ORIE 5355: People, Data, & Systems
Lecture 11: Algorithmic pricing:
Pricing in Ride-hailing

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Course webpage: https://orie5355.github.io/Fall_2021/

Announcements & reminders

- No class on Monday 10/25
  - Replaced with guest lecture in early November
    - Live (remote) guest lecture in non-traditional class time
    - Will be recorded to watch later
- Remote only lecture Wednesday 10/27
- Office hours
  - NO OHs today
  - Zhi's OHs this Friday, 1:30 – 2:30
- Due dates are shifted back a bit:
  - HW4 (released next week)
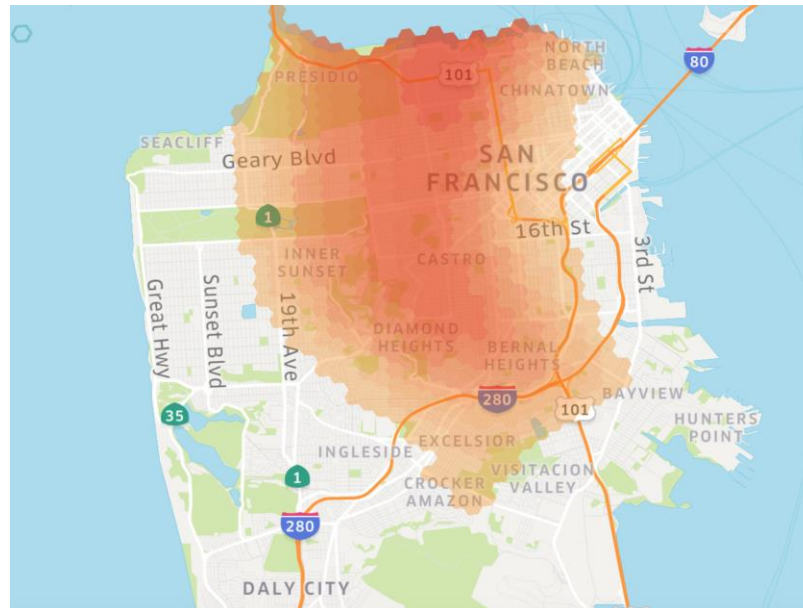 - Project part 1 + 2 (released in next 2 weeks)
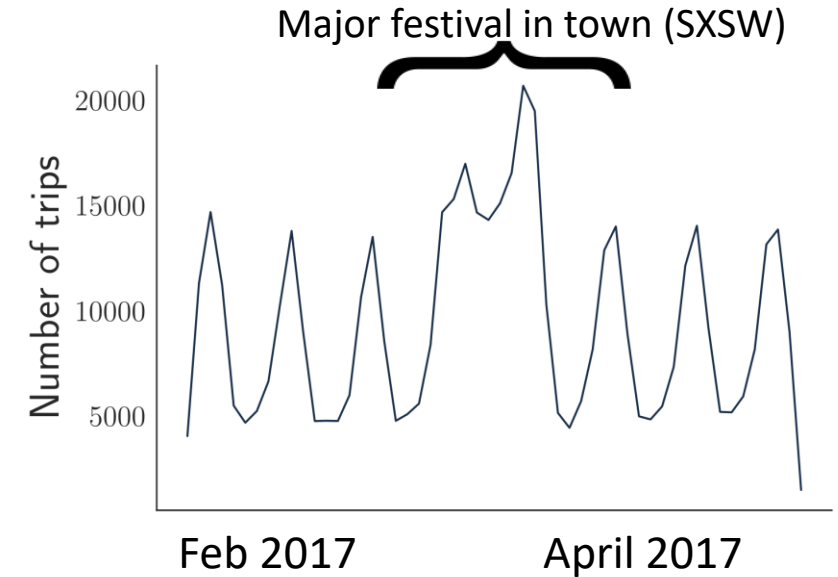
Dynamic pricing in ride-hailing

Surge pricing

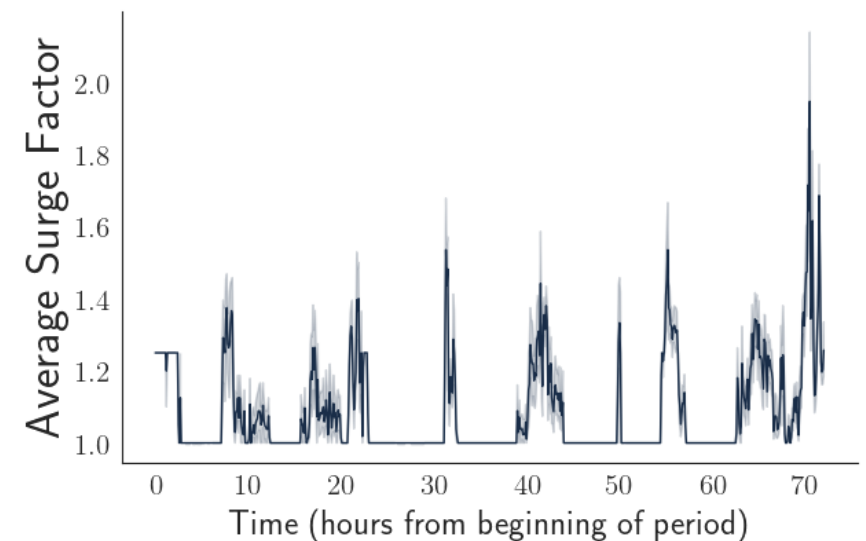Demand fluctuates substantially

Surge matches demand with supply

Spatially:

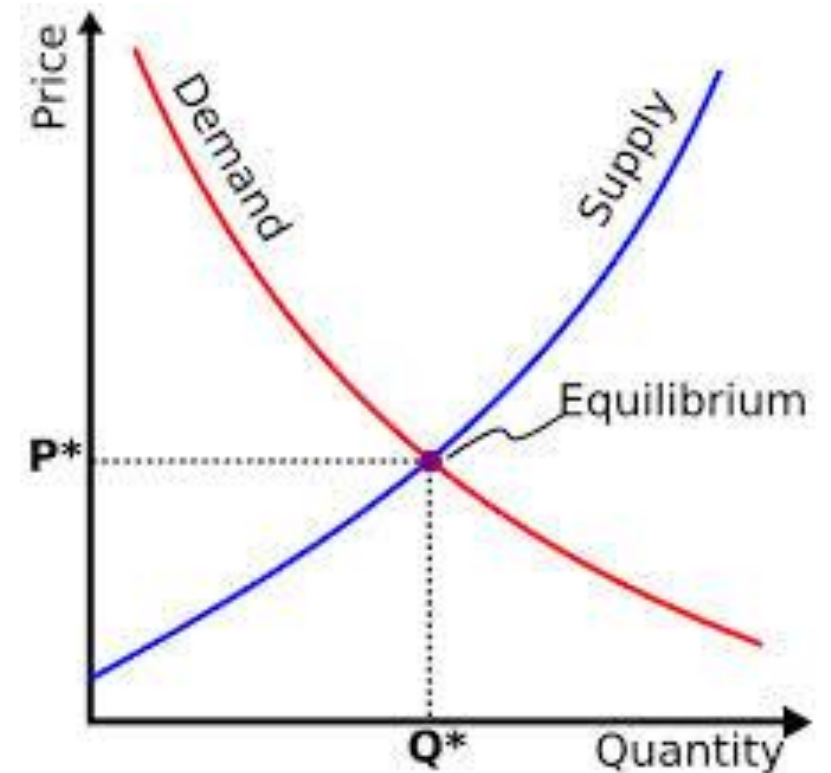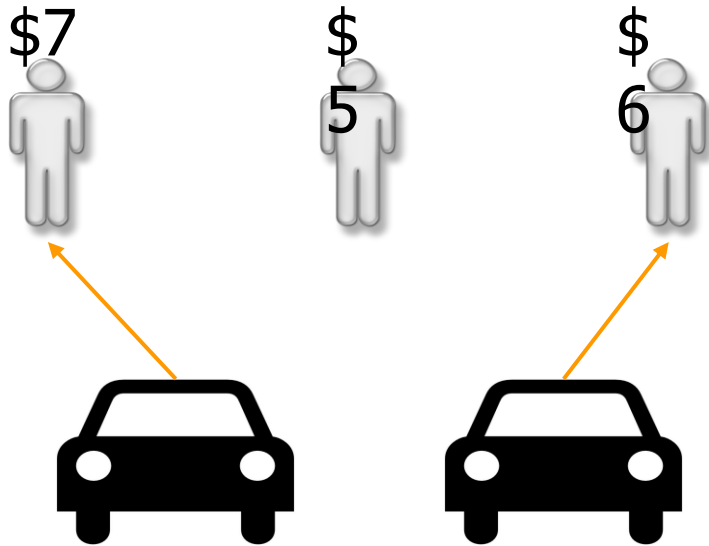Within **weeks**:

Major festival in town (SXSW)

Within a **day**:

Surge Pricing Goal

**Efficient** and **Reliable** allocation of scarce resources via price increase

Slide credit: Hamid Nazerzadeh, Uber & USC

Dynamics for a Single Trip (a single driver's perspective)

ETR

ETA

On-Trip

E[Time waiting for Request]

E[Time for driver to get to rider]

Drop-off   Dispatch   Pick-up   Drop-off
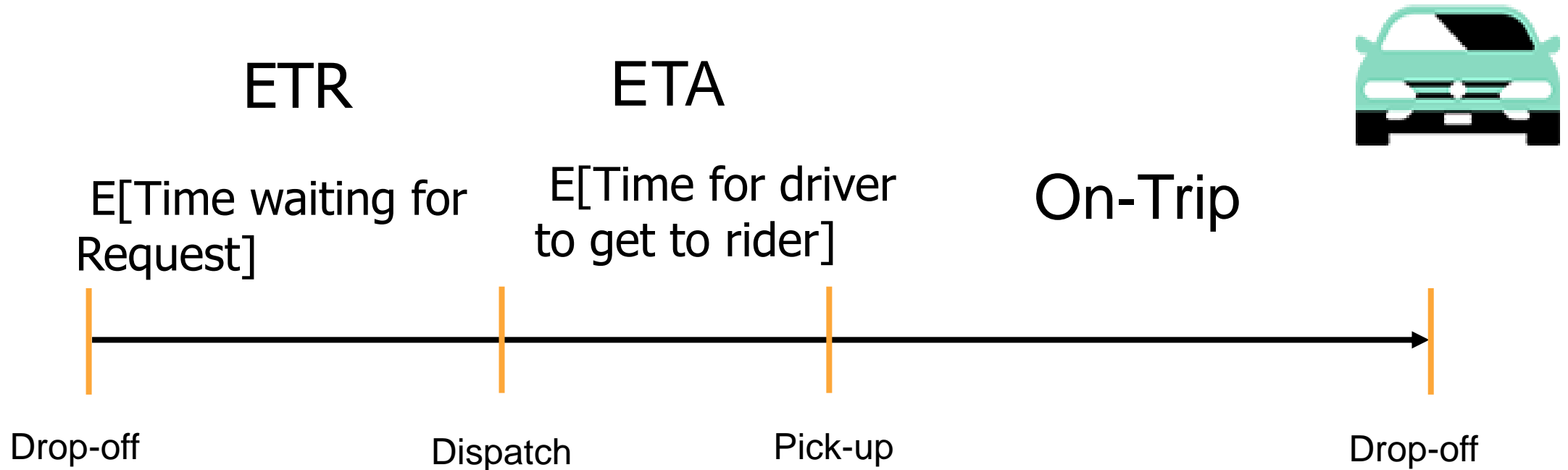
Efficiency = Total On-Trip / (Total ETR + Total ETA + Total On-Trip)

Dynamic pricing regulates the level of Open Cars to maintain reliability and to increase efficiency.

Slide credit: Hamid Nazerzadeh, Uber & USC
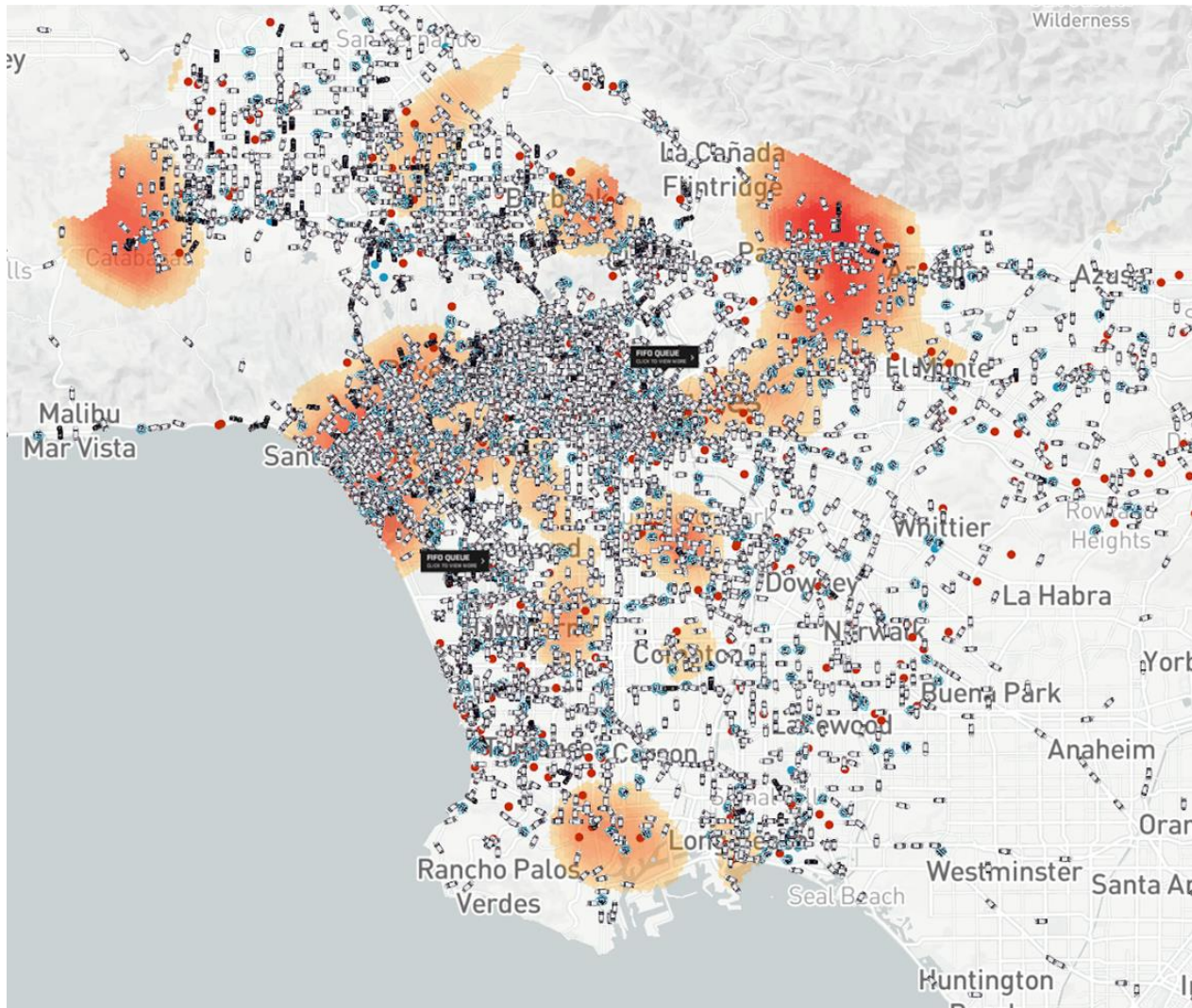
Prices too low
⇒
Too many requests
⇒
Few open drivers
⇒
Takes longer to drive to rider
⇒
Efficiency suffers

Slide credit: Hamid Nazerzadeh, Uber & USC
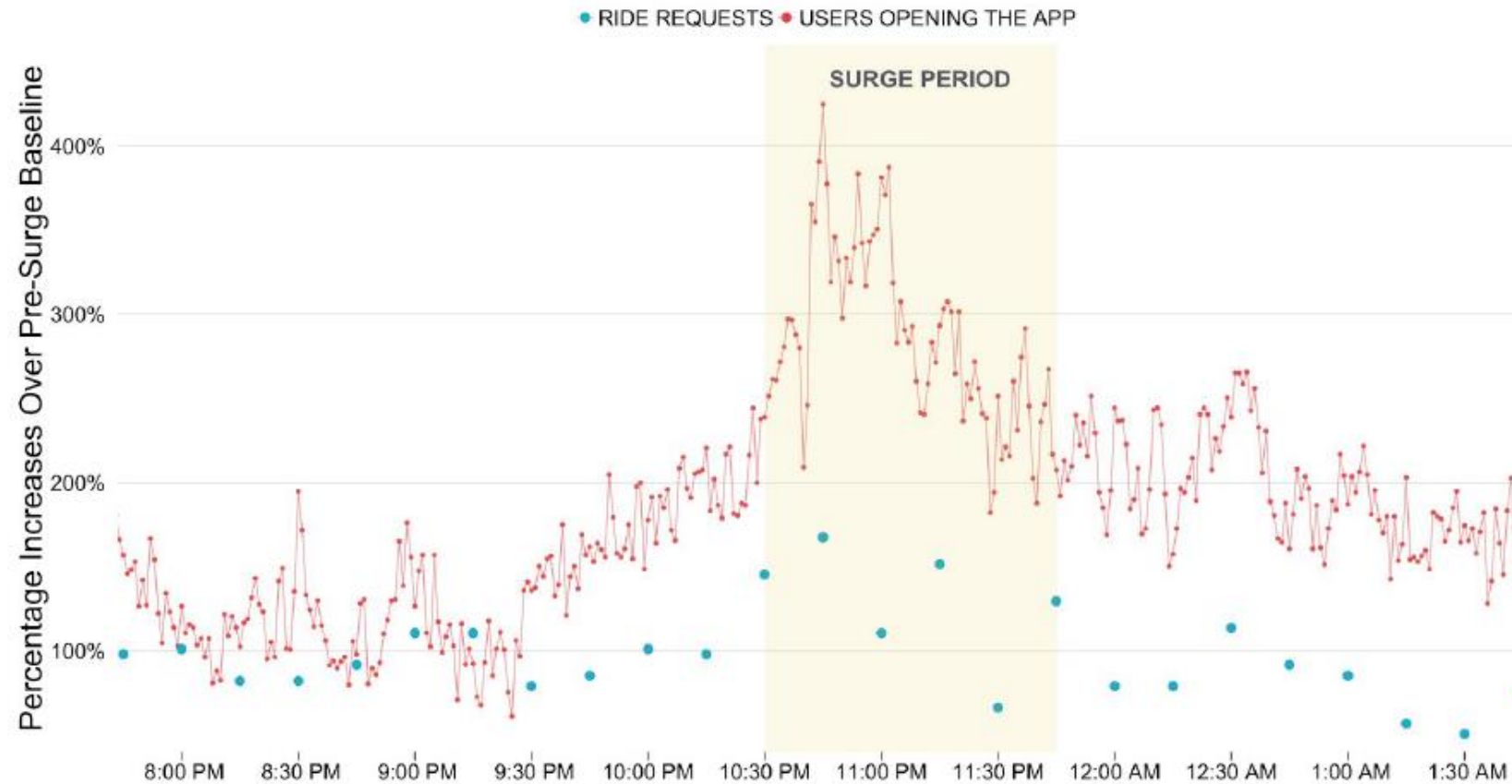
Surge makes the marketplace reliable.

Sold Out Ariana Grande Concert,
Madison Square Garden, New York March 21, 2015

Surge makes the marketplace reliable.

Surge multiplier and trip demand following Ariana Grande concert

Marketplace health indicators
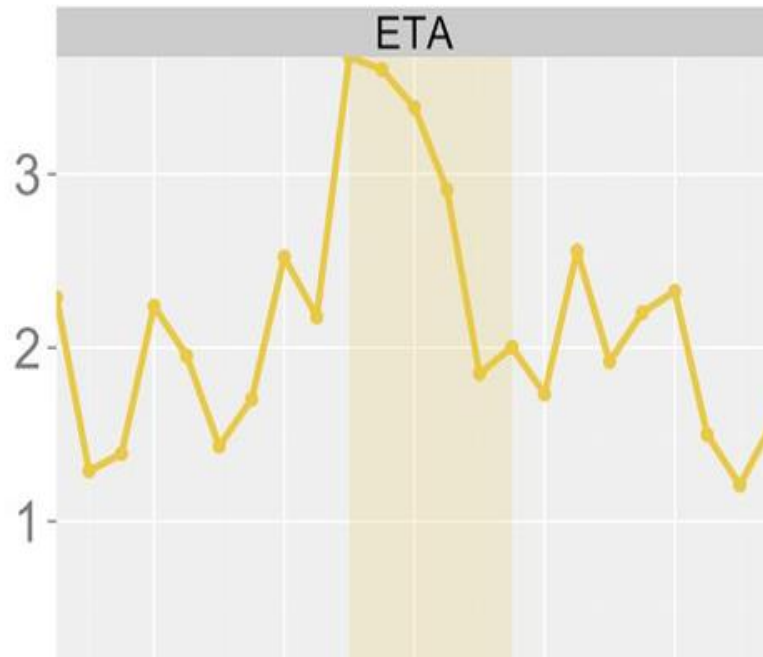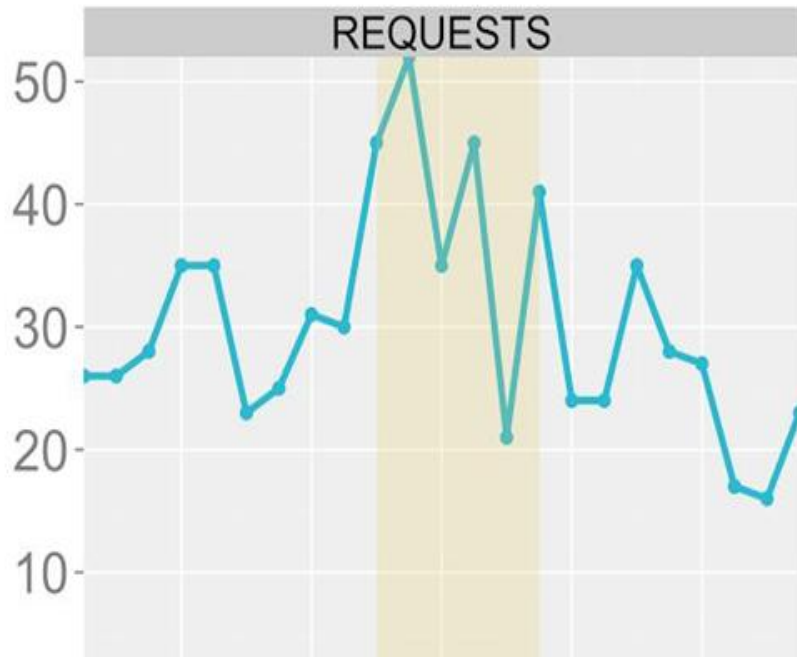
Yellow band shows surge period.

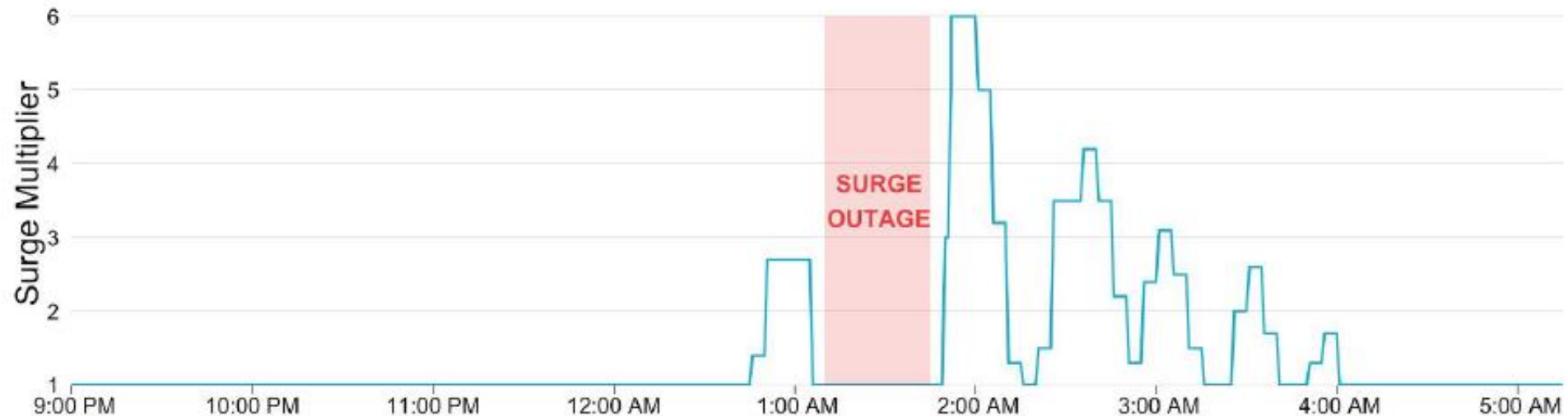Raising prices maintains a "healthy market" as measured by ETA and Completion Rate.

Slide credit: Hamid Nazerzadeh, Uber & USC

Surge Outage

New York City, New Year's Eve 2014
20 Minute Long Surge Outage

What happens if the prices don't rise?

Due to a technical glitch, the surge multiplier was inoperable (stuck at 1) for 26 minutes (1:24 AM to 1:50 AM) on Jan 1, 2015 in NYC.

Slide credit: Hamid Nazerzadeh, Uber & USC

Effects of Surge Outage
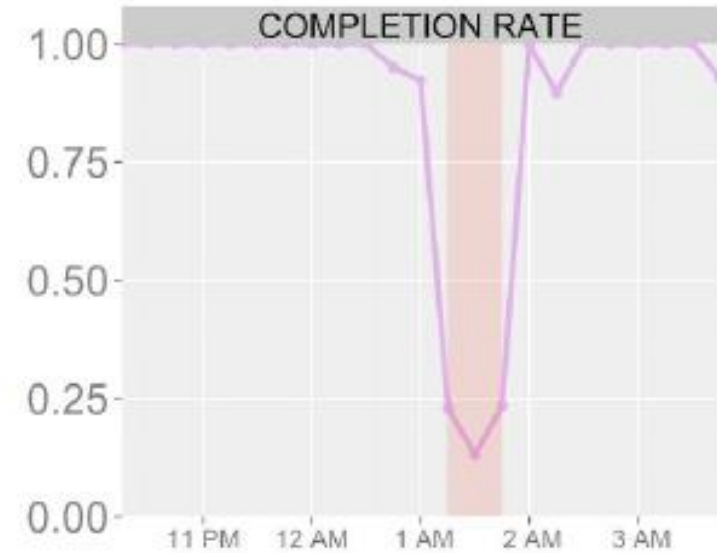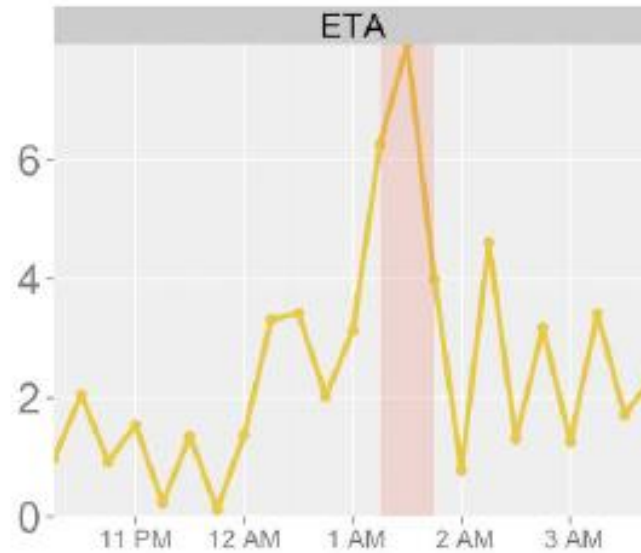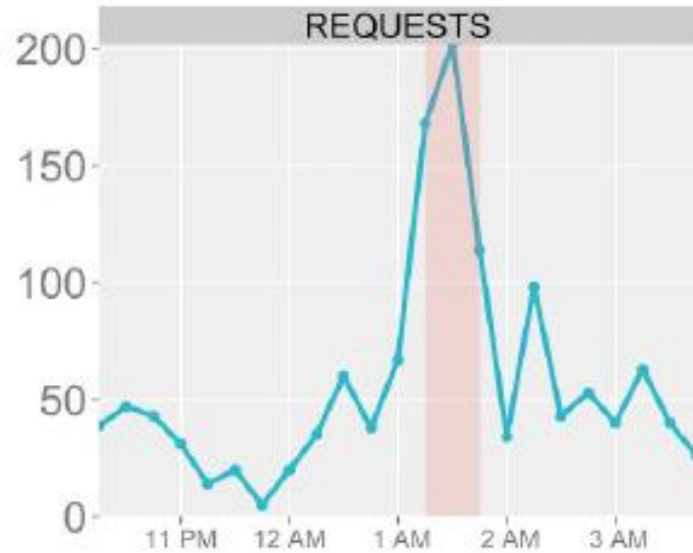
The pink band is the period of surge outage.

The outage resulted in a severe degradation in marketplace health.
[Hall, Kendrick, Nosko 2015]

Slide credit: Hamid Nazerzadeh, Uber & USC

Evolution of Surge

2011
City-wide surge

2013
Rider location

2014
Demand modeling

2015
Higher geo and time granularity

Slide credit: Hamid Nazerzadeh, Uber & USC
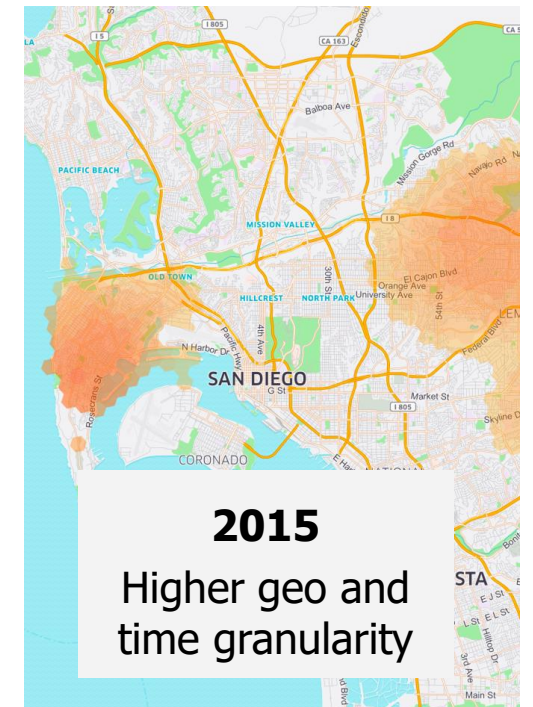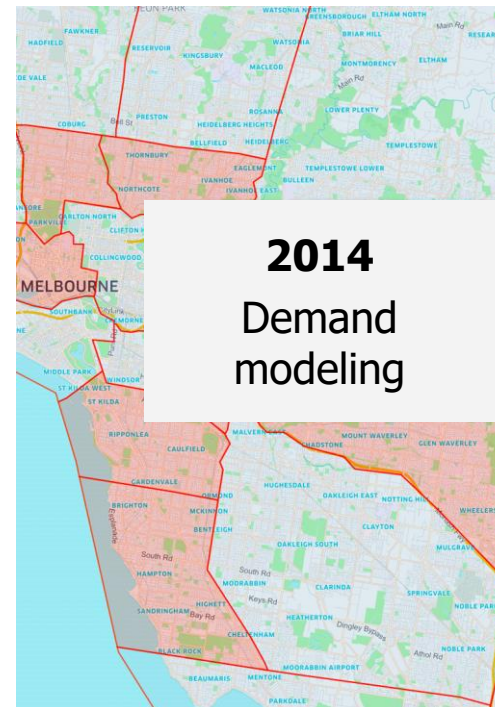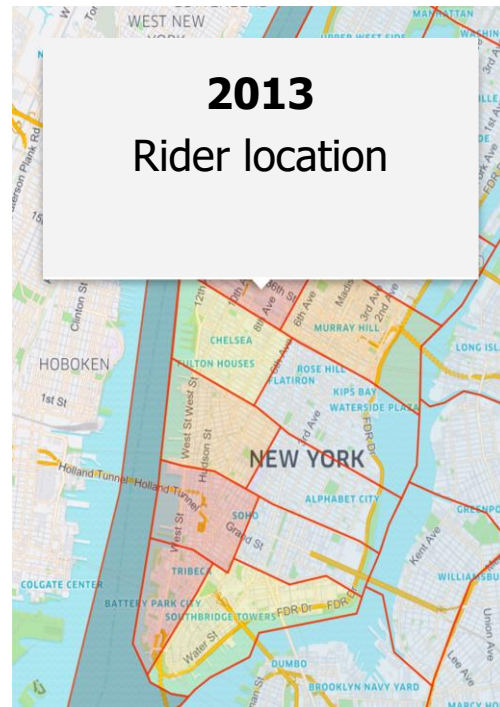
Fine-grained Dynamic Spatial-Temporal Pricing

- Fine spatial grid

- Updated every two minutes
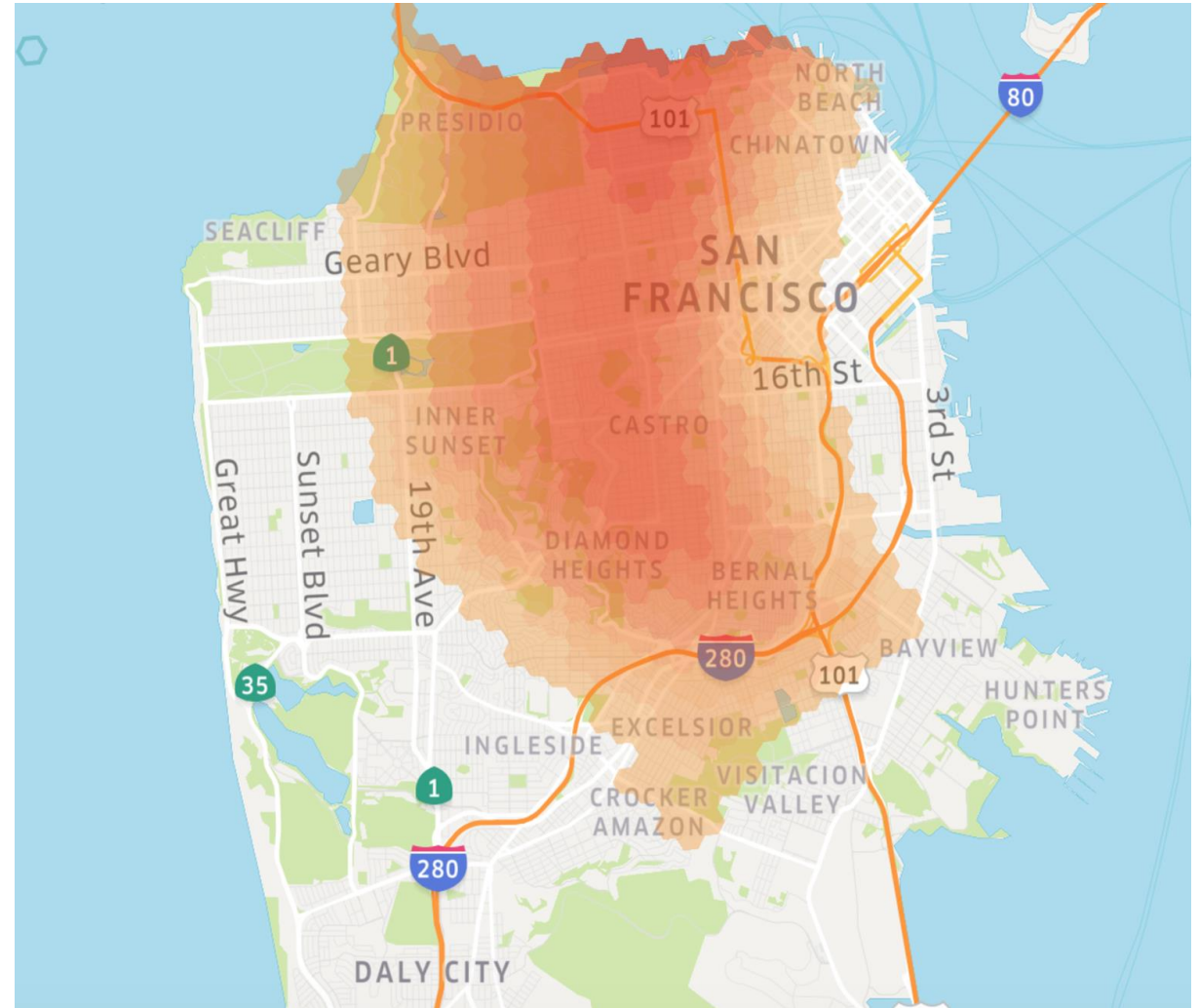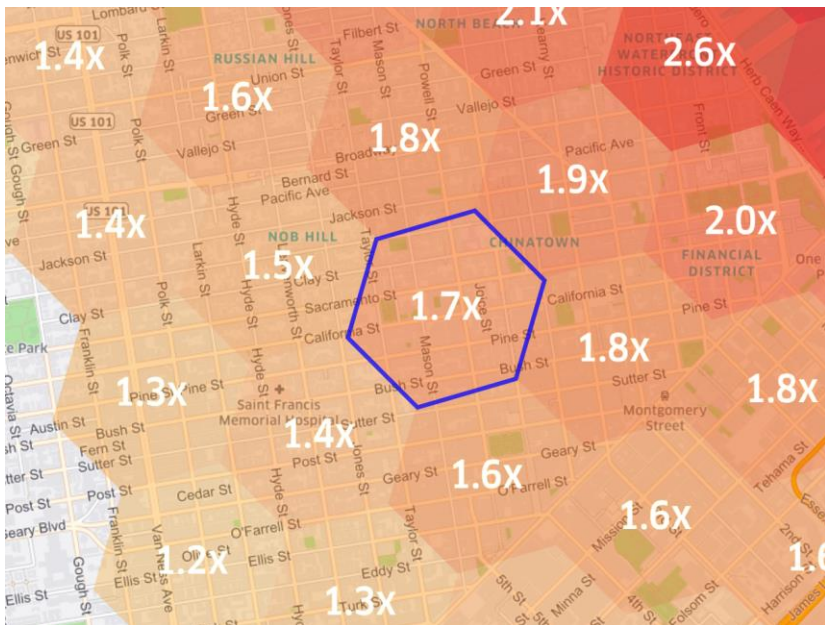
Slide credit: Hamid Nazerzadeh, Uber & USC

Other (potential) aspects of rider pricing

- Pickup times:

  Do you charge just for the time the rider is in the car, or also the time it takes to pick them up?

- Personalized pricing:

  These platforms send coupons to individual riders – easy way to personalize

  Goal of personalization? Convince riders who otherwise wouldn't ride, to ride

  Customers who haven't ridden in a while; new customers

- Open question: predictable surge, or purely stochastic (random) surge?

Question 17

On Uber/Lyft, drivers have to drive longer to pick up the passengers in certain suburbs or neighborhoods, because they tend to be farther away. Is it acceptable for them to charge more to passengers from these neighborhoods?

Legend:
- Completely Fair
- Acceptable
- Unfair
- Very Unfair

Pie chart values: 58.9%, 14.3%, 23.2%
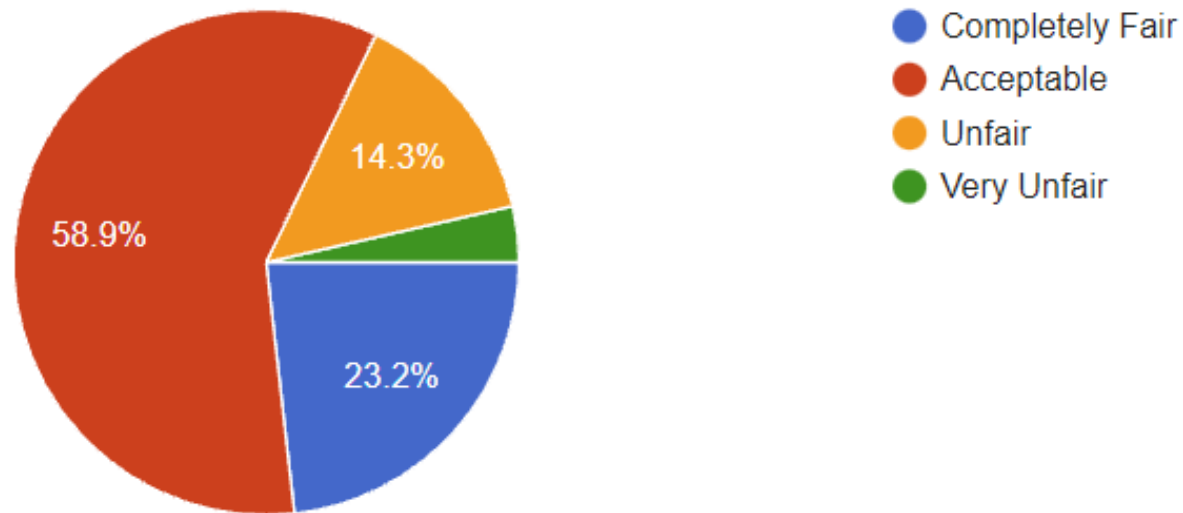
Question 18

On Uber/Lyft, drivers have to drive longer to pick up the passengers in certain suburbs or neighborhoods, because they tend to be farther away. Is it acceptable for them to charge more to passengers from these neighborhoods, if these neighborhoods tend to be socioeconomically disadvantaged historically?

Driver-side (dynamic) payments

Surge and payments from driver perspective

- In ride-hailing (like taxis), drivers are paid per-trip
  - Historically, earn a fixed % of what the rider paid
- Generally, do not earn money while online and waiting for a trip
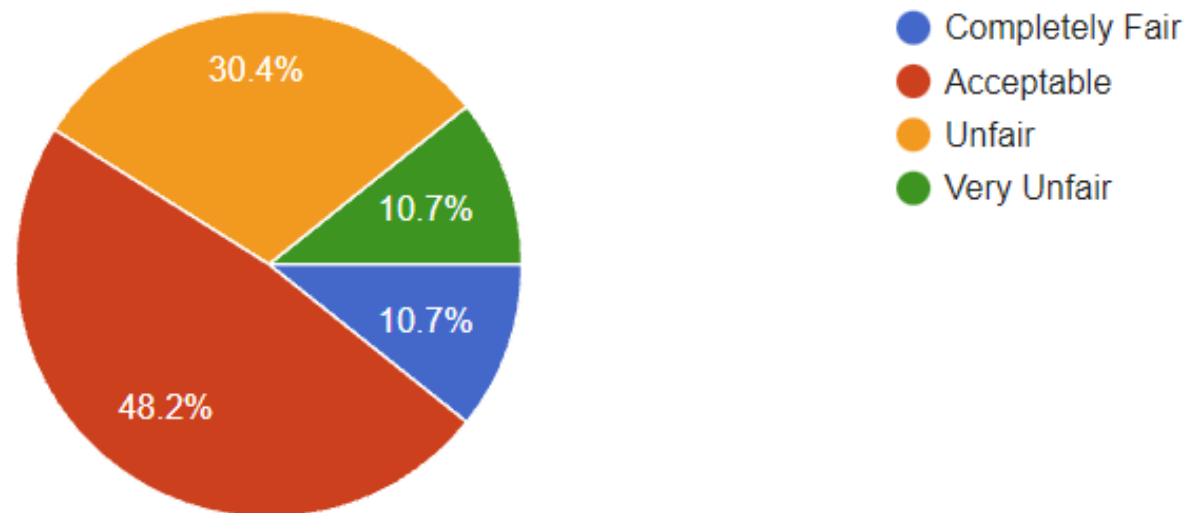- Historically, do not earn money while driving to the customer
- Justification: want to align driver incentives, so that they earn more money when the platform earns money
  - Incentivized to drive when and where there are more riders
- Two ways drivers can respond to prices:
  - What times of day, and where in the city, do they *begin driving*
  - During their shift, do they *relocate* from one part of the city to another
    Heatmap influenced driver movement toward surge. [Frazier and Lu, 2018]

Challenge 1: Fast vs Slow

Will it still be surging by the time I get there?

Mean Multiplier (from Surge) (x)

MON JAN 22 7:01AM

1.2   1.4   1.5   1.7
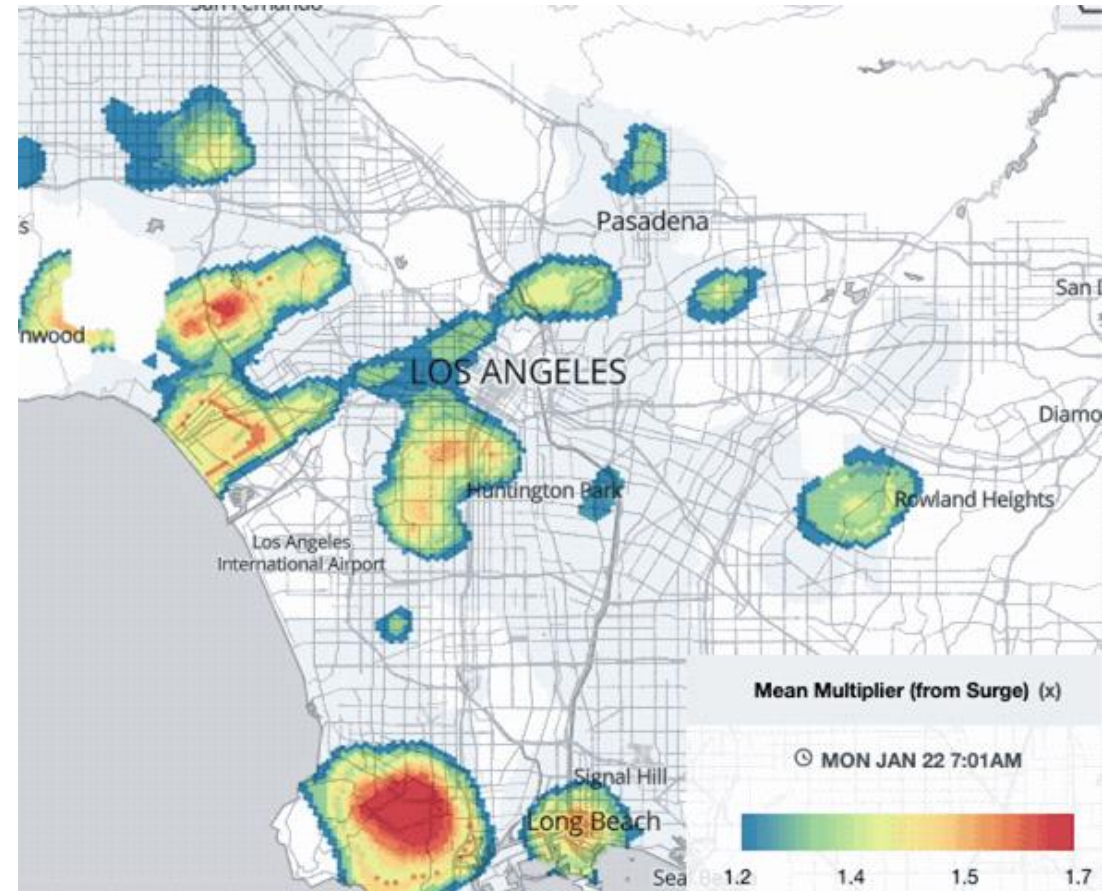
Slide credit: Hamid Nazerzadeh, Uber & USC

Drivers did not "trust" surge as a reliable relocation signal.

"In the beginning I chased surges but I **gave up** the urges to do so. They generally **disappear** by the time I arrived to the surge area, and find it **inefficient**."

"The surge when it appears on the map is **fake a lot of times** to encourage drivers to go to a certain area. Then get no surge rides. I have pictures of this happening multiple times."

Slide credit: Hamid Nazerzadeh, Uber & USC

How to improve drivers' experience with Surge?

Fundamental challenge:

- Riders respond to prices **quickly**
- Drivers respond to prices **slowly**

Solution: **Decoupled Pricing**

(Surge updates differently for riders and drivers)

Slide credit: Hamid Nazerzadeh, Uber & USC

Challenge 2: Destination spatial pricing

- Earlier: higher prices in *pick-up* locations that were busy
- For the driver, *destination* also matters – their next trip will probably be close to where they dropped off the previous rider!
- Do you compensate the driver for being taken to a location that hurts their future earnings?
- Do you charge the rider more?
  Potentially illegal, depending on destination

Driver Location Value

Location (positioning) matters

Average Earnings-Per-Hour
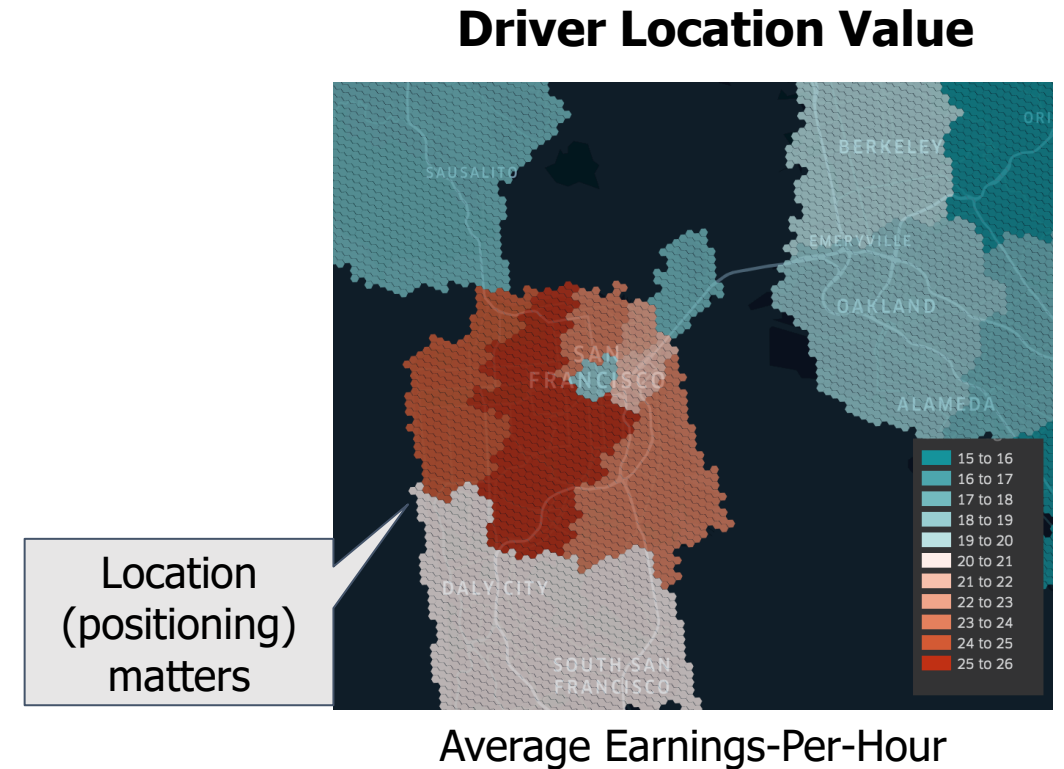
Other aspects of driver-side pricing

- Gender wage gap: There is a 7% earnings gap between men and women drivers! [Cook et al. 2020]
  How? Presumably, Uber isn't actually paying drivers based on gender
  Experience on the platform, preferences and constraints over where to work, and driving speed
- Can Uber increase average overall earnings per hour, without limiting how many drivers are on the road?
  Of course, right? Just increase driver's pay per trip
  Issue: If more drivers join platform as a result, then drivers spend more of their time waiting for a trip, lowering average earnings
  [Hall et al 2021]

Pricing module summary

Things we covered

- Revenue maximization when selling a single item (no capacity constraints)
- Demand estimation
- Personalized pricing with personalized demand estimates
- Pricing over time with capacity constraints
- Pricing 2 items jointly
- Pricing ethics

Many of these will be used in the class project!

Much more to say about algorithmic fairness

- When to include demographic features, when to exclude them
- How to audit for fairness (hard problem)
- Intersects with other hard problems: causal inference (in a few weeks), algorithmic explainability
- Many open legal questions

Other topics – possible end of class lectures

- Congestion pricing

- Carbon pricing

- Matching/Recommendations + Pricing together

- More on pricing in 2 sided marketplaces