The 7th CIRP IPSS Conference
21-22 May 2015
Saint-Etienne, France

Modeling Bike Sharing System using Built Environment Factors

by

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Outline

- Context and Literature review
- Data and method
- Results
- Conclusion and perspective

Modeling Bike Sharing System using Built Environment Factors

CONTEXT AND LITERATURE REVIEW

Bike sharing system (BSS) development

Definition: service of short term bike renting with a system of stations, bikes and docks

Advantage: no theft, no maintenance, mobility cost, no bike parking, whenever we want

1960s
Netherland
1st generation

1990s
Denmark
2nd generation

2005
Lyon – France
3rd generation

2014
E-bike sharing
4th generation

- BiciMad - Spain
- Bycyklen - Denmark

Réalisation : Tien-Dung Tran, LET-ISH, Lyon

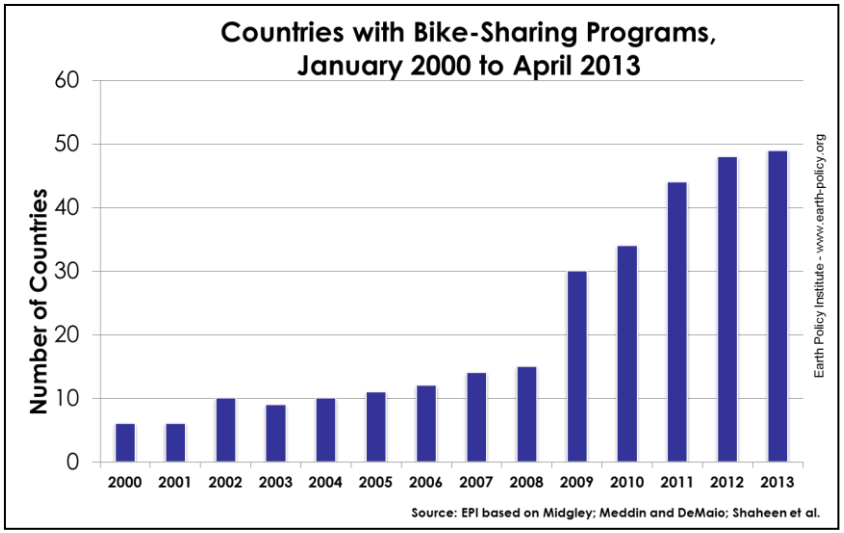
Bike sharing system (BSS) development

- In the world:

49 countries, more than 500 cities, 700 000 bikes

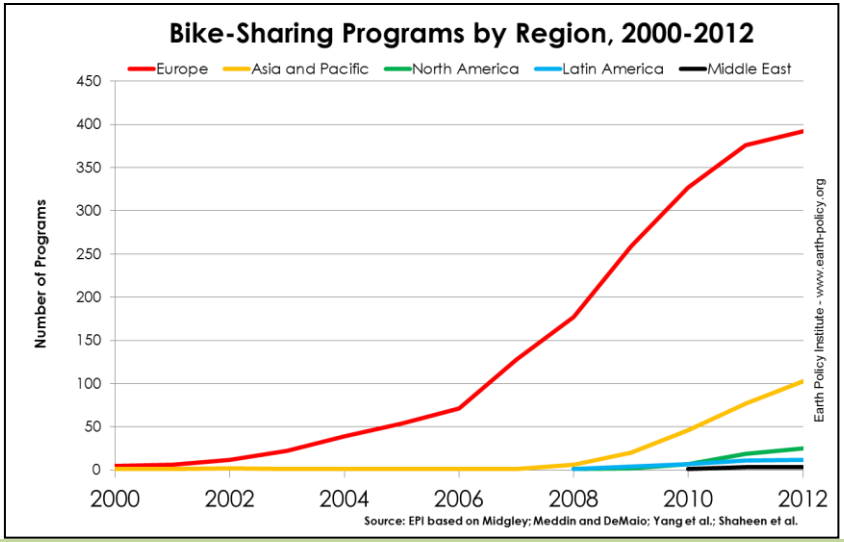
Stagnation in Europe,

Development in North America



- In France:

more than 30 systems, important success in Paris and Lyon



Lyon's BSS – Vélo'v

- Started in May 2005: 173 stations, 2000 bikes, 20 000 long-term users
- BSS trips represent 33% bikes trips in Lyon in 2009
- In 2014: 345 stations and 4 000 bikes
  - 2011: 6.2 million trips
  - 2012: 7.1 million trips
  - 2013: 7.2 million trips
  - 2014: 8.2 million trips

Earlier researches and our paper

- **Few quantitative researches on bike sharing demand**
  - Data aggregated : by day, by month, by year → loose information about the factors affecting the BSS trips purpose
  - At district level →loose information about the spatial effect of land use and built environment
  - No distinction of subscribers type: long term subscribers and short term subscribers

- **Our paper:** Modeling the BSS demand for each **type of subscribers** during **different peak periods** of working day using variables of built environment at station level.

DATA AND METHOD

Data and method

Data

- Bike sharing trips in 2011 (more than 6 million trips)
- Built-environment variables around bike sharing stations
- Data is geocomputed by the platform MOSART

Method

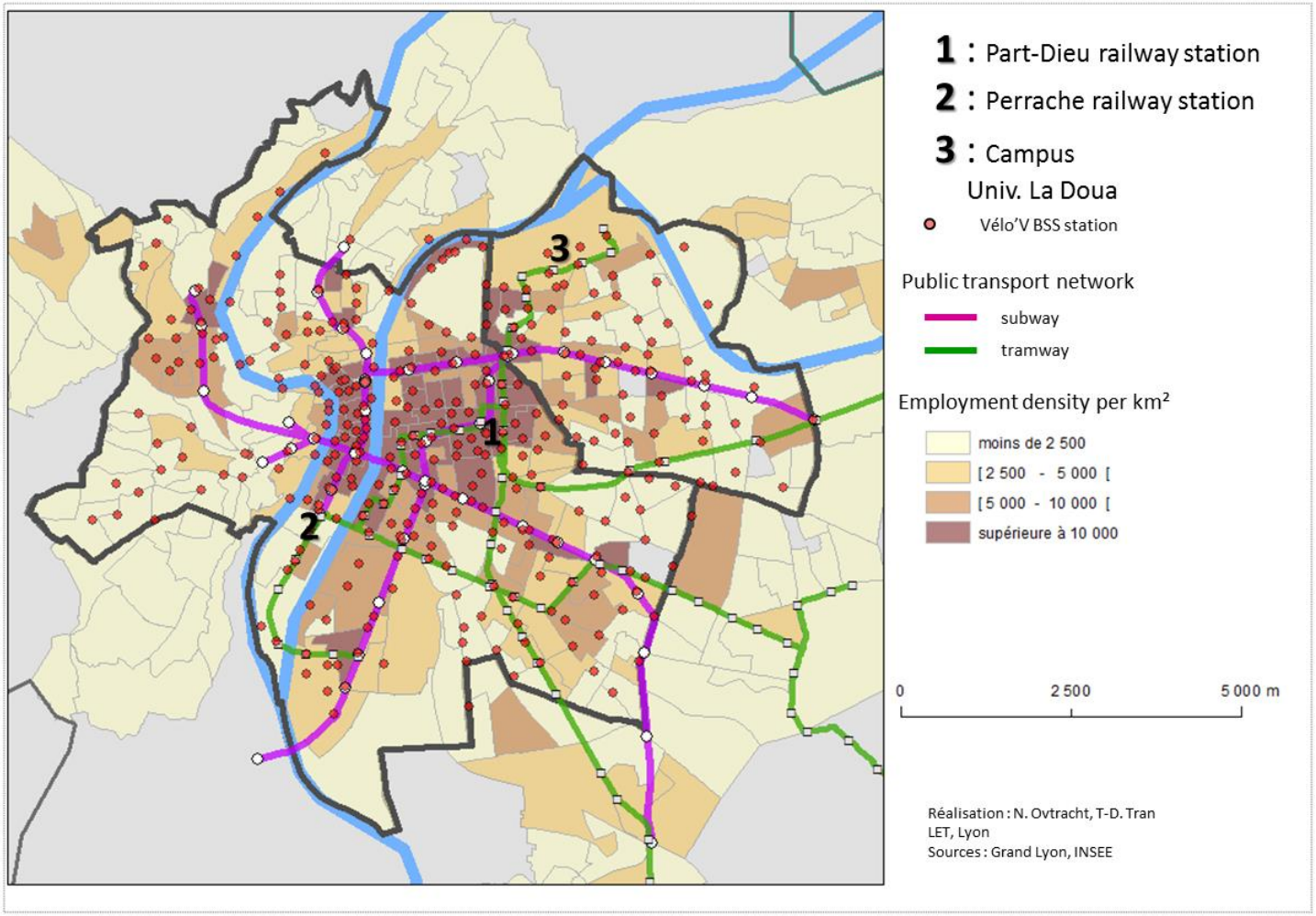
- Method: **robust linear regression** between BSS flows and socio-economic variables

$$Yi = BXi + Ei$$

With

Yi: Bike sharing flows of station *i* (341 stations)
Xi: Socio-economic variables around BSS station *i*
Ei: Errors of estimation

Spatial distribution of Lyon BSS



Data and method

- Dependent variable: bike sharing flows
  - for **different peak periods in a working day (AM and PM)** during 100 days
  - for **annual members and daily users**
- Explanatory variables (14 variables):
  - calculated in **a buffer zone 300m** around each BSS station
  - socio-economic, leisure and recreation, public transport and characteristic of BSS variables

Continuous variable	Min	Max	Mean	Std. Dev.
Population	4	10977	4707.17	2481.25
Job	148	11828	2332.09	2114.43
Students in campus	0	25788	799.59	2892.43
Student residence	0	10	1.326	1.98
Railway station	0	20	0.26	2.02
Metro station	0	12	1.51	2.71
Tramway station	0	27	1.69	4.33
Altitude (m)	164	289	180.84	28.04
Bicycle infrastructure (m)	0	2835	1024.95	650.50
Station capacity	10	40	19.37	5.89
Network density	45	277	238	57.94
Cinema	0	4	0.25	0.68
Restaurant	0	28	3.06	5.34
Categorical variable			Percentage	
Embankment road	0	1	8%	

RESULTS

Preliminary results

The models are different for :

- 2 types of BSS users: annual members and daily users
- 2 types of flows: inbound and outbound flows
- 2 peak periods: AM and PM peaks

Results – Morning Peak Models

	Parameters	Long term users		Short term users	
		coefficients	t-stat	coefficients	t-stat
Arrival flow	Intercepts	-1.8641	-0.0105	9.2555	1.2144
	Altitude	-2.8990	-4.1288	-0.1611	-5.3569
	Capacity	22.7220	6.7138	1.0943	7.5471
	Network density	1.7982	4.2554	0.0788	4.3552
	Jobs	0.1316	11.1600	0.0019	3.7614
	Student in campus	0.0312	4.6965	0.0029	10.0350
	Railway station	77.0490	7.8939	3.6001	8.6091
	R^2	0.690		0.635	
Departure flow	Intercepts	-211.1900	-1.3020	-13.9110	-1.6777
	Altitude	-1.6371	-2.5658	-0.0678	-2.0784
	Capacity	10.7790	3.4000	0.8460	5.2202
	Network density	3.2136	7. 8712	0.1406	6.7379
	Population	0.0632	6.5039	0.0027	5.3786
	Railway station	143.4000	16.1730	3.9988	8.8229
	Student residence	29.5140	3.2595	1.4368	3.1041
	R^2	0.692		0.559	

Results – Morning Peak Models

- BSS usage of annual members and daily users is likely **similar during morning peak: commuting trips** (from home to work)
- **Positive impact** of public transport, station capacity, number of BSS stations
- **Negative impact** of relief on bike sharing usage
- BSS usage in the morning peak period: **home-based and work-based trips**

Results – Evening Peak Models

	Parameters	Long term users		Short term users	
		coefficients	t-stat	coefficients	t-stat
Arrival flow	Intercepts	367.1500	1.4273	47.1600	1.2325
	Altitude	-7.4067	-7.3199	-0.8322	-5.4668
	Capacity	22.8160	4.5382	4.0471	5.6413
	Network density	6.4859	10.0180	0.6075	7.3440
	Population	0.0629	4.0785	-	-
	Railway station	84.4820	6.0085	9.7802	4.6797
	Student residence	58.2370	4.0557	9.6920	4.3822
	Cinema	-	-	20.0550	2.7625
	Restaurant	-	-	5.1413	5.1189
	Embankment road	-	-	60.7550	4.0967
	R^2	0.654		0.584	
Departure flow	Intercepts	-82.8110	-0.3227	-13.9110	-1.6777
	Altitude	-4.4700	-4.4138	-0.0678	-2.0784
	Capacity	28.9370	5.9279	0.8460	5.2202
	Network density	5.9692	9.7935	0.1406	6.7379
	Job	0.0921	5.4126	-	-
	Railway station	105.9300	7.5243	3.9988	8.8229
	Student in campus	0.0357	3.7246	-	-
	Student residence	-	-	11.1950	5.3041
	Cinema	-	-	17.1610	5.8732
	Restaurant	-	-	3.6477	3.8055
	Embankment road	-	-	57.3750	4.0538
	R^2	0.663		0.579	

Results – Evening Peak Models

- **A clear difference** of BSS usage between **annual members and daily users**
  - Home-based and work-based trips for annual members
  - Leisure and recreational trips for daily users
- Positive impact of public transport, station capacity, number of BSS stations
- Negative impact of relief on bike sharing usage

CONCLUSION AND PERSPECTIVE

Conclusion and perspective

- The models are useful for improving the BSS quality by:
  - determining time of day based bicycle demand profiles
  - regulating bicycle and slot availability and rebalancing operations at station level: where, when and how many bike need to be regulated.
- The models could provide guidance on:
  - how to choose the position and to size a new station
  - how to regulate the bike sharing and bike sharing slots at station level
- The models for off-peak periods should be developed

Acknowledgements

- The research is in the project ANR Vél'innov (managed by LET) about the bike sharing system of Lyon.

- Thanks to JC Decaux for the bike sharing data.

Thank you for your attention

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