How may Air Pollution Affect Bike-sharing Choice?

A Mode Choice Behaviour Study in a Developing Country with Policy Implications

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Objectives

- Investigate the factors affecting mode choice behaviour in China with a focus on bike-sharing

- Quantify the modal splits under several possible policy pathways aiming at increasing bike-sharing ridership

Background

Urban mobility challenges in developing countries

- Car ownership
- Congestion & Air pollution

Role of bike-sharing

- Avoid parking troubles with private bikes
- Connection to public transport
- Travel time and cost reduction
- Open opportunities for more social and leisure purposes

Background

Bike-sharing in developing countries

- Plenty of schemes
- Lack of research:
  - Mode choice behaviour
  - Impact of air pollution

Case Study: Taiyuan

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Popular bike-sharing

-used 0.45 billion times in total

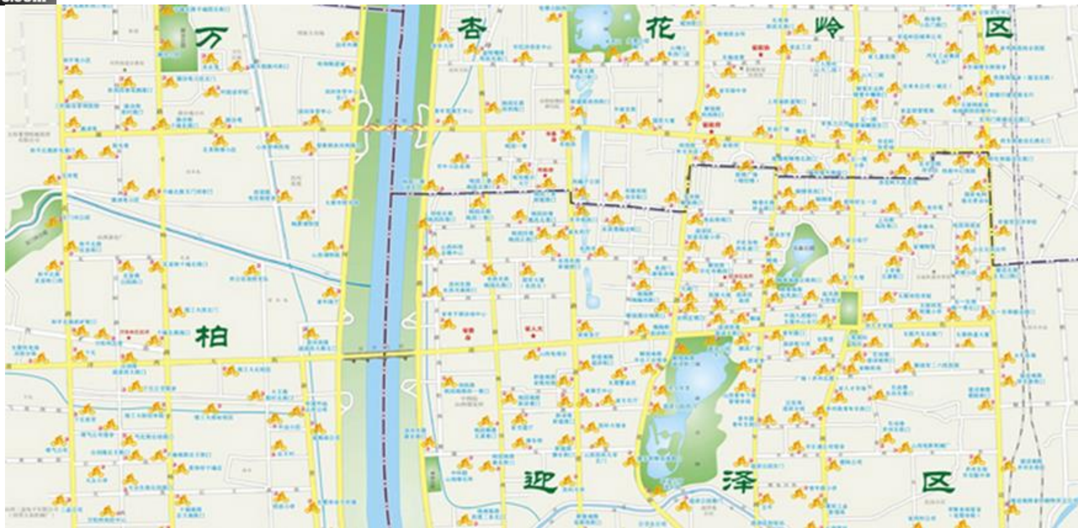
-highest daily demand 0.57 million

-average daily demand 0.4 million

-a bike used 10.24 times per day

data from 09/2012 to 06/2016

Severe & seasonal air pollution



Survey Design

Questionnaire

- Personal socio-economic characteristics
- Household socio-economic characteristics
- Trip dairy
- Attitudes and perceptions
- Retrospective survey
- Stated preference experiment

RP

SP

Stated Preference Experiment

An example

Scenario: travel within 2km, to work/education, sunny day, 10° C, with light pollution

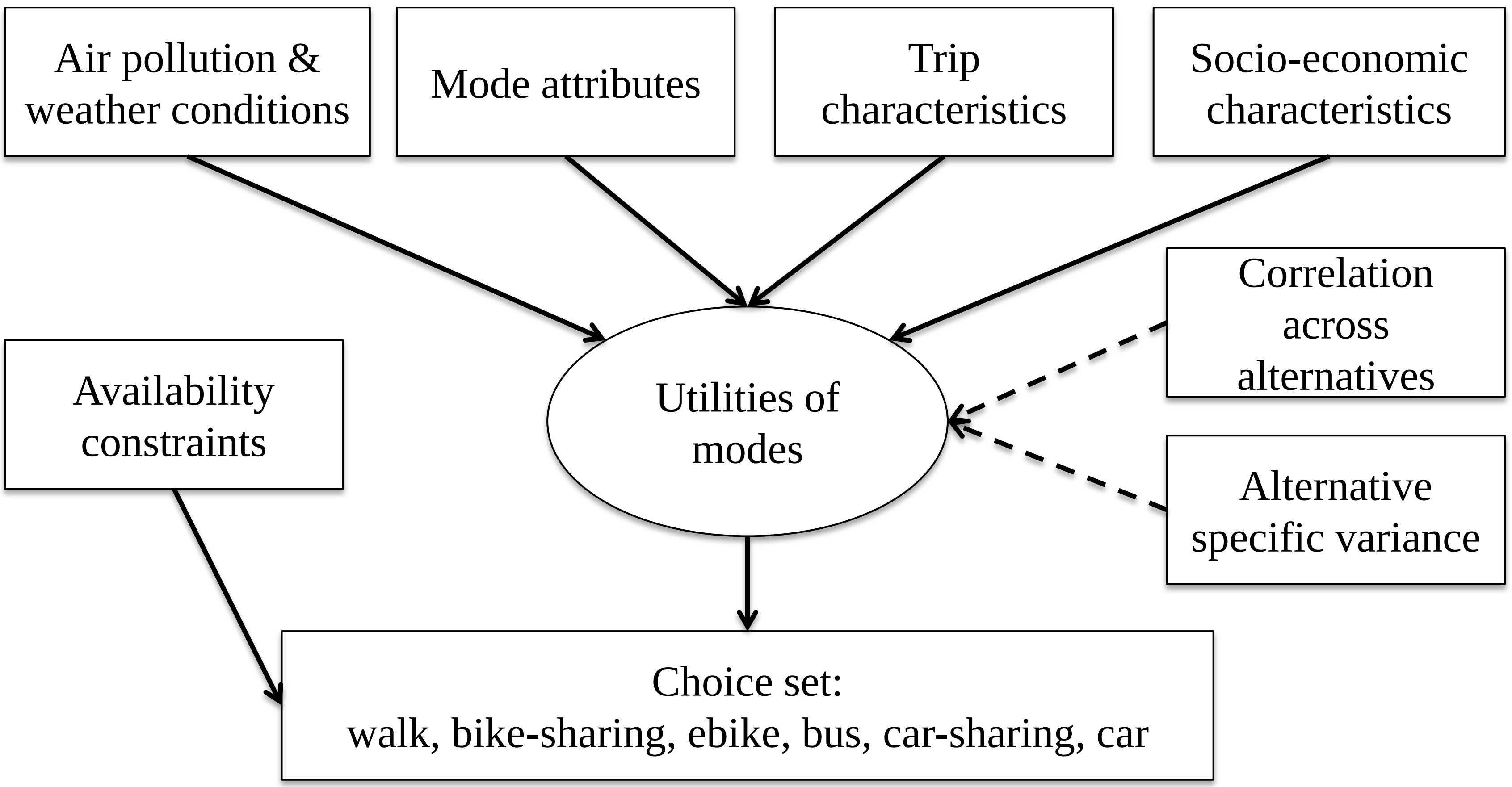
	Car	**E-bike**	**Bus**	**Car share**	**Bike share**	**Walk**
	Drive 3 min	Ride 5 min	Drive 5 min	Drive 7 min	Ride 8 min	Walk 20 min
	Fuel ￥1.2		Ticket ￥1	Cost ￥3	Cost ￥0	
	Easy to park car					
	Parking ￥5/h					
			Walk 5 min to station	Walk 5 min to station	Walk 2 min to station	
			Every 2 min			
			With app	With app	With app	
Your choice (please tick)						

Data Collection

- Pilot survey in January 2015
- Summer data collection 2015: 15000 paper questionnaires distributed, 9499 individuals provided valid data
- Winter data collection 2016: 492 individuals provided valid data

- Air pollution data
- Weather condition data

Modelling Framework



Modelling Framework

$$U_{in} = \sum_{k=1}^{K} \beta_k X_{ink} + \sigma_i \eta_{in} + \varepsilon_{in}$$

One multinomial logit (MNL) model, two mixed MNL models
SP data of the **short-distance trips** (9,499 individuals & 15,878 SP observations)

Results: bike-sharing part

	MNL		MMNL (correlation across alternatives)		MMNL (alternative specific variance)	
	Coef.	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
α_{bikesh}	1.16	2.63	1.16	2.63	1.16	2.63
Commute-bike share	- 0.42	- 4.32	- 0.42	- 4.32	- 0.55	- 4.95
Rain-bike share	- 1.06	- 6.00	- 1.06	- 6.00	- 1.12	- 5.56
Snow-bike share	- 0.78	- 7.38	- 0.78	- 7.38	- 0.87	- 7.00
Temperature-bike share	*0.0027*	*0.65*	*0.0027*	*0.65*	*0.0017*	*0.37*
Air pollution-bike share	- 0.0025	- 5.08	- 0.0025	- 5.08	- 0.0025	- 4.32
Travel time-bike share	*0.06*	*1.22*	*0.06*	*1.22*	0.13	2.48
Travel cost-bike share	- 0.36	- 3.49	- 0.36	- 3.49	- 0.50	- 4.41
Walk time-bike share	- 0.08	- 4.57	- 0.08	- 4.57	- 0.11	- 5.12
App availability-bike share	- 0.28	- 3.71	- 0.28	- 3.71	- 0.39	- 4.42
Male-bike share	*0.02*	*0.42*	*0.02*	*0.42*	*- 0.02*	*- 0.34*
Age (lower)-bike share	*- 0.10*	*- 1.29*	*- 0.10*	*- 1.29*	*- 0.06*	*- 0.73*
Income (lower)-bike share	*0.08*	*1.11*	*0.08*	*1.11*	*0.15*	*1.54*
Education (lower)-bike share	*0.02*	*0.46*	*0.02*	*0.46*	*0.01*	*0.14*

Results: model comparisons

	MNL		MMNL (correlation across alternatives)		MMNL (alternative specific variance)	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
σ_{share}			*0.09*	*0.34*		
σ_{auto}			*0.01*	*0.05*		
σ_{walk}					1.51	5.73
σ_{bikesh}					*0.03*	*0.07*
σ_{ebike}					0.00	-
σ_{bus}					0.85	3.50
σ_{carsh}					7.66	2.35
σ_{car}					*0.91*	*1.70*
Number of observations	15878		15878		15878	
Final log-likelihood	- 23458.0		- 23457.9		- 23428.6	
Likelihood ratio test	3155.4		3155.5		3214.2	

Result Summary (short-distance trips)

- As air pollution levels increase, the possibilities of choosing walk, bike-sharing and electric bike decrease. The slower the mode, the more it will be affected by air pollution.

- Shared modes are not preferred for commute trips.

- Negative willingness to pay for transport services is discovered.

Result Summary (short-distance trips)

- The younger generation do not prefer bike-sharing, walk or electric bike and would rather choose car-sharing or bus.
- Lower income groups prefer bike-sharing and car-sharing.
- Travellers with higher educational levels are more likely to choose new mobility services.

Policy Impact Simulation

Policies	
P1	20% air quality increase
P2	50% air quality increase
P3	50% air quality increase + 20% bike-sharing cost reduction
P4	50% air quality increase + 50% bike-sharing cost reduction
P5	50% air quality increase + 50% bike-sharing cost reduction + 20% walk time decrease to bike-sharing station
P6	50% air quality increase + 50% bike-sharing cost reduction + 50% walk time decrease to bike-sharing station

Modal Splits

	Bike-sharing	Walk	Electric bike	Bus	Car-sharing	Car
Baseline	13.8%	27.4%	10.3%	27.3%	11.1%	10.1%
P1	13.9%	28.9%	10.3%	26.3%	10.9%	9.7%
P2	14.0%	31.3%	10.1%	24.8%	10.7%	9.1%
P3	14.2%	31.2%	10.1%	24.7%	10.7%	9.1%
P4	14.6%	31.1%	10.0%	24.5%	10.7%	9.1%
P5	15.6%	30.7%	9.9%	24.2%	10.7%	8.9%
P6	17.1%	30.2%	9.6%	23.7%	10.6%	8.8%

Policy Impact Simulation: insights

- **For short-distance trips**, reducing air pollution has limited effect, but still, an opportunity for a virtuous circle.
- **For short-distance trips**, reducing walking distance is more effective than reducing price.
- If policies focus only on bike-sharing, its market share increase mainly comes from the shrinking bus demand instead of a significant decrease in private car usage.

Future Research (bike-sharing)

- Medium- & long-distance trips
- Analysis based on RP data (i.e. seasonal comparison between summer and winter)
- Latent variables

Thank you!

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