

How parking affects traffic performance on urban networks

Other Conference Item

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How Parking Affects Traffic Performance on Urban Networks

SVT

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Vancouver

June 2016



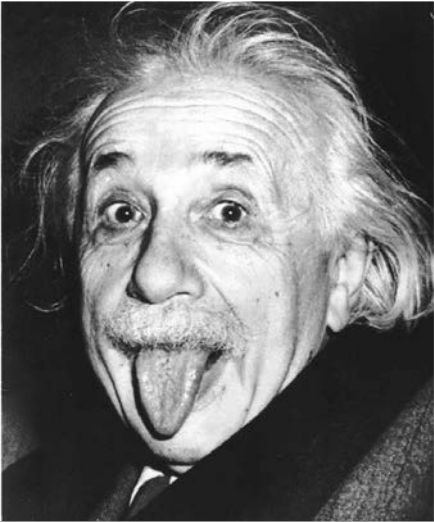
World Parking Symposium

Symposium Mondial sur le Stationnement

a parking and transportation symposium
un symposium de stationnement et de transport

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



Swiss Federal
Polytechnic
(1896–1900)





Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Transport Planning
(VP)

Transport Systems
(VS)

Traffic Engineering
(SVT)

Dr. Menendez



Goal:

To achieve more efficient and sustainable transportation systems from the traffic operations perspective





Traffic is NOT the number of lanes.
Traffic engineers' job is NOT about building bigger roads.

Transportation & Traffic in Zurich

SVT



Zurich: A World Class Transit Metropolis



09:43

HD

Select Language Share

Zurich: Where People Are Welcome and Cars Are Not

by Clarence Eckerson Jr. on October 15, 2014 | 39,992 Plays

Tweet G+ 5 Like 422 Email Share

When it comes to smart transportation options and city planning, Zurich can credibly claim to be the global champ. This Swiss city has enacted a number of policies and practices that have produced streets where people come first. Getting around and simply experiencing the city is a pleasure.

Parking: Cap and trade

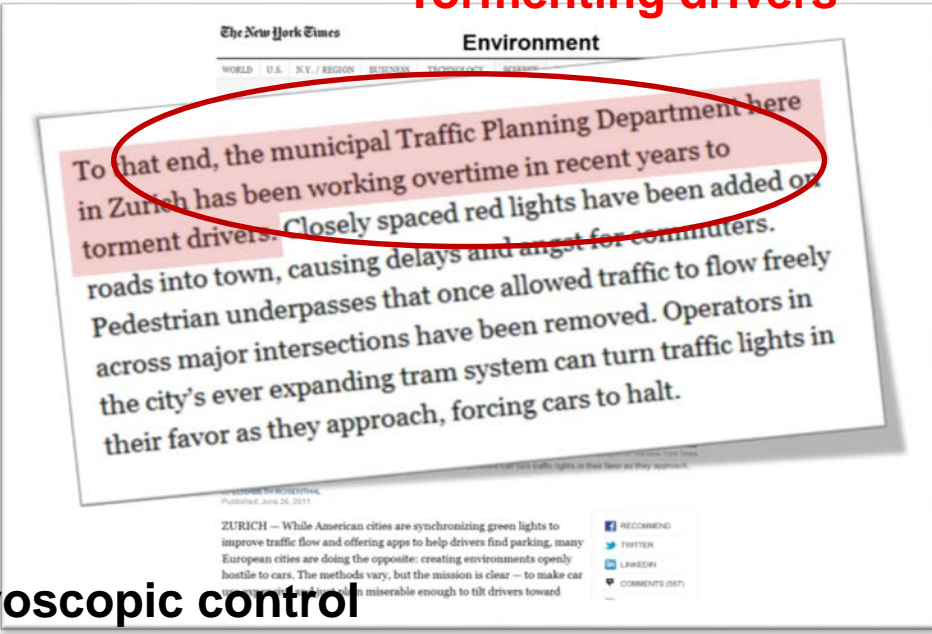
How did they do it? In a 1996 city decree referred to as "a historic compromise," Zurich decided to cap the number of parking spaces. From then on, when new parking spaces were built anywhere in Zurich, an equivalent number of spaces had to be eliminated elsewhere within the city limits. Many of the new spaces that have been built since then come in the form of underground garages, which allow for more car-free areas, plazas, and shared-space streets.

Zurich also has an intricate system of more than 4,500 sensors that monitor the number of cars entering the city. When that number exceeds the level Zurich's streets can comfortably accommodate, all cars are halted on highways and main roads into the city until congestion is relieved. Thus, there is never significant traffic back-up in the city itself.

Traffic: Macroscopic control



Tormenting drivers



Source:
<http://www.streetfilms.org/zurich-a-world-class-transit-metropolis/>
<http://www.eaue.de/winuwd/45.htm>

This presentation ... Zurich

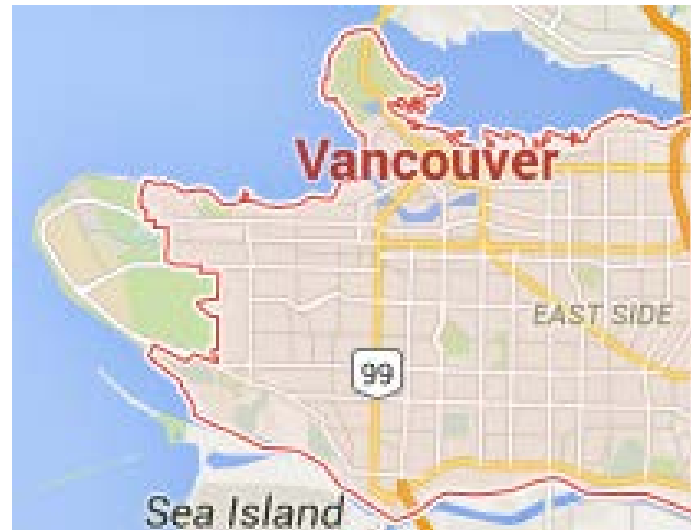
PART I: Parking policy/condition



Part II: Searching for parking



PART I: Parking policy/condition



	Zurich	Vancouver	% of Vancouver
Density	4,135 /km ²	5,249/km ²	79%
Public Parking	67,081 (2011)	?	?%
Car Ownership	177855 (2013)	?	?
PP per car	0.38	?	?

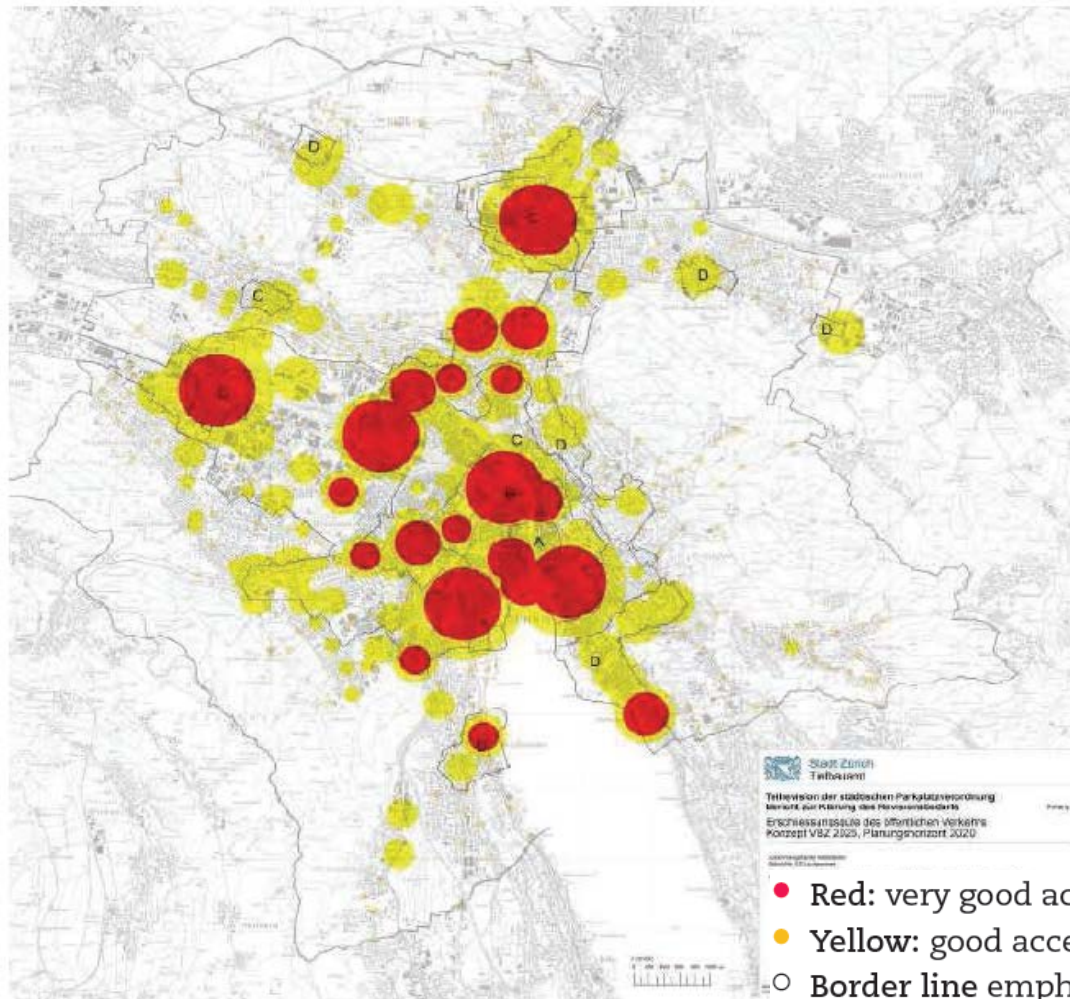
Core difference: All parking spaces are central controlled. Private parking spaces are illegal to be used toward public. Profit is not as important.

Private Parking

Parking requirements for different land use in Zurich

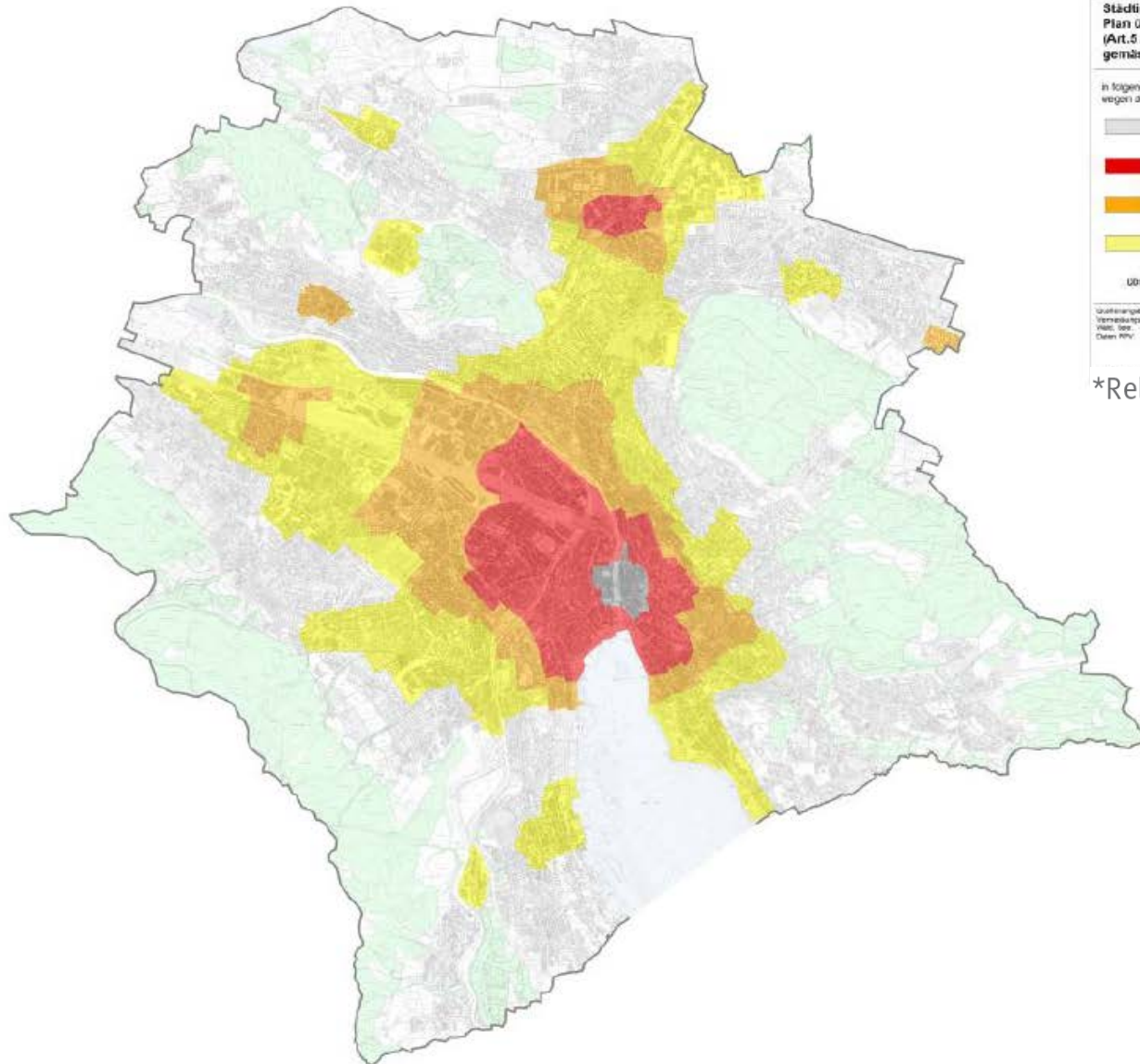
LAND USE TYPE	PARKING REQUIREMENT
Residential	1 space/120 m ²
Commercial	
First 500 m ² per unit	1 space/120 m ²
Over 500 m ² per unit	1 space/210 m ²
Retail	
First 2000 m ² per unit	1 space/100 m ²
Over 2000 m ² per unit	1 space/160 m ²
Restaurants, cafes, bars	1 space/40 m ²

Private Parking



New parking ordinance (28.11.2010):

Parking reduction where PT is well connected.



Stadt Zürich Tiefbauamt

Städtischer Plan UB (Art. 5 Allg.) gemäss

in folgende Zonen unterteilt

AREA	MINIMUM (%)	MAXIMUM (%)	*MAXIMUM 2 (%)
A	10	10	10
B	25	45	50
C	40	70	75
D	60	95	105
Übrige			
Remaining Areas	70	115	130

Quelle: Stadt Zürich Tiefbauamt, Stand: 2010

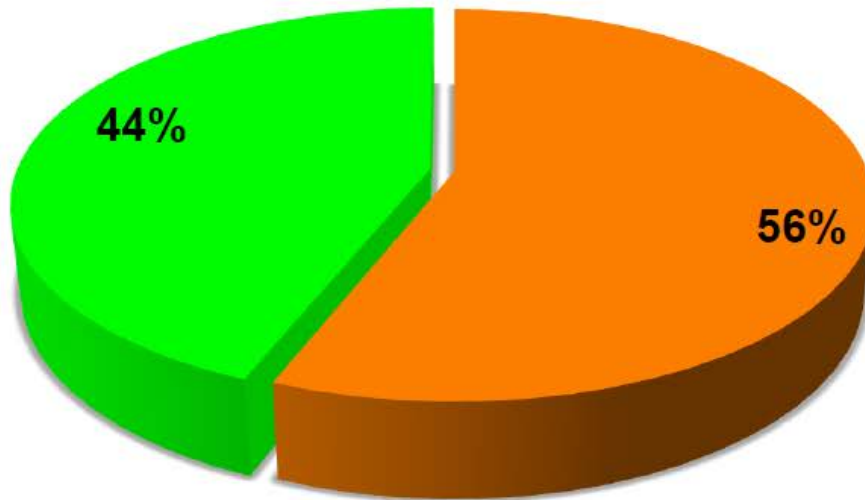
*Related to clean air regulations and road capacity

Encouraging car-free

SVT

Car-free housing: increasing demand

umverkehR
Zukunft inkl.



- households with at least one car
- households without car



Encouraging car-free

SVT

Development „Kalkbreite“:
Car-free housing is possible

umverkehR
Zukunft inkl.



Public Parking: On-street parking

SVT

Blue zone



Parking disc
Free for short time.



Residential Areas
15 CHF/day/all zone
300 CHF/year



Supplement Private Parking

Public Parking: On-street parking

White zone

- **Time control** 0.5h - 8h depends
- Must leave when time is up.
- 0.5 sFr. – 2.5 Sfr. /hour



Enforcement

SVT



Many gentlemen happen to meet the wrong ladies when going out.

Die Bekanntschaft mit diesen Tauersten bleibt Ihnen erspart, wenn Sie das Auto in Zürich zuhause lassen. Und auf Tram und Bus umsteigen. In der Stadt ist die nächste Haltestelle im Durchschnitt nur gerade 300 Meter entfernt. Dort finden Sie alle paar Minuten Anschluss. Und können sich ohne Parkplatz-

probleme ins Kino, ins Restaurant oder an die Party chauffieren lassen. So kommen Sie in jeder Hinsicht besser an. Fürs erste Kennenlernen empfehlen wir Ihnen die ZVV-Tageskarte für CHF 7.20. Weitere Informationen unter www.vbz.ch

VBZ Zürich Linie

Umsteigen lohnt sich.

Enforcement

Examples

200th	Exceeding the permissible parking time	Fine
a.	to 2 hours	40
b.	more than 2 but not more than 4 hours	60
c.	by more than 4 but not more than 10 hours	100

224.. 1	Parking available on the tram tracks to 60 minutes	120
--- .. 2	Keep on the tram tracks	80
225.. 1	To park closer than 1.5 m from the next tram rail to 60 minutes	120
--- .. 2	Keep closer than 1.5 m from the next tram rail	80
226.. 1	Parking available on the hard shoulder of a motorway to 60 minutes	120
--- .. 2	Keep on the hard shoulder of a motorway except emergency	80
227.. 1	Parking available on the hard shoulder of a motorway to 60 min	120
--- .. 2	Keep on the hard shoulder of a motorway except emergency	80

Public Parking: Off-street parking

Off-street parking: Pricing/Time control

- 1 sFr. – 5 Sfr. /hour
- progressive pricing

Parkhaus Accu



Adresse:

Otto-Schütz-Weg
8050 Zürich

Angebot:

194 Plätze

Normal-Tarife:

Mo - Sa: 08.00 - 21.00
0.5 Std. / CHF 1.00

Parkhaus Center Eleven



Adresse:

Sophie-Täuber-Strasse
8050 Zürich

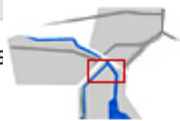
Angebot:

342 Plätze

Normal-Tarife:

Mo - Sa: 08.00 - 21.00
0.5 Std. / CHF 1.00

Parkhaus Globus



Adresse:

Löwenstrasse 50
8001 Zürich

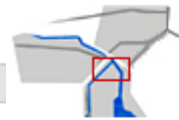
Angebot:

149 Plätze

Normal-Tarife:

Mo - Sa: 08.00 - 20.00
1.0 Std. / CHF 3.50

Parkhaus City Parking



Adresse:

Gessnerallee 14
8001 Zürich

Angebot:

620 Plätze

Normal-Tarife:

0.5 Std. / CHF 2.00
Tagespauschale CHF 40.00

Parkhaus



Adresse:

Uraniastrasse
8001 Zürich

Angebot:

607 Plätze
davon 451 Kurzparking

Normal-Tarife:

0.25 Std. / CHF 1.10



Historischer Kompromiss

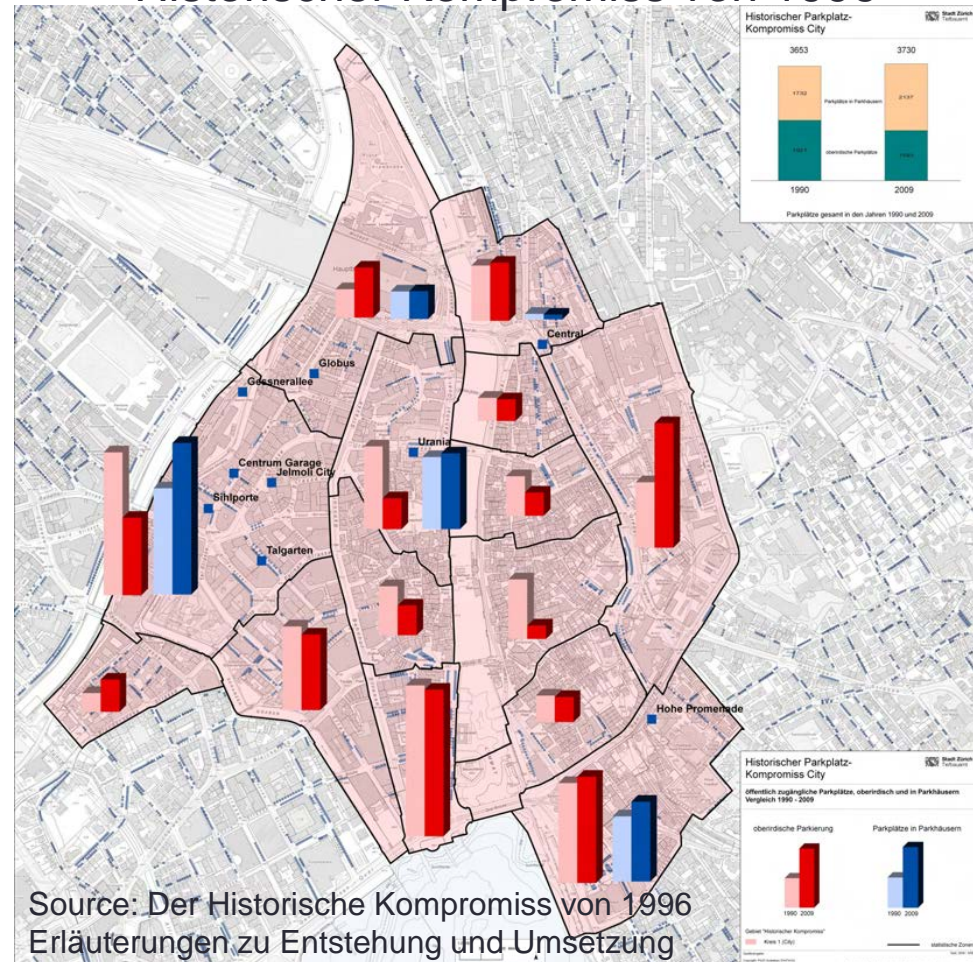
Kreis 1 1.8 km²

1990-2009

On-street parking removed
10% (189 spaces)

Off-street parking increased
34% (544 spaces)

Historischer Kompromiss von 1996



Public Parking



Parking Income (Public spaces)

~450 Million CHF / Year only consider three main business areas

Source:

Förderung der städtischen Standortattraktivität
durch effizienten und finanzierbaren Verkehr

Teil 1: Wirtschaftliche Bedeutung von Parkplätzen in
der Stadt Zürich

Quartier	Lage Parkplatz	Parkplätze Total	Ø Jahreswert- schöpfung je Parkplatz	Quartier- wertschöpfung pro Jahr in Mio CHF
Innenstadt	Strasse	1'593	151'519.-	241
	Parkhaus	2'137	77'260.-	165
Oerlikon	Strasse	251	63'072.-	16
	Parkhaus	442	42'111.-	19
Wipkingen	Strasse	32	18'980.-	0.6
	Parkhaus	101	14'098.-	1.4

PART II: Search for parking

Title:

How parking affects traffic performance on urban networks



How much time individual travellers spent on Searching for parking?

Did the traffic got worse because of parking issue?

Parking search estimation

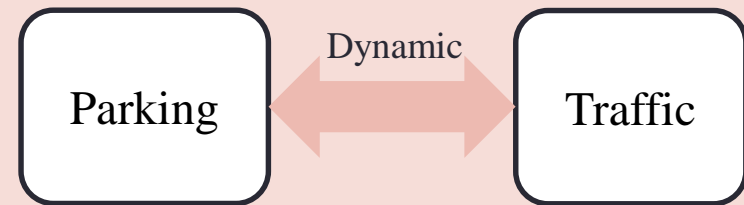
Existing studies

Empirical studies

Multi-agent simulations

Traffic assignment

Macroscopic Model

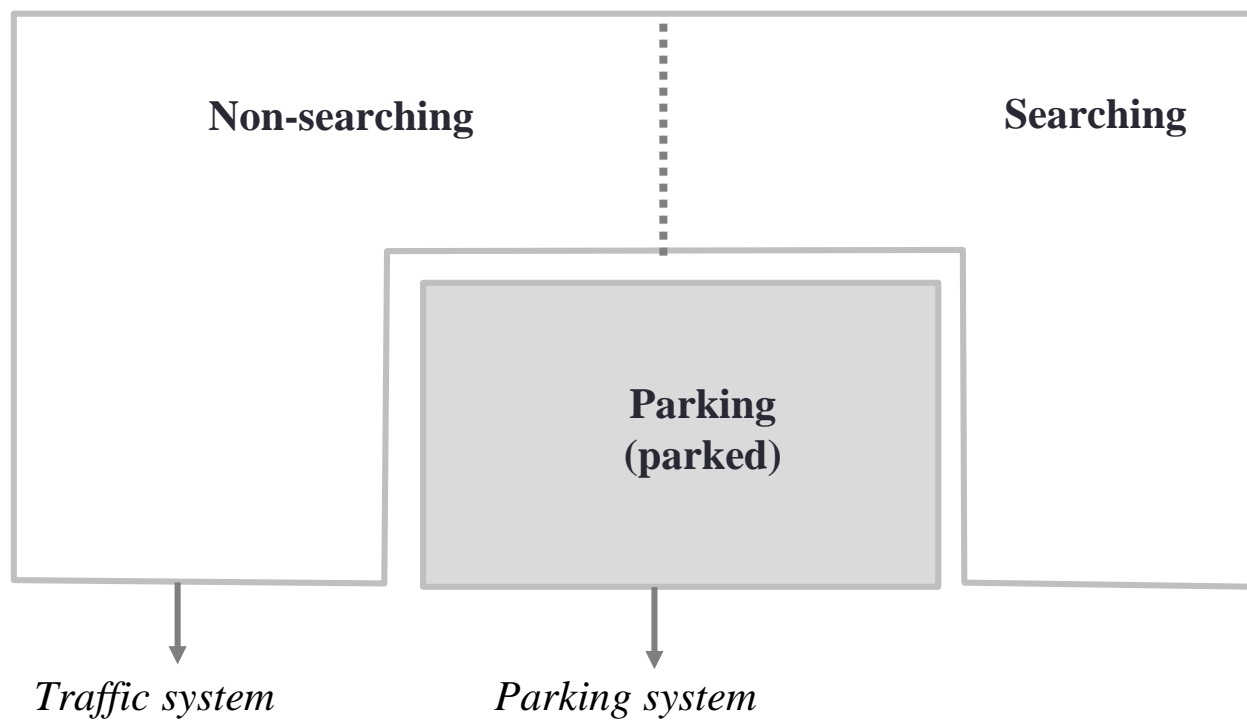


See full model in:

Cao, J., M. Menendez (2015) System dynamics of urban traffic based on its parking-related-states, Transportation Research Part B: Methodological, 81(2015): 718-736.

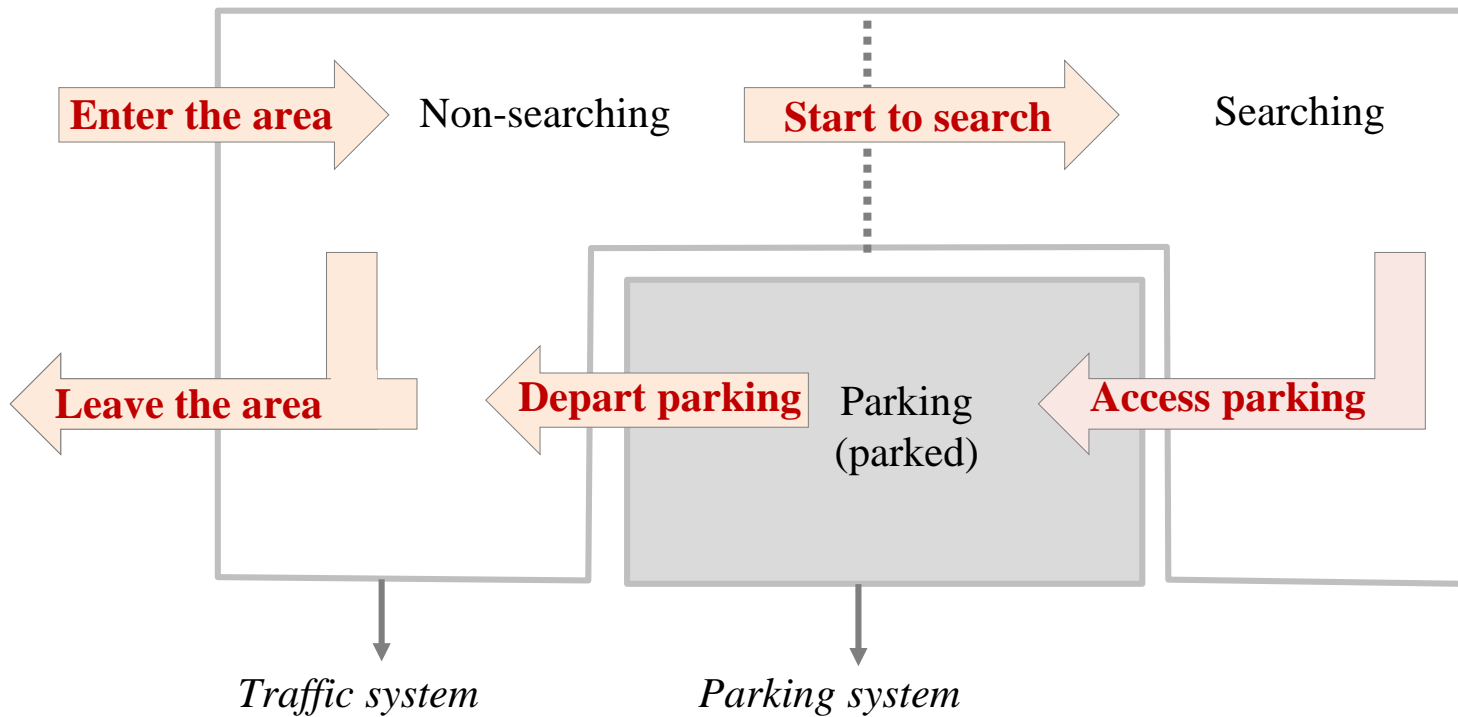
A parking-state transition matrix

Parking-related states:



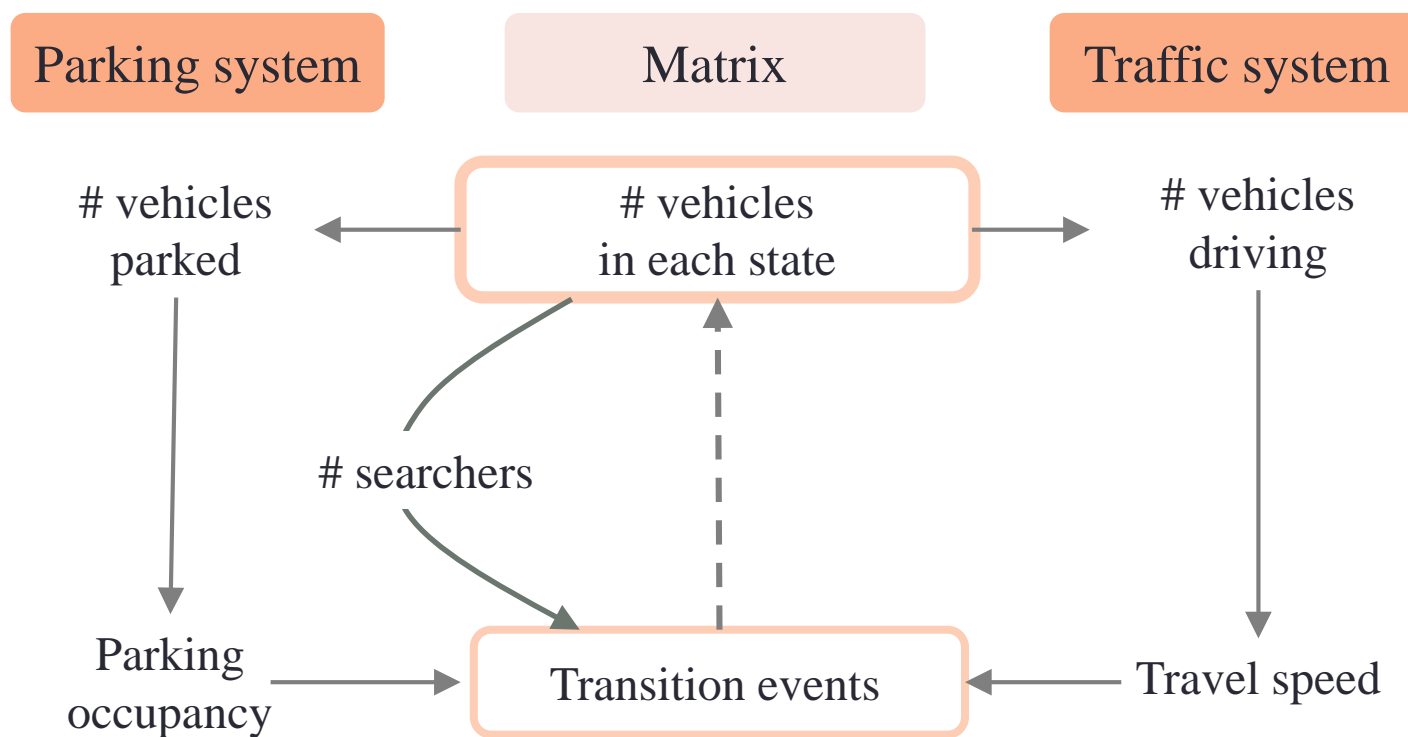
A parking-state transition matrix

Transition events:

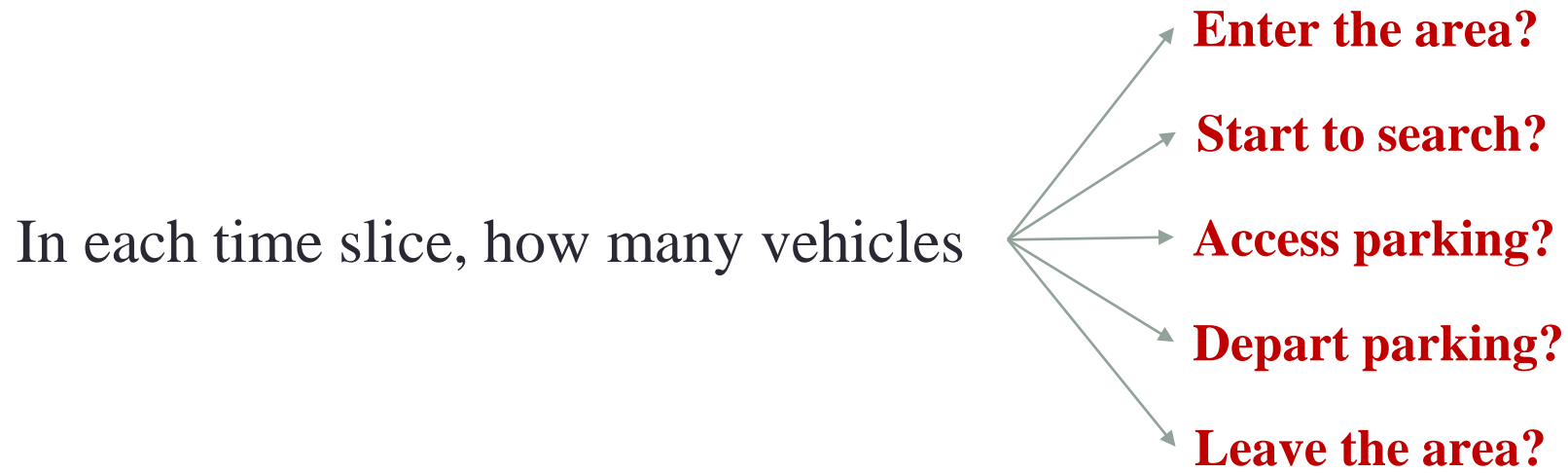


A parking-state transition matrix

Separate time into very small slices...



A parking-state transition matrix

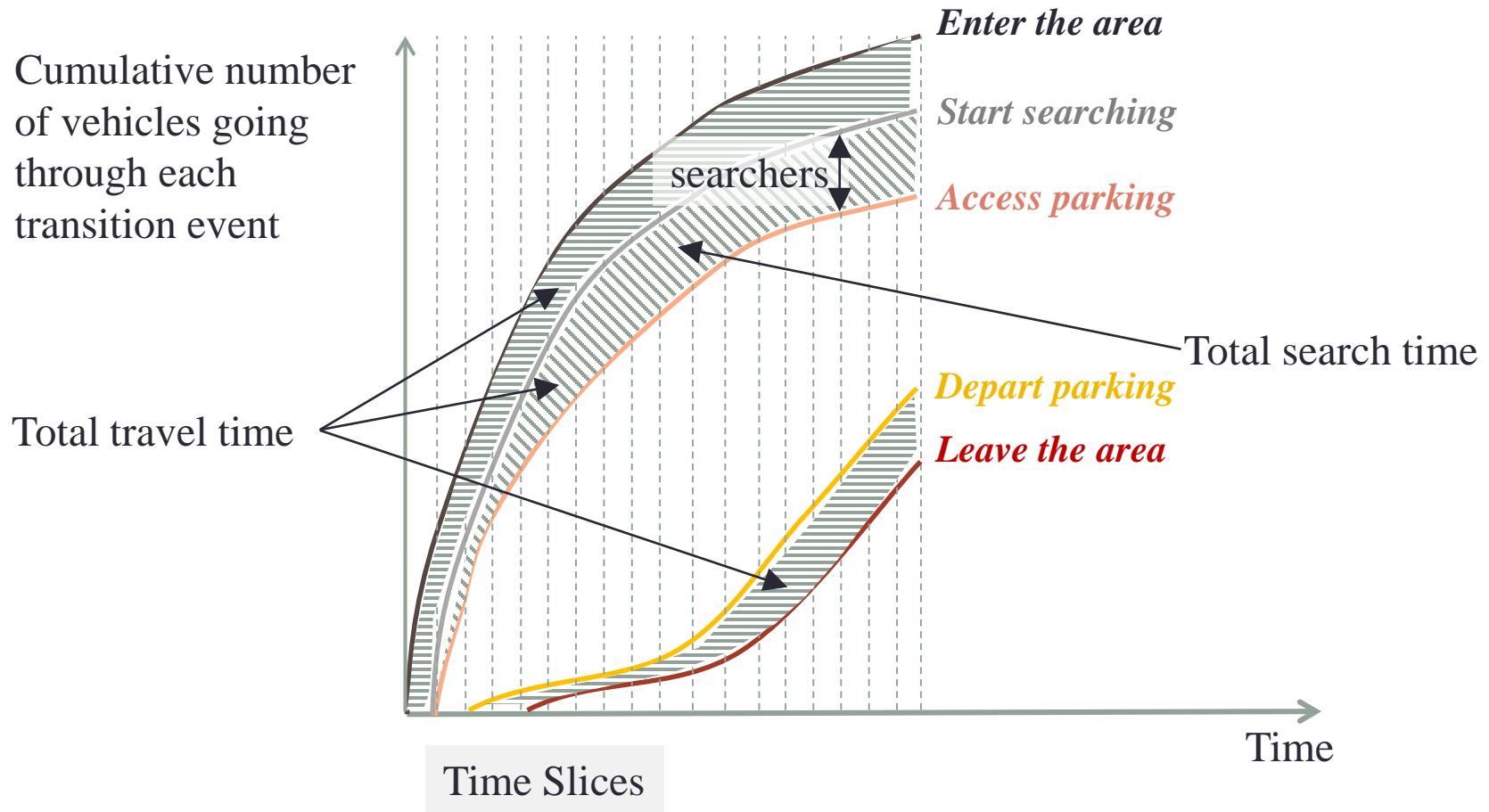


Cumulative over time



“Queuing” Diagram

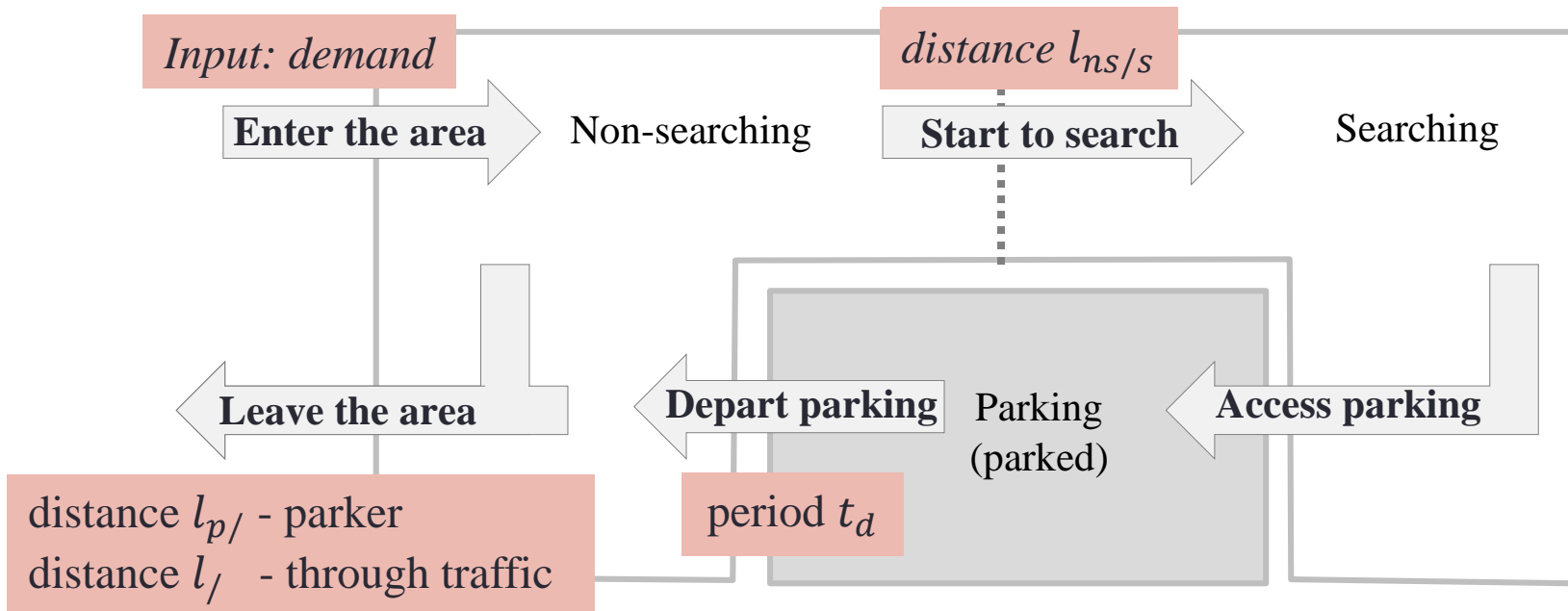
Macroscopic model



“Queuing diagram” of vehicles on urban networks

Methodology

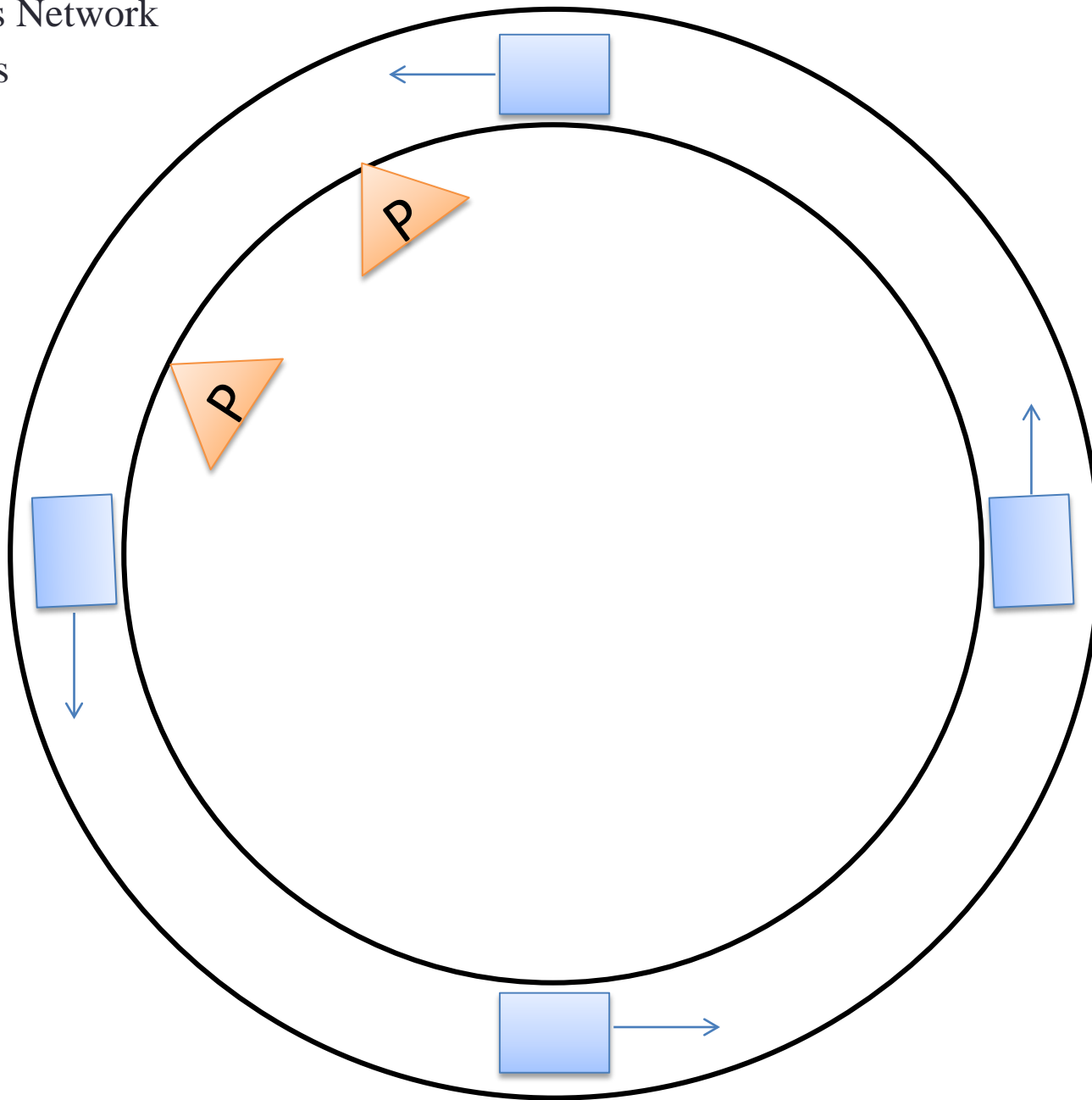
In each time slice, how many vehicles



Homogenous Network

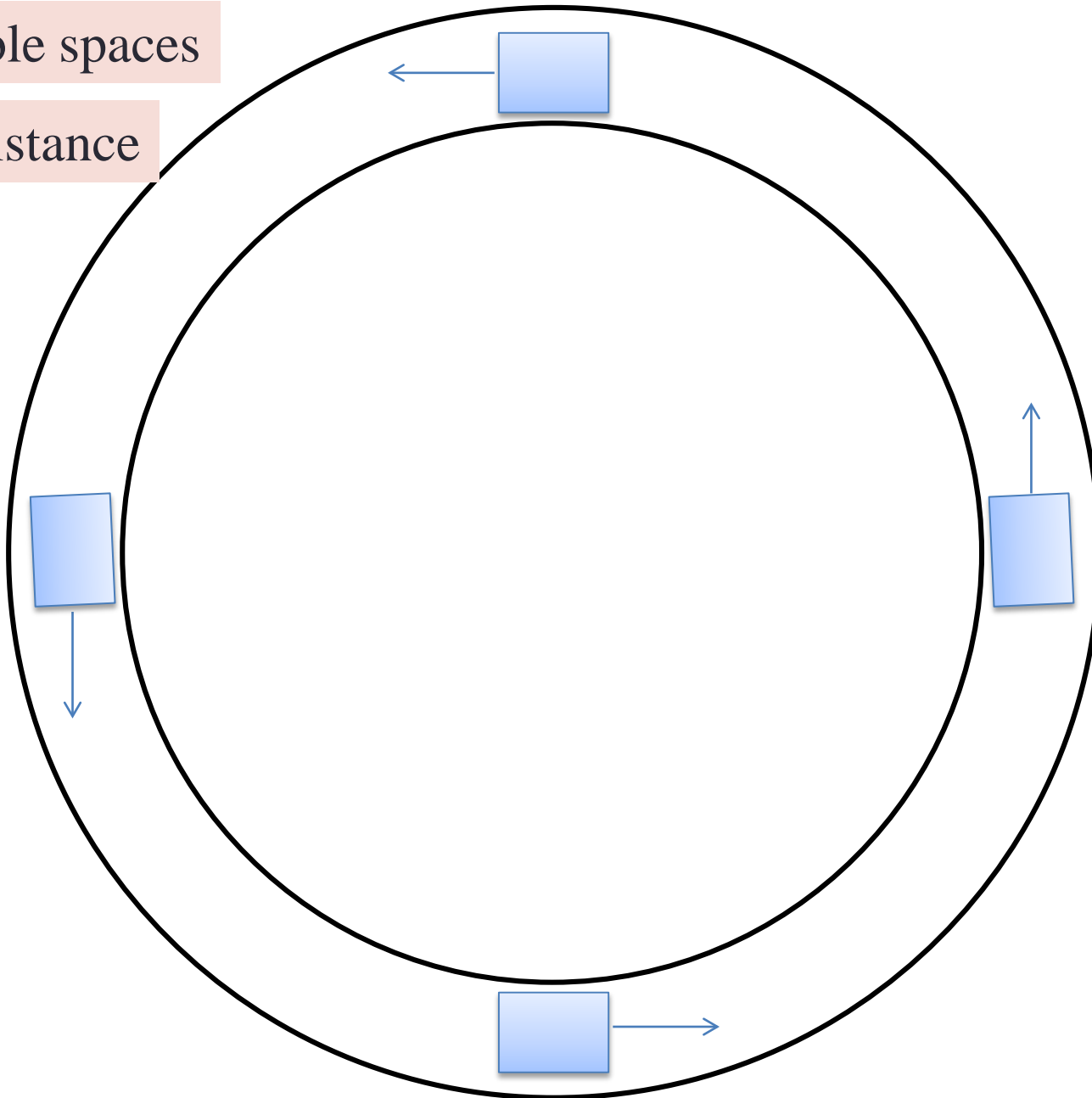
Parking spots

Searchers



available spaces

Travel distance



Methodology (Access parking)

A parking space can be visited at most by **1** searcher

$$\text{if } d^i \in [0, s^i] \rightarrow n_{s/p}^i = N_s^i \cdot \left[1 - \left(1 - \frac{d^i}{L} \right)^{A^i} \right]$$

A parking space
more than

if $d^i \in (s^i, L]$

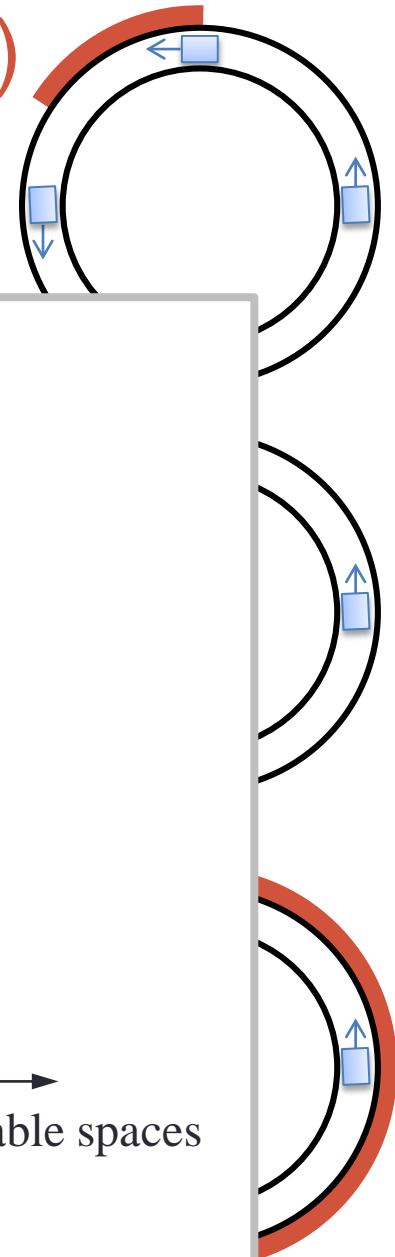
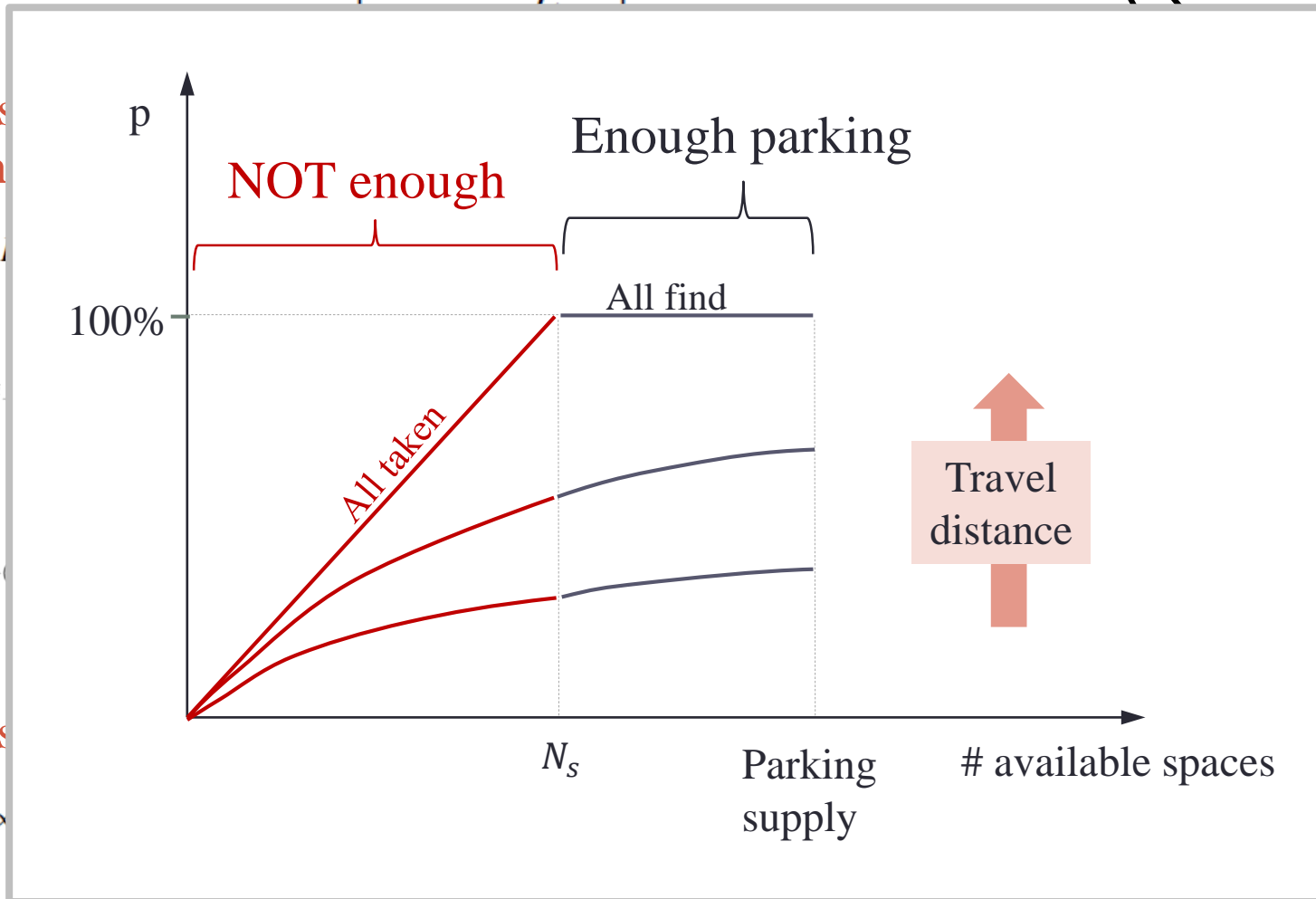
Where,

- $p_1 = \int_0^{d^i}$

- $p_2 = \int_{d^i}^{s^i}$

A parking space

if $d^i \in [L, \infty)$

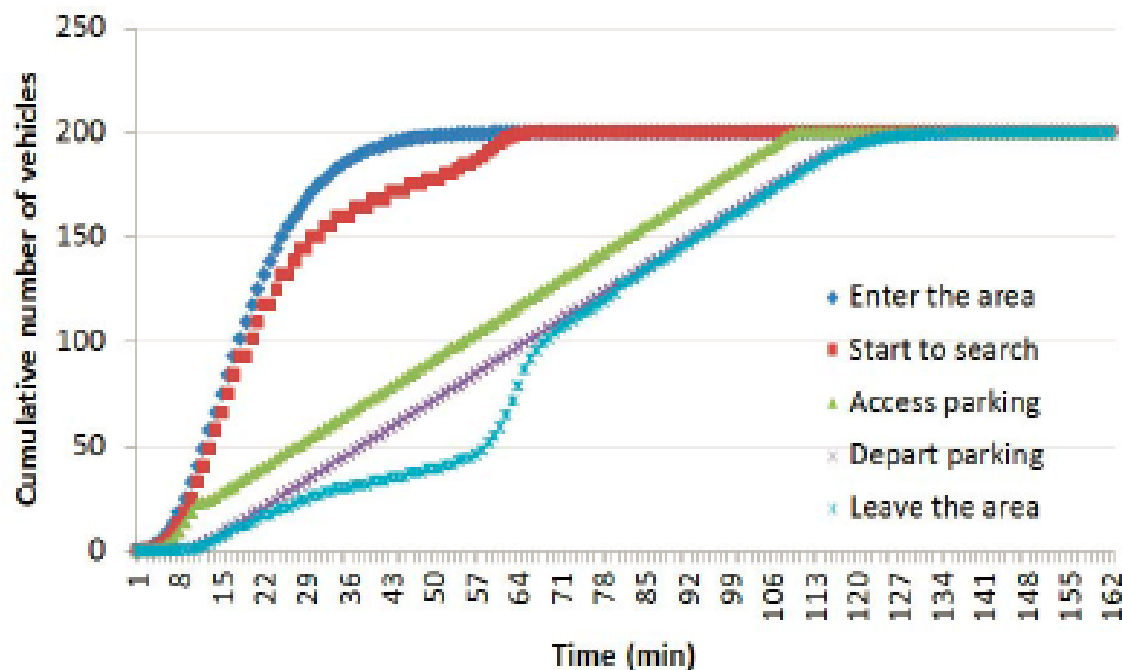


Numerical Example

Assumptions:

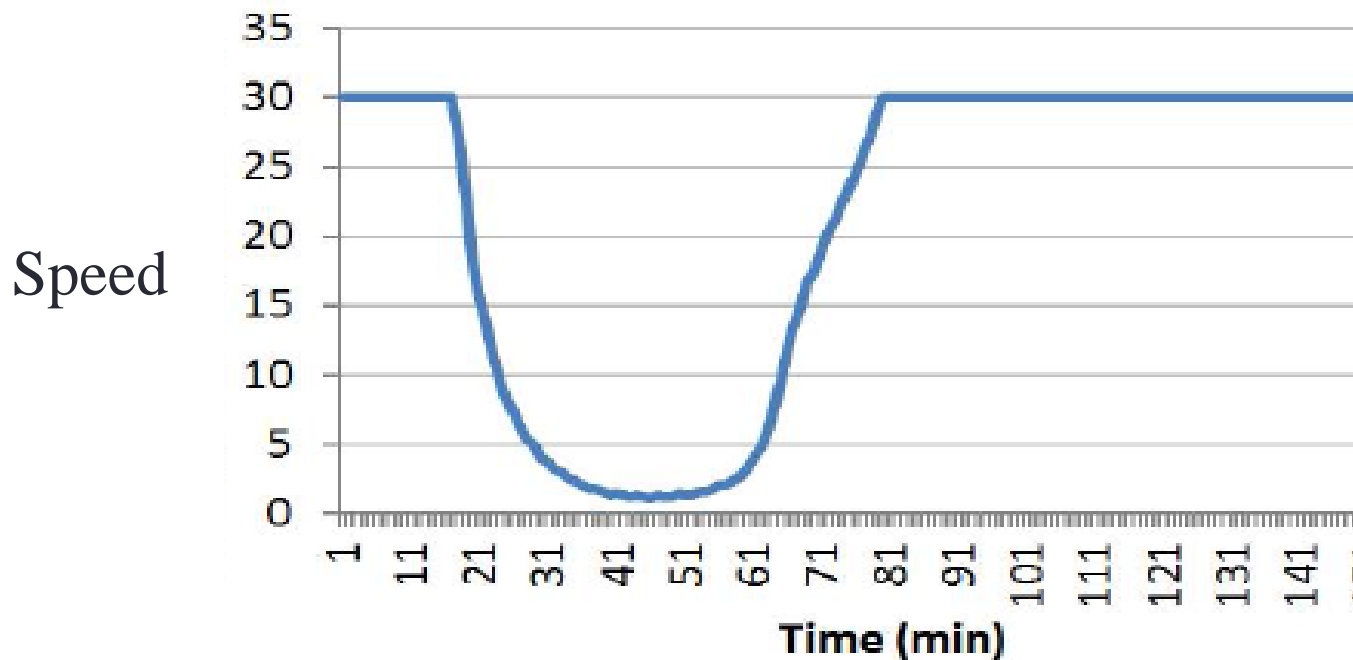
- $L = 1$ km
- $v = 30$ km/h
- $kc = 60$ veh/km/lane
- $kj = 150$ veh/km/lane
- $Q_{max} = 1800$ veh/h/lane
- $L_{ns/s} = 0.5$ km
- $L_p = 0.5$ km
- $N = 200$ trips
- No through traffic
- $A = 21$ spaces
- Average parking duration is 10 minutes

Queuing diagram



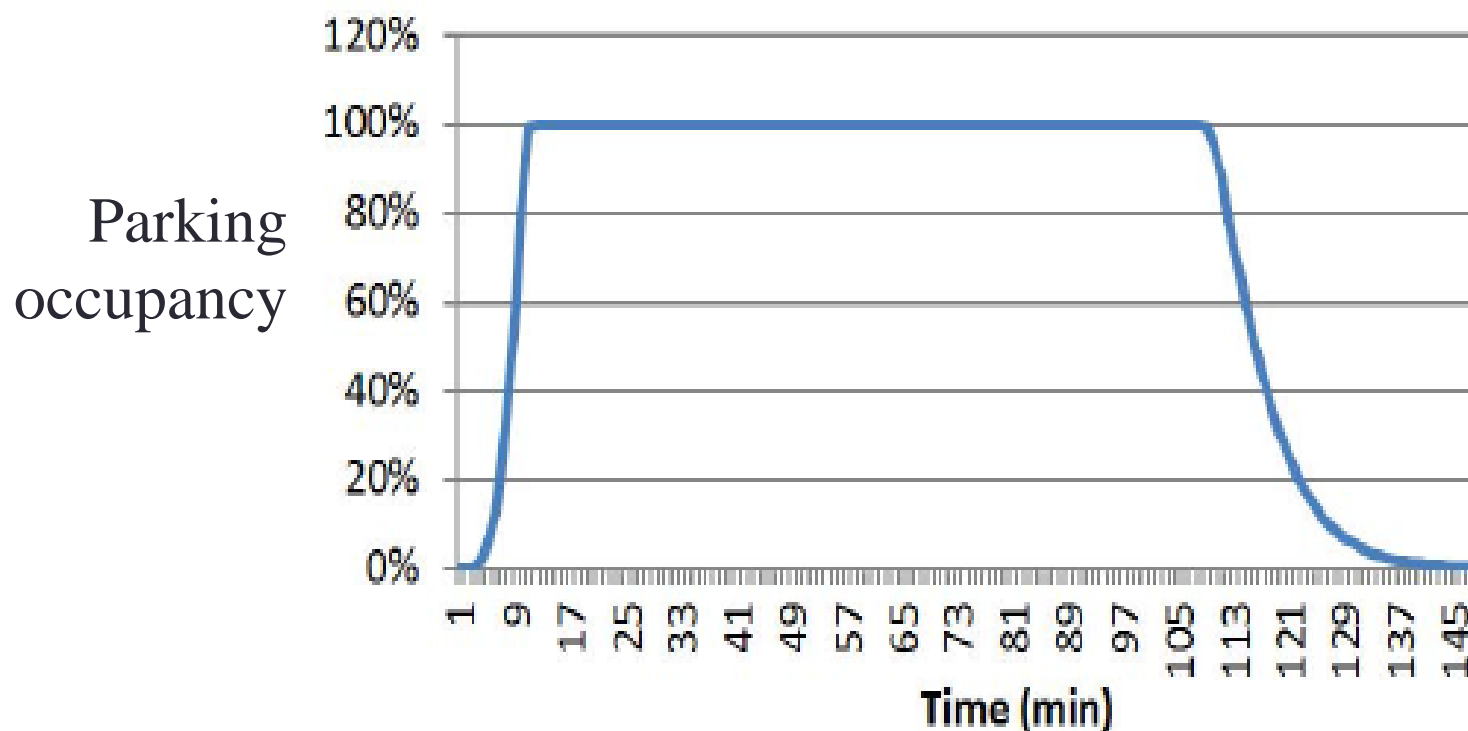
Application: Prediction (traffic/ parking/ searching/ pollution)

Traffic



Application: Prediction (traffic/ parking/ searching/ pollution)

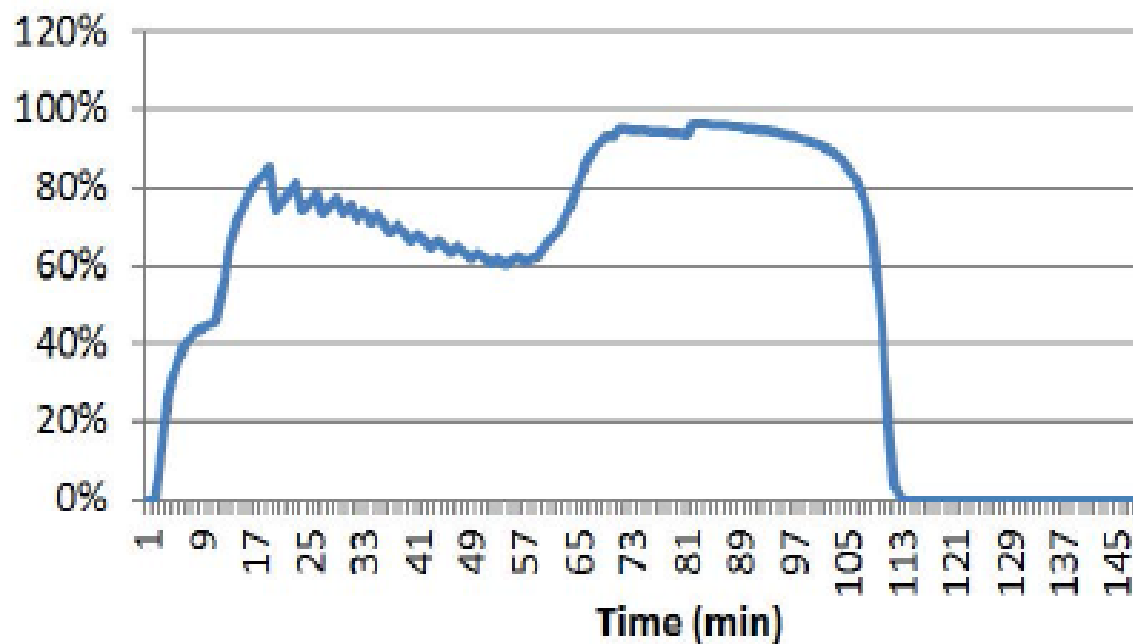
Parking



Application: Prediction (traffic/ parking/ searching/ pollution)

Searching

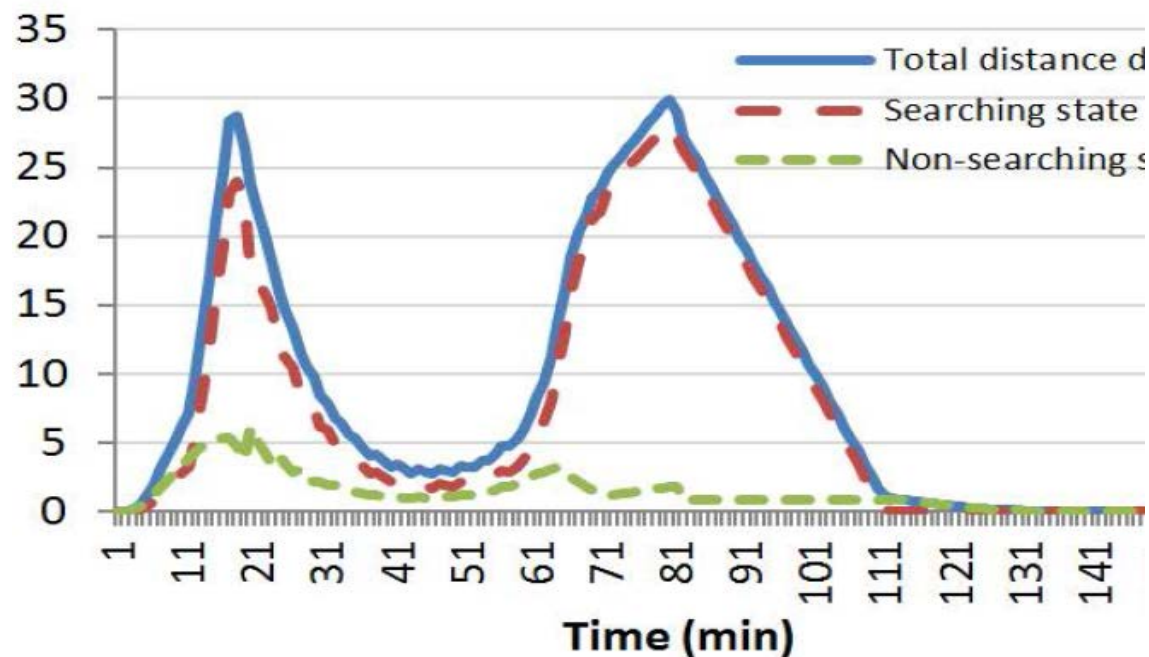
Proportion of
searching
traffic



Application: Prediction (traffic/ parking/ searching/ pollution)

Pollution

Travel
distance



Application: Policy test

21 parking spaces
No time control
(avg. parking duration 10min)

		Searching time (min/veh)	Total driven distance (km)
Policy A. More supply	Original	30.9	1394
	A1 (22 parking spaces)	29.5 (-4.5 %)	1449 (+3.9 %)
	A2 (23 parking spaces)	27.9 (-9.7 %)	1447 (+3.8 %)
Policy B. Time control	B1 (20 minutes maximum)	29.3 (-5.2 %)	1365 (-2.1 %)
	B2 (10 minutes maximum)	22.2 (-28.2%)	1295 (-7.1 %)

Time is reduced

Distance is increased

Some policies may **reduce search time** but simultaneously **increase travel distance**

Macroscopic model: Applications

Searching

- # searchers
- share of searching traffic
- searching time
- searching distance

Parking

- occupancy

Traffic

- density
- speed
- travel distance

Pollution



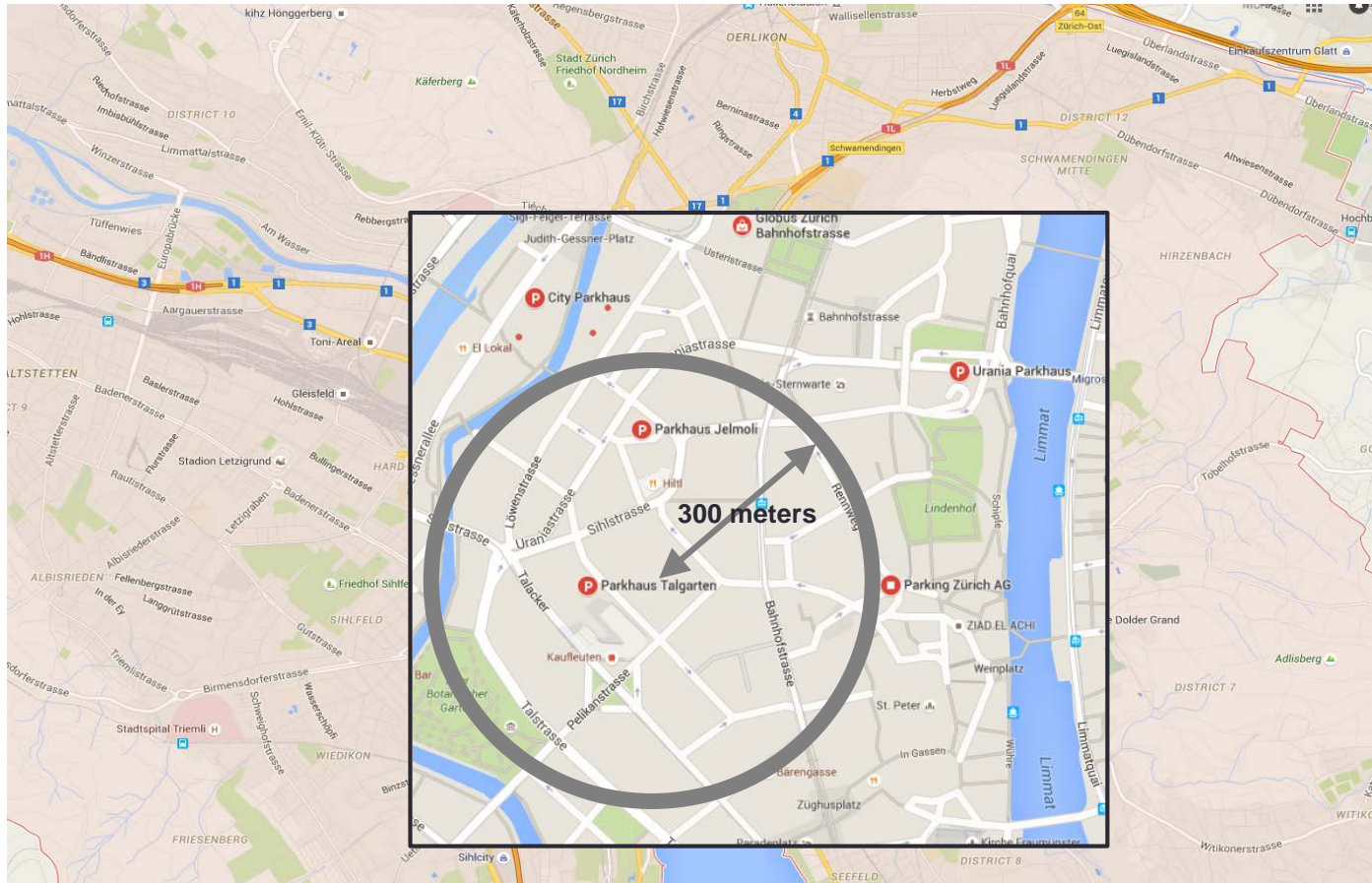
Shoup (2005)

- 30% traffic searching on road?
- **LA:** Cruising distance 5794 kilometers each day (equivalent to two round trips to the moon each year)?

Zurich?



Parking search (Jelmoli area)



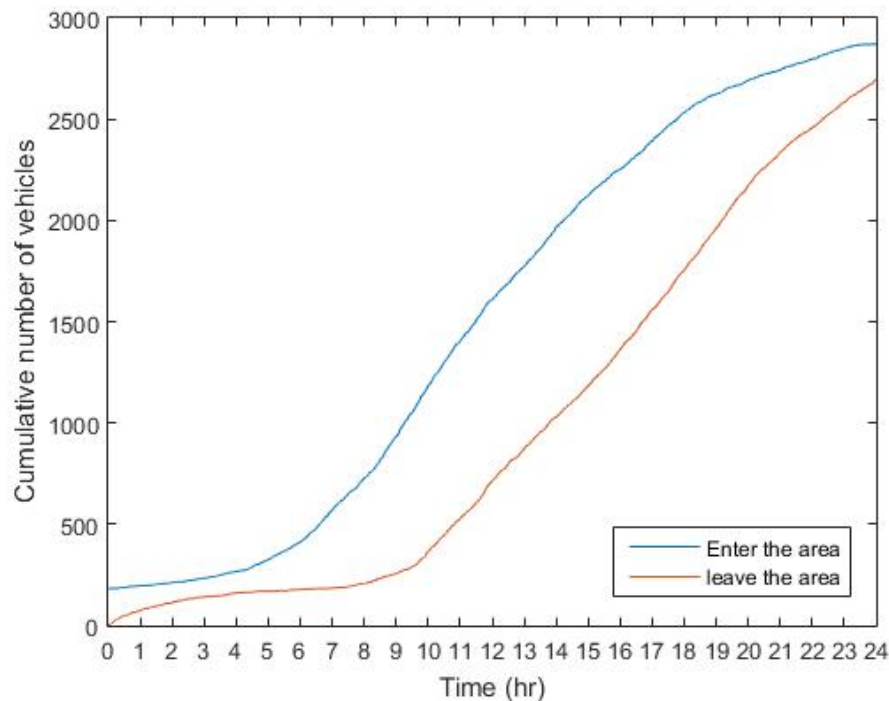
332 off-street
parking spaces

207 on-street
parking spaces

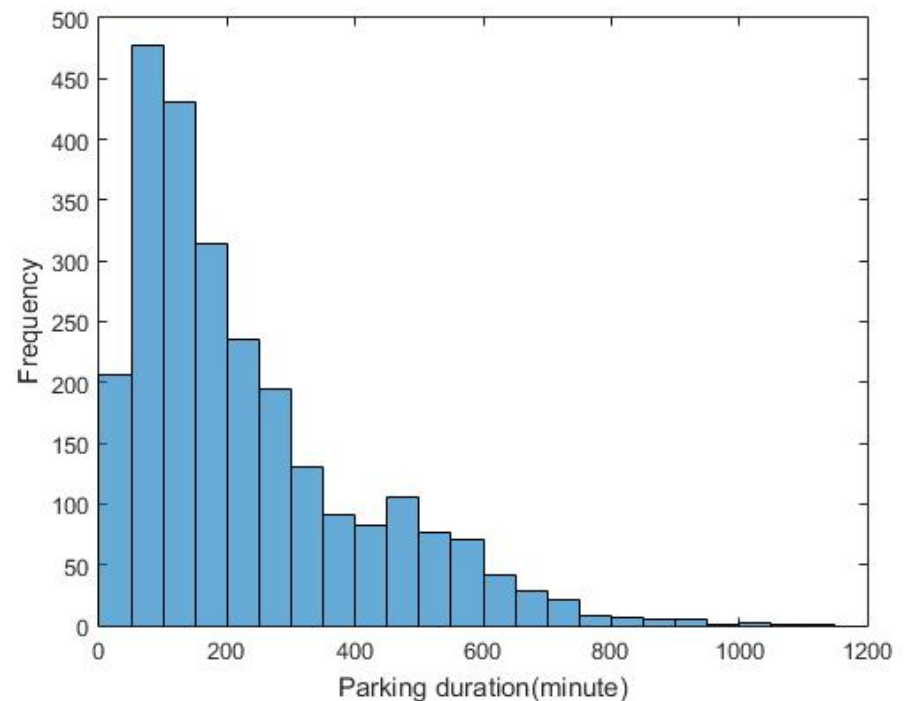
106 links
7.7 kilometers

Parking search (Jelmoli area)

- Inputs include demand and parking duration



Cumulative number of vehicles entering and leaving the area

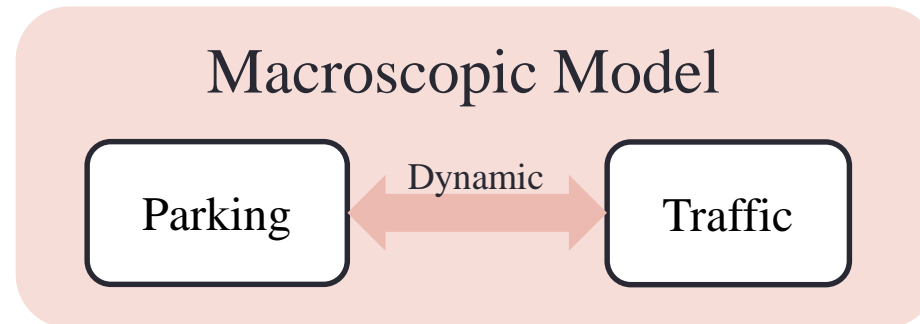


Histogram of the parking durations

Parking search (Jelmoli area)

- Methodology

Cao, J., M. Menendez (2015) System dynamics of urban traffic based on its parking-related-states, Transportation Research Part B: Methodological, 81(2015): 718-736.



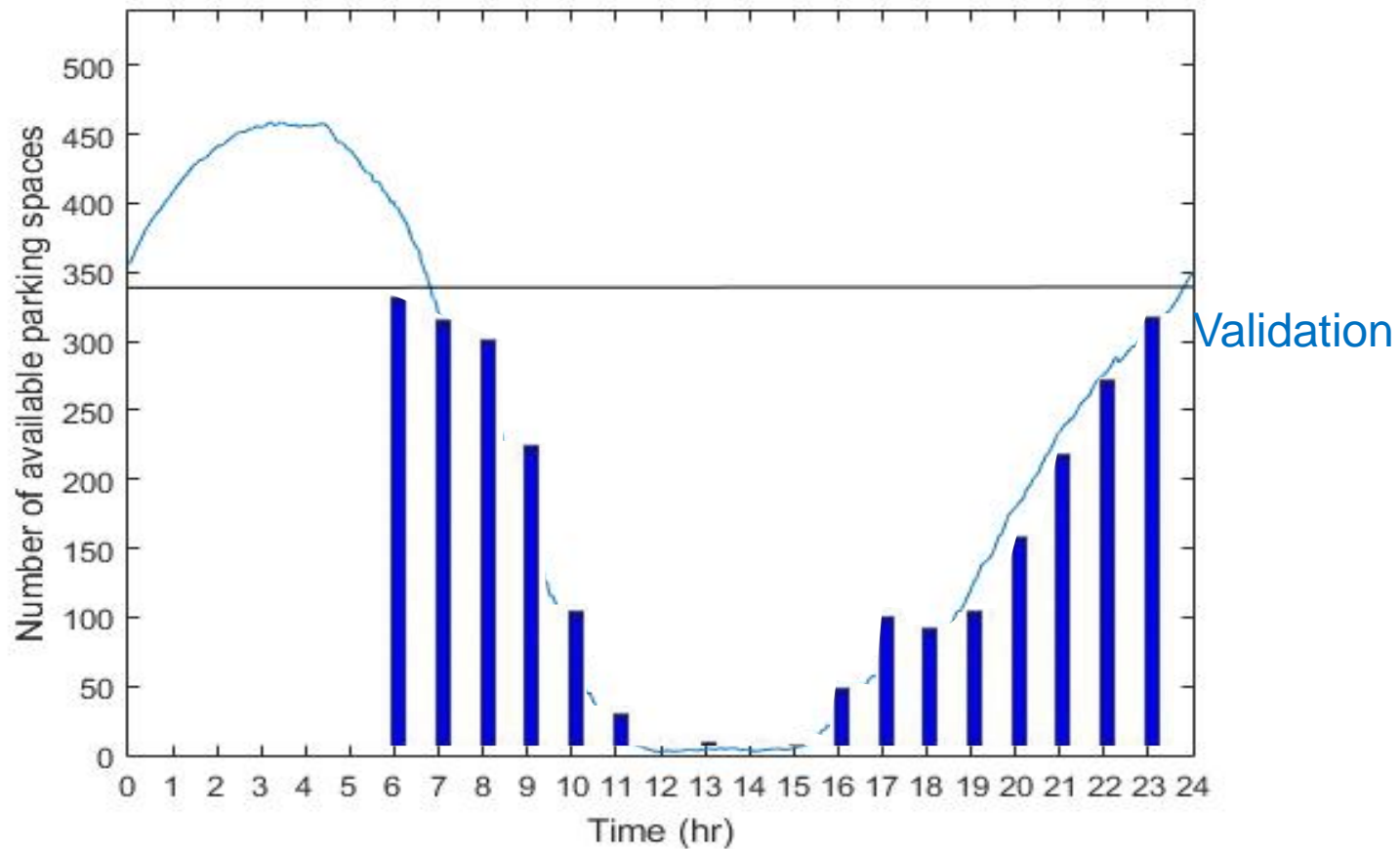
- Results

One day

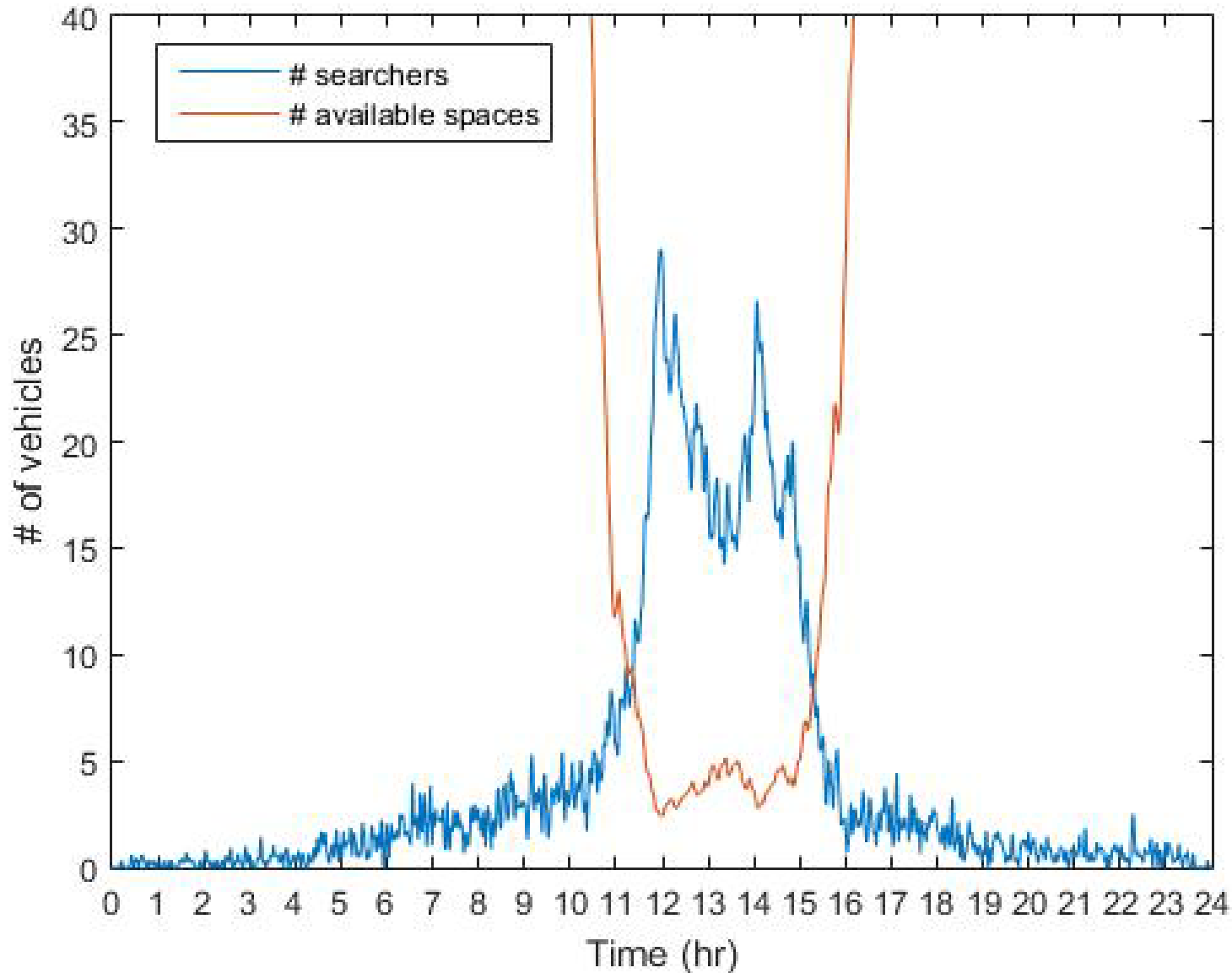
Cruising time: 105 hours

Cruising distance: 1575 kilometers

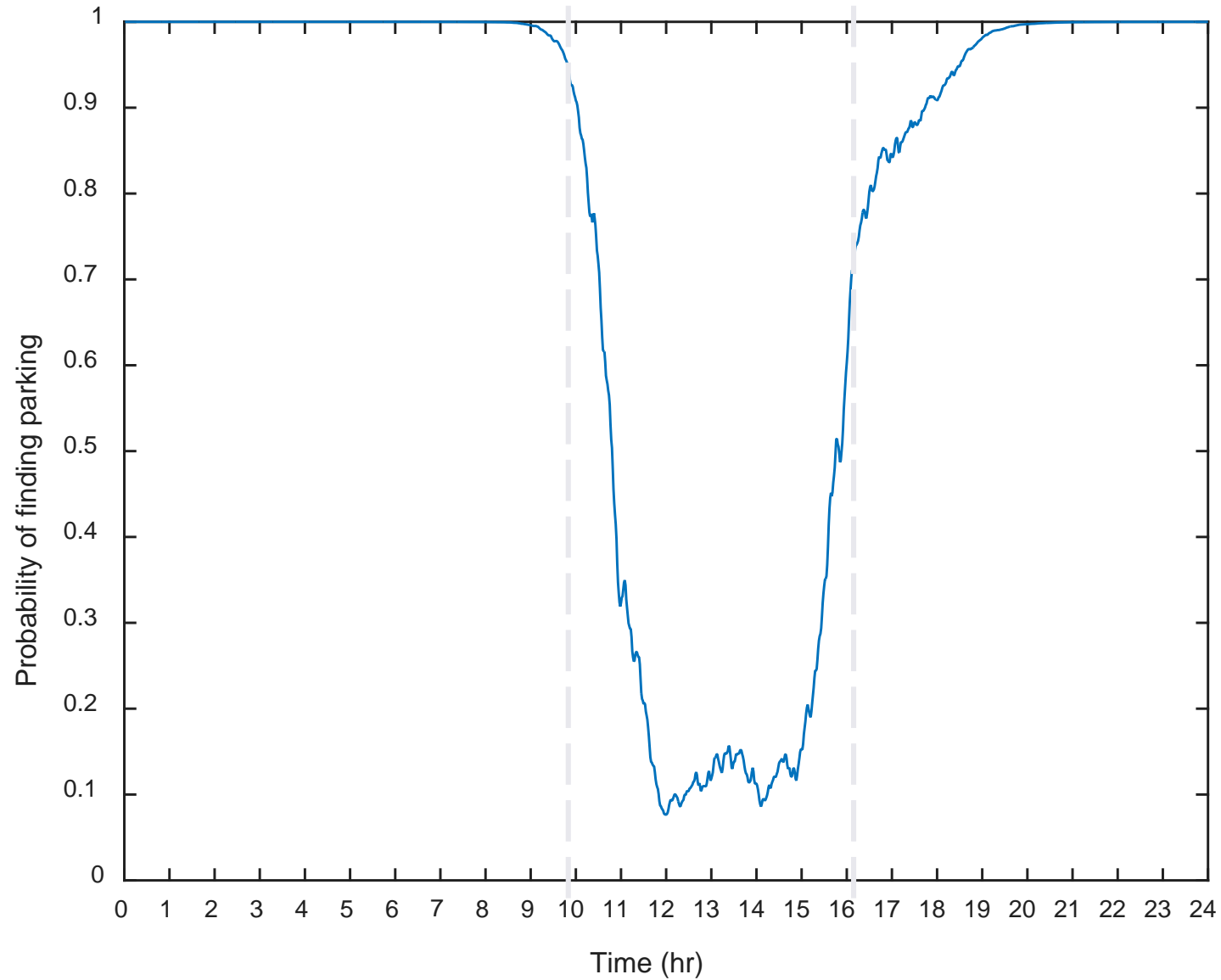
available parking spaces



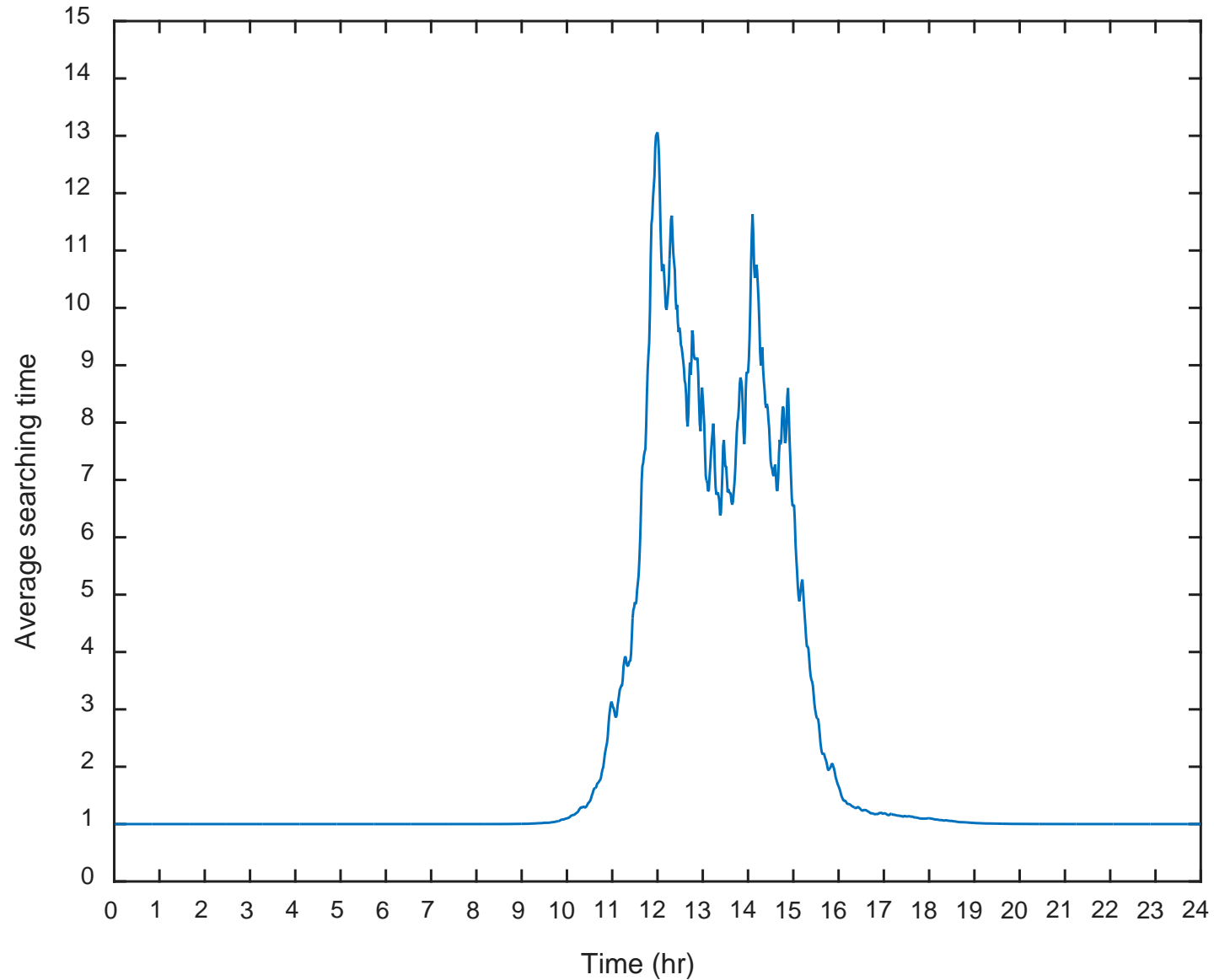
searchers VS. # available parking spaces



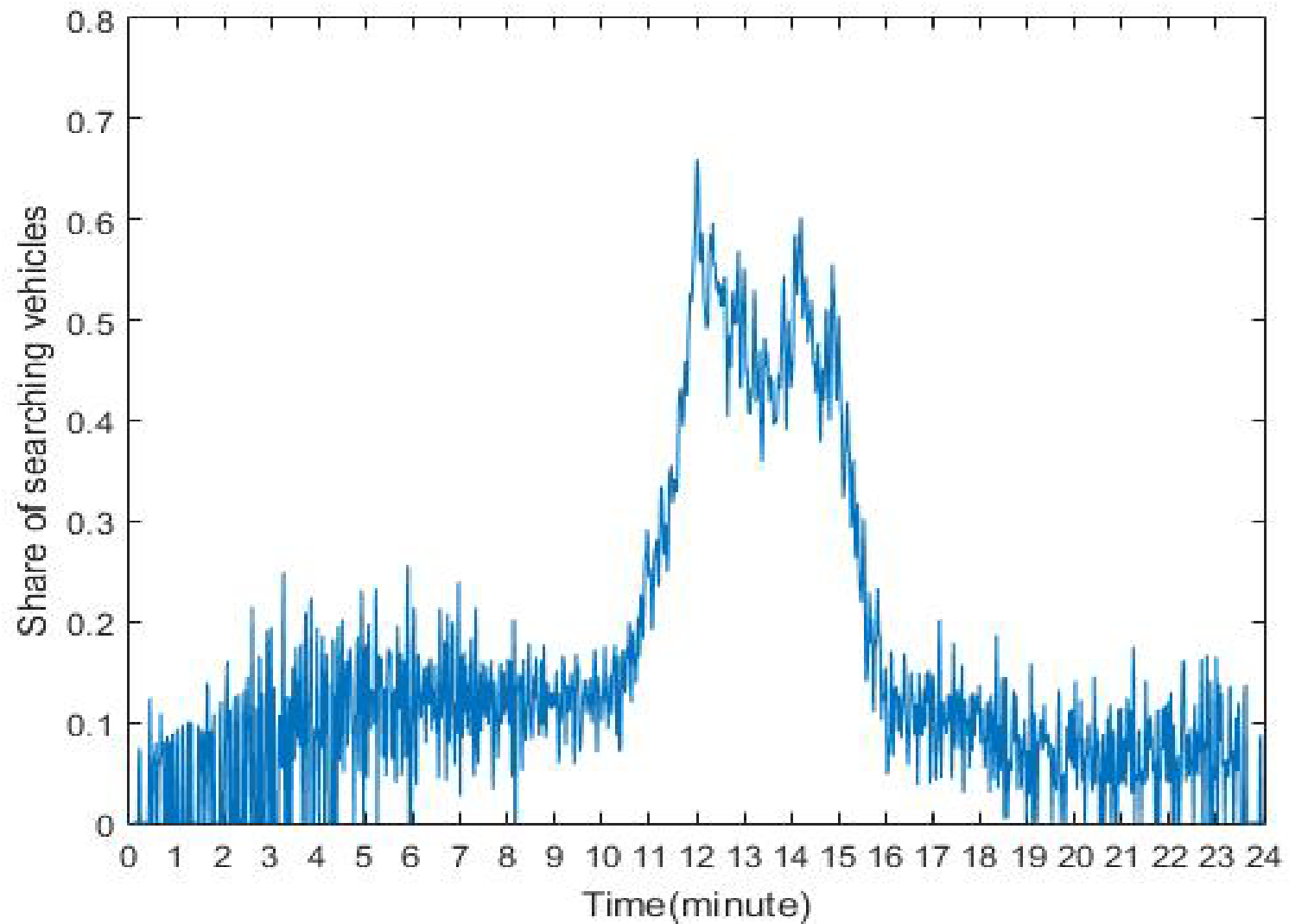
Probability of finding parking



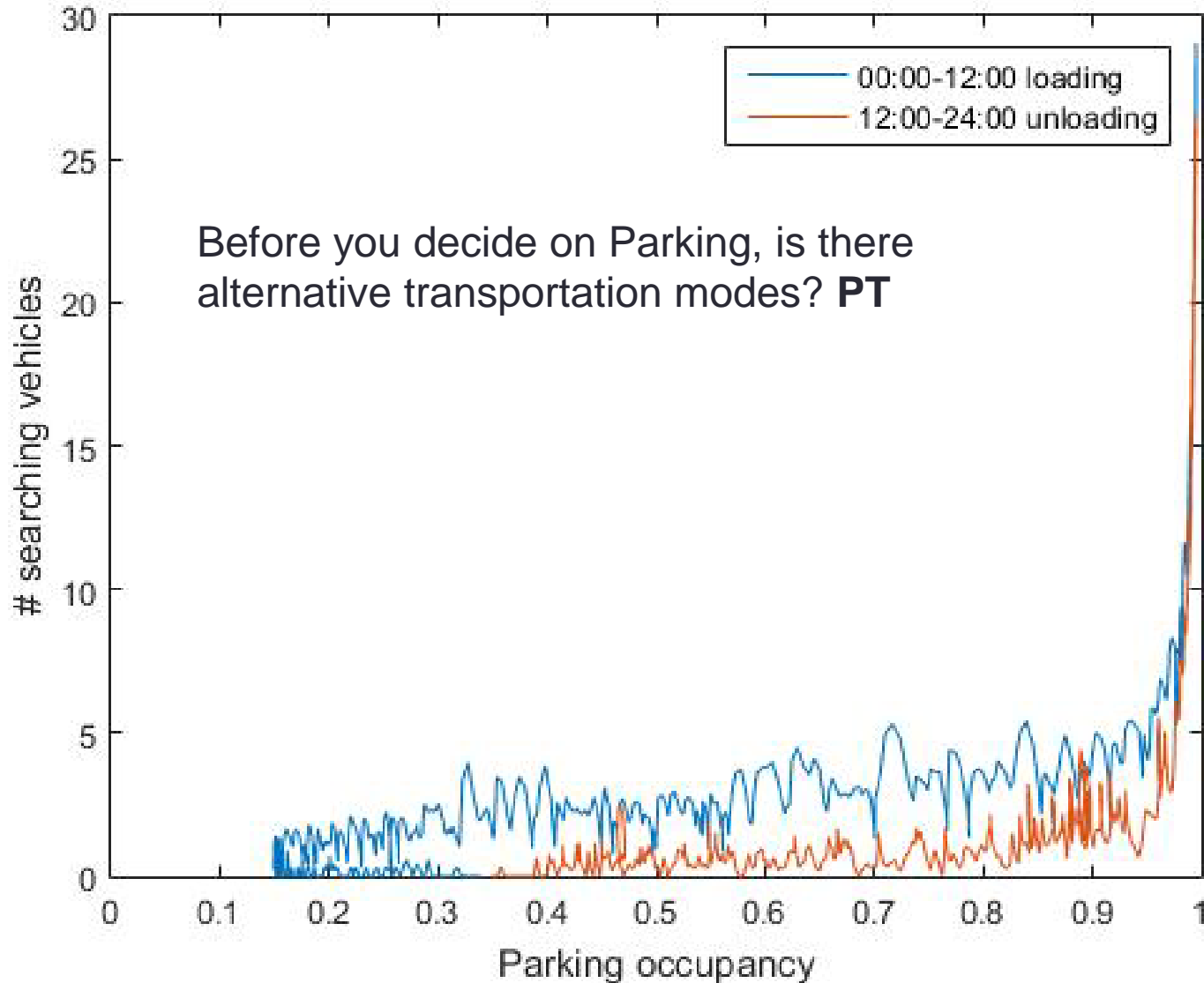
Search time (reciprocal of probability)



Share of searching vehicles



Searchers v.s. parking occupancy



Conclusion



- In Zurich: Parking search exist in the area, not only for on-street, but also for off-street garages. The searching condition is acceptable.
- In other cities? Parking could be potentially BAD for traffic.
- Parking information such as estimated searching time should be provided, and taken into consideration before trips are made.
- Parking supply cannot be isolated from PT.
- Policy & Technology:
 - Dynamic pricing?
 - ParkU (Airbnb for private parking)
 - Time control?
 - Pay by phone?
 - Real time parking data?



Tai'an (Shandong)



Zurich
Vancouver



Shanghai



US cities

THANK YOU!

Jin Cao, IVT, ETH Zurich.
Jin.cao@ivt.baug.ethz.ch

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