Evaluating the Costs and Benefits of Shared Dockless E-Scooters

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Agenda

Section 1

General Background

A both successful and controversial introduction

Introduced in 2018 in Lyon and Paris, Lime free-floating e-scooters generate **mixed-reactions.**

A rapid and massive adoption…

9 million

Estimated number of Lime trips in 2019 in Paris

3 million

Estimated number of Lime trips in 2019 in Lyon

…that raised concerns

- Public space occupation
- Durability
- Vandalism
- Security
- Unregulated market

A challenging context

In front of these concerns, there is a growing **need to supervise free-floating e-scooters** from public authorities, that are wondering whether they should support or regulate their development.

Paris

8.8 million daily trips

40% 40% 14%

Lyon-Villeurbanne

1.9 million daily trips

41% 35% 21%

Two distinct cities that face similar mobility challenges

Decrease air pollution & greenhouse gas

11 teq CO2/hab in Paris
7 teq CO2/hab in Lyon

Source:: wwf

Reduce congestion

39% : congestion level in Paris
30% : congestion level in Lyon

Source: TomTom Traffic Index

A limited literature on the impacts of e-scooters

In this context, operators have to adapt their service to be able to bring **the highest value to collectivity** and to demonstrate it based on quantitative data.

Exisiting data-driven studies on free-floating e-scooters in France is very limited:

-> Antoine Pestour. *Approche socio-économique des enjeux relatifs aux trottinettes électriques en libre-services en France.* 2019

It's an exploratory work and **first attempt of CBA** on free-floating e-scooter in France, whose results must be confirmed by further analysis based on more robust data.

Main difficulties

- **Lack of available data**
- **Recentness of the service**
- **Constant improvements in the service**

Key issue

What is the collective added value that Lime brought to Paris and Lyon in 2019?

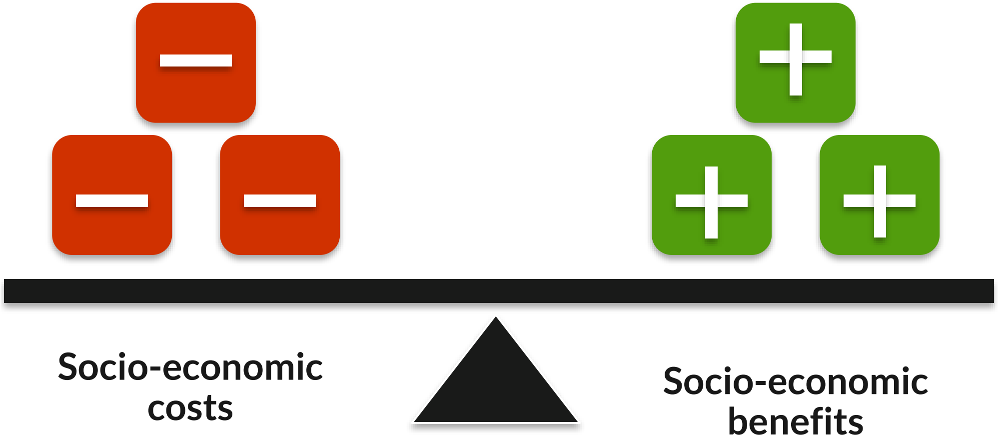
Section 2

Methodology

General methodology

- **Comparative evaluation** : costs and benefits with a project vs costs and benefits without a project

- **Monetary valuation:** In order to be able to compare two scenarios, costs and benefits are expressed in monetary values



Project Scenario
Availability of Lime's free-floating e-scooters

Baseline countrefactual Scenario
Absence of Lime's free-floating e-scooters

Key stakeholders

Users

What is the added value compared to other alternatives ?

Operator

How much profit does the operator generate?

Municipality

What are the benefits of adding shared e-scooters for the city?

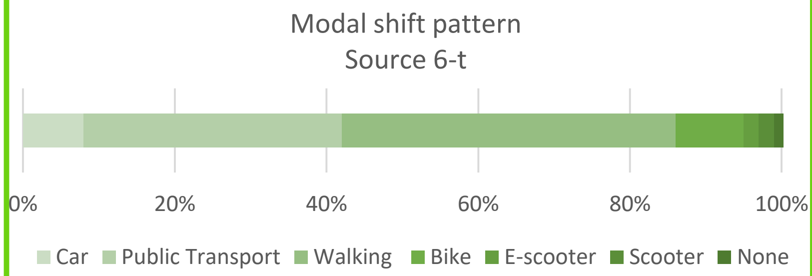
Externalities

To what extent are e-shared scooters eco-friendly ?

Main data of the reference scenario

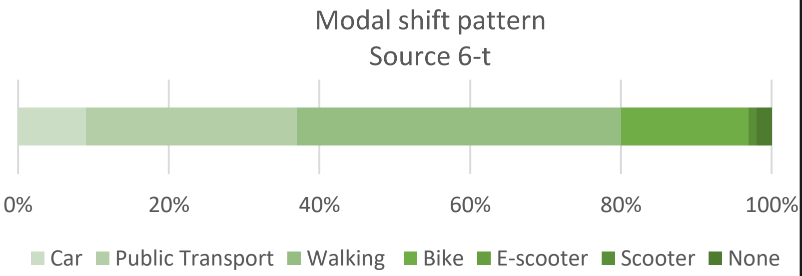
Paris 2019

Data	#	Sources
Estimated number of trip	9 million	*Lime*
Average trip distance (km)	3,8	*6-t*
Average trip time (min)	15,1	*6-t*
Average speed (km/h)	15	*6-t*
Fleet size at the end of the year	5000	*Lime*



Lyon 2019

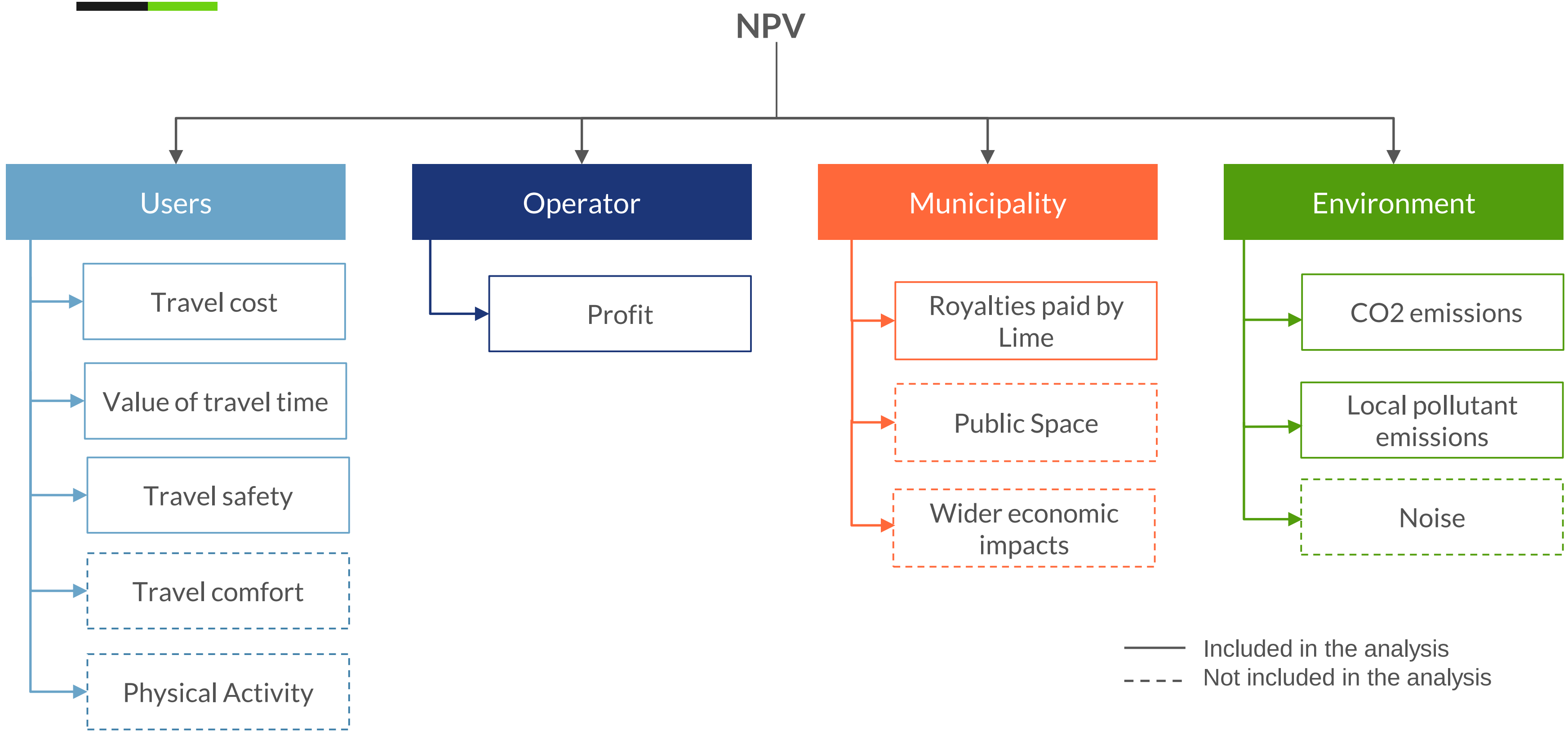
Data	#	Sources
Estimated number of trip	3 million	*Lime*
Average trip distance (km)	3,22	*6-t*
Average trip time (min)	12,9	*6-t*
Average speed (km/h)	15	*6-t*
Fleet size at the end of the year	2000	*6-t*



Section 3

Results

Socio-economic Net present value (NPV)



Users Surplus Analysis

The total user surplus, over one year, is estimated to be **€US1 million** in Paris and **€US2 million** in Lyon.

X million hours saved in a year by the users in Paris (or x minutes per trip on average) and **X million** hours saved in Lyon.

X million additional spending in a year by the users in Paris (or €X per trip on average) and **€X** in Lyon.

Risk of death in e-scooter is n% the average level with the alternative modes.

Our analysis does not take into account the pleasure associated with riding a e-scooter leading to an understimation of the user surplus.

Paris

Total user surplus split in million €

Lyon

Total user surplus split in million €

Users Surplus Analysis – key assumptions

- One of the key assumptions of the user surplus calculation are **the modal shift patterns.**
- The latter are also used in the computation of the environmental surplus.

		Paris	
		Modal Shift	Trip purpose
Car	Professional reasons	8%	5%
	Home-office/university reasons		50%
	Other reasons (shopping, etc.)		45%
	Unknown		0%
Public transport	Professional reasons	34%	5%
	Home-office/university reasons		50%
	Other reasons (shopping, etc.)		44%
	Unknown		1%
Walking	Professional reasons	44%	4%
	Home-office/university reasons		46%
	Other reasons (shopping, etc.)		48%
	Unknown		2%
Bike	Professional reasons	9%	4%
	Home-office/university reasons		56%
	Other reasons (shopping, etc.)		40%
	Unknown		1%
E-scooter	Professional reasons	2%	2%
	Home-office/university reasons		55%
	Other reasons (shopping, etc.)		40%
	Unknown		4%
Scooter	Professional reasons	2%	2%
	Home-office/university reasons		55%
	Other reasons (shopping, etc.)		40%
	Unknown		4%
None	Professional reasons	2%	12%
	Home-office/university reasons		72%
	Other reasons (shopping, etc.)		16%
	Unknown		0%
Unknown	Professional reasons	0%	0%
	Home-office/university reasons		40%
	Other reasons (shopping, etc.)		56%
	Unknown		44%

Source : 6-t

Users Surplus Analysis – key assumptions

Monetary values of time

	2019 - Ile de France
Professional	24,57 €/h
Home-office/university	13,89 €/h
Others	9,64 €/h
Without detail of the purpose	11,82 €/h

Source : Rapport Quinet

Monetary value of a statistical life (VSL)

	2019
VSL	€3 000 000

Source : French government

Total cost of ownership

	2019
Car	0,23 €/km
Public transport	0,10 €/km
Bike	0,13 €/km
E-scooter	0,27 €/km
Scooter	0,27 €/km
Taxi (fixed costs)	4,18 €
Taxi (variable costs)	1,12 €/km
Lime (fixed costs)	1,00 €
Lime (variable costs)	0,15 €/min

Source : Ecomobilité & Lime

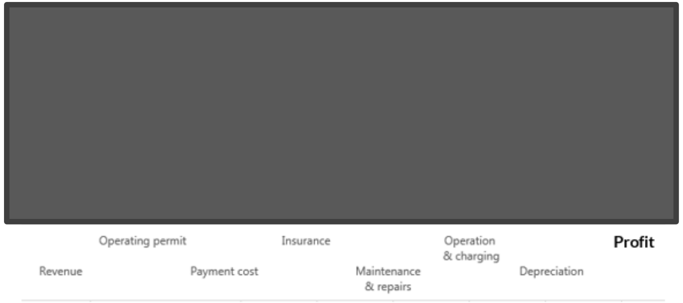
Operator Surplus Analysis

The total operator surplus, over one year, is estimated to be **€XX million** in Paris and **€YY million** in Lyon.

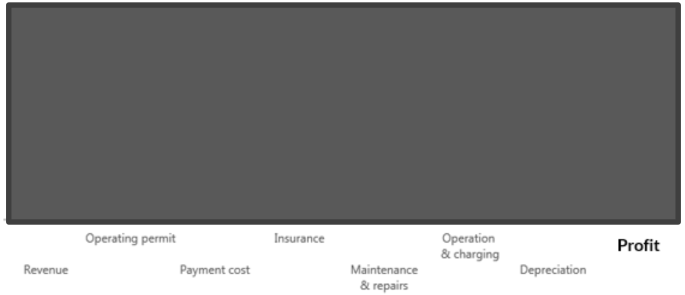
- **Operating costs** and **depreciation** are the two main costs.
- The difference of revenue per trip between the two cities comes from shorter trips on average in Lyon, which decreases the profitability of each trip
- These results are very sensitive to assumptions that must be confirmed, as explained in the limit part.

Revenue decomposition estimation 2019

Paris



Lyon



Operator Surplus Analysis – key assumptions

	2019
Average cost of a e-scooter	330 €
Payment cost	-0,3500 €/trip
Insurance	-0,0026 €/min
Maintenance & repairs	-0,0258 €/min
Operating & charging	-0,0876 €/min
Number of trips during lifetime	480

Source : BCG

Municipality surplus

Municipalities require **royalties** from operators to allow them to develop their service in the streets, the amount of which is the content of the municipality surplus.

Main hypothesis

Lyon		
€/e-scooter/year		
45		
Paris		
Tax	*Lower boundary*	*Higher Boundary*
€/e-scooter/year	*# e-scooter*	*# e-scooter*
50	0	499
55	500	999
60	1000	2999
65	3000	-

Results

	Paris	Lyon
Royalties (€/year)	464 835	119 250
Municipality surplus after applying opportunity cost (€/year)	581 044	149 063

x1,25

These results should be compared to the price to implement parking spots dedicated to e-scooters

Environmental Surplus Analysis

The total environmental surplus, over one year, is estimated to be **€ES1** in Paris and **€ES2** in Lyon.

X tonnes of CO2 emission in a year due to e-scooters in Paris (or 282 grams per trip on average) and **Y tonnes** in Lyon.

Manufacturing and **transport** from production sites in Asia to France of the e-scooter are the main contributors of e-scooter CO2 emissions.

These results are very sensitive to assumptions that must be confirmed, mainly the **lifetime** of an e-scooter.

Paris

Total environmental surplus split in thousands €

GHG reduction | Local pollutant reduction

[redacted]

Lyon

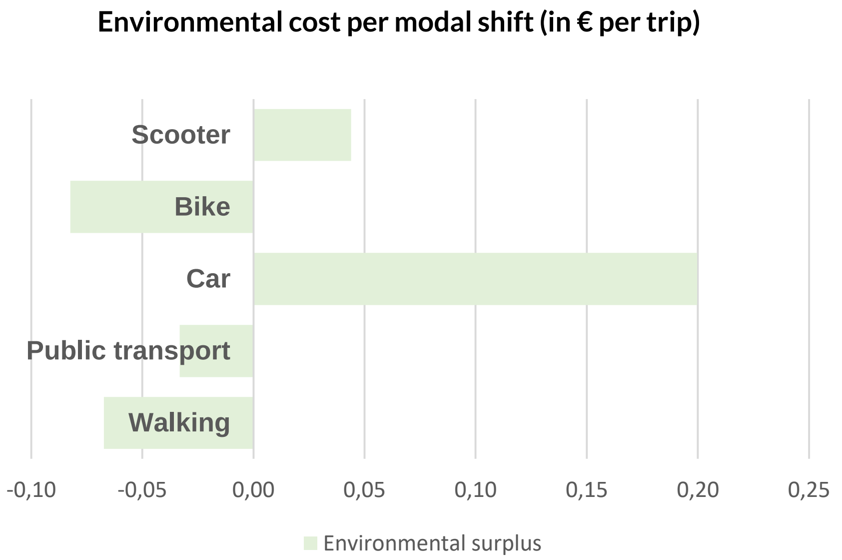
Total environmental surplus split in thousands €

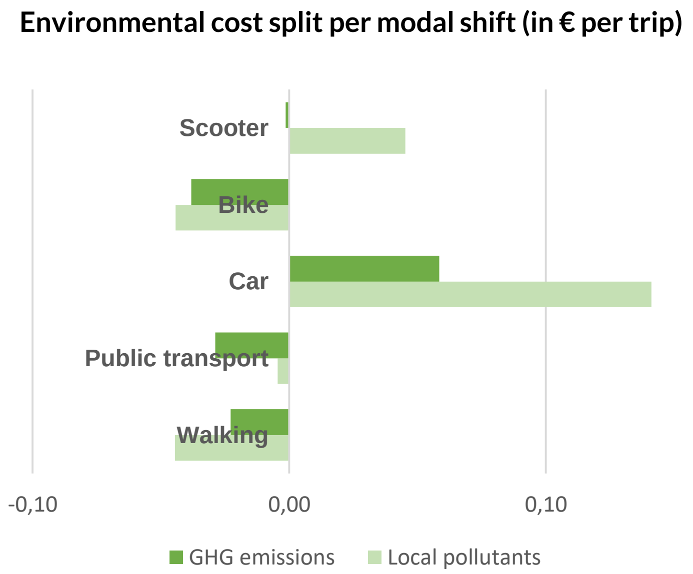
[redacted]

Environmental Surplus Analysis - Paris

The more e-scooters substitute carbon and pollutant intensive transport mode, the better the environmental impact is. Lyon has similar trends.

Paris





Section 4

Sensitivity Analysis

Sensitive parameters

Our results are very sensitive to the following parameters:

- Trip cost
- Modal shift patterns
- E-scooter lifetime
- Trip distance
- Values of time

How do results vary when changing these parameters?

Stated vs estimated travel costs

Heterogenity in the travel cost data…

€/km	Stated travel costs		Estimated travel costs
Source	*6-t*	*6-t*	*Ecomobilité*
Location	*Paris*	*Lyon*	*France*
Walking	*0,04*	*0,01*	*0*
Public transport	*0,58*	*0,72*	*0,098*
Private car	*1,29*	*0,95*	*0,225*
Non private car	*3,89*	*8,09*	*4,2+1,1/km*
Bike	*0,21*	*0,11*	*0,1*
Scooter	*0,55*	*0,12*	*0,3*
E-scooter	*1,21*	*1,20*	*1+0,15/km*

We are more confident in the estimated travel costs than the stated costs because people often **misperceive** total cost of ownership of a transport mode

… impacts the results

It impacts the average travel cost savings per trip….

Paris Lyon

[redacted]

Estismated travel cost scenario ■ Stated travel costs scenario

… that in turn impacts the NPV

€	Estismated travel costs scenario	Stated travel costs scenario
Paris	[redacted]	
Lyon		

With the stated travel costs, Paris NPV is positive for 2019, (highest proportion of taxis and VTC in Paris than in Lyon (6% vs 3%), inconsistency in the stated costs)

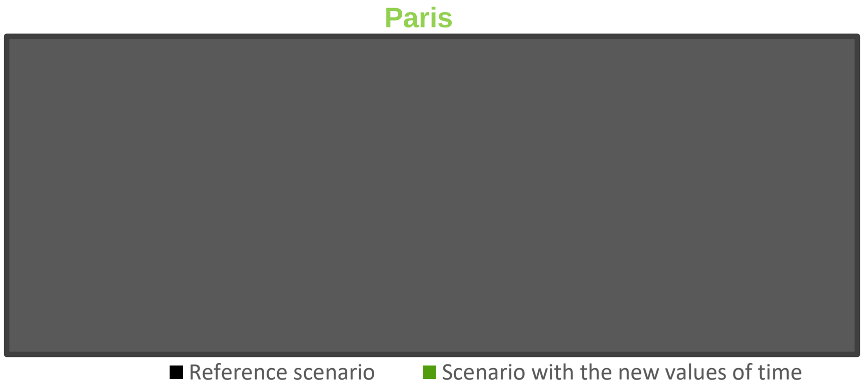
Values of time - How to include the specificity of riding a e-scooter in the value of time?

We have estimated roughly values of time per transport mode per purpose from the literature:

		€/h
Car	Professional reasons	16,22
	Home-office/university reasons	9,17
	Other reasons (shopping, etc.)	6,36
	Unknown	7,8
Public Transport	Professional reasons	9,02
	Home-office/university reasons	5,1
	Other reasons (shopping, etc.)	3,54
	Unknown	4,34
Walking	Professional reasons	36,08
	Home-office/university reasons	20,4
	Other reasons (shopping, etc.)	14,16
	Unknown	17,36
Bike	Professional reasons	20,79
	Home-office/university reasons	11,75
	Other reasons (shopping, etc.)	8,16
	Unknown	10,00
Scooter	Professional reasons	31,19
	Home-office/university reasons	17,63
	Other reasons (shopping, etc.)	12,24
	Unknown	15,00
E-scooter	Professional reasons	10,00
	Home-office/university reasons	31,19
	Other reasons (shopping, etc.)	17,63
	Unknown	12,24

Source: Own estimates based on Börjesson and Eliasson

These new values of time impact the user surplus …

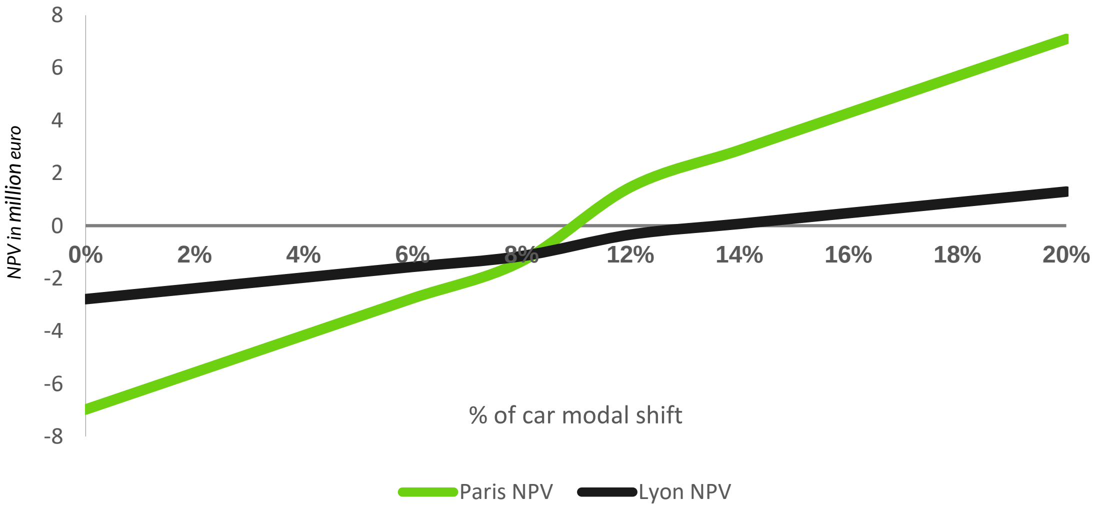


… that in turn impact the NPV

With the values of time per transport mode, Paris NPV is positive for 2019.

Modal shift

NPV evolution with car modal shift increase



Greater sensitivity in Paris

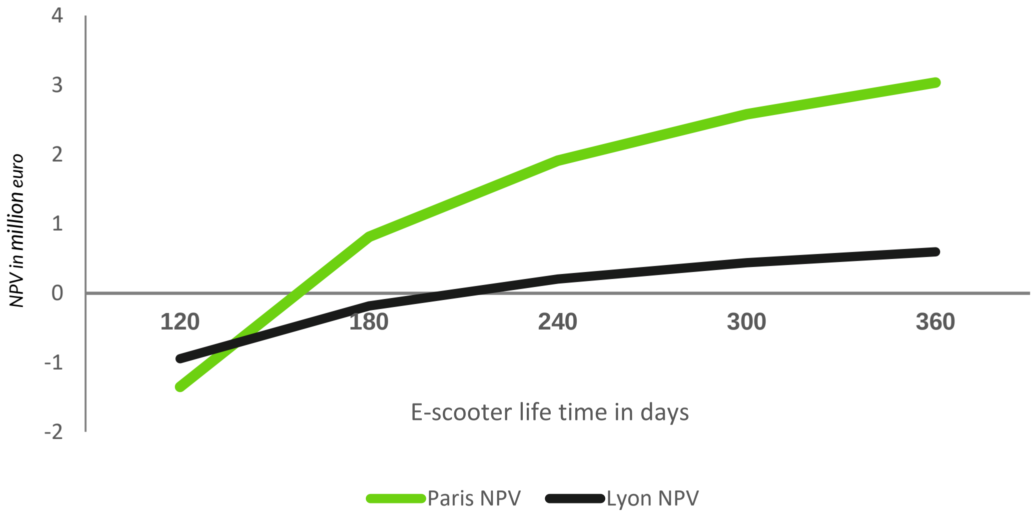
-Trip volume

- Lime substitutes away

- more taxis and VTC trips in Paris than in Lyon
- and more PT trips

E-scooter lifetime

NPV evolution with lifetime increase (in million €)



Improvements come from:

- Increase in **the operator surplus,** due to the the decrease of the depreciation
- Increase in **the environmental surplus**

1.5 year

rough estimation of the e-scooter lifetime needed to have a positive impact on CO2 emission in both cities

Trace vs 6t data

Using the trace data decreases the users surplus by 64% and decreases the operator surplus by 75% due to shorter average trips. We use in our reference scenario 6t data because we have no trace for Lyon and because of the uncertainties associated with this method (waiting time, random trip purpose attribution).

Paris

Data google API

1.360 km

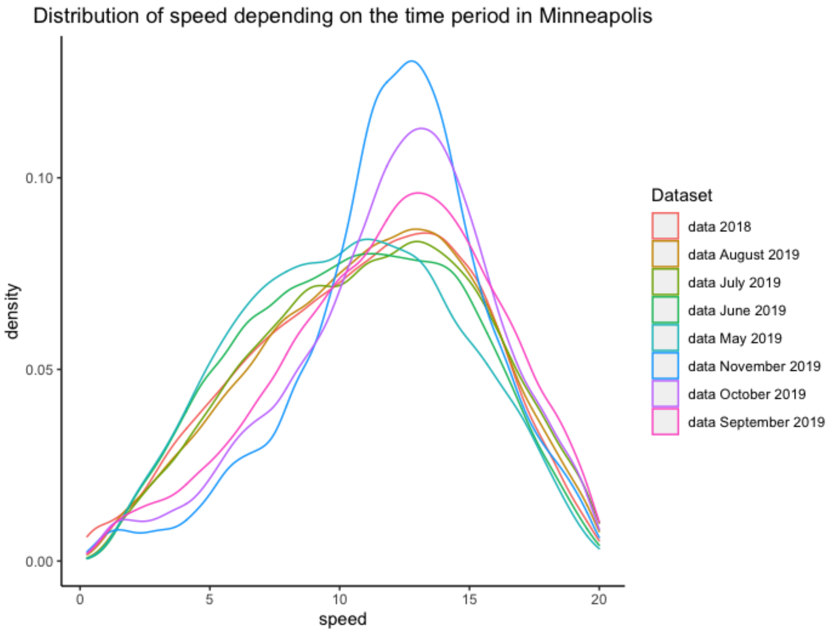
5.7 min

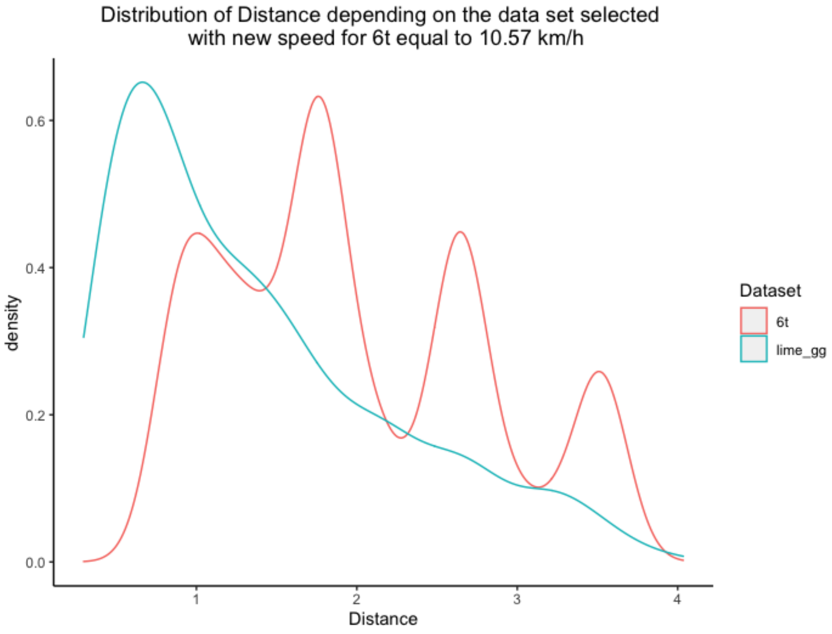
=> Trips 3 times shorter than with 6t data

	Paris			
	Trace		Reference scenario	
	€/trip	*€/year*	*€/trip*	*€/year*
Users Surplus	[redacted]			
Value of the travel time savings/losses				
Travel cost savings/losses				
Travel Safety				
Operator Surplus				
Profit				
Municipality Surplus				
Taxes & Royalities paid by Lime				
Environmental Costs				
GHG reduction				
Local pollutant reduction				
TOTAL SURPLUS (NPV)				

Trace vs 6t data

Speed distribution study





Limits

Inappropriate **values of time** that do not account for the specificity of Lime and leads to a probable underestimation of the users surplus.

Neglect of the impact of the new **intermodality** enabled by the presence of Lime.

Uncertainty and rapid-evolving **data**

Section 5

Conclusion

Discussion & Recommendations

Key take-away:

- Shared e-scooters are **more interesting for large cities** with a highly concentration of activity in the center and a saturated transport system
- E-scooters **lifetime extension** and **modal shift** from cars to e-scooters are two important levers to enhance the value Lime brings to society

Further work needed:

- Refining the **values of time** by building a discrete choice model based on a specific stated-preferences survey to users
- Precisely estimate modal shift (including within intermodal trips)
- Life-cycle analysis: improve robustness of results (including life expectancy)?
- Exploit data on **profitability** of the operator

Discussion & Recommendations

Recommendations:

- Implement **swapable battery** in order to reduce CO_2 emissions by developping intra-logistics instead of inter-logistics
- **Target people living in the suburbs** with a view to increase car modal shift in complex modal shift patterns.

Contacts

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Section 6

Appendix

Scope

	Baseline counterfactual scenario	Project scenario with Lime	% of the trips*
Induced demand	No trip		3%
Simple modal shift			74%
Complex modal shift			23%

*Source : 6-t

Trips included in the CBA

Trips not included in the CBA

Data sources

	Data	Sources	Limits
Travel time savings	2019 Value of time/purpose/city	Rapport Quinet	Unappropriate values of time
	Trip time/modal shift/purpose	6-t report	Stated data : risk of misperceptions
Travel cost savings	Cost of ownership /mode /km	Ecomobilité	
	Trip distance/modal shift	6-t report	Stated data : risk of misperceptions
Travel safety	Fatality rate /other mode/km	OCDE Report	
	Value of a statistical life	French government	
	Trip distance/modal shift	6-t report	Stated data : risk of misperceptions
Operator Profit	Cost breakdown	BCG	Non specific to France
	E-scooter lifetime	BCG	Non specific to France
	Average trip distance	6-t	Stated data : risk of misperceptions
Municipality surplus	Royalties amount/city/e-scooter	Lime	
	Fleet size/city	Lime	
GHG Reduction	E-scooter CO2 emission / km	EY / Arcadis /Ademe	Non specific data to Lime
	CO2/km/other modes	EY /Ademe / MDPI	
	Trip distance/modal shift	6-t report	Stated data : risk of misperceptions
	E-scooter lifetime	BCG	Non specific to France
Local Pollutants	Pollutants emission/mode	Academic paper	Non specific to France, neither recent
	Trip distance/modal shift	6-t report	Stated data : risk of misperceptions
	E-scooter lifetime	BCG	Non specific to France

User profile answering 6-t survey

The main source of data of the reference scenario are the results of the survey conducted in 2019 by 6t.

66 % of man

34 years old

66 % of full-time workers

53 % of executives and senior intellectual workers

Median income **€2,333**

Average in France: €1,692 in 2015 (Insee)

58 % of local people

(from Ile-de-France or the metropole of Lyon)

Environmental Surplus Analysis –key assumptions

Monetary value of CO2

€/tonne	2019
CO2	70,5

Sources: Valeur de l'action pour le Climat

CO2 emission per transport mode

g/person/km	2019
Petrol car	275
Electric car	193
Metro	18
Electric bus	32
Diesel Bus	69
Walking	0
Bike	0
E-scooter	111
Scooter	33

Sources: Arcadis & EY & MDPI

Monetary values of pollutants

€/g	2019
Nox	0,02
PM2,5	0,10 €/g
SO2	0,02 €/g

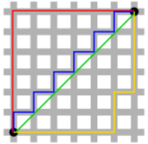
Sources: Rapport Quinet

Pollutants emission per transport mode

	SO2 g/pax-km		PM2 Emission g/pax-km		NOx emission g/pax-km	
	Min	Max	Min	Max	Min	Max
Car	0,23	0,69	0,09	0,28	0,44	1,32
Public transport	0,01	0,04	0,04	0,14	0,14	0,54
Walking	-	-	-	-	-	-
Bike	0,01	0,01	0,06	0,06	0,01	0,02
E-scooter	0,09	0,02	0,10	0,19	0,01	0,03
Scooter	0,04	0,08	0,20	0,40	0,08	0,15

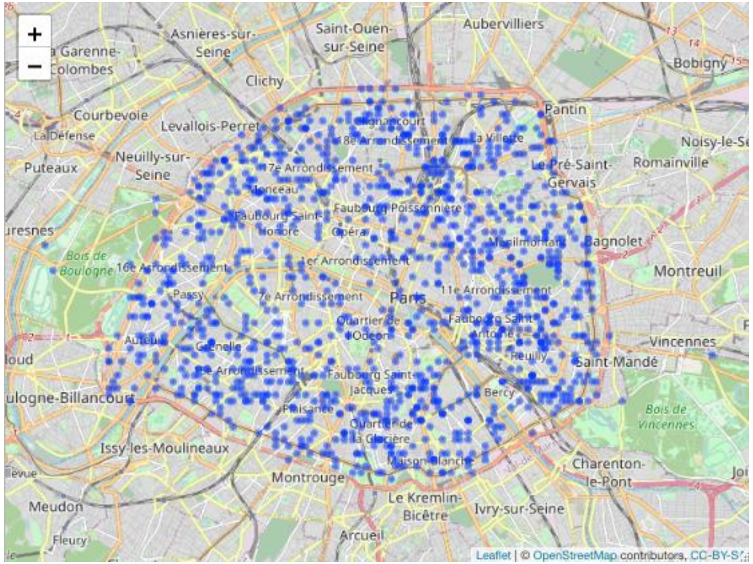
Sources: Cherry. Weinert. Xinmiao. 2008. Comparative environmental impacts of electric bikes in China.

Trace vs 6t data



Using google API to build a new model

- Merging start and end datasets
- Using google API to compute travelling time
- Removing too long distances according to Manhattan distances principle
- Adding weights to certain transport modes to create fairness between modes
- Attributing trip purposes and modal shift to the new trips defined



Starting points