IMPACTS OF PARKING ON URBAN TRAFFIC

Mónica Menéndez
ETH Zürich

November 2017
EPFL
Why is parking important?

Because every car trip begins from and ends in a parking.

No parking → No car trips
Is that so?

Parking versus Car Use

Activities in City versus Parking

Cities with high driving rates provide up to 3 times more parking for each new job or resident. Very costly, uses lots of land and creates a horrible walking environment.

Cities with more parking end up accommodating many fewer jobs and residents per square mile.

Source: Norman Garrick (data from US cities)
What are different types of parking facilities?

- On-street parking
- Off-street parking
What are different types of parking facilities?

Off-street parking

- Open lots
- Parking garages
What are the effects of parking?

**Mode choice**

**Mobility**

- [Image of parking lot]
- [Image of airport parking]
- [Image of parking receipt]
- [Image of parking sign: Park and Ride Sat and Sun Free bus service]
What are the effects of parking?

**Urban life, space usage**

**Retail and businesses**
What are the effects of parking?

Economics

Traffic, capacity reduction
How can we study parking?
How do we study parking?

Before

Assess parking demand and evaluate present conditions

Allocate required parking, and suggest strategies to alleviate remaining parking problems

Towards...

Suggest land use and parking policies

Evaluate influences on traffic and surrounding, and suggest alternative methods
How do we study parking?

- Financial feasibility, and/or pricing optimization analysis
- Functional and structural design
- Demand studies
- Operational studies
- …
What terminology do we use?

- **Space-hour**: Unit of parking that defines the use of a single parking space for a period of one hour.
- **Volume**: Total number of vehicles that park during a specific length of time (often one day).
- **Accumulation**: Number of vehicles parked at a given time.
- **Turnover**: Rate of use of a parking space, i.e., number of vehicles utilizing the same stall over a given period of time.
### What terminology do we use?

<table>
<thead>
<tr>
<th>Termination</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy</td>
<td>percent of occupied parking spaces at a given time</td>
</tr>
<tr>
<td>Load</td>
<td>number of space-hours used during a specified period of time</td>
</tr>
<tr>
<td>Peak flows</td>
<td>maximum rates of arrivals and/or departures</td>
</tr>
<tr>
<td>Average duration</td>
<td>average length of time that a car is parked at a given parking space</td>
</tr>
</tbody>
</table>
How do we measure it?

- Peak flow
- N
- Volume
- Load
- Accumulation
- Duration
- t
How do we measure it?
How do we measure it?

Cars parked (accumulation)

Capacity = 600

90%
How do we measure it?

- Single group of parkers
  - Shorter average duration
  - Higher turnover

- Two groups of parkers
  - Longer average duration
  - Lower turnover
How do we measure it?

occupancy = \(100 \cdot \frac{\text{number of spaces occupied}}{\text{total spaces available}}\)

turnover = \(\frac{\text{number of different vehicles parked}}{\text{number of parking spaces}}\)

load = \(\sum_{i=1}^{N} t_i\)

average duration = \(\frac{\text{load}}{\text{total number of vehicles parked}} = \frac{\sum_{i=1}^{N} t_i}{N}\)

average accumulation = \(\frac{\text{load}}{\text{total time period}} = \frac{\sum_{i=1}^{N} t_i}{T}\)
How do we measure it?

Can you measure parking demand?

Or measure the usage and just infer the demand?
Selected data collection methods

**Ins and outs**
- Vehicles parked in the focus area counted at the beginning and end of the survey
- Entering and exiting vehicles are counted during survey period

**Patrol survey**
- Vehicles parked in the focus area counted at fixed time intervals during the survey period

**Individual vehicle tracking**
- Individual vehicles (or individual parking stalls) are tracked (either continuously or at fixed intervals)
## Selected data collection methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ins and outs</td>
<td>- Can generate most important data</td>
<td>- Not suitable for on-street or public parking</td>
</tr>
<tr>
<td>e.g. Loop detectors in entrance/exit, Camera and ticket control at entrance/exit</td>
<td></td>
<td>- High cost for facilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Could generate only queuing diagrams</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Limited and incomplete data (bias)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Labor requirements</td>
</tr>
<tr>
<td>Patrol survey</td>
<td>- Easy to conduct</td>
<td></td>
</tr>
<tr>
<td>e.g. Fixed period sampling plate survey</td>
<td>- Low cost</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- No fixed infrastructure required</td>
<td></td>
</tr>
<tr>
<td>Individual vehicle tracking</td>
<td>- Can generate full and complete database</td>
<td>- Expensive to install</td>
</tr>
<tr>
<td>e.g. Sensors, Full view cameras</td>
<td></td>
<td>- High requirements for maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Large database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hard to extract data</td>
</tr>
</tbody>
</table>
Does parking affect traffic? Does traffic affect parking? How?
Parking and traffic (microscopic level): Example

Example:
• At 10:00
• At a given location
• A parking maneuver blocks traffic for 10 sec

This time-space diagram shows:
• Total delay
• Vehicles’ trajectories
• Shockwaves

Source: J. Cao and M. Menendez (2013) HEART Conference
Possible effects on traffic

When the parking stall is near the intersection, then it *might* generate

- A throughput reduction in the current cycle
- Long delay for individual cars
- A lingering delay (i.e., a delay that lingers to the next cycle(s))

*Source: J. Cao and M. Menendez (2013) hEART Conference*
Possible effects on traffic

When the parking stall is near the intersection, then it *might* generate

- A **throughput reduction** in the current cycle
- Long **delay** for individual cars
- A **lingering delay** (i.e., a delay that lingers to the next cycle(s))

Source: J. Cao and M. Menendez (2013) hЕАRT Conference
Possible effects on traffic

When the parking stall is near the intersection, then it *might* generate
- A throughput reduction in the current cycle
- **Long delay** for individual cars
- A lingering delay (i.e., a delay that lingers to the next cycle(s))

*Source: J. Cao and M. Menendez (2013) hEART Conference*
Possible effects on traffic

When the parking stall is near the intersection, then it *might* generate

- A throughput reduction in the current cycle
- Long delay for individual cars
- A lingering delay (i.e., a delay that lingers to the next cycle(s))

Long green (local delay)  Short green (lingering delay)

Source: J. Cao and M. Menendez (2013) hEART Conference
What does that mean for Zurich? Example

**Parking skills**
- Time parking maneuvers block traffic
  - 8.93 seconds (mean)

**Distance**
- 55.14 meters (mean)

Note: Data for P includes 56 observations where the parking maneuvers block traffic. Data for Lu includes 207 intersections.

What does that mean for Zurich? Example

Compare the result and data from City Zurich:

• **18%** of Signalized Intersections with parking downstream have throughput reduction of 37%. (38 out of 207)

• **34%** of Signalized Intersections with parking downstream have throughput reduction of (0%,37%). (71 out of 207)

*Note: The example above assumes the worst possible scenario
Source: J. Cao and M. Menendez (2013) hEART Conference*
How else can parking affect traffic, and vice versa?
Parking and traffic

Little parking supply

- More searching traffic
- Longer travel time/distance, lower speeds
- More lane changing maneuvers
- Queuing for parking
- Illegal parking behavior
- ...

- May reduce traffic in the long term, but it can really disturb traffic in the short term

Growing parking supply

- More space used for parking in limited urban areas
- Bottlenecks caused by on-street parking behavior, queuing
- Accidents???
- ...
- Will generate more traffic and parking demand in long term

What is the right balance?
Planning / Policy / Control
Could parking become the equivalent of road pricing?

Parking supply inventory

Pricing and time controls
Parking supply inventory

• Function of:
  • Parking demand or generation rates (e.g., size of retail space, number of residential units)
  • Local policies (e.g., car free zones)
  • Availability of alternative transportation modes (e.g., an airport with limited access to public transportation must offer more parking)
  • Permitted land uses (e.g., parking lots might be encouraged (or discouraged) in certain areas)
  • ...
Inventory control schemes

- Since the early 1990s there has been a cap on the amount of public parking in the city centre and no additional parking spaces are allowed; and

Public parking in Zurich has historically been mainly on-street. With the cap on capacity, the fees for use are set high to both discourage car use into the centre and also to offer guaranteed car accessibility for those who need or prefer to use the car for such travel. In addition the on-street provision is also being gradually replaced by parking in garages or underground.

Implementation

Public parking in Zurich has historically been mainly on-street. With the cap on capacity, the fees for use are set high to both discourage car use into the centre and also to offer guaranteed car accessibility for those who need or prefer to use the car for such travel. In addition the on-street provision is also being gradually replaced by parking in garages or underground.

Privately parking fees for new developments across the city are set by a three stage process:
- There is a pre-defined 'normal need' level for each type of land-use;
- This 'need' is then modified by translation to a lower maximum norm to reflect the level of provision that can actually be provided within the area; and
- This level of provision is then adjusted in accordance with the planning strategy and the city's overall transportation policies.
“4 million more parking stalls are needed in Beijing”

According to China Quality Daily, 5 million private vehicles only have 2.5 million parking stalls. If count 1.3 parking stall for each car on average, 4 million parking spaces more are needed, but the city is full.

CURRENT SOLUTIONS:
• Control car usage
  Vehicles with certain plate number are forbidden to drive

• Encourage use of public transportation
  Beijing government, set bus ticket €0.06 with no control for travel distance
Pricing / Time control schemes

Encourage high turnover (i.e., short stays)
- e.g., downtown area, specific stores
- Variable pricing, time controls…
  - e.g., 2CHF for up to ½ hr, 8CHF per hr thereafter; or maximum of 1-hr parking

Encourage low turnover (i.e., long stays)
- e.g., airport parking, large retail surfaces
- Variable pricing, time controls…
  - e.g., 4CHF for up to 1 hr, 0.50CHF per hr thereafter; or minimum of 1-day parking
Fee collection schemes

- Manual parking meters
- Digital parking meters
- Separated parking paying machines
- Authorization cards
- Manual or automatic collectors at the exit
- Permits
- ...

Many gentlemen happen to meet the wrong ladies when going out.
Parking and its relation with traffic

How do these control schemes affect traffic performance on urban networks?
Case study: Zurich - Jelmoli area

Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).
Car demand and desired parking durations

Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, Transportation (accepted, DOI: 10.1007/s11116-017-9832-9).
Macroscopic parking model

**Transition events:**

- Enter the area
- Start to search
- Access parking
- Depart parking
- Leave the area

Transitions are modeled for very small time slices (e.g., 1 minute) with steady conditions.

To visualize matrix → queuing diagram

Cumulative number of vehicles going through each transition event

- **Enter the area**
- **Start searching**
- **Access parking**
- **Depart parking**
- **Leave the area**

**Time**
To visualize matrix → queuing diagram

Cumulative number of vehicles going through each transition event

Total search time

Time

Enter the area
Start searching
Access parking
Depart parking
Leave the area
To visualize matrix → queuing diagram

Cumulative number of vehicles going through each transition event

Total travel time

- Enter the area
- Start searching
- Access parking
- Depart parking
- Leave the area

Time
To visualize matrix → queuing diagram

Cumulative number of vehicles going through each transition event

- **Enter the area**
- **Start searching**
- **Access parking**
- **Depart parking**
- **Leave the area**

Time
Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).
Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).
Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, Transportation (accepted, DOI: 10.1007/s11116-017-9832-9).
Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).
Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).
Sensitivity to parking supply

Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, Transportation (accepted, DOI: 10.1007/s11116-017-9832-9).
Sensitivity to parking supply

Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, Transportation (accepted, DOI: 10.1007/s11116-017-9832-9).
Sensitivity to parking time controls

Cao, J., M. Menendez and R. Waraich (2017) Impacts of urban parking system on cruising traffic and policy development: The case of Zurich downtown area, Switzerland, *Transportation* (accepted, DOI: 10.1007/s11116-017-9832-9).
More advanced parking technology

- Occupancy detectors
- Automatic linkage between occupancy detectors and fee collection systems
- Real time information about parking availability (e.g., for on-street parking)
- ...
More advanced parking technology

Source: www.sparkparking.com
More advanced parking technology
More advanced parking technology

- Pricing (demand responsive pricing per block, time of day, and day of week), both for on-street and garage parking
- Wireless pavement sensors (to track parking availability)
- Meters (accepting different types of payment, incl. credit)
- Open source data for developers
- PayByPhone (add time without returning to meter, reminder messages for expiring meters, online receipts)
- Computer apps (real time information on cells, text messages, computer maps, variable signs)

Source: www.sfpark.org
Questions?