Daily Labor Supply and Adaptive Reference Points

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Motivation 1

- Central assumption in labor supply models: Intertemporal optimization (MaCurdy 1981)
- A prominent challenge to this assumption comes from studies of daily labor supply that find evidence of daily income targeting (Camerer et al. 1997)
- Prompted an ongoing debate about the *role of reference dependence in labor supply*
  - Binary view: neoclassical vs. reference dependence
  - Studies assume a particular view of what constitutes the reference point

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  - If reference points were the expectations held by the decision maker at the time of realization, then reference dependence would have no effect

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  - What do we mean by expectations?
  - If reference points were the expectations held by the decision maker at the time of realization, then reference dependence would have no effect
- The question becomes: *How quickly do reference points adjust?*

This paper

1. Shows that within-day accumulated earnings affect labor-supply decisions in the context of New York City taxi drivers using data on all 170 million cab fares in 2013

2. Asks a new question—whether the *recency* of earnings within a day affects labor-supply decisions—to shed light on reference-point formation and adaptation

3. Introduces and structurally estimates a model of reference-point adjustment that bridges the neoclassical view and the standard daily income targeting alternative to explain the evidence

Preview

Methodology

- Non-parametric additive hazards model (Aalen 1989)
- Instrumental-variable analysis based on other drivers' speed
- Structural estimation to examine the influence of reference points

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   Overall: Elasticity of stopping with respect to earnings of 0.3

2. **Stronger effect for more recent earnings**

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Structural model: Adaptive reference points

- Reconciles conflicting interpretations of previous evidence

Literature

Daily labor supply

Taxi drivers: Camerer et al. (1997), Chou (2002), Ashenfelter et al. (2010), Doran (2014), Dupas and Robinson (2014), Agarwal et al. (2015), Jonason (2013), Farber (2015); Pear packers: Chang and Gross (2014); Swordfish fishermen: Nguyen and Leung (2015); Lobster fishermen: Stafford (2013)

Dynamics of reference dependence

Game show: Post et al. (2008); Lab experiment: Gill and Prowse (2012), Song (2017); Job search: Dellavigna et al. (2017); Theory: Kőszegi and Rabin (2009)

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→ *Field evidence with high-frequency adjustment and precise timing effects*

Roadmap

Data

Effect of earnings and timing on labor supply

Structural model of adaptive reference points

Discussion

Data

Data

- NYC Taxi and Limousine Commission tripsheet data from 2013

Trips	over 170 million
Drivers	over 40,000
Medallions	all 13,437 medallions (medallion type, agency, and drop-off zip code)

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Earnings	Fare, and credit card tip (55% of trips)
Time	Start and end times
Location	Pick-up and drop-off GPS coordinates; miles driven

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Earnings	Fare, and credit card tip (55% of trips)
Time	Start and end times
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- Merge with minute-level weather from NOAA

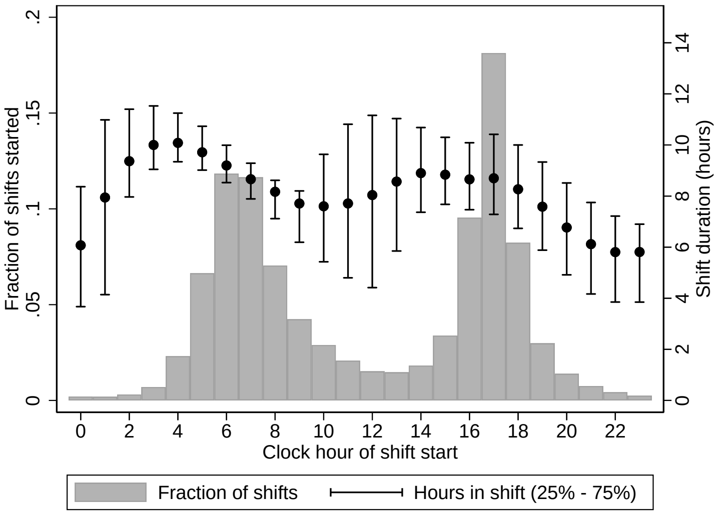
Data: Tripsheets — Trip Level

Trip length and fare distribution

	Mean	25p	50p	75p
Ride duration in minutes	12.6	6.1	10.0	16.0
Wait duration in minutes	11.3	2.0	5.0	12.0
Fare in dollars	12.2	6.5	9.5	14.0

Shift (or a day of work): consecutive trips of the same driver in the same cab with less than 6 hours in between

Data: Tripsheets — Shift Level table ↬



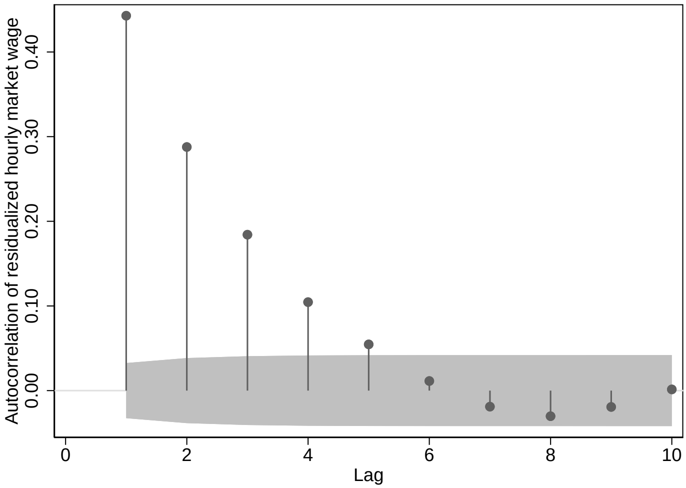
Stopping decision within a day

Model the decision of a driver who chooses at the end of each trip whether to continue or stop working for the day ⇝

Neoclassical prediction:

- At the end of any given trip, all else equal, small changes in accumulated daily earnings do not affect the decision to quit working for the day
- In particular, the timing of earnings is irrelevant
  - Behavioral models of income targeting implicitly make this assumption as well

Data: Predictability of fare earnings



Shaded region represents Bartlett 95% confidence band about 0

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Daily income effects ↪

Non-parametric additive hazards model

$$\text{stop}_{int} = f(h_{int}) + \beta(h_{int})y_{int} + X_{int}\gamma(h_{int}) + \mu_i(h_{int}) + \epsilon_{int}, \quad \text{(TT)}$$

- h_{int} cumulative minutes up to trip t by driver i in shift n
- $f(\cdot)$ baseline hazard
- $\beta(\cdot)$ effect of an additional dollar of accumulated daily earnings on the probability of ending a shift
- y_{int} cumulative \$ earned up to trip t by driver i in shift n
- X_{int} time of day, location, and weather controls
- μ_i driver ”fixed effects”

Test whether $\beta = 0$

Daily income effects ↔

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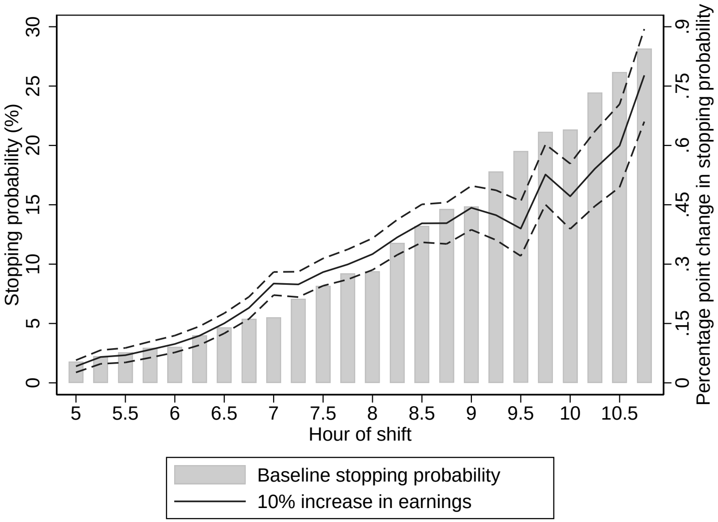
Estimation

- Use local linear regression techniques to estimate the baseline hazard and the time-varying coefficients
- For any given time h, the associated parameter estimates solve a separate weighted least squares problem with weights $w(\cdot)$:

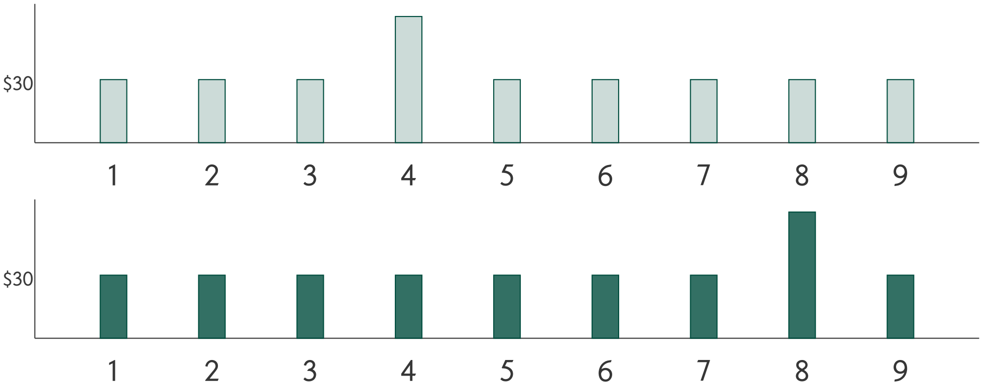
$$\min_{\alpha,\gamma,\beta,\mu} \sum_{i,n,t} w(h - h_{int})(d_{int} - (\alpha h_{int} + \beta y_{int} + X_{int}\gamma + \mu_i))^2$$

- Using uniform weights, the coefficients at any time h represent the fit of a linear model to a localized subset of the data

Daily income effects: Estimates



Fungibility of money within a day



Is stopping decision at hour 9 affected by the time path of money earned?

Example: $300 earned after 9 hours, positive shock occurring in hour 4 vs. hour 8

Test of fungibility of within-day earnings

$$\text{stop}_{int} = f(h_{int}) + \sum_{\ell} \beta^{\ell}(h_{int}) y_{int}^{\ell} + X_{int}\gamma(h_{int}) + \mu_i(h_{int}) + \epsilon_{int}$$

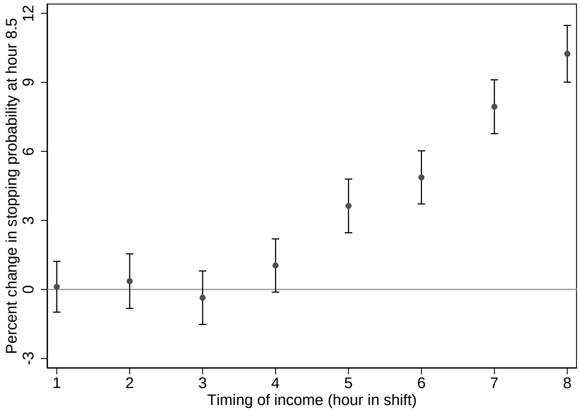
Of the income earned so far, y_{int}^k is the amount earned in hour k

$$\sum_k y_{int}^k = y_{int}$$

Test whether β^k is independent of k

Fungibility of money: After 8.5 hours

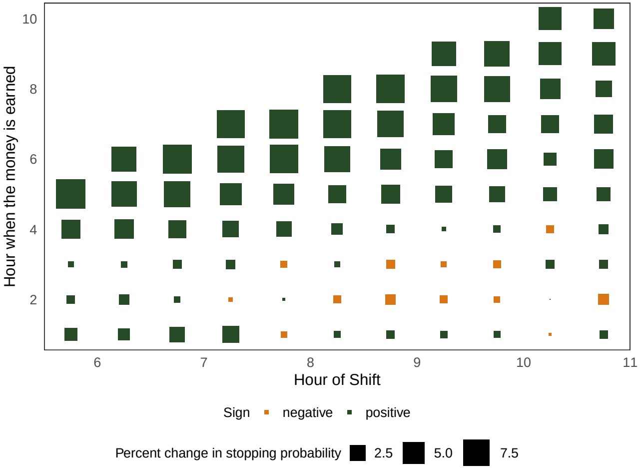
Impact of $26 earned at hour 1 through hour 8



Standard errors clustered at the driver level

Fungibility of money: After 6 to 11 hours

Impact of $26 earned at hour 1 through current hour



Alternative explanations

- Unobserved effort: intensity of work in place of working hours
- Taking breaks: fewer breaks on high-earning days?
- Across days: higher earnings $\longrightarrow$ save energy for tomorrow?
- Experience: does experience reduce the effect?
- Liquidity constraints

Alternative explanations

- Unobserved effort: intensity of work in place of working hours
  instrument for earnings using average speed of other drivers
- Taking breaks: fewer breaks on high-earning days?
  the role of breaks
- Across days: higher earnings $\longrightarrow$ save energy for tomorrow?
  no daily autocorrelation
- Experience: does experience reduce the effect?
  across-driver; within-driver
- Liquidity constraints
  medallion owners

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Overview

The evidence constitutes a rejection of both the neoclassical model and static daily income targeting

- To explain the role of the path of within-day earnings, we propose a model of adaptive reference points which nests the two approaches above
- Embed adaptive reference points in a specific model—loss aversion
- Illustrate identification and structurally estimate the parameters of the model

Models of daily labor supply

A general stopping model

- At the end of trip t, a driver with cumulative earnings I_t and hours of work H_t chooses whether to stop or continue working
- Driver decides to quit for the day if the value of stopping exceeds the expected value of continuing to work, i.e.,

$$\mathbb{E}_t[v(I_{t+1}, H_{t+1})] - v(I_t, H_t) + \varepsilon_t < 0$$
$$\varepsilon_t \overset{\text{i.i.d.}}{\sim} \mathcal{N}\left(0, \sigma^2\right)$$

- Expected value of continuing depends on the joint distribution of the fare f_{t+1} and duration h_{t+1} of trip $t+1$, given the circumstances at the end of trip t
- Error term $\varepsilon_t = x_t\beta + \xi_t$, where $x_t\beta$ captures the effect of control variables and ξ_t are i.i.d.

Models of daily labor supply

A neoclassical model

- Marginal utility of lifetime income does not vary in response to small, within-day changes in wealth
- Assume the objective function takes the form

$$v(I_t, H_t) = I_t - \frac{\psi}{1+\nu} H_t^{1+\nu},$$

  ψ parameterizes the disutility of work
  ν is the (inverse) elasticity parameter

- Quasi-linear objective function: labor supply does not decrease in response to additional accumulated earnings

  as long as the continuation value does not decrease in I_t

Models of daily labor supply

A reference-dependent model

- Explaining recent-income effects requires non-trivial within-day changes in the marginal utility of income
- To the standard outcome-based consumption component, add a gain-loss component which captures how decision makers assess choices relative to a reference point:

$$v^{LA}(I_t, H_t) = (1-\eta)v(I_t, H_t) + \eta n\left(I_t \,\middle|\, I_t^r\right)$$

where I_t^r denotes the **reference point** for income (i.e., expected earnings for the shift), and **gain-loss utility** is

$$n(I \mid I^r) = \left(\mathbb{1}_{\{I>I^r\}} + \Lambda \mathbb{1}_{\{I<I^r\}}\right)(I - I^r),$$

where $\Lambda \geq 1$ parameterizes the degree of loss aversion

Models of daily labor supply

Specifications of the reference point

Models of daily labor supply

Specifications of the reference point

Reference point	Overall income	Timing pattern
Static		
Instantaneous adjustment		
Slow adjustment		

Models of daily labor supply

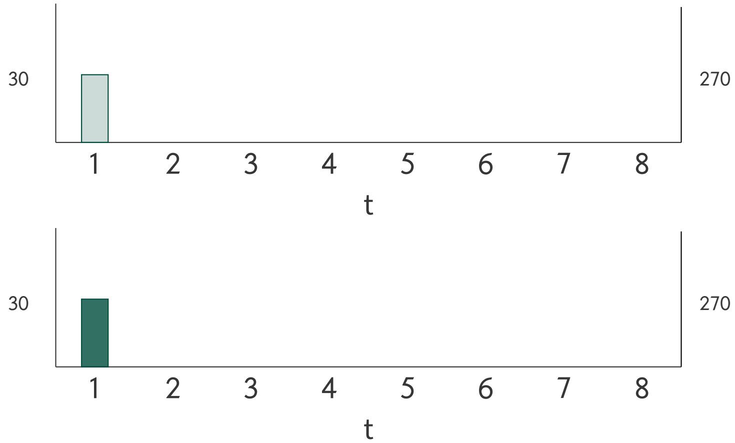
Reference points: Static

$$I_t^r = I_0^r$$

- Each hour expect \$30
- Target at beginning
  $I_0^r = \$30 \times 9 = \$270$
- One-time shock of \$30:
  $\Delta_4 = 30$ vs. $\Delta_8 = 30$

Bar (left): *hourly \$*

Line (right): *target* I_t^r



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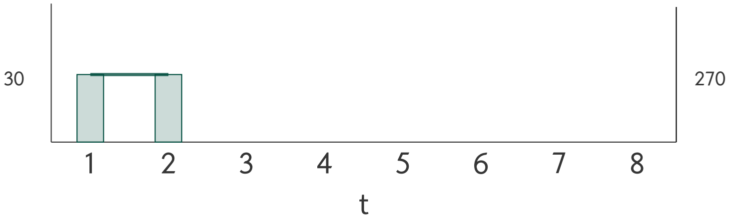

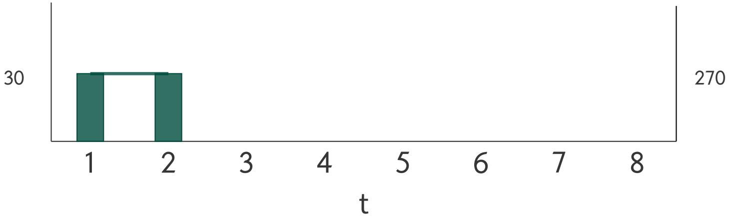

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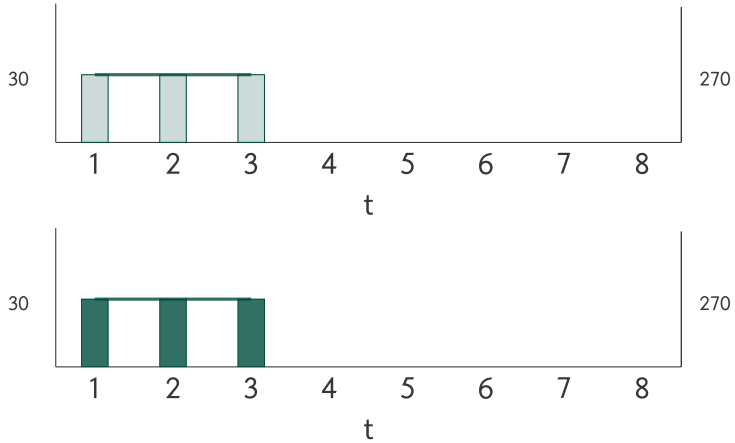

Models of daily labor supply

Reference points: Static

- Each hour expect \$30
- Target at beginning $I^r_0 = \$30 \times 9 = \$270$
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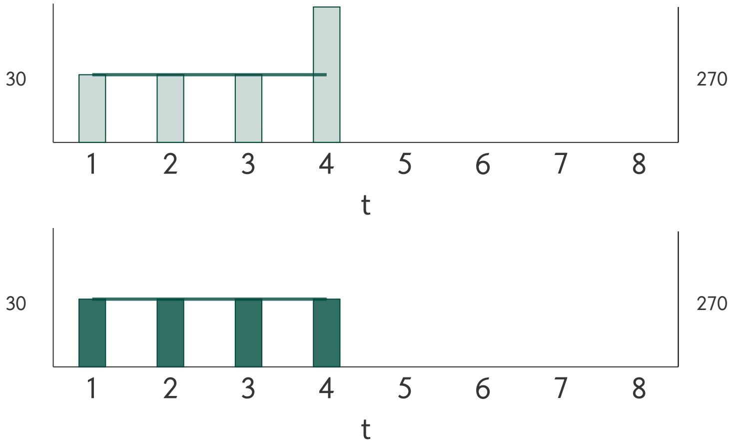
$$I^r_t = I^r_0$$



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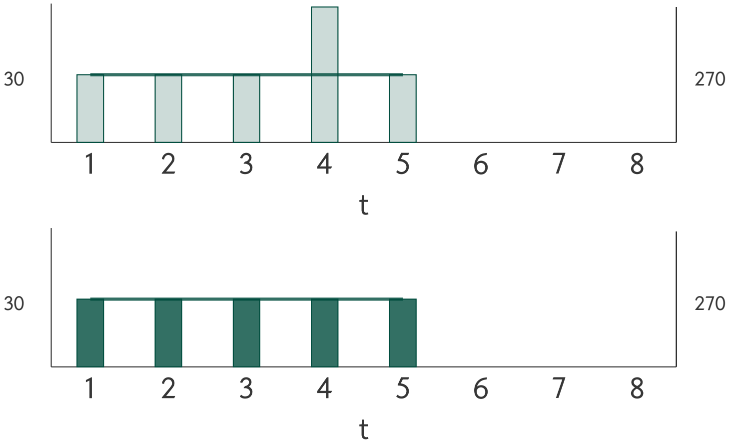

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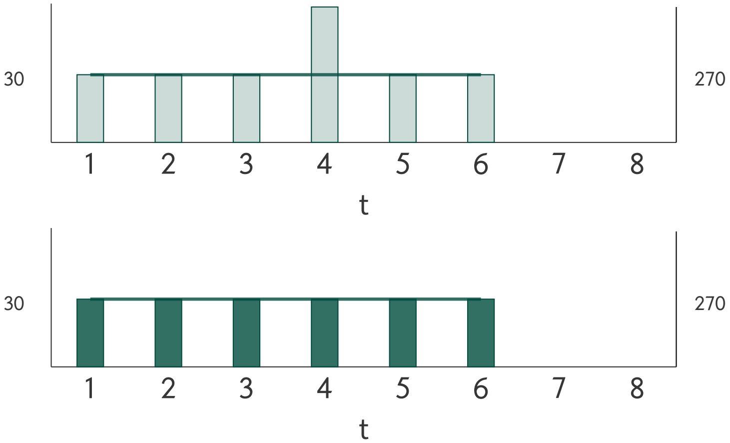

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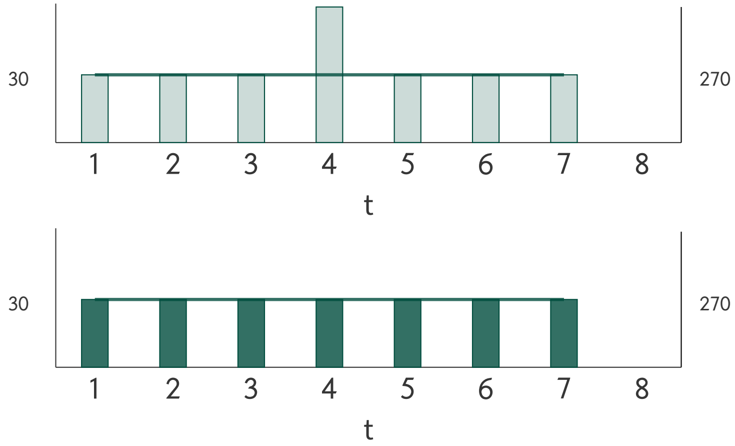

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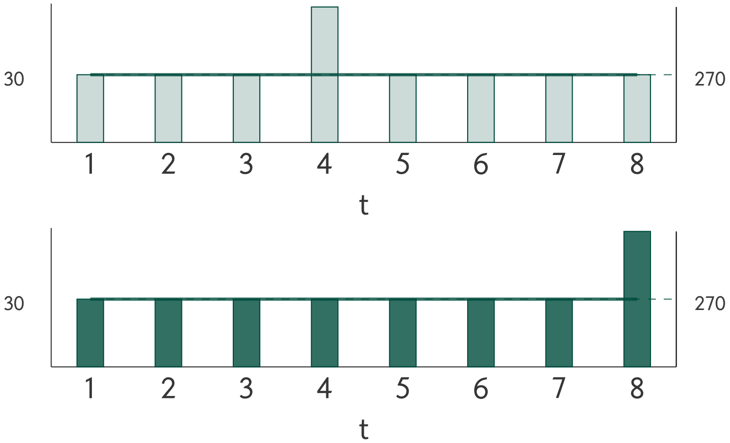

Models of daily labor supply

Specifications of the reference point

	Overall income	Timing pattern
Static	Yes	No
Instantaneous adjustment		
Slow adjustment		

Models of daily labor supply

Reference points: Instantaneous adjustment

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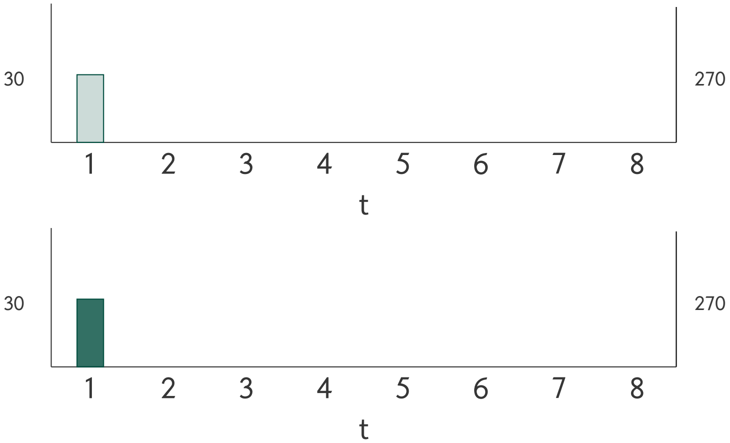

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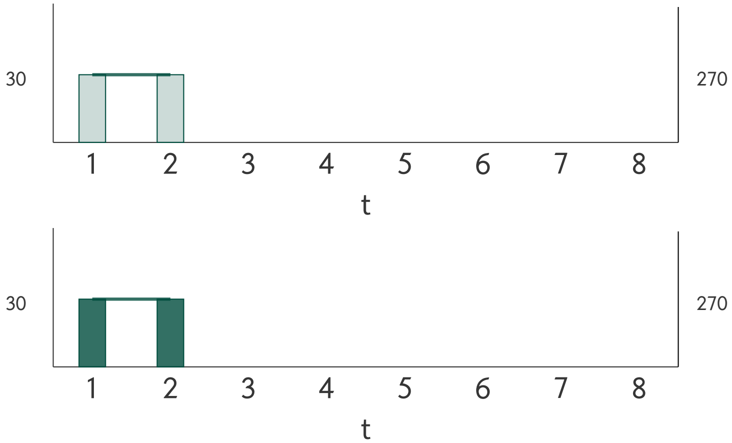

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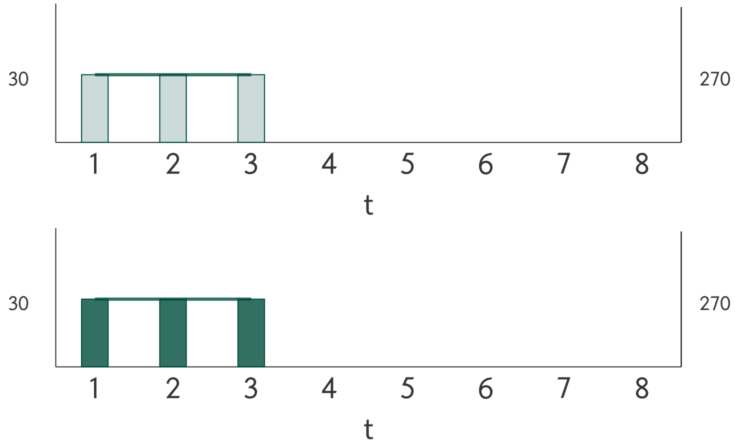

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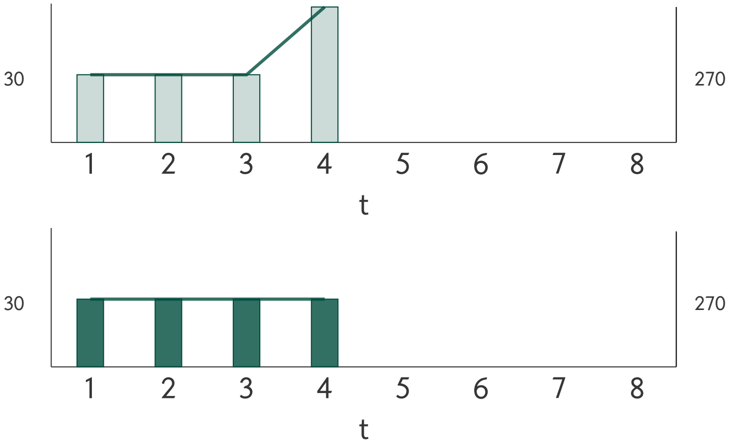

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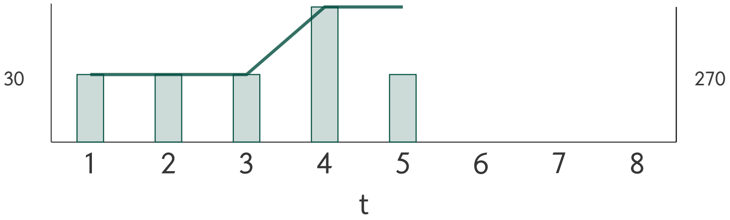
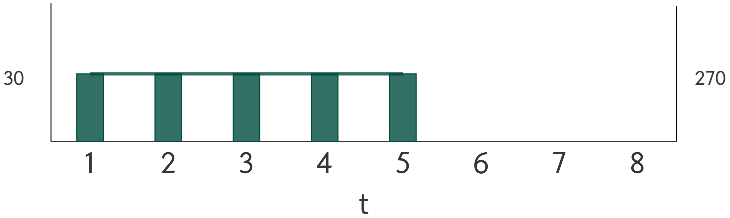


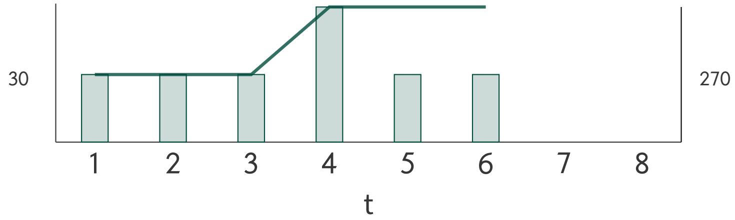


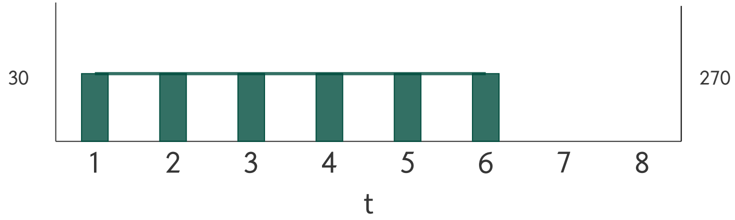
Models of daily labor supply

Reference points: Instantaneous adjustment

$$I_t^r = I_0^r + \sum_{\tau=1}^{t} \Delta_\tau$$

- Each hour expect $30
- Target at beginning $I_0^r = \$30 \times 9 = \$270$
- One-time shock of $30: $\Delta_4 = 30$ vs. $\Delta_8 = 30$





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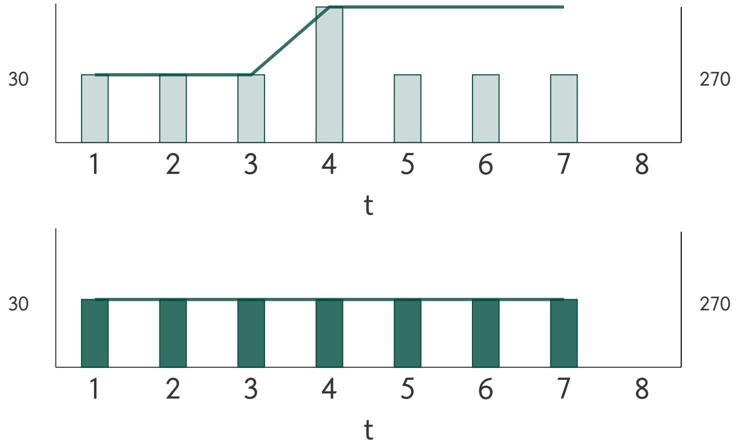

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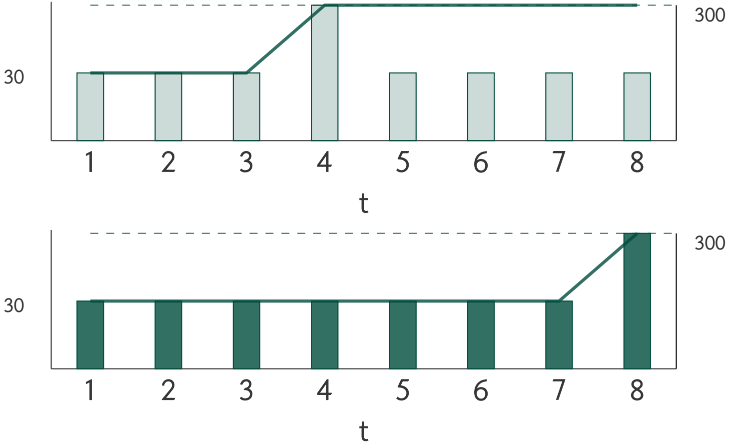

Models of daily labor supply

Specifications of the reference point

	Overall income	Timing pattern
Static	Yes	No
Instantaneous adjustment	No	No
Slow adjustment		

Models of daily labor supply

Reference points: Slow within-day adjustment

- Adaptive reference point: convex combination of lagged reference point and reference point that fully incorporates new information
- New information at trip t is Δ_t: difference between realized and expected earnings in trip t
- Expectation of daily earnings after trip t is $E_t = I_0^r + \sum_{\tau=1}^{t} \Delta_\tau$
- Define the updated reference point as

$$I_t^r = \theta I_{t-1}^r + (1-\theta) E_t$$

  - $\theta = 1 \implies$ no adjustment (static)
  - $\theta = 0 \implies$ instantaneous adjustment

Models of daily labor supply

Reference points: Slow adjustment

$$I_t^r = I_0^r + \sum_{\tau=1}^{t} (1 - \theta^{t+1-\tau}) \Delta_\tau$$

- Each hour expect \$30
- Target at beginning $I_0^r = \$30 \times 9 = \$270$
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Bar (left):*hourly \$*

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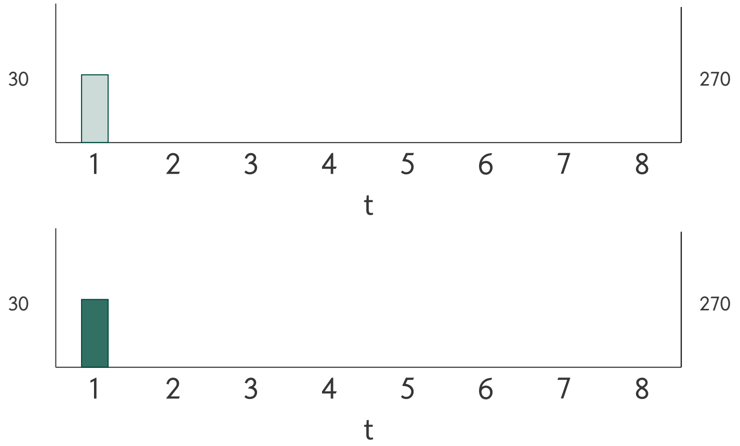

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Bar (left):*hourly \$*

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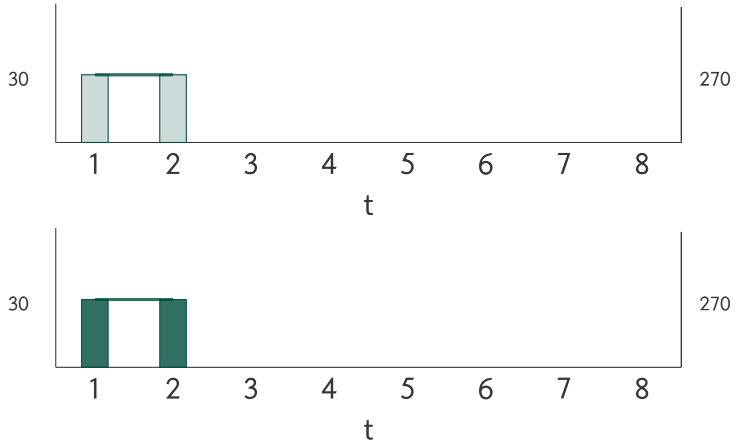

Models of daily labor supply

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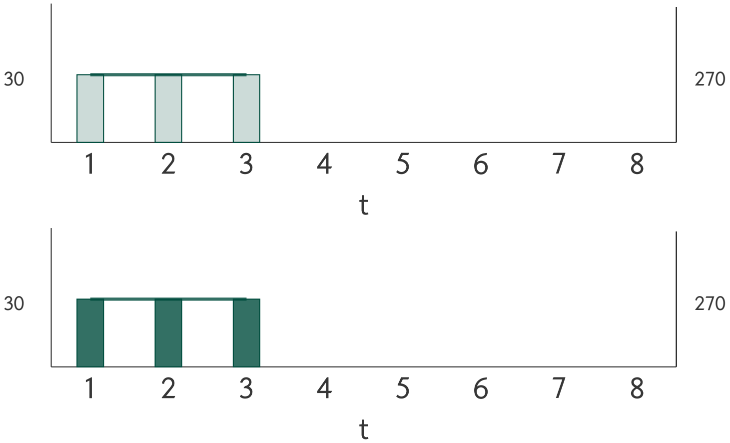

Models of daily labor supply

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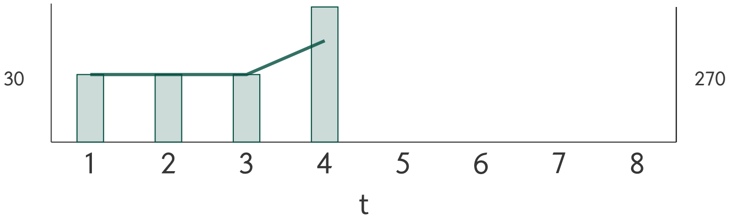

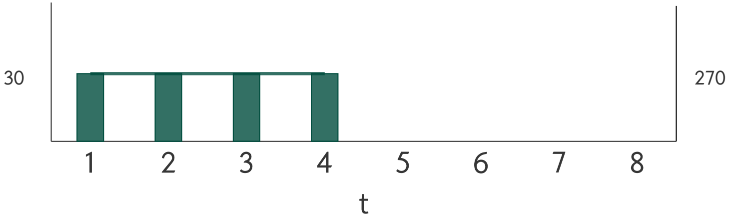

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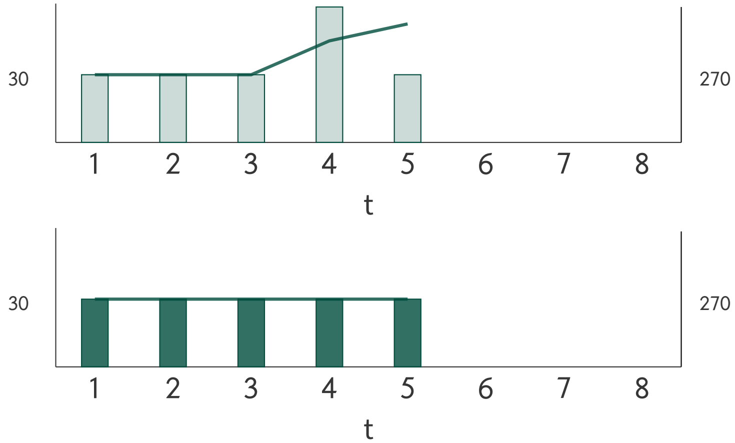

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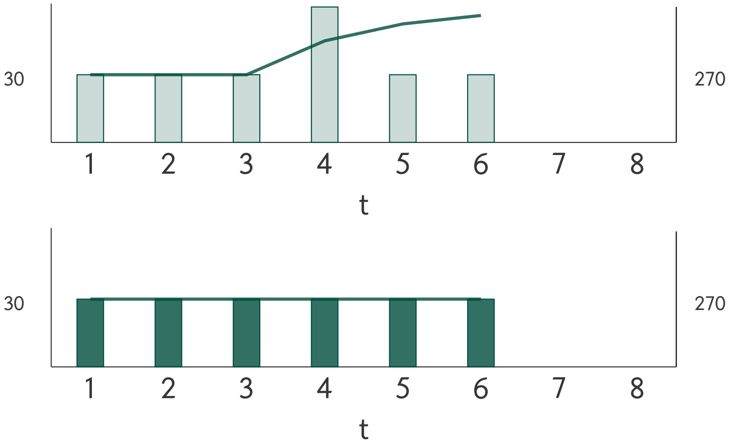

Models of daily labor supply

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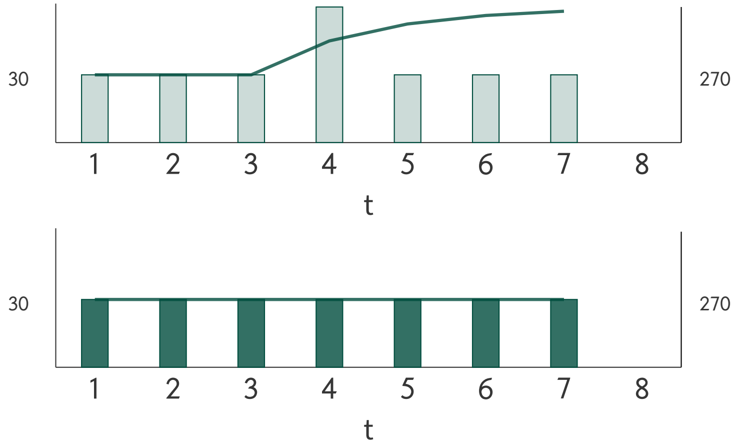

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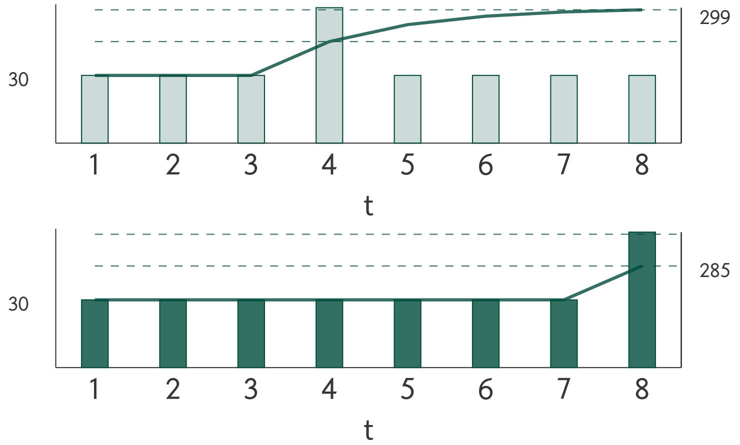


Bar (left): *hourly $*

Line (right): *target* I_t^r

Models of daily labor supply

Specifications of the reference point

	Overall income	Timing pattern
Static	Yes	No
Instantaneous adjustment	No	No
Slow adjustment	Yes	Yes

Estimation

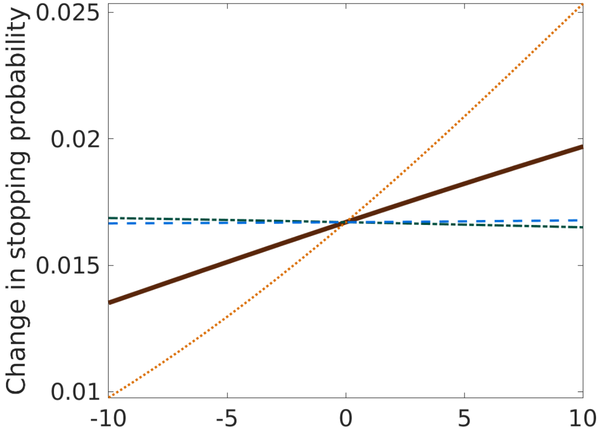
- Estimate the model via maximum likelihood
  - Parameters: disutility of effort vector ψ, elasticity parameter ν, loss aversion Λ, speed of adjustment θ, controls β, distribution of error term σ^2
- Likelihood functions of the following form

$$\sum \log \Phi\left(\frac{v(I_t, H_t) - \mathbb{E}_t[v(I_{t+1}, H_{t+1})] - x_t\beta}{\sigma}\right)$$

- Estimate parameters and obtain standard errors using subsampling (Politis and Romano 1994)

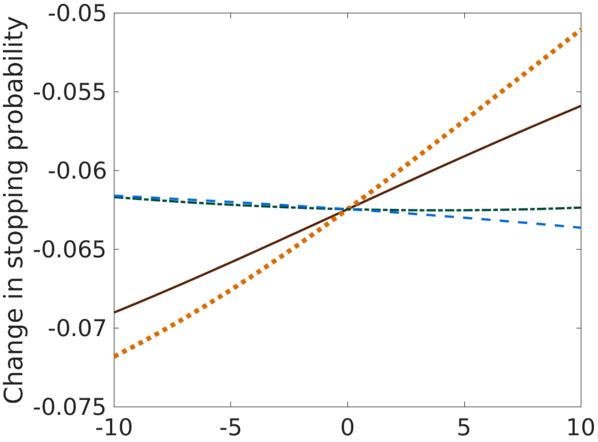
Identification of ψ

Effect of working an additional 10 minutes



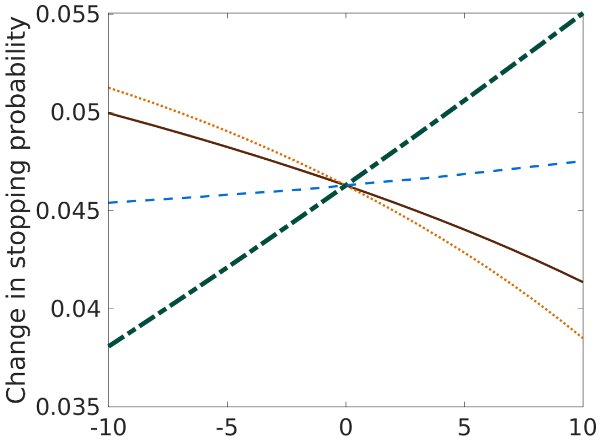
Identification of ν ↩

Effect of 10 percent wage increase



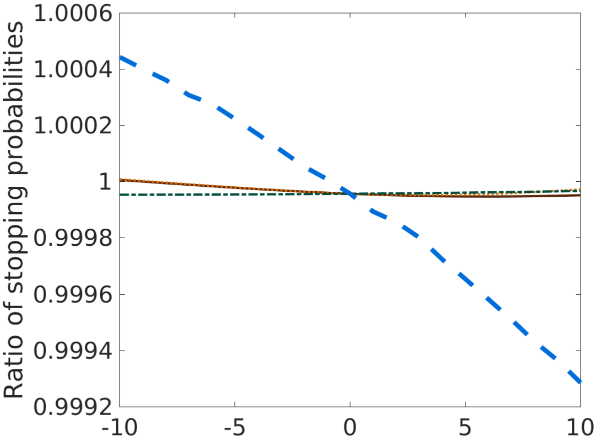
Identification of Λ ↩

Effect of increase in accumulated earnings



Identification of θ ↩

Effect of earnings in most recent hour relative to 3 hours earlier

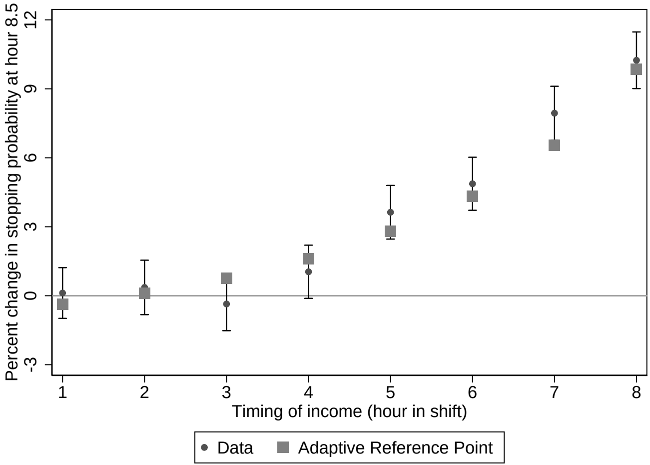


Parameter estimates

Disutility of effort ψ	0.1210	0.2051	0.1532
	(0.0821)	(0.1601)	(0.0796)
Elasticity ν	0.8268	0.7771	0.8460
	(0.2600)	(0.2675)	(0.2186)
Loss aversion Λ		2.0275	2.6184
		(0.2177)	(0.3178)
Adaptation θ			0.8413
			(0.0376)
Error term distribution σ	0.2541	0.4168	0.4073
	(0.0322)	(0.0844)	(0.0799)
Test $\Lambda = 1$		< 0.001	< 0.001
Test $\theta = 1$			< 0.001

Model fit

Magnitude of the income effect



Variants of the model

Alternative specifications of the reference point

- Adaptive reference point (equivalent formulation): weighted average of multiple lagged values of expectations

$$I_t^r = \theta I_{t-1}^r + (1-\theta) E_t$$
$$= \theta^t I_0^r + (1-\theta) \sum_{\tau=1}^{t} \theta^{t-\tau} E_\tau .$$

- Forward-looking reference point: based on a one-period lag of expectations (Kőszegi-Rabin 2006, 2009)
  - Previous trip
  - Previous hour
  - Previous day
  - Fixed

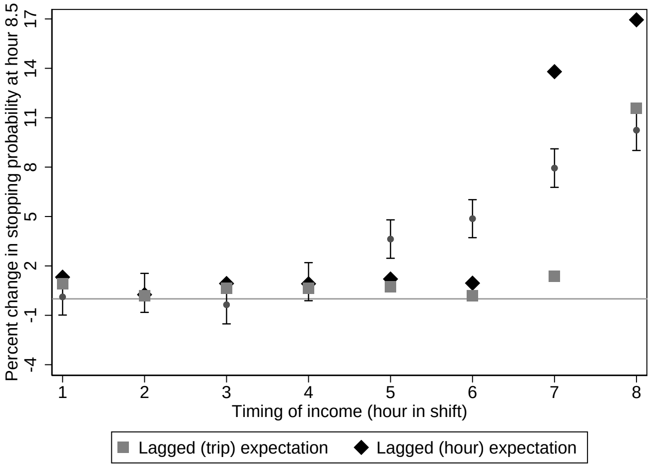
Parameter estimates

One-period lagged expectation

	Fixed Reference Point	Day	Hour	Trip
Disutility of effort ψ	0.0145	0.2051	0.0231	0.0164
	(0.0019)	(0.1601)	(0.0043)	(0.0026)
Elasticity ν	1.6749	0.7771	1.7334	1.8046
	(0.0658)	(0.2675)	(0.0653)	(0.0650)
Loss aversion Λ	1.4816	2.0275	2.6507	2.1452
	(0.0564)	(0.2184)	(0.3321)	(0.2570)
Error term distribution σ	0.2315	0.4168	0.4705	0.3748
	(0.0216)	(0.0844)	(0.0859)	(0.0644)
Test $\Lambda = 1$	<0.001	<0.001	<0.001	<0.001

Model fit: Alternative specifications

Magnitude of the income effect



Variants of the model

Alternative specifications of the model

Relaxing the following simplifying assumptions

- No reference level for hours of work (Crawford and Meng 2011)
- Piecewise linear gain-loss function rules out diminishing sensitivity (decision makers experience smaller marginal changes in gain-loss sensations further away from their reference levels)
- Abstracting from stochasticity whereby the reference levels represent the full distribution of potential earnings for a given shift

Parameter estimates

	Hours Loss Aversion	Diminishing sensitivity	Stochastic Reference Point
Disutility of effort ψ	0.1461	0.0250	0.2878
	(0.0208)	(0.0053)	(0.0375)
Elasticity ν	0.4479	2.0616	0.7042
	(0.0635)	(0.1124)	(0.0397)
Loss aversion Λ	1.8097	2.7332	5.1969
	(0.0709)	(0.2723)	(0.2004)
Adaptation θ	0.7913	0.8164	0.7833
	(0.0490)	(0.0365)	(0.0056)
Standard deviation target ς			0.3829
			(0.0384)
Error term distribution σ	0.2582	0.5620	0.5691
	(0.0229)	(0.0810)	(0.0146)

Roadmap

Data

Effect of earnings and timing on labor supply

Structural model of adaptive reference points

Discussion

Discussion

Discussion

Income effects vs. wage effects

Our facts: Labor supply exhibits excess sensitivity to daily earnings, but extent of the effect depends on the timing of income

- Distinct from the sign of daily wage elasticity of labor supply
- Avoid mechanical bias in estimating daily wage elasticity in settings with non-constant within-day wage profile

Positive

Taxi drivers: Jonason (2013), Farber (2015)

Stadium vendors: Oettinger (1999)

Lobster fishermen: Stafford (2013)

Negative

Taxi drivers: Camerer et al. (1997), Chou (2002), Ashenfelter et al. (2010), Doran (2014), Dupas and Robinson (2014), Agarwal et al. (2015)

Pear packers: Chang and Gross (2014)

Swordfish fishermen: Nguyen and Leung (2015)

Discussion

Existing evidence of daily income effects

Our facts: Labor supply exhibits excess sensitivity to daily earnings, but extent of the effect depends on the timing of income

Reconcile with existing evidence on income effects:

- Observational data (Farber 2005, 2015)
  - Elasticity of stopping with respect to earnings:
    - Farber 2005 (-.20, .44) vs. this paper (.25, .33)
  - Methodological differences: probit/LPM vs. local linear ⇝
- Experimental data
  - No income effect from early overpayment (Andersen et al. 2017) ⇝
  - Liquidity constraints (Dupas et al. 2017) ⇝

Discussion

Speed of adaptation

- Previous field evidence on reference-point adaptation
  - Willingness to pay for housing among movers (Simonsohn and Loewenstein 2006)
  - Risky choices in a game show (Post et al. 2008)
  - Unemployment benefit cuts (DellaVigna et al. 2017)
- Variation in the speed of adaptation could arise due to differences in
  - frequency of decisions
  - size of the stakes
  - familiarity of the choices
  - the extent to which the decision maker pays attention to the problem

Roadmap

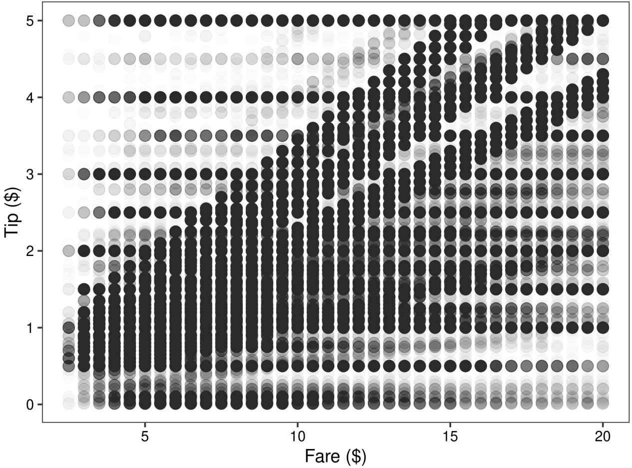
Appendix slides

Appendix slides

Data: Tripsheets — Shift Level ↩

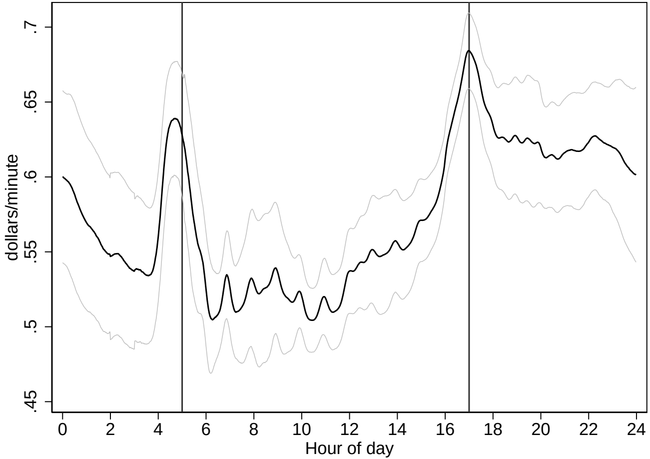
	Mean	25p	50p	75p
Shifts per driver	163	100	170	226
Trips in a shift	22	16	22	27
Total hours	8.6	7.2	8.7	10.1
Driving hours	4.5	3.5	4.5	5.5
Fraction break time	0.16	0.00	0.13	0.25
Shift income ($)	271	214	268	324
Average wage ($/hour)	31.6	27.7	31.7	35.6

Data: Fares and credit card tips ↩



Darker points represent higher concentration

Daily wage pattern



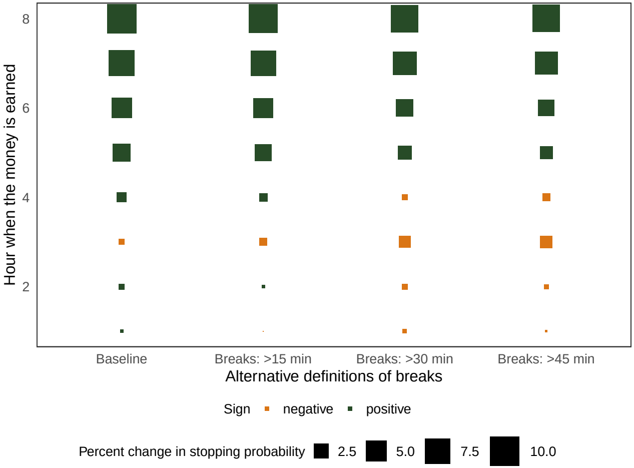
Average wage of cabs on the street at each clock minute averaging over 365 days

Summary of instrumental variables approach

- To address potential endogeneity concerns (e.g., income is positively correlated with unobserved determinants of the decision to end a shift such as effort), instrument for earnings using other drivers' speed
  - Results hold using trips that stay within the dense streets of Manhattan, which plausibly arises due to traffic conditions unrelated to the driver's decisions to exert additional effort

Fungibility of money: Breaks

Impact of $26 at hour 1 through hour 8 after 8.5 hours



Breaks as an outcome

- If break taking decreases in response to additional earnings, then the stopping model may incorrectly attribute the effect of hours to income
- Instead of directly controlling for break time as in Farber (2005) (e.g., if taking breaks constitutes an outcome of earnings), re-estimate the stopping model with breaks as the outcome
- We find an increase in the probability of taking a break at earlier hours of the shift and no significant change in the probability of taking a break at later hours of the shift
  - An additional *10 percent* in earnings corresponds to an increase of *0.0072 to 0.0756 percentage points* in the probability of taking a break at 8.5 hours

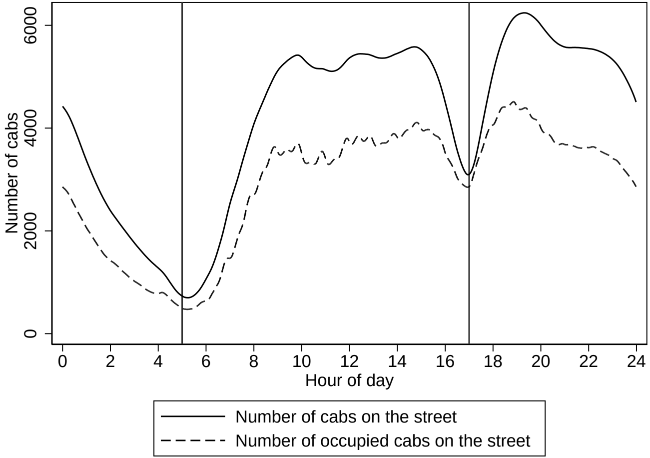
Within-driver experience ↩

	(1)	(2)			
Shifts	Overall	Hour 2	Hour 4	Hour 6	Hour 8
0–10%	0.2883	0.2984	-0.1003	0.0515	0.1307
	(0.1056)	(0.1558)	(0.1655)	(0.1633)	(0.1723)
10–20%	0.1874	-0.0933	-0.2133	0.0919	0.5044
	(0.1085)	(0.1516)	(0.1568)	(0.1568)	(0.1622)
80–90%	0.5603	0.0479	0.3023	0.4168	0.6786
	(0.1150)	(0.1638)	(0.1698)	(0.1689)	(0.1783)
90–100%	0.4625	-0.0130	0.3062	0.3309	0.5580
	(0.0805)	(0.1236)	(0.1284)	(0.1267)	(0.1335)

Across-driver experience ↩

	(1)	(2)			
Drivers	Overall	Hour 2	Hour 4	Hour 6	Hour 8
0–10%	0.2349	-0.1266	0.0472	0.2517	0.3175
	(0.0997)	(0.1480)	(0.1532)	(0.1544)	(0.1630)
10–20%	0.2828	-0.1579	0.0733	0.3156	0.4273
	(0.0795)	(0.1149)	(0.1195)	(0.1188)	(0.1279)
80–90%	0.5797	0.2356	0.1648	0.2102	0.5454
	(0.0848)	(0.1205)	(0.1231)	(0.1267)	(0.1318)
90–100%	0.6205	0.2226	0.0381	0.4017	0.4289
	(0.0883)	(0.1206)	(0.1339)	(0.1333)	(0.1456)

Data: Taxis in a day wage



Number of cabs on the street at each clock minute averaging over 365 days

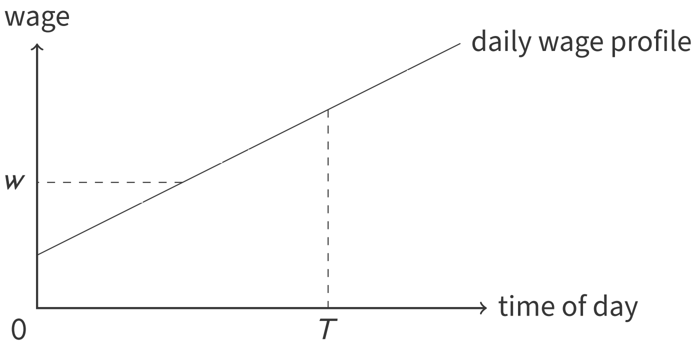
Wage elasticity: No representative wage ↩

Mechanical bias if there is a daily wage pattern

Wage elasticity: No representative wage

Mechanical bias if there is a daily wage pattern

True wage elasticity of 0, stopping around time T



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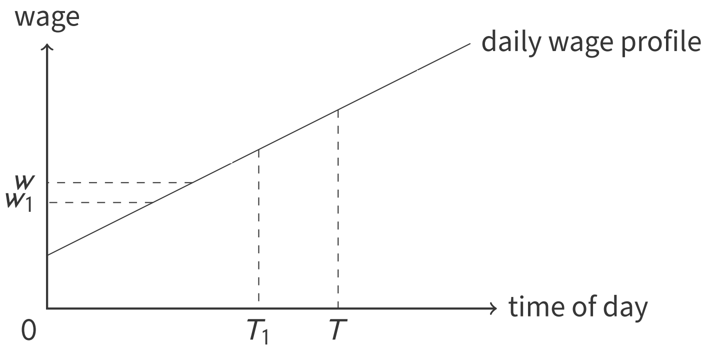

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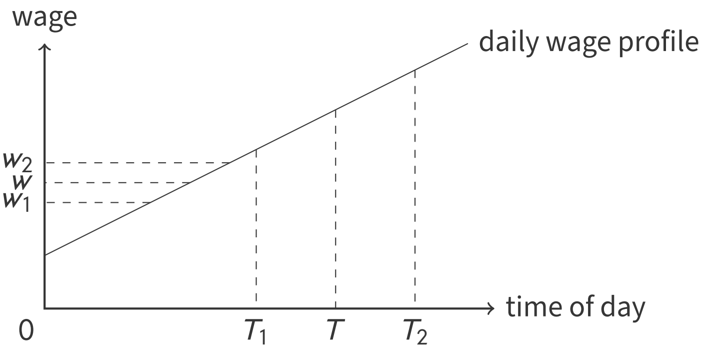
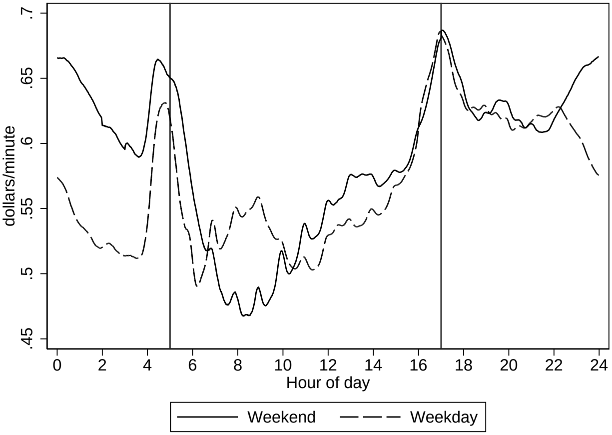


Daily wage pattern ↩

Weekday vs. weekend



Average wage of cabs on the street at each clock minute averaging over 365 days

Wage elasticity estimates ↩

Weekday vs. weekend

Shift	Time	OLS	IV
Night	Weekday	-0.3546	0.2825
		(0.0027)	(0.0088)
Night	Weekend	-0.1419	1.2797
		(0.0041)	(0.0247)

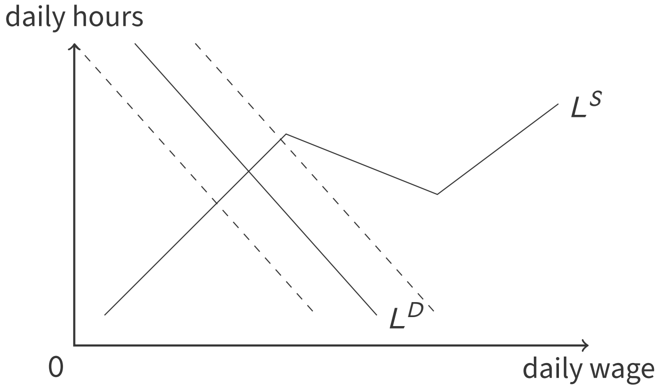
Wage elasticity estimates ↩

Weekday vs. weekend

Shift	Time	OLS	IV
Night	Weekday	-0.3546	0.2825
		(0.0027)	(0.0088)
Night	Weekend	-0.1419	1.2797
		(0.0041)	(0.0247)
Day	Weekday	-0.1636	0.2697
		(0.0031)	(0.0071)
Day	Weekend	-0.1214	0.0553
		(0.0040)	(0.0261)

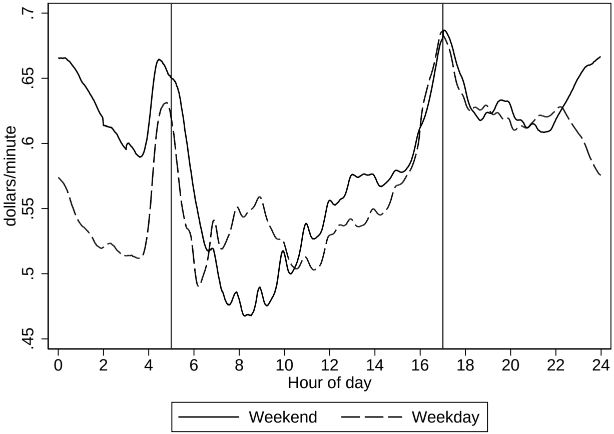
Wage elasticity ↩

Not enough to reject reference-dependence models



Daily wage pattern

Weekday vs. weekend



Average wage of cabs on the street at each clock minute averaging over 365 days

Daily income effects

	Individual location	Previous-day income	Medallion owners
Income in hour 2	-0.0479	0.0431	0.0282
	(0.0815)	(0.0603)	(0.4259)
Income in hour 4	0.0800	0.1044	0.4852
	(0.0800)	(0.0589)	(0.4254)
Income in hour 6	0.4463	0.4870	1.0571
	(0.0802)	(0.0588)	(0.3895)
Income in hour 8	1.1150	1.0194	0.7236
	(0.0859)	(0.0627)	(0.3699)
Previous-day income		-0.0291	
		(0.0150)	
Driver $\times$ NTA	X		

Simulation exercise TT ↩

Stopping rules in which decisions do not depend on earnings:

Simulation 1: End the shift with certainty at the end of a trip if hours exceeds 9.5, and stop with independent probability 0.05 at the end of any given trip that ends before 9.5 hours

Simulation 2: Driver i ends the shift with certainty at the end of a trip if hours exceeds a driver-specific level of hours $\bar{H}_i$, and stops with independent probability 0.05 at the end of any given trip that ends before $\bar{H}_i$ hours, where we define $\bar{H}_i$ as one less than the mean hours across all of driver i's shifts in the data

Simulation exercise TT ↩

$$\Pr\left(\text{stop}_{i,n,t}\right)$$

$$= f\left(h_{int}\right) + \beta\left(h_{int}\right) y_{int} + X_{int}\gamma\left(h_{int}\right) + \mu_i\left(h_{int}\right) + \epsilon_{int} \tag{TT}$$

$$= \Phi\left(\alpha h_{i,n,t} + \beta y_{i,n,t} + \mu_i\right) \tag{F-1}$$

$$= \Phi\left(\sum_j \alpha_j \mathbb{1}_{\{h_{i,n,t} \in H_j\}} + \beta y_{i,n,t} + \mu_i\right) \tag{F-2}$$

$$= \Phi\left(\sum_j \alpha_j \mathbb{1}_{\{h_{i,n,t} \in \hat{H}_j\}} + \sum_j \beta_j \mathbb{1}_{\{y_{i,n,t} \in \hat{Y}_j\}} + \mu_i\right) \tag{F-3}$$

$$= \Phi\left(\sum_j \alpha_j \mathbb{1}_{\{h_{i,n,t} \in \hat{H}_j\}} + \sum_{j,\ell} \delta_{j,\ell} \mathbb{1}_{\{h_{i,n,t} \in \hat{H}_j\}} \mathbb{1}_{\{y_{i,n,t} \in \hat{Y}_\ell\}} + \mu_i\right) \tag{F-4}$$

Simulation exercise TT ↩

	Simulation 1: stop at 9.5		Simulation 2: stop at $\bar{H}_i$	
	Effect of 20% increase in income	*p*-value: income coefficients = 0	Effect of 20% increase in income	*p*-value: income coefficients = 0
TT	-0.0032 (0.0031)	0.6731	-0.0021 (0.0044)	0.7401
F-1	-0.0090 (0.0005)	0.0000	-0.0261 (0.0006)	0.0000
F-2	-0.0002 (0.0004)	0.6789	-0.0110 (0.0006)	0.0000
F-3	0.0384 (0.0054)	0.0000	-0.0103 (0.0111)	0.0000
F-4	-0.0042 (0.0050)	0.0000	-0.0038 (0.0188)	0.0000

Simulation exercise TT ↩

Stopping rules in which income affects decisions, but within-day timing is irrelevant:

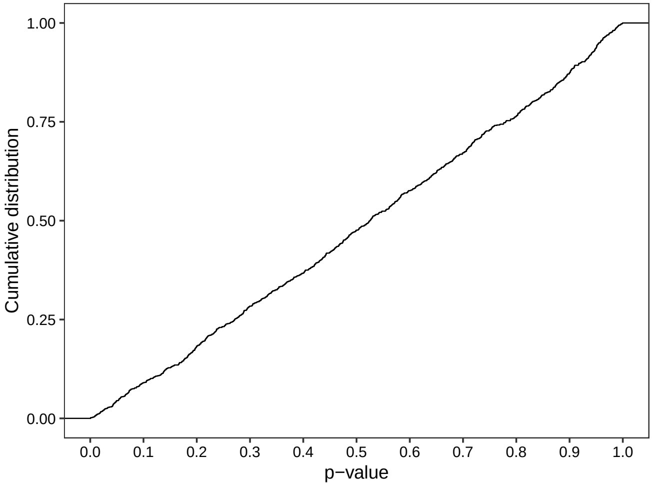
Simulation 3: End the shift with certainty at the end of a trip if hours exceeds 9.5, and stop with independent probability $0.05 \cdot y_{int}$ at the end of any given trip that ends before 9.5 hours, where y_{int} denotes cumulative daily earnings.

Simulation exercise TT ↩

	Simulation 3: Pr(stop) increases in income
	Effect of 20% increase in income
TT	
Income in hour 2	0.0048
	(0.0214)
Income in hour 4	0.0341
	(0.0224)
Income in hour 6	0.0466
	(0.0218)
Income in hour 8	0.0205
	(0.0228)
p-value: income coefficients = 0	0.0000
p-value: Equality of income coefficients	0.8932

Simulation exercise TT ↩

Distribution of *p*-values from the non-parametric specification (TT)



Betel-nut vendors ↩

- Big purchase early in the day: more time to adjust labor supply
- No change in labor supply

Betel-nut vendors ↩

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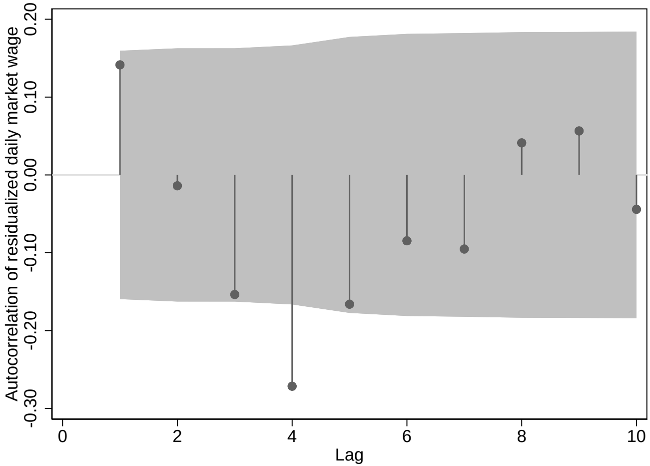
Data: Predictability of fare earnings



Shaded region represents Bartlett 95% confidence band about 0