Rational Attention in a Repeated Decision Problem

Eugenio J. Miravete[1] Ignacio Palacios-Huerta[2]

[1]University of Texas at Austin
& Centre for Economic Policy Research

[2]London School of Economics

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Setting the tone...

Frank Knight (1921), Risk, Uncertainty and Profit

"It is evident that the rational thing to do is to be irrational where deliberation and estimation cost more than they are worth."

Deliberation Costs

- Habit and inertia might be good responses to changing environments if potential benefits are small relative to cognition and deliberation costs.
- If agents face unobserved, individual-specific, deliberation costs, some of their apparently irrational behavior might actually be rational.
- How large should benefits be for consumers to actively engage in learning?

Preview of Results

- Households learn very fast: Mistakes do happen, but they are not systematic.
- Households actions are aimed to reduce tariff payments: They respond to incentives worth only \$5.00-\$6.00.
- Results do not support models where consumers decisions are driven by inertia, inattention, or impulsiveness.

Basic Message

- Details in econometric modeling matter (potentially a lot).
  - The existence of unobserved heterogeneity due to state dependence reverse the results of misspecified models.
- Results indicate that individuals, on average, switch tariff choices in response to very low potential gains. Furthermore, they seem to learn from past experimentation.
  - Deliberation costs appear to be very small.
- Telecommunications offer an excellent area of study for researchers interested in behavioral economics.
  - A. de Fontenay, M. H. Shugard, and D. S. Sibley (1990): *Telecommunications Demand Modeling.* North-Holland.

References

- Della Vigna and Malmendier - AER (2006).
- Economides, Seim, and Viard - RAND (2008).
- Miravete - AER (2002).

Outline of the Presentation

- Data Review - Tariff Experiment.
- Simple Theoretical Framework.
- Econometric Modeling.
- Results.

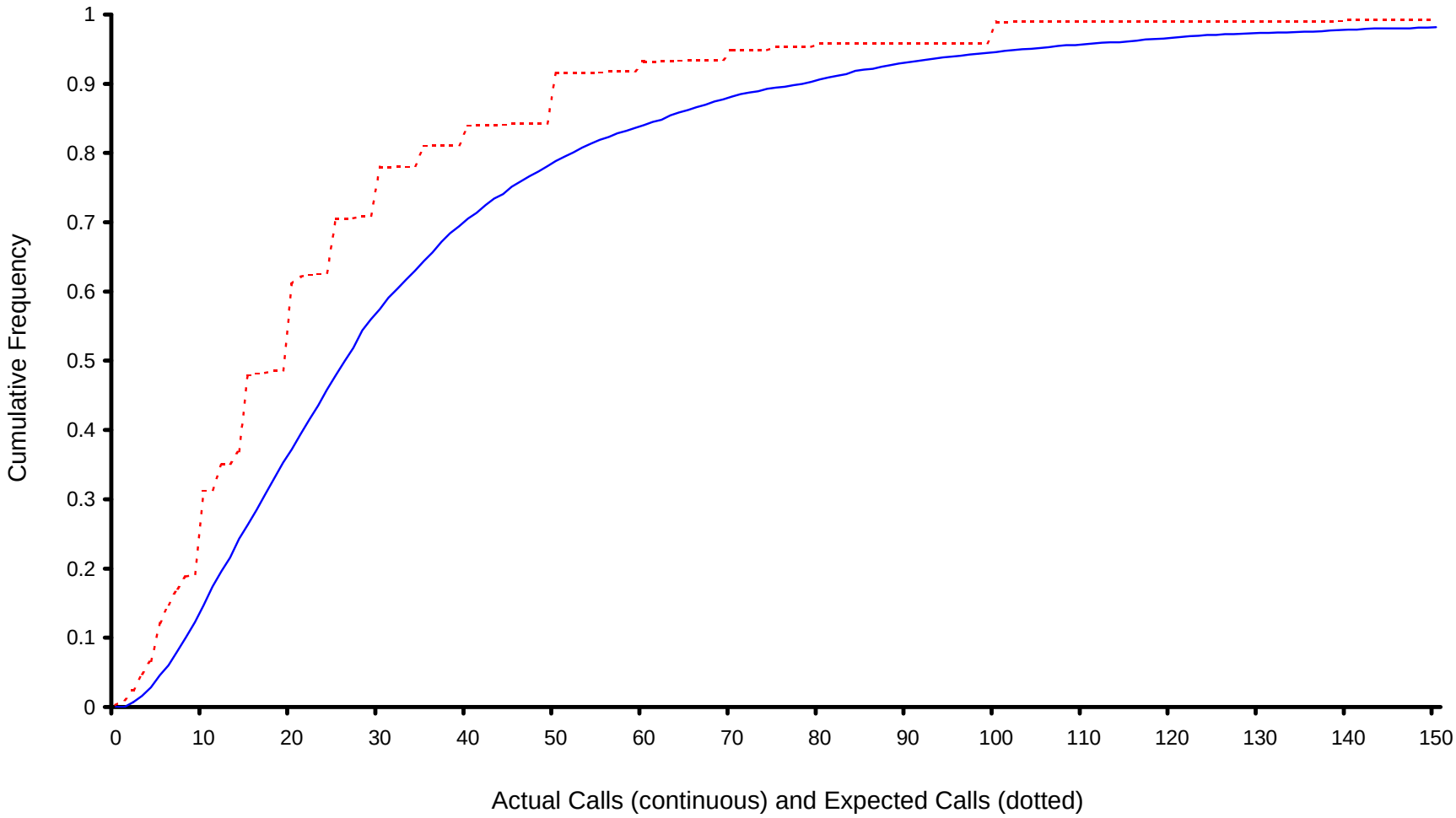
The Kentucky Tariff Experiment

Experiment to evaluate the impact of introducing optional measured tariffs.

- Data collection in the Spring and Fall of 1986.
  - Spring: Mandatory flat tariff.
  - Fall: Choice between flat and measured tariff options.
- Monthly information for about 2,500 individuals in Louisville (penetration rate above 92%):
  - Demographics.
  - Usage Expectations (Spring).
  - Local telephone usage (Spring and Fall).
  - Tariff choice:
    - Flat tariff. Untimed local calls with a fixed monthly fee of $18.70.
    - Measured option: Monthly fee of $14.02; $5.00 allowance; setup, peak-load, and zone pricing.

Table 1: Variable Definitions and Descriptive Statistics

Variables	Description	ALL		FLAT		MEASURED	
MEASURED	Optional measured service chosen this month	0.2971	(0.46)	0.0000	(0.00)	1.0000	(0.00)
EXPCALLS	Household own estimate of weekly number of calls	26.8884	(31.34)	30.1341	(35.05)	19.2104	(17.78)
CALLS	Current weekly number of calls	37.6093	(38.48)	44.4898	(42.62)	21.3326	(17.64)
BIAS	*CALLS — EXPCALLS*	10.7209	(39.92)	14.3558	(45.67)	2.1223	(18.04)
SWCALLS	Household average number of calls during Spring	37.9434	(37.16)	44.0499	(40.80)	23.4980	(20.32)
SWBIAS	*SWCALLS — EXPCALLS*	11.0550	(39.37)	13.9158	(44.55)	4.2876	(21.39)
BILL	Monthly expenditure in local telephone service	19.4303	(4.41)	18.7000	(0.00)	21.1578	(7.82)
SAVINGS	Potential savings of switching tariff options	−9.9223	(16.53)	−15.1557	(16.45)	2.4578	(7.82)
SAVINGS-SPR	Potential savings of subscribing the measured option	−15.4206	(15.27)	−18.7859	(16.21)	−7.4596	(8.56)
SAVINGS-OCT	Potential savings in October	−9.4898	(16.99)	−14.2444	(17.61)	1.7578	(7.60)
SAVINGS-NOV	Potential savings in November	−9.2864	(15.03)	−13.6444	(15.30)	1.0230	(7.47)
SAVINGS-DEC	Potential savings in December	−10.9908	(17.41)	−16.4967	(17.22)	2.0340	(8.83)
INCOME	Monthly income of the household	7.0999	(0.81)	7.0767	(0.84)	7.1547	(0.74)
HHSIZE	Number of people who live in the household	2.6168	(1.51)	2.7858	(1.56)	2.2170	(1.28)
TEENS	Number of teenagers (13–19 years)	0.2440	(0.63)	0.2908	(0.68)	0.1336	(0.49)
DINCOME	Household did not provide income information	0.1577	(0.36)	0.1831	(0.39)	0.0977	(0.30)
AGE = 1	Head of household is between 15 and 34 years old	0.0632	(0.24)	0.0614	(0.24)	0.0676	(0.25)
AGE = 2	Head of household is between 35 and 54 years old	0.2686	(0.44)	0.2604	(0.44)	0.2880	(0.45)
AGE = 3	Head of household is above 54 years old	0.6682	(0.47)	0.6782	(0.47)	0.6444	(0.48)
COLLEGE	Head of household is at least a college graduate	0.2240	(0.42)	0.1821	(0.39)	0.3230	(0.47)
MARRIED	Head of household is married	0.5253	(0.50)	0.5342	(0.50)	0.5042	(0.50)
RETIRED	Head of household is retired	0.2433	(0.43)	0.2417	(0.43)	0.2471	(0.43)
BLACK	Head of household is black	0.1161	(0.32)	0.1295	(0.34)	0.0843	(0.28)
CHURCH	Telephone is used for charity and church purposes	0.1711	(0.38)	0.1785	(0.38)	0.1536	(0.36)
BENEFITS	Household receives some federal or state benefits	0.3095	(0.46)	0.3282	(0.47)	0.2654	(0.44)
MOVED	Head of household moved in the past five years	0.4025	(0.49)	0.3899	(0.49)	0.4324	(0.50)
Observations		1,344		949		395	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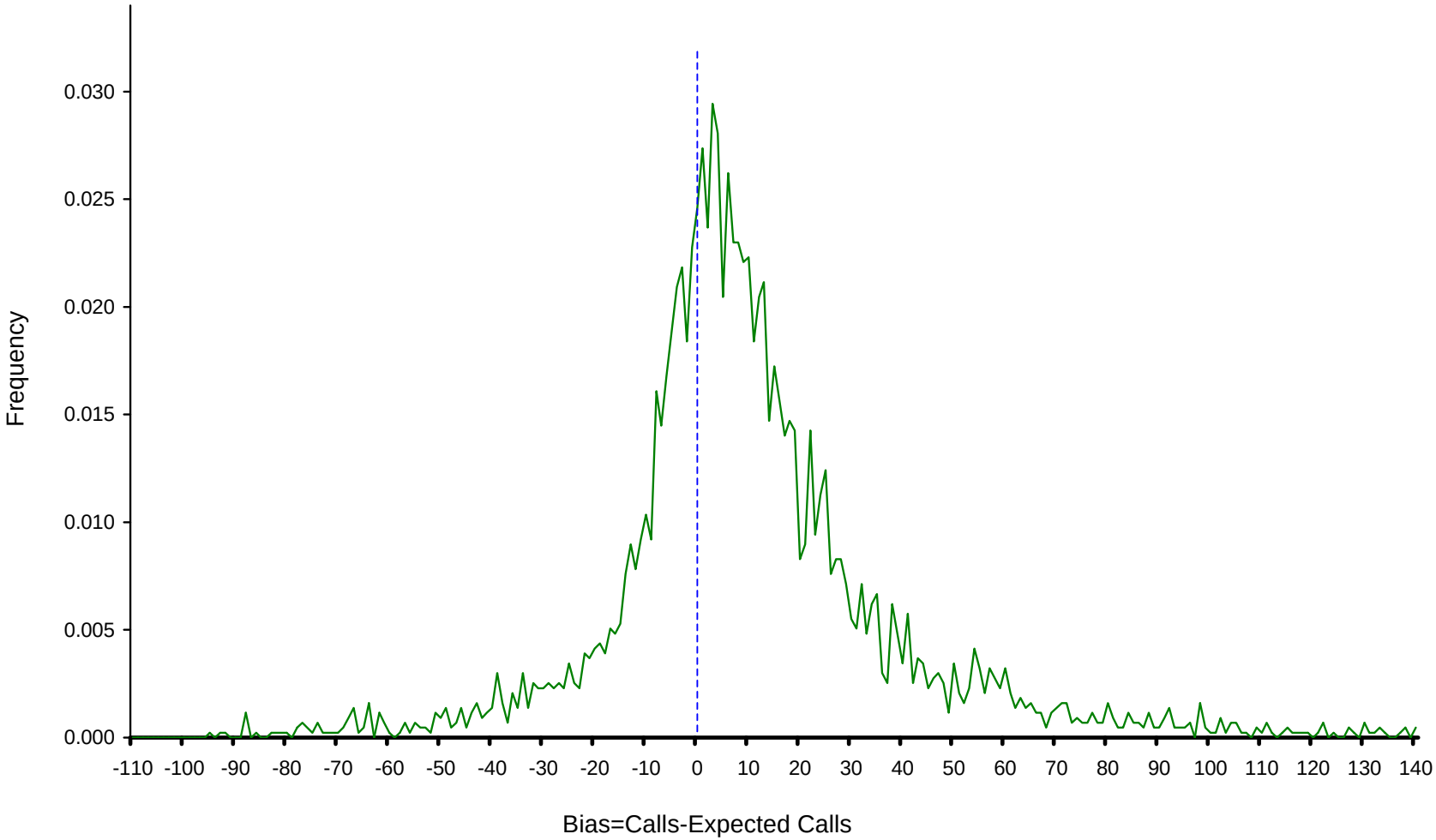
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Actual Calls (continuous) and Expected Calls (dotted)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0.020
0.015
0.010
0.005
0.000
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Bias=Calls-Expected Calls

Decision Maker (DM)

- DM must choose an action a from a menu $\mathcal{A}$.
- DM has a prior probability density $q(\theta)$ on state $\theta \in \Theta$.
- Action a yields von Neumann-Morgenstern utility $u(a, \theta)$ in state θ where $u : \mathcal{A} \times \Theta \to \mathbf{R}$.
- There are two states $\Theta = \{\mathrm{L}, \mathrm{H}\}$ and two actions: $\mathcal{A} = \{\mathrm{F}, \mathrm{M}\}$.
- Each plan is the least expensive option for some usage level:

$$u(\mathrm{M}, \mathrm{L}) > u(\mathrm{F}, \mathrm{L}) ,$$
$$u(\mathrm{F}, \mathrm{H}) > u(\mathrm{M}, \mathrm{H}) ,$$

- DM observes the outcome of an n-sample $x^n = (x_1, ..., x_n) \in \mathbf{X}^n$ of experiments.

- After observing x^n, the DM updates his prior beliefs and takes the action that maximizes his expected utility given the sample.

- The DM optimally chooses action F if and only if $q \geq q^\star$ for some $q^\star \in (0, 1)$.

- Action M is selected if beliefs after observing x^n are:

$$q_n = Prob\left(\mathrm{H} \mid x^n\right) < q^\star = \frac{u\left(\mathrm{M}, \mathrm{L}\right) - u\left(\mathrm{F}, \mathrm{L}\right)}{u\left(\mathrm{M}, \mathrm{L}\right) - u\left(\mathrm{F}, \mathrm{L}\right) + u\left(\mathrm{F}, \mathrm{H}\right) - u\left(\mathrm{M}, \mathrm{H}\right)}.$$

- The expected payoffs in states L and H are:

$$\begin{aligned}
\text{L} &: Prob\left(q_n < q^\star \mid \text{L}\right) u(\text{M},\text{L}) + Prob\left(q_n \geq q^\star \mid \text{L}\right) u(\text{F},\text{L}) \,, \\
\text{H} &: Prob\left(q_n \geq q^\star \mid \text{H}\right) u(\text{F},\text{H}) + Prob\left(q_n < q^\star \mid \text{L}\right) u(\text{M},\text{H}) \,.
\end{aligned}$$

- The *ex-ante* payoff from sampling n observations are:

$$\begin{aligned}
V_{q,u}(n) = \; & (1-q)\left[(1-\alpha_n)\, u\left(\text{M},\text{L}\right) + \alpha_n u(\text{F},\text{L})\right] \\
& + q\left[(1-\beta_n)\, u\left(\text{F},\text{H}\right) + \beta_n u(\text{M},\text{H})\right] \,,
\end{aligned}$$

where α_n and β_n denote error probabilities:

$$\begin{aligned}
\alpha_n &= Prob\left(q_n \geq q^\star \mid \text{L}\right) \,, \\
\beta_n &= Prob\left(q_n < q^\star \mid \text{H}\right) \,.
\end{aligned}$$

Deliberation Costs

- Cost of thinking reduces to the (observable) sequence of past actions.
- Sampling past n demand realization and choices of the past individual history leads to a flow cost $c(n) \geq 0$.
- DM chooses n to maximize:

$$V_{q,u}(n) - c(n) \cdot n \,,$$

so that consumers will continue sampling and gathering information as long as the value of information exceeds the cost of gathering it.

Static Implications

- Consumers with high demand should choose the flat tariff option and *vice versa*.
- Simple reduced form model of simultaneous choice of tariff plan ($\text{M} \Rightarrow y_1 = 1$) and usage level ($\text{L} \Rightarrow y_2 = 1$):

$$y_j^* = X\Pi_j + v_j\,, \qquad j = 1, 2.$$

- Conditional on observed demographics, we assume that:

$$(v_1, v_2) \sim N\left(\mathbf{0}, \mathbf{\Sigma_v}\right)\,; \qquad \mathbf{\Sigma_v} = \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\,.$$

- No systematic mistakes: The estimate of ρ is positive.

Table 2: Choice of Tariff and Usage Level

	MEASURED		LOW USAGE	
CONSTANT	−0.6763	(5.56)	−0.8099	(7.06)
LOW INC	−0.0604	(0.57)	0.0418	(0.46)
HIGH INC	−0.2317	(1.79)	−0.0320	(0.32)
DINCOME	−0.4846	(4.23)	−0.1144	(1.43)
HHSIZE = 2	−0.3548	(3.32)	−0.3128	(3.46)
HHSIZE = 3	−0.5645	(4.29)	−0.3979	(3.81)
HHSIZE = 4	−0.4854	(3.17)	−0.3866	(2.97)
HHSIZE > 4	−0.7187	(4.04)	−0.6709	(4.22)
TEENS	−0.1768	(1.27)	0.0115	(0.11)
AGE = 1	−0.0216	(0.14)	0.1761	(1.38)
AGE = 3	−0.0491	(0.53)	0.1707	(2.03)
COLLEGE	0.2910	(3.42)	0.0709	(0.93)
MARRIED	0.2301	(2.47)	−0.0509	(0.66)
RETIRED	0.0497	(0.43)	−0.1967	(2.24)
BLACK	0.0287	(0.26)	−0.1845	(1.72)
CHURCH	−0.0274	(0.30)	−0.0084	(0.11)
BENEFITS	−0.2189	(2.03)	−0.0360	(0.42)
MOVED	−0.0542	(0.64)	0.0915	(1.24)
OVEREST	−0.3548	(2.42)	−0.7881	(5.17)
UNDEREST	−0.4164	(4.14)	−1.1597	(9.70)
LOW USAGE$_{Spring}$	0.6418	(4.87)	1.4125	(11.26)
ρ	0.8408	(7.46)		
$\ln \mathcal{L}$	−2,463.197			
Observations	4,032			

Inertia and Learning

- Taking advantage of the panel data structure of our sample we are interested in testing two hypotheses:
  - Inertia: Do consumers remain subscribed to the same tariff option regardless of their past realized usage and tariff choices?

$$\text{MEASURED}_t = \beta_0 + \beta_1 \text{LOW USAGE}_{t-1} + \beta_2 \text{MEASURED}_{t-1} + \varepsilon_t$$

  - Learning: Are households who made mistakes more likely to continue making mistakes in the future?

$$\text{WRONG}_t = \beta_0 + \beta_1 \text{MEASURED}_{t-1} + \beta_2 \text{WRONG}_{t-1} + \varepsilon_t$$

- Answers:
  - Naïve Econometrician (ML): YES, NO.
  - Sophisticated Econometrician (GMM): NO, YES.

Table 4: Attention and Inertia in Tariff Subscription (ML)

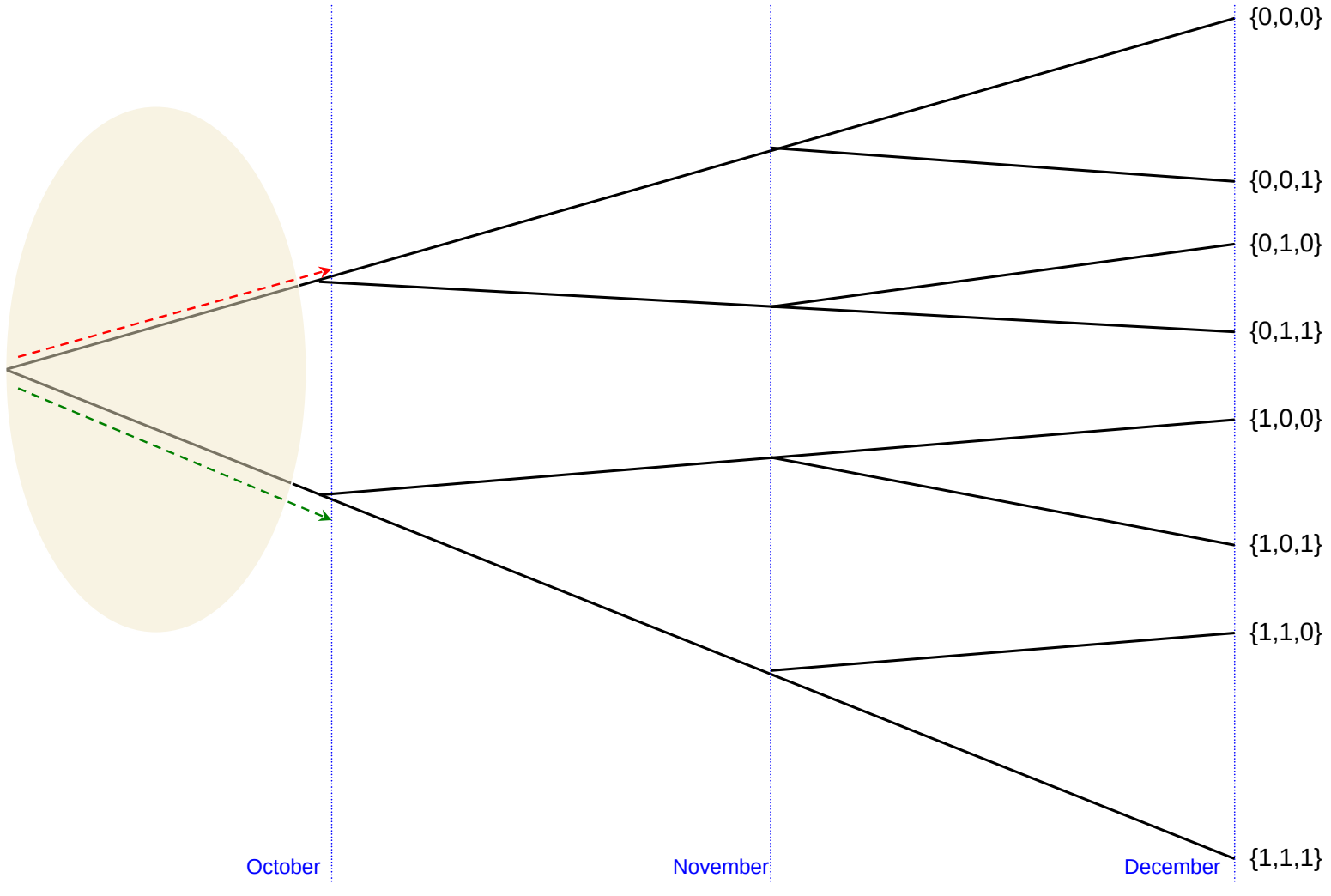
Sample:	CONSTANT		LOW USAGE$_{t-1}$		MEASURED$_{t-1}$		$-\ln \mathcal{L}$	Obs.
ALL	−1.7022	(77.82)	0.5388	(10.54)	3.2177	(43.13)	2329.368	3,950
LOW INC = 1	−1.7328	(31.75)	0.3642	(2.91)	3.2571	(17.11)	369.992	668
LOW INC = HIGH INC = 0	−1.6912	(66.50)	0.5764	(9.59)	3.2276	(36.69)	1722.898	2,874
HIGH INC = 1	−1.7331	(24.92)	0.5619	(3.58)	3.1155	(14.58)	234.266	408
DINCOME = 1	−2.0408	(30.19)	0.7973	(6.11)	3.1935	(15.58)	260.263	683
DINCOME = 0	−1.6499	(70.87)	0.5048	(9.05)	3.2107	(39.93)	2050.425	3,267
HHSIZE = 1	−1.4620	(32.84)	0.3982	(4.65)	3.2386	(20.51)	648.485	817
HHSIZE = 2	−1.6579	(44.46)	0.6111	(7.25)	3.2278	(25.10)	823.698	1,303
HHSIZE = 3	−1.8118	(35.60)	0.1405	(1.08)	3.0371	(18.32)	395.571	811
HHSIZE = 4	−1.7839	(30.27)	−0.0466	(0.30)	3.3795	(15.08)	284.013	585
HHSIZE > 4	−2.1003	(24.49)	1.0141	(3.39)	3.5299	(11.53)	132.586	434
TEENS = 1	−2.0677	(32.49)	0.6782	(3.23)	3.3546	(16.04)	242.481	750
TEENS = 0	−1.6356	(69.51)	0.4885	(9.21)	3.1926	(39.77)	2062.152	3,200
AGE = 1	−1.6210	(18.73)	0.2697	(1.46)	2.9167	(11.34)	155.355	235
AGE = 2	−1.6259	(40.43)	0.5921	(6.04)	3.0474	(23.61)	694.975	1,051
AGE = 3	−1.7432	(63.64)	0.5488	(8.63)	3.3448	(33.70)	1473.016	2,664
COLLEGE = 1	−1.4680	(33.53)	0.4433	(4.63)	3.1072	(21.59)	622.282	792
COLLEGE = 0	−1.7707	(69.62)	0.5542	(9.15)	3.2418	(37.08)	1688.301	3,158
MARRIED = 1	−1.7238	(57.30)	0.6684	(8.77)	3.1634	(31.62)	1203.917	2,095
MARRIED = 0	−1.6768	(52.61)	0.4303	(6.14)	3.2856	(29.10)	1122.760	1,855
RETIRED = 1	−1.7400	(38.21)	0.7143	(6.99)	3.3179	(19.90)	544.966	963
RETIRED = 0	−1.6904	(67.77)	0.4762	(8.04)	3.1897	(38.11)	1782.296	2,987
BLACK = 1	−1.7978	(28.21)	1.1195	(5.49)	3.1317	(14.16)	255.872	494
BLACK = 0	−1.6886	(72.43)	0.4929	(9.26)	3.2324	(40.60)	2068.828	3,456
CHURCH = 1	−1.7209	(32.81)	0.5254	(4.27)	3.1127	(17.95)	403.143	697
CHURCH = 0	−1.6982	(70.56)	0.5413	(9.63)	3.2404	(39.15)	1925.785	3,253
BENEFITS = 1	−1.7931	(43.65)	0.4840	(5.12)	3.3164	(22.33)	646.447	1,265
BENEFITS = 0	−1.6630	(64.23)	0.5632	(9.22)	3.1765	(36.76)	1677.616	2,685
MOVED = 1	−1.6377	(48.57)	0.3136	(3.94)	3.2189	(27.50)	974.101	1,554
MOVED = 0	−1.7471	(60.65)	0.6934	(10.36)	3.2209	(33.00)	1348.630	2,396
OVEREST = 1	−1.9955	(41.00)	0.4503	(4.02)	3.0646	(18.91)	400.129	1,116
OVEREST = UNDEREST = 0	−1.5673	(59.79)	0.4145	(7.44)	3.3420	(34.15)	1722.032	2,484
UNDEREST = 0	−1.8784	(23.42)	0.4421	(1.98)	2.8298	(12.32)	159.640	350

Table 6: Persistence in the Wrong Choice of Tariffs (ML)

Sample:	CONSTANT		MEASURED$_{t-1}$		WRONG$_{t-1}$		$-\ln \mathcal{L}$	Obs.
ALL	−1.3560	(77.89)	0.8354	(15.90)	1.3827	(34.11)	4100.418	3,950
LOW INC = 1	−1.3614	(32.29)	0.7466	(5.30)	1.4310	(14.83)	694.868	668
LOW INC = HIGH INC = 0	−1.3563	(66.20)	0.8411	(14.12)	1.3514	(28.41)	2981.507	2,874
HIGH INC = 1	−1.3454	(25.28)	0.9418	(5.21)	1.5206	(11.69)	421.787	408
DINCOME = 1	−1.3812	(32.85)	0.8612	(5.74)	1.1121	(11.23)	682.776	683
DINCOME = 0	−1.3495	(70.62)	0.8126	(14.30)	1.4375	(32.20)	3410.681	3,267
HHSIZE = 1	−1.0573	(29.43)	0.4383	(5.27)	1.2120	(18.01)	1166.283	817
HHSIZE = 2	−1.2785	(43.34)	0.9422	(11.49)	1.1375	(16.98)	1477.969	1,303
HHSIZE = 3	−1.4939	(37.19)	0.7898	(4.49)	1.6838	(14.49)	682.011	811
HHSIZE = 4	−1.5722	(31.53)	1.2116	(6.67)	1.6317	(11.96)	446.790	585
HHSIZE > 4	−1.7703	(27.23)	1.0586	(2.92)	1.6733	(6.69)	239.488	434
TEENS = 1	−1.7098	(35.80)	0.3091	(1.21)	2.2813	(13.35)	452.514	750
TEENS = 0	−1.2896	(68.05)	0.8287	(15.56)	1.2905	(30.65)	3603.162	3,200
AGE = 1	−1.1530	(17.50)	0.5292	(2.73)	1.4017	(9.02)	293.859	235
AGE = 2	−1.3810	(40.53)	0.8353	(8.04)	1.5116	(18.35)	1049.965	1,051
AGE = 3	−1.3657	(64.14)	0.8578	(13.30)	1.3338	(27.24)	2748.582	2,664
COLLEGE = 1	−1.2466	(32.83)	0.6957	(6.95)	1.6055	(19.87)	924.480	792
COLLEGE = 0	−1.3828	(70.51)	0.8751	(14.10)	1.2943	(27.42)	3158.056	3,158
MARRIED = 1	−1.4388	(58.24)	1.0518	(13.76)	1.3041	(20.89)	1956.573	2,095
MARRIED = 0	−1.2715	(51.37)	0.6457	(8.93)	1.4106	(26.20)	2125.535	1,855
RETIRED = 1	−1.3772	(38.69)	0.9576	(9.58)	1.1225	(13.68)	990.614	963
RETIRED = 0	−1.3495	(67.57)	0.7849	(12.70)	1.4689	(31.31)	3100.573	2,987
BLACK = 1	−1.5838	(29.24)	0.9984	(4.57)	1.4243	(7.95)	368.718	494
BLACK = 0	−1.3274	(71.92)	0.8187	(15.12)	1.3666	(32.70)	3720.910	3,456
CHURCH = 1	−1.3834	(32.96)	0.9122	(7.25)	1.2699	(12.88)	700.132	697
CHURCH = 0	−1.3501	(70.56)	0.8196	(14.17)	1.4048	(31.58)	3398.716	3,253
BENEFITS = 1	−1.3851	(44.59)	1.0138	(10.57)	1.1353	(15.68)	1275.014	1,265
BENEFITS = 0	−1.3418	(63.83)	0.7387	(11.65)	1.5017	(30.40)	2812.217	2,685
MOVED = 1	−1.3168	(48.13)	0.7074	(8.30)	1.5454	(24.80)	1675.876	1,554
MOVED = 0	−1.3823	(61.16)	0.9286	(13.91)	1.2543	(23.43)	2412.525	2,396
OVEREST = 1	−1.9257	(42.41)	1.7689	(8.15)	0.9299	(4.15)	471.857	1,116
OVEREST = UNDEREST = 0	−1.1442	(55.42)	0.7105	(13.10)	1.2399	(29.08)	3237.562	2,484
UNDEREST = 0	−1.7267	(24.77)	0.9792	(3.23)	1.4056	(5.51)	216.562	350

Unobserved Heterogeneity and State Dependence

- Consumer actions are likely to be conditioned by the individual history of tariff choices and demand realizations.
- However, we do not observe all individual histories.
- Include lagged, discrete, dependent variables among the regressors.
  - Endogeneity problems - Consistency.
  - Difficult to envision nonlinear instrumental variables.
- Consider predetermined rather than exogenous regressors to obtain consistent estimates.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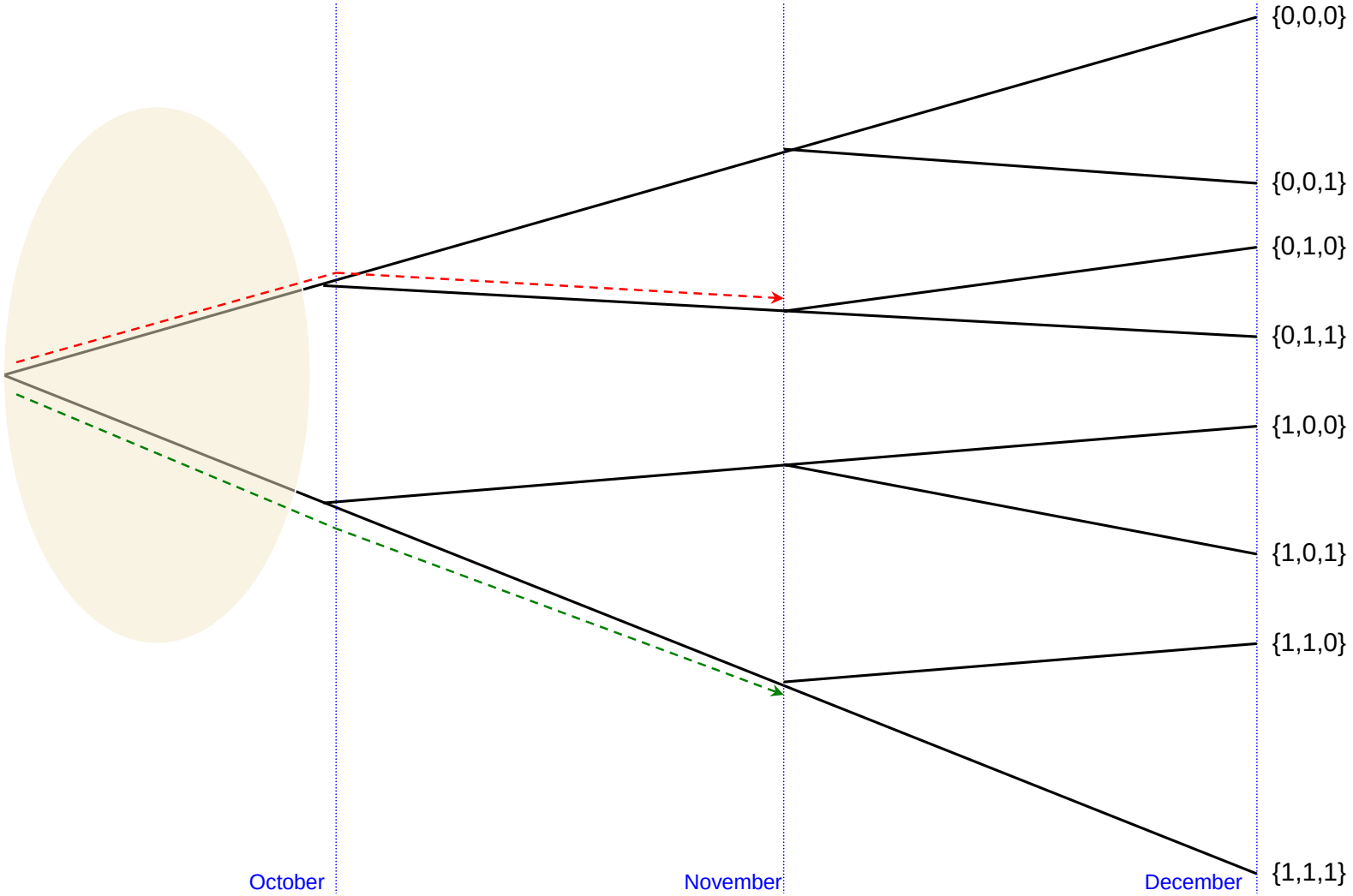
November
December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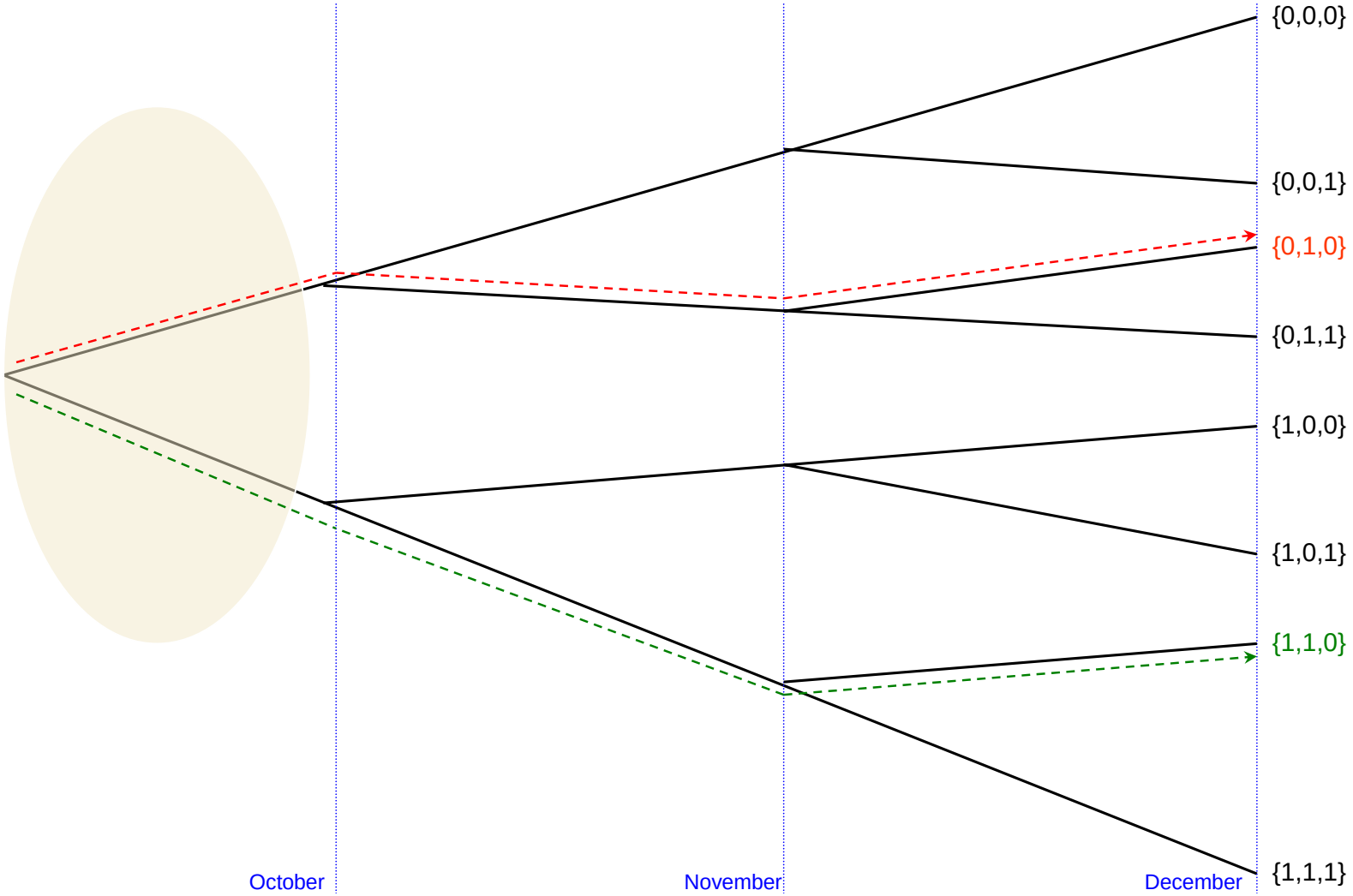
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Is the problem of unobserved heterogeneity due to state dependence something new?

- No, this is a classical problem in econometrics:
  - Neyman and Scott - Econometrica (1948).
  - Heckman - "Structural Analysis..." (1981).
  - Lancaster - J.Econometrics (2000)
- It is however a very difficult problem to address and there are very few solutions available:
  - Honoré and Kyriazidou - Econometrica (2000).
  - Honoré and Lewbel - Econometrica (2002).
  - Arellano and Carrasco - J.Econometrics (2003)

GMM

- Subscription to the measured option depends on characteristics of consumers plus their expectation on the realization of demand:

$$y_{it} = \mathbf{1}\left\{\beta z_{it} + E\left(\eta_i \mid w_i^t\right) + \varepsilon_{it} \geq 0\right\}, \quad \varepsilon_{it} \mid w_i^t \sim N\left(0, \sigma_t^2\right).$$

- Conditional probability of choosing the measured option at each time given the history w_i^t:

$$Prob\left(y_{it} = 1 \mid w_i^t\right) = \Phi\left[\frac{\beta z_{it} + E\left(\eta_i \mid w_i^t\right)}{\sigma_t}\right].$$

Lattice Histories

- Regressors are dichotomous with support on a lattice lattice defined by $2J$ nodes $\{\phi_1, ..., \phi_{2J}\}$.
- The $t \times 1$–vector of regressors $z_i^t = \{z_{i1}, ..., z_{it}\}$ has a multinomial distribution and may take up to J^t different values.
- The vector of histories can be summarized by a cluster of nodes representing the sequence of tariff choices and demand realizations since w_i^t is defined on $(2J)^t$ values, for $j = 1, ..., (2J)^t$.
- The conditional probability can then be rewritten as:

$$p_{jt} = Prob\left(y_{it} = 1 \mid w_i^t = \phi_j^t\right) \equiv h_t\left(w_i^t = \phi_j^t\right) \ , \ j = 1, \ldots, (2J)^t \ .$$

Removing Unobserved Heterogeneity

- Look for all individuals with identical histories up to time t.
- Compute $\hat{p}_{jt}$ as the proportion of them that subscribe to M.
- Take first differences of the inverse of the conditional probability:

$$\sigma_t \Phi^{-1}\left[h_t\left(w_i^t\right)\right] - \sigma_{t-1}\Phi^{-1}\left[h_{t-1}\left(w_i^{t-1}\right)\right] - \beta\left(x_{it} - x_{i(t-1)}\right) = \xi_{it}\,.$$

- Then, by the law of iterated expectations:

$$E\left[\xi_{it} \mid w_i^{t-1}\right] = E\left[E\left(\eta_i \mid w_i^t\right) - E\left(\eta_i \mid w_i^{t-1}\right) \middle| \, w_i^{t-1}\right] = 0\,.$$

Results on Inertia

- Inertia:
  - Negative effect of LOW USAGE_{t-1} captures the idea of mistakes.
  - Negative effect of MEASURED_{t-1} indicates that consumers switch tariffs and that the hypothesis of automatic renewal (inertia) is not supported by the data.
  - Results are robust across demographic strata.

Table 3: Attention and Inertia in Tariff Subscription (GMM)

Sample:	CONSTANT		LOW USAGE$_{t-1}$		MEASURED$_{t-1}$		d.f.	Obs.
ALL	−1.9751	(7.99)	−4.4181	(17.88)	−8.9011	(36.02)	9	3,950
LOW INC = 1	−2.3919	(6.22)	1.1055	(2.87)	−20.0065	(52.02)	8	668
LOW INC = HIGH INC = 0	−1.9692	(7.35)	−5.5032	(20.54)	−6.0887	(22.73)	9	2,874
HIGH INC = 1	−2.1159	(5.00)	−6.2151	(14.68)	−12.4203	(29.34)	8	408
DINCOME = 1	−3.1042	(7.09)	−10.1293	(23.14)	−8.2131	(18.76)	7	683
DINCOME = 0	−1.8781	(7.46)	−3.5418	(14.06)	−8.1274	(32.26)	9	3,267
HHSIZE = 1	−1.2827	(3.64)	−3.2181	(9.13)	−4.3519	(12.35)	9	817
HHSIZE = 2	−1.6469	(5.16)	−6.5772	(20.60)	−11.5899	(36.29)	9	1,303
HHSIZE = 3	−2.6187	(6.82)	−5.4355	(14.16)	−6.3259	(16.48)	6	811
HHSIZE = 4	−2.3548	(5.86)	−11.4859	(28.57)	−16.0243	(39.86)	6	585
HHSIZE > 4	−3.4691	(6.82)	−13.4427	(26.44)	−31.7962	(62.54)	4	434
TEENS = 1	−3.1895	(7.63)	−25.6940	(61.46)	−25.8714	(61.89)	5	750
TEENS = 0	−1.8713	(7.41)	−2.9598	(11.72)	−7.3084	(28.93)	9	3,200
AGE = 1	−1.9711	(4.18)	−4.7308	(10.04)	−7.9214	(16.81)	6	235
AGE = 2	−1.9399	(5.79)	−4.1165	(12.28)	−5.6042	(16.71)	8	1,051
AGE = 3	−2.0563	(7.48)	−4.6915	(17.07)	−9.9864	(36.34)	9	2,664
COLLEGE = 1	−1.1912	(3.35)	−5.7461	(16.15)	−5.4816	(15.40)	8	792
COLLEGE = 0	−2.2028	(8.25)	−4.2893	(16.07)	−9.9372	(37.23)	9	3,158
MARRIED = 1	−1.6761	(5.42)	−11.7802	(38.08)	−15.1276	(48.91)	9	2,095
MARRIED = 0	−2.0548	(6.99)	−2.8714	(9.76)	−5.6511	(19.22)	9	1,855
RETIRED = 1	−1.9671	(5.63)	−5.5897	(15.99)	−12.6135	(36.09)	8	963
RETIRED = 0	−1.9684	(7.42)	−4.6514	(17.52)	−7.8735	(29.66)	9	2,987
BLACK = 1	−2.7295	(6.14)	−3.3922	(7.62)	−7.5027	(16.86)	6	494
BLACK = 0	−1.8738	(7.30)	−4.8573	(18.92)	−9.7249	(37.88)	9	3,456
CHURCH = 1	−2.1763	(5.56)	−5.3369	(13.63)	−4.7470	(12.13)	8	697
CHURCH = 0	−1.9526	(7.58)	−4.3052	(16.70)	−10.1812	(39.50)	9	3,253
BENEFITS = 1	−2.3831	(7.11)	−2.3833	(7.11)	−10.0434	(29.96)	8	1,265
BENEFITS = 0	−1.7939	(6.64)	−5.5373	(20.49)	−8.4938	(31.43)	9	2,685
MOVED = 1	−1.9123	(6.45)	−3.5743	(12.05)	−6.1390	(20.70)	9	1,554
MOVED = 0	−1.8605	(6.28)	−7.9804	(26.92)	−15.4823	(52.23)	9	2,396
OVEREST = 1	−3.1880	(8.00)	−8.4407	(21.17)	−20.5573	(51.56)	5	1,116
OVEREST = UNDEREST = 0	−1.7056	(6.48)	−2.3276	(8.85)	−6.1550	(23.40)	9	2,484
UNDEREST = 0	−2.6209	(5.21)	−7.5750	(15.07)	−28.5742	(56.84)	5	350

Results on Learning

- Learning:
  - Negative effect of MEASURED_{t-1} indicates that switching is not symmetric (together with the results of the previous Table): Consumers previously subscribed to the M option are more likely to switch tariffs, perhaps because of lower deliberation costs.
  - Negative effect of WRONG_{t-1} indicates that mistakes are not permanent and that switching tariff options is aimed at reducing the cost of local telephone service.
  - Results are robust across demographic strata.

Table 5: Persistence in the Wrong Choice of Tariffs (GMM)

Sample:	CONSTANT		MEASURED_{t-1}		WRONG_{t-1}		d.f.	Obs.
ALL	−1.5233	(7.02)	−7.9160	(36.49)	−1.3889	(6.40)	9	3,950
LOW INC = 1	−1.5432	(4.42)	−10.4758	(30.03)	−1.8594	(5.33)	8	668
LOW INC = HIGH INC = 0	−1.5394	(6.59)	−7.4235	(31.77)	−1.2332	(5.28)	9	2,874
HIGH INC = 1	−1.6780	(4.30)	−6.2998	(16.13)	−3.0077	(7.70)	8	408
DINCOME = 1	−1.9619	(5.82)	−4.7247	(14.02)	−3.3609	(9.98)	7	683
DINCOME = 0	−1.4890	(6.56)	−7.7598	(34.18)	−1.0294	(4.53)	9	3,267
HHSIZE = 1	−0.7568	(2.54)	−5.3754	(18.07)	−1.2829	(4.31)	9	817
HHSIZE = 2	−1.4364	(5.13)	−5.4678	(19.51)	−0.9912	(3.54)	9	1,303
HHSIZE = 3	−2.0489	(5.98)	−7.3731	(21.53)	−1.8405	(5.37)	6	811
HHSIZE = 4	−2.0654	(5.43)	−13.2991	(34.96)	−2.1146	(5.56)	6	585
HHSIZE > 4	−2.8353	(5.92)	−20.5004	(42.84)	−12.1551	(25.40)	4	434
TEENS = 1	−2.5513	(6.42)	4.0823	(10.27)	−15.0762	(37.92)	5	750
TEENS = 0	−1.3811	(6.17)	−7.1850	(32.12)	−0.8616	(3.85)	9	3,200
AGE = 1	−1.3851	(3.33)	−1.4152	(3.40)	−1.3488	(3.24)	6	235
AGE = 2	−1.5545	(5.00)	−6.3919	(20.58)	−2.0171	(6.49)	8	1,051
AGE = 3	−1.5052	(6.30)	−9.1007	(38.08)	−1.8012	(7.54)	9	2,664
COLLEGE = 1	−0.7895	(2.27)	−5.2913	(15.18)	−5.9640	(17.11)	8	792
COLLEGE = 0	−1.6363	(7.10)	−9.2367	(40.09)	−1.0372	(4.50)	9	3,158
MARRIED = 1	−1.7349	(6.51)	−7.5556	(28.34)	−1.7565	(6.59)	9	2,095
MARRIED = 0	−1.3233	(5.30)	−7.4267	(29.72)	−1.3819	(5.53)	9	1,855
RETIRED = 1	−1.5378	(5.05)	−8.9728	(29.48)	−1.6826	(5.53)	8	963
RETIRED = 0	−1.5171	(6.48)	−7.3404	(31.37)	−1.5495	(6.62)	9	2,987
BLACK = 1	−2.3144	(5.70)	−7.1978	(17.73)	−1.7701	(4.36)	6	494
BLACK = 0	−1.4402	(6.48)	−7.7858	(35.04)	−1.4408	(6.48)	9	3,456
CHURCH = 1	−1.7183	(5.03)	−6.5395	(19.15)	−0.9614	(2.82)	8	697
CHURCH = 0	−1.4916	(6.57)	−7.8236	(34.47)	−1.7712	(7.80)	9	3,253
BENEFITS = 1	−1.6166	(5.58)	−11.3664	(39.27)	−1.3053	(4.51)	8	1,265
BENEFITS = 0	−1.4863	(6.23)	−6.7109	(28.12)	−1.4499	(6.07)	9	2,685
MOVED = 1	−1.4874	(5.58)	−6.7672	(25.41)	−0.5919	(2.22)	9	1,554
MOVED = 0	−1.5394	(6.12)	−8.6180	(34.27)	−2.2472	(8.94)	9	2,396
OVEREST = 1	−3.0922	(8.31)	−23.0542	(61.95)	4.9509	(13.30)	5	1,116
OVEREST = UNDEREST = 0	−1.1158	(4.86)	−5.5119	(24.01)	−0.4217	(1.84)	9	2,484
UNDEREST = 0	−2.4090	(4.81)	−25.6046	(51.07)	−4.2901	(8.56)	5	350

How Do Probabilities Change with the State?

Table 7: Marginal Effects

Previous Transition	October	November	December	Fall
From (Flat,Right) to (Flat,Wrong)	−11.60	−6.52	−4.27	−7.46
From (Measured,Right) to (Measured,Wrong)	−0.01	−1.67	−2.13	−1.27
From (Flat,Right) to (Measured,Right)	−17.73	−17.82	−11.64	−15.73
From (Flat,Wrong) to (Measured,Wrong)	−6.13	−12.98	−9.49	−9.53

Percent change in the probability of choosing the current tariff option wrongly conditional on each transition among states.

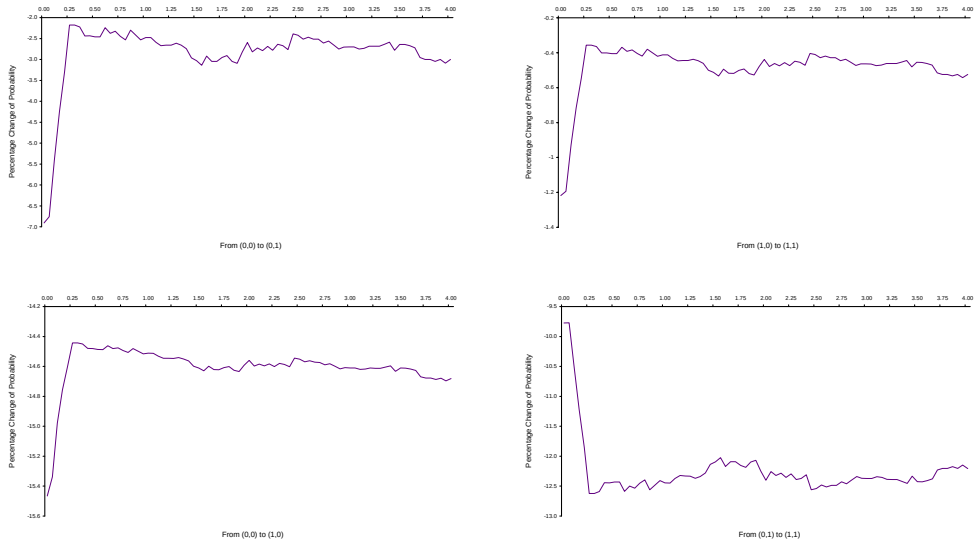
The probability of subscribing to the wrong tariff plan when we compare two states $z_{it} = z^0$ and $z_{it} = z^1$ changes by the proportion:

$$\hat{\triangle}_t = \frac{1}{N}\sum_{i=1}^{N}\left\{\Phi\left(\hat{\sigma}_t^{-1}\hat{\beta}\left(z^1 - z_{it}\right) + \Phi^{-1}\left[\hat{h}_t\left(w_i^t\right)\right]\right) - \Phi\left(\hat{\sigma}_t^{-1}\hat{\beta}\left(z^0 - z_{it}\right) + \Phi^{-1}\left[\hat{h}_t\left(w_i^t\right)\right]\right)\right\}$$

- The probability of making a mistake is substantially lower after subscribing to the measured option.
- This probability reduction is more important for those with low demand for which the measured service is the least expensive option.

Accounting for Deliberation Costs

Figure 1: Marginal Effects at Different Mistake Thresholds



- Change the definition of WRONG adding a positive threshold ranging from \$0.00 to \$4.00 in increments of 5 cents.
- Marginal effects experience an abrupt change in the neighborhood of 25-30 cents.