Consumer Surplus of Alternative Payment Methods: Paying Uber with Cash

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Outline

- Use experimental and observational data to estimate the consumer surplus accruing from using cash as a payment method for Uber rides.
- Motivation:
  - Broad: central banks are considering disincentivizing the use of cash (e.g. India demonetization, Rogoff: “curse of cash", etc.).
  - Money demand, choice of means of payments, intensive & extensive margin.

    Lucas-Stokey (1987), Prescott (1987), Alvarez-Lippi (2017), Stokey (2019).
  - Uber paid with cash: 400+ cities, 40+ in Mexico.
  - Actual ban on use in cash in cities in Mexico and elsewhere.

- Four quasi-natural experiments
  - Event study on 15 cities around the introduction of cash.
  - Geolocalized data comparing introduction of cash within Greater Mexico City.
  - Synthetic control to evaluate ban on cash on Puebla + rider conversion rate.
  - Ban and reintroduction of cash in Panama.
- Simple model of riders choices defining Consumer Surplus
- Estimate model using three large field experiments ($\approx$ 400,000 riders):
  - Experiment 1: estimate elasticity of substitution cash/credit η.
  - Experiment 2: estimate elasticity of demand of Uber ϵ.
  - Experiment 3: estimate cost of adopting card as a payment method ψ.
  - External Validation: two other price experiments, natural experiment in Panama, and survey.

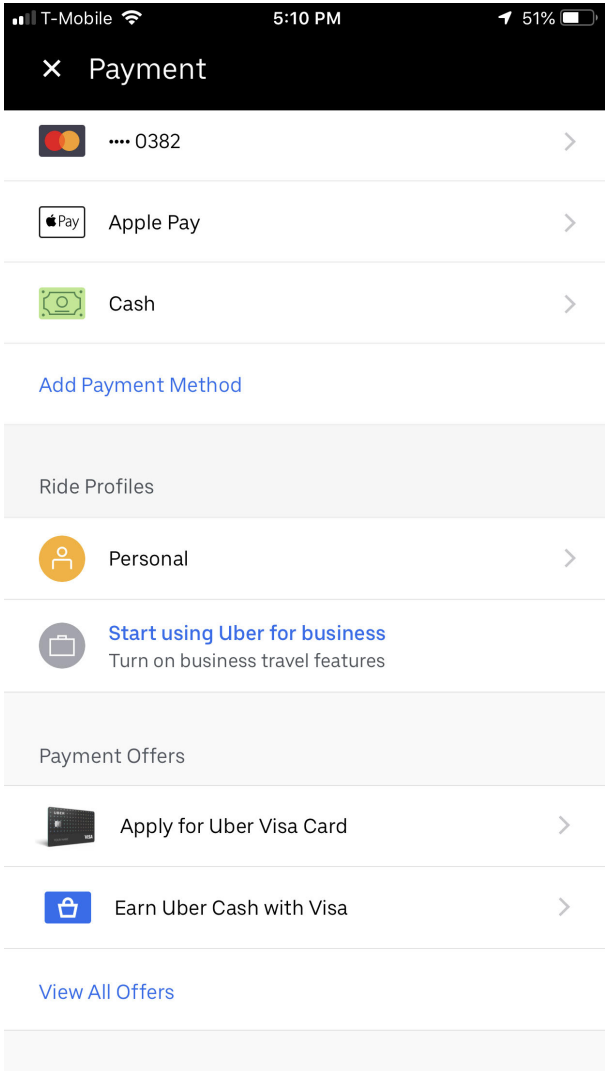
Consumer surplus lost after cash ban > 50% of total fares paid in cash.

Outline

Uber cash

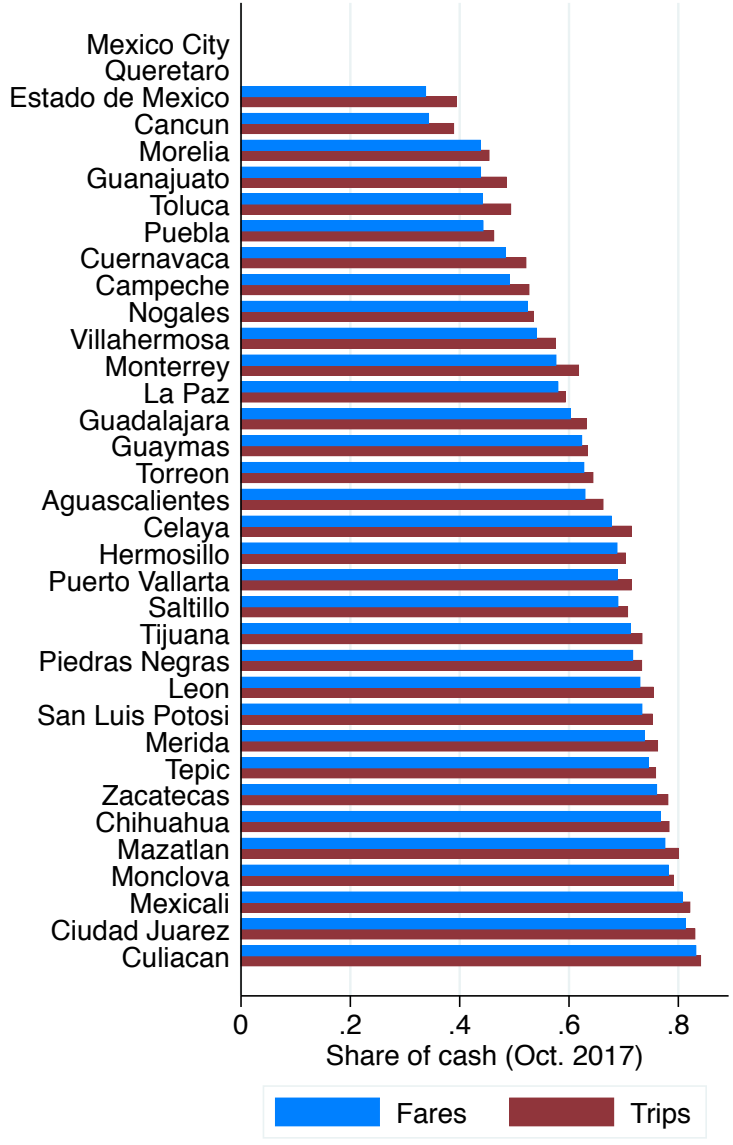
Demographics

- May 2015: Uber rolled out cash in Hyderabad, India.
- Offered in 150 cities in 2016 and in over 400 by 2018 worldwide.
- In Latin America accounts for more than 50% of the rides.
- Uber Mexico in 2013, cash introduced in 2016.
- Greater Mexico City in 2017:
  - 30% fares (25% users) pure credit
  - 50% fares (50% users) mixed users
  - 20% fares (25% users) pure cash

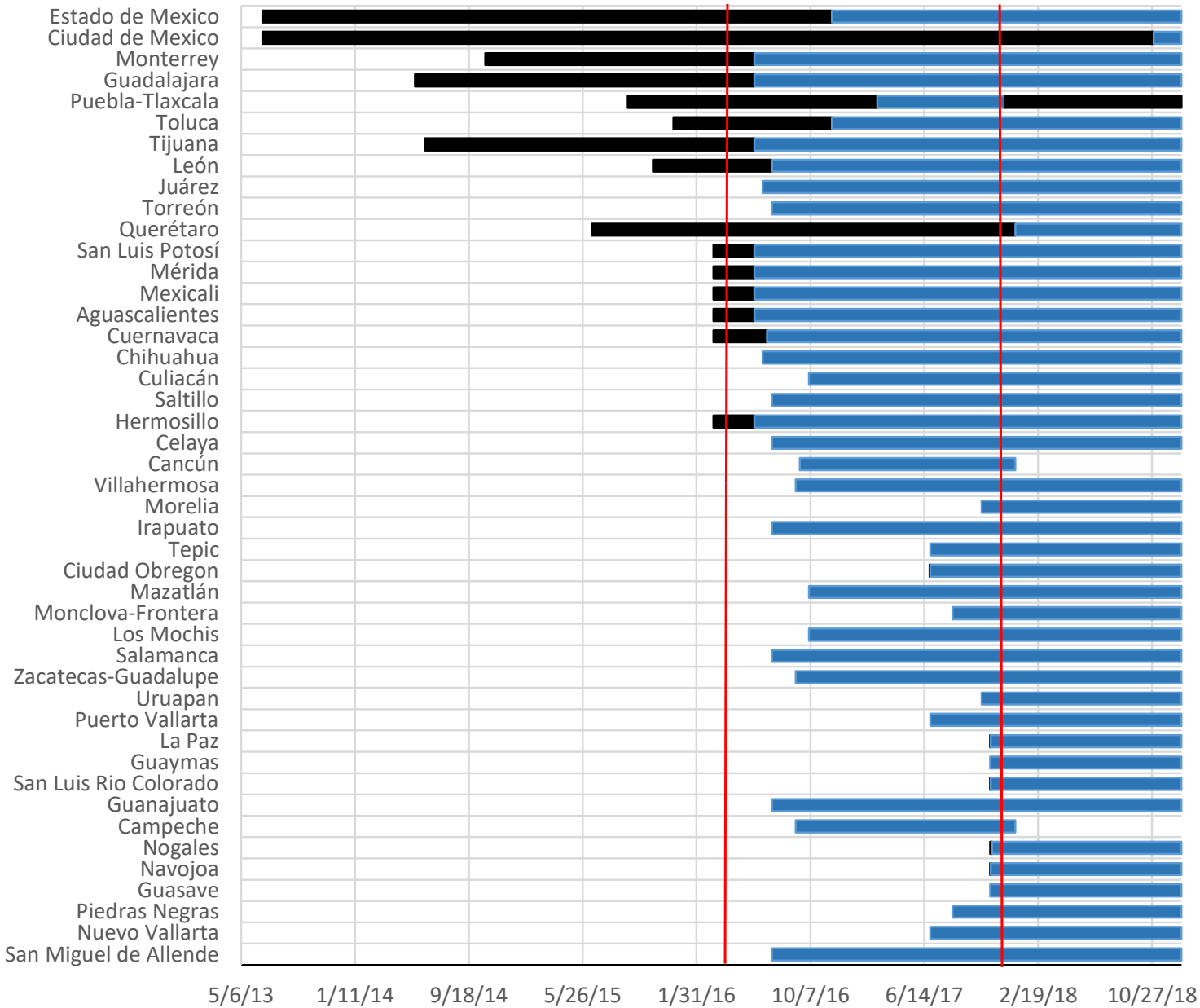


Outline

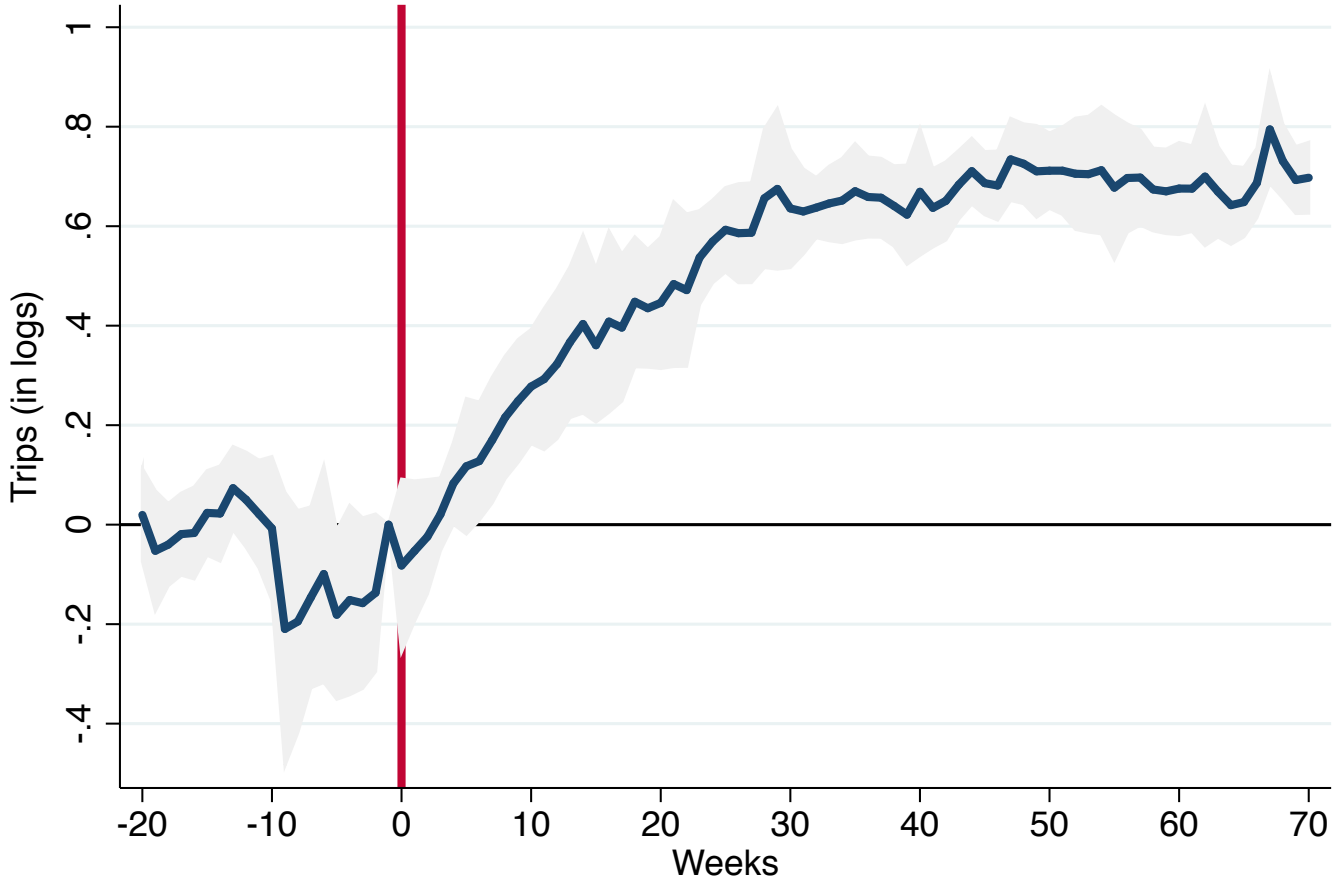
Uber Mexico: Share of fares paid in cash



Uber Mexico: timeline of cash introduction

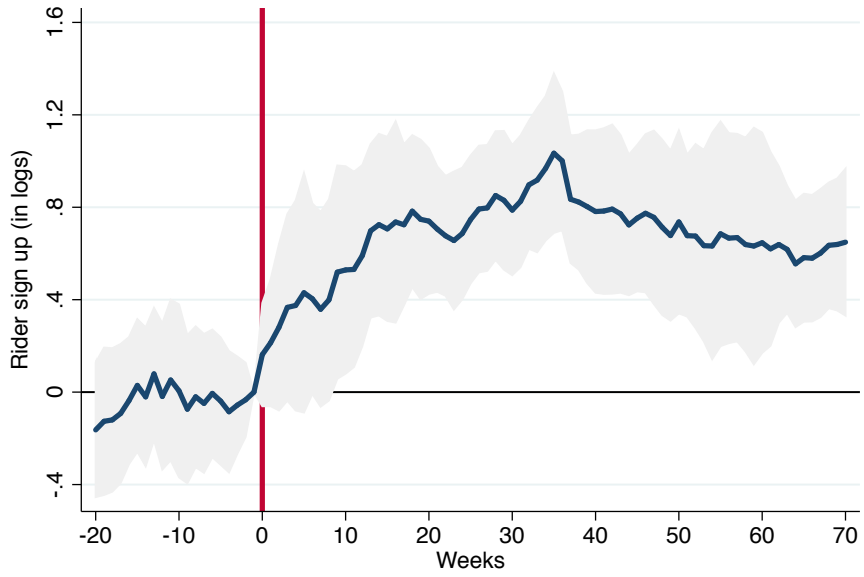


Event study: total trips

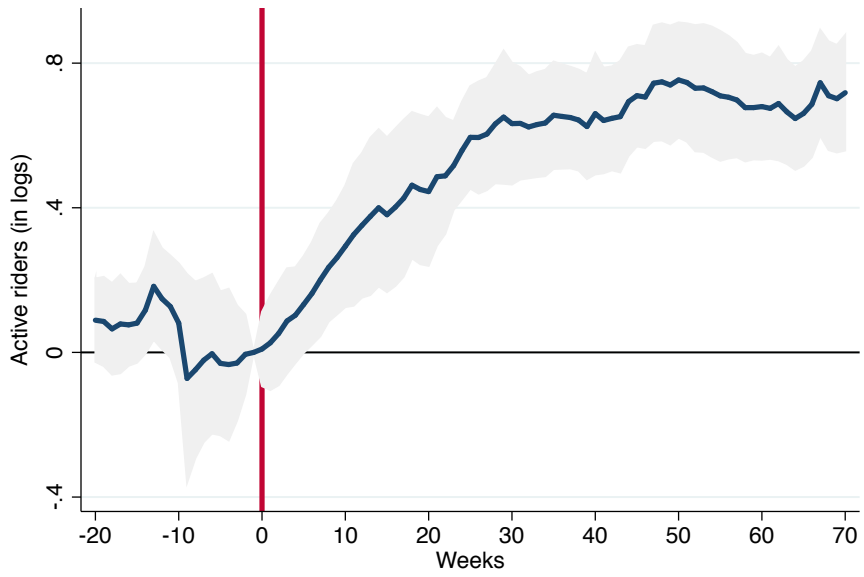


- Trips, miles, and fares more than double after the introduction of cash.

Event study: riders



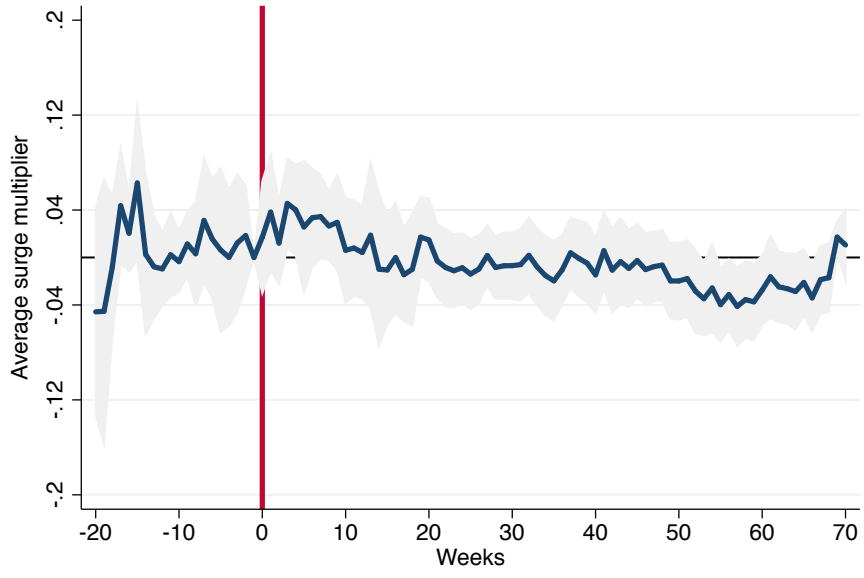
(a) Rider Sign Ups



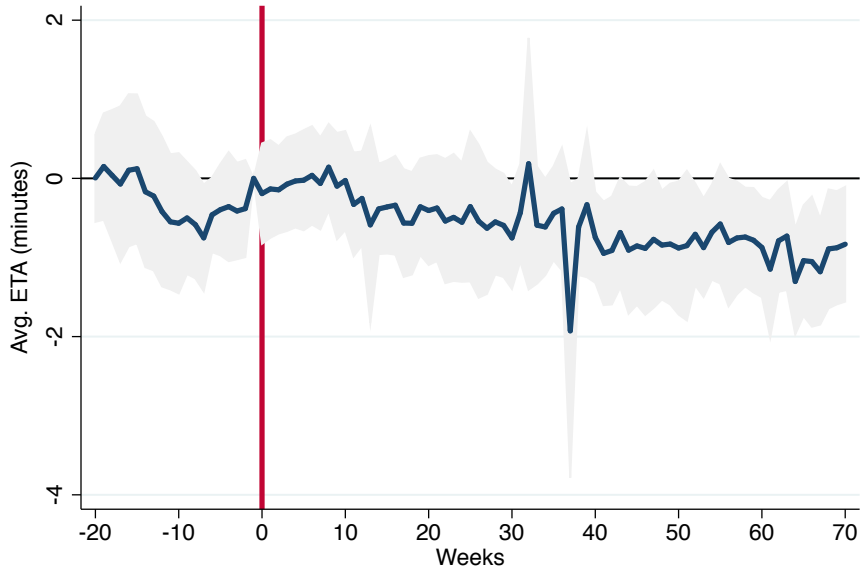
(b) Active Riders

- Increase in trips by both new and existing riders.

Event study: prices



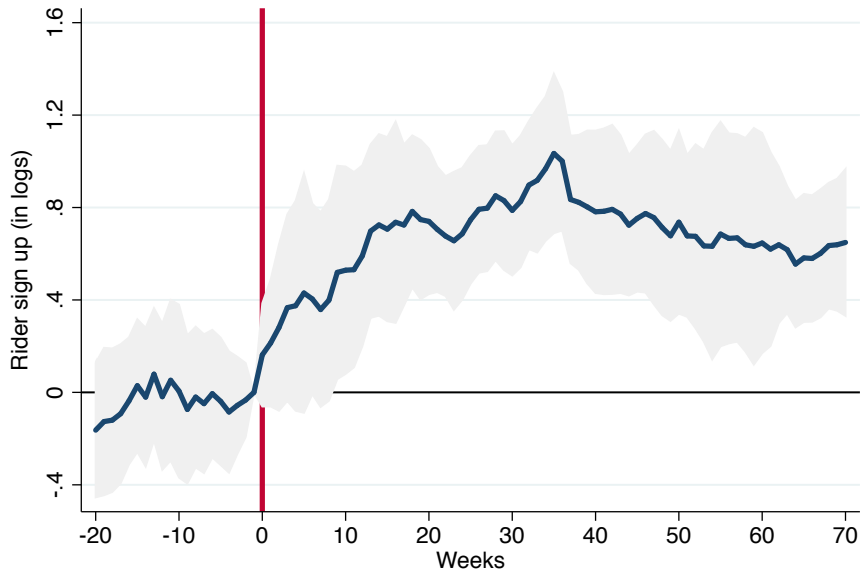
(a) Surge Multiplier



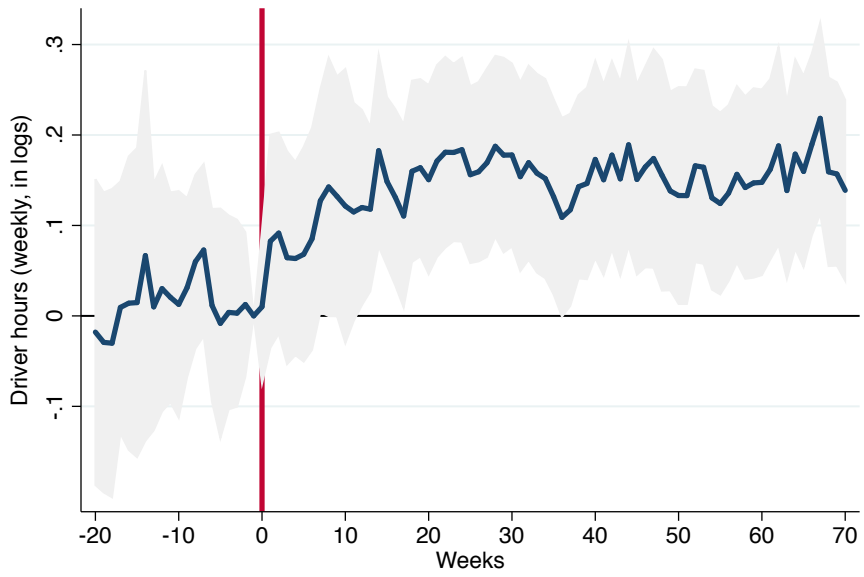
(b) Estimated Time of Arrival

- Prices remain mostly constant after the introduction of cash.

Event study: drivers



(a) Driver Sign Ups



(b) Driver Hours

- Increase in driver hours compensated increase in demand.

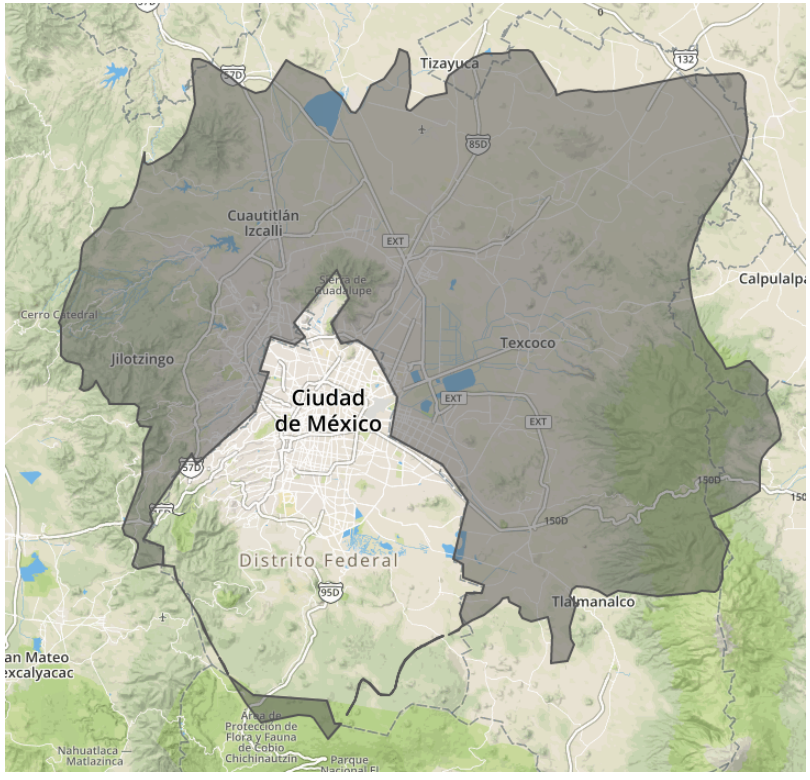
Event study: other results ▸ Other Results

- Supply curve very elastic
  - Uber data: no evidence of changes in prices or ETAs.
  - CPI taxi prices: no evidence of changes in the prices of substitutes. ▸ CPI
  - EC taximeter: no evidence of changes in the ETAs of substitutes. ▸ EC taximeter
  - Google Maps: no price changes after ban/reentry of cash (Panama). ▸ Google
- Marginal increase in driver's cancellation rate ▸ Canc. Rates

Outline

Mexico City: match geolocalized trips to census blocks

- All trips in Aug. 2016, 2017, & 2018.
- Assign each trip to the closest census block (80 $\times$ 80 mts).
- 56,554 blocks in Mexico City, 65,508 in the State of Mexico.
- Demographics at census blocks.

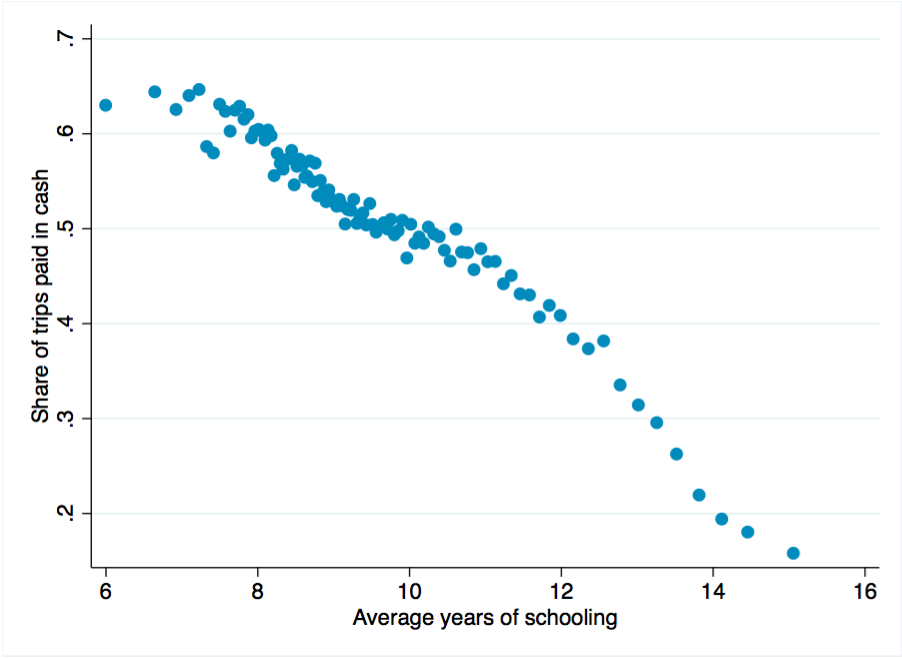


Cash introduced in **shaded area**

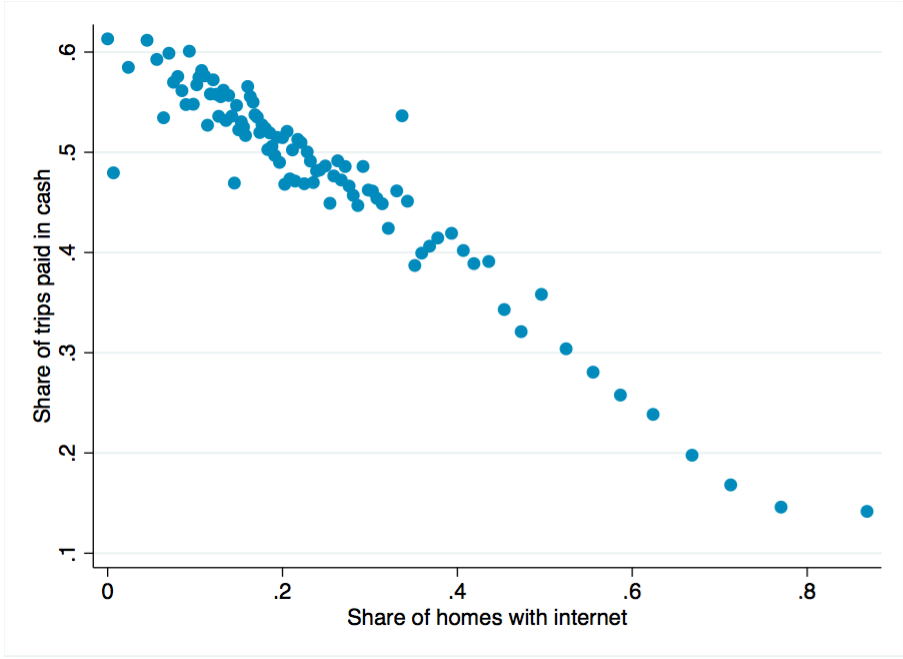
▸ Maps ▸ Matching ▸ Accuracy

Cash share and census blocks demographics

Other



(a) Education

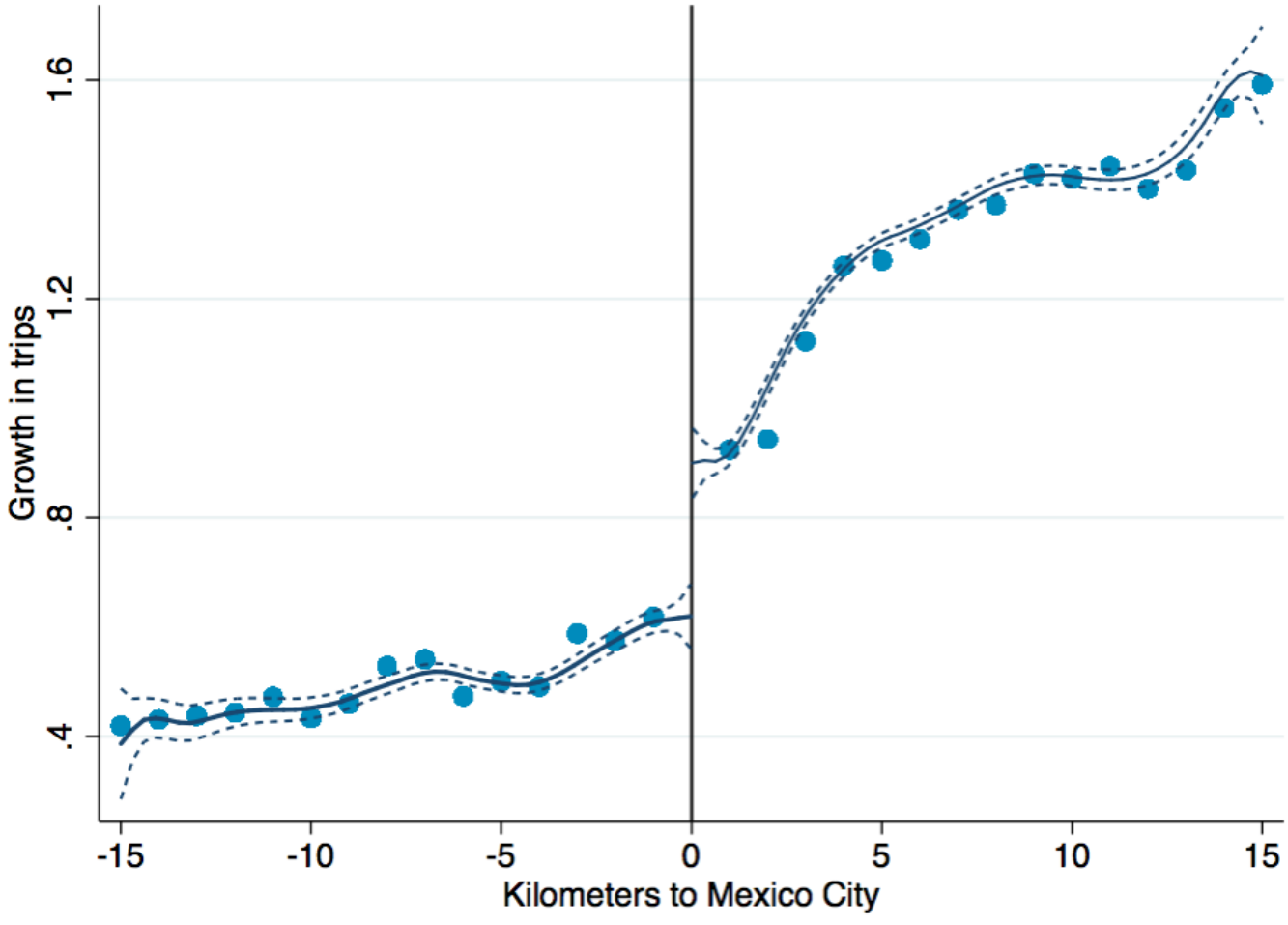


(b) Homes with internet

- Share of cash decreases with income and increases in suburban areas.

Growth rate before and after cash

▸ Users ▸ Observables ▸ DW



Mexico City

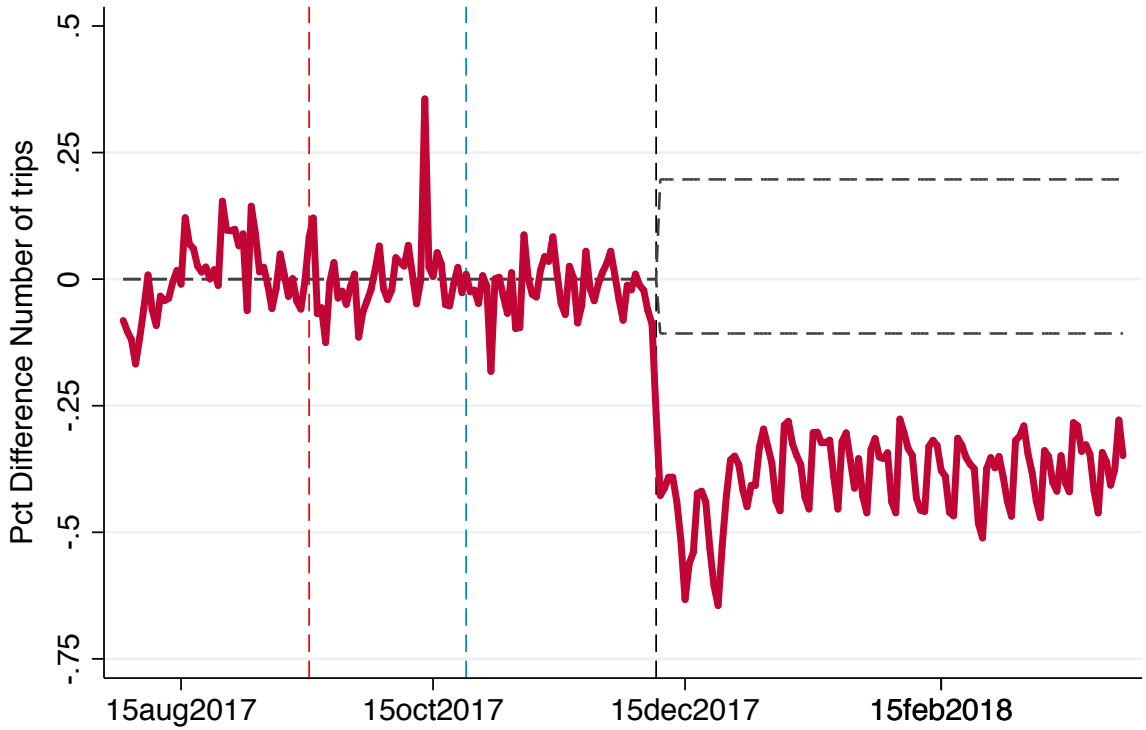
State of Mexico

Outline

Puebla: difference synthetic and actual

Details CEM

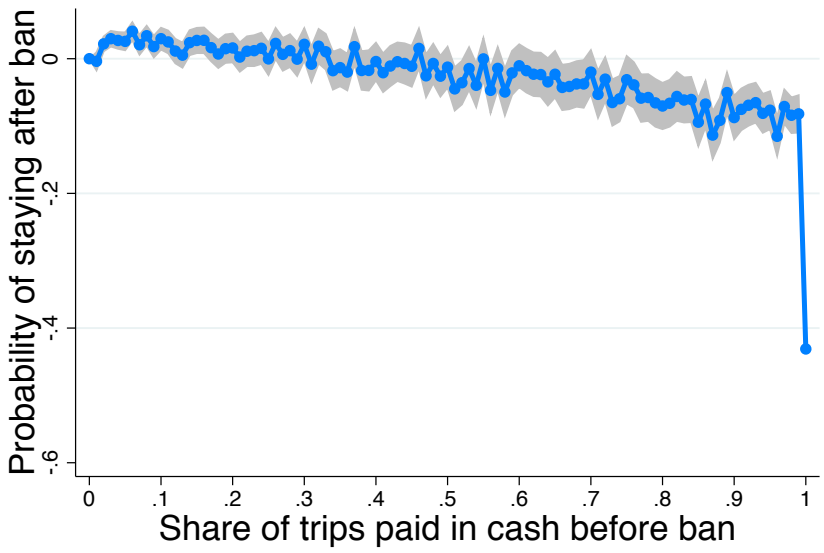
- Variables: Trips in cash (daily), fares (daily), trips (Sep 1st), Trips (Aug 15)
- SC weights: 0.05 (Qro), 0.45 (Gto), 0.42 (Mex), 0.07 (DF). RMSPE 0.001



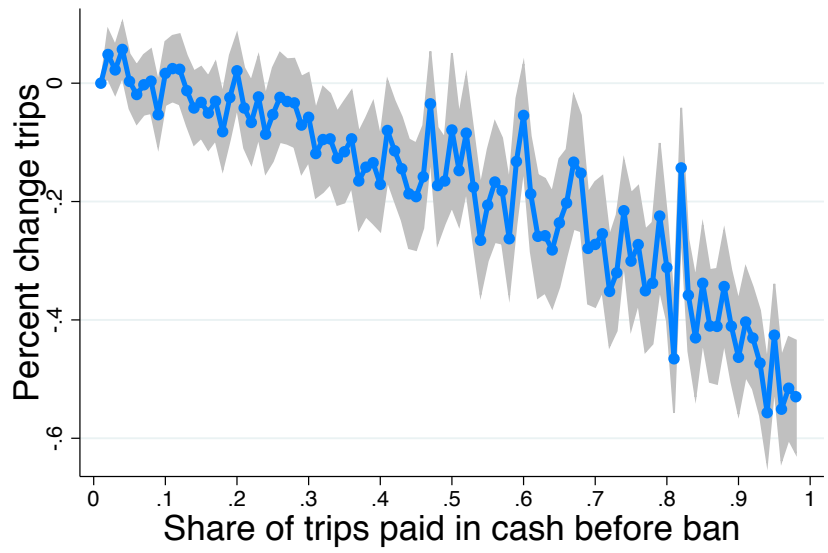
- 60% decrease of trips on impact, about 40% thereafter.
- No effect on prices. Prices

Extensive and intensive margin adjustment to Ban

(a) Probability of staying as an Uber user



(b) Percent change in trips



- Migration from pure cash to pure credit $\Rightarrow$ extensive margin
- Differential effects on mixed users $\Rightarrow$ cash-credit imperfect substitutes

Key takeaways

- Cash is heavily used: large effects of the introduction and ban on cash.
- Many mixed users.
- Imperfect substitution between cash and credit at both the intensive and extensive margins
- Supply curve elastic: small effect on credit users or producer surplus.

Outline

$$\mathcal{CS}_{ban} = \underbrace{\text{Loss from mixed users switching to pure credit}}_{\textbf{Intensive Margin}}$$

$$+ \underbrace{\text{Loss from pure cash users either dropping or switching to pure credit}}_{\textbf{Extensive Margin}}$$

$$\mathcal{CS}_{ban} = \int \mathbb{1}_c(1,1;\theta)[\underbrace{v(1,1;\phi)}_{\text{mixed}} - \underbrace{v(\infty,1;\phi)}_{\text{pure credit}}]\, dF(\theta)$$

$$+ \int (1 - \mathbb{1}_c(1,1;\theta))[\underbrace{v(1,\infty;\theta)}_{\text{pure cash}} - \underbrace{\mathcal{V}(\infty,1;\phi)}_{\text{pure credit vs no uber}}]\, dF(\theta)$$

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- In principle, estimate $\mathcal{CS}_{ban}$ increasing permanently p_a since:

$$\mathcal{CS}_{ban} = \int_1^{\infty} A(p_a,1)\, dp_a \text{ where}$$

$$A(p_a,1) = \int [\mathbb{1}_c(1,1;\theta)\, \tilde{a}(p_a,1;\phi) + (1 - \mathbb{1}_c(1,1;\theta))\, a^*(p_a,1;\theta)]\, dF(\theta)$$

$$\mathcal{CS}_{ban} = \int \mathbb{1}_c(1,1;\theta)[\underbrace{v(1,1;\phi)}_{\text{mixed}} - \underbrace{v(\infty,1;\phi)}_{\text{pure credit}}]\, dF(\theta)$$

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- In practice:
  - Price decreases for short periods of time (one week)
  - Combine 2 previous field experiments + three new ones + one natural one
  - Parametric model: CES across methods, demand with finite choke price

▸ Details

Outline

Experiments on mixed users

- Active users, with majority of trips in State of Mexico, 2+ trips in 2018.
- **Experiment 1: 10% or 20% off paying only cash, only credit or both**
  - Control 90 K, six treatment groups 11K each, balanced in observables.
  - Duration one week. Comms: e-mails at start + reminders, and alloy card.
  - Elasticity substitution cash-credit: $\eta \approx 3$
  - Composite Uber elasticity: $\epsilon \approx 1.1$

Elasticity of substitution* η

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
η	3.421***	3.156***	2.852***	3.239***	2.786***	2.786***	2.364***
	(0.363)	(0.340)	(0.177)	(0.213)	(0.103)	(0.103)	(0.078)
# Obs.	53,963	53,963	46,325	53,963	53,963	53,963	71,517
Controls	No	Yes	Yes	Yes	Yes	Yes	No
Type	1 pct Transf.	1 pct Transf.	5 pct Transf.	1 pct Transf. Constant	1 pct CES 1^{st}-order	1 pct CES 2^{nd}-order	1 pct IV $\hat{\alpha}$

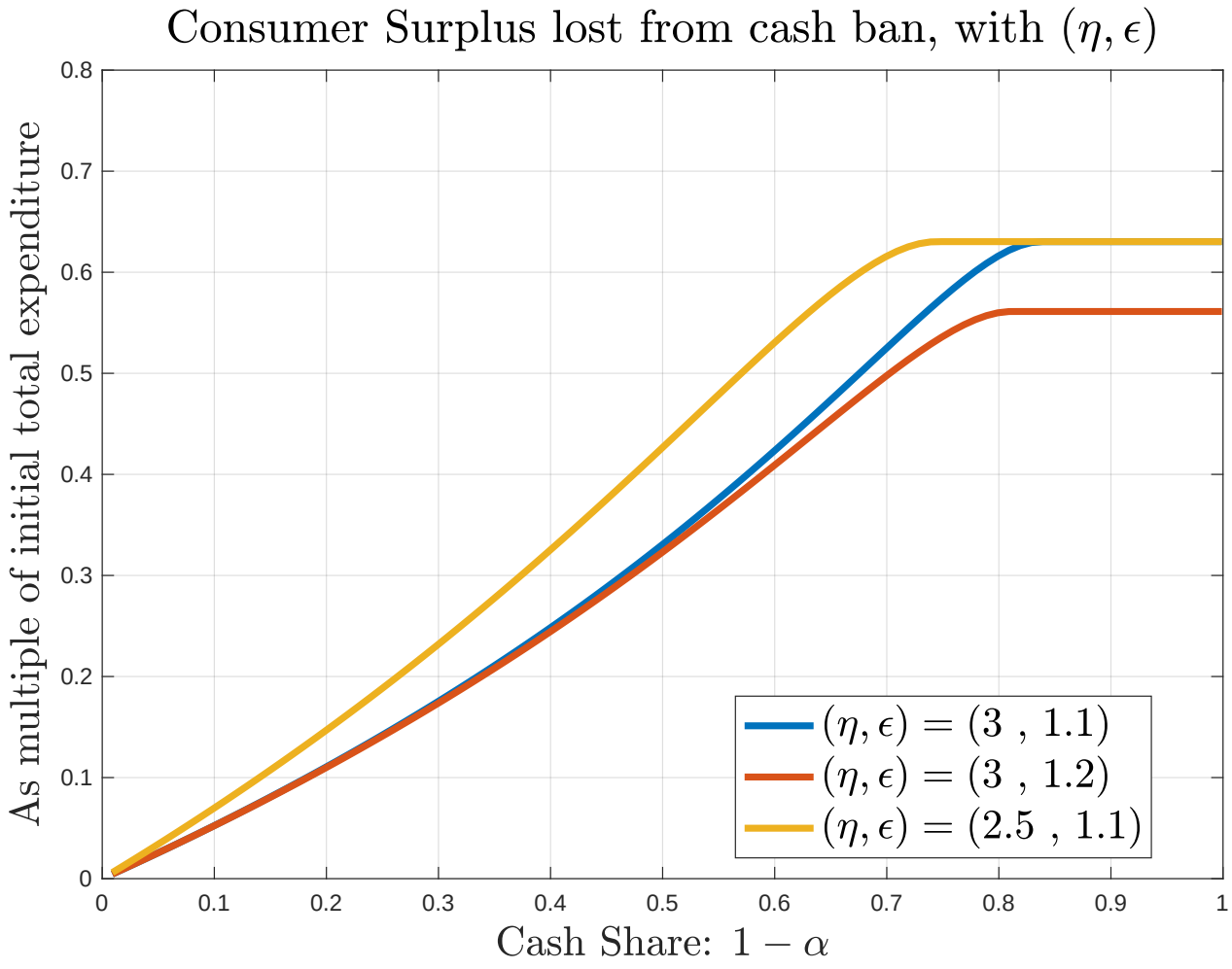
- Use variation on prices and estimated shares (α) from historical data
- Variations on share in experiment: $s_c = \alpha - (\eta - 1)\alpha(1 - \alpha)\ln(\frac{p_c}{p_a})$
- 1-5 pct: highest and lowest historical share excluded
- Robust to require at least 5 trips (to better estimate historical share)

Mixed users price elasticity ϵ (miles) ▸ Poisson ▸ Summary-Stats

	(1) AA	(2) AA	(3) AA	(4) Mandin	(5) Ubernomics
Elasticity	1.082***	1.030***	1.096***	1.278***	1.452***
	(0.103)	(0.086)	(0.093)	(0.075)	(0.296)
Observations	109,365	109,365	98,773	11,660	4,306
Controls	No	Yes	Yes	Yes	Yes
Type	1 pct	1 pct	5 pct	1 pct	1 pct

- Semi-log specification: $a_i = \beta_0 + \beta_1 \ln p_i$, elasticity ϵ evaluated at equilibrium prices (no discounts)
- 1-5 pct: highest and lowest historical share excluded
- AA: Alvarez-Argente, Mandin & Ubernomics two other Uber price experiments in Greater Mexico. Mandin last 4-weeks

Mixed users: consumer surplus lost from cash ban



- CS for mixed users $\approx$ 25 % of total fares.
- CS mixed users $\approx$ 60 % of fares paid in cash (share of cash $\approx$ 0.42).

Experiments on pure cash users

- Active users, with majority of trips in State of Mexico, 2+ trips in 2018.
- **Experiment 2: 10%, 15%, 20% and 25% off**
  - Control 56 K, four treatment groups 23K each, balanced in observables.
  - Duration one week. Comms: e-mails at start + reminders, and alloy card.
  - $\epsilon \approx 1.4$.
- **Natural experiment: Panama, price increases** ◂ Panama
- **Survey Instrument: choke prices** ◂ Survey

Pure cash users price elasticity (miles) ▸ Poisson

	(1) AA	(2) AA	(3) Mandin	(4) Ubernomics
Elasticity	1.375***	1.383***	1.113***	0.813**
	(0.101)	(0.078)	(0.165)	(0.414)
Observations	138,725	138,725	4,279	3,569
Controls	No	Yes	Yes	Yes

- Semi-log Specification $a_i = \beta_0 + \beta_1 \ln p_i$, elasticity ϵ evaluated at equilibrium prices (no discounts)
- AA: Alvarez-Argente, Mandin & Ubernomics two other Uber price experiments in Greater Mexico. Mandin last 4-weeks

Extensive margin correction ▸ Migration ▸ Moments

- **Experiment 3: rewards if they register card**.
  - Rewards $\approx$ 3, 6 and 9 average weekly fares (1, 2, & 3 avg. trips).
  - Two different horizons to register card, 1 week or 6 weeks.
  - Comms: e-mails at start + reminders, and alloy card.
- **Natural experiment: Puebla**
  - 30 % of cash riders become credit riders after ban.
  - those riders decrease the number of trips taken after ban
- Use Puebla & RCT's to estimate distribution of fixed cost ψ. ▸ Details

Experiment 3: adopting/registering credit card *

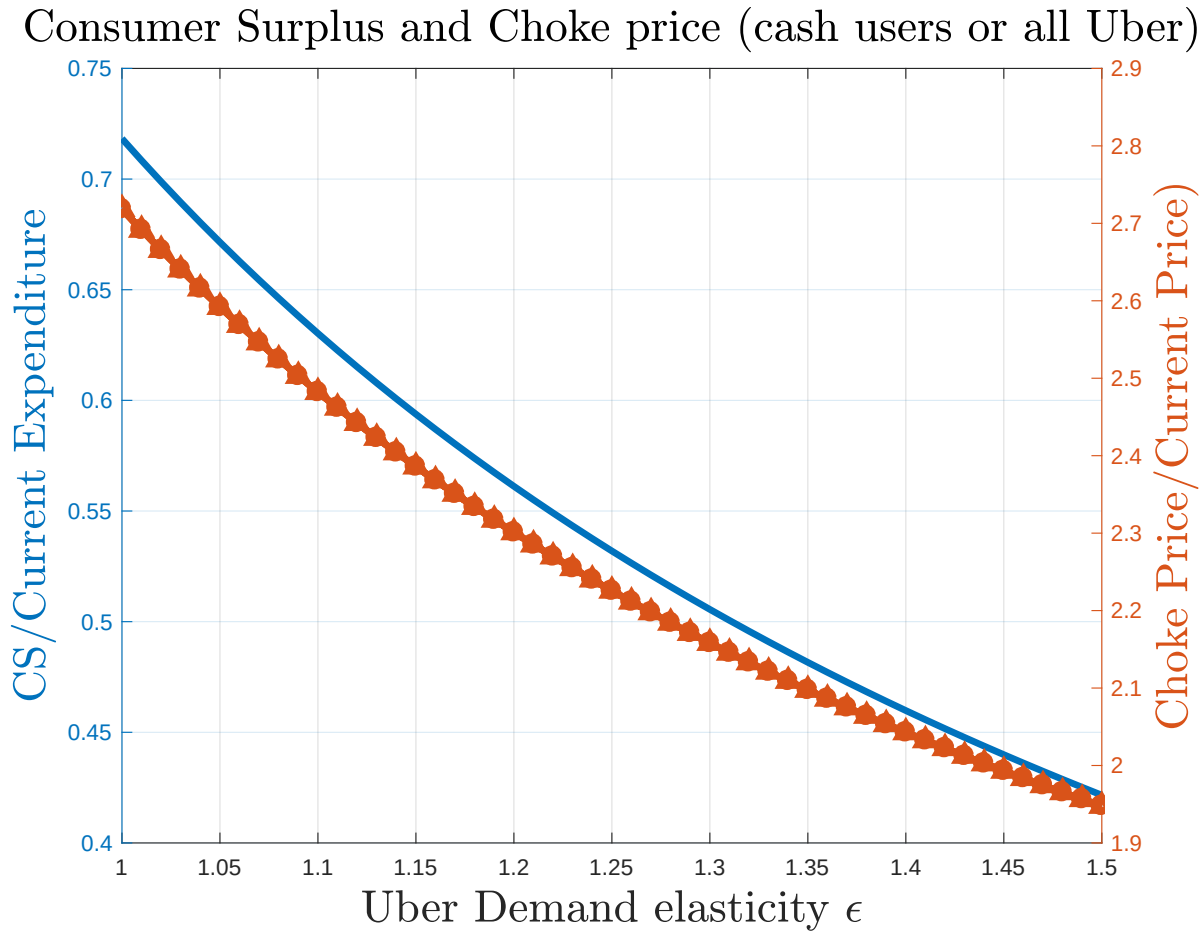
Graph

Migrate	(1) 1 week	(2) 1 week	(3) 1-6 weeks	(4) 1-3 weeks	(5) 4-6 weeks
Treatment 1 - 1 week	0.0241***				
	(0.004)				
Treatment 2 - 1 week	0.0269***				
	(0.004)				
Treatment 3 - 1 week	0.0366***				
	(0.004)				
Treatment 1 - 6 week		0.0166***	0.0333***	0.0283***	0.0112***
		(0.004)	(0.004)	(0.004)	(0.003)
Treatment 2 - 6 week		0.0217***	0.0394***	0.0382***	0.0088***
		(0.004)	(0.004)	(0.004)	(0.003)
Treatment 3 - 6 week		0.0390***	0.0468***	0.0485***	0.0088***
		(0.004)	(0.004)	(0.004)	(0.003)
Constant (control)	0.0272***	0.0272***	0.0711***	0.0445***	0.0372***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Observations	20,609	20,677	46,996	36,184	46,996
R-squared	0.005	0.005	0.005	0.006	0.001

- Treatment # $\approx$ free trips given as reward for registering card
- Conditional on making a trip since start of experiment

Unconditional

CS lost: pure cash riders ▸ formula



- 65% leave Uber, Consumer Surplus $\approx$ 0.49 Expenditure
- 30% pure users pay cost ψ change to pure credit, and take fewer trips.
- Average CS $\approx$ 0.47 Expenditure

Outline

Summary and conclusions

- Cash: large increases in trips, fares, miles, riders, and drivers.
  - Mostly so in suburban areas, less bancarized areas, low-income riders.
  - Increase in the conversion rate to credit after ban.
- Consumer Surplus > 50% of total fares paid in cash
  - Large number of mixed users (50%)
  - Low estimates for the cash-credit elasticity of substitution ($\eta \approx 3$).
  - Supply of trips very elastic.
  - Low price elasticity of mixed & pure cash users (ϵ in 1-1.4 range)
  - Costly to register card for pure-cash users, lower bound $\psi \approx$ 28 USD/year
- Related work (now forthcoming):
  - Cash-management in times of COVID-19 (US, Chile, Argentina).
  - Impact of cash on crime and tax evasion (Mexico).

Event study

- Data: 15 cities from April 4th, 2016 to Dec. 4th, 2017.
- Y_{it}: outcome variable for city i and time t (e.g. number of trips, total fares, cancellation rate, average surge multiplier, number of active drivers, etc).

$$Y_{it} = \alpha + \sum_{k=-\infty}^{\infty} \gamma_k \mathbb{1}\{K_{it} = k\} + \theta_i + \lambda_t + \zeta X_{it} + \epsilon_{it}$$

- θ_i: city fixed effects.
- λ_t: time fixed effects.
- K_{it}: number of periods relative to the introduction of cash.
- X_{it}: city-specific time varying controls (e.g. unemployment rate, average income of the population, level of precipitation, tenure of Uber in city).
- DK standard errors (clustered at city level and NW-like on time).

Effect of introduction of cash on State of Mexico

- Growth rate in trips (fares) at the census block level.
- Using Mexico City's blocks as counterfactual:
  - Average Treatment Effect: Coarsened Exact Matching. ▸ CEM ▸ OLS
    - match each block in terms of 4 observables
    - compare growth rate of State of Mexico w/ matched City of Mexico
- Average Effect $\approx$ 100% (State of Mexico is low cash intensity).
- No effect on prices.

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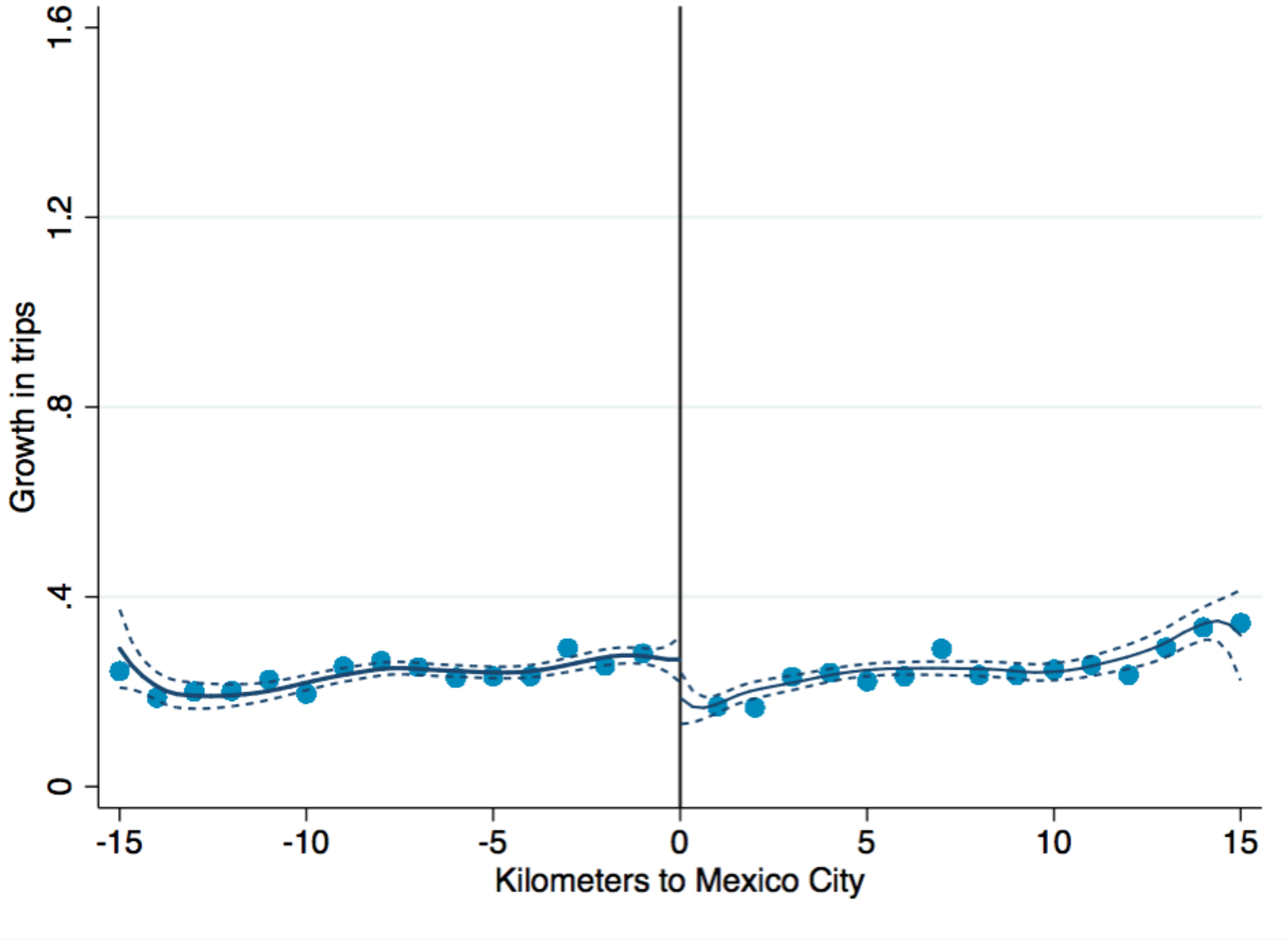
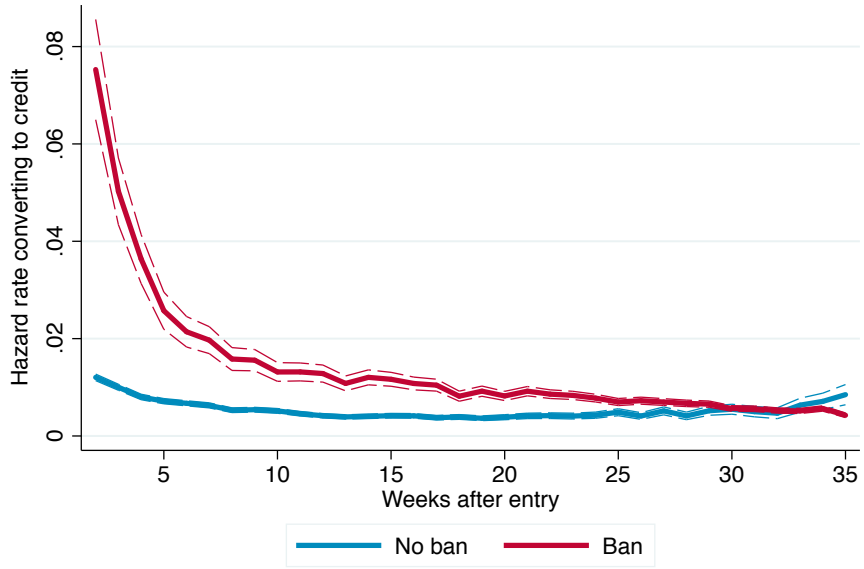
- Average Effect $\approx$ 100% (State of Mexico is low cash intensity).
- No effect on prices.
- Local treatment effect: Regression discontinuity design ▸ RDD

Growth rate after cash: placebo (no change in means of payments)

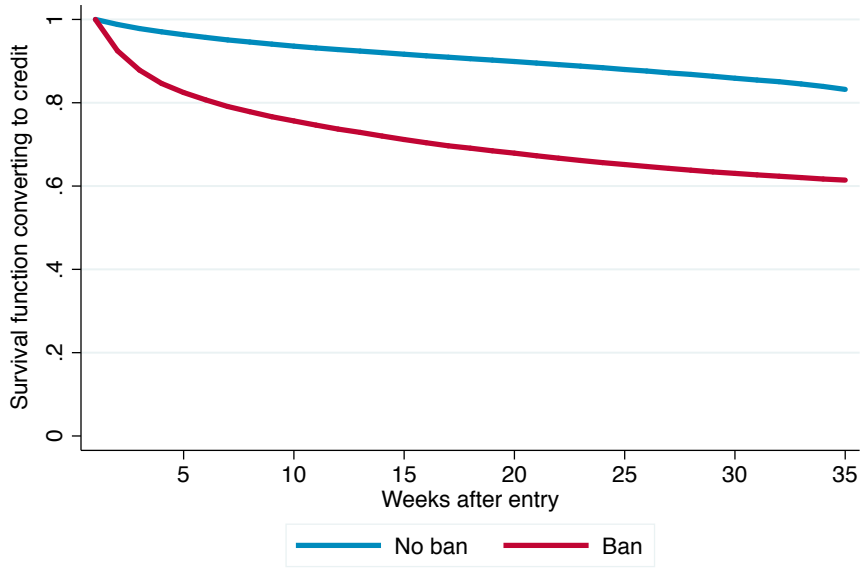


Survival function and hazard rate before and after ban

- Users that first used the application from the week cash was introduced.
- Last cohort considered those that enter the week of the ban.



(a) Hazard rate



(b) Survival function

- Summary: 30 % extra migrations:
  pure cash users before ban $\rightarrow$ pure credit users after ban.

Uber rider's preferences

- There are $n+1$ goods, x_1 is composite Uber rides.
- $(x_2, \ldots, x_n)$ are closed-substitutes and complements to Uber rides.
- Quasi-linearity: good $n+1$ represent the rest of the goods

$$u(x_1, x_2, \ldots, x_n; \phi) + x_{n+1}$$

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- Composite rides are given by CRTS: $x_1 = H(a, c; \phi)$ where

  a Uber trips paid in cash and c Uber trips paid in credit

- Fixing other prices: $p_2, \ldots, p_n$ define indirect utility function:

$$v(p_a, p_c, p_2, p_3, \ldots, p_n; \phi) = \max_{a,c,x_2,\ldots,x_{n+1}} u\left(H(a, c; \phi), x_2, \ldots, x_n\right) + x_{n+1}$$

$$\text{subject to } p_a a + p_c c + \sum_{i=2}^{n} p_i x_i + x_{n+1} \leq I$$

Uber rider's problem, cont.

▸ Indirect Utility ▸ Demand Functions ▸ Test quasi linear

- The full problem for the rider is:

$$\mathcal{V}(p_a, p_c; \theta) \equiv \max \{ v(p_a, p_c; \phi) - \psi \,,\; v(p_a, \infty; \phi) \} \tag{1}$$

where the type is $\theta = (\psi, \phi)$.

Uber rider's problem, cont.

▸ Indirect Utility ▸ Demand Functions ▸ Test quasi linear

- The full problem for the rider is:

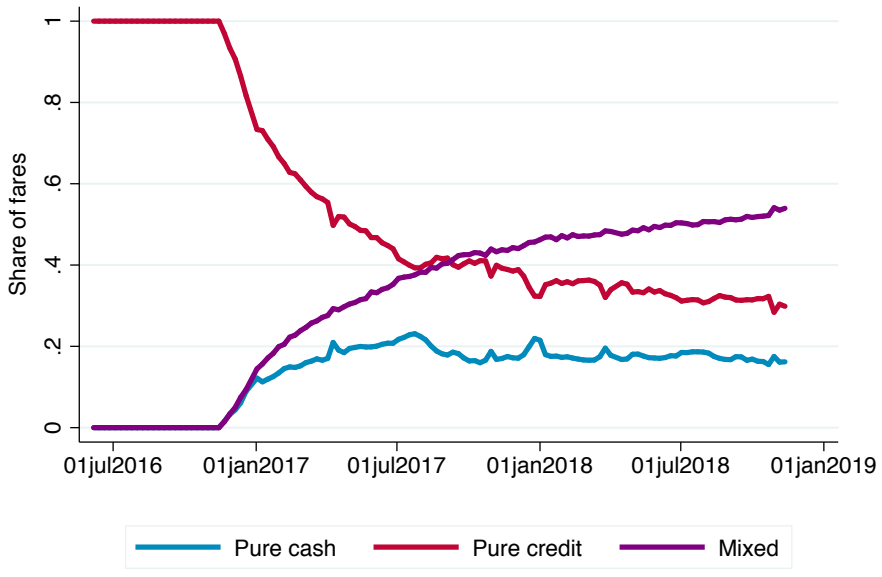
$$\mathcal{V}(p_a, p_c; \theta) \equiv \max \{ v(p_a, p_c; \phi) - \psi, \; v(p_a, \infty; \phi) \} \tag{1}$$

  where the type is $\theta = (\psi, \phi)$.

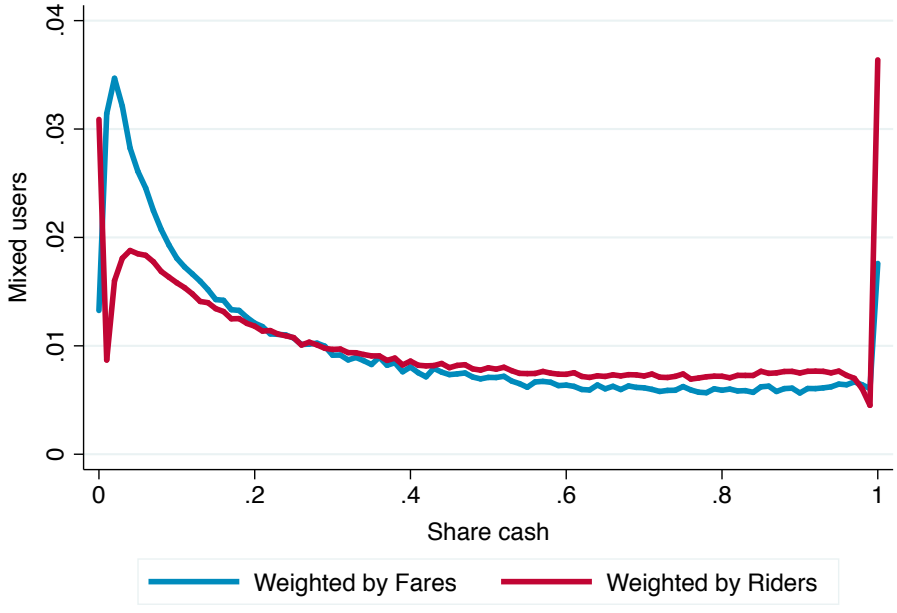
- Indicator that is optimal to adopt credit card: $\mathbb{1}_c(p_a, p_c; \theta)$
- $\tilde{a}(p_a, p_c, \phi)$ demand assuming that rider has credit card
- $a^*(p_a, p_c, \theta)$ demand taking into account extensive margin decision
- Let F be the implied distribution of types θ.
- Normalize baseline length of trips so that $p_a = p_c = 1$.

Mixed users: State of Mexico

▸ Individual level



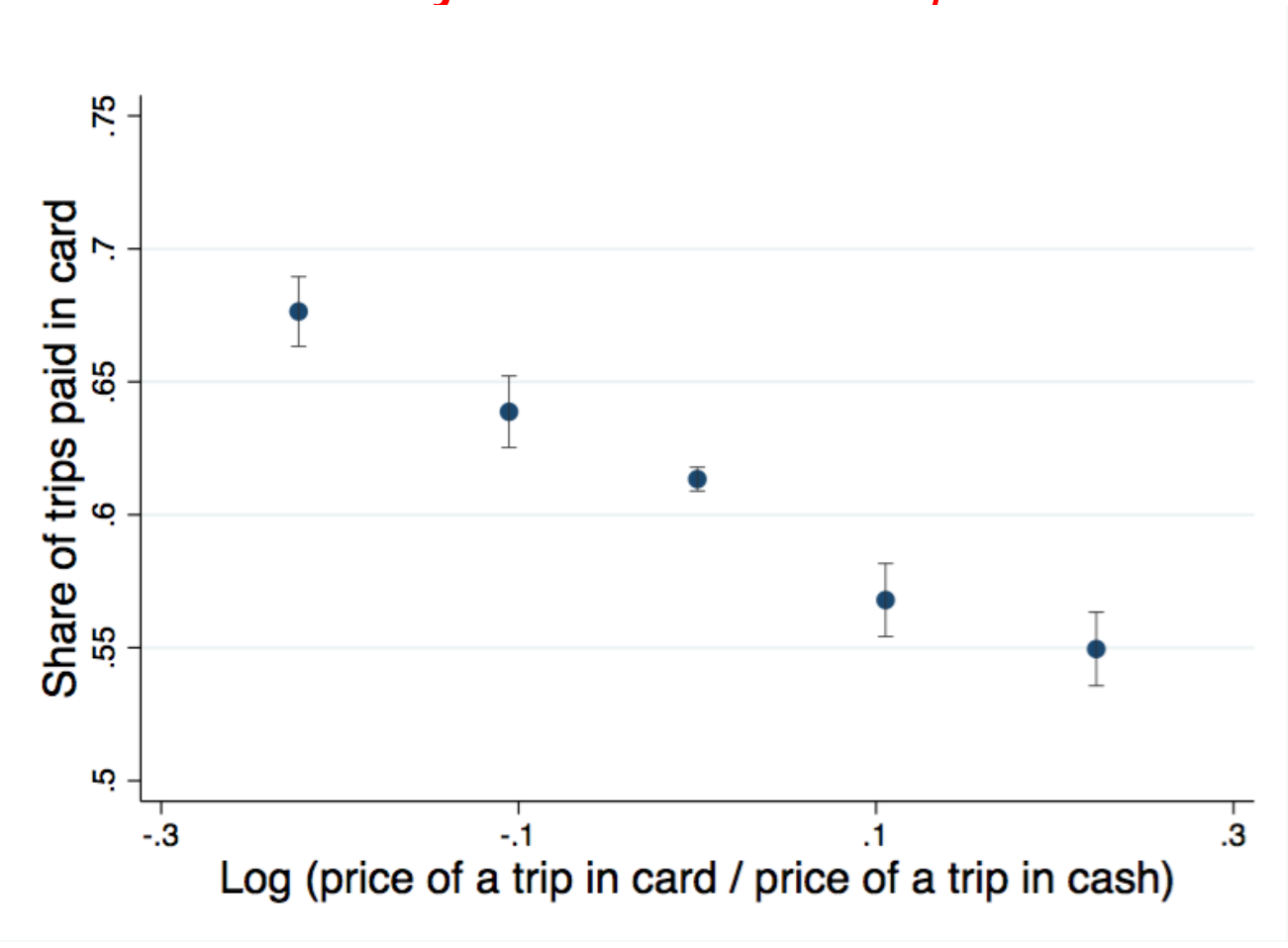
(a) Distribution of Fares by Type of User



(b) Cash share - Mixed Users

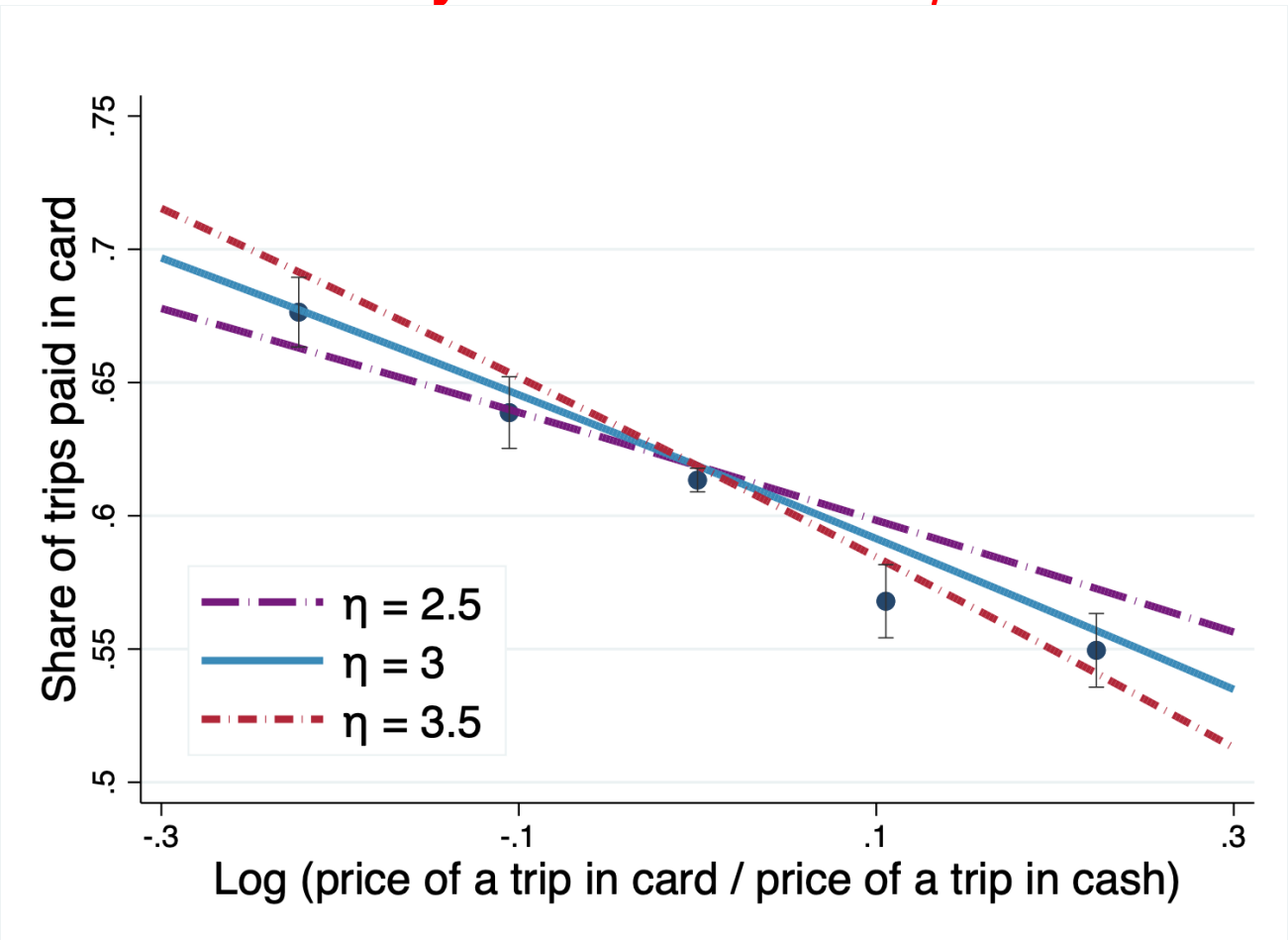
- 30% fares (25% users) pure credit
- 50% fares (50% users) mixed users
- 20% fares (25% users) pure cash

Mixed users: elasticity substitution η



- Share credit s_c riders (> 0), during experiment, facing prices $\frac{p_c}{p_a}$.

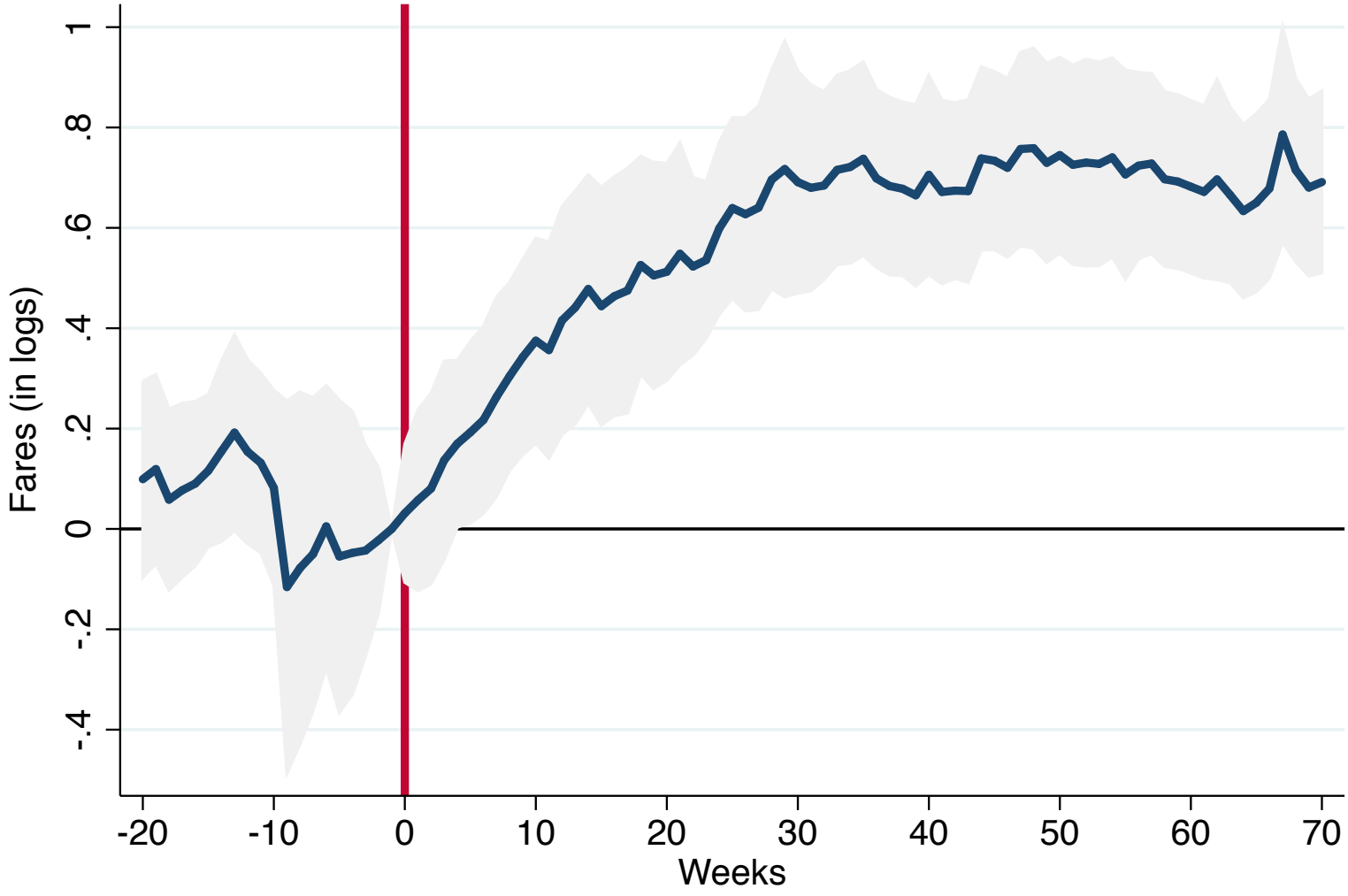
Mixed users: elasticity substitution η



- Share credit s_c riders (> 0), during experiment, facing prices $\frac{p_c}{p_a}$.
- Historical distribution of α (share at equal prices)
- $s_c = \alpha - (\eta - 1)\alpha(1-\alpha)\ln\left(\frac{p_c}{p_a}\right) + \frac{1}{2}(1-\eta)^2\alpha(1-\alpha)(1-2\alpha)\ln\left(\frac{p_c}{p_a}\right)^2$

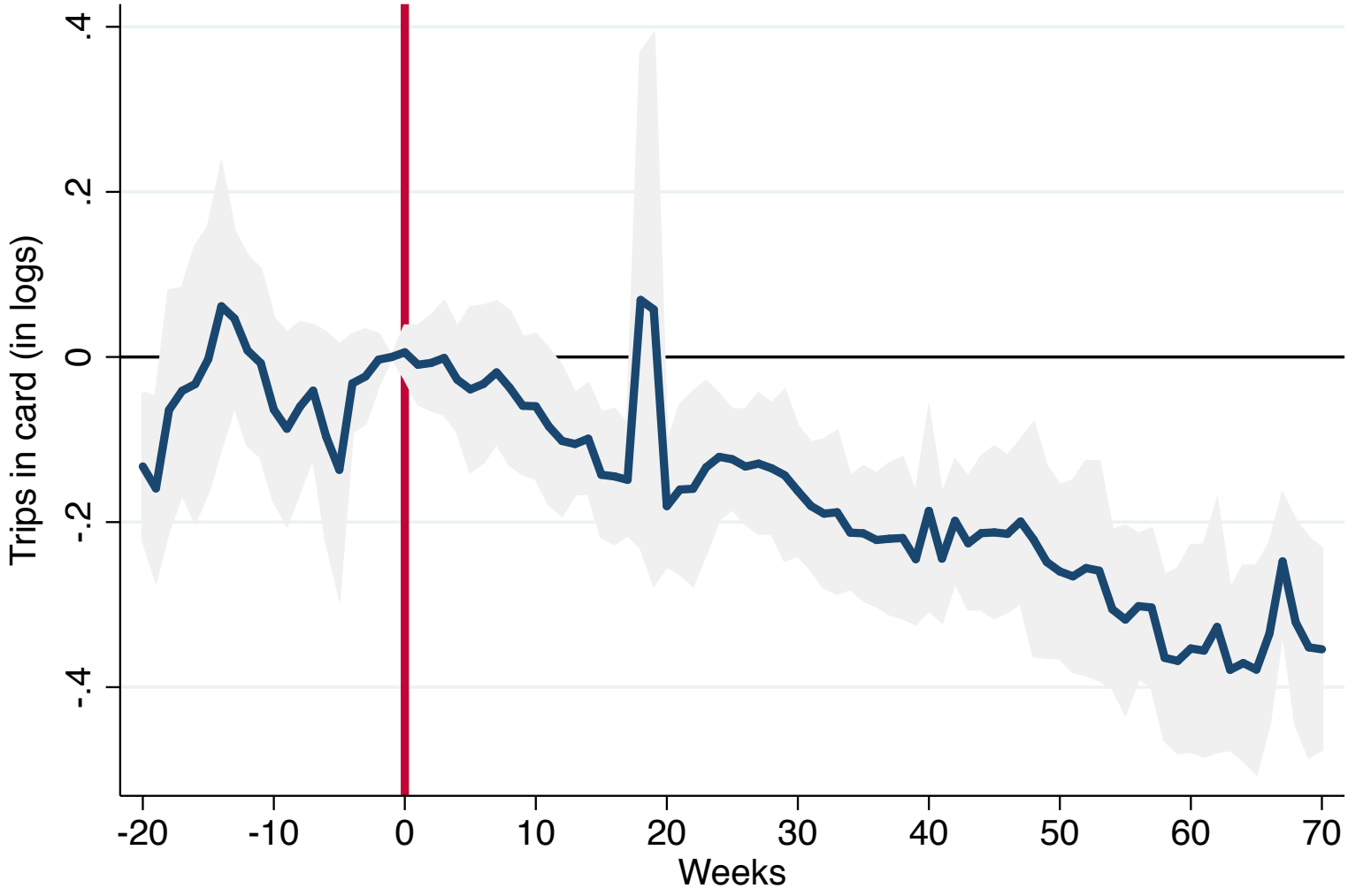
Event study: total fares

Back



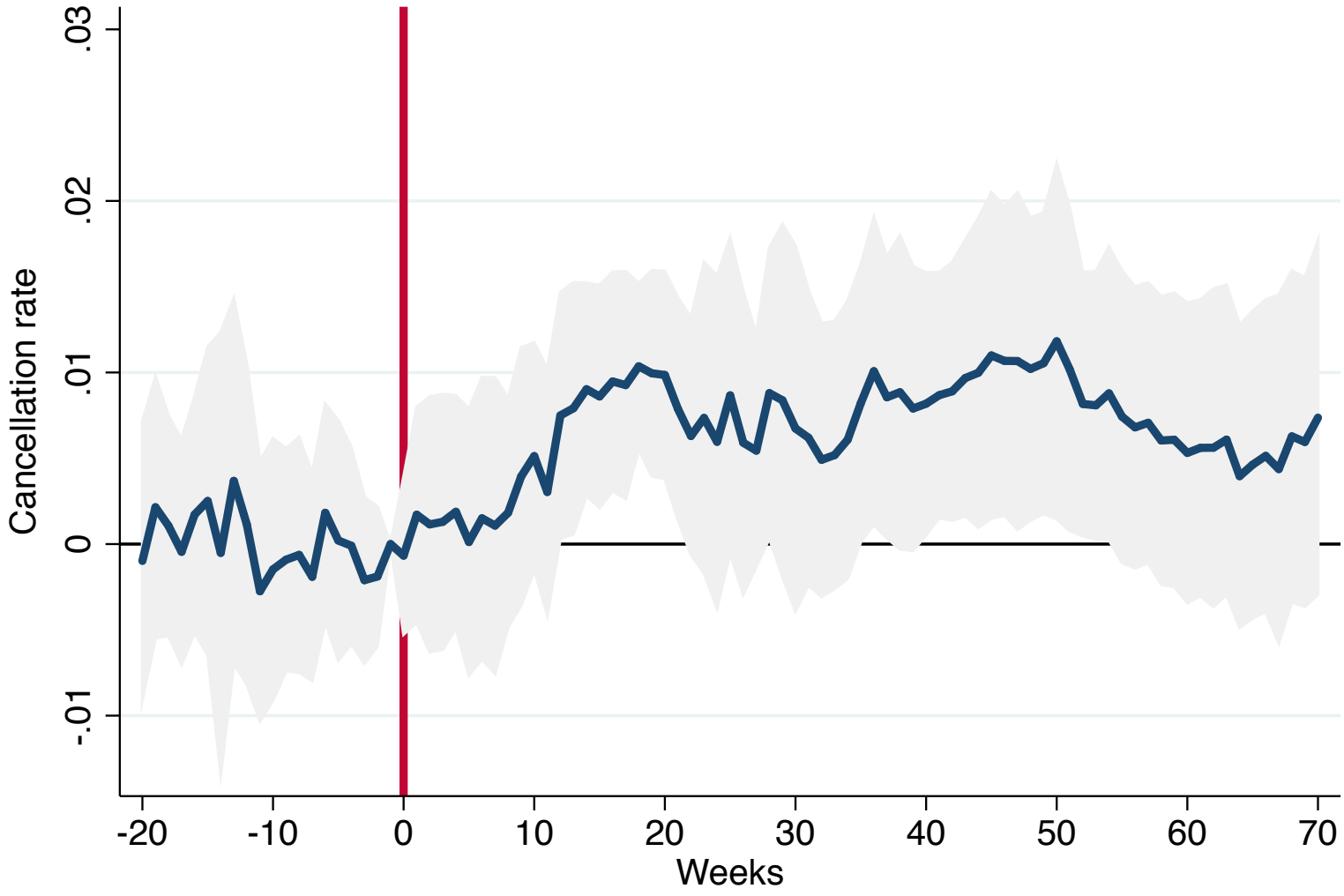
Event study: total trips paid in credit

Back



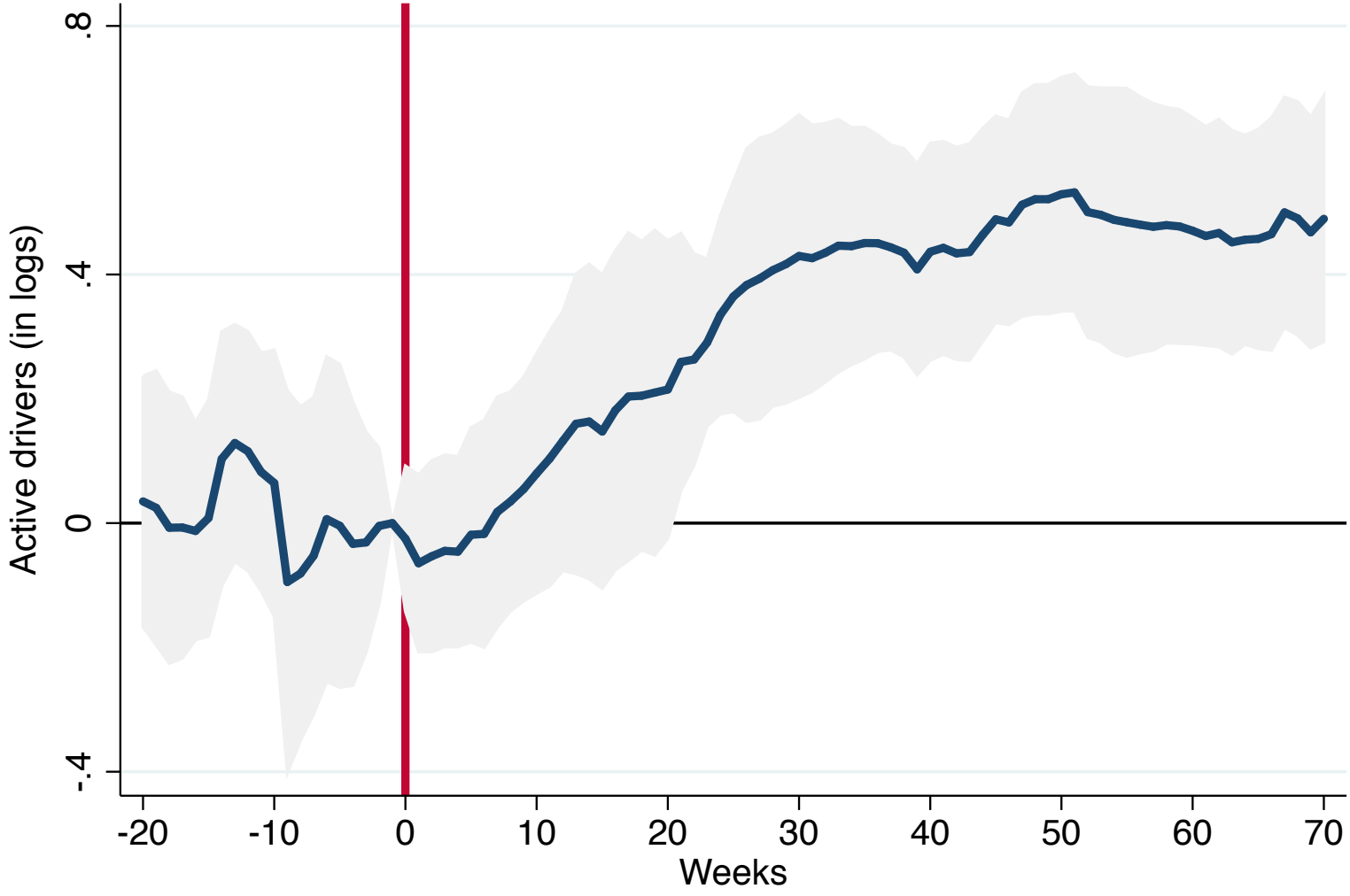
Event study: cancellation rate (avg. approx. 3%)

Back



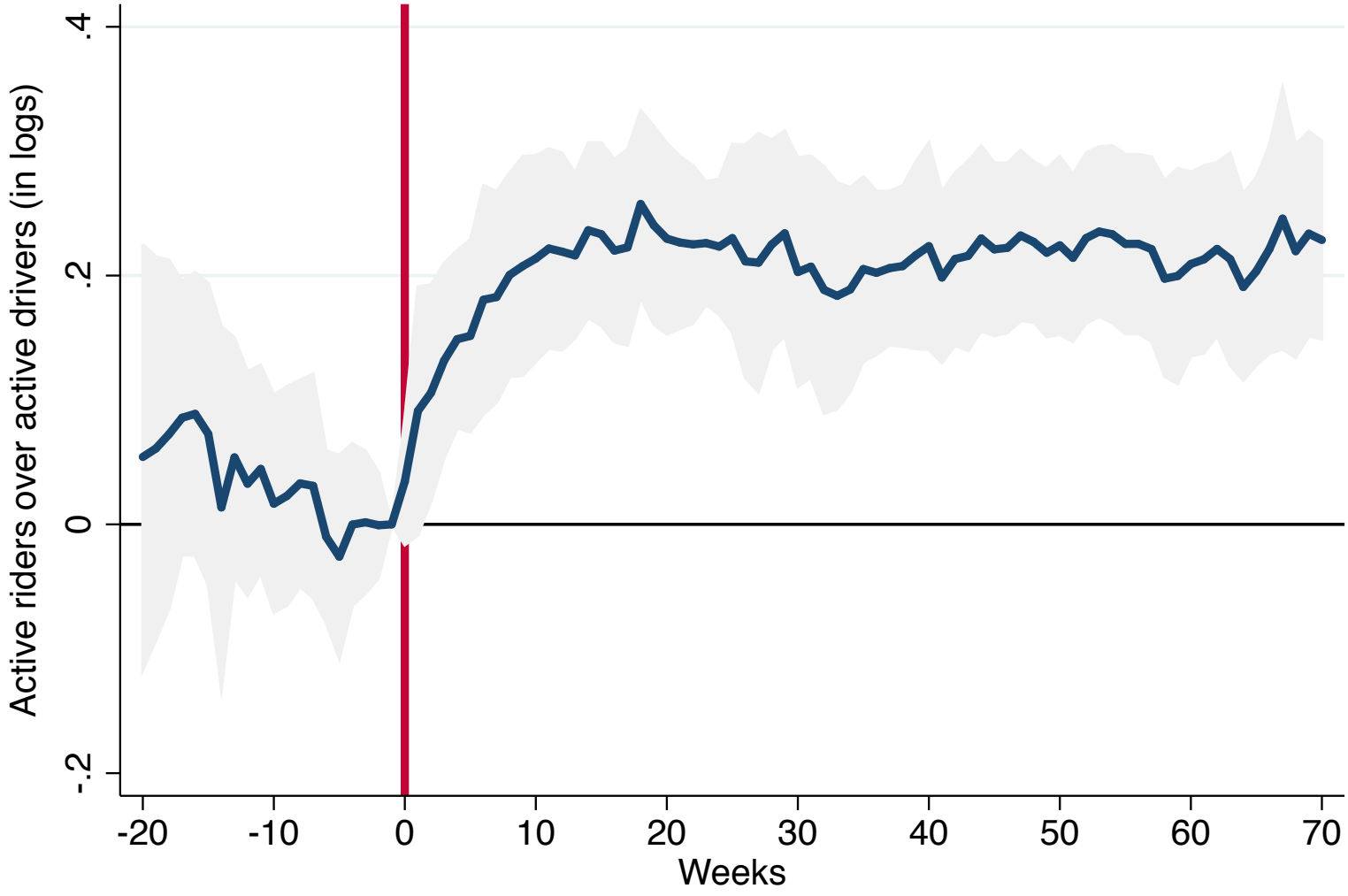
Event study: active drivers

Back



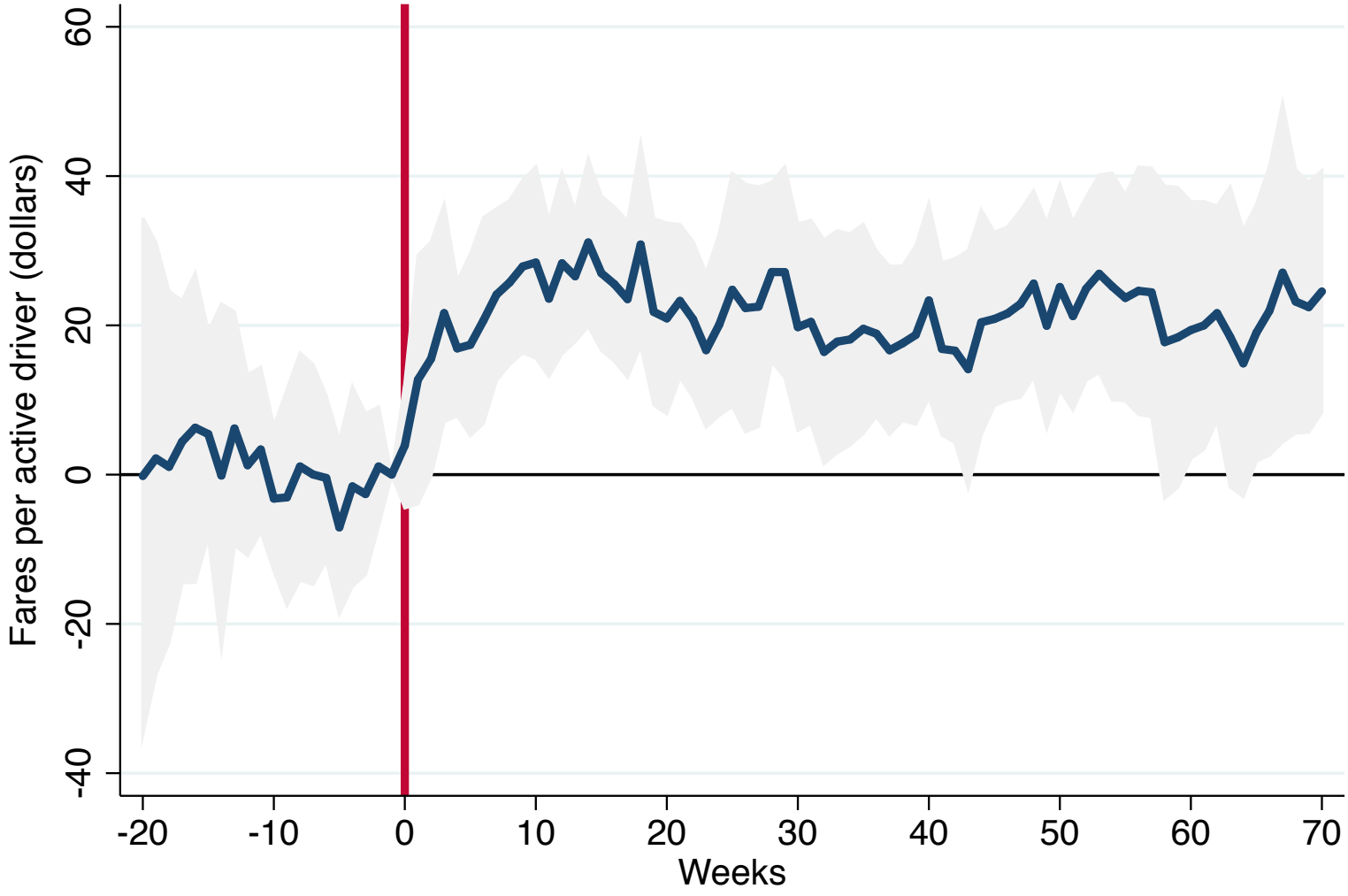
Event study: active riders over drivers

Back



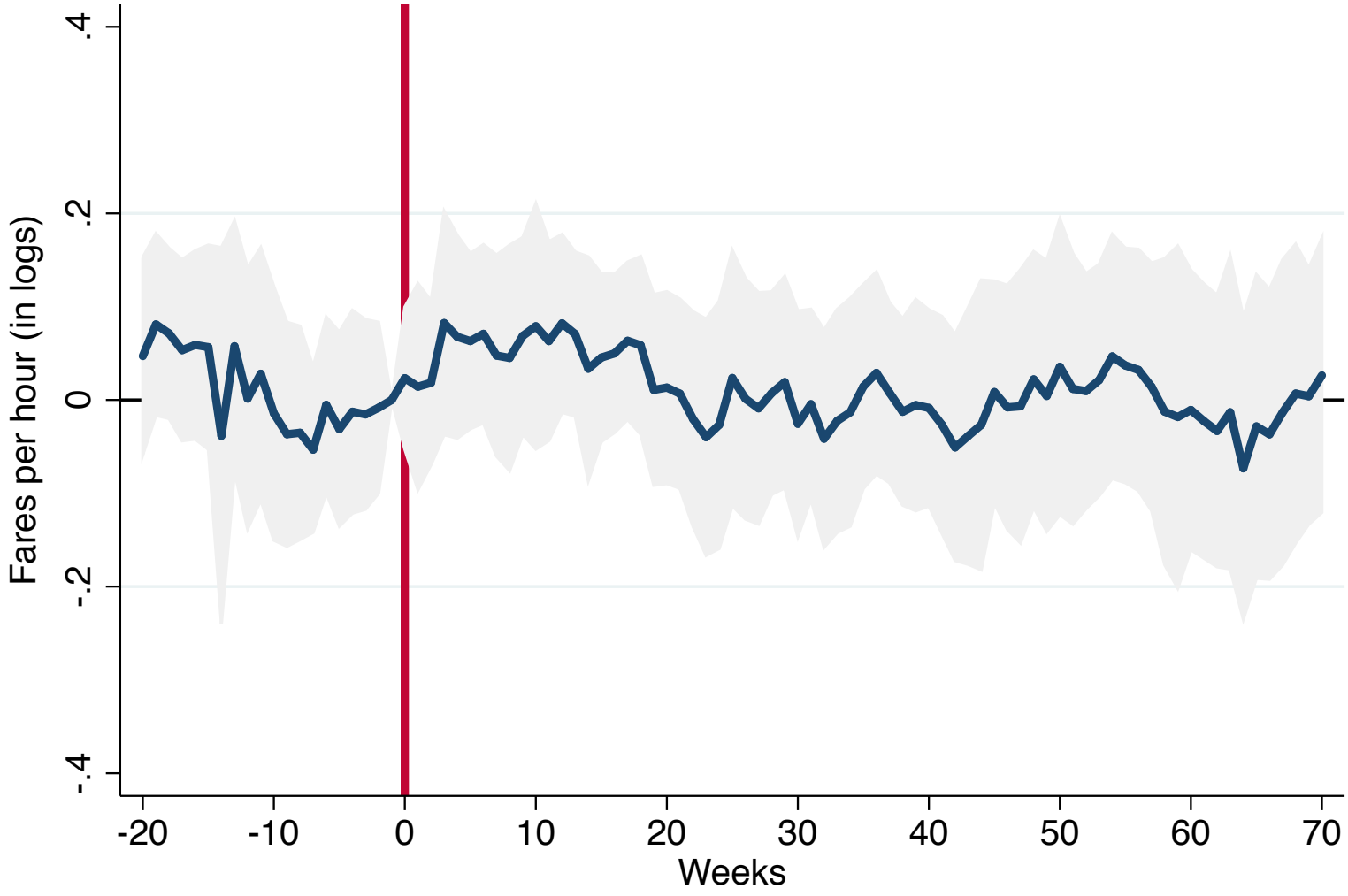
Event study: fares per active driver

Back



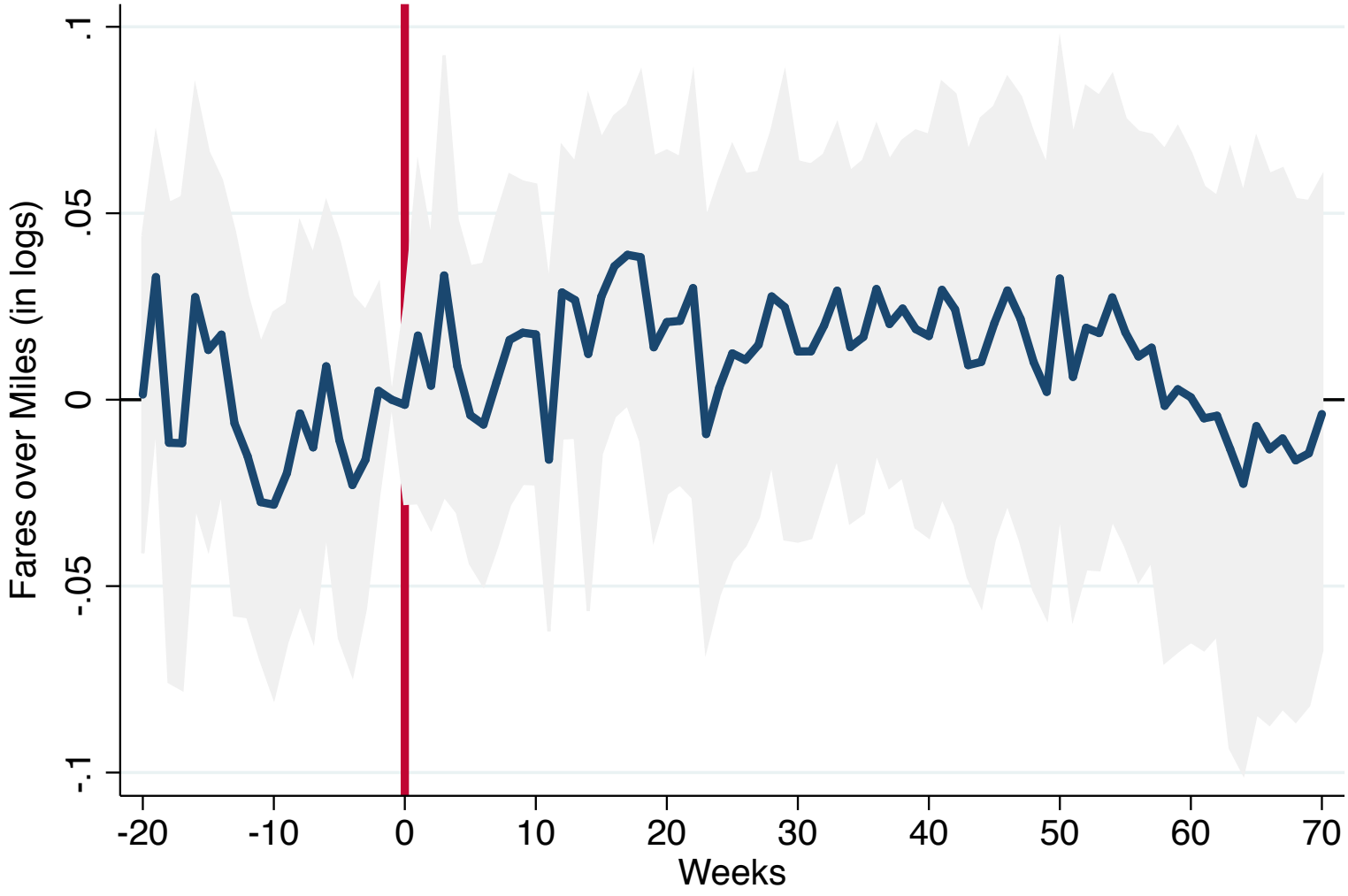
Event study: fares per driver's hour

Back



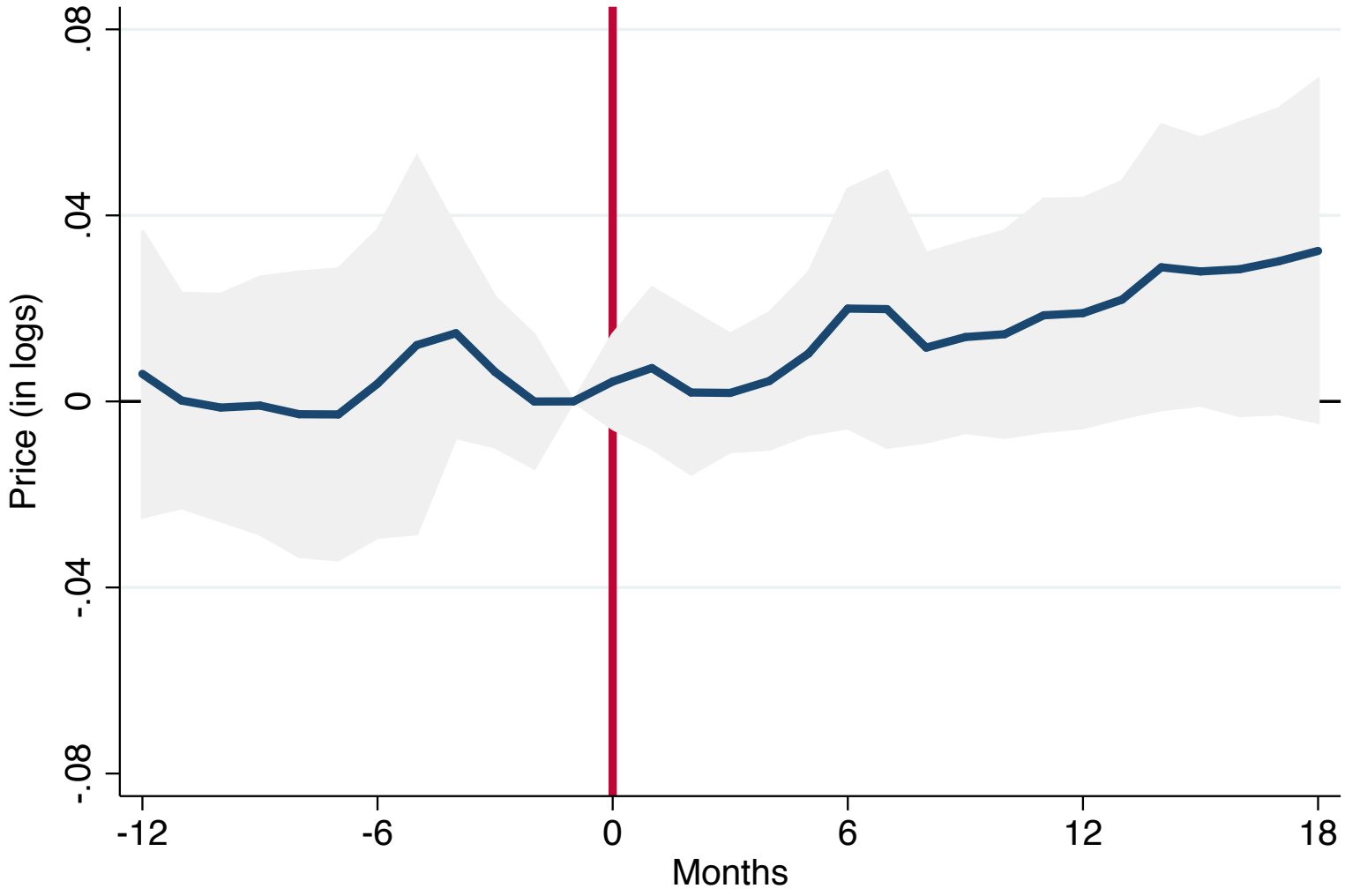
Event study: price

Back



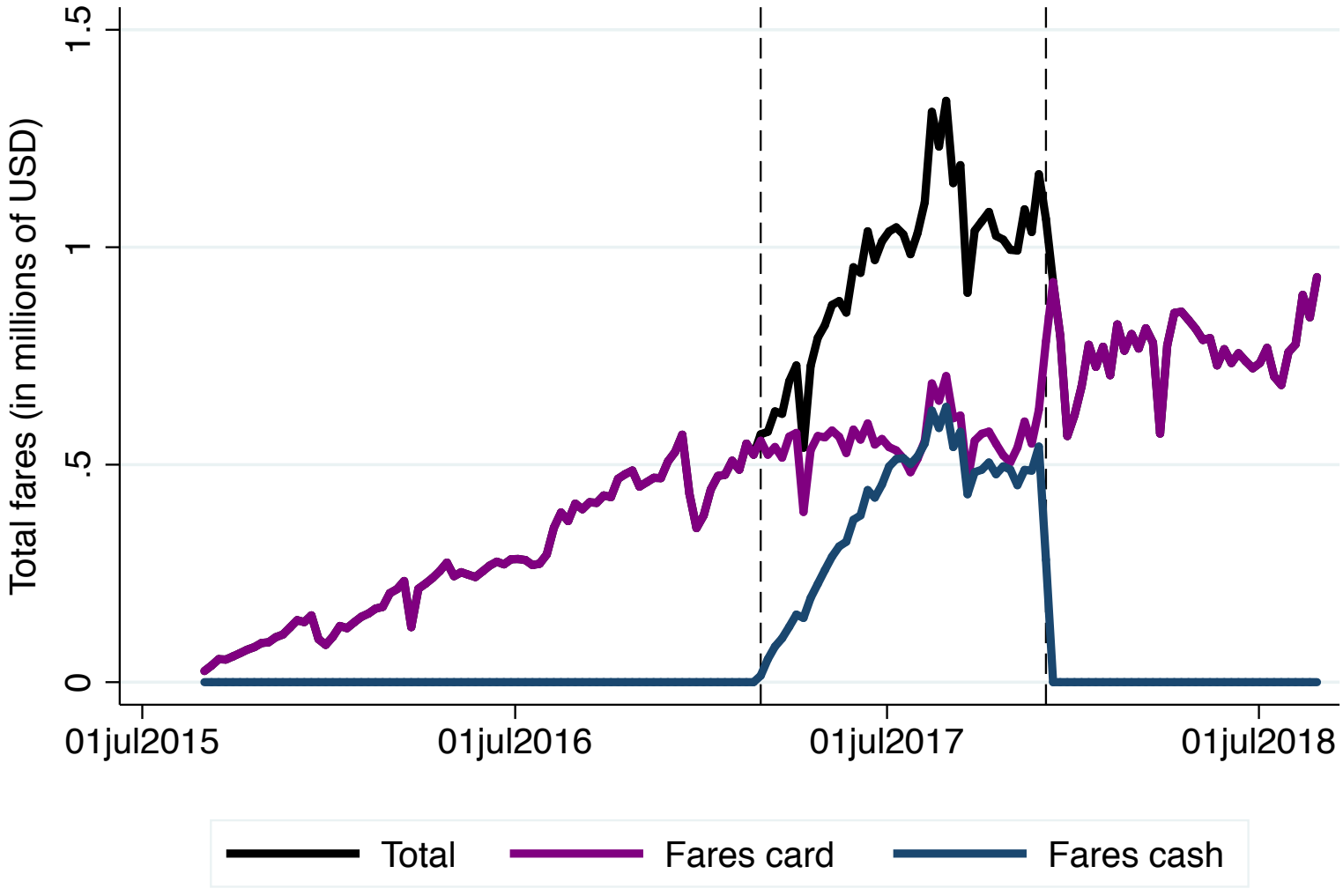
Event study: price of taxis

Back



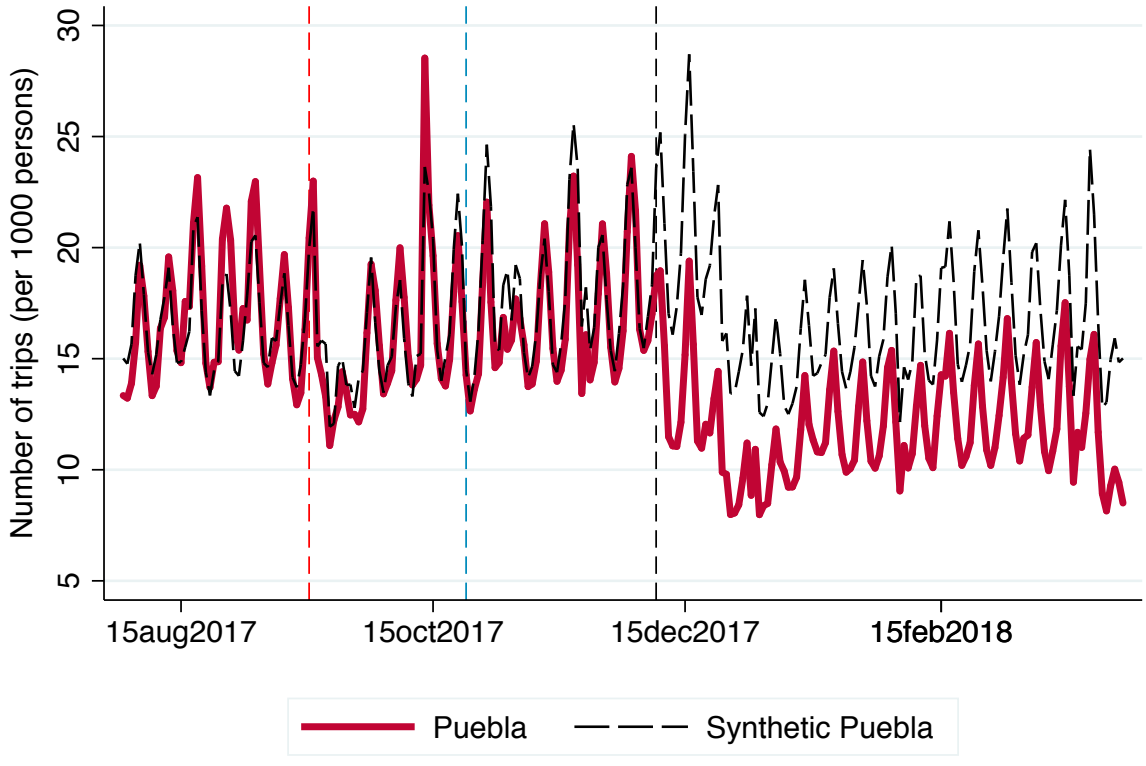
Puebla: ban on cash

Back



Puebla: Synthetic control total trips

- Variables: Trips in cash (daily), fares (daily), trips (Sep 1st), Trips (Aug 15)
- SC weights: 0.05 (Qro), 0.45 (Gto), 0.42 (Mex), 0.07 (DF). RMSPE 0.001



- 60% decrease of trips on impact, an average of 35% thereafter.

Synthetic Control Method: Balance

Back

- Ban in cash at Uber 3 months after Mara crime in Cabify.
- Construct an Synthetic Puebla: weighted average of other 31 cities.
- Weights chosen so that it behaves as Puebla before the ban of cash.

	Puebla	Synthetic
Trips paid in cash per capita (daily)	0.0019	0.0019
Total fares per trip (daily)	3.4698	3.4748
Total trips per capita (Sept 1, 2017)	0.0220	0.0202
Total trips per capita (Aug. 15, 2017)	0.0148	0.0148

- SC weights: 0.051 (Qro), 0.45 (Gto), 0.42 (Edo Mex), 0.07 (Cd Mex)
- The root mean square prediction error (RMSPE) is 0.00152.

Cash in Mexico City

Back

- The geographical boundary is set based on the limits of Mexico City and State of Mexico.
- Cash was introduced in the State on Mexico in November of 2016.
- Cash trips can be requested within the limits of State of Mexico but not within the limits of Mexico City.
- 26% of the trips starting in the State of Mexico (cash enabled) end in Mexico City
- 8.5% of the trips starting in Mexico City (no cash) end in the State of Mexico

Methodology

Back

- Riders whose most frequent city is Mexico City
- Approximately 30 million trips, in August (2016-2018)
- Match geolocalized trips to census tracts (coordinates in the Lambert conformal conic projection - LCC)
  - Convert coordinates of UBER trips to the LCC (Elipsoide: GRS80)
  - Find the centroid of the polygon around each census tract minimizing the sum of squared Euclidean distances between itself and each point in the set
  - Find closest centroid for each UBER trip using Euclidean distance
  - Correction for difference in geofence from Uber and geolocalization of trips (due to the difference between the polygon that defines are for cash acceptance of Uber and EdoMex)

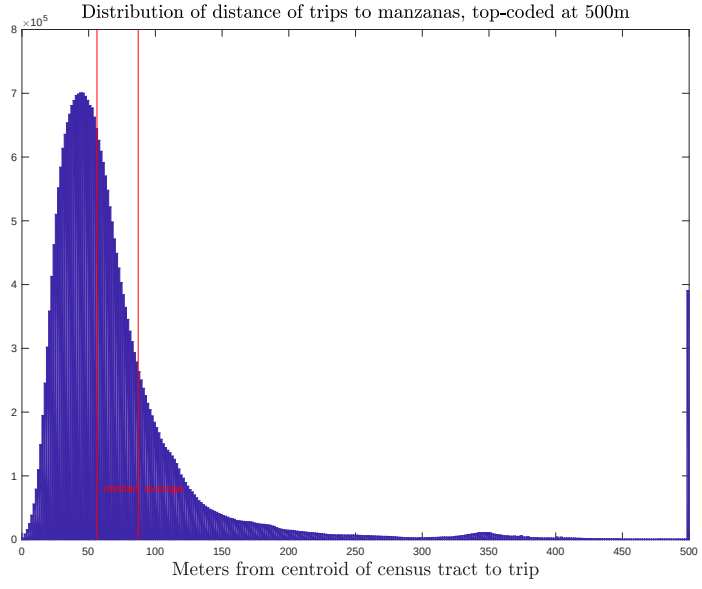
Potential Measurement Error

Back

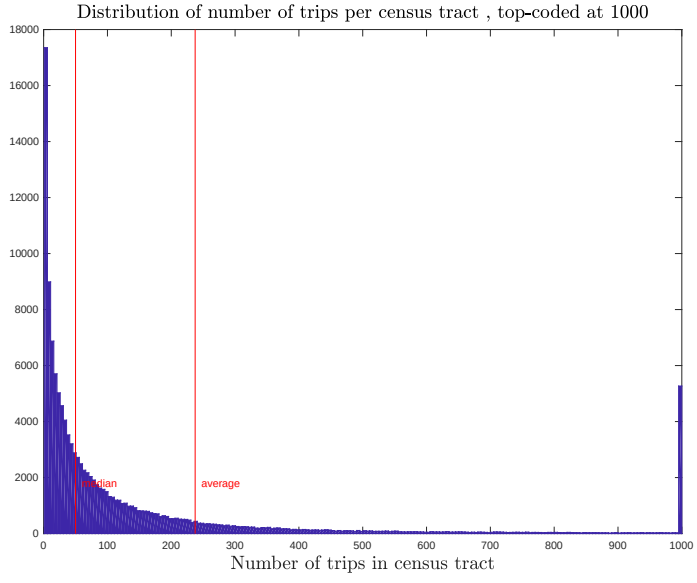
- Differences between trips defined in cash when rider asked them in the app and the location where the driver actually pick up the rider (very hard to measure)
- Geolocalizing trips with a grid using centroids of census tracts (average distance to a centroid is about 60 meters).
- Transformation to LCC (presumably very small)
- Uber GPS system (presumably very small)

Matching of trips to census blocks

Back



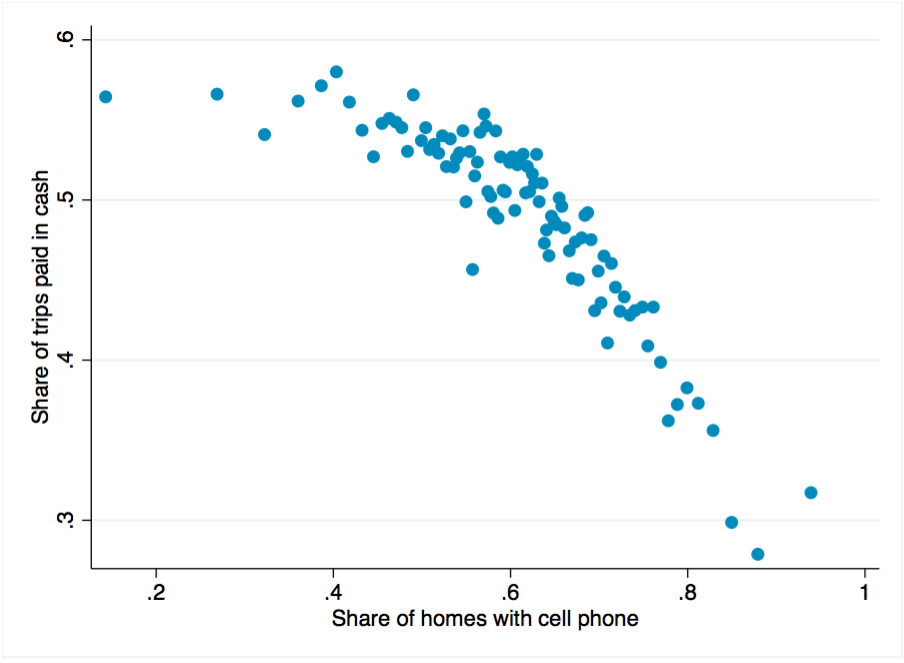
(a) Distance of Trips to Block: Median 50 mts.



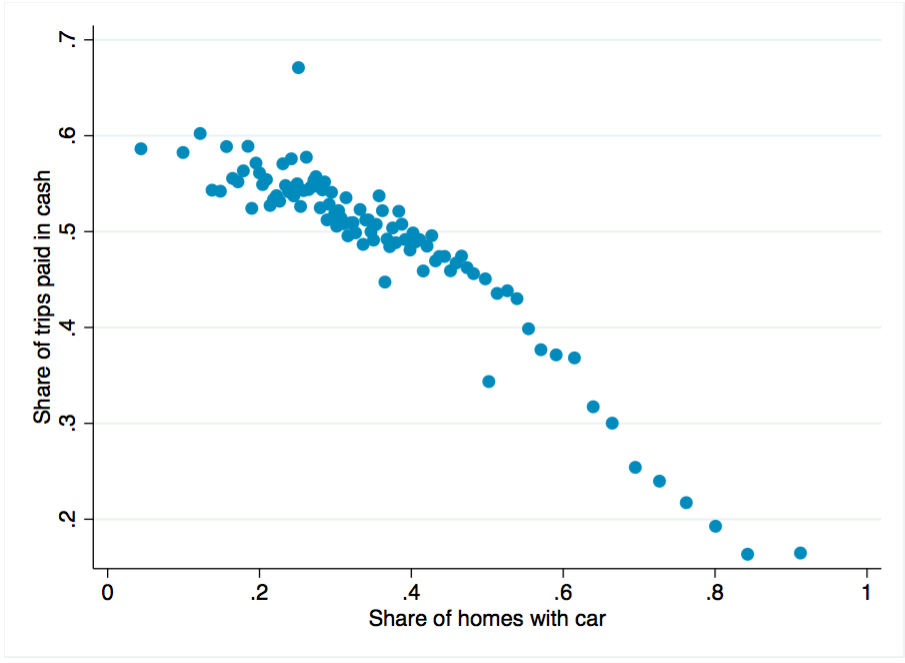
(b) Trips per Block: Median 90 per month

Cash share and census blocks demographics

Back



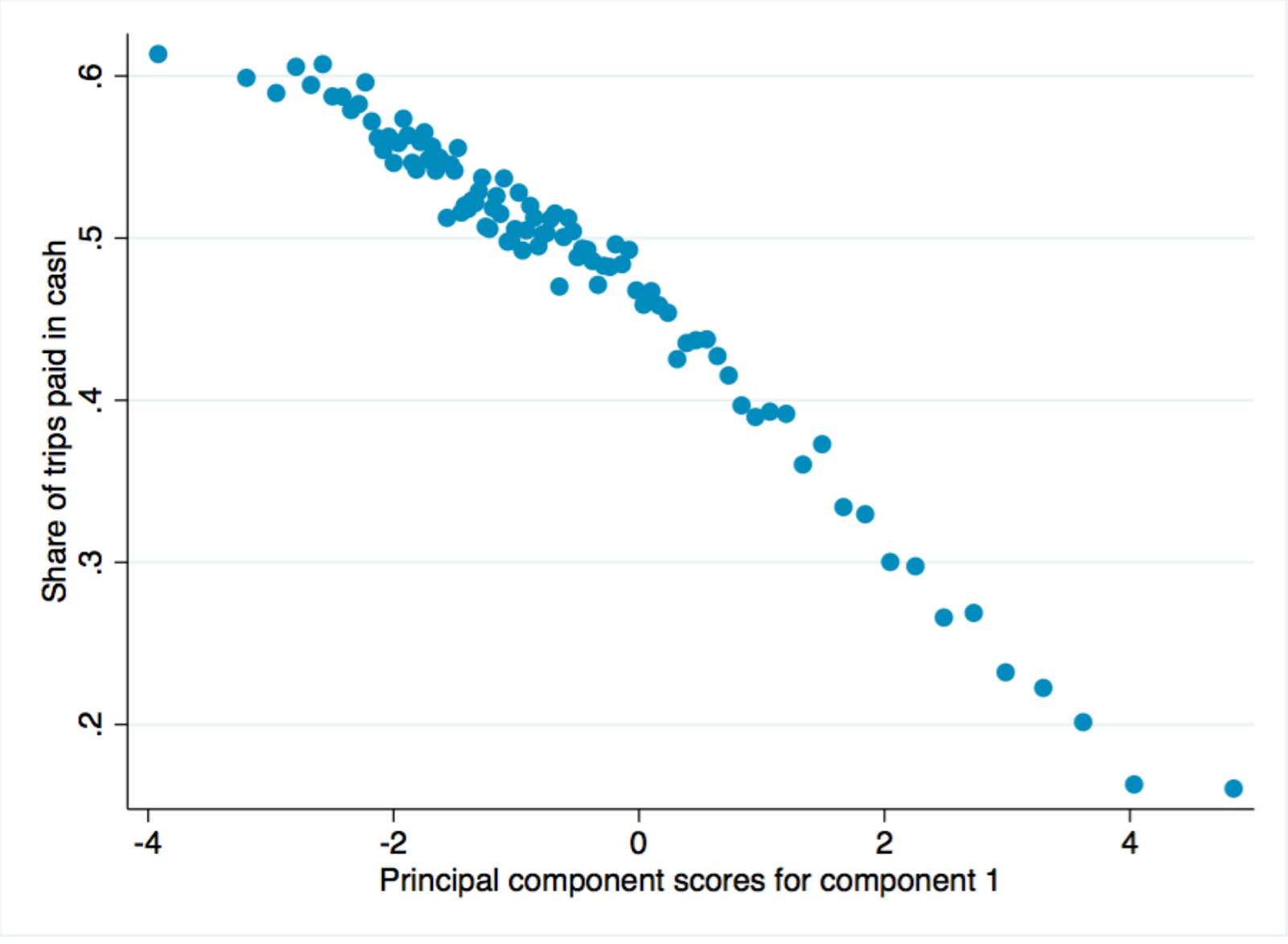
(a) Homes with cell phones



(b) Homes with car

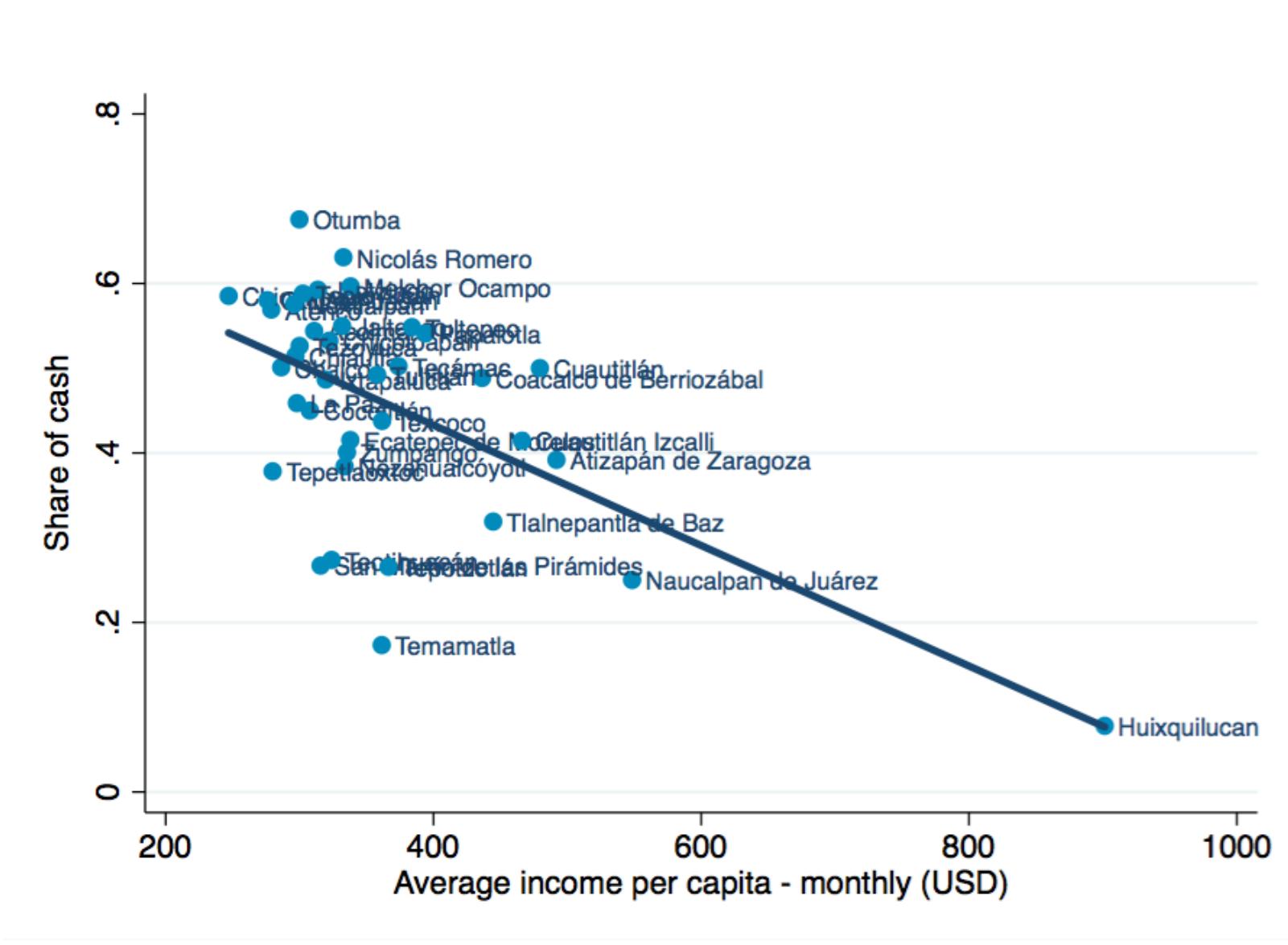
Share of fares paid in cash - principal component

Back



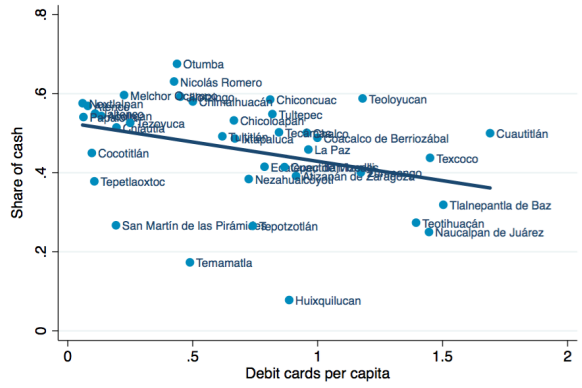
Share of fares paid in cash - income per capita

Back

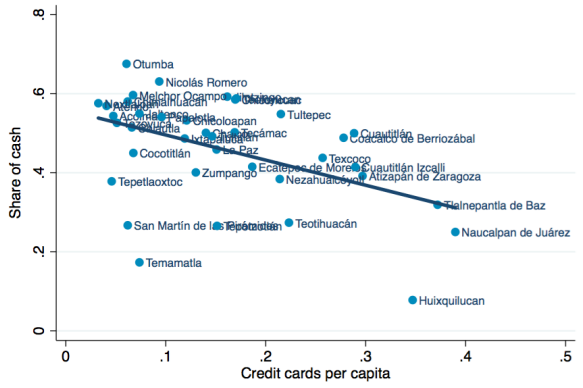


Banking services: share of fares paid in cash

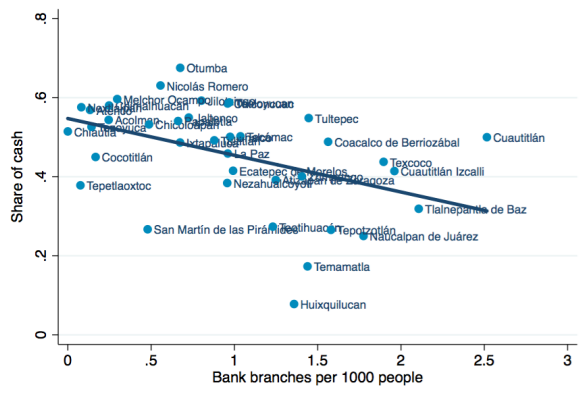
Back



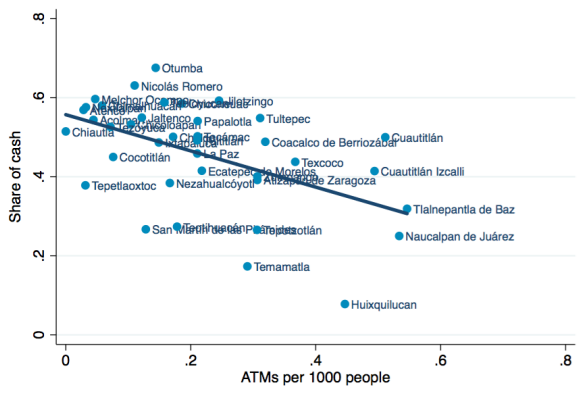
(a) Debit card per capita



(b) Credit cards per capita



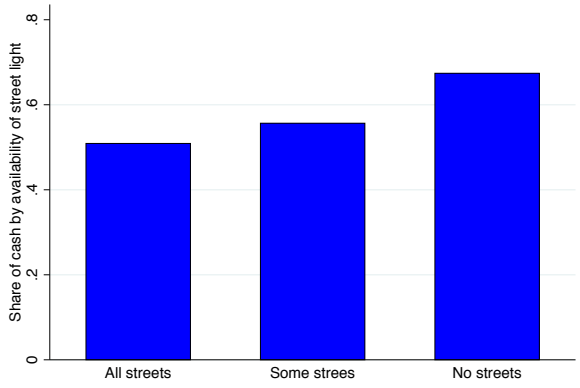
(c) Branches per 1000 people



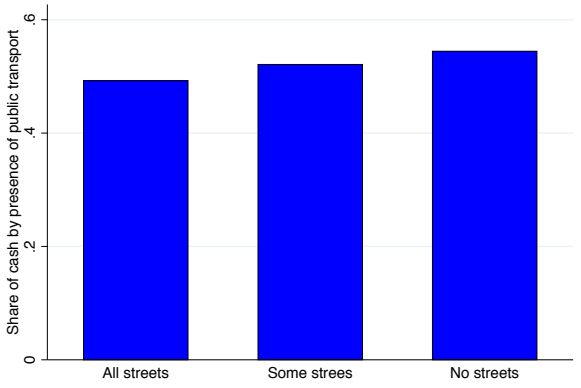
(d) ATMs per 1000 people

Infrastructure: share of fares paid in cash

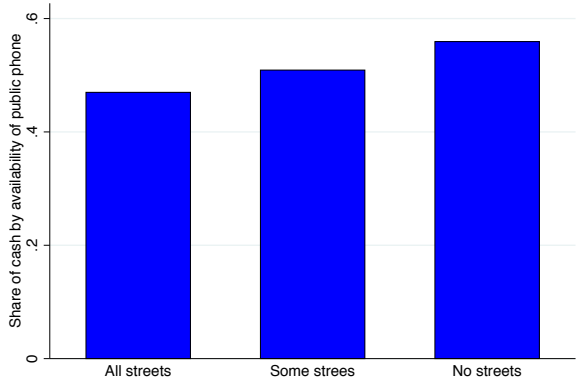
Back



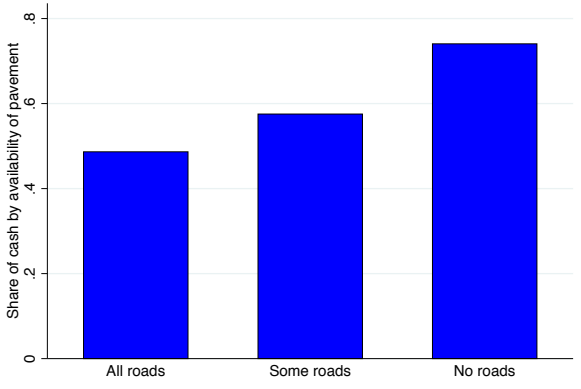
(a) Street light



(b) Public transport



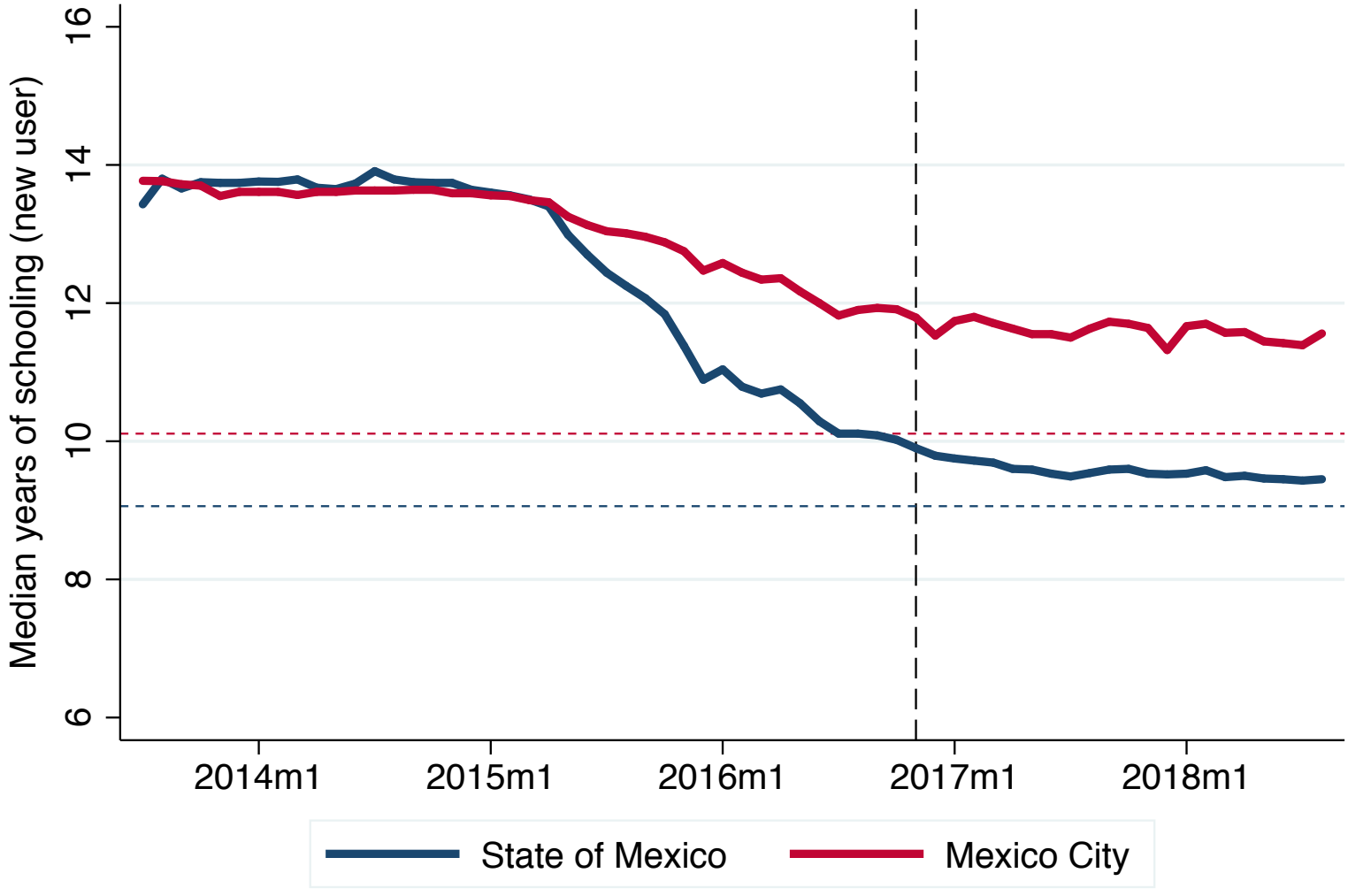
(c) Public phone



(d) Pavement

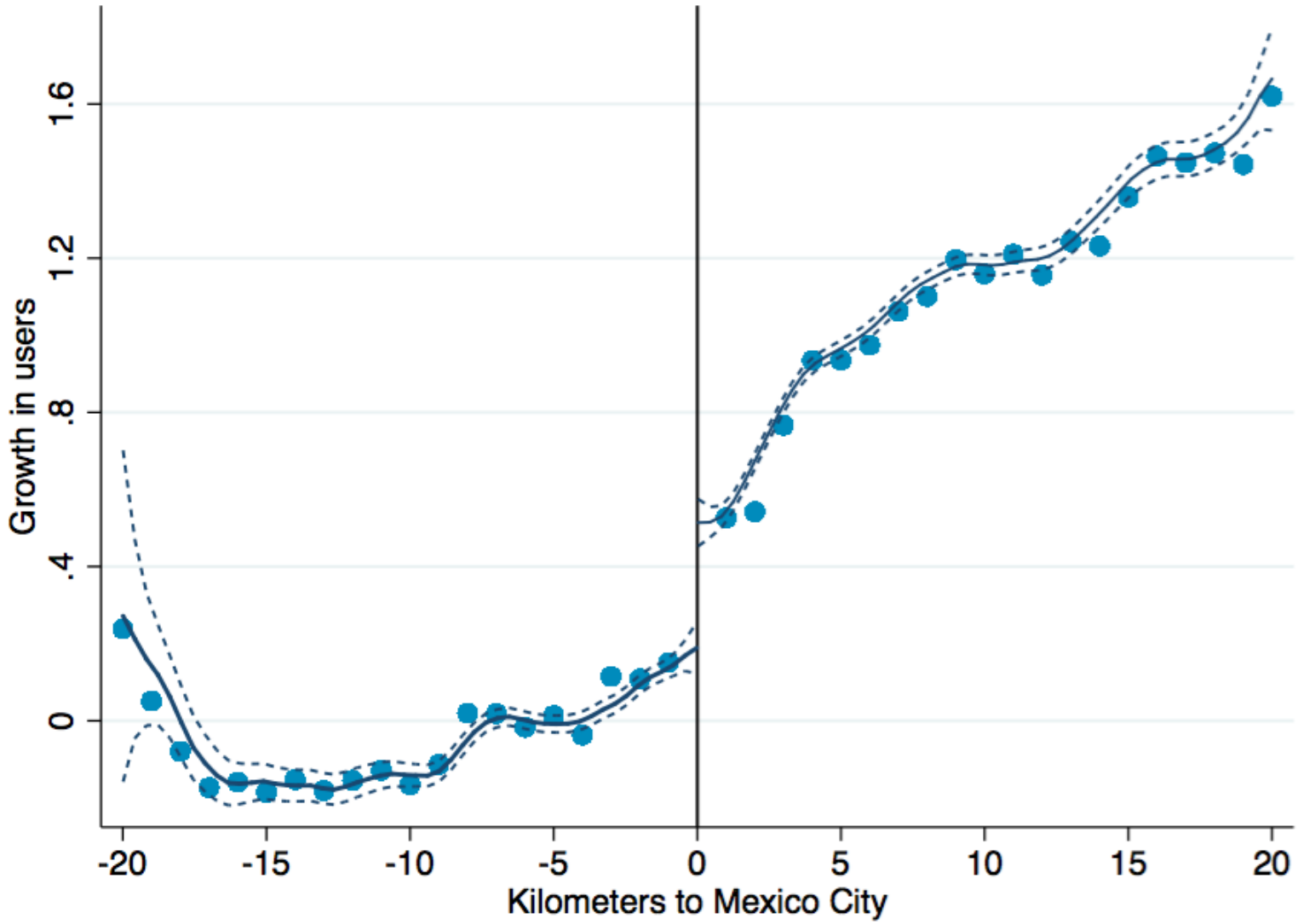
Years of education of new users: Edo-Mex vs DF

Back



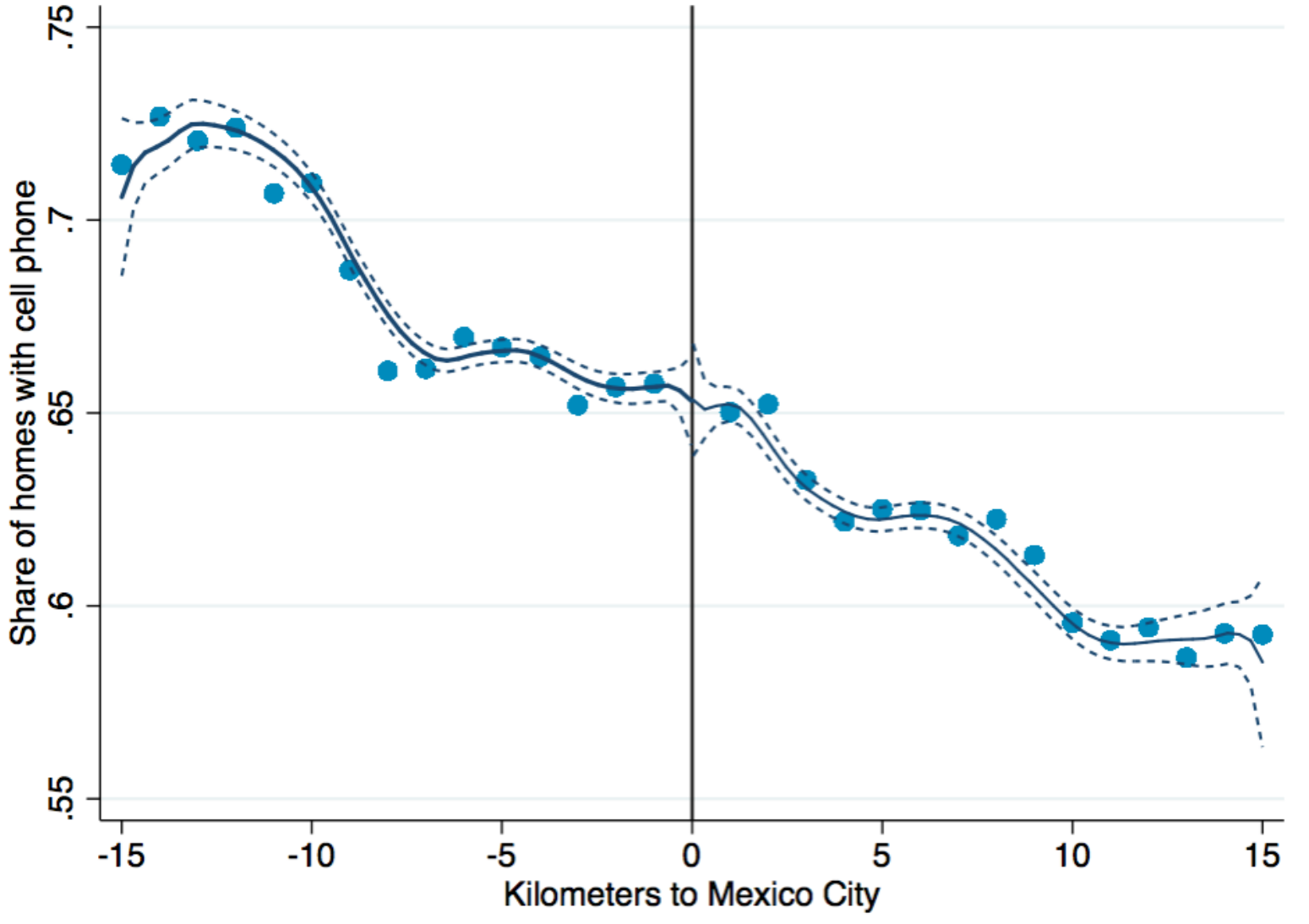
Users 2016-2017

Back



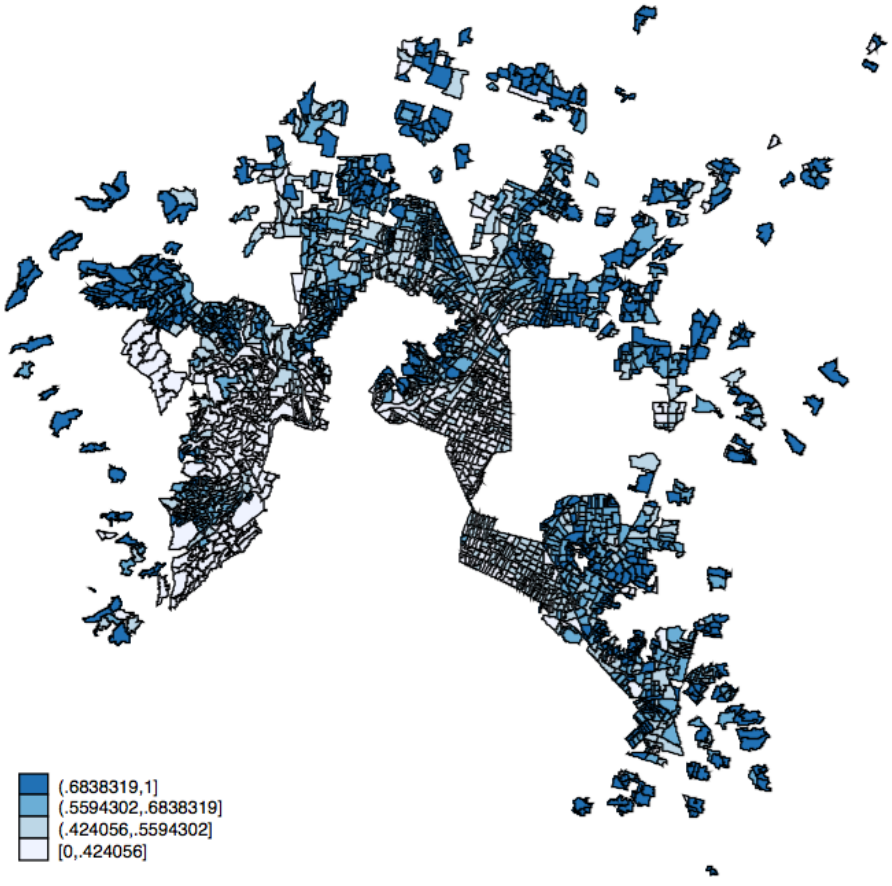
Trips 2016-2017 - homes with cell phone

Back

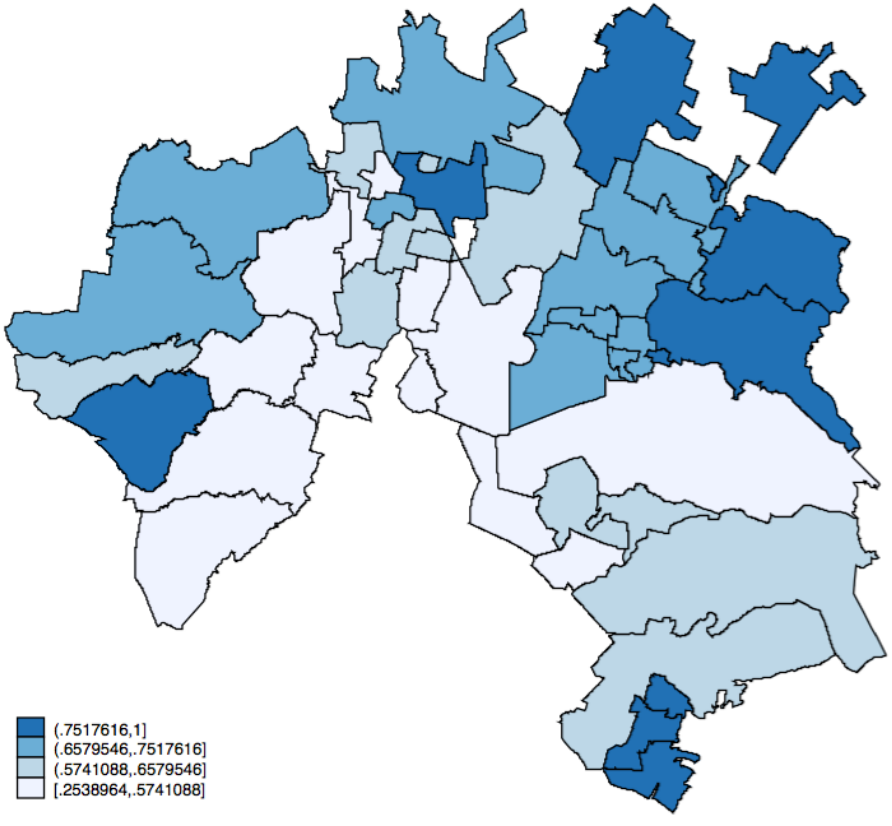


Share of cash in 2017: State of Mexico

Back



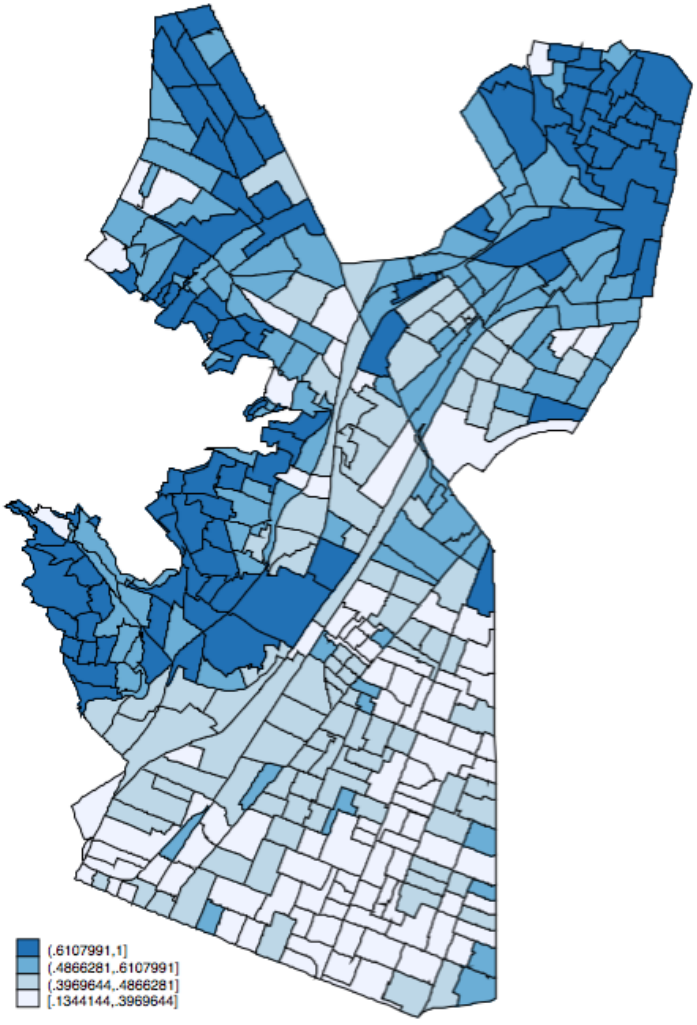
(a) Basic Geostatistical Area



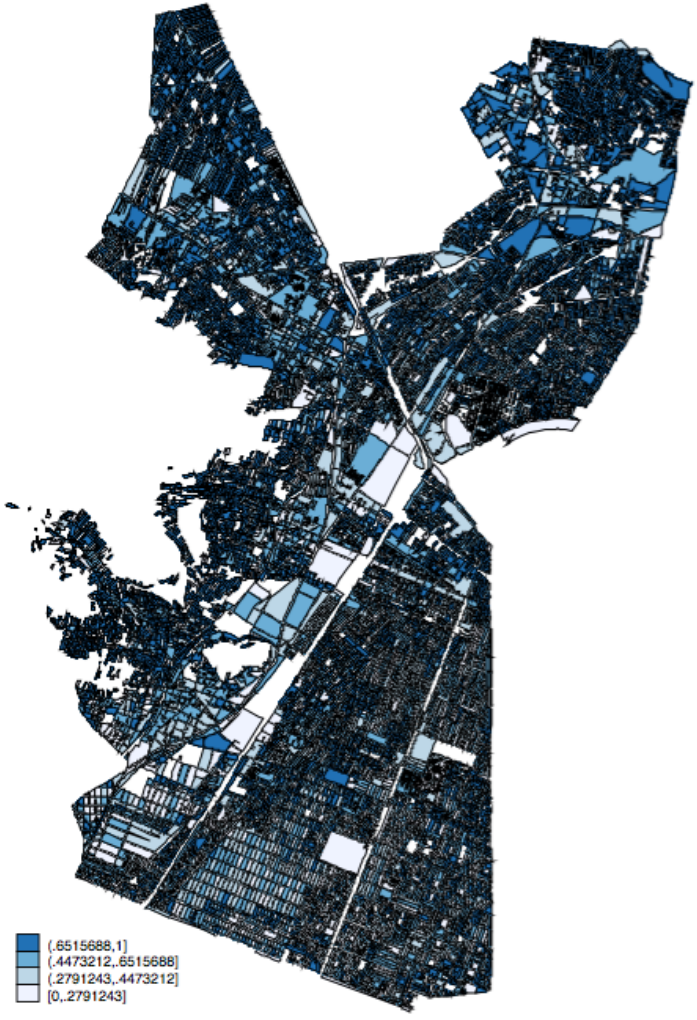
(b) Municipality

Ecatepec: share of trips paid in cash

Back



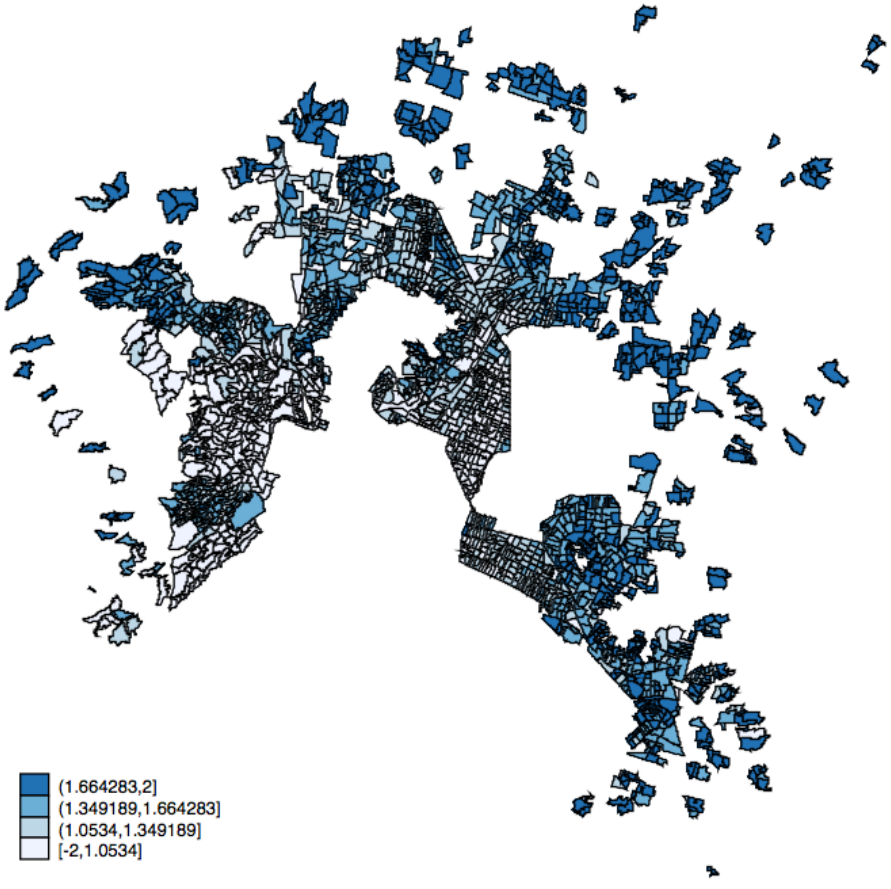
(a) Basic Geostatistical Area



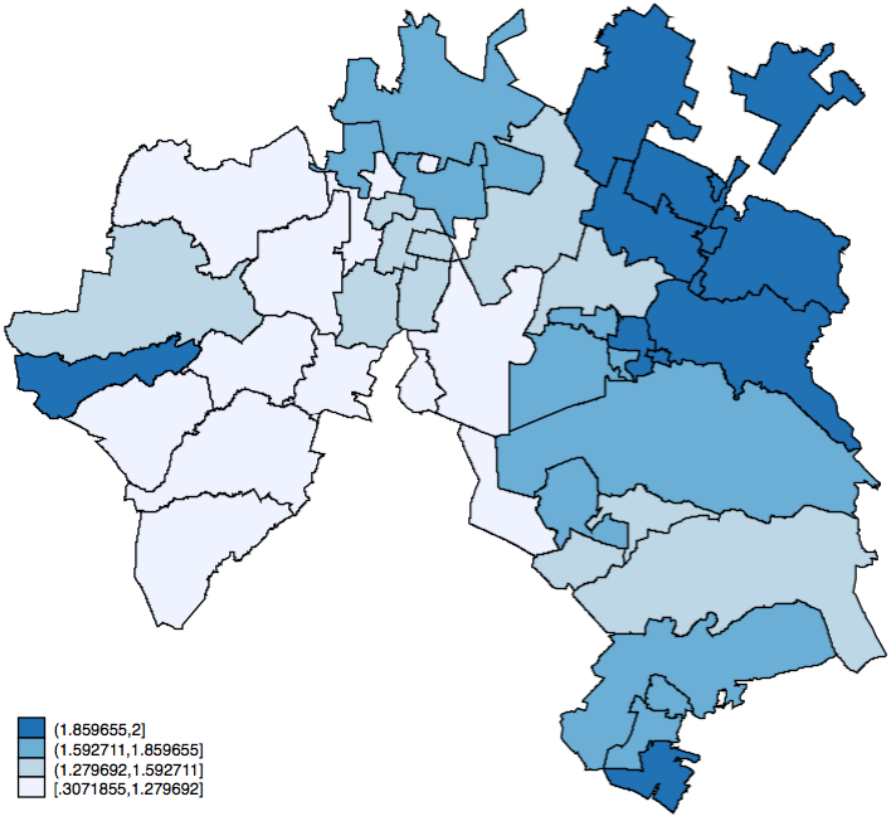
(b) Census Block

Change in trips 2016-2017: State of Mexico

Back



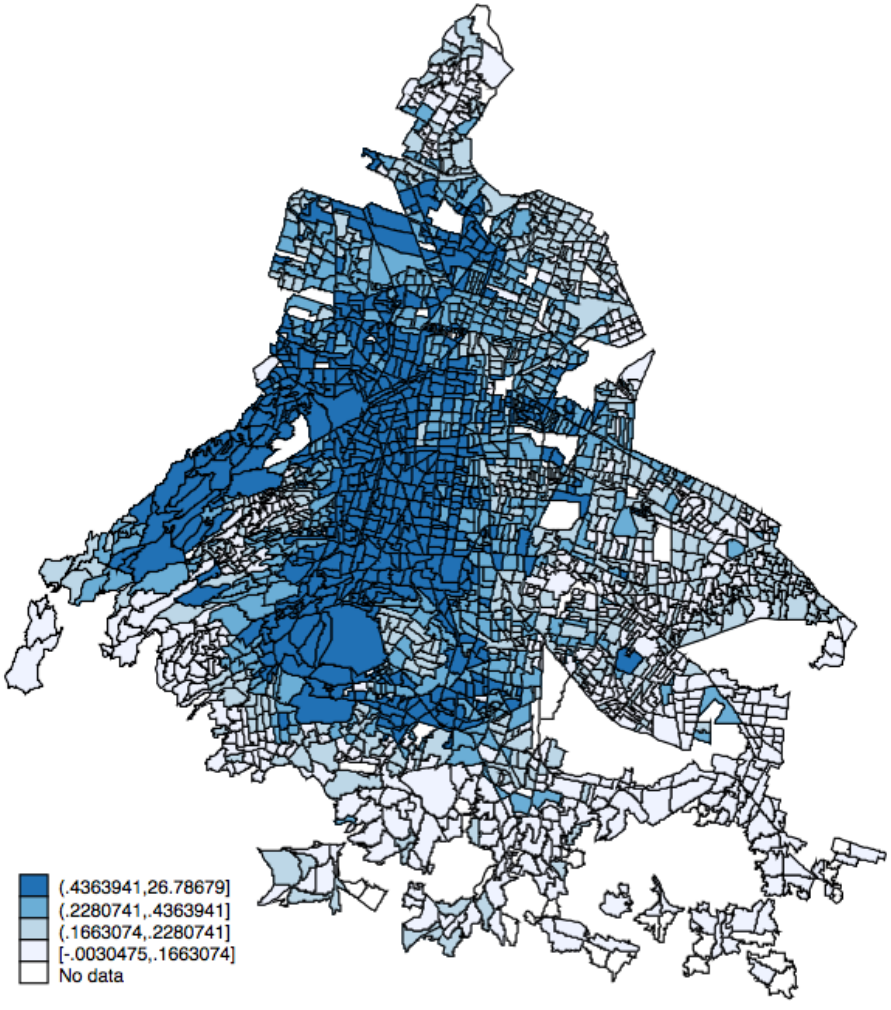
(a) Basic Geostatistical Area



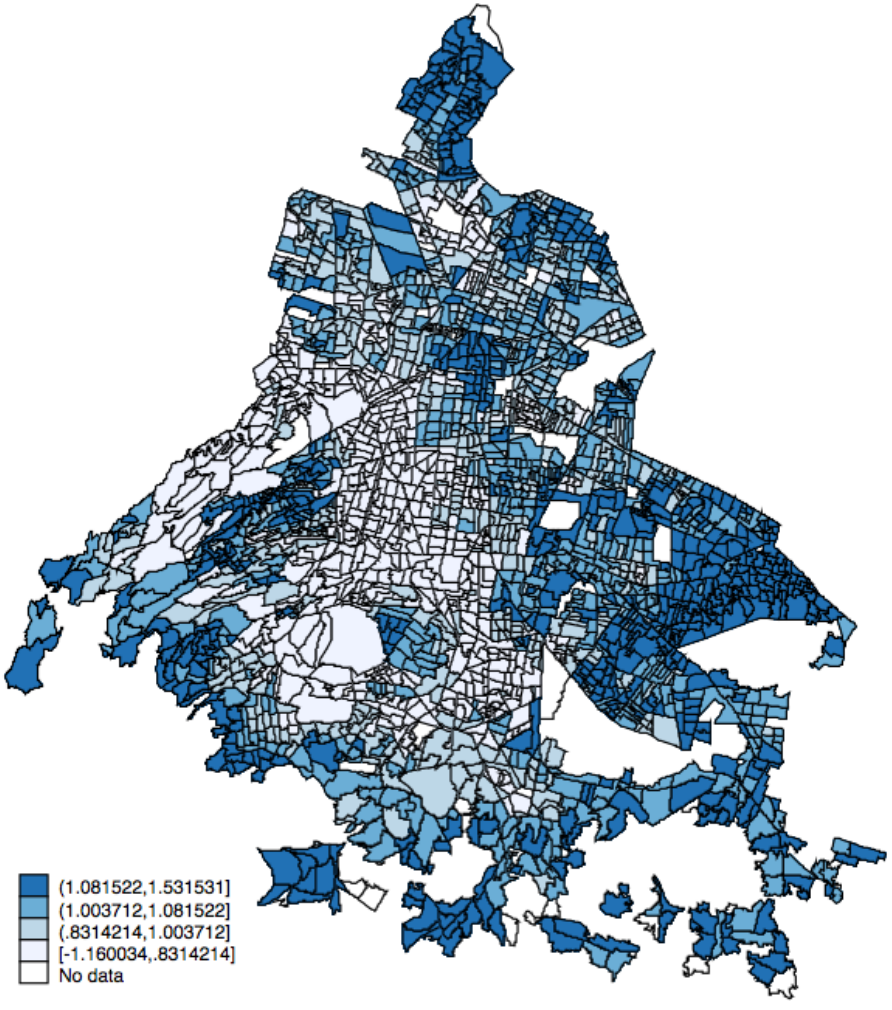
(b) Municipality

Mexico City: predicted trips after introduction of cash

Back



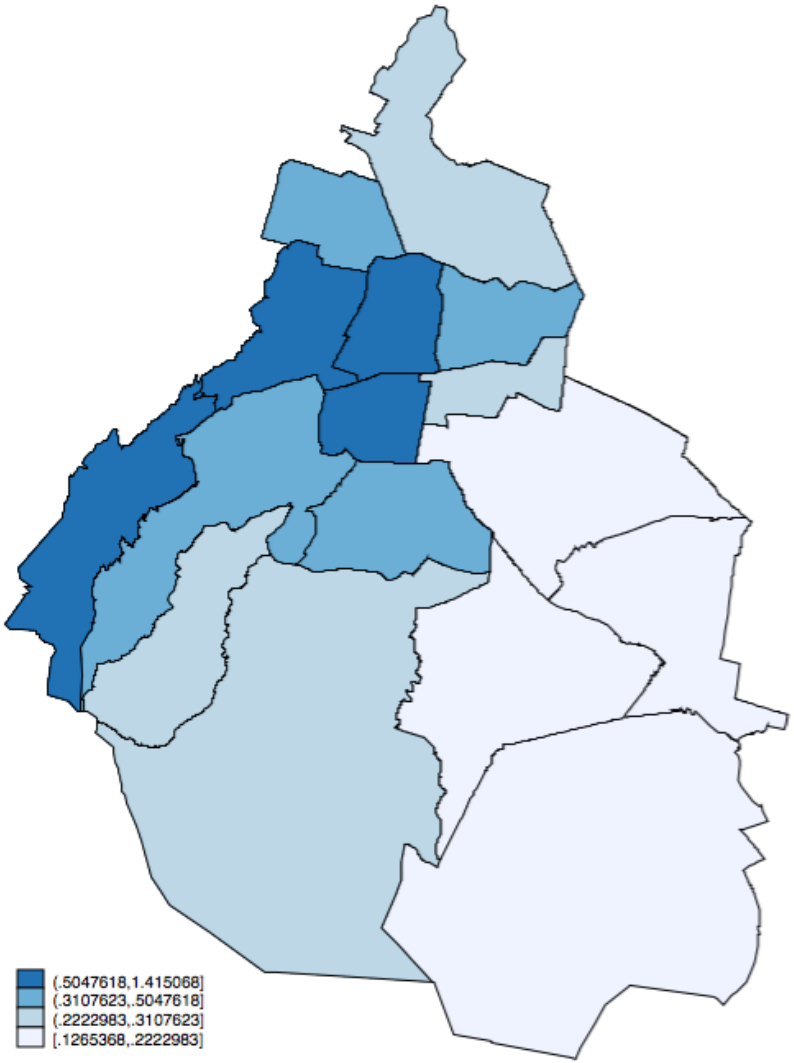
(a) Trips in cash per capita



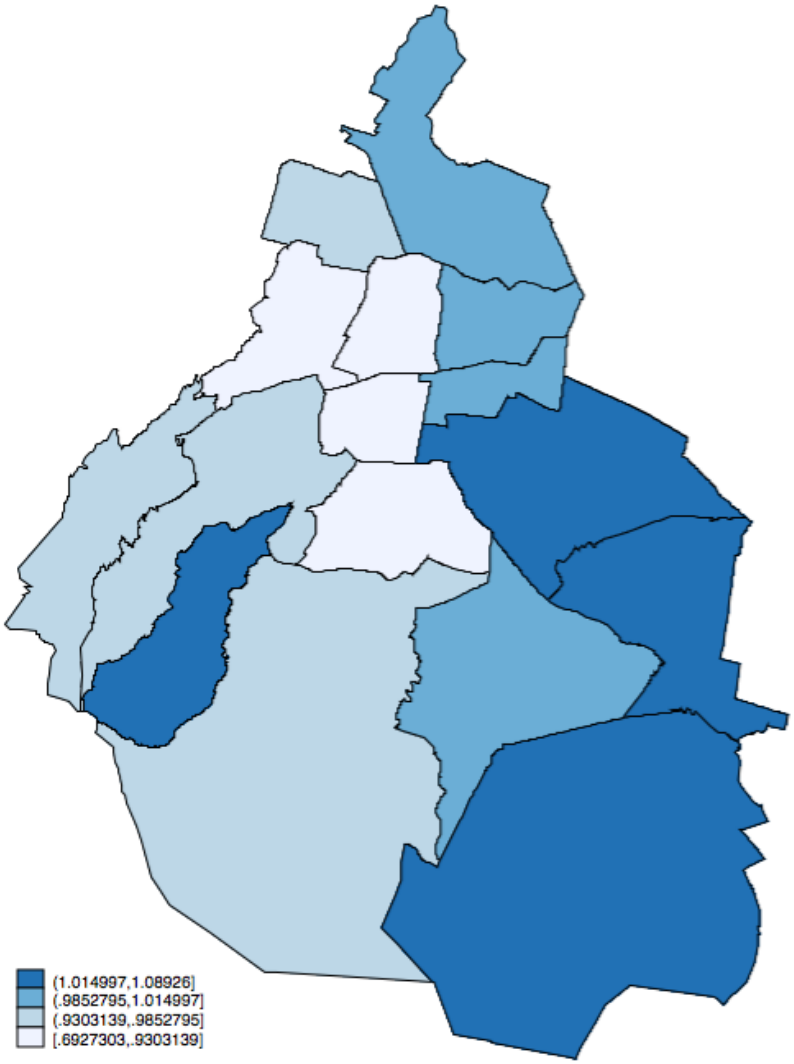
(b) Change in trips

Mexico City: predicted trips after introduction of cash

Back



(a) Trips in cash per capita



(b) Change in trips

DW and Log growth rates

Back

- Compute growth rates taking into account zeros at t or $t+1$
- DW growth rate defined as:

$$DW\ growth\ rate \equiv \frac{X_{t+1} - X_t}{\left(\frac{1}{2}X_{t+1} + \frac{1}{2}X_t\right)}$$

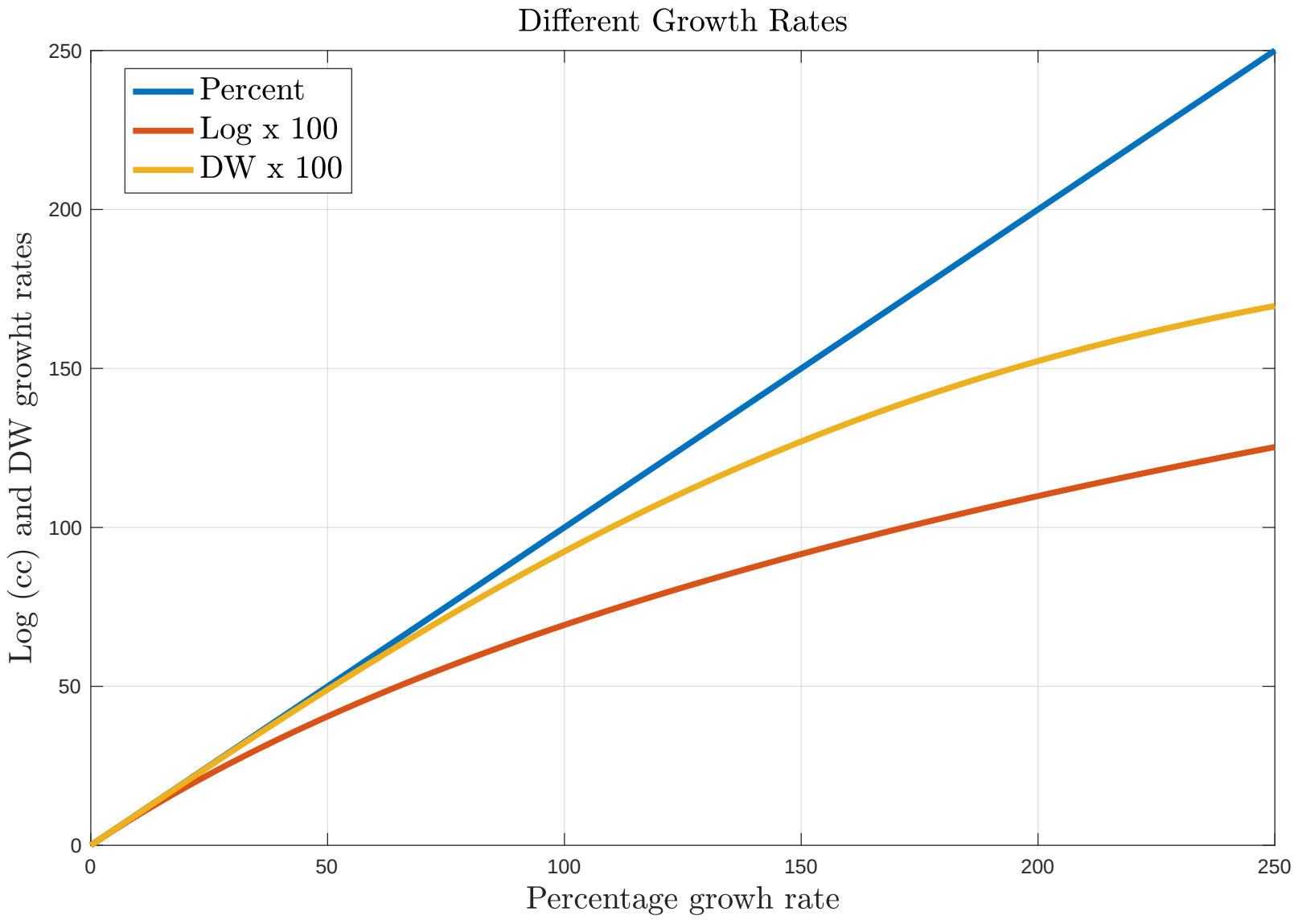
- Uses mid-point in denominator to avoid infinite growth rates
- Takes values between $[-2, 2]$, or -200% and +2–%.
- Log or continuously compounded rates are used because they are additive

  instead of multiplicative for percentage rates.

  additive are required for some techniques, such as Event Studies.

Three growth rates

Back



Change in trips 2016-2017

Back

	(1)	(2)	(3)	(4)
State of Mexico	0.824***	0.615***	0.460***	0.294***
	(0.005)	(0.009)	(0.011)	(0.023)
Observations	108,272	87,036	37,744	7,702
R-squared	0.227	0.326	0.245	0.142
Controls	No	Yes	Yes	Yes
Distance	All	All	$<$5Km	$<$1Km

- Controls: Retail bank in census block, share of homes with internet, shre of homes with cell phone, share of homes with a car, education, share of economically active population.

Change in trips 2016-2017: Heterogeneity

Back

	(1)	(2)	(3)	(4)	(5)	(6)
State of Mexico	0.615***	0.846***	1.316***	0.924***	1.009***	0.904***
	(0.010)	(0.014)	(0.038)	(0.040)	(0.031)	(0.017)
Bank	-0.028***					
	(0.010)					
State of Mexico x Bank	-0.027					
	(0.025)					
Internet		-0.279***				
		(0.038)				
State of Mexico x Internet		-0.726***				
		(0.035)				
Education			-0.020***			
			(0.003)			
State of Mexico x Education			-0.068***			
			(0.004)			
Econ. Active				-0.022		
				(0.050)		
State of Mexico x Econ. Active				-0.703***		
				(0.087)		
Cell phone					0.364***	
					(0.039)	
State of Mexico x Cell phone					-0.603***	
					(0.046)	
Car						0.339***
						(0.030)
State of Mexico x Car						-0.693***
						(0.034)
Observations	87,036	87,036	87,036	87,036	87,036	87,036
R-squared	0.326	0.334	0.333	0.327	0.328	0.333
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Distance	All	All	All	All	All	All

Change in trips 2016-2017: CEM

Back

	(1) $\Delta Trips$	(2) $\Delta Trips_I$	(3) $\Delta Trips_E$	(4) $\Delta Fares$	(5) $\Delta Fares_I$	(6) $\Delta Fares_E$	(7) $\Delta Price$
State of Mexico	0.657***	0.377***	0.280***	0.517***	0.237***	0.280***	0.003
	(0.006)	(0.004)	(0.006)	(0.006)	(0.005)	(0.006)	(0.002)
Obs.	81,931	81,931	81,931	81,929	81,929	81,929	63,132
R^2	0.137	0.081	0.026	0.088	0.031	0.026	0.00
Margin	All	Intensive	Extensive	All	Intensive	Extensive	All

- Use blocks of Mexico City as counterfactuals for State of Mexico
- Observables in 20 bins: % houses w/internet, % houses w/car, % w houses w/cell phone, years of education. 94% of blocks matched.
- $2 \times (y_t - y_{t-1})/(y_t + y_{t-1}) = 66\% \implies$ 100% growth rate

Change in trips 2016-2017: RDD

Back

	(1)	(2)	(3)	(4)	(5)
State of Mexico	0.390***	0.313***	0.216***	0.173***	0.239***
	(0.013)	(0.018)	(0.023)	(0.029)	(0.034)
Observations	87,036	87,036	87,036	87,036	87,036
R-squared	0.351	0.352	0.353	0.354	0.354
Controls	Yes	Yes	Yes	Yes	Yes
Distance	All	All	All	All	All
Degree	1	2	3	4	5

Using polynomials of different degree and controls.

Accounting Identity

Back

- Cash, Credit and Total trips at time t: A_t, C_t, T_t
- No cash at t : $A_t = 0$.
- After cash intro: $T_{t+1} = C_t\, e^{g_t} + A_{t+1}$
- Growth rate of total trips $\frac{T_{t+1}}{T_t} = \frac{e^{g_t}}{1-s_{t+1}}$

  where share of cash $s_{t+1} \equiv \frac{A_{t+1}}{T_{t+1}}$ and g_t is the growth rate of credit
- In log growth points:

$$\log \frac{T_{t+1}}{T_t} = g_t - \log(1 - s_{t+1})$$

Experiment 3: Adopting/registering credit card

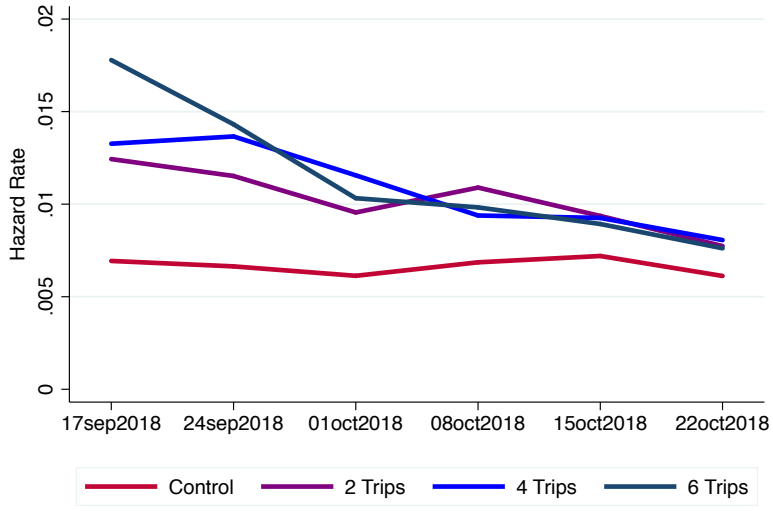
	(1) Migrate 1 week	(2) Migrate 1 week	(3) Migrate 1-6 weeks	(4) Migrate 1-3 weeks	(5) Migrate 4-6 weeks
Treatment 1 - 1 week	0.0069***				
	(0.001)				
Treatment 2 - 1 week	0.0073***				
	(0.001)				
Treatment 3 - 1 week	0.0094***				
	(0.001)				
Treatment 1 - 6 week		0.0054***	0.0333***	0.0283***	0.0112***
		(0.001)	(0.004)	(0.004)	(0.003)
Treatment 2 - 6 week		0.0062***	0.0394***	0.0382***	0.0088***
		(0.001)	(0.004)	(0.004)	(0.003)
Treatment 3 - 6 week		0.0106***	0.0468***	0.0485***	0.0088***
		(0.001)	(0.004)	(0.004)	(0.003)
Constant	0.0069***	0.0069***	0.0711***	0.0445***	0.0372***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Observations	96,965	97,035	46,996	36,184	46,996
R-squared	0.001	0.001	0.005	0.006	0.001

- Treatment # $\approx$ free trips given as reward for registering card
- Entire sample, regardless if trips > 0.

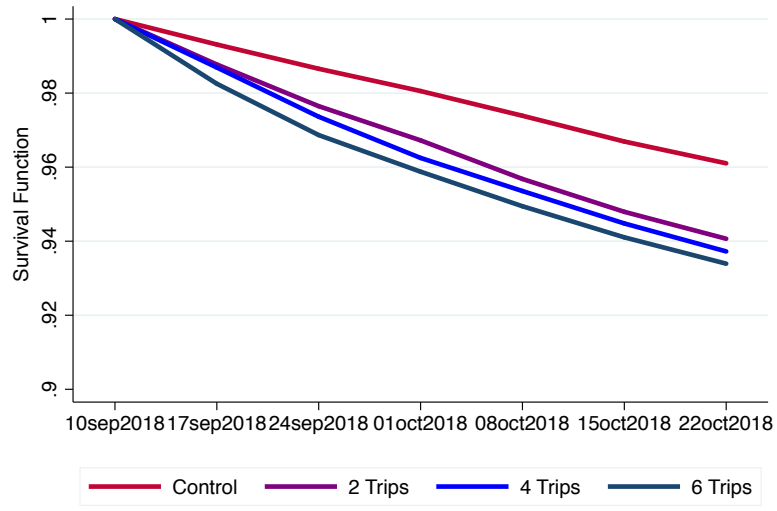
Back

Extensive margin: survival function and hazard (6-week experiment)

Back



(a) Hazard rate



(b) Survival function

Moment conditions for ψ in the support of $G(\cdot|\phi)$

◂ Back ◂ Back-Ext

- Cash users prefer not to switch to become mixed/credit users.

$$\underline{\psi} = [v(1,1;\phi) - v(1,\infty;\phi)]$$

- Excess migration from cash to credit after the ban in Puebla

$$\overline{\psi} = [v(\infty,1;\phi) - v(\infty,\infty;\phi)]$$

- Experimental evidence on the excess migration due to incentives

$$\psi_k = [v(1,1;\phi) - v(1,\infty;\phi)] + \rho d_k$$

  for $k = 1, 2, 3$ and ρ converts reward d_k into flows.

- These conditions depends on (α, η), unobserved for this group, and on $(k, \bar{P})$, observed for this group.

Indirect Utilities

Back

1. Mixed user

$$v(1,1) = -k + kI - k\log\bar{P}$$

2. Pure cash user

$$v(1,\infty) = \begin{cases} k(1-\alpha)^{\frac{1}{1-\eta}}\left[\log\left(\frac{(1-\alpha)^{\frac{1}{1-\eta}}}{\bar{P}}\right) - 1\right] + kI & (1-\alpha)^{\frac{1}{1-\eta}} \leq \bar{P} \\ -k\bar{P} + kI & \text{if } (1-\alpha)^{\frac{1}{1-\eta}} > \bar{P} \end{cases}$$

3. Pure credit user

$$v(\infty,1) = \begin{cases} k\alpha^{\frac{1}{1-\eta}}\left[\log\left(\frac{\alpha^{\frac{1}{1-\eta}}}{\bar{P}}\right) - 1\right] + kI & \alpha^{\frac{1}{1-\eta}} \leq \bar{P} \\ -k\bar{P} + kI & \text{if } \alpha^{\frac{1}{1-\eta}} > \bar{P} \end{cases}$$

4. Non-Uber user

$$v(\infty,\infty) = -k\bar{P} + kI$$

Demand Functions

Back

1. Mixed users cash demand when facing $p = p_a = p_c$:

$$\tilde{a}(p, p) = \begin{cases} (1-\alpha)k \log \bar{P} - (1-\alpha)k \log p & \text{if } p < \bar{P} \\ 0 \text{ otherwise} \end{cases}$$

2. Pure cash users, i.e. users facing arbitrary p_a but infinite credit price $p_c = \infty$.

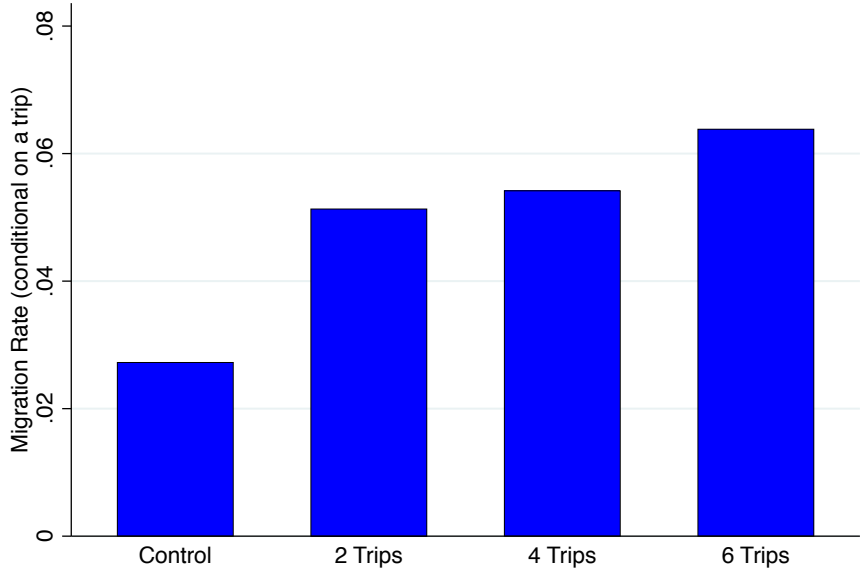
$$\tilde{a}(p_a, \infty) = \begin{cases} k(1-\alpha)^{\frac{1}{1-\eta}} \left[\log \left(\frac{\bar{P}}{(1-\alpha)^{\frac{1}{1-\eta}}} \right) \right] & \\ -k(1-\alpha)^{\frac{1}{1-\eta}} \log p_a & \text{if } (1-\alpha)^{\frac{1}{1-\eta}} p_a < \bar{P} \\ 0 & \text{otherwise} \end{cases}$$

3. Pure credit users, i.e. credit demand when facing arbitrary p_c but infinite cash price $p_a = \infty$.

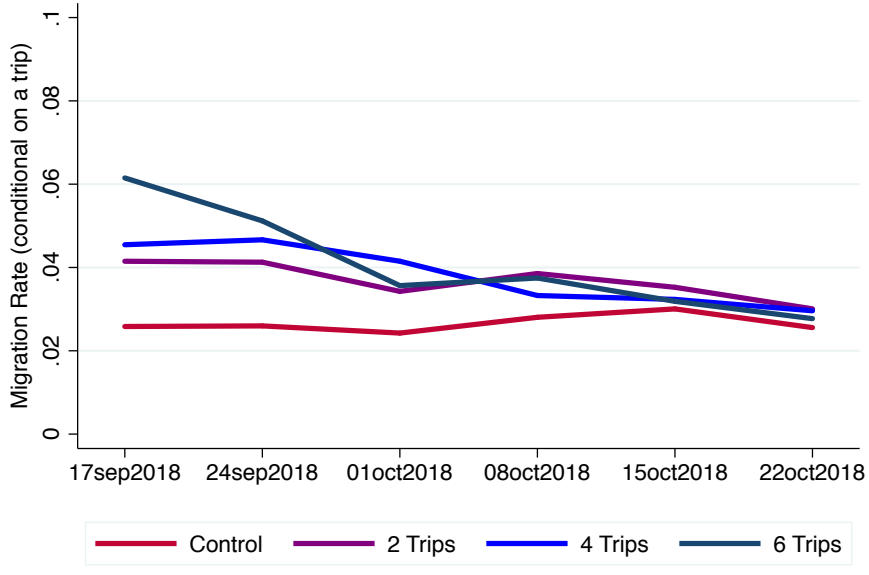
$$\tilde{c}(\infty, p_c) = \begin{cases} k\alpha^{\frac{1}{1-\eta}} \left[\log \left(\frac{\bar{P}}{\alpha^{\frac{1}{1-\eta}}} \right) \right] - k\alpha^{\frac{1}{1-\eta}} \log p_c & \text{if } \alpha^{\frac{1}{1-\eta}} p_c < \bar{P} \\ 0 & \text{otherwise} \end{cases}$$

Migration (conditional on a trip)

Hazard Back Back-to-Table



(a) 1-Week



(b) 6-Week

Mixed Users: Poisson regression # trips

Back

	(1) AA	(2) AA	(3) AA	(4) Mandin	(5) Ubernomics
Log Price	-0.996***	-0.998***	-0.998***	-0.829***	-1.133***
	(0.044)	(0.044)	(0.048)	(0.043)	(0.145)
Observations	109,365	109,365	98,773	11,660	4,306
Controls	No	Yes	Yes	Yes	Yes
Type	1 pct	1 pct	5 pct	1 pct	1 pct

Specification has constant elasticity of Expected trips on price.

Mixed Users: Price elasticity ϵ (trips) ▸ Summary Stats ▸ Back

	(1) AA	(2) AA	(3) AA	(4) Mandin	(5) Ubernomics
Elasticity	1.106***	1.050***	1.084***	1.175***	1.235***
	(0.094)	(0.076)	(0.082)	(0.068)	(0.262)
Observations	109,365	109,365	98,773	11,660	4,306
Controls	No	Yes	Yes	Yes	Yes
Type	1 pct	1 pct	5 pct	1 pct	1 pct

- Semi-log specification: $a_i = \beta_0 + \beta_1 \ln p_i$, elasticity ϵ evaluated at equilibrium prices (no discounts)
- 1-5 pct: highest and lowest historical share excluded
- AA: Alvarez-Argente, Mandin & Ubernomics two other Uber price experiments in Greater Mexico. Mandin last 4-weeks

Pure cash users: Poisson regression # trips

Back

	(1) AA	(2) AA	(3) Mandin	(4) Ubernomics
Log Price	-1.094***	-1.110***	-0.795***	-1.091***
	(0.039)	(0.039)	(0.107)	(0.217)
Observations	138,725	138,725	4,279	3,569
Controls	No	Yes	Yes	Yes

Specification has constant elasticity of Expected trips on price.

Pure Cash Users Price elasticity ϵ (trips) Back

	(1) AA	(2) AA	(3) Mandin	(4) Ubernomics
Elasticity	1.271***	1.270***	1.080***	1.218***
	(0.093)	(0.071)	(0.157)	(0.384)
Observations	138,725	138,725	4,279	3,569
Controls	No	Yes	Yes	Yes

- Semi-log specification, $a_i = \beta_0 + \beta_1 \ln p_i$, evaluated at equilibrium prices (no discounts)
- AA: Alvarez-Argente, Mandin & Ubernomics two other Uber price experiments in Greater Mexico. Mandin last 4-weeks

Summary Statistics AA experiments

Back

	(1) Pure Cash	(2) Mixed 1%	(3) Mixed 5%	(4) Pure Credit
Fares per week (historical)	1.54	4.26	3.84	3.58
Trips per week (historical)	0.36	0.83	0.76	0.52
Fares per week cash (historical)	1.54	1.57	1.57	0.00
Trips per week cash (historical)	0.36	0.34	0.34	0.00
Share of fares cash (historical)	1.00	0.43	0.45	0.00
Tenure in weeks (historical)	42.99	74.52	72.92	90.61
Fares week (experiment)	1.73	4.35	3.94	3.88
Trips week (experiment)	0.40	0.82	0.76	0.55
Fares cash week (experiment)	1.73	1.51	1.51	0.00
Trips cash week (experiment)	0.40	0.32	0.32	0.00
Users	138725	109365	98773	88844

Summary Statistics Mandin experiments

Back

	(1) Pure Cash	(2) Mixed 1%	(3) Mixed 5%	(4) Pure Credit
Fares per week (historical)	4.30	12.32	10.61	11.53
Trips per week (historical)	1.08	2.37	2.10	2.12
Fares per week cash (historical)	4.30	3.27	3.65	0.00
Trips per week cash (historical)	1.08	0.71	0.79	0.00
Share of fares cash (historical)	1.00	0.34	0.39	0.00
Tenure in weeks (historical)	50.91	86.15	82.23	115.73
Fares week (experiment)	6.74	14.68	13.21	13.10
Trips week (experiment)	1.66	2.87	2.65	2.47
Fares cash week (experiment)	6.43	4.03	4.48	0.00
Trips cash week (experiment)	1.60	0.89	0.98	0.00
Users	5668	11660	9254	47849

Summary Statistics Ubernomics experiments

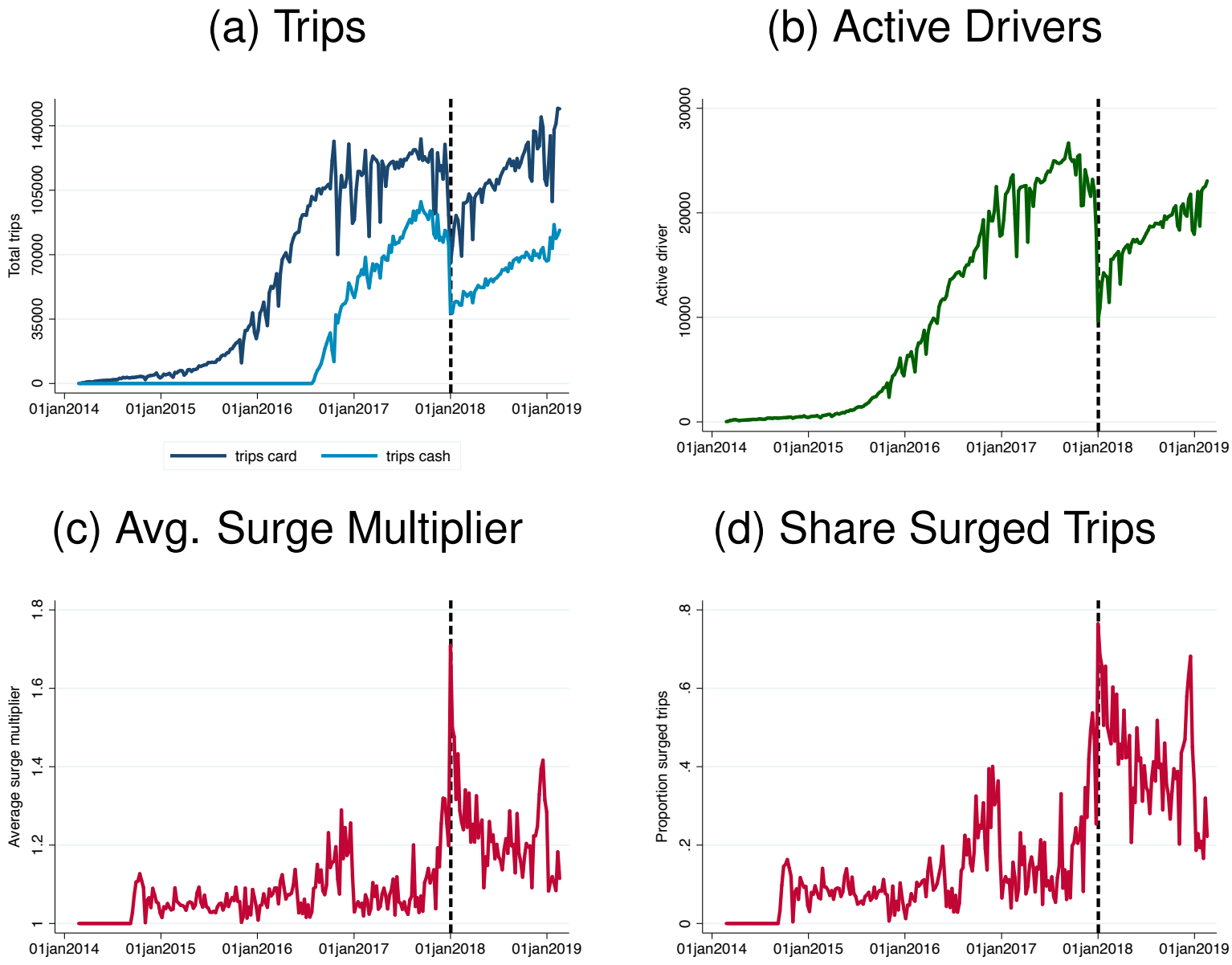
Back

	(1) Pure Cash	(2) Mixed 1%	(3) Mixed 5%	(4) Pure Credit
Fares per week (historical)	1.43	5.29	4.56	5.16
Trips per week (historical)	0.36	1.11	0.98	1.02
Fares per week cash (historical)	1.43	1.33	1.44	0.00
Trips per week cash (historical)	0.36	0.31	0.33	0.00
Share of fares cash (historical)	1.00	0.33	0.37	0.00
Tenure in weeks (historical)	47.36	88.80	85.53	114.83
Fares week (experiment)	3.00	7.00	6.34	6.55
Trips week (experiment)	0.73	1.40	1.27	1.19
Fares cash week (experiment)	2.91	2.22	2.39	0.00
Trips cash week (experiment)	0.71	0.49	0.53	0.00
Users	4869	4306	3719	26162

Panama Background (2018) ◂ Back ◂ Back Concl

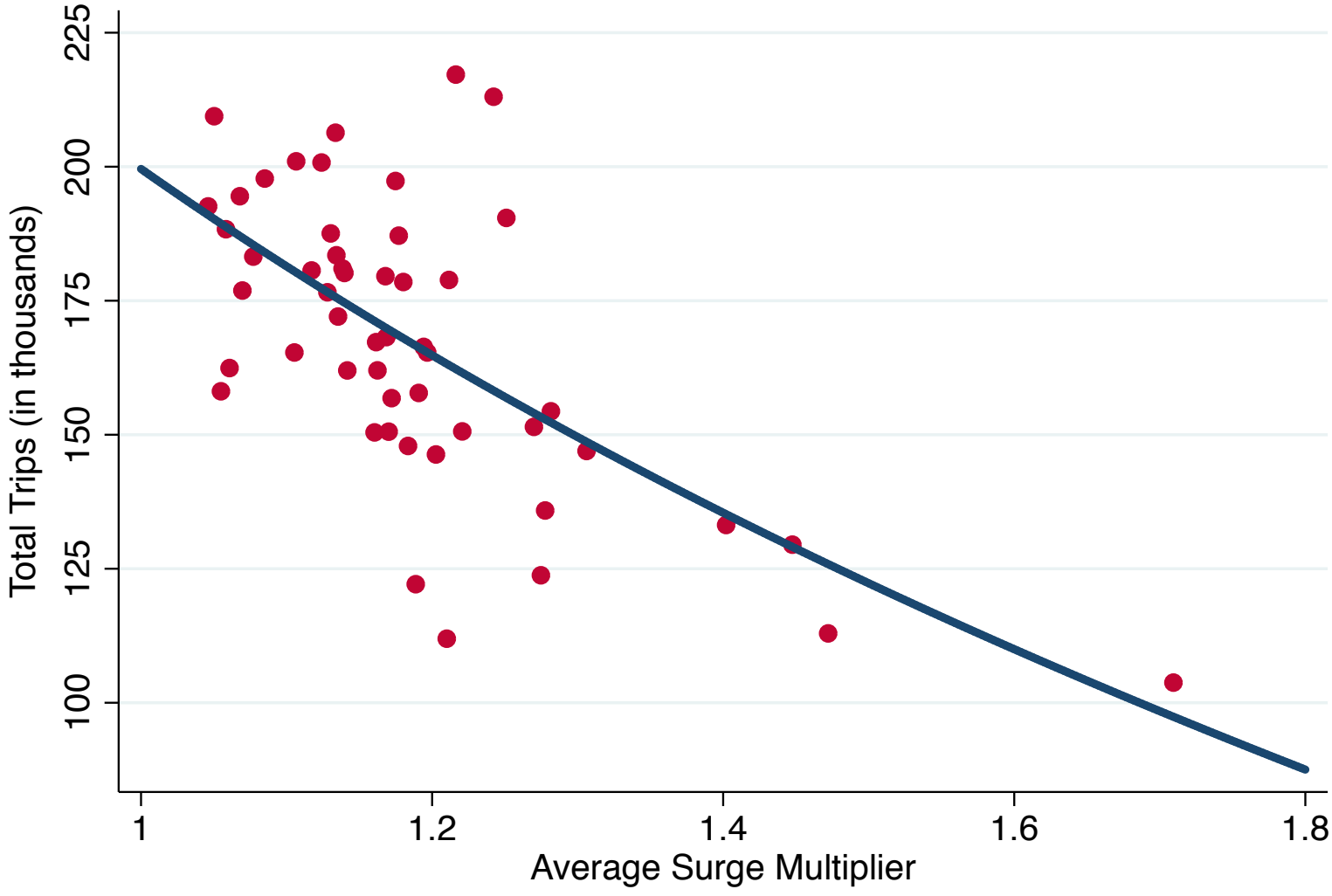
- January 2018 Panama government impose restrictions to Uber drivers
- Require new license, 200 USD, training
- On impact affected 80% registered drivers. A year after still about 1/2 registered drivers.
- Surge prices increase substantially.

Figure: **Panama: Trips, Fares, and Drivers**



Panama - exponential demand (2018)

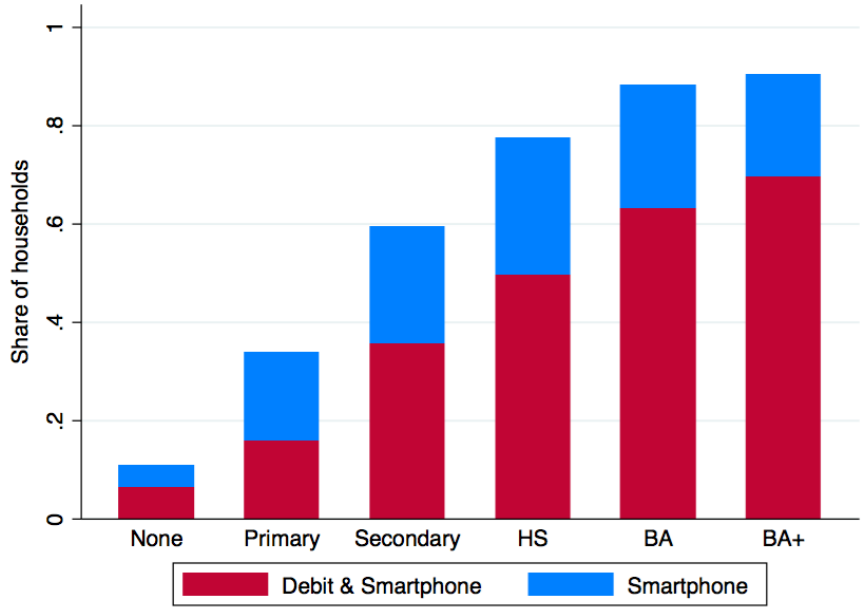
Back Back-3-exp



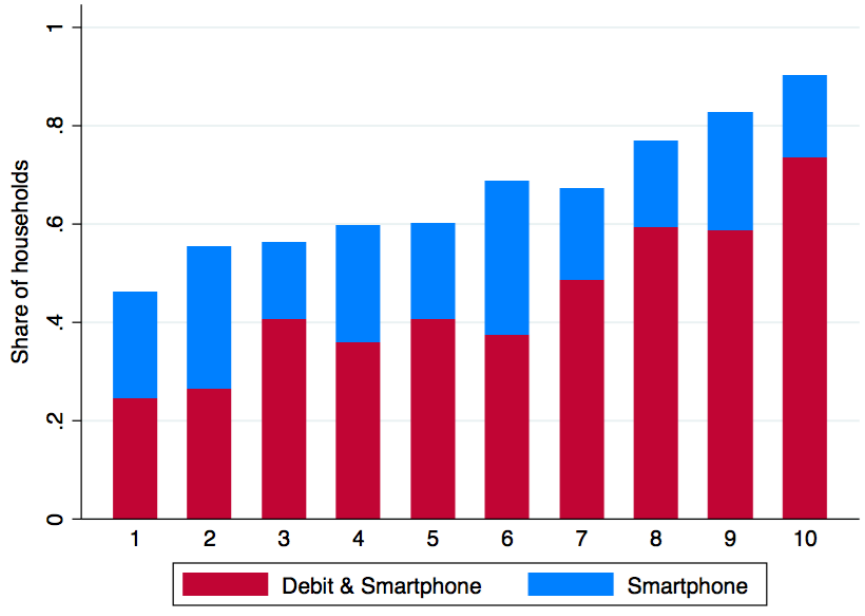
Uses seasonally adjusted prices

Smartphone and Debit Card Usage

Back



(a) Education



(b) Income

Intuition of proposition (intensive margin)

Back

- Given the quasi-linearity replacing the budget constraint, and using the assumption that I is large enough:

$$v(p_a, p_c, p_2, \ldots, p_n; \phi) = \max_{a,c,x_2,\ldots,x_n} u\left(H\left(a, c; \phi\right)\right), x_2, \ldots, x_n; \theta) - \left[p_a a + p_c c + \sum_{i=2}^{n} p_i x_i\right] + I$$

- Using the envelope theorem:

$$\frac{\partial}{\partial p_a} v(p_a, p_c, p_2, \ldots, p_n; \phi) = -\tilde{a}\left(p_a, p_c, p_2, \ldots, p_n; \phi\right)$$

- Using the fundamental theorem of calculus:

$$v(\bar{p}_a, p_c, p_2, \ldots, p_n; \phi) - v(\underline{p_a}, p_c, p_2, \ldots, p_n; \phi) = -\int_{\underline{p_a}}^{\bar{p}_a} \tilde{a}\left(p_a, p_c, p_2, \ldots, p_n; \phi\right) dp_a$$

Intuition of proposition (extensive margin)

Back

- Extensive Margin: pay fixed cost and register credit card.
- Define $\bar{\psi}(p_a, p_c\phi)$ at which:

$$v(\infty, p_c, p_2, \ldots, p_n) = v(p_a, p_c, p_2, \ldots, p_n) + \bar{\psi}(p_a, p_c, \phi)$$

- Extensive margin adjustment in Aggregate demand $A(p_a)$ smooth out if fixed cost distribution G have a continuous density.
- As p_a increases, those that migrate and those that don't have the same indirect utility.

Effect of Ban in cash in Puebla: Back
blocks of state of Mexico as counterfactual to Puebla

	(1) $\Delta Trips$	(2) $\Delta Trips_I$	(3) $\Delta Trips_E$	(4) $\Delta Fares$	(5) $\Delta Fares_I$	(6) $\Delta Fares_E$
Puebla	-0.493***	-0.460***	-0.032***	-0.491***	-0.459***	-0.032***
	(0.010)	(0.006)	(0.008)	(0.010)	(0.006)	(0.008)
Observations	51,991	51,991	51,991	51,987	51,987	51,987
R-squared	0.048	0.117	0.000	0.045	0.099	0.000
Estimator	CEM	CEM	CEM	CEM	CEM	CEM
Rule	Sturges	Sturges	Sturges	Sturges	Sturges	Sturges
Margin	All	Intensive	Extensive	All	Intensive	Extensive

Matching on:

- average education of each census block,
- trips per capita in 2017.
- share of households with: cell phones $\times$ internet access $\times$ own a car
- share of economically active population,

Consumer Surplus for different Demands

Back

- Let $\epsilon(P)$ elasticity at P
- Linear Demand: $Q(P) = a + bP$

$$\frac{CS}{PQ(P)} = \frac{\epsilon(P)}{2}$$

- Semi-log Demand: $Q(P) = a + b \log P$

$$\frac{CS}{PQ(P)} = \epsilon(P)\left[e^{1/\epsilon(P)} - 1\right] - 1$$

- Log-Log Demand: $\log Q(P) = a + b \log P$

$$\frac{CS}{PQ(P)} = \frac{1}{\epsilon(P) - 1}$$

Quasi-linear preferences

Back Back Concl

- Main motivation: low budget share of Uber paid in cash $\approx 1.5\%$ or less.
- Test of Quasi-linearity
  - Let $x = (x_1, ..., x_n)$ and price vector $p = (p_1, ..., p_n)$:

$$\max_x u(x) - p \cdot x$$

  - Let $\{x^a, x^b, ..., x^k\}$ observed choices for observed price vectors $\{p^a, \ldots, p^k\}$. Find utility levels $\mu^s \equiv u(x^s), \mu^r \equiv u(x^r)$ s.t.:

$$\mu^s - p^r \cdot x^r \geq \mu^s - p^r \cdot x^s$$
$$\mu^s - p^s \cdot x^s \geq \mu^r - p^s \cdot x^r$$

$$\Longrightarrow \frac{1}{2}(p^s - p^r)(x^s - x^r) \leq 0$$

    for all $r, s \in \{a, b, \ldots, k\}$
  - Test inequalities involving combinations of $p^r \cdot x^s$ or use linear programming.
  - Use experimental data (>2000 inequalities), every inequality is satisfied.

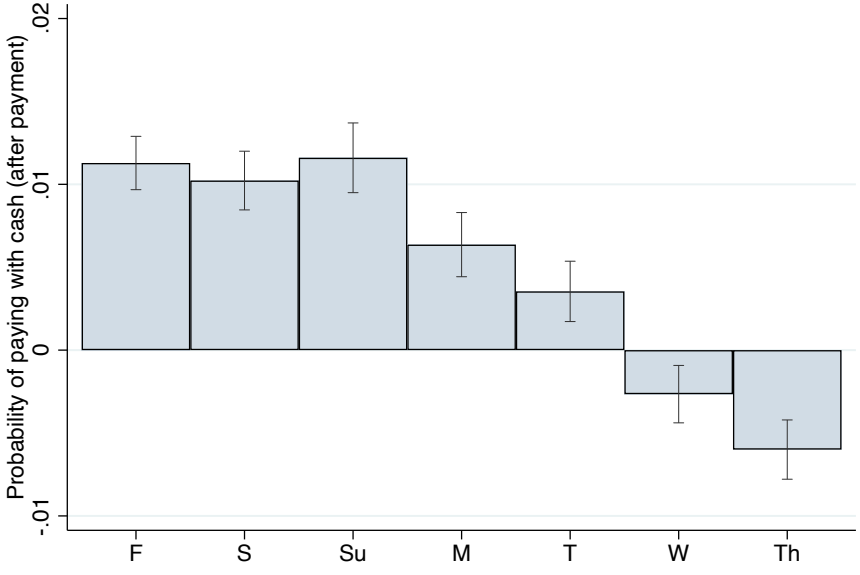
Validation / Choke Price Survey

Back Concl

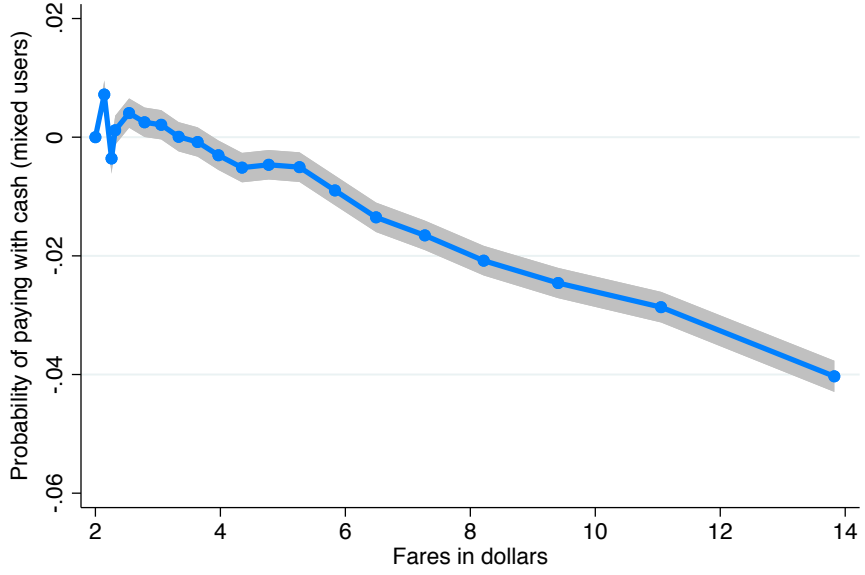
- Three questions to experiments participants
- 9 months after experiments
- One question about small price variation (20%) to compare with estimated elasticities
- Two questions with large price variation to estimate choke price
- Small response rate $\approx$ 1.5% or 5500 usable surveys (by e-mail)
- Similar local elasticities.
- Similar or larger choke prices.
- Plan to correct for selection using Pilot experiment.

Cash intensity: individual level (mixed users)

Back



(a) Days after payment



(b) Fare per trip

- linear probability model for whether trip is paid in cash
- includes individual fixed effects and time effects
- paydays are two fridays/months

Functional Forms

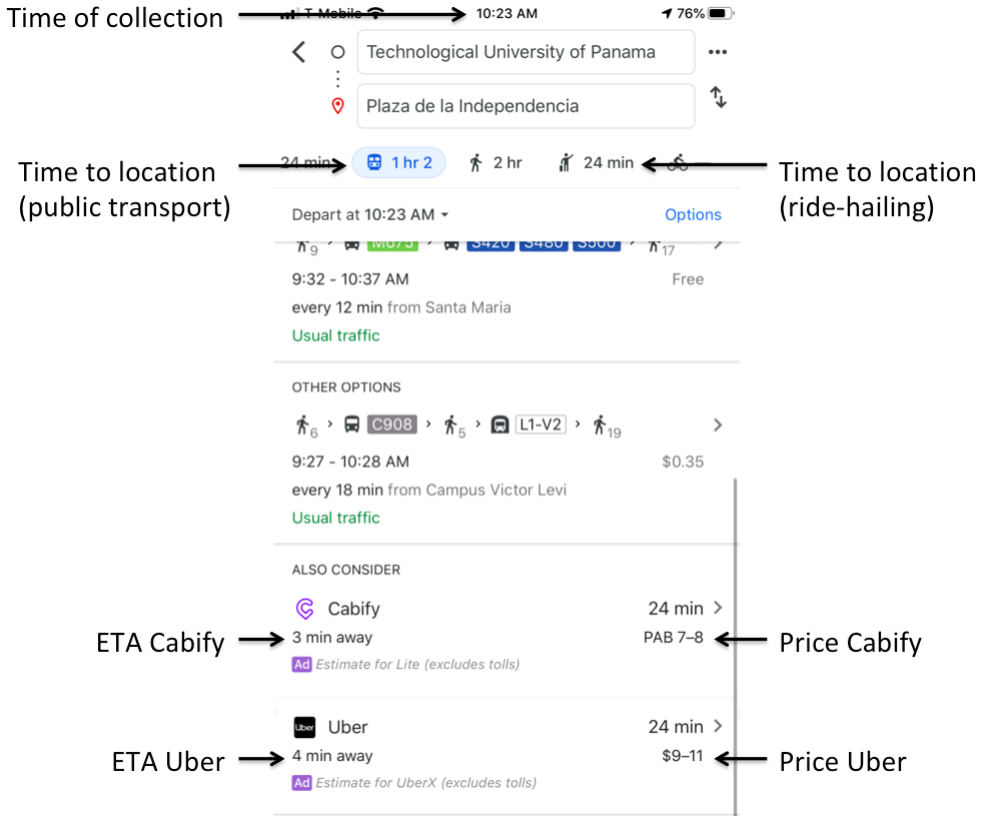
Back

Model	Identification
$u(x_1, x_2, \ldots, x_n; \phi) + x_{n+1}$	test using experimental data
$U(x) = -k\ exp(-(x + \bar{x})/k)$	$\epsilon(P)$: experiments 1 and 2 Panama and survey
$H(a, c) = \left[\alpha^{\frac{1}{\eta}} c^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} a^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$	α: data, η experiment 2
$\mathcal{V}(p_a, p_c; \theta)$	ψ: experiment 3 and Puebla
$1_{(1,1)}, a(1,1), c(1,1)$	joint dist.: historical data

Ban on cash in Panama: Data collection

Map Decree

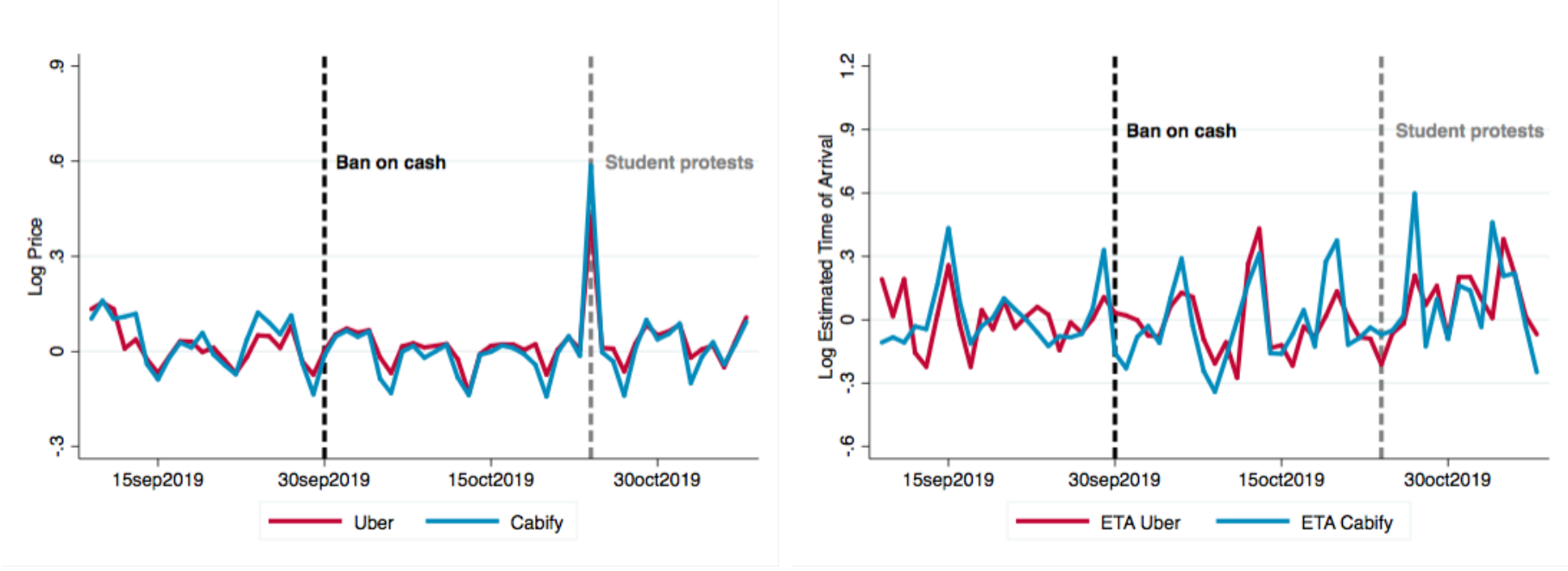
- Data collected before, during, and after ban using Google maps.
- All transportion methods: Uber, Cabify, and public transport.
- Prices, ETA, time to location, time of collection.
- 20 different addresses across Panama City.



Back

Panama: Prices and ETA

Back



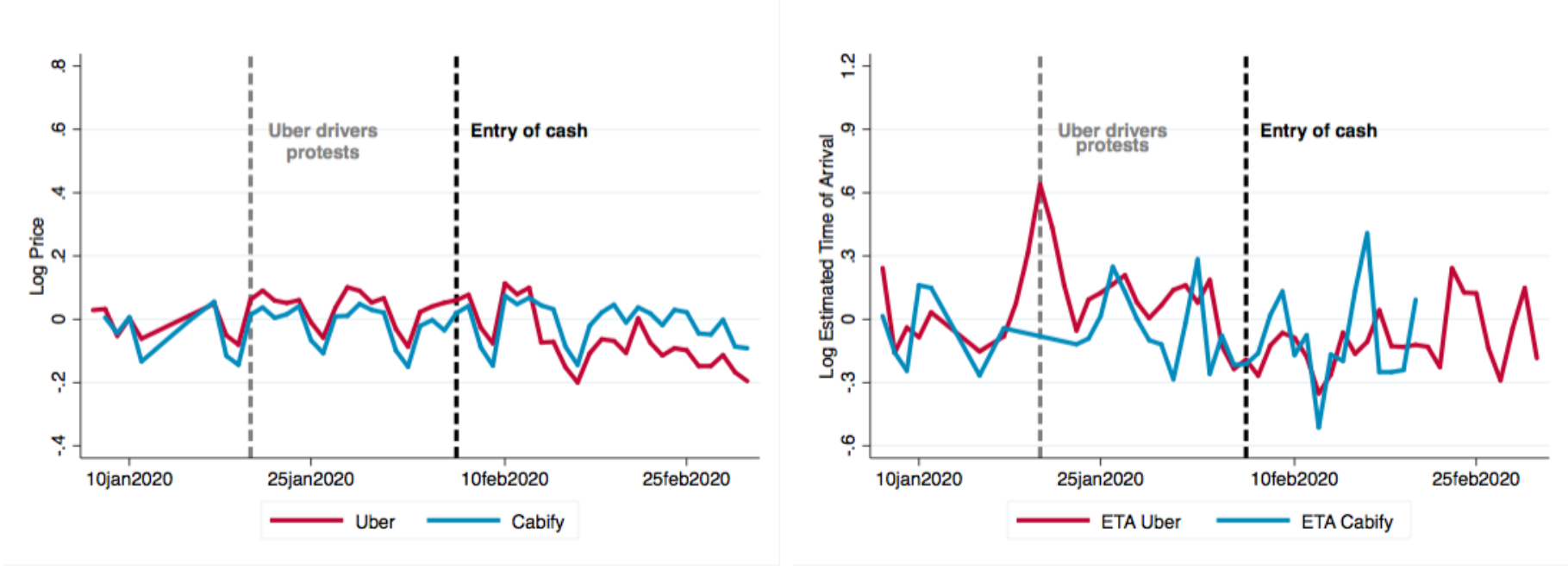
(a) Prices

(b) Estimated Time of Arrival

- No change in prices or ETA during the ban on cash.
- Only spike in prices occurs during a student protest that blocked the main road of the city.

Panama: Prices and ETA

Back



(a) Prices

(b) Estimated Time of Arrival

- No change in prices or ETA after reentry of cash.
- Only spike in prices occurs during Uber drivers' protest that blocked the main road of the city.

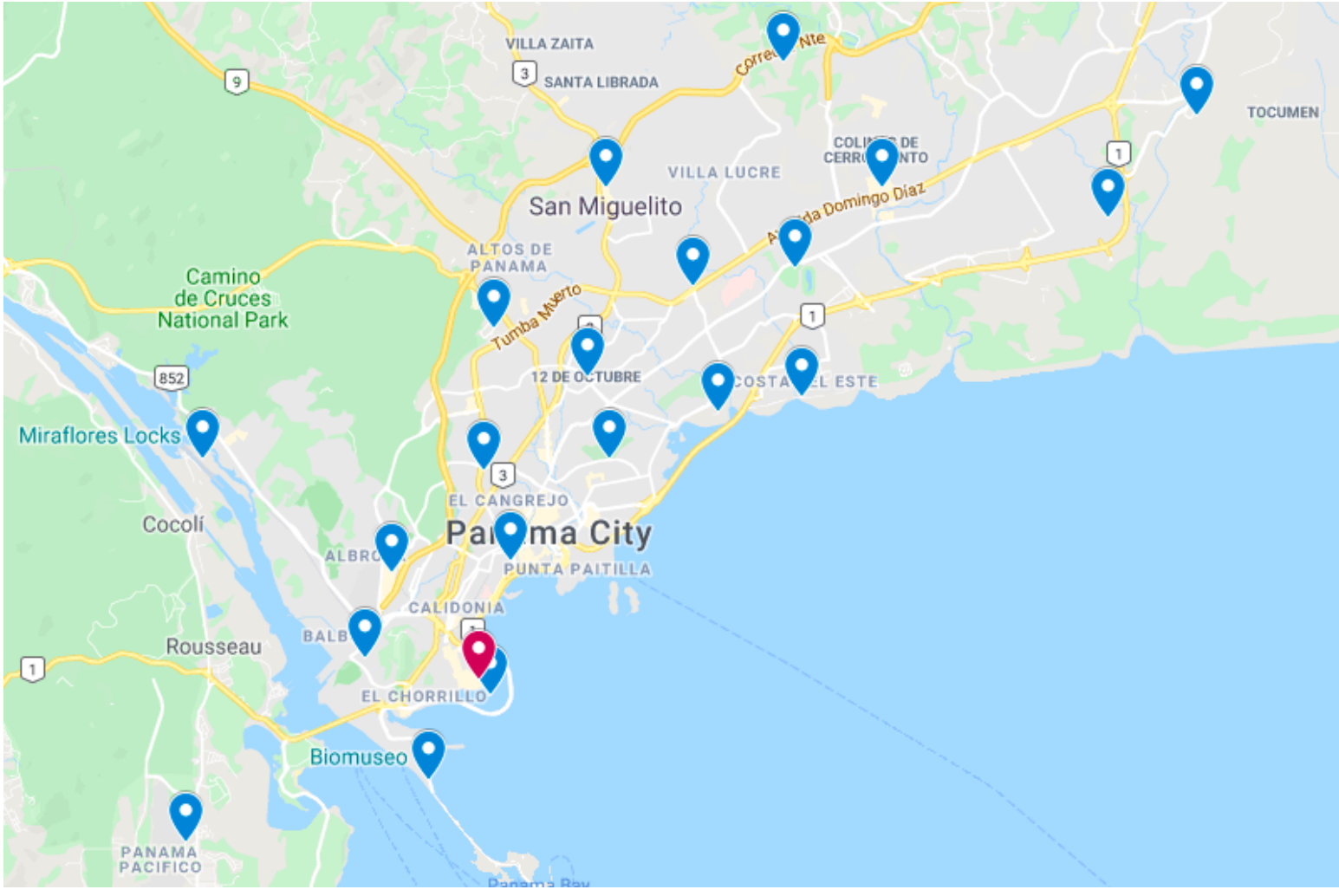
Ban on cash in Panama: Background

Back

- October 2017: a decree imposing restrictions on Uber was put in place. The decree includes a prohibition on cash.
- January 2018: Uber negotiated extensions of the deadline for the ban on cash every 6 months.
- The extension was not renewed and the government imposed a ban on cash on all ride hailing companies effective on September 30, 2019.
- Panama's Supreme Court voided the prohibition of cash payments for ride-hailing services two months later.
- Cash re-introduced on February 6th, 2020.

Panama locations of data collection

Back



- All information was collected for rides from the blue pins to the red pin.

Survey Instrument

Back

- Users in our experiments (6K responses), sent 10 months after.
- 6 different surveys randomly assigned to users, each with 3 questions.
- Adjust the covariate distribution such that it is similar to population
- Reported elasticities are informative about the revealed preferences
- "If price of trips is permanently tripled, how would you change your trips"

  a) no change, b) decrease substantially, c)stop traveling

- **Mixed users:** if we double prices, 56% (survey 55.49%) of the users stop traveling, if we triple prices 73% (survey 66.58%)
- **Pure cash users:** if we double prices, 41% (survey 54.43%) of the users stop traveling, if we triple prices 71% (survey 69.44%)

Puebla: Difference synthetic and actual (prices)

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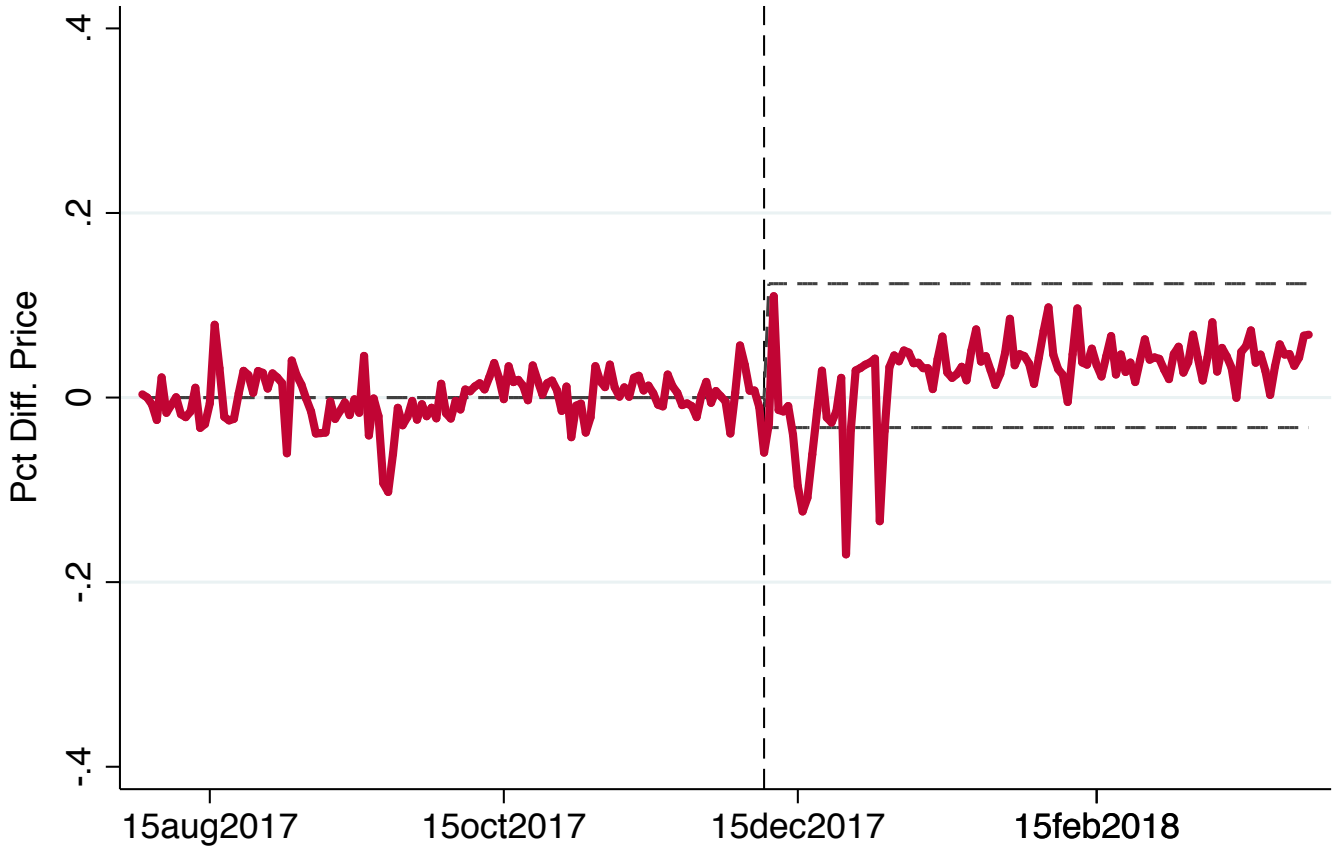

EC Taximeter

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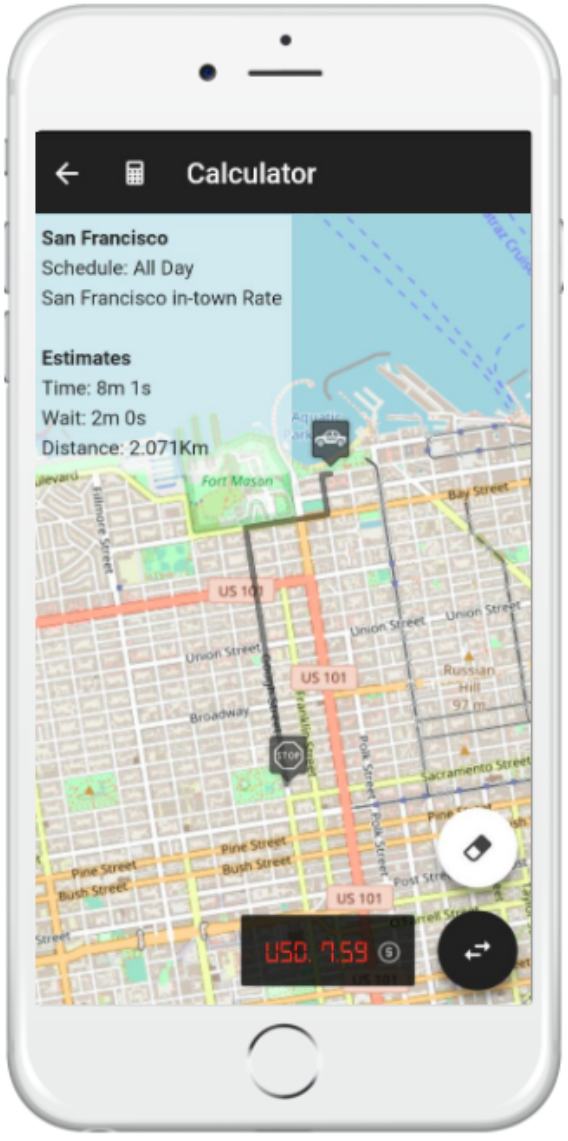
- Application calculates the cost of the taxi ride and allows users to start a taximeter in their own phone.
- Information on the distance, duration of the trip and wait time.
- We use data for the Greater Mexico City from June 2016 until July 2017.
- Information of 12,238 trips: radio taxis, regular taxis, taxicab stands.



Taxis Estimated Time of Arrival After the Entry of Cash

$$\ln \text{ETA}_{ijt} = \alpha + \beta\, \textit{Cash}_t + \gamma\, \textit{Cash}_t \times \textit{StateMexico}_j + \zeta X_{ijt} + \theta_j + \epsilon_{ijt}$$

	(1)	(2)	(3)	(4)	(5)
Cash	-0.463***	-0.238***	-0.390**	-0.356***	-0.198*
	(0.109)	(0.036)	(0.153)	(0.122)	(0.106)
State of Mexico × Cash	-0.060	-0.285	-0.213	-0.266	-0.924
	(0.230)	(0.204)	(0.252)	(0.232)	(0.720)
Observations	1,884	12,117	1,613	1,345	1,260
R-squared	0.062	0.053	0.234	0.435	0.403
Distance	$<$ 1Km	All	$<$ 1Km	$<$ 1Km	$<$ 1Km
Controls	N	N	Y	Y	Y
Region	Mun.	Mun.	Mun.	AGEB	Block

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Adjustment to CS for migration of pure cash users *

- Need counterfactual for pure cash users becoming pure credit users
- Estimate share parameter in CES H
- Assume H has the same elasticity substitution
- Experiment II: (price variation)
  pure-cash users demand Uber composite rides partially identify U
- Use (corrected) observation from ban in Puebla:
  - 30% pure cash users converted to pure credit
  - those that converted have few trips
- Experiment III (incentive to register credit cards)
  partially identify distribution cost ψ

Adjustment to CS for migration of pure cash users

- Pure cash riders demand: $\tilde{a}(p, \infty; \phi) = \beta_0 + \beta_1 \log p$
- The consumer surplus lost for switchers can be written as:

$$\widehat{CS}_{ban,a}(\alpha; \beta_0, \beta_1, \eta) = [-\beta_0 + \beta_1 - \beta_1 \exp(-\beta_0/\beta_1)] - \int_{\underline{\widehat{\psi}}}^{\max\{\underline{\widehat{\psi}}, \widehat{\psi}_{ban}\}} \left[\psi - \underline{\widehat{\psi}}\right] \widehat{g}(\psi) d\psi$$

$$\underline{\widehat{CS}}_{ban,a}(\alpha; \beta_0, \beta_1, \eta) \equiv [-\beta_0 + \beta_1 - \beta_1 \exp(-\beta_0/\beta_1)] - \tilde{\psi} \int_{\underline{\widehat{\psi}}}^{\max\{\underline{\widehat{\psi}}, \widehat{\psi}_{ban}\}} \widehat{g}(\psi) d\psi$$

where $\tilde{\psi} \equiv \widehat{\psi}_{ban} - \underline{\widehat{\psi}}$ and $\tilde{\psi}$, $\underline{\widehat{\psi}}$ and $\widehat{\psi}_{ban}$ are evaluated at $(\alpha; \beta_0, \beta_1, \eta)$.

- $\tilde{\psi}$ is a single-peaked function maximum at $\alpha = \underline{\alpha}$ or at $\alpha = 1/2$.
- Assume η is the same for all users and choose α to minimize CS lost:
  - Pure cash rider adopting credit must have positive demand after the ban.
  - Pure cash rider adopting credit takes fewer rides after the ban.
- Use rewards and excess migration rates to calculate CS lower bound.

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