Online Appendix to

New York City Cabdrivers' Labor Supply Revisited: Reference-Dependent Preferences with Rational-Expectations Targets for Hours and Income

By Vincent P. Crawford and Juanjuan Meng

June 2010

Online Appendix A: Estimations of Tables 2-4 without weights.

Table A1: Marginal Effects on the Probability of Stopping: Probit Estimation with Split Samples

		(1)			(2)		
	Evaluation Point for Marginal Effect	Pooled data	First hour's earning > expected	First hour's earning < expected	Pooled data	First hour's earning> expected	First hour's earning <= expected
Cumulative total hours	8.0	.020***	0.025***	0.017**	0.009***	0.026***	0.004
		(.006)	(0.006)	(0.009)	(0.003)	(0.009)	(0.004)
Cumulative Income/100	1.5	0.035*	0.030	0.037	0.020	0.034	0.029*
		(.016)	(0.020)	(0.026)	(0.014)	(0.028)	(0.022)
Min temp<30	0.0	-	-	-	0.004*	0.011	0.011
					(0.008)	(0.021)	(0.011)
Max temp>80	0.0	-	-	-	-0.017*	-0.041	-0.017
					(0.010)	(0.025)	(0.012)
Hourly rain	0.0	-	-	-	0.011	-0.520	0.098
					(0.164)	(0.718)	(0.122)
Daily snow	0.0	-	-	-	-0.001	-0.004	-0.084
					(0.005)	(0.010)	(0.094)
Downtown	0.0	-	-	-	0.002	0.009	-0.002
					(0.008)	(0.019)	(0.009)
Uptown	0.0	-	-	-	-0.002	-0.006	-0.003
					(0.006)	(0.015)	(0.007)
Bronx	0.0	-			0.072	0.099***	.148**
					(0.071)	(0.030)	(.122)
Queens	0.0	-	-	-	0.045	0.040	0.060
					(0.045)	(0.087)	(0.067)
Brooklyn	0.0	-	-	-	0.088***	0.140*	0.070**
					(0.041)	(0.107)	(0.050)
Kennedy Airport	0.0	-	-	-	0.076***	0.184***	0.038
					(0.040)	(0.086)	(0.041)
LaGuardia Airport	0.0	-	-	-	0.073***	0.176***	0.007
					(0.037)	(0.079)	(0.028)
Other	0.0	-	-	-	0.148***	0.233**	0.082
					(0.084)	(0.132)	(0.105)
Drivers (21)		No	No	No	Yes	Yes	Yes
Day of week (7)		No	No	No	Yes	Yes	Yes
Hour of day (19)	2:00 p.m.	No	No	No	Yes	Yes	Yes
Log likelihood		-1550.452	-806.30573	-742.87617	-1344.8812	-683.58849	-628.45562
Pseudo R^2		0.1239	0.1314	0.1172	0.2401	0.2636	0.2532
Observation		8958	4664	4294	8958	4664	4294

Note: Standard errors are computed for the marginal effects to maximize comparability with Farber's estimates, but with significance levels computed for the underlying coefficients rather than the marginal effects: *10%, **5%, ***1%. Robust standard errors clustered by shift are assumed. We use Farber's evaluation point: after 8 total working hours and $150 earnings on a dry day with moderate temperatures in midtown Manhattan at 2:00 p.m. Driver fixed effects and day of week dummies are equally weighted. For dummy variables, the marginal effect is calculated by the difference between values 0 and 1. As in Farber (2008), we do not distinguish between driving hours and waiting time between fares. Among the dummy control variables, only driver fixed effects, hour of the day, day of the week, and certain location controls have effects significantly different from 0.

Table A2: Marginal Effects on the Probability of Stopping: Reduced-Form Model Allowing Jumps at the Targets

		Using driver specific sample average income and hours prior to the current shift as targets		Using driver and day-of-the-week specific sample average income and hours prior to the current shift as targets	
	Evaluation point for marginal effect	(1)	(2)	(3)	(4)
Cumulative total hours>hours target		0.040***	0.065***	0.047***	0.109***
		(0.013)	(0.031)	(0.014)	(0.039)
Cumulative income > income target		0.052***	0.024	0.043***	0.038*
		(0.06)	(0.025)	(0.015)	(0.024)
Cumulative total hours	8.0	0.012***	0.019***	0.013***	0.016***
		(0.004)	(0.009)	(0.004)	(0.008)
Cumulative Income/100	1.5	-0.007	0.024	-0.001	0.006
		(0.013)	(0.035)	(0.015)	(0.029)
Weather (4)		No	Yes	No	Yes
Locations (9)		No	Yes	No	Yes
Drivers (21)		No	Yes	No	Yes
Days of the week (7)		No	Yes	No	Yes
Hour of the day (19)	2:00 p.m.	No	Yes	No	Yes
Log likelihood		-1546.1866	-1369.5477	-1535.036	-1349.809
Pseudo R^2		0.1630	0.2587	0.1691	0.2693
Observation		10337	10337	10337	10337

Note: Standard errors are computed for the marginal effects to maximize comparability with Farber's estimates, but with significance levels computed for the underlying coefficients rather than the marginal effects: *10%, **5%, ***1%. Robust standard errors clustered by shift are assumed. We use Farber's evaluation point: after 8 total working hours and $150 earnings on a dry day with moderate temperatures in midtown Manhattan at 2:00 p.m. Driver fixed effects and day of week dummies are equally weighted. For dummy variables, the marginal effect is calculated by the difference between values 0 and 1. As in Farber (2008), we do not distinguish between driving hours and waiting time between fares. Among the dummy control variables, only driver fixed effects, hour of the day, day of the week, and certain location controls have effects significantly different from 0.

Table A3: Structural Estimates under Alternative Specifications of Expectations					
	(1) Use driver and day-of-the-week specific sample averages prior to the current shift as the income/hours targets and the next-trip earnings/times expectation	(2) Use driver and day-of-the-week specific sample averages prior and after the current shift as the income/hours targets and next-trip the earnings/times expectation	(3) Use driver and day-of-the-week specific sample averages prior to the current shift as the income/hours targets and fit the sophisticated next-trip earnings/time expectation	(4) Use driver (without day-of-the-week difference) specific sample averages prior to the current shift as income/hours targets and the next-trip earnings/time expectation	(5) Income target only: use driver and day-of-the-week specific sample averages prior to the current shift as income target and next-trip earnings/time expectation
$\eta(\lambda_H - 1)$	2.338***	4.327***	0.872***	0.237***	-
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	
$\eta(\lambda_I - 1)$	0.631***	0.610***	0.267***	0.044*	3.163***
[p-value]	[0.004]	[0.000]	[0.008]	[0.0594]	[0.000]
θ	0.015***	0.020***	0.018***	0.099***	0.014***
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[.000]
ρ	0.839***	0.483	0.883***	0.258***	1.645***
[p-value]	[0.003]	[0.403]	[0.000]	[0.000]	[0.000]
σ	0.196	0.185	0.096	0.040	0.539***
[p-value$^+$]	[0.168]	[0.293]	[0.996]	[0.105]	[0.757]
c	0.007	0.006	-0.012	0.134	0.138
[p-value]	[0.954]	[0.958]	[0.998]	[0.782]	[0.719]
Test $\lambda_H = \lambda_I$ [p-value]	[0.214]	[0.177]	[0.996]	[0.204]	-
Observations	10337	10337	10337	10337	10337
Log-likelihood	-1360.9672	-1361.711	-1351.4242	-1368.8756	-1371.8068

Notes: Significance levels *10%, **5%, ***1%. We perform likelihood ratio test on each estimated parameter and indicate the corresponding p-value and significance level. $^+$The null-hypothesis is that each parameter equals zero except for the variance estimate where we test $\sigma = 1$. Control variables include driver fixed effects (18), day of week (6), hour of day (18), location(8), and weather (4).

Online Appendix B: Derivation of the Likelihood Function in the Structural Estimation

Given a driver's preferences,

(B1) $V(I,H \mid I^r,H^r) = (1-\eta)\left[I - \frac{\theta}{1+\rho}H^{1+\rho}\right] + \eta\left[1_{(I-I^r\le 0)}\lambda(I-I^r) + 1_{(I-I^r>0)}(I-I^r)\right]$

$$-\eta\left[1_{(H-H^r\ge 0)}\lambda\left[\frac{\theta}{1+\rho}H^{1+\rho} - \frac{\theta}{1+\rho}(H^r)^{1+\rho}\right]\right] - \eta\left[1_{(H-H^r<0)}\left[\frac{\theta}{1+\rho}H^{1+\rho} - \frac{\theta}{1+\rho}(H^r)^{1+\rho}\right]\right].$$

We assume the driver decides to stop at the end of a given trip if and only if his anticipated gain in utility from continuing work for one more trip is negative. Again letting I_t and H_t denote income earned and hours worked by the end of trip t, this requires:

(B2) $E[V(I_{t+1}, H_{t+1}|I^r,H^r)] - V(I_t, H_t|I^r,H^r) + \varepsilon < 0,$

where $I_{t+1} = I_t + E(f_{t+1})$ and $H_{t+1} = H_t + E(h_{t+1})$, $E(f_{t+1})$ and $E(h_{t+1})$ are the next trip's expected fare and time (searching and driving), $x_t\beta$ include the effect of control variables, c is the constant term, and ε is a normal error with mean zero and variance σ^2. The likelihood function can now be written, with i denoting the shift and t the trip within a given shift, as:

(B3)

$$\sum_{i=1}^{584}\sum_{t=i}^{T_i}\ln\Phi[((1-\eta)(A_{it} - \frac{\theta}{\rho+1}B_{it}(\rho)) + \eta(\lambda a_{1,it} + a_{2,it} - \lambda\frac{\theta}{\rho+1}b_{1,it}(\rho) - \frac{\theta}{\rho+1}b_{2,it}(\rho)) + x_t\beta + c)/\sigma]$$

$A_{it} = I_{i,t+1} - I_{i,t}$.

$B_{it}(\rho) = H_{i,t+1}^{\rho+1} - H_{i,t}^{\rho+1}$.

$a_{1,it} = 1_{(I_{i,t+1}-I_i^r\le 0)}(I_{i,t+1} - I_i^r) - 1_{(I_{i,t}-I_i^r\le 0)}(I_{i,t} - I_i^r)$.

$a_{2,it} = 1_{(I_{i,t+1}-I_i^r> 0)}(I_{i,t+1} - I_i^r) - 1_{(I_{i,t}-I_i^r> 0)}(I_{i,t} - I_i^r)$.

$b_{1,it}(\rho) = 1_{(H_{i,t+1}-H_i^r\ge 0)}(H_{i,t+1}^{\rho+1} - (H_i^r)^{\rho+1}) - 1_{(H_{i,t}-H_i^r\ge 0)}(H_{i,t}^{\rho+1} - (H_i^r)^{\rho+1})$.

$b_{2,it}(\rho) = 1_{(H_{i,t+1}-H_i^r< 0)}(H_{i,t+1}^{\rho+1} - (H_i^r)^{\rho+1}) - 1_{(H_{i,t}-H_i^r< 0)}(H_{i,t}^{\rho+1} - (H_i^r)^{\rho+1})$.

Note that

$A_{it} = a_{1,it} + a_{2,it}$ and

$B_{it} = b_{1,it}(\rho) + b_{2,it}(\rho)$.

Substituting these equations yields a reduced form for the likelihood function:

(B4) $$\sum_{i=1}^{584}\sum_{t=i}^{T_i}\ln\Phi[((1-\eta+\eta\lambda)a_{1,it} + a_{2,it} - (1-\eta+\eta\lambda)\frac{\theta}{\rho+1}b_{1,it}(\rho) - \frac{\theta}{\rho+1}b_{2,it}(\rho) + x_t\beta + c)/\sigma].$$

Online Appendix C: Trip Fares and Time Estimates Whose Fitted Values are Used as Proxies for Drivers' Expectations in Table 4, column 3

Table C1: Trip Fares and Time Estimates Whose Fitted Values Are Used as Proxies for Drivers' Sophisticated Expectations in Table 4

	Time	Fare		Time	Fare
Clock hours			Day of the Week		
0	-0.100	0.006	Monday	0.017	-
	(0.228)	(0.022)		(0.025)	-
1	-0.121	-0.005	Tuesday	-0.007	0.001
	(0.231)	(0.022)		(0.023)	(0.003)
2	-0.255	-0.025	Wednesday	-0.012	-0.002
	(0.239)	(0.024)		(0.023)	(0.004)
3	-0.193	-	Thursday	0.013	0.004
	(0.265)	-		(0.023)	(0.004)
4	-	0.026	Friday	-0.003	-0.000
	-	(0.039)		(0.023)	(0.003)
5 - 10	-0.022	-0.006	Saturday	0.038*	0.006*
	(0.226)	(0.021)		(0.022)	(0.003)
11	-0.022	-0.011	Sunday	-	0.001
	(0.227)	(0.022)		-	(0.004)
12	0.026	-0.005	Mini temp < 30	0.016	0.000
	(0.227)	(0.022)		(0.027)	(0.004)
13	-0.032	-0.001	Max temp > 80	0.019	-0.002
	(0.227)	(0.021)		(0.023)	(0.003)
14	-0.074	-0.003	Hourly rain	-0.147	-0.073
	(0.227)	(0.021)		(0.317)	(0.046)
15	-0.084	-0.005	Daily snow	0.006	0.000
	(0.227)	(0.021)		(0.010)	(0.001)
16	-0.074	0.007	Downtown	-0.025	0.013
	(0.227)	(0.022)		(0.121)	(0.018)
17	-0.132	-0.006	Midtown	-0.066	0.001
	(0.226)	(0.021)		(0.120)	(0.018)
18	-0.152	-0.010	Uptown	-0.036	0.003
	(0.226)	(0.021)		(0.121)	(0.018)
19	-0.189	-0.016	Bronx	-	-
	(0.226)	(0.021)		-	-
20	-0.137	-0.006	Queens	0.337**	0.080***
	(0.226)	(0.021)		(0.151)	(0.022)
21	-0.160	-0.008	Brooklyn	0.180	0.052***
	(0.226)	(0.021)		(0.135)	(0.020)
22	-0.177	-0.004	Kennedy Airport	0.645***	0.164***
	(0.226)	(0.021)		(0.136)	(0.020)
23	-0.128	0.003	LaGuardia Airport	0.333**	0.110***
	(0.226)	(0.021)		(0.130)	(0.019)
Constant	0.307	0.051*	Others	0.154	0.030
	(0.260)	(0.029)		(0.156)	(0.023)
Driver dummy 21	Yes	Yes	R2	0.122	0.202
Observations	2989	2989		2989	2989

Notes: Significance levels: * 10%, ** 5%, *** 1%. Fare and (driving, waiting and breaking) time for the next trip are jointly estimated as seemingly unrelated regressions.

Online Appendix D: Implied Average Probabilities of Stopping for Various Ranges

Table D1. Implied Average Probabilities of Stopping for Various Ranges Relative to the Targets

	(1) Use driver and day-of-the-week specific sample averages prior to the current shift as the income/hours targets and the next-trip earnings/times expectation	(2) Use driver and day-of-the-week specific sample averages prior and after the current shift as the income/hours targets and next-trip the earnings/times expectation	(3) Use driver and day-of-the-week specific sample averages prior to the current shift as the income/hours targets and fit the sophisticated next-trip earnings/time expectation	(4) Use driver (without day-of-the-week difference) specific sample averages prior to the current shift as income/hours targets and the next-trip earnings/time expectation
Wage in the first hour > expected				
Before income target	0.020	0.021	0.019	0.022
At income target	0.083	0.097	0.080	0.092
In between two targets	0.105	0.109	0.103	0.103
At hours target	0.159	0.148	0.139	0.134
Above hours target	0.175	0.156	0.175	0.150
Wage in the first hour < expected				
Before hours target	0.0180	0.0193	0.018	0.021
At hours target	0.081	0.086	0.094	0.094
In between two targets	0.106	0.109	0.113	0.119
At income target	0.161	0.148	0.181	0.138
Above income target	0.188	0.180	0.187	0.164

Note: The probability of each range is calculated from the average predicted probabilities of trips. A range is two-sided with tolerance 0.1: before target means < 0.95×target; at target means > 0.95×target but < 1.05×target; and above target means > 1.05×target. The probabilities are first computed for each driver and range and then averaged across drivers within each range, hence do not sum to one.