



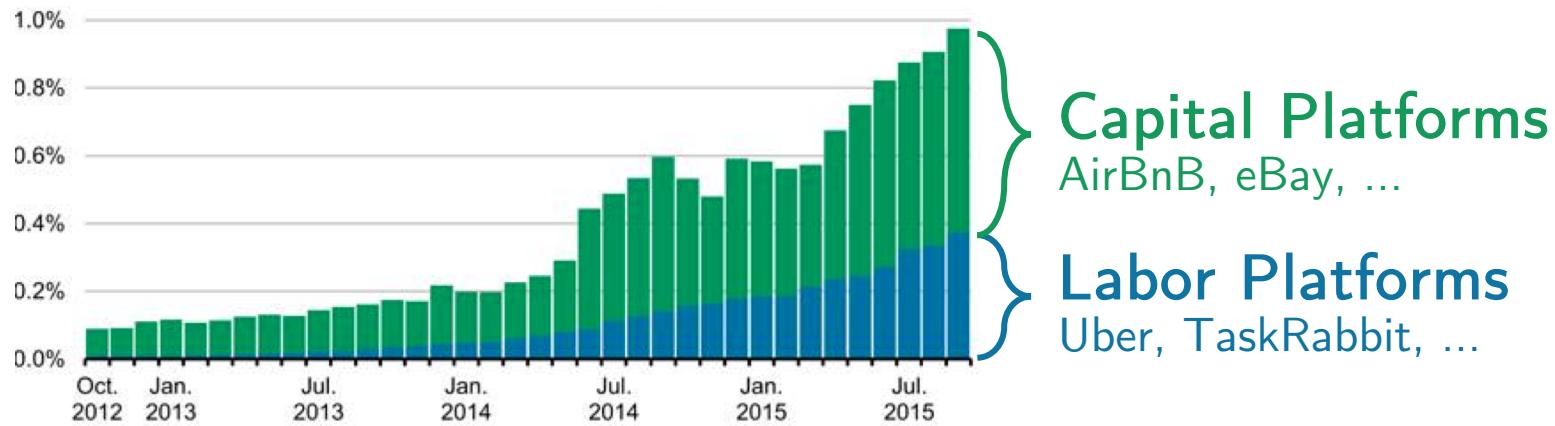
The Impact of Behavioral and Economic Drivers on Gig Economy Workers

INFORMS 2018



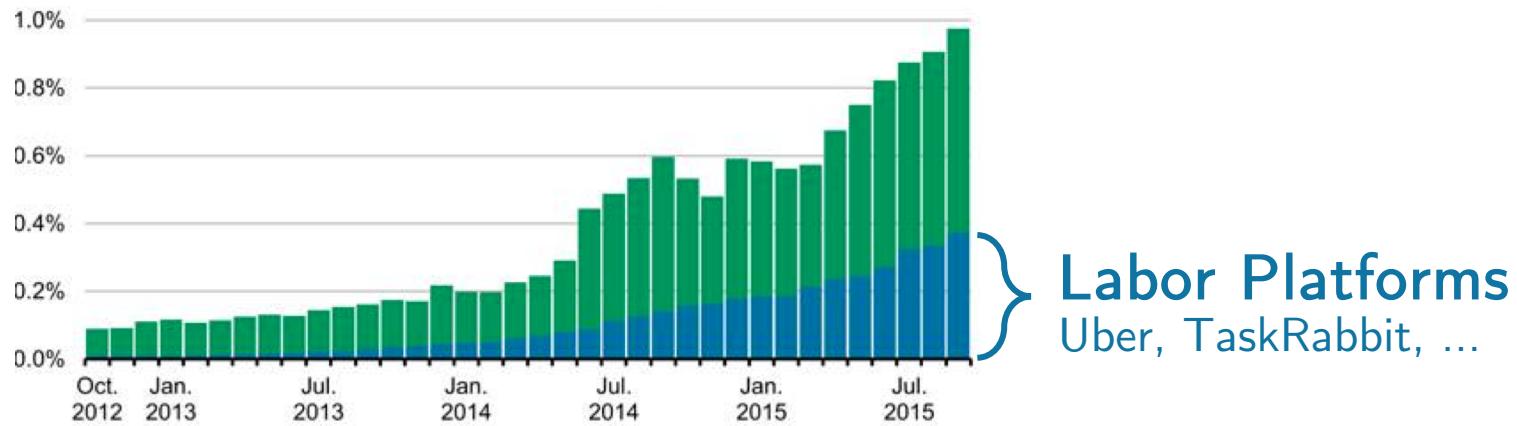
Park Sinchaisri (Wharton)
Gad Allon (Wharton), Maxime Cohen (NYU)

Share of US adults earning income in a given month via online platforms



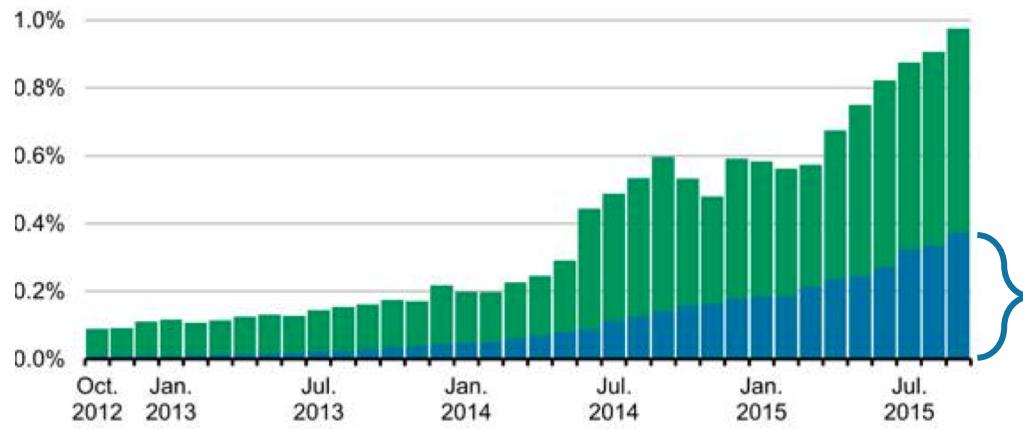
Gig Economy

Share of US adults earning income in a given month via online platforms



Gig Economy

Share of US adults earning income in a given month via online platforms

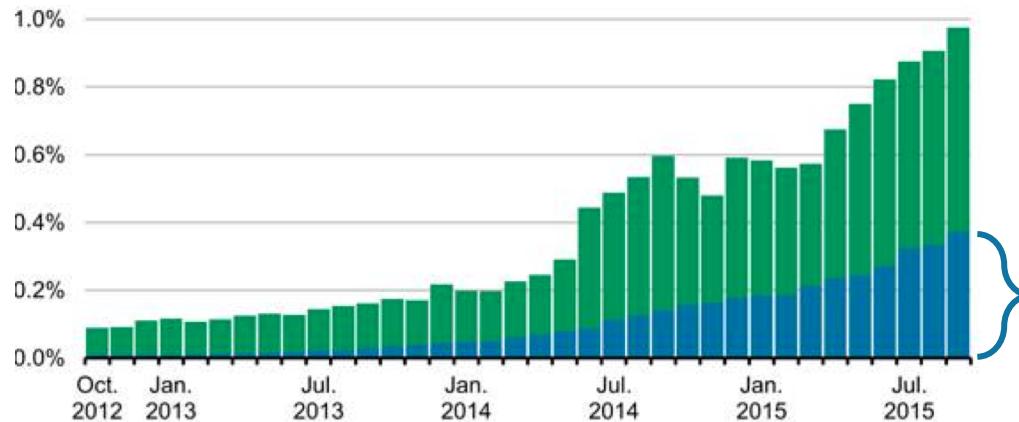


2015

44M people
in the US took on gig work (34%)
\$792B spending

Gig Economy

Share of US adults earning income in a given month via online platforms



2015

44M people

in the US took on gig work (34%)

\$792B spending

2027

Boost global GDP by \$2.7 trillion

Gig work will become workforce majority

Who are Gig Workers?

70% by choice

44% primary income

~50% millennials

Who are Gig Workers?

70% by choice

44% primary income

~50% millennials



when to work?



how long?



which platforms?

Who are Gig Workers?

70% by choice

44% primary income

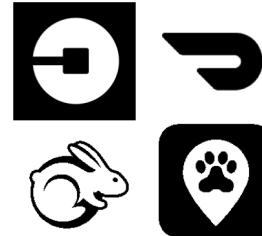
~50% millennials



when to work?



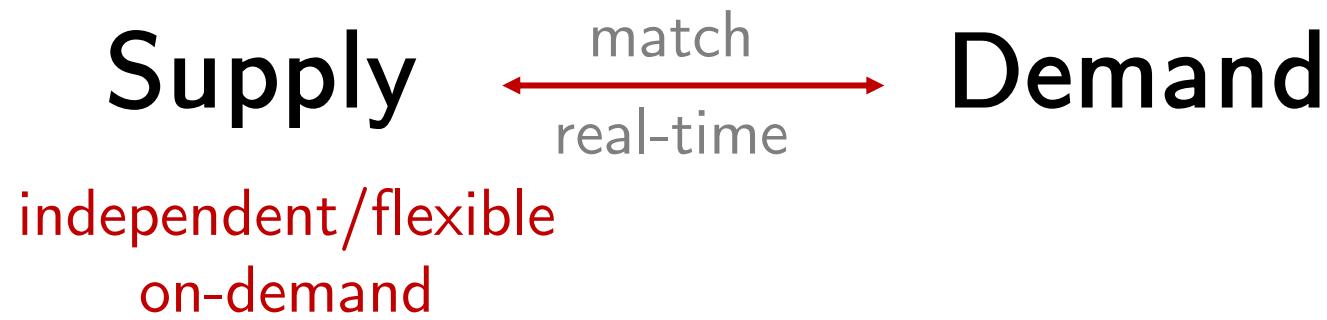
how long?



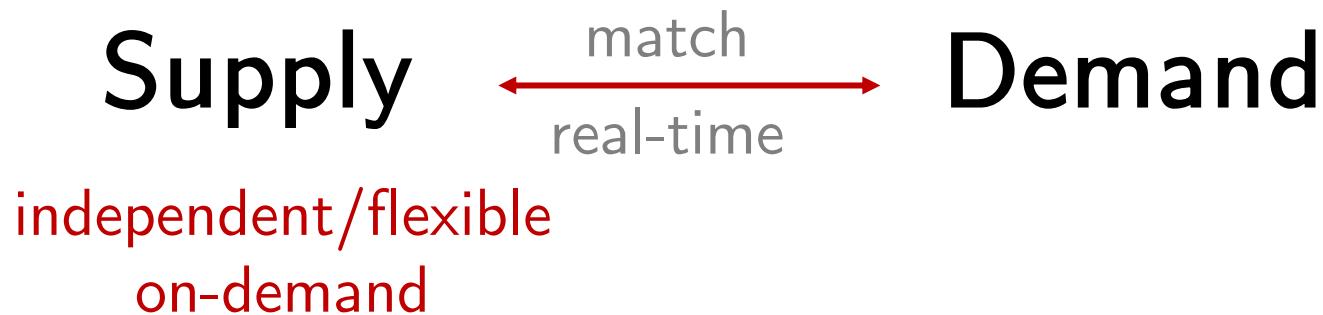
which platforms?

Workers decide work schedules

Gig Company



Gig Company



Workforce planning is challenging

Research Questions

How do gig economy workers
make labor decisions?

Research Questions

How do gig economy workers
make labor decisions?

How can the platform influence
their decisions?

Outline

- **What has been done**

- Practice / labor economics / OM

- **Data and empirical strategy**

- Dealing with endogeneity and selection bias

- **Results**

- Impact of incentive and behavioral elements on labor decisions

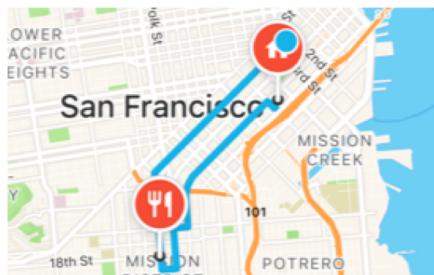
- **Implications**

- Simulation of optimal incentive re-allocation

In Practice

Real-time “surge pricing”

Deliver by 6:15pm Decline



Mission Chinese Food

\$22.78 subtotal (2 items)

BUSY PAY: +\$1.50

4.1 miles total

Accept Order

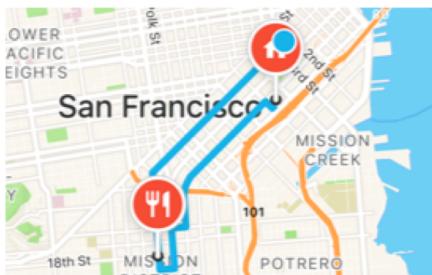


<https://dasherhelp.doordash.com/busy-pay>

In Practice

Real-time “surge pricing”

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Mission Chinese Food
\$22.78 subtotal (2 items)

BUSY PAY: +\$1.50

4.1 miles total

Accept Order



Pre-announced bonus

5:00 PM–6:00 PM

+10% (5:00pm - 5:30pm)
+30% (5:30pm - 6:00pm)

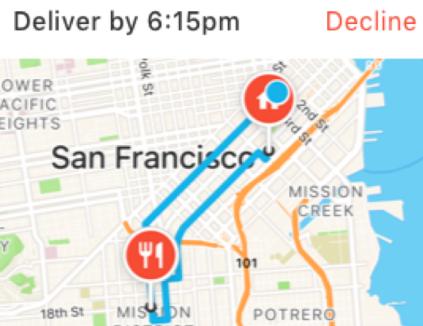
6:00 PM–7:00 PM

+30% (6:00pm - 6:30pm)
+40% (6:30pm - 7:00pm)

caviar

In Practice

Real-time “surge pricing”



4.1 miles total

Accept Order

 DOORDASH

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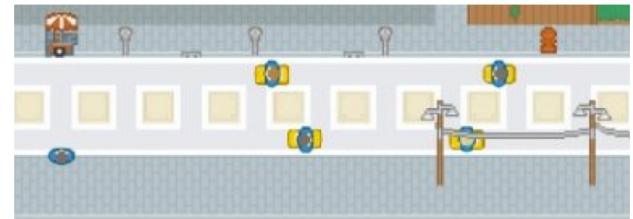


6:00 PM–7:00 PM

+30% (6:00pm - 6:30pm)
+40% (6:30pm - 7:00pm)

caviar

“You’re so close to
your precious target”



How Uber Uses
Psychological Tricks to
Push Its Drivers' Buttons

Theories of Labor Supply

Neoclassical

- Maximize lifetime utility

Theories of Labor Supply

Neoclassical

- Maximize lifetime utility
- **Positive** income elasticities

Wage ↑
Work more

Theories of Labor Supply

Neoclassical

- Maximize lifetime utility
- **Positive** income elasticities

Carrington (1996) 

Oettinger (1999) 

Wage ↑
Work more

Stafford (2013) 

Chen/Sheldon (2016)
Sheldon (2016) 

Theories of Labor Supply

Neoclassical

- Maximize lifetime utility
- **Positive** income elasticities

Carrington (1996) ○

Oettinger (1999) ○

Wage ↑
Work more

Stafford (2013) ○

Chen/Sheldon (2016)
Sheldon (2016) ○○

Behavioral

- Reference-dependence, targets

Theories of Labor Supply

Neoclassical

- Maximize lifetime utility
- **Positive** income elasticities

Carrington (1996)

Oettinger (1999)

Wage ↑
Work more

Stafford (2013)

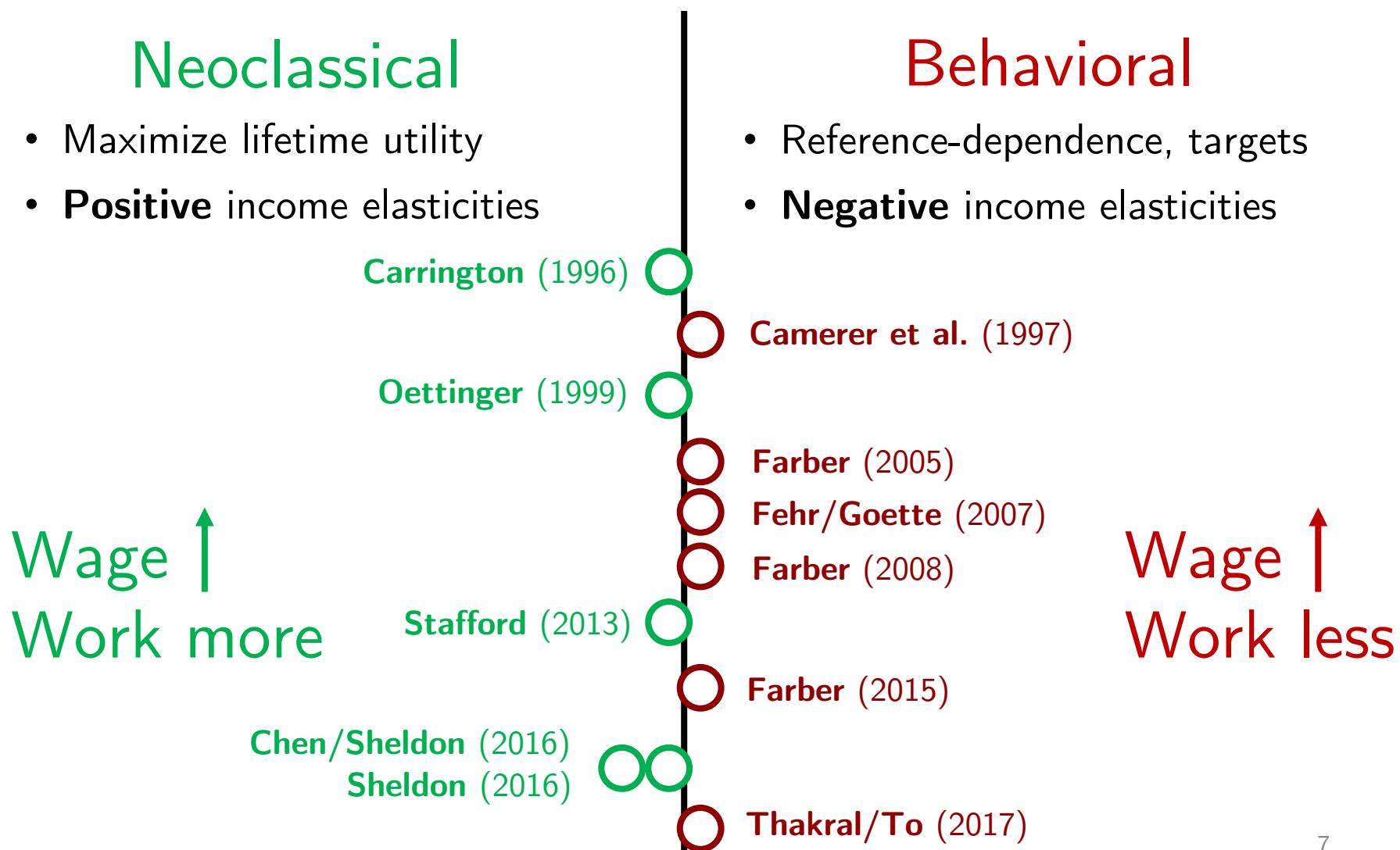
Chen/Sheldon (2016)
Sheldon (2016)

Behavioral

- Reference-dependence, targets
- **Negative** income elasticities

Wage ↑
Work less

Theories of Labor Supply



Recent work in OM

Theoretical

Dong & Ibrahim (2018)
Taylor (2017)
Cachon, Daniels & Lobel (2017)
Hu & Zhou (2017)
Ibrahim (2017)
Bimpikis, Candogan & Saban (2017)
Gurvich, Lariviere & Moreno (2016)
Tang et al. (2016)
Banerjee, Riquelme & Johari (2016)
Benjaafar et al. (2015)
...

Empirical

Kabra, Belavina & Girotra (2017)
Karacaoglu, Moreno & Ozkan (2017)
Chen, Chevalier, Rossi & Oehlsen (2017)
Cui, Li & Zhang (2017)
Li, Moreno & Zhang (2016)
...

Our Paper

- Behavioral drivers of decisions
- Rich data with complete description of the supply side
- Connect to system-wide decisions

Data

US ride-hailing firm

Drivers are guaranteed an hourly base rate.

Data

US ride-hailing firm

Drivers are guaranteed an hourly base rate.



Shift-level financial incentives and driving activity *for all*

Data

US ride-hailing firm

Drivers are guaranteed an hourly base rate.



Shift-level financial incentives and driving activity *for all*

5.5M

Observations

358

Days

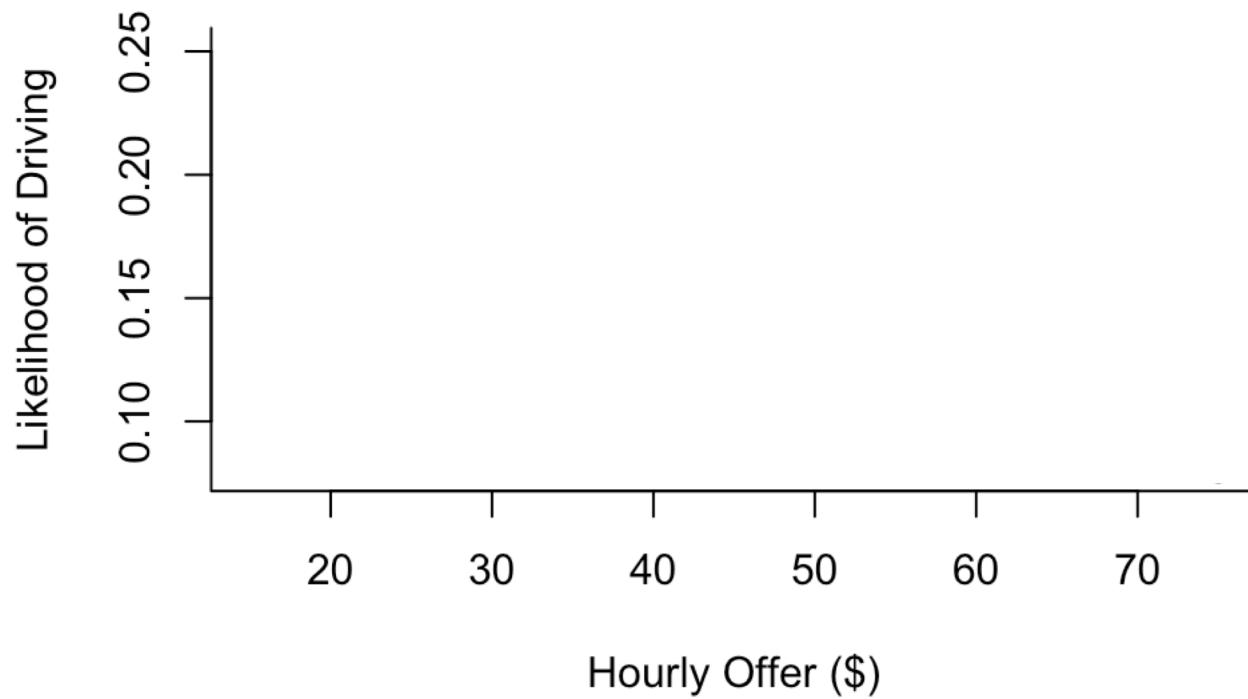
Oct 2016 – Sep 2017

7,826

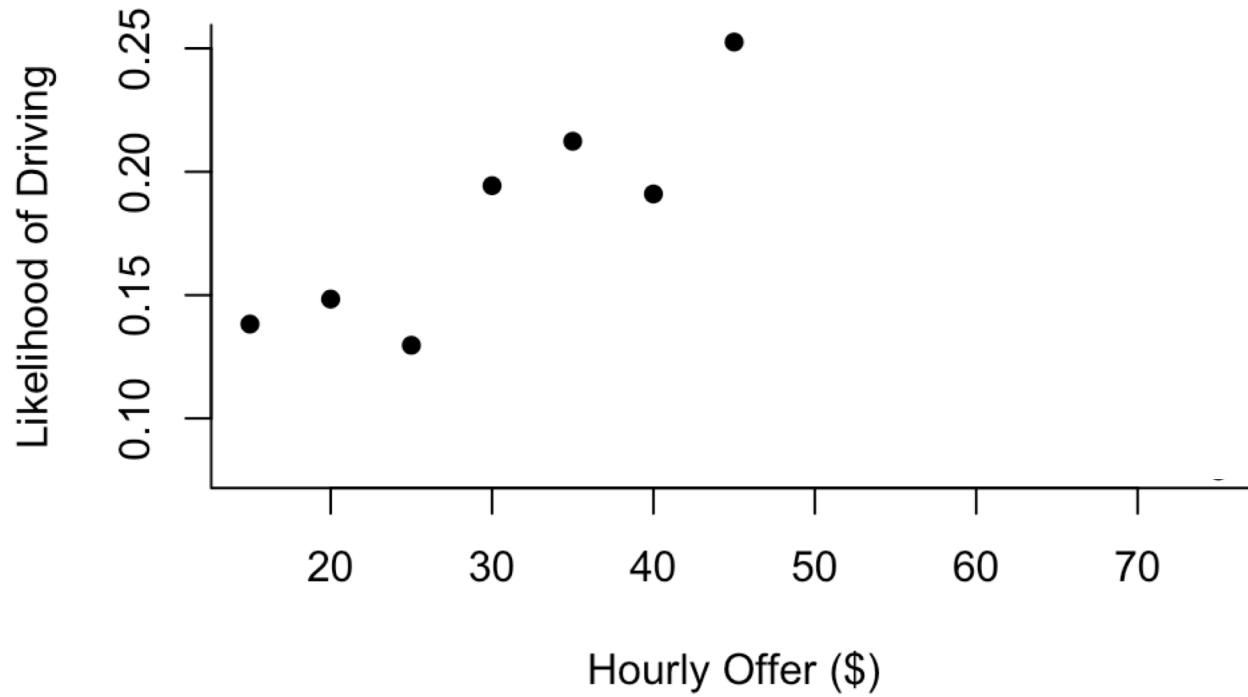
Unique drivers

SUV/Sedan/Van

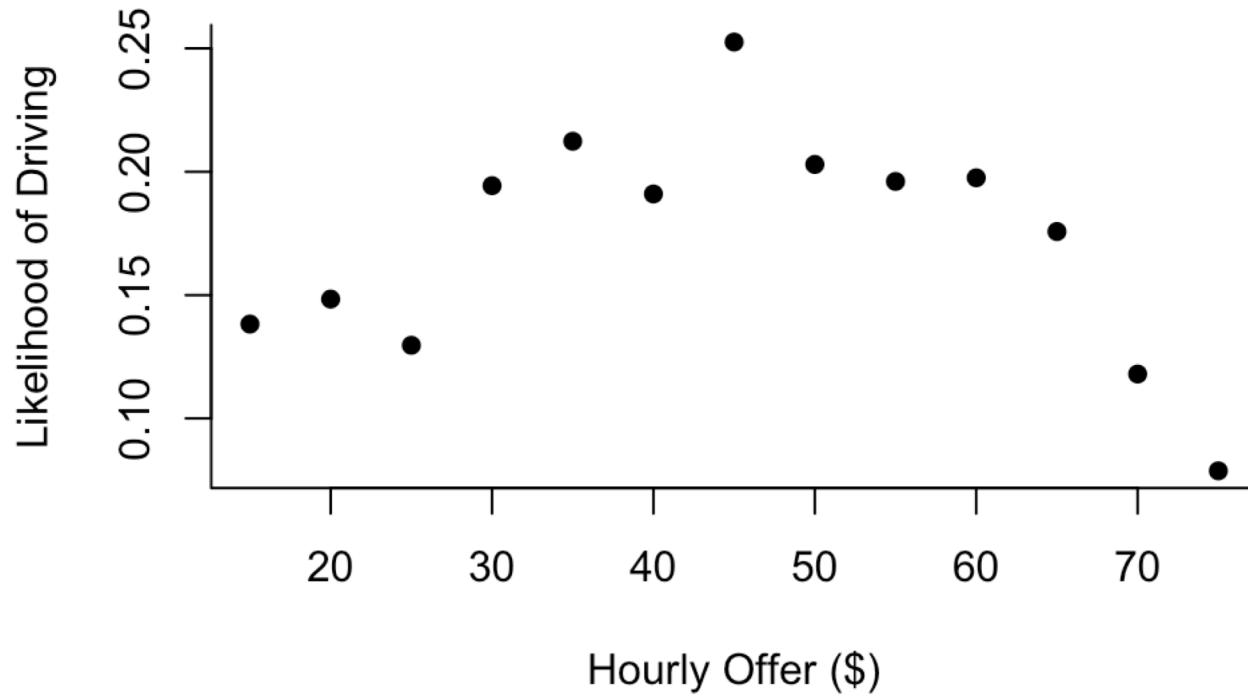
Challenges



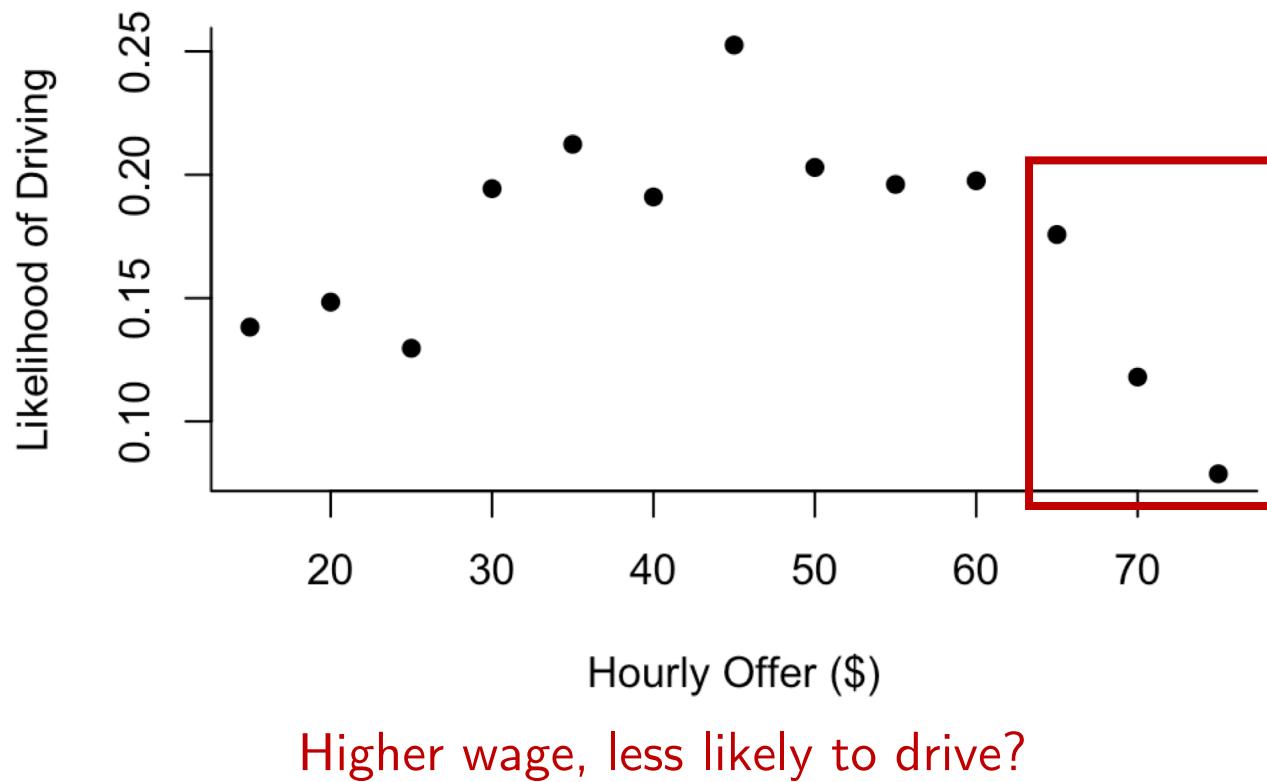
Challenges



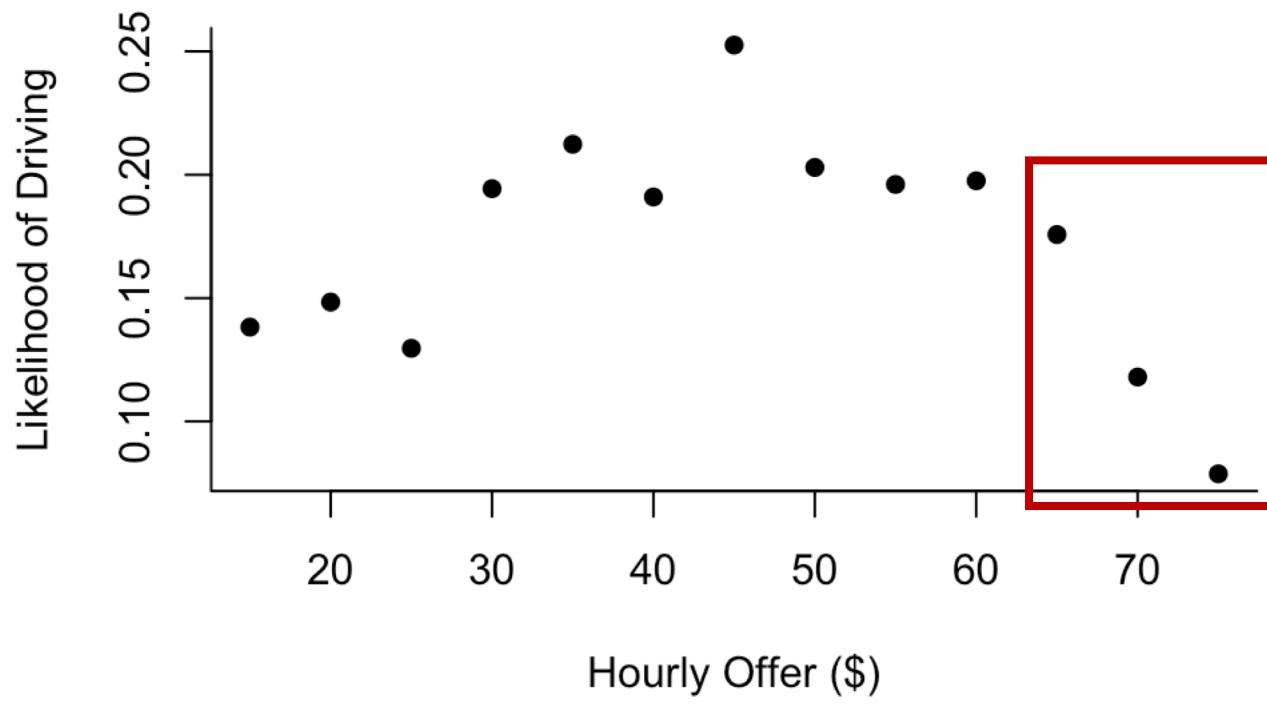
Challenges



Challenges



Challenges

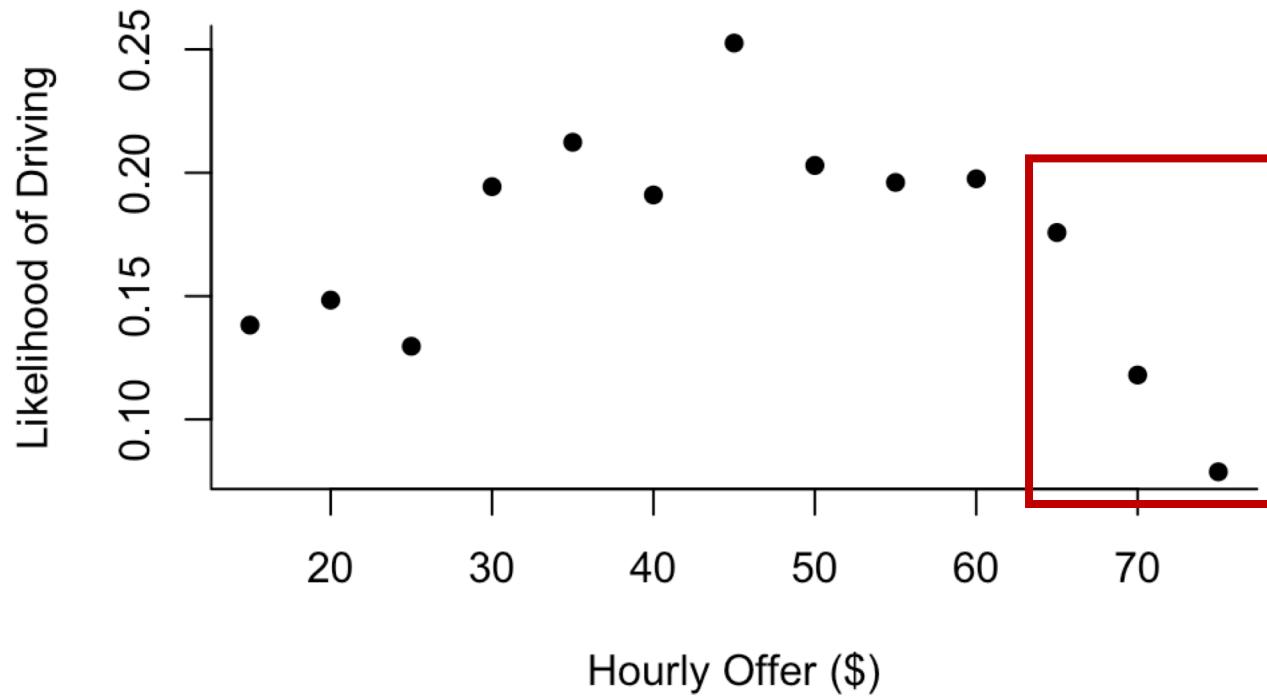


Higher wage, less likely to drive?

Use higher wage to attract inactive drivers

Challenges

Simultaneity



Higher wage, less likely to drive?

Use higher wage to attract inactive drivers

Challenges

Simultaneity

Solution: Instrumental Variables

- **Offer:** Average of other drivers' offers (Hausman 1996, Sheldon 2016, Xu et al 2017)

Challenges

Simultaneity

Solution: Instrumental Variables

- **Offer:** Average of other drivers' offers (Hausman 1996, Sheldon 2016, Xu et al 2017)
- **Promo** (binary): Lagged value from the same shift in the previous week
(Villas-Boas & Winer 1999, Yang et al 2003, Archak et al 2011, Ghose et al 2012)

Challenges

Simultaneity

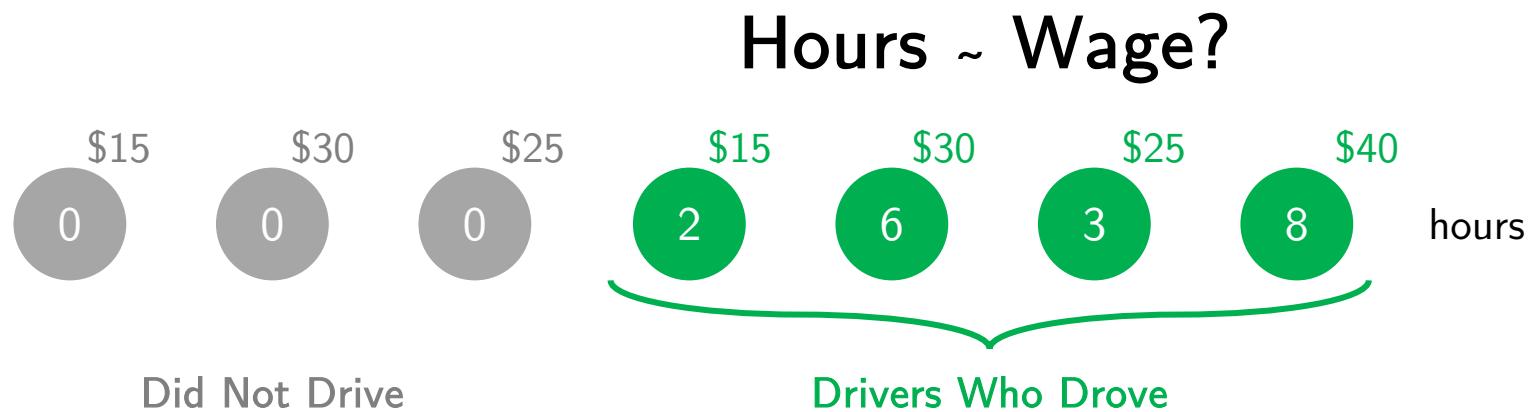
Solution: Instrumental Variables



Challenges

Simultaneity

Solution: Instrumental Variables



Challenges

Simultaneity

Solution: Instrumental Variables

Decision to work is **not random**

Hours ~ Wage?

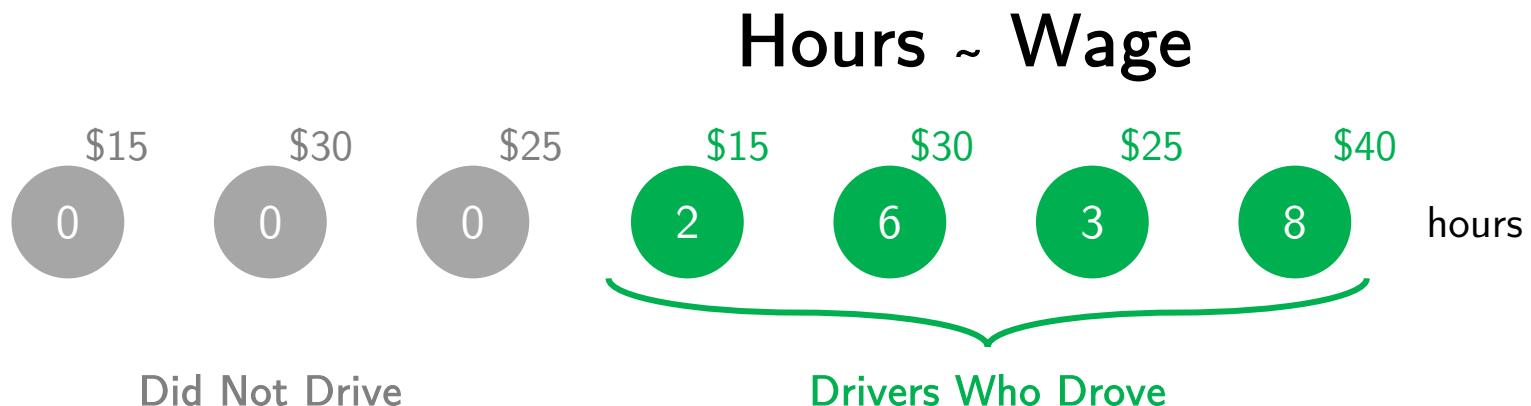


Challenges

Simultaneity

Solution: Instrumental Variables

Selection Bias



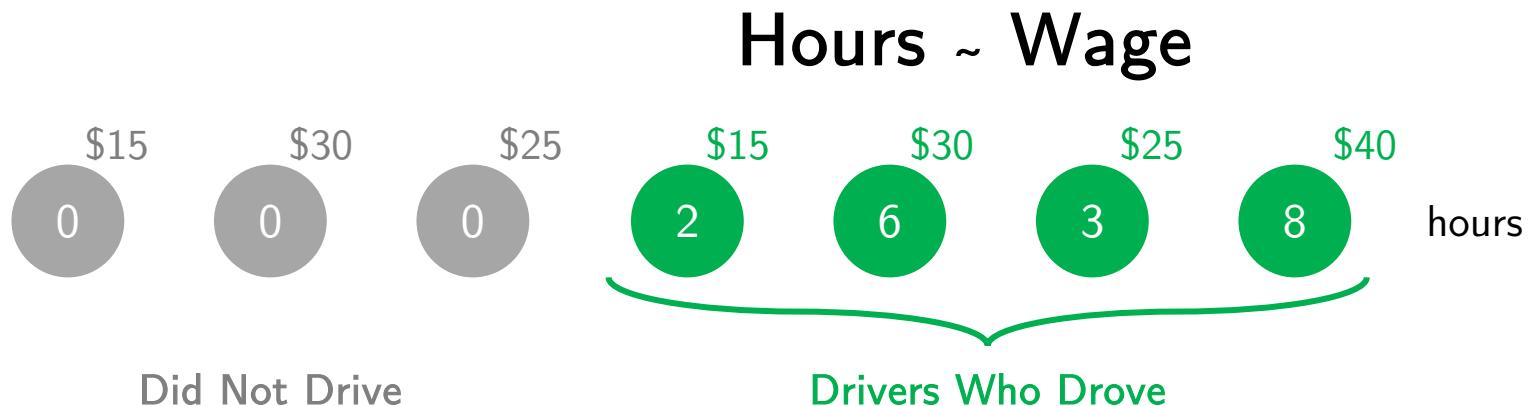
Challenges

Simultaneity

Solution: Instrumental Variables

Selection Bias

Solution: Heckman Two-Stage Method
("Heckit" - Heckman 1979)



Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:
 $P(\text{drive})$ on *Offer* + *Promo*

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive})$ on *Offer* + *Promo* + Controls

Hourly Weather Humidity, Temp, Precipitation

Holiday, Day of Week

Month-Year FE

Past Work Habits

Total last week, same day last week, same shift last week

Driver's Experience New?

Driver's FE

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive})$ on *Offer* + *Promo*

+ Controls

Demand { Hourly Weather Humidity, Temp, Precipitation
Holiday, Day of Week
Month-Year FE

Short-term Habits { Past Work Habits
Total last week, same day last week, same shift last week

Long-term Habits { Driver's Experience New?
Driver's FE

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive}) \text{ on } \textit{Offer} + \textit{Promo} + \text{ISF} + \text{Controls}$

Income So Far

= accumulated income since beginning of day

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive}) \text{ on } \textit{Offer} + \textit{Promo} + \text{ISF}$ + Controls

Income So Far
= intensity of work

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive}) \text{ on } \textit{Offer} + \textit{Promo} + \textcolor{red}{ISF} + \textcolor{purple}{HSF} + \text{Controls}$

Income So Far
= intensity of work

Hours So Far
= accumulated time
logged in since beginning of day

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive}) \text{ on } \textit{Offer} + \textit{Promo} + \textcolor{red}{ISF} + \textcolor{purple}{HSF} + \text{Controls}$

Income So Far
= intensity of work

Hours So Far
= amount of active time

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive}) \text{ on } \textit{Offer} + \textit{Promo} + \text{ISF} + \text{HSF} + \text{Controls}$

Income So Far
= intensity of work

Hours So Far
= amount of active time

Conditional
on working

2 How long to work?

2SLS with Fixed Effects

Hours on $\textit{Earning} + \text{ISF} + \text{HSF} + \text{Controls}$

Empirical Strategy

Heckman + IV

1 Work or not?

Control Function Probit:

$P(\text{drive}) \text{ on } \textit{Offer} + \textit{Promo} + \textcolor{red}{ISF} + \textcolor{purple}{HSF} + \text{Controls}$

Income So Far
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Conditional
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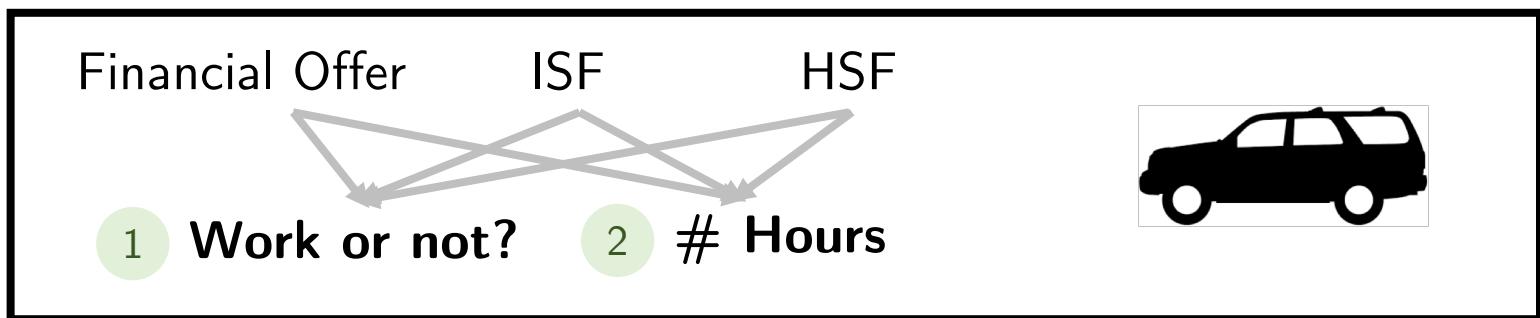
2 How long to work?

2SLS with Fixed Effects

Hours on $\textit{Earning} + \text{ISF} + \text{HSF} + \textcolor{green}{IMR} + \text{Controls}$

Inverse Mills Ratio
= correct for selection bias

Results



Within-Day

Midday



Late Night

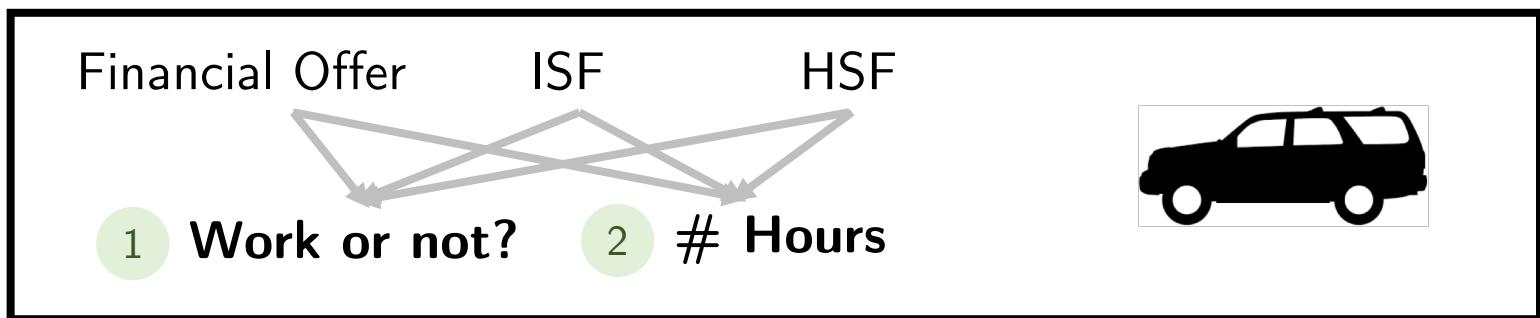
Across-Days

Tuesday



Sunday

Results



Within-Day

Midday



Late Night

Across-Days

Tuesday



Sunday

+

-

Positive Negative

Results Within Day

1

Work or not?

Offer

Midday	+
PM peak	+
PM off	+
Late night	+

Financial incentives have
a **consistently positive**
impact.

Results Within Day

1

Work or not?

	Offer	ISF
Midday	+	+
PM peak	+	-
PM off	+	-
Late night	+	-

Income
Target

Income Target:
The more you earned,
the less likely you'll work
a new shift.

The negative impact of
income target kicks in
later in the day.

Results Within Day

1

Work or not?

	Offer	ISF	HSF
Midday	+	+	+
PM peak	+	-	+
PM off	+	-	+
Late night	+	-	+

Income
Target

Inertia

Inertia: The longer you've been active, the more likely you'll work another shift.

Inertia has a consistently positive impact.

Results Within Day

	1 Work or not?			2 # Hours		
	Offer	ISF	HSF	Earning	ISF	HSF
Midday	+	+	+	-	+	+
PM peak	+	-	+	+	-	+
PM off	+	-	+	+	-	+
Late night	+	-	+	+	-	+

Income Inertia Income Inertia

Target Target

The negative impact of income target kicks in later in the day for both stages.

Results Across Days

	1 Work or not?			2 # Hours		
	Offer	ISF	HSF	Earning	ISF	HSF
Tuesday	+	+	+	+	+	+
Wednesday	+	+	+	+	-	+
Thursday	+	-	+	+	-	+
Friday	+	-	+	+	-	+
Saturday	+	-	+	+	-	+
Sunday	+	-	+	+	-	+

Income Target Inertia Income Target Inertia

The results are consistent across days as well.

Results Summary

Neoclassical
Financial Incentive

As day/week proceeds...



encourages working

Results Summary

Neoclassical
Financial Incentive

Behavioral
Income Target

As day/week proceeds...



encourages working

discourages working later on

Results Summary

Neoclassical
Financial Incentive

As day/week proceeds...

encourages working

Behavioral
Income Target

discourages working later on

New
Inertia

encourages working

Outline

- What has been done
 - Practice / labor economics / OM
- Data and empirical strategy
 - Dealing with endogeneity and selection bias
- Results
 - Impact of incentive and behavioral elements on labor decisions
- Implications
 - Simulation of optimal incentive re-allocation

Optimal Targeted Incentive



Optimal Targeted Incentive



Optimal Targeted Incentive

Ranking each driver by her
minimum work-inducing incentive
= how much to trigger working decision



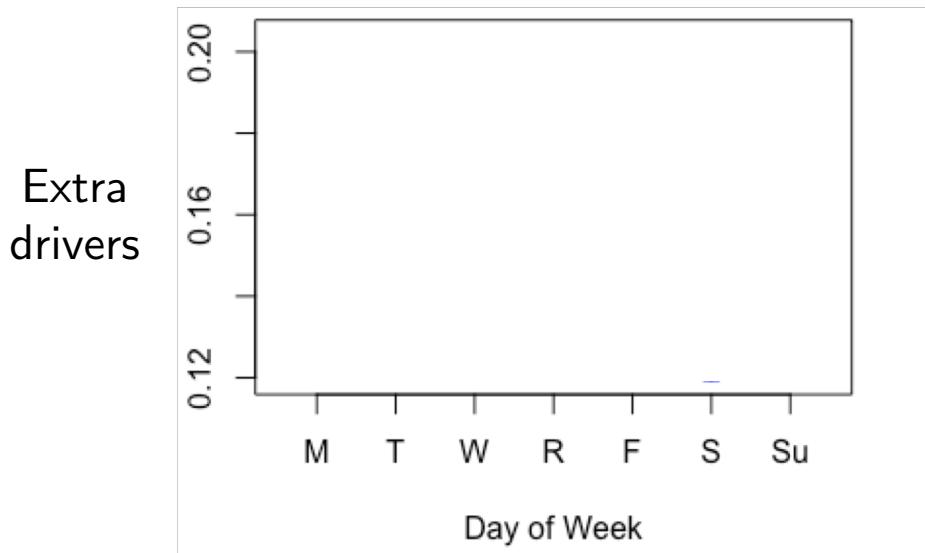
Reallocating Incentives

Compared to current practice from Jan to Sep 2017 out-of-sample

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Compared to current practice from Jan to Sep 2017 out-of-sample

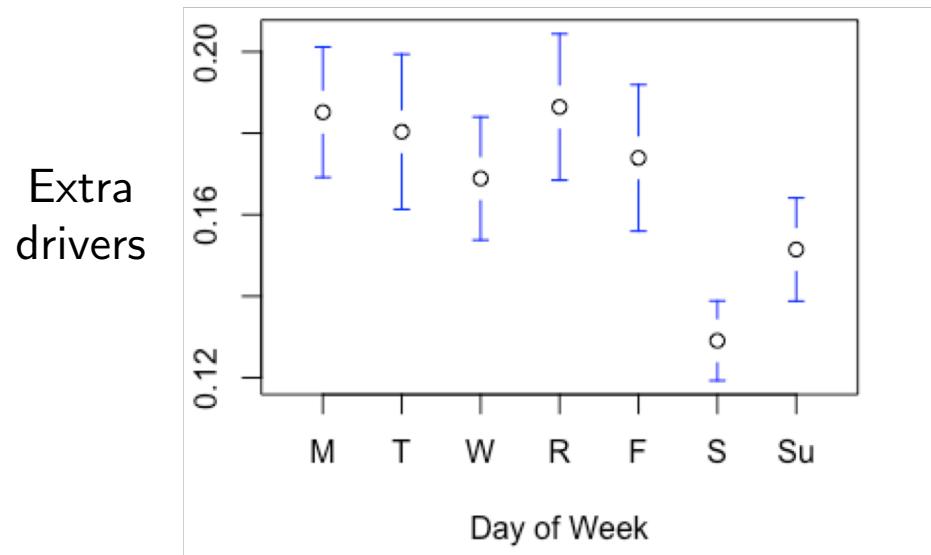
Given the same budget



Reallocating Incentives

Compared to current practice from Jan to Sep 2017 out-of-sample

Given the same budget



Can recruit **17% more drivers**

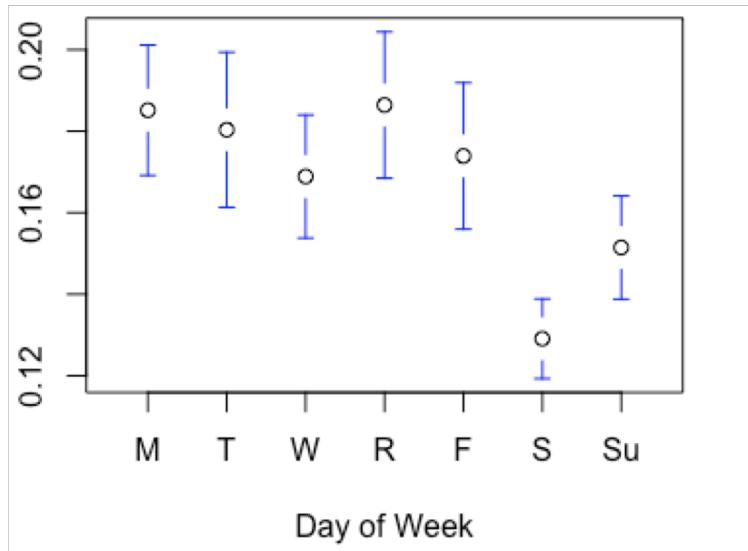
Average promo: 1.61x

Reallocating Incentives

Compared to current practice from Jan to Sep 2017 out-of-sample

Given the same budget

Extra
drivers

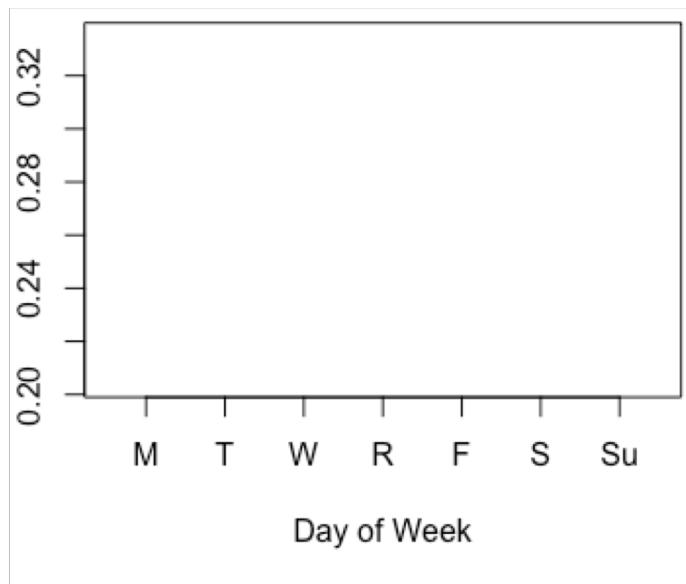


Can recruit **17% more drivers**

Average promo: 1.61x

Given the same capacity

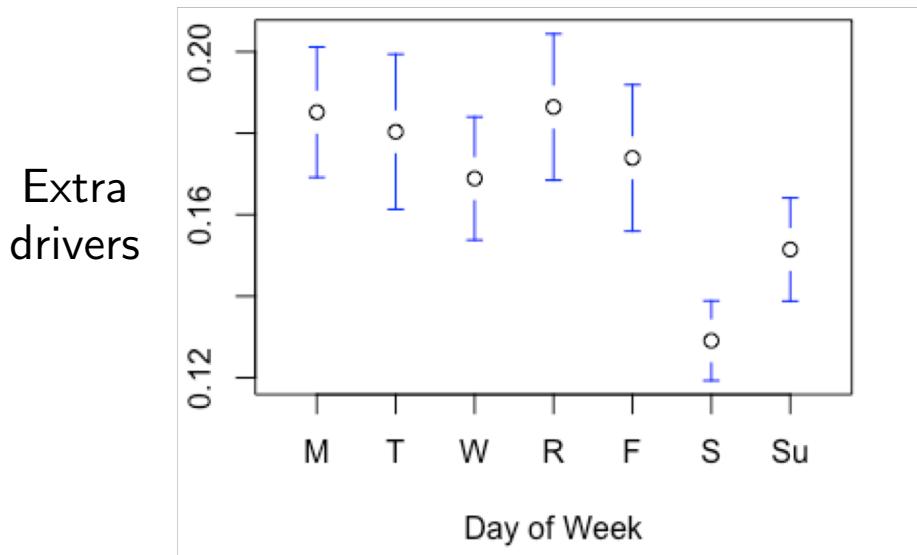
Cost
saved



Reallocating Incentives

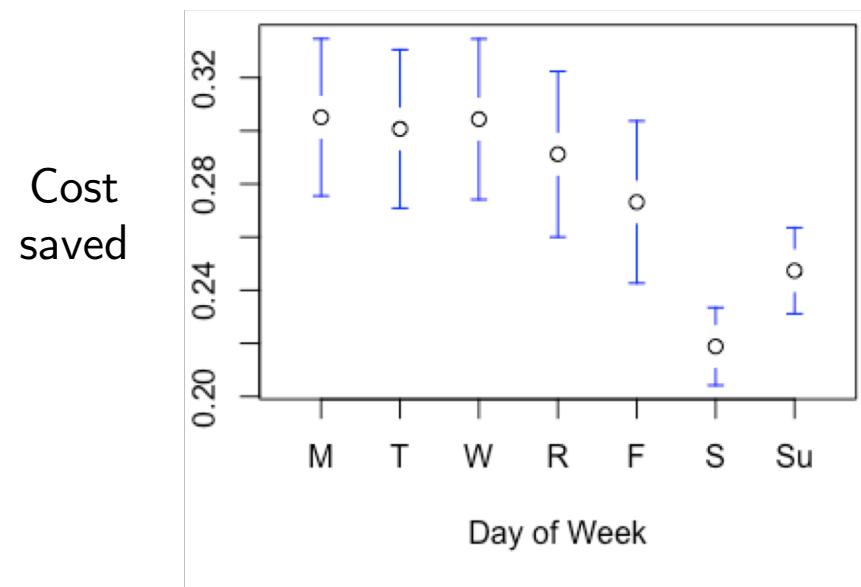
Compared to current practice from Jan to Sep 2017 out-of-sample

Given the same budget



Can recruit **17% more drivers**
Average promo: 1.61x

Given the same capacity



Costs 28% less to maintain capacity

Summary

How do gig economy workers make labor decisions?

Approach

- Shift-level data from ride-hailing company
- Modified Heckman estimation w/ IVs and fixed effects

Findings

As day/week proceeds...

Neoclassical

Financial Incentive

encourages working

Behavioral

Income Target

discourages working later on

New phenomenon

Inertia

encourages working

Implications

- Compared to current practice, our approach can improve service capacity without incurring extra cost or maintain the same capacity at a lower cost

Appendix

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings		
Promo		
Income so far		
Hours so far		
AIC	95,856.010	72,887.620

N = 166,766

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far		
Hours so far		
AIC	95,856.010	72,887.620

Financial incentives and
getting a “deal”
encourage working

N = 166,766

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far		-0.002*** (0.0002)
Hours so far		
AIC	95,856.010	72,887.620

N = 166,766

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far	Income Target	-0.002*** (0.0002)
Hours so far		
AIC	95,856.010	72,887.620

N = 166,766

The more you've earned,
the less likely you're going to
continue working.

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far	Income Target	-0.002*** (0.0002)
Hours so far		
AIC	95,856.010	72,887.620

N = 166,766

For average driver,
\$100 additional income so far,
 $P(\text{drive})$ decreases by 2.5%

The more you've earned,
the less likely you're going to
continue working.

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far	Income Target	-0.002*** (0.0002)
Hours so far		0.361*** (0.007)
AIC	95,856.010	72,887.620

N = 166,766

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far	Income Target	-0.002*** (0.0002)
Hours so far	Inertia	0.361*** (0.007)
AIC	95,856.010	72,887.620

N = 166,766

The longer you've been active,
the more likely you'll continue
working

Late Night

1

	Work or not?	
	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)
Promo	0.229*** (0.038)	0.285*** (0.046)
Income so far	Income Target	-0.002*** (0.0002)
Hours so far	Inertia	0.361*** (0.007)
AIC	95,856.010	72,887.620

N = 166,766

For average driver,
1 additional hour so far,
 $P(\text{drive})$ increases by 4.1%

The longer you've been active,
the more likely you'll continue
working

Late Night

1

2

	Work or not?		# Hours		
	Base	+ Targets	Naive	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)			
Promo	0.229*** (0.038)	0.285*** (0.046)			
Income so far	Income Target	-0.002*** (0.0002)			
Hours so far	Inertia	0.361*** (0.007)			
IMR					
AIC/R ²	95,856.010	72,887.620			

N = 166,766

Late Night

1

2

	Work or not?		# Hours		
	Base	+ Targets	Naive	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)	-0.010*** (0.001)	-0.001 (0.001)	0.001*** (0.0002)
Promo	0.229*** (0.038)	0.285*** (0.046)			
Income so far	Income Target	-0.002*** (0.0002)			
Hours so far	Inertia	0.361*** (0.007)			
IMR				***	***
AIC/R ²	95,856.010	72,887.620	0.313	0.324	0.957

N = 166,766

N = 18,941

Late Night

1

2

	Work or not?		# Hours		
	Base	+ Targets	Naive	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)	-0.010*** (0.001)	-0.001 (0.001)	0.001*** (0.0002)
Promo	0.229*** (0.038)	0.285*** (0.046)			
Income so far	Income Target	-0.002*** (0.0002)			-0.0002*** (0.00002)
Hours so far	Inertia	0.361*** (0.007)			0.187*** (0.001)
IMR				***	***
AIC/R ²	95,856.010	72,887.620	0.313	0.324	0.957

N = 166,766

N = 18,941

Late Night

1

2

	Work or not?		# Hours		
	Base	+ Targets	Naive	Base	+ Targets
Hourly offer/ earnings	0.008*** (0.001)	0.012*** (0.001)	-0.010*** (0.001)	-0.001 (0.001)	0.001*** (0.0002)
Promo	0.229*** (0.038)		The more you've earned, you'll drive shorter hours.		
Income so far	Income Target	-0.002*** (0.0002)		Income Target	-0.0002*** (0.00002)
Hours so far	Inertia	0.361*** (0.007)		Inertia	0.187*** (0.001)
IMR	The longer you've been active, you'll drive longer hours.				
AIC/R ²	95,856.010	72,887.620	0.313	0.324	0.957

N = 166,766

N = 18,941

Gig Economy x Retail



- Retail candidates value **flexible shift patterns** and shorter work weeks over compensation and benefits.
- Benefits of adopting flexible workforce: **Seasonality, resolving high turnover, matching consumer trend, high quality/fresh perspective**
- Many have already adopted/worked closely with gig companies
 - Delivery business: Walmart x Uber/Lyft, GM x Lyft, Apple x Didi
 - Flexible staffing: IKEA x TaskRabbit, Samsung x Upwork



Heckit with IVs

1. Choice Equation “Drive or not?”

CF: Regress hourly offer/promo on IVs. Keep residuals

Probit: Estimate $P(\text{drive})$

$$P(\text{Drive}_{i,t} = 1 | \mathbf{X}_{i,t}) = \Phi(\alpha_{0,t} + \alpha_w w_{i,t} + \alpha_\psi \psi_{i,t} + \boldsymbol{\alpha} \mathbf{X}_{i,t} + \alpha_e \hat{e}_{i,t})$$

C

Inverse Mills Ratio (IMR)

$$\lambda(c_z) = \frac{\phi(c_z)}{1 - \Phi(c_z)}$$

Conditional on driving

2. Level Equation “How long?”

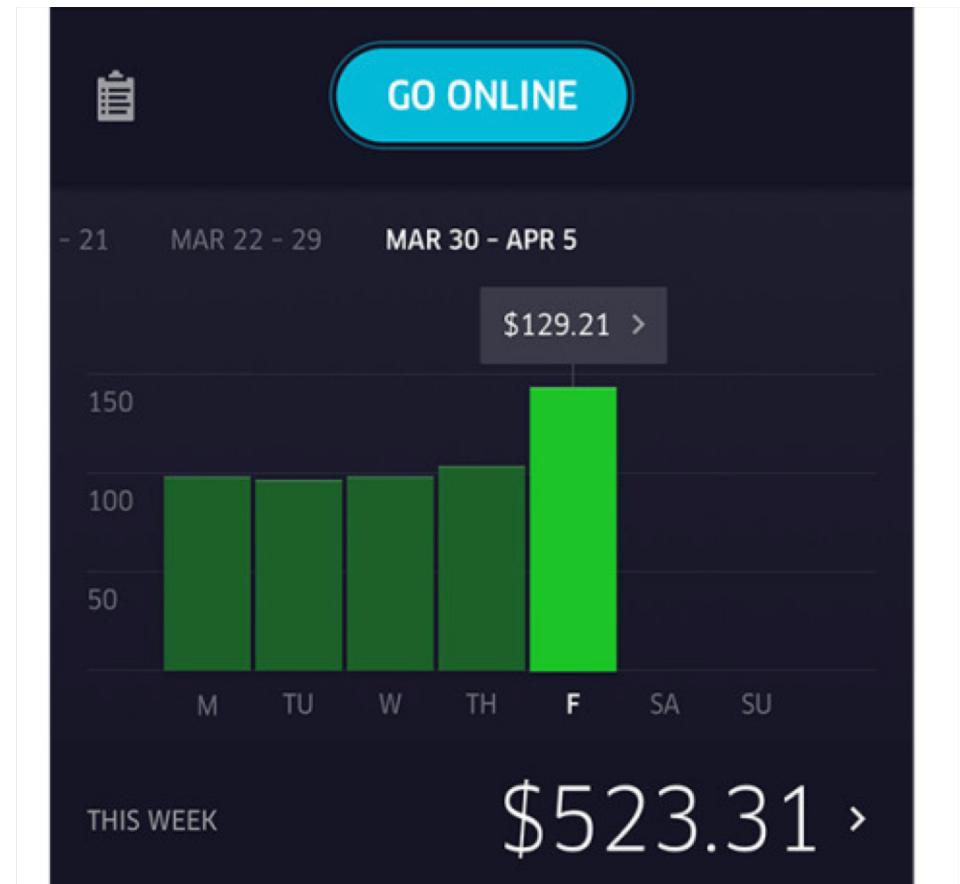
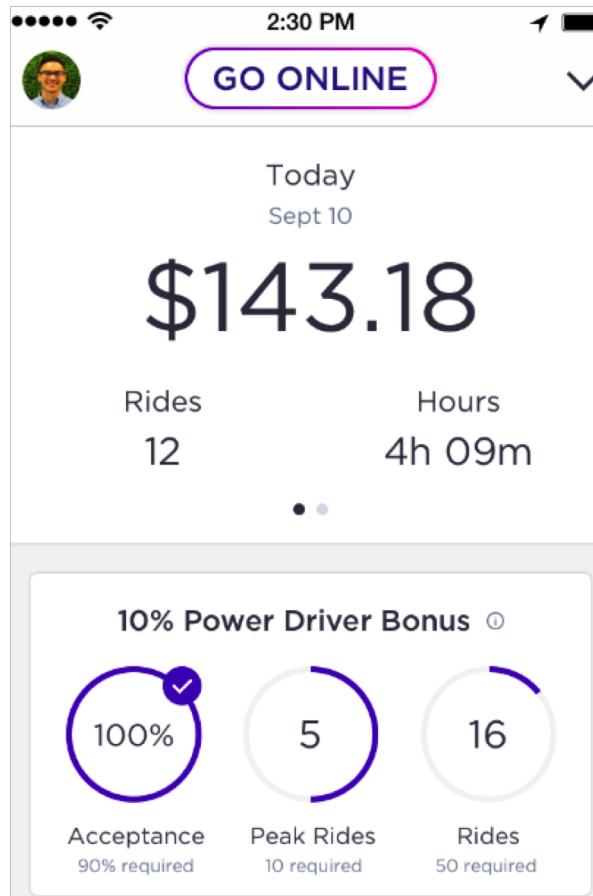
IV: Estimate hourly earning from IVs

OLS: Estimate hours

$$f(\text{Hour}_{i,t}) = \beta_{0,i} + \beta_w w_{i,t} + \boldsymbol{\beta} Z_{i,t} + \theta \lambda_{i,t} + u_{i,t}$$

L

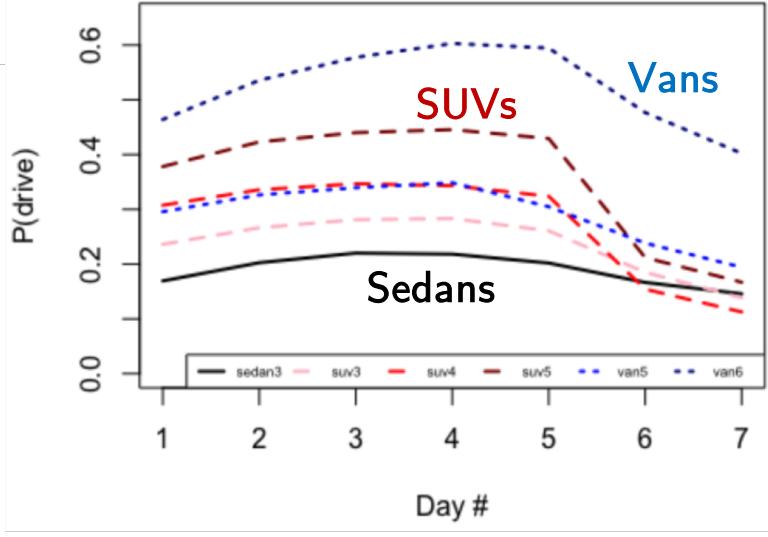
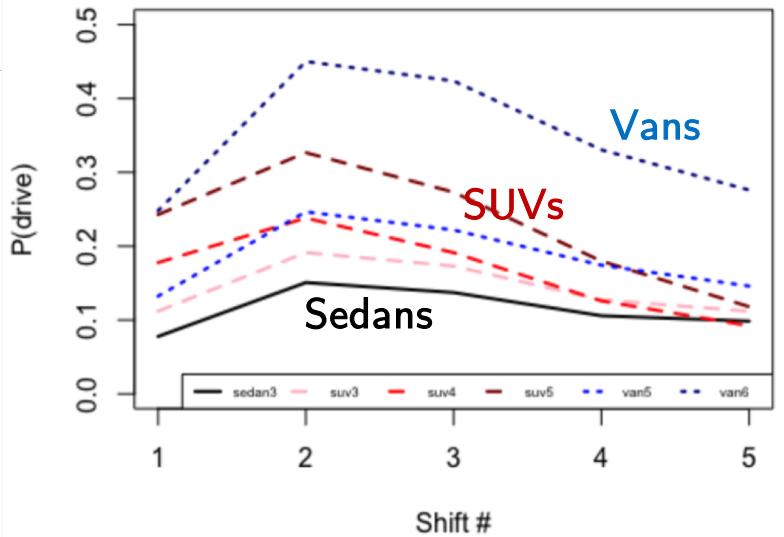
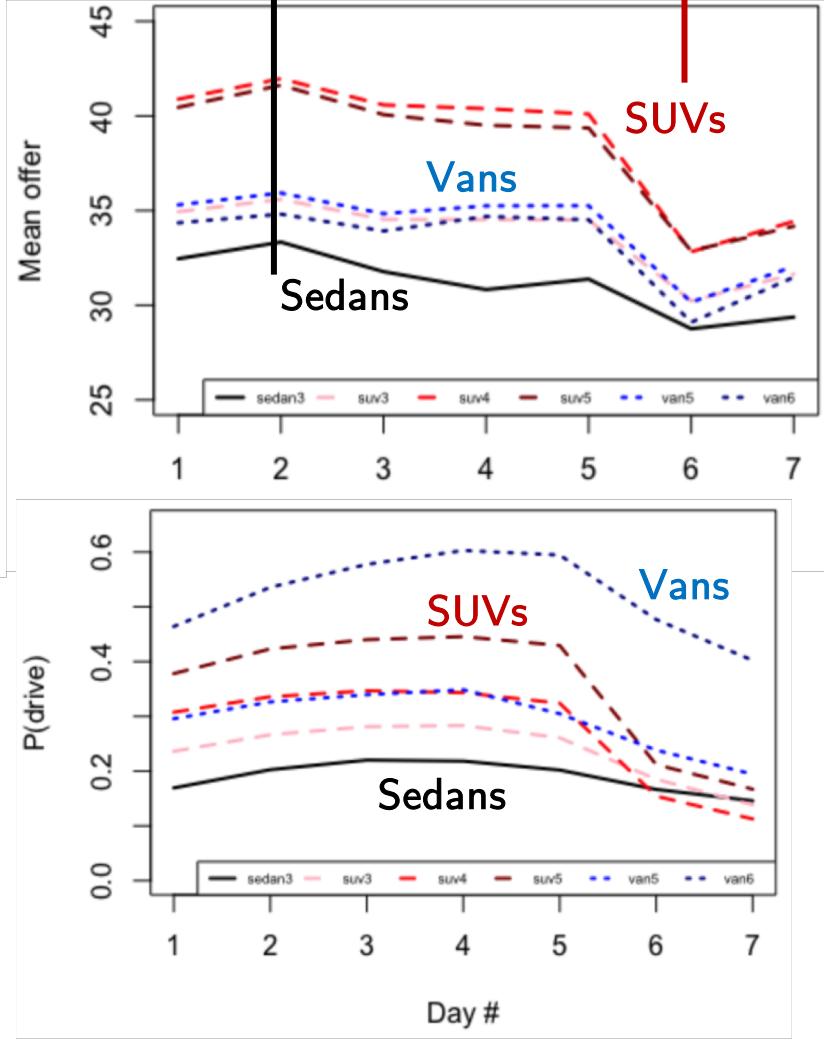
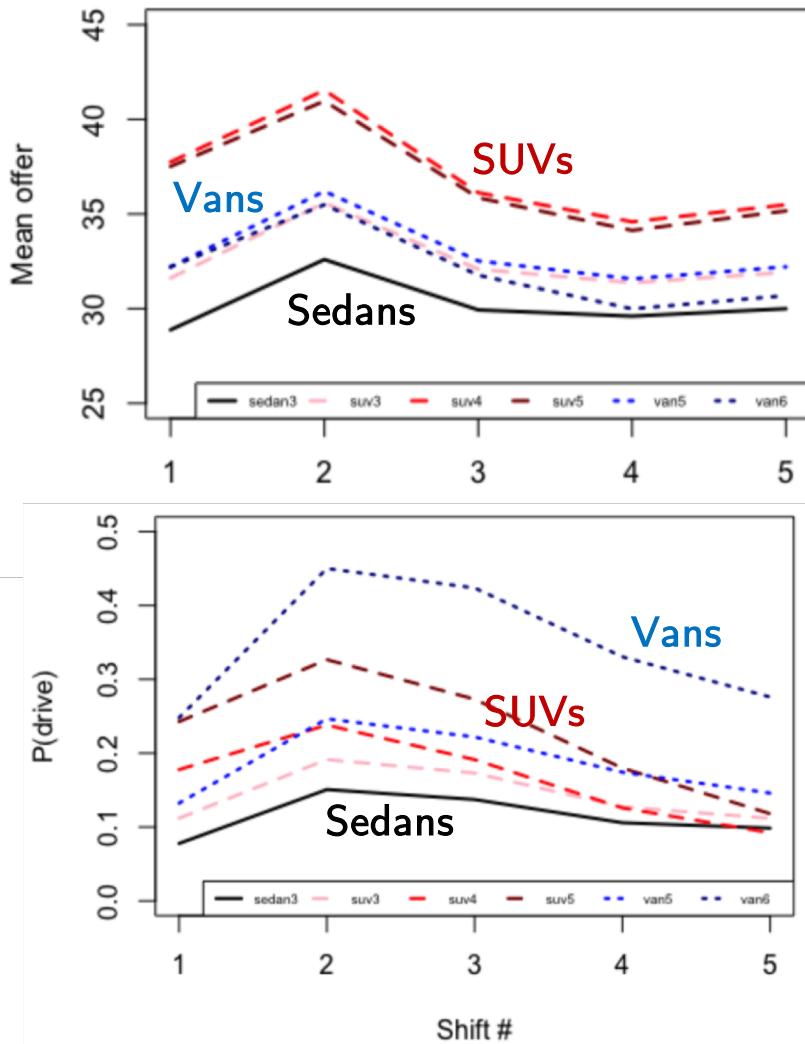
Salience of ISF/HSF



Drivers

5.33 hrs/day, 12.65 hrs/wk

4.86 hrs/day, 5.86 hrs/wk



Late Night

1

2

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Work or not?



Late Night

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	Work or not?			# Hours		
	Offer	ISF	HSF	Earning	ISF	HSF
Late night	+	-	+	+	-	+

Results Across Shifts

1

Work or not?

	Offer	ISF	HSF
Midday	+	+	+
PM peak	+	-	+
PM off	+	-	+
Late night	+	-	+

Income
Target

Financial incentives and inertia have a **consistently positive** impact.

Results Across Shifts

1

Work or not?

	Offer	ISF	HSF
Midday	+	+	+
PM peak	+	-	+
PM off	+	-	+
Late night	+	-	+

Income Target Inertia

The negative impact of income target kicks in later in the day.

Results Across Shifts

	Work or not?			# Hours		
	Offer	ISF	HSF	Earning	ISF	HSF
Midday	+	+	+	-	+	+
PM peak	+	-	+	+	-	+
PM off	+	-	+	+	-	+
Late night	+	-	+	+	-	+

Income Inertia Income Inertia

Target Target

The negative impact of income target kicks in later in the day for both stages.