The literature on effort provision with reference-dependent preferences

Linh T. Tô

Harvard University
Introduction: Labor-supply problem

- One thousand dollars per hour only in the next 24 hours
Introduction: Labor-supply problem

- One thousand dollars per hour only in the next 24 hours
  - Work more, no sleep for a day
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Introduction: Labor-supply problem

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  - Work less
- Do expectations and reference points affect work / leisure decision?
Prospect theory and daily income

The diagram illustrates the relationship between daily target $T$ and daily income. The graph shows a linear increase in daily income as the daily target $T$ is approached or exceeded.
Implication 1: Negative wage elasticity
Implication 2: Daily income effects

Income effects: do small changes in wealth affect labor supply?

- Prospect theory: additional income brings you closer to the target, makes you more likely to end a shift
- Neo-classical: any additional income is used to smooth out consumption over the rest of life, does not affect daily labor supply
Real-life laboratories

- Stadium vendors: Oettinger (1999)
- Bicycle messengers: Fehr and Goette (2007)
- Swordfish fishermen: Nguyen and Leung (2009)
- Lobster fishermen: Stafford (2013)
- Pear packers: Chang and Gross (2014)
Real-life laboratories

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Implication 1: Camerer et al. 1997

Data on NYC taxi drivers

- 192 → 70 trip sheets, 13 fleet drivers in 1994 (TRIP)
- 1044 trip sheets, 484 fleet and lease drivers (TLC1)
- 712 trip sheets, 712 lease and owner drivers (TLC2)

Low quality, many drivers, few days
Implication 1: Camerer et al. 1997
Implication 1: Camerer et al. 1997

\[
\log h_{i,t} = \alpha + \beta \log\left(\frac{Y_{i,t}}{h_{i,t}}\right) + X_{i,t}\Gamma + \epsilon_{i,t}
\]

- Log daily hours on log average hourly wage, controlling for supply factors (weather, day/night, driver FE\text{s})
- Wage elasticity $\hat{\beta}$: TRIP -0.186 (s.e. 0.129), TLC1 -0.618 (s.e. 0.051), TLC2 -0.355 (s.e. 0.051).
$h_{i,t}$ measured with noise: $\tilde{h} = h_{i,t} \times \phi_{i,t}$

$$\log \tilde{h}_{i,t} = \alpha + \beta \log \left( \frac{Y_{i,t}}{\tilde{h}_{i,t}} \right) + X_{i,t} \Gamma + \epsilon_{i,t}$$

- Instrument wage using other workers’ wage on the same day
- Wage elasticity $\hat{\beta}$: TRIP 0.005 (s.e. 0.273), TLC1 -0.926 (s.e. 0.259), TLC2 -0.975 (s.e. 0.478).
Implication 1: Farber 2015

NYC data from 2009 to 2013, all 13,437 medallions:

• 40,000 drivers and 170–180 million trips, 7–8 million shifts per year
• Start and end times
• Pick-up and drop-off GPS coordinates
• Fare, tips (credit-card paying trips)
Farber 2015: Wage elasticity OLS

<table>
<thead>
<tr>
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## Farber 2015: Wage elasticity IV

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Implication 1: Mixed evidence

Wage elasticity:

- **Positive**: Jonason and Wållgren (2013) on taxi drivers in Stockholm; and Stafford (2013) on lobster fishermen in Florida

- **Negative**: Chou (2002) and Agarwal et al. (2015) on taxi drivers in Singapore; Ashenfelter et al. (2010) and Doran (2014) on taxi drivers in New York City; Dupas and Robinson (2013) on bicycle-taxi drivers in Kenya; Chang and Gross (2014) on pear packers in California; and Nguyen and Leung (forthcoming) on swordfish fishermen in Hawaii
Wage elasticity: Issue 1

• Is there a representative wage for the whole day?
Wage elasticity: Issue 1

- Is there a representative wage for the whole day?
- Mechanical bias if not
Wage elasticity: Issue 1

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True wage elasticity of 0, stopping around time $T$
Wage elasticity: Issue 1

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Wage elasticity: Issue 1

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True wage elasticity of 0, stopping around time $T$

![Daily wage profile diagram](image)
Daily wage pattern

![Graph showing the daily wage pattern with two lines representing Weekend and Weekday wages over the hours of the day. The graph indicates varying wage rates throughout the day, with peaks and troughs at certain times.]
<table>
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Wage elasticity: Issue 2

Not enough to reject prospect theory

![Graph showing wage elasticity with dashed lines representing demand (L^D) and supply (L^S) curves, and a solid line showing a point where demand and supply intersect at a non-zero daily wage value.]
Implication 2: Old observational data

- Farber JPE 2005: No income effects in Camerer et al. 1997 data
- Goette, Huffman, and Fehr JEEA 2004: Controlling for clock-hour effects removes much of the variation in earnings and quitting
Farber 2005: Stopping model

- Intertemporal optimization equivalent to static one-period objective function:

\[ v(h_t) = \lambda y_t(h_t) - g(h_t, \lambda), \]

- Daily earnings \( y_t(\cdot) \)
- Disutility of effort \( g(\cdot) \)
- Marginal utility of lifetime income \( \lambda \) along the optimal path

- Stopping decision at the end of trip \( n \) is:

\[ d_{t,n} = 1\{v(h_{t,n+1}) + \varepsilon_{t,n+1} < v(h_{t,n})\} \]
Farber 2005: Stopping model

- Do small changes in wealth affect labor supply?
- Test of income effects:

\[
\Pr(\text{Stop}_{i,t,n}) = \Phi(\gamma_1 h_{i,t,n} + \gamma_2 y_{i,t,n} + X_{i,t,n} \beta + \mu_i)
\]
Implication 2: Experimental results

Andersen, Brandon, Gneezy, and List 2014: Betel-nut vendors
Implication 2: Experimental results

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Andersen, Brandon, Gneezy, and List 2014: Betel-nut vendors

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

- Oettinger 1999 — stadium vendors
- Fehr and Goette 2007 — bicycle messengers
- Farber 2008 — “stochastic” reference point
- Crawford and Meng 2011 — two targets, rational expectations for income and hours
- Farber 2015 — on experience
Implication 2: Using the new taxi data

- Do small changes in wealth affect labor supply?
- Test of income effects:

\[
\Pr(\text{stop}_{int}) = \sum_{j} \left[ (\gamma_j y_{int} + \alpha_j h_{int} + X_{int} \beta_j + \mu_{ij}) \mathbf{1}_{\{h_{int} \in H_j\}} \right]
\]

- \(h_{i,t,n}\): hours worked so far and \(y_{i,t,n}\): money earned so far
- \(X\): interacting hour of day with day of week, week of year, 196 census tracts, minute-level weather
- \(\mu_i\): driver fixed effects

- Test whether \(\gamma_2 = 0\)
Implication 2: Using the new taxi data
Farber Stopping model

- No income effects for night shifts!
- **Validation exercise:** Simulate stopping decisions independent of income; our approach estimates zero income effect, while existing approaches yield spurious results
Implication 2: Is there a puzzle?

So what is going on?

• Do people respond to unexpected income earned at the daily level?

• Does the answer depend on other factors? Shouldn’t a dollar mean a dollar always?
Daily income effects: Timing by start hour

Timing of income (hour in shift)

Percent change in stopping probability at hour 8.5

Standard errors clustered at the driver level
Reconciliation: Reacting to a surprise

- The timing pattern of the income effect requires that the target level moves during the day
- By the time a driver is deciding to stop, a gain early in the shift is old news, so he doesn’t react much
  - Target adjusts — a gain about the future is no longer a gain when the future arrives
  - Utility is more strongly affected by contemporaneous gains/losses
Models of daily labor supply

Expectations-based loss aversion

Objective function of the driver takes the following form:

\[ v^{LA}(I_t, H_t) = v(I_t, H_t) + \sum_{x \in \{I, H\}} n(x_t | x'_t), \]

where \( I'_t \) and \( H'_t \) denote the reference points for income and hours (i.e., expected earnings and hours for the shift), and the gain-loss utility is piecewise-linear:

\[ n(x | x') = (1_{x > x'} + \lambda 1_{x < x'})(v_x(x) - v_x(x')), \]

\( \lambda \geq 1 \) parameterizes the degree of loss aversion.
Models of daily labor supply

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</tr>
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Models of daily labor supply

Reference points: Static

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

**Bar:** hourly income  
**Line:** target \( I_t^r \)
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\[ I^r_t = I^r_0 \]
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Bar: hourly income
Line: target \( I_t^r \)

\[
I_t^r = I_0^r + \sum_{\tau=1}^{t} \Delta_{\tau}
\]
Models of daily labor supply

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  \[ l_t^r = l_0^r = 30 \times 9 = 270 \]
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Bar: hourly income
Line: target $I'_t$

$$I'_t = I'_0 + \sum_{\tau=1}^{t} \Delta_\tau$$
# Models of daily labor supply

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Models of daily labor supply

Reference points: Slow within-day adjustment

- $\Delta_t$: difference between realized and expected earnings in trip $t$
- Reference point: convex combination of lagged reference point and expectation that obtains under full adjustment

\[
I^r_t = \theta I^r_{t-1} + (1 - \theta) \left( I^r_0 + \sum_{\tau=1}^{t} \Delta_{\tau} \right) \\
= I^r_0 + \sum_{\tau=1}^{t} (1 - \theta^{t+1-\tau}) \Delta_{\tau}
\]

- $\theta = 1 \implies$ no adjustment (static)
- $\theta = 0 \implies$ instantaneous adjustment
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  \( I_r^0 = 30 \times 9 = 270 \)
- One-time shock of $30:
  \( \Delta_4 = 30 \) vs. \( \Delta_8 = 30 \)

Bar: hourly income
Line: target \( I_t^r \)

\[
I_t^r = I_0^r + \sum_{\tau=1}^{t} (1 - \theta^{t+1-\tau}) \Delta_\tau
\]
Models of daily labor supply

Reference points: Slow within-day adjustment

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Bar: *hourly income*

Line: *target $I^r_t$*

\[ I^r_t = I^r_0 + \sum_{\tau=1}^{t} (1 - \theta^{t+1-\tau}) \Delta_\tau \]
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## Models of daily labor supply

**Reference points**

<table>
<thead>
<tr>
<th></th>
<th>Overall income</th>
<th>Timing pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>Loss Aversion</td>
<td>Yes</td>
</tr>
<tr>
<td>Instant adj</td>
<td>Loss Aversion</td>
<td>No</td>
</tr>
<tr>
<td>Slow adj</td>
<td>Loss Aversion</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Yes No

No Yes
Conclusion

- Large daily income effects dependent on timing: Richer story than the standard neoclassical vs. prospect theory dichotomy
- Targets adjust: Simple income targeting story doesn’t hold up
- Rejecting the neoclassical model does not imply the success of a particular alternative theory
Simulation exercise

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

\[ \Pr(\text{stop}_{i,n,t}) = \sum_j \left[ (\alpha_j h_{i,n,t} + \gamma_j y_{i,n,t} + \mu_{i,j})1\{h_{i,n,t} \in H_j\} \right] + \epsilon_{i,n,t} \quad \text{(TT)} \]

\[ = \Phi(\alpha h_{i,n,t} + \gamma y_{i,n,t} + \mu_i) \quad \text{(F-1)} \]

\[ = \Phi\left( \sum_j \alpha_j 1\{h_{i,n,t} \in H_j\} + \gamma y_{i,n,t} + \mu_i \right) \quad \text{(F-2)} \]

\[ = \Phi\left( \sum_j \alpha_j 1\{h_{i,n,t} \in \hat{H}_j\} + \sum_j \gamma_j 1\{y_{i,n,t} \in \hat{Y}_j\} + \mu_i \right) \quad \text{(F-3)} \]

\[ = \Phi\left( \sum_j \alpha_j 1\{h_{i,n,t} \in \hat{H}_j\} + \sum_{j,\ell} \delta_{j,\ell} 1\{h_{i,n,t} \in \hat{H}_j\} 1\{y_{i,n,t} \in \hat{Y}_\ell\} + \mu_i \right) \quad \text{(F-4)} \]
Simulation 1: stop at 9.5

<table>
<thead>
<tr>
<th>Effect of 20% increase in income</th>
<th><em>p</em>-value: income coefs. = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT</td>
<td>0.1979</td>
</tr>
<tr>
<td>(0.0030)</td>
<td></td>
</tr>
<tr>
<td>F-1</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0005)</td>
<td></td>
</tr>
<tr>
<td>F-2</td>
<td>0.2329</td>
</tr>
<tr>
<td>(0.0004)</td>
<td></td>
</tr>
<tr>
<td>F-3</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0056)</td>
<td></td>
</tr>
<tr>
<td>F-4</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0052)</td>
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</table>

Simulation 2: stop at \( \hat{H}_i \)

<table>
<thead>
<tr>
<th>Effect of 20% increase in income</th>
<th><em>p</em>-value: income coefs. = 0</th>
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<tbody>
<tr>
<td>TT</td>
<td>0.9368</td>
</tr>
<tr>
<td>(0.0043)</td>
<td></td>
</tr>
<tr>
<td>F-1</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0006)</td>
<td></td>
</tr>
<tr>
<td>F-2</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0006)</td>
<td></td>
</tr>
<tr>
<td>F-3</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0110)</td>
<td></td>
</tr>
<tr>
<td>F-4</td>
<td>0.0000</td>
</tr>
<tr>
<td>(0.0186)</td>
<td></td>
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</table>
Table VII: Marginal Effects of Income and Hours on Probability of Ending Shift

<table>
<thead>
<tr>
<th>Income ($)</th>
<th>Day Shift (1)</th>
<th>Night Shift (1)</th>
<th>Hours</th>
<th>Day Shift (3)</th>
<th>Night Shift (3)</th>
<th>Day Shift (4)</th>
<th>Night Shift (4)</th>
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<tbody>
<tr>
<td>100-149</td>
<td>0.0001</td>
<td>-0.0045</td>
<td>3-5</td>
<td>0.0020</td>
<td>-0.0049</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0003)</td>
<td></td>
<td>(0.0004)</td>
<td>(0.0003)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150-199</td>
<td>0.0044</td>
<td>-0.0077</td>
<td>6</td>
<td>0.0001</td>
<td>0.0007</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(0.0006)</td>
<td>(0.0005)</td>
<td></td>
<td>(0.0007)</td>
<td>(0.0006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200-224</td>
<td>0.0157</td>
<td>-0.0062</td>
<td>7</td>
<td>0.0034</td>
<td>0.0223</td>
<td></td>
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<tr>
<td></td>
<td>(0.0010)</td>
<td>(0.0007)</td>
<td></td>
<td>(0.0011)</td>
<td>(0.0010)</td>
<td></td>
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</tr>
<tr>
<td>225-249</td>
<td>0.0264</td>
<td>-0.0046</td>
<td>8</td>
<td>0.0281</td>
<td>0.0536</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0013)</td>
<td>(0.0008)</td>
<td></td>
<td>(0.0017)</td>
<td>(0.0016)</td>
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<tr>
<td>250-274</td>
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<td>-0.0042</td>
<td>9</td>
<td>0.0750</td>
<td>0.0897</td>
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<td></td>
<td>(0.0017)</td>
<td>(0.0011)</td>
<td></td>
<td>(0.0025)</td>
<td>(0.0022)</td>
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<td>275-299</td>
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<td>-0.0033</td>
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<td>0.1210</td>
<td>0.1603</td>
<td></td>
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<tr>
<td></td>
<td>(0.0020)</td>
<td>(0.0013)</td>
<td></td>
<td>(0.0035)</td>
<td>(0.0031)</td>
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<td>300-349</td>
<td>0.0596</td>
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<tr>
<td></td>
<td>(0.0024)</td>
<td>(0.0017)</td>
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<td>(0.0050)</td>
<td>(0.0051)</td>
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<td>0.0607</td>
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<td>12</td>
<td>0.1004</td>
<td>0.2573</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(0.0028)</td>
<td>(0.0024)</td>
<td></td>
<td>(0.0078)</td>
<td>(0.0142)</td>
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</tr>
<tr>
<td>≥ 400</td>
<td>0.0702</td>
<td>0.0101</td>
<td>≥ 13</td>
<td>0.1093</td>
<td>0.2406</td>
<td></td>
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<tr>
<td></td>
<td>(0.0034)</td>
<td>(0.0035)</td>
<td></td>
<td>(0.0050)</td>
<td>(0.0063)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Daily wage pattern

Weekday vs. weekend

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

Day vs. night

![Graph showing percent change in stopping probability over hours of shift for different shift types.]

- Shift type:
  - Day Weekday
  - Day Weekend
  - Night Weekday
  - Night Weekend

- Percent change in stopping probability
- Hour of shift