

# Rational Attention in a Repeated Decision Problem

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# Disclaimer

I could talk for 15 hours straight about my research of the last 15 years but fortunately for you I only have 15 minutes...



# Timeline

- ◆ 0:10 Disclaimer
- ◆ 0:30 Overview
- ◆ 2:00 Paper with Ignacio
  - 2:10 Theoretical motivation
  - 4:00 Data: Kentucky Tariff Experiment
  - 6:00 Preliminary Results
  - 8:00 Econometric Model – State Dependence
  - 10:00 Regressions: Inertia vs. tariff switching
  - 11:00 Regressions: Learning from experience



- ◆ 12:00 Relation to other evidence
  - 12:10 Simple response to potential savings
  - 12:30 Bayesian learning
  - 13:00 More firms
  - 13:30 Bundling and tariff switching
- ◆ 14:00 The supply side: Foggy Pricing
- ◆ 14:45 A forgotten reference



## Basic Message

- ◆ Telecommunications offer an excellent area of study for researchers interested in behavioral economics.
- ◆ Results indicate that individuals, on average, switch tariff choices in response to very low potential gains.
- ◆ Available evidence does not support that engaging in deceptive strategies is profitable.



# This Paper: Motivation

- ◆ Decision making is costly: habit and inertia might be good responses to changing environments if potential benefits are small relative to cognition and deliberation costs.
- ◆ However, there is not yet any empirical evidence on the size of these deliberation costs in a natural setting.



# More Motivation

- ◆ 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?



## Goal

- ◆ To address empirically the trade-off between potential benefits and cost of deliberation.
- ◆ Estimate the size of deliberation and cognition costs.
- ◆ Analyze whether our micro data distinguishes between rational and irrational behavior.



# Findings

- ◆ Households learn very fast.
  - Mistakes do exist, 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.



# The Kentucky Tariff Experiment (again)

## ◆ Features.

- Experiment to evaluate the impact of introducing optional measured tariffs.
- Data collection in the Spring and Fall of 1986.
- 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.



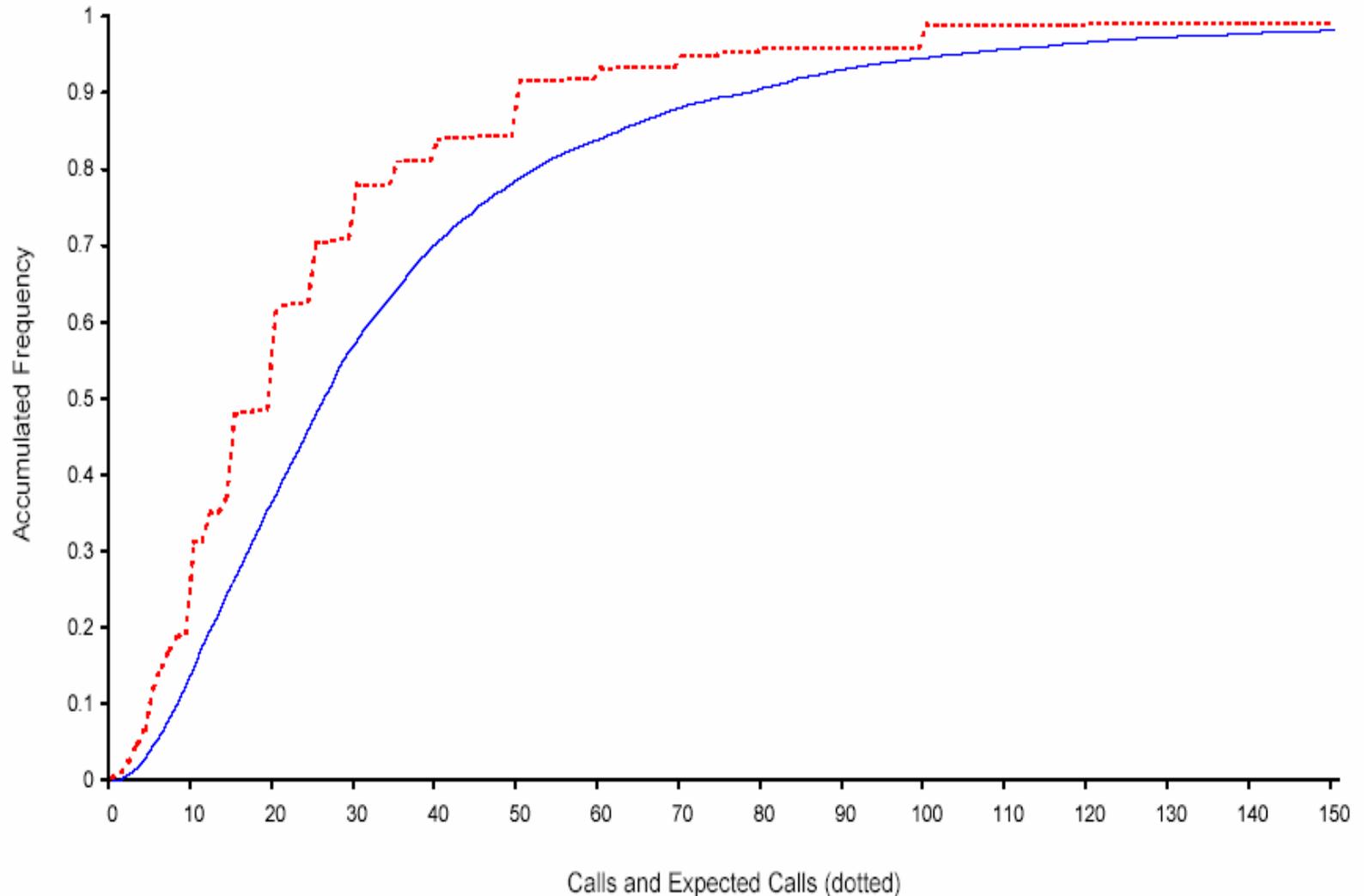
# Data

Table 1. Descriptive Statistics

| Variables    | Description  | ALL              | FLAT             | MEASURED        |
|--------------|--|------------------|------------------|-----------------|
| MEASURED     | Optional measured service chosen this month          | 0.2971 (0.46)    | 0.0000           | 1.0000          |
| EXPCALLS     | Household own estimate of number of weekly 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         | <i>CALLS — EXPCALLS</i>                              | 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       | <i>SWCALLS — EXPCALLS</i>                            | 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)   |
| AGE1         | Head of household is between 15 and 34 years old     | 0.0632 (0.24)    | 0.0614 (0.24)    | 0.0676 (0.25)   |
| AGE2         | Head of household is between 35 and 54 years old     | 0.2686 (0.44)    | 0.2604 (0.44)    | 0.2880 (0.45)   |
| AGE3         | 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             |

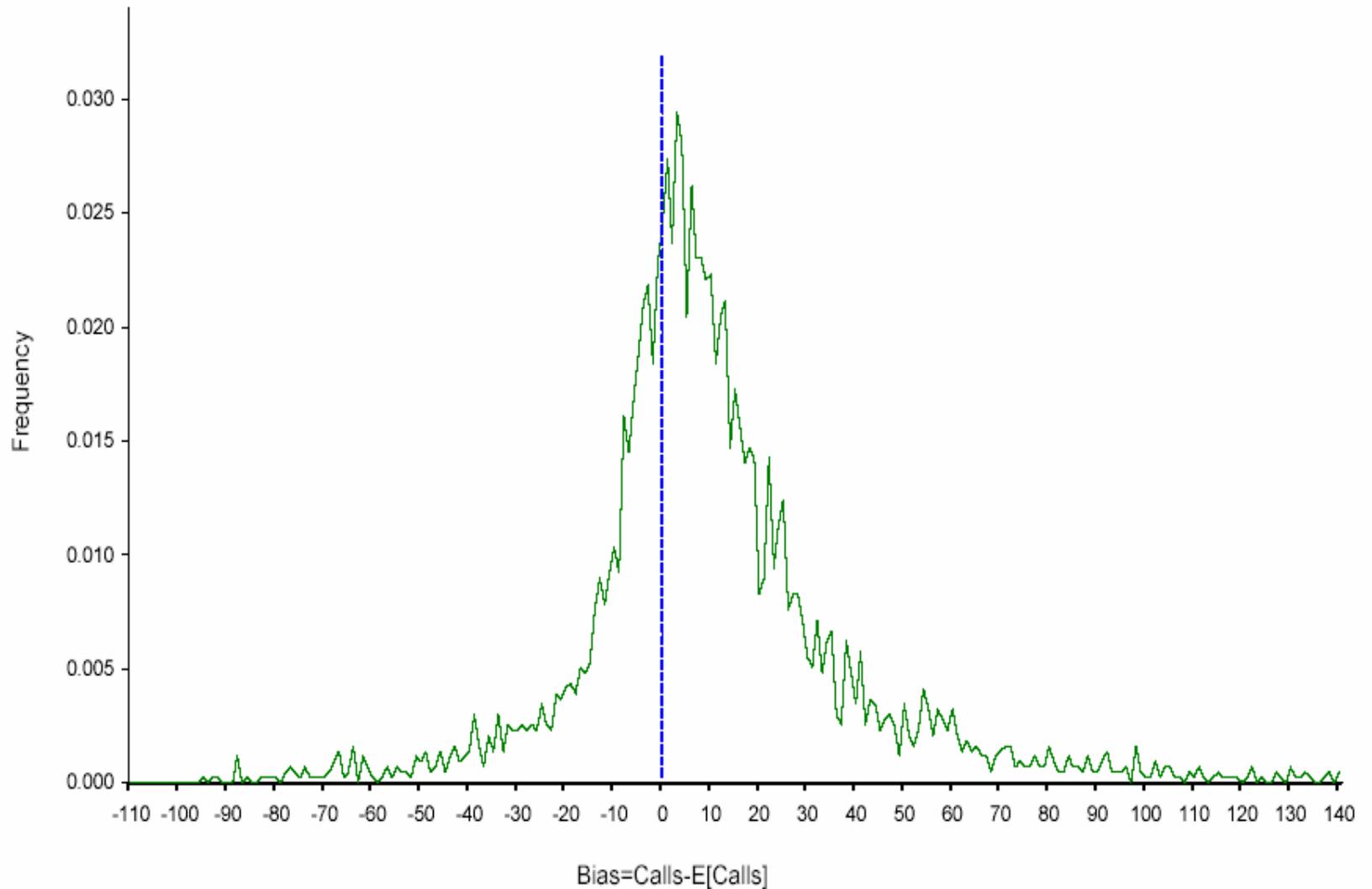


# Underestimation of Consumption





# Forecast Errors





# Do Consumers Make Mistakes?

Table 2. Choice of Tariff and Usage Level

|                         | MEASURED       | LOW USAGE      |
|-------------------------|----------------|----------------|
| Constant                | -0.6763 (5.56) | -0.8099 (7.06) |
| LOW INCOME              | -0.0604 (0.57) | 0.0418 (0.46)  |
| HIGH INCOME             | -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 > 5              | -0.7187 (4.04) | -0.6709 (4.22) |
| TEENS                   | -0.1768 (1.27) | 0.0115 (0.11)  |
| AGE1                    | -0.0216 (0.14) | 0.1761 (1.38)  |
| AGE3                    | -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)  |
| UNDERESTIMATION         | -0.4164 (4.14) | -1.1597 (9.70) |
| OVERESTIMATION          | -0.3548 (2.42) | -0.7881 (5.17) |
| LOW USAGE <i>Spring</i> | 0.6418 (4.87)  | 1.4125 (11.26) |
| $\rho$                  | 0.8408 (7.46)  |                |
| Observations            | 4,032          |                |
| Log-likelihood          | -2,463.197     |                |



# Do Consumers Respond to Savings?

Table 3. Potential Savings and Tariff Switching

| PATH                        | FFF                | FFM               | FMF                 | FMM               | MFF                | MMF                | MMM               |
|-----------------------------|--------------------|-------------------|---------------------|-------------------|--------------------|--------------------|-------------------|
| SAMPLE OBSERVATIONS         | 953                | 5                 | 1                   | 38                | 28                 | 13                 | 375               |
| POPULATION SHARE            | 0.8603             | 0.0045            | 0.0009              | 0.0343            | 0.0067             | 0.0031             | 0.0901            |
| SWCALLS-EXPCALLS<br>PERCENT | 12.5845<br>-0.1954 | 9.3826<br>-0.1631 | -51.0870<br>-1.7669 | 3.3370<br>-0.0027 | 15.1761<br>0.0593  | 0.5246<br>-0.2019  | 3.0600<br>-0.2598 |
| <i>OCTOBER</i>              |                    |                   |                     |                   |                    |                    |                   |
| WRONG<br>POTENTIAL SAVINGS  | 0.1070<br>-15.2358 | 0.6000<br>-2.7268 | 0.0000<br>-7.6810   | 0.4211<br>-2.0849 | 1.0000<br>16.7640  | 1.0000<br>17.5189  | 0.5733<br>1.1859  |
| <i>NOVEMBER</i>             |                    |                   |                     |                   |                    |                    |                   |
| WRONG<br>POTENTIAL SAVINGS  | 0.1133<br>-13.9896 | 0.6000<br>-1.8204 | 1.0000<br>5.6830    | 0.5789<br>2.5909  | 0.0000<br>-14.4198 | 1.0000<br>14.8302  | 0.5573<br>0.8899  |
| <i>DECEMBER</i>             |                    |                   |                     |                   |                    |                    |                   |
| WRONG<br>POTENTIAL SAVINGS  | 0.0619<br>-16.9373 | 0.4000<br>2.6848  | 0.0000<br>-4.0760   | 0.6842<br>3.7008  | 0.0000<br>-15.3860 | 0.0000<br>-18.3705 | 0.6667<br>2.6647  |



## What does the data show so far?

- ◆ Most consumers choose the tariff choice that is least expensive for their realized demand.
- ◆ Biased expectations appear to have little economic consequences.
- ◆ About 90% of the population always chose correctly the flat tariff option.
- ◆ A small fraction of consumer switched tariffs, apparently prompted by small potential savings.



# Dynamic Discrete Choice Models

- ◆ Consumer actions are likely to be conditioned by the individual history of tariff choices and demand realizations.
  - Include lagged, discrete, dependent variables among the regressors.
    - Endogeneity problems.
      - ◆ Difficult to envision nonlinear instrumental variables.
      - ◆ Consider “pre-determined” regressors vs. the common exogeneity requirement to obtain consistent estimates.



# The Econometric Model

- ◆ Specification:

$$y_{it} = \mathbb{I}\{\beta x_{it} + E(\eta_i | \omega_i^t) + \varepsilon_{it} \geq 0\},$$

$$\varepsilon_{it} | \omega_i^t \sim \mathcal{N}(0, \sigma_t^2),$$

- ◆ Conditional Probability:

$$\Pr(y_{it} = 1 | \omega_i^t) = \Phi \left[ \frac{\beta x_{it} + E(\eta_i | \omega_i^t)}{\sigma^t} \right].$$

$$p_{tj} = \Pr(y_{it} = 1 | \omega_i^t = \phi_j^t) \equiv h_t(\omega_i^t = \phi_j^t), \quad j = 1, \dots, (2J)^t.$$



- ◆ Building the moment conditions:
  - First differences of the inverse of the conditional probability:

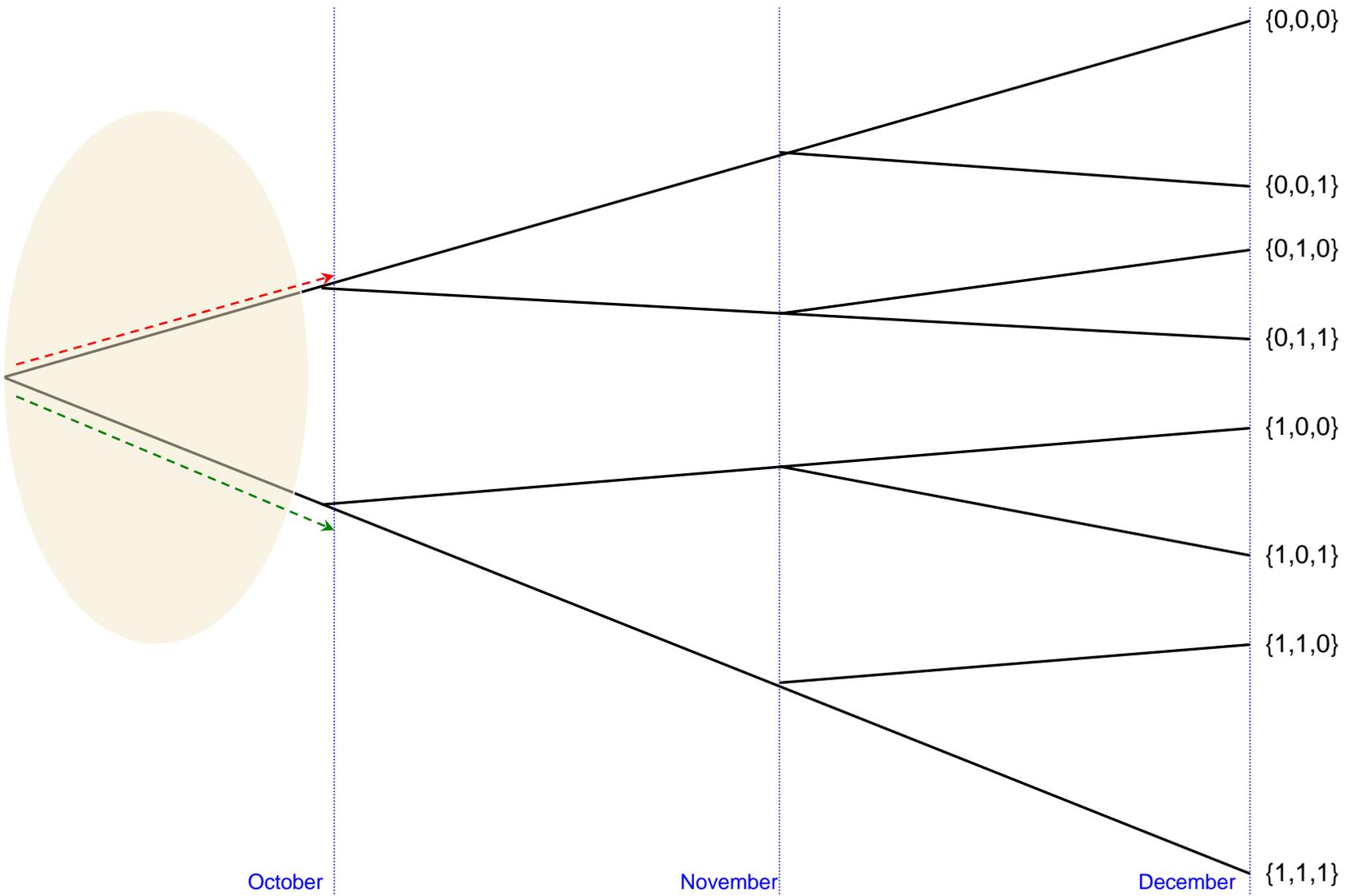
$$\sigma_t \Phi^{-1}[h_t(\omega_i^t)] - \sigma_{t-1} \Phi^{-1}[h_{t-1}(\omega_i^{t-1})] - \beta(x_{it} - x_{i(t-1)}) = \xi_{it},$$

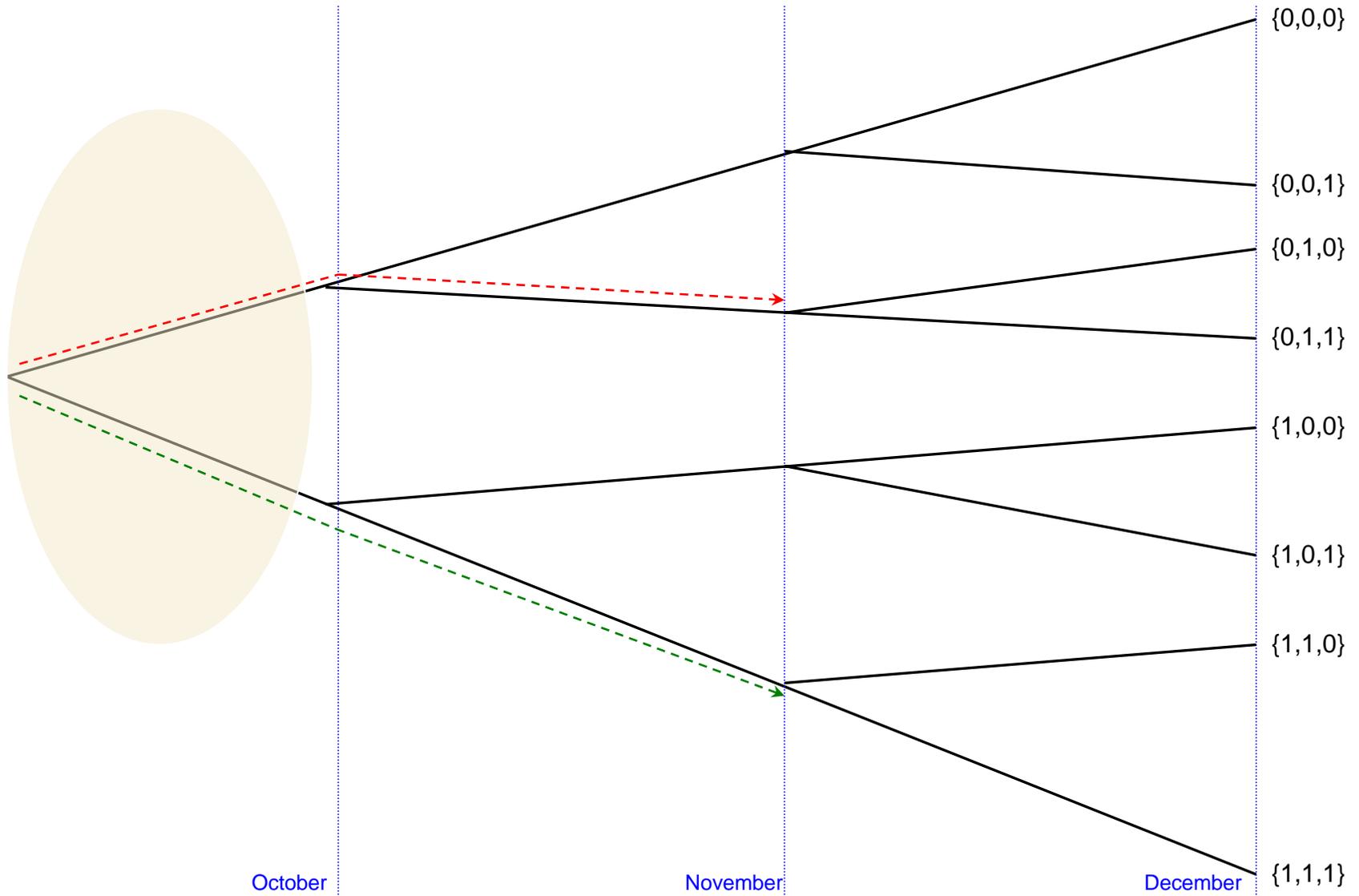
- Law of iterated expectations:

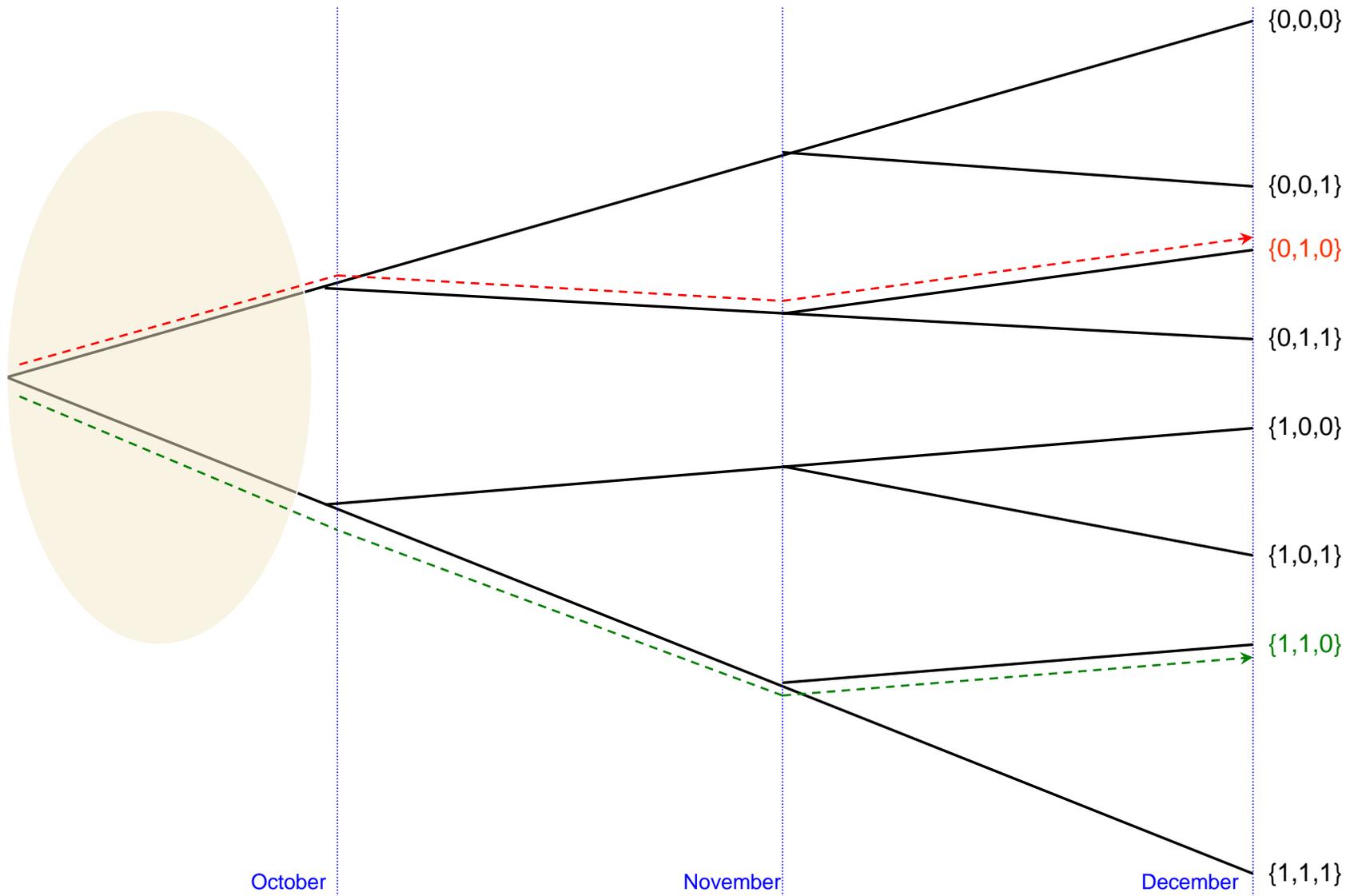
$$E[\xi_{it} | \omega_i^{t-1}] = E[E(\eta_i | \omega_i^t) - E(\eta_i | \omega_i^{t-1}) | \omega_i^{t-1}] = 0.$$

- ◆ Probability associated at each state:

$$\hat{h}_t(\omega_i^t) = \sum_{j=1}^{(2J)^t} \mathbb{I}\{\omega_i^t = \phi_j^t\} \cdot \hat{p}_{tj},$$









# Evidence of Tariff Switching

Table 4. Testing for Attention and Inertia in Tariff Suscription

|                          | STATIC<br>POOL  | PSEUDO-DYNAMIC<br>PANEL | RANDOM EFFECTS<br>DYNAMIC PANEL |
|--------------------------|-----------------|-------------------------|---------------------------------|
| Constant                 | -0.6275 (10.83) | -1.2448 (16.49)         | -1.8180 (6.95)                  |
| LOW INCOME               | -0.0406 (0.78)  | -0.0625 (0.91)          | -0.1105 (0.42)                  |
| HIGH INCOME              | -0.2180 (4.06)  | -0.2092 (2.89)          | -0.1082 (0.41)                  |
| DINCOME                  | -0.4654 (9.19)  | -0.3965 (6.20)          | -1.2911 (4.94)                  |
| HHSIZE = 2               | -0.3885 (7.91)  | -0.2932 (4.66)          | -0.2421 (0.93)                  |
| HHSIZE = 3               | -0.6375 (10.15) | -0.4636 (5.77)          | 0.1631 (0.62)                   |
| HHSIZE = 4               | -0.5488 (7.70)  | -0.4251 (4.68)          | 0.4255 (1.63)                   |
| HHSIZE > 5               | -0.7721 (8.92)  | -0.5657 (5.35)          | 0.2058 (0.79)                   |
| TEENS                    | -0.1905 (3.49)  | -0.1602 (2.37)          | -0.0641 (0.24)                  |
| AGE1                     | -0.0210 (0.29)  | -0.0252 (0.26)          | 0.1313 (0.50)                   |
| AGE3                     | -0.0288 (0.67)  | -0.0385 (0.68)          | -1.2077 (4.62)                  |
| COLLEGE                  | 0.2963 (7.82)   | 0.2242 (4.47)           | -0.2865 (1.10)                  |
| MARRIED                  | 0.2366 (5.08)   | 0.1882 (3.19)           | 0.5212 (1.99)                   |
| RETIRED                  | 0.0433 (0.86)   | 0.0330 (0.52)           | -0.5431 (2.08)                  |
| BLACK                    | 0.0144 (0.26)   | 0.0764 (1.09)           | -0.1452 (0.56)                  |
| CHURCH                   | -0.0334 (0.76)  | -0.0208 (0.37)          | -0.1421 (0.54)                  |
| BENEFITS                 | -0.2332 (4.78)  | -0.1750 (2.86)          | -0.3390 (1.30)                  |
| MOVED                    | -0.0541 (1.37)  | -0.0476 (0.92)          | -0.1958 (0.75)                  |
| UNDERESTIMATION          | -0.4478 (10.15) | -0.3282 (5.64)          | -0.5730 (2.19)                  |
| OVERESTIMATION           | -0.3538 (5.43)  | -0.2926 (3.26)          | -0.1294 (0.49)                  |
| LOW USAGE <sub>t-1</sub> |                 | 0.4034 (7.21)           | -3.9039 (14.93)                 |
| MEASURED <sub>t-1</sub>  |                 | 3.1919 (41.30)          | -6.1359 (23.46)                 |
| Log-likelihood           | -1,358.900      | -749.658                |                                 |



# Evidence of Learning

Table 5. Testing for Persistence in the Wrong Choice of Tariff

|                         | STATIC<br>POOL  | PSEUDO-DYNAMIC<br>PANEL | RANDOM EFFECTS<br>DYNAMIC PANEL |
|-------------------------|-----------------|-------------------------|---------------------------------|
| Constant                | -0.5114 (9.71)  | -1.0033 (16.69)         | -1.4118 (6.30)                  |
| LOW INCOME              | 0.0065 (0.14)   | -0.0013 (0.02)          | -0.1166 (0.52)                  |
| HIGH INCOME             | -0.0788 (1.56)  | -0.0267 (0.50)          | -0.0729 (0.33)                  |
| DINCOME                 | -0.1975 (4.63)  | -0.1014 (2.17)          | -0.1238 (0.55)                  |
| HHSIZE = 2              | -0.2682 (6.03)  | -0.1446 (2.92)          | -0.2172 (0.97)                  |
| HHSIZE = 3              | -0.3800 (6.80)  | -0.1884 (3.18)          | -0.1589 (0.71)                  |
| HHSIZE = 4              | -0.3317 (4.96)  | -0.1786 (2.54)          | -0.1152 (0.51)                  |
| HHSIZE > 5              | -0.5214 (6.65)  | -0.3188 (3.87)          | -0.0922 (0.41)                  |
| TEENS                   | -0.1236 (2.50)  | -0.0866 (1.69)          | -0.1582 (0.71)                  |
| AGE1                    | 0.1227 (1.84)   | 0.1486 (2.09)           | -0.0370 (0.17)                  |
| AGE3                    | 0.0869 (2.20)   | 0.0745 (1.74)           | -0.4698 (2.10)                  |
| COLLEGE                 | 0.1767 (4.83)   | 0.0948 (2.40)           | -0.1226 (0.55)                  |
| MARRIED                 | -0.0105 (0.25)  | -0.0539 (1.25)          | -0.3837 (1.71)                  |
| RETIRED                 | -0.1533 (3.13)  | -0.1390 (2.62)          | -0.1689 (0.75)                  |
| BLACK                   | -0.1205 (2.29)  | -0.0879 (1.57)          | -0.0992 (0.44)                  |
| CHURCH                  | -0.0235 (0.59)  | -0.0113 (0.26)          | -0.1233 (0.55)                  |
| BENEFITS                | -0.1213 (2.72)  | -0.0692 (1.44)          | -0.2260 (1.01)                  |
| MOVED                   | 0.0425 (1.21)   | 0.0335 (0.87)           | -0.2657 (1.19)                  |
| UNDERESTIMATION         | -0.7510 (17.47) | -0.6278 (13.65)         | -0.2452 (1.09)                  |
| OVERESTIMATION          | -0.5773 (9.51)  | -0.5000 (7.77)          | -0.0724 (0.32)                  |
| MEASURED <sub>t-1</sub> |                 | 0.8087 (15.40)          | -6.0301 (26.92)                 |
| WRONG <sub>t-1</sub>    |                 | 1.2331 (29.80)          | -1.2128 (5.41)                  |
| Log-likelihood          | -1,626.166      | -1,328.439              |                                 |



# Robustness of the Results

- ◆ Miravete's 2002 AER
  - Static, reduced form model. Control only for observed heterogeneity.
  - Individuals respond by switching tariffs in order to take advantage of their (small) potential savings.



- ◆ Narayanan-Chintagunta-Miravete's 2007 QME
  - Structural continuous-discrete model of tariff choice and usage with Bayesian learning.
  - Panel. Control for observed and non- observed heterogeneity (not related to history).
  - Learning is faster for consumers with lower monitoring costs (no children, measured service,...)



- ◆ Seim-Viard's 2006 manuscript
  - Learning is also significant when more than one firms operate in the market.
  
- ◆ Economides-Seim-Viard's 2006 manuscript
  - Consumers switch tariffs and carriers to reduce billing.
  
  - They respond to minimal gains in the presence of bundled services.



# The Supply Side

- ◆ Seim-Viard's 2006 manuscript
  - Entry triggers an increase in tariff offerings.
  
- ◆ Miravete's 2007 manuscript
  - Entrants offer new non-dominated tariffs.
  - Incumbents resort more frequently to foggy pricing.
  - In the short run tariff fogginess may increase.
  - In the long run competition always simplify tariffs and turn nonlinear pricing much more transparent.
  - The use of deceptive pricing strategies has a very limited life and profitability.



# A Forgotten Reference

A. de Fontenay, M.H. Shugard, and D.S. Sibley (eds.): *Telecommunications Demand Modeling*, Amsterdam: North-Holland, 1990.