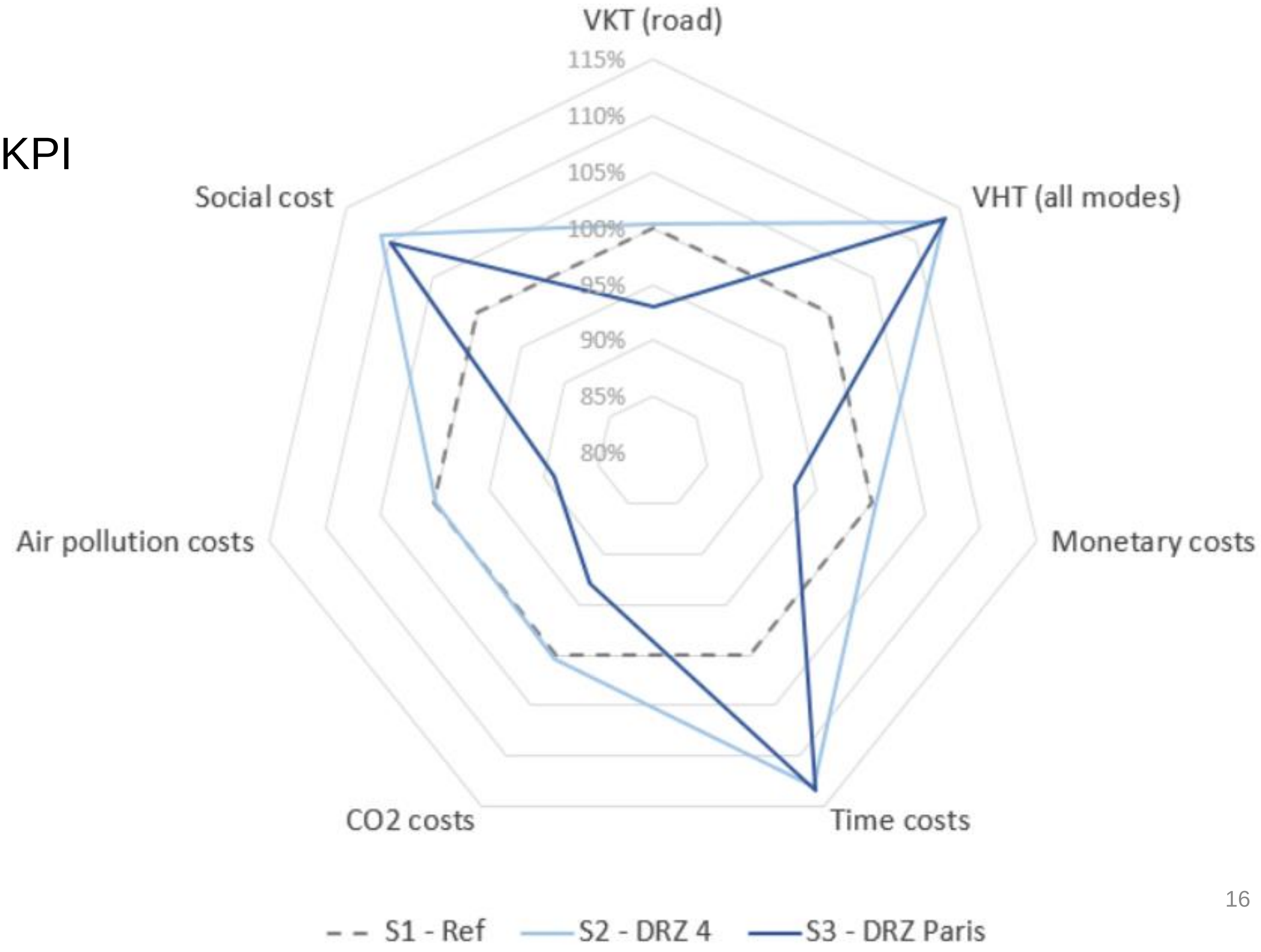
- Air pollutants (g/day)

	Paris region (R<=20 km)	Paris			Outside of Paris (R<=20 km)		
	CO_2	NO_x	SO_2	PM2.5	NO_x	SO_2	PM2.5
Reference	5.12×10^8	1.19×10^5	199.67	964.65	$1{,}43 \times 10^6$	2.37×10^3	1.07×10^4
DRZ 4 districts	5.17×10^8 (+1,0%)	1.08×10^5 (-9,2%)	181.54 (-9,1%)	880.32 (-8,7%)	$1{,}45 \times 10^6$ (+1.8%)	2.41×10^3 (+1.8%)	1.09×10^4 (+2.0%)
DRZ Paris	4.67×10^8 (-8,8%)*	0.61×10^5 (-48,7%)	105.08 (-48,7%)	546.76 (-47,4%)	$1{,}35 \times 10^6$ (-5.6%)	2.24×10^3 (-5.5%)	1.02×10^4 (-4.9%)

* Values in parenthesis are those compared with reference.

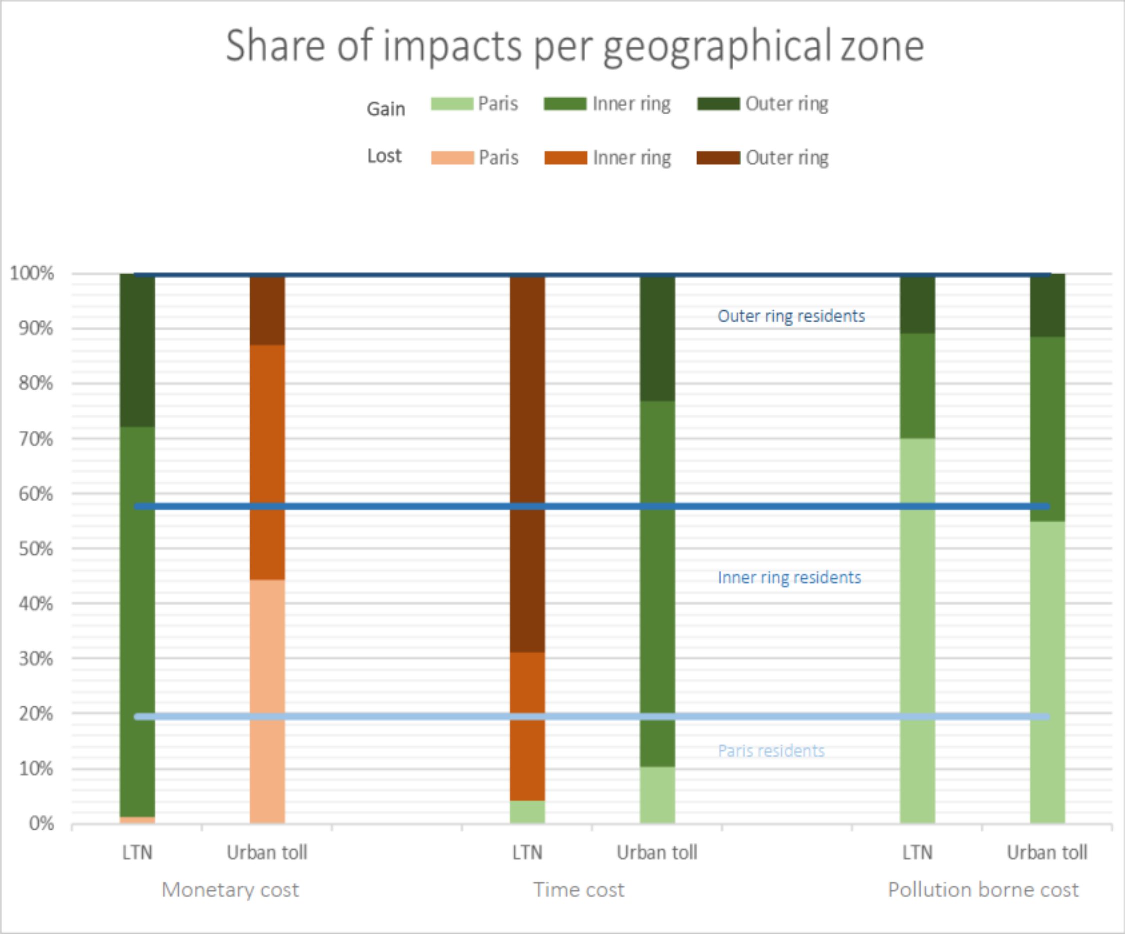
4. Results

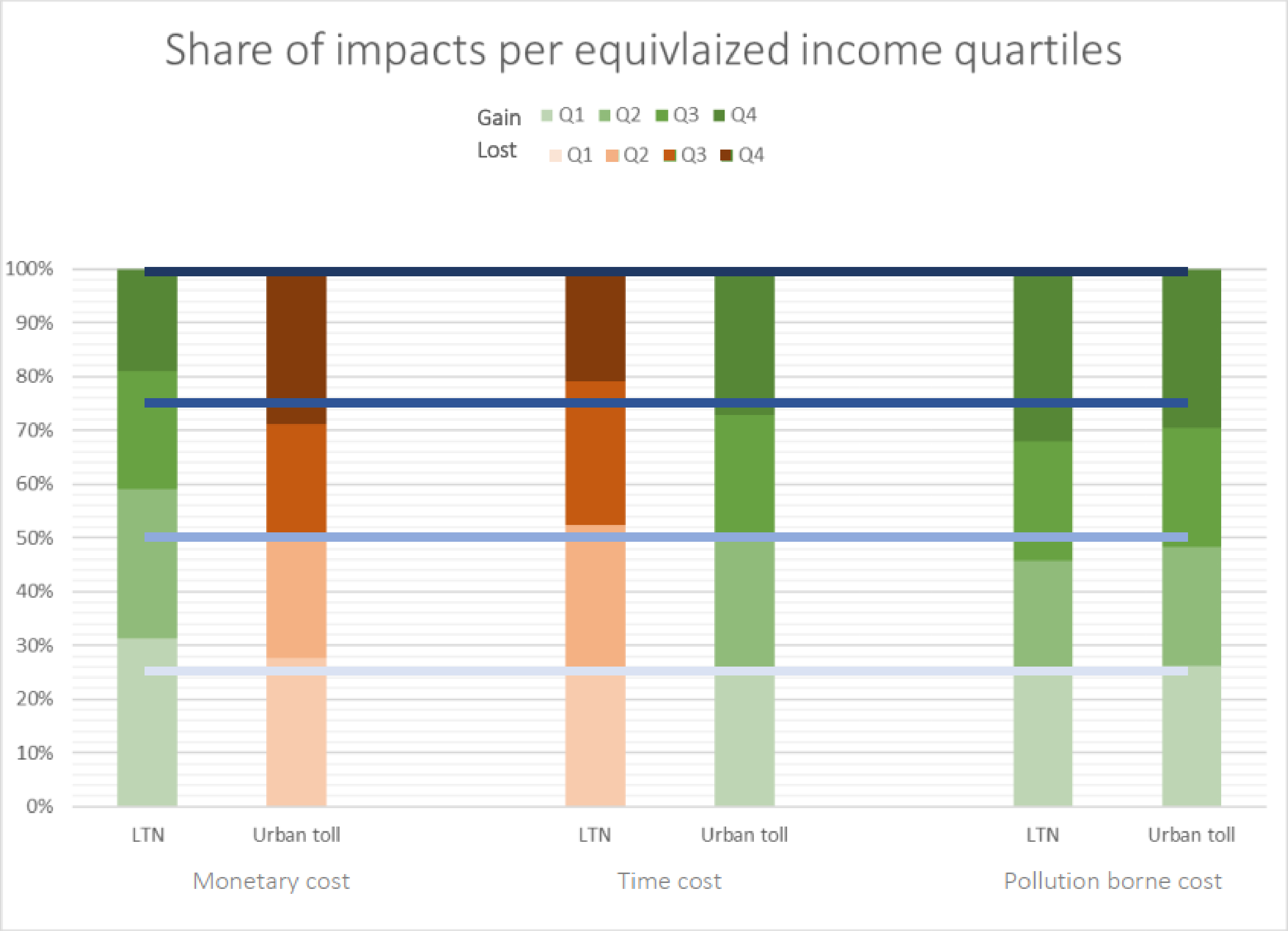
❑ Socio-economic KPI



Equity Analysis

- A remarkable unequal share of impacts, A priori compensated by another impact
- Paris residents are the main losers from urban toll
- Outer ring residents are the main losers from LTN





5. Discussion and conclusion

- **Main findings**
  - Projected scenario (4 districts)
    - Limited impact on modal shift, thus negligible environmental benefits
      - Even increase in CO_2 emissions
    - Very costly in terms of time
  - Ambitious scenario (Paris)
    - More effective, with substantial environmental benefit
    - For a barely greater time cost than in the previous scenario
    - Increase in social cost
      - A x4 valuation of environmental benefits would be needed to offset the extra time cost
  - .Impacts greatly vary inside/outside Paris -> equity issues

- **Future work**
  - Add parking contraints
    - searching parking locations (road-side lots or garages), capacity limitation and parking fees
  - Generalize intermodality with other modes (e.g. micromobility + PT)
  - Calibrate parameters with real-time data from GoogleAPI
  - Investigate more detailed DRZ policies, e.g., only prohibit passing vehicles (except taxis, buses, emergency and rescue services, ridesharing vehicles, person with reduced mobility)

Thank you for your attention!

Questions?

4. Results

- Traffic emissions based on HBEFA 4.1 (before scaling)

    - CO_2 (g/link/day) on the road network