Inattention, Choice Dependence, and Learning from Experience in a Repeated Decision Problem*

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Abstract

We study the role of inertia (inattention), state dependence, and learning in the choice of options using a rich micro-panel data set with repeated observations from numerous subjects when optional measured tariffs for local telephone calls were first introduced in Kentucky in an unanticipated manner. We find that in general, consumers align correctly their choice of tariff and telephone usage. We conclude that inertia is strong enough to overcome individuals' attempt to correct mismatches between tariff and usage level choices and thus, mistakes are not systematic across individuals: they actively engage in tariff switching in order to reduce the monthly cost of local telephone services despite low potential savings. Most importantly, our estimates account for unobservable individual heterogeneity linked to experience. We show that the bias from ignoring unobservable heterogeneity and endogeneity of past choices is large enough to reverse our results if we fail to address them.

Keywords: Tariff Choice, Inertia, State Dependence, Learning.

JEL Codes: D42, D82, L96.

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"Errare humanum est, in errore perservare stultum."
Lucius A. Seneca (4BC – 65AC).

1 Introduction

Choosing among different alternatives is the quintessential economic decision that all of us engage in routinely as consumers. For well over a century, since the marginalist revolution, utility maximization was the single foundation of the theoretical models of consumer behavior trying to explain individual and aggregate demand as the result of agents' explicit attempt to make the most out of their limited budget to fulfill unbounded needs according to their particular preferences.

Choosing among different alternatives is also a rather complex activity, very much tailored to the nature of the specific good or service we have to decide upon. In some cases we revise our decisions almost immediately, in others on a regular basis, and in some other cases only when unexpected market changes or extraordinary events compel us to engage again in such a choice process, *e.g.*, Tobin (1982). The different frequency with which we revise decisions may reflect individuals' own optimizing behavior with respect to the decision process itself, *i.e.*, balancing the potential benefits of choosing with the costs of making such decisions, *e.g.*, Stigler and Becker (1977).

Only recently —see the survey by Della Vigna (2009)— the field of behavioral economics has questioned the assumed rationality behind consumers' decision process. Several inconsistencies between the prediction of *simple* models of optimal rational behavior and the available empirical evidence have been documented. Thus, for instance, and without attempting to be exhaustive, Laibson (2000) points out to time-inconsistency among repeated decisions of consumers over time; Heiss, McFadden, and Winter (2007) shows how consumers make wrong choices when they first face complex alternatives; Abaluck and Gruber (2010) documents that individuals pay excessive attention to some features of each option, which translates in them not choosing the least expensive option for their consumption. Other attempts to explain observed behavior that does not conform predictions from rational models include loss-aversion, *e.g.*, Koscegi and Heidhues (2008), the reference-dependent preferences of Koscegi and Rabin (2006), and in a paper very closely related to the application of this one, Grubb (2009) consumer overconfidence.

However, very few papers provide evidence supporting rationality of consumer choice over time and they all hint at learning as the corrective force fixing wrong choices over time. Among them, see for instance the works of Agarwal, Chomsisengphet, Liu, and Souleles (2006) and Miravete (2003). Other than these papers, most of the available empirical results of behavioral studies emphasize the importance of inertia in different environments. Both Della Vigna and Malmendier (2006) and Madrian and Shea (2001) point out that default options and time-independent conditions are among the strongest determinants of individual choices in a dynamic setting, thus overcoming insignificant potential learning effects, which are addressed by Choi, Laibson, Madrian, and Metrick (2009).[1]

This paper wants to add to this literature by separating the effect of inertia (*i.e.*, inattention) from state dependence to conclude that inertia alone does not explain the sequence of choices of individuals and that while they make mistakes in choosing tariff options for their given telephone usage, these mistakes are not systematic and the subsequent tariff switching is aimed at reducing the overall monthly telephone bill. And last, but not least, our econometric estimation also addresses the endogeneity of other decisions that may influence individuals' choices and their ability to learn. We show, in a spirit similar to the work of Ackerberg and Botticini (2002), that the estimation bias resulting from ignoring heterogeneity linked to the endogenous sequence of choices that conforms individual experiences may be large enough to reverse the results of the analysis.

We would expect that various decades of research on this central issue would have produced detailed empirical evidence on the type of decision problems where consumers behave irrationally and the type of problems where they are rational. Further, we would know how the different types of behaviors depend on the size of information, time, and perhaps even cognitive costs, as well as on the benefits of better decision making. And for the problems that consumers are attentive to, we should also have detailed information on whether subjects are able to reason accurately or tend to make systematic errors. The fact, however, is that we are quite far from this ideal. There is an important recent theoretical

[1] Seneca's quote from his *Ad Lucilium Epistolae Morales* at the outset of this section reads; "It is human to make a mistake, it is stupid to persist on it."

literature modelling inattention and its implications in macroeconomics, and there is also an important theoretical literature on bounded rationality, but to the best of our knowledge there is no empirical evidence from real life settings that could be considered to belong to the ideal just described.

A number of empirical problems that are typically insurmountable justify the existing situation. In natural settings there are often great difficulties in finding *individual* decision making situations, as opposed to aggregate market-level;[2] observing all relevant characteristics of individuals; precisely determining individuals' choice and strategy sets; measuring the exact incentive structures that individuals face; and in carefully addressing selection problems in settings where preferences are endogenous to the environment or to the behavior of others, and in knowing the determinants of the endogenous frequency of choices. In addition to these difficulties, sufficiently rich detailed data including repeated individual choices are rarely available to allow researches to address the posibility of dynamic effects of learning, attention and state dependence while controlling for the effects of unobserved heterogeneity, which we show are important in properly estimating these effects.

In this paper we take advantage of a unique opportunity to overcome these obstacles by studying a natural setting where none of these difficulties are present. South Central Bell (SCB) implemented a detailed tariff experiment for the Kentucky Public Service Commission in 1986. SCB collected demographic and economic information for about 2,500 households in Louisville. In the Spring of 1986, *all* households in Kentucky were on mandatory flat rates, paying \$18.70 per month with unlimited local telephone calls. This was the only tariff available. In July 1986, optional measured services were introduced for the first time in a way that was *unanticipated* by consumers. This alternative tariff included a \$14.02 monthly fixed fee, a \$5.00 allowance, and a tariff per call that depended on its duration, distance, and period (time of the day and day of the week). The basic problem that households faced each month was to determine whether their expected demand for local phone calls next month would be above or below \$19.02, as they would not be billed for the \$5.00 allowance unless their usage level exceeded this limit. That is, an attentive household would have to think

[2] At the market or other aggregate levels downward-slopping demand functions can be derived *even* as consequences of agents' *random* choices subject to a budget constraint (*e.g.*, Becker (1962) and Gode and Sunder (1993)). As a result, it is generally not possible to distinguish rational from irrational behavior at *any* level of aggregation.

at time t about the expected consumption level at $t+1$ and the tariff rate to be applied to that consumption level; consumption choices will then take place at time $t+1$. These choices were repeated every month and switching tariffs simply required a free phone call. A rich panel dataset on all the variables and characteristics of interest is available during the months of April-June and October-December.

This setting includes a number of desirable characteristics that overcome the data shortcomings mentioned above: we deal with an individual decision making situation where it is trivial to determine strategy sets and straighforward to observe and characterize individuals' choices over time. It is also relatively simple to measure the incentives and rewards that subjects face since local telephone service amounts to a small fraction of consumers' budget, thus ruling out strategic and risk-aversion considerations. The monthly frequency of choices is exogenously given and thus, we do not need to address the endogeneity of the timing of decisions. Finally, we do not face self-selection problems since the penetration of local telephone service is nearly universal and does not include any conspicuous motives that may call into question the representativeness of the study case to address the importance of inertia and learning.

We can therefore address whether or not individuals learned about their own demand, thus overcoming inertia. If that was not the case, as in the evidence reported by Della Vigna and Malmendier (2006) and Madrian and Shea (2001), inertia could include elements of rational and irrational inattention but the relative size of the two could not be determined. We show, however, that local telephone subscribers do not make systematic mistakes, and that while inertia exists, it likely points only at the role played by rational inattention, as individuals actively engage in tariff switching in order to reduce the monthly cost of local telephone services. We show that the role of state dependence is also important in this process and thus, past individual decisions, rather than impulsiveness or random behavior, shape future individual actions. Finally, we show how important it is to address the endogeneity of lagged explanatory variables that identify inertia and state dependence as failing to do so may generate biases large enough to reverse the conclusions of the econometric analysis.

1.1 On Rational Inattention

An important literature has recently explored the potential of modelling rational inattention in consumers and producers. Reis (2006a) studies the consumption decisions of agents who face costs of acquiring, absorving and processing information. His model predicts that aggregate consumption adjusts slowly to shocks, and is able to explain the excess sensitivity and excess smoothness puzzles.[3] Reis (2006b) studies the same problem for producers and applies the results to a model of inflation. The resulting model fits remarkably well a number of quantitative facts on post-war inflation. Mankiw and Reis (2002) and Ball, Mankiw, and Reis (2005) study inattentiveness on the part of price-setting firms and find that the resulting model matches well the dynamics of inflation and output observed in the data. In the finance literature, Gabaix and Laibson (2002) assume that investors update their portfolio decisions infrequently, and show that this can help explaining the equity premium puzzle. In the large and growing literature on bounded rationality, the importance of deliberation and processing costs is relevant for most theories that postulate deviations from the assumption of rational, computationally unconstrained agents.[4]

With respect to microeconomic empirical evidence, it mainly comes from survey and experimental studies. Lusardi (1999), Lusardi (2003) and Americks, Caplin, and Leahy (2003), for instance, find that a significant fraction of survey respondents make financial plans infrequently and that their behavior has a significant impact on the amount of wealth that they accumulate. In the experimental literature, Gabaix, Laibson, Moloche, and Weinberg (2006) study a cognition model which successfully predicts the aggregate empirical regularities of information acquisition both within and across experimental games. Costa-Gomes,

[3] Sims (2003) and Moscarini (2004) develop alternative models focusing on the information problem that agents face.

[4] These include the behavioral economics literature (*e.g.*, Sims (1955) and Sims (1987)), learning and robustness in macroeconomics (*i.e.*, Sargent (1993), Hansen and Sargent (2008)), game theory (Rubinstein (1998)), the study of the demand for information in Bayesian decision theory (Moscarini and Smith (2001) and Moscarini and Smith (2002)), the determinants of the adoption of rules of thumb in individual and social learning contexts (Ellison and Fudenberg (1993)), the study of cognitive dissonance and near-rational theories (Akerlof and Dickens (1982) and, Akerlof and Yellen (1982), the study of business decisions and long-term contracting situations (Bolton and Fauré-Grimaud (2005b) and Bolton and Fauré-Grimaud (2005a)) and others. On the infinite regress problem, see Savage (1954) and Lipman (1991).

Crawford, and Broseta (2006), and Costa-Gomes and Crawford (2006) also study cognition and behavior in different experimental games.

When subjects are attentive, it is then important to know whether they get it right or wrong. Conslik (1996) reviews the literature on bounded rationality, including experimental studies where subjects make errors in updating probabilities, display overconfidence, and violate several assumptions of unbounded rationality, as well as others where subjects reason accurately, especially after practice.[5] Ultimately, he concludes, the important question is "when and why people get it right or wrong."

All these studies show that modeling attention and experimentally studying the predictions of limited rationality models offer a great deal of promise for improving our understanding of human decision making. Relative to the existing theoretical, survey and experimental literature this paper differs by providing what, to the best of our knowledge, is the first empirical microeconometric study of attentiveness in a real world setting using a large panel dataset of a fully representative sample while controlling for unobserved heterogeneity and endogeneity of past choices at the same time that we separate inertia from the effect of state dependence.

The remainder of our paper proceeds as follows: Section 2 describes in detail the Kentucky tariff experiment including the data set and some descriptive evidence. Section 3 presents our dynamic discrete choice panel data model, Section 4 the empirical results, and Section 5 concludes.

2 Description of the Tariff Experiment

In the second half of 1986, South Central Bell (SCB) carried out a detailed tariff experiment aimed at providing the Kentucky Public Service Commission (KPSC) with evidence in favor of authorizing the introduction of optional measured tariffs for local telephone service. Prior to this tariff experiment, in the Spring of 1986, all households in Kentucky were on mandatory flat rates and SCB collected demographic and economic information for about 2,500 households in the local exchange of Louisville. In July of 1986, the tariff was modified in

[5] Arrow (1987) and Lucas (1987) discuss some limitations of experiments to study bounded rationality.

this city. Customers were given the choice to remain in the previous flat tariff regime—paying $18.70 per month with unlimited calls—or switch to the new measured service option. The measured service included a $14.02 monthly fixed fee, a $5.00 allowance,[6] and distinguished among setup, duration, peak periods, and distance.[7] Choices could be made every month and, unless a household indicated to SCB otherwise, its current choice of tariff would serve as default choice for the following month.[8] The regulated monopolist also collected monthly information on usage (number and duration of calls classified by time of the day, day of the week, and distance within the local loop), and payments during two periods of three months, one right before (March-May) and the other (October-December) three months after the measured tariff option was introduced.

As indicated before, panel data sets that follow the repeated discrete choices of individuals and their subsequent usage decisions in environments where, framing issues, risk-aversion, or prior experience can be ruled out for all individuals are not easy to find. It is thus not surprising that this data set has been repeatedly used in the past. In chronological order: Miravete (2002) identifies the distributions of *ex-ante* and *ex-post* telephone usage to evaluate the profit and welfare performance of sequential pricing mechanisms consisting of optimal two-part tariffs. The two sources of asymmetry of information are identified by analyzing the choice of plan separately from the usage decision. Next, Miravete (2003) evaluates the effect of expectations of future consumption as stated by consumers as well as the role of potential savings in driving household tariff switching behavior. The interesting finding is not only that initial expectations are less and less relevant in determining the choice of tariff plan as consumers gain in experience, but also that they respond by switching tariffs with the apparent aim at reducing overpayment by an average of five dollars. These two papers can only evaluate the performance of the offered two-part tariffs. On the contrary,

[6] Consumers on the measured option were not billed for the first $5.00 unless their usage exceeded that limit. Thus, depending on the accumulated telephone usage over a month, a marginal second of communication could cost $5.00.

[7] The tariff differentiated among three periods: peak was from 8 a.m. to 5 p.m. on weekdays; shoulder was between 5 p.m. to 11 p.m. on weekdays and Sunday; and off-peak was any other time. For distance band A, measured charges were 2, 1.3, and 0.8 cents for setup and price per minute during the peak, shoulder, and off-peak period, respectively. For distance band B, setup charges were the same but duration was fixed at 4, 2.6, and 1.6 cents, respectively.

[8] Switching tariffs simply required a free phone call to request the change of service.

Miravete (2005) uses the empirical distribution of stated future expected consumption to evaluate the profit and welfare performance of sequential pricing mechanisms where options are fully nonlinear tariffs. Finally, Narayanan, Chintagunta, and Miravete (2007) estimate a structural discrete/continuous model of plan choice and demand of local telephone service where consumers update of future usage expectation is conditioned by the choice of tariff made. Relative to these papers, the present one separates the role of inertia (or inattention) from state dependence while allowing for learning through the accumulated experience that makes individuals simply different from each other because they follow a different sequence of decisions over time.

The data set has a number of very valuable features to address the consequences of inertia (inattention), state-dependence, and learning. First, local telephony is a basic service and its market penetration is close to 100% in the U.S. Thus, there are no potential self-selection problems or conspicuous consumption considerations that may lead to biased estimates because of selection into this market. Second, it is safe to rule out any risk aversion argument that could otherwise explain systematic mistakes regarding the choice of tariff options because of the low magnitude of the cost differences between the alternative tariff choices relative to the average household income. Third, it is valuable for the purpose of the analysis that in addition to demographic and economic variables, SCB also collected information on customers' own telephone usage expectations in the Spring of 1986, which is a good approximation of consumers' own expected satiation levels as marginal tariffs were nil.

Households receive every month the bill of their consumption. In this sense, the costs of searching for information are minimal, and thus the costs of deliberation and cognition, relative to the expected payoffs, would likely be the main, and perhaps only, determinant of their behavior. For the purpose of the econometric analysis, we will assume that individuals know *immediately* whether their consumption exceeds or falls short of what is optimal for the tariff chosen. In practice, there might be important asymmetries in the cognitive costs associated with the problem that a households faces depending on the tariff chosen. Households in the measured tariff simply need to compare their actual bill with the $18.70 cost of the alternative flat tariff in order to ascertain whether or not they made a mistake. On the contrary, households in the flat tariff option need to monitor every phone call and

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 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 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	Pot. sav. 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	Household head between 15 and 34 years old	0.0632	(0.24)	0.0614	(0.24)	0.0676	(0.25)
AGE = 2	Household head between 35 and 54 years old	0.2686	(0.44)	0.2604	(0.44)	0.2880	(0.45)
AGE = 3	Household head above 54 years old	0.6682	(0.47)	0.6782	(0.47)	0.6444	(0.48)
COLLEGE	Household head is a college graduate	0.2240	(0.42)	0.1821	(0.39)	0.3230	(0.47)
MARRIED	Household head is married	0.5253	(0.50)	0.5342	(0.50)	0.5042	(0.50)
RETIRED	Household head is retired	0.2433	(0.43)	0.2417	(0.43)	0.2471	(0.43)
BLACK	Household head is black	0.1161	(0.32)	0.1295	(0.34)	0.0843	(0.28)
CHURCH	Telephone used for charity and church matters	0.1711	(0.38)	0.1785	(0.38)	0.1536	(0.36)
BENEFITS	Household receives federal or state benefits	0.3095	(0.46)	0.3282	(0.47)	0.2654	(0.44)
MOVED	Household head moved in the past five years	0.4025	(0.49)	0.3899	(0.49)	0.4324	(0.50)
Observations		1,344		949		395	

Mean and standard deviation of demographics and usage variables. This balanced sample contains 1,344 household observations. Income is measured in logarithms of thousands of 1986 dollars.

compute whether the total cost of all of their calls in the month would have been above or below $19.02 had they subscribed the measured service, where each call is metered differently depending on their duration, distance, and periods. Clearly, this task is much more complex and requires a great deal of monitoring effort. Empirically, we expect to find asymmetric state dependence on tariff choice and telephone consumption that are likely linked to these asymmetric cognitive costs play an important role in explaining observed behavior.

Table 1 defines the different variables and presents basic descriptive statistics for the whole sample and for two groups of consumers split according to their choice of tariff in October. Only active consumers were considered and a number of observations with missing values for some variables were excluded.[9] These descriptive statistics initially suggest that individual heterogeneity in consumption and tariff subscription is important. Consumers who subscribe to the FLAT and MEASURED tariffs are in fact quite different. Households subscribing to the optional FLAT service, for instance, are on average larger, with teenagers, and with a lower level of education than those subscribing to the and MEASURED tariff. Further, they not only differ in their level of local telephone usage —as captured by CALLS— but also in their expectations regarding future telephone usage. Subjects tend to under-estimate their demand for telephone services, especially those in the flat tariff in October. Furthermore, there is an important self-selection effect: variability of demand of those who subscribe to the optional flat tariff almost doubles those on measured service: $4.28 *vs.* $2.30 a month in the monthly bill as given by the the measured tariff option in Louisville (in order to account for heterogeneity in usage across zone and time bands).

Table 2 documents the joint distribution of tariff choice and usage levels as well as potential savings, had these individuals switched to the alternative option, and how many of them ended up switching tariffs. The table shows important asymmetries among consumers. First, notice that most of them actually choose the right option for their realized telephone usage. Most of those choosing the right tariff subscribed to the flat option (63% of the sample) as their demands clearly exceeded the usage threshold beyond which the flat tariff is always the least expensive one. Notice that had they chosen the measured option, these

[9] Miravete (2002) documents that excluding households with missing information does not lead to biased results. The only variable with a substantial number of missings is income. In these cases we recoded the missing observations to the yearly average income of the population in Louisville and also included a dummy variable, DINCOME, to control for non-responses regarding household earnings.

Table 2: Joint Distribution of Usage and Tariff Choice

	LOW USAGE=1			LOW USAGE=0		
	Share	Savings	Switchers	Share	Savings	Switchers
MEASURED=1	0.0906	-4.68	0.0000	0.1961	6.61	0.1439
MEASURED=0	0.0877	4.68	0.1695	0.6256	-16.76	0.0356

Data from October of 1986. *Share* indicates the percentage of the sample in a particular tariff choice and usage level combination. *Savings* shows the average dollar gain of choosing the other tariff option given the usage level (positive values). *Switchers* indicate the percentage of those on a particular tariff choice and usage combination that ends up switching tariff options during the fall of 1986.

individuals would have paid, on average, almost 17 dollars more. Second, the table shows that switching is more common among those who are overpaying: 14% of those on measured tariff with too high demand (and average potential savings of 6.61 dollars a month) and 17% of those on flat tariff with too low an usage level (and average potential savings of 4.68 dollars a month). Lastly, those choosing the right tariff option for their usage switch far less frequently: only 3.56% for those rightly choosing the flat tariff, and none among those choosing the measured option using telephone only sparsely.

Switching is thus not random, and apparently responds to potential savings. A main goal of the empirical analysis of this paper is to determine whether the wrong tariff choice and usage level combination tends to induce this switching, or if alternatively it is recurrent among the same individuals. Table 1 shows that potential savings from switching decreases slightly over time, which hints at learning as a positive driving force that must qualify the cross-section evidence that shows that some individuals make mistakes. Descriptive statistics alone are not sufficient to determine this result as the environment we study is not stationary. Demand needs change over time and thus, for instance, potential savings from switching increase again in December as usage increases for all consumers regardless of the tariff chosen.

Despite all the remarkable features of the data, there are two issues that we need to address econometrically. First, about 10% of consumers subscribed to the optional measured option when given that possibility. Our sample, however, includes 30% of those customers. Choice-based sampling bias can easily be dealt with using well known methods, *e.g.*, Amemiya (1985, §9.5). All estimates reported in the analysis take into account this choice-based sampling as we use the weighting procedure of Lerman and Manski (1977) to obtain choice-based, heteroskedastic-consistent, standard errors. Second, when the tariff experiment began in July of 1986, all households were assigned the preexisting flat tariff as default option. Consumers may learn about their telephone usage profile as they switch tariff options, and thus, over time, they will differ in experience as summarized by the different sequences of past tariff choices and usage levels. Studying the importance of inattention (inertia) and state dependence in the choice of tariff options requires addressing the endogeneity of past choices and controlling for their induced individual heterogeneity. To that end we use the semiparametric estimator suggested by Arellano and Carrasco (2003) in Section 3.

In a first attempt to examine whether households tend to choose *ex-post* the correct tariff option for their usage level, we now study the pattern of correlations among tariff choice and usage decisions using a simple static model of simultaneous choice. We estimate the following reduced form model:

$$y_j^* = X\Pi_j + v_j\,, \qquad j = 1, 2, \tag{1}$$

and where, conditional on observed demographics, we assume that:

$$(v_1, v_2) \sim N\left(\mathbf{0}, \boldsymbol{\Sigma}_{\mathbf{v}}\right)\,; \qquad \boldsymbol{\Sigma}_{\mathbf{v}} = \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\,. \tag{2}$$

These two equations are estimated simultaneously as a bivariate probit model, thus providing a consistent estimate of ρ conditional on all available household information. In this model $y_1 = 1$ if the household subscribes to the MEASURED tariff and $y_2 = 1$ if the household makes LOW USAGE of telephone service defined as consumption below $19.02 when metered according to the measured tariff rate. Thus, the significant positive estimate of ρ can be interpreted as the result of some unobservable element, *e.g.*, learning, rational inattention, or unbiased expectations, that induce the appropriate tariff choice for each usage level. The model includes the same set of demographic variables in both equations to control for the effect of observable individual heterogeneity over the tariff choice and consumption decisions. Data also include household specific information from the Spring

Table 3: 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		0.2616	(5.05)	
$\ln \mathcal{L}$		−2,463.197		
Observations		4,032		

Estimates are obtained by weighted maximum likelihood (bivariate probit). Absolute, choice-biased sampling, heteroscedastic consistent, t-statistics are reported between parentheses.

months to control, at least in part, for the accuracy of predictions of individual future usage. We thus include two dummies to indicate whether consumers significantly over or underestimated future consumption when marginal consumption was not priced at all.[10] Similarly, we construct an indicator of usage intensity for each household during the Spring months, LOW USAGE$_{Spring}$, which equals one when the usage level during Spring (at zero marginal charge) is less than $19.02 had it been metered according to the optional measured tariff that will later be in place during the Fall. We include this variable in order to account for any systematic effect of demographics not included in our data on usage. Table 3 reports the estimates of these reduced form parameters.

[10] The UNDEREST dummy is equal to one if SWCALLS exceeds EXPCALLS by more than 50% of the standard deviation of SWBIAS. The OVEREST dummy is defined accordingly when EXPCALLS exceeds SWBIAS.

The positive estimate of ρ reflects the correlation between the choice of the measured service and a low demand realization. This suggests that consumers do not appear to make systematic mistakes when choosing among optional tariffs. This is a reduced form estimate and we cannot attribute it to any cause in particular, be it inertia or rational inattention, state dependence, learning, or any other. In any case, this positive estimate is a clear evidence that some unobservable process is at work so that tariff choice and telephone usage are generally aligned.[11]

Some demographics also have a direct influence in having the choices of tariff plans and telephone usage aligned. Thus, for instance, larger households tend to subscribe to the flat tariff option and to realize high usage levels, which is the less expensive option for the telephone usage profile. Similarly, households with a low usage profile during the Spring months are also more likely to present a low usage profile in the Fall and consequently, correctly choose the measured tariff option. Finally, consumers that either over or underestimated their future telephone usage quite significantly are less likely to subscribe to the measured option, but are also far less likely to realize a low usage level. Thus, households who made the largest absolute forecast errors are among those with very high levels of demand, and thus, they are more likely to choose the right option by subscribing to the flat tariff.

Table 2 showed that all consumers not choosing the right tariff-usage combination were equally likely to switch to the alternative option. Consumers were classified as having chosen correctly or incorrectly each tariff option *ex-post* keeping the usage pattern unchanged, that is independently of price responses, which provides an approximate upper bound to the gains of switching to a different tariff option. Therefore, those choosing the measured service while experiencing high demand for telephone were, by far the most common among those making the wrong tariff choice for a given usage pattern. It is interesing to note that consumers on the measured option enjoy *de facto* negligible deliberation costs since they just have to compare their past monthly bill to the cost of the flat option to decide whether or not to switch tariff plans. Among those more likely to subscribe to the

[11] The approach behind estimates of Table 3 is similar to Chiappori and Salanié (2000) and a significant correlation coefficient in this estimation supports the idea of the existence of asymmetric information beyond the observable demographics of our data. Results regarding the sign and significance of all parameter estimates, including ρ are robust to alternative specifications that exclude the Spring usage pattern and individual expectation accuracy dummies.

measured option irrespective of their telephone usage are those households whose head are married, holds a college degree or do not receive any kind of benefits. At the other end, those experiencing high telephone usage regardless of their tariff choice include older and retired households.

After this descriptive evidence, we turn toward the more substantive questions: Do consumers simply stay on their previously chosen tariff because of inertia, *i.e.*, rational inattention? Are consumption levels, tariff choices, and the tariff switching that we observe in the data sufficient to provide evidence that consumers are *rationally* attentive and respond to potential savings? What is the role of previous tariff choices and demand realizations on the decision to subscribe to one of the two options? Do consumers learn from past experience or do they persist on making wrong choices? In order to answer these questions we need more sophisticated econometric methods that allow us to account for state dependence, unobserved heterogeneity, and dynamic learning. We study such model next.

3 A Model of Repeated Tariff Choice

In this section we first present a semi–parametric, random effects, discrete choice model with predetermined variables based on the work by Arellano and Carrasco (2003) that controls for the effect of unobservable heterogeneity in a dynamic discrete choice model wich also accounts for state dependence. As the model is essentially a difference estimator in a repeated discrete choice environment, the effect of time-invariant demographics are not identified. We later estimate two specifications of this model in Section 4 to study the choices of tariffs and consumption levels over time and the persistence of wrong tariff-usage choice combination, respectively.

3.1 A Dynamic Discrete Choice Panel Data Model

A risk-neutral individual chooses one of two tariff options in order to minimize the expected cost of telephone service. The probability of subscribing to a given tariff option may depend on some intrinsic characteristics of consumers, including their telephone usage profile, as well as on their expectation on the realization of demand. This can be written as follows:

$$y_{it} = \mathbb{1}\left\{\gamma + \beta z_{it} + E\left(\eta_i \mid w_i^t\right) + \varepsilon_{it} \geq 0\right\} , \qquad \varepsilon_{it} \mid w_i^t \sim N\left(0, \sigma_t^2\right) , \tag{3}$$

where $y_{it} = 1$ ($y_{it} = 0$) is the measured (flat) tariff option is subscribed. The constant γ captures the effect of inertia, *i.e.*, the result of all time-invariant determinants of the choice of individuals.[12] The set of predetermined variables z_{it} includes a the past realization of demand x_{it} as well as the previous choices of tariffs $y_{i(t-1)}$ so that together they define the particular realization of the state for each individual i when choosing a tariff option at time t, *i.e.*, $w_{it} = \left\{x_{it}, y_{i(t-1)}\right\}$. Thus, estimates of β identify the effect of state dependence separately from inertia as z_{it} includes time-varying regressors that are only predetermined, *i.e.*, they are not directly correlated with the current or future values error ε_{it} although lagged values of errors ε_{it} might be correlated with z_{it}.

The probability of subscribing to a given tariff option, and hence the probability of switching tariffs in the future, depends on the particular sequence of past choices and past realizations of demand for each consumer. As time goes by, individuals become increasingly different as they follow different decisions which can be summarized by $w_i^t = \{w_{i1}, \ldots, w_{it}\}$, which is the history of past choices represented by a sequence of realizations: $w_{it} = \left\{x_{it}, y_{i(t-1)}\right\}$. Addressing individual heterogeneity in this model adds up to controlling for the different observed sequence of decisions of each individual. As consumers choose differently, they accumulate different experiences and invest differently in information gathering and deliberation efforts. These experiences in turn change the information set upon which they decide in the future. For instance, consumers that have previously chosen the measured option may have learned that their demand is systematically high, so that in the future they will be more likely to subscribe to the flat tariff option. Consumers that have always remained on the flat tariff option have accumulated different

[12] The specification of Arellano and Carrasco (2003) is more general in the sense that it also includes a time-varying component common to all individuals, γ_t. With the exception of monthly indicators, all our available demographics are time-invariant. We also included these monthly indicators in our empirical analysis but they did not improve our estimations, even when interacted with past subscription decisions and past realizations of demand.

experiences, which also affects their conditional probability of renewing their subscription to the flat tariff option.

The last element of the model is η_i, an individual effect whose forecast is revised each period t as the information summarized by the history w_i^t accumulates. In our case η_i is the intrinsic individual value of tariff option $y_{it} = 1$. This value of choosing the measured option is not known to individuals and thus, only its expectation enters the decision rule, *i.e.*, the probability of choosing the measured option is not affected by inertia (γ) and state dependence (β), but also by the learning effect identified by $E\left(\eta_i \mid w_i^t\right)$ after controlling for individual heterogeneity.[13]

In our second application of this model y_{it} does not represent the choice of tariff, but whether the combined choice of tariff and usage level is not the right one. In such a case γ identifies elements conducing to inattention that make individuals choose the wrong choice systematically while the effect of state dependence β identifies whether individuals revise their choices to avoid making mistakes systematically or not depending on their past experience. Accounting for individual heterogeneity amounts to addressing the value of rational inattention, *i.e.*, the cost of making wrong choice combinations which may eventually trigger switching tariffs.

Thus, the model defines conditional probabilities for every possible sequence of realizations of state variables in order to deal with regressors that are predetermined but not exogenous, such as the previous choices of tariffs and the past realizations of demand in our setting. Then, the estimator computes the probability of subscribing to a given tariff along every possible path of past realizations of demand and subscription decisions. The panel data structure allows us to identify the effect of individual unobserved heterogeneity since at each time consumers make different decisions even if they have shared the same history of realizations of state variables until then.

Notice that the conditional distribution of the sequence of expectations $E\left(\eta_i \mid w_i^t\right)$ is left unrestricted, and hence the process of updating expectations as information accumulates

[13] Since this distribution is conditional on the individual's history w_i^t, and thus, on the observable subsets of histories available in our sample, which may make estimates subject to the initial conditions problem, *e.g.*, see Heckman (1981). Arellano and Carrasco (2003) point out that this feature of the model is shared by many other discrete choice panel data models when dealing with unobserved heterogeneity, including Chamberlain (1984) and Newey (1994) among them.

is not explicitly modeled. This is the only aspect that makes the model semi-parametric. While the assumption of normality of the distribution of errors is not essential, the assumption that the errors ε_{it} are not correlated over time is necessary for the estimation. Since errors are assumed to be normally distributed, conditional on the history of past decisions, the probability of choosing the measured option at time t for any given history w_i^t can be written as:

$$\text{Prob}\left(y_{it} = 1 \mid w_i^t\right) = \Phi\left[\frac{\gamma + \beta z_{it} + E\left(\eta_i \mid w_i^t\right)}{\sigma_t}\right] . \tag{4}$$

3.2 Econometric Implementation

Since all our regressors are dichotomous variables, their support is a lattice with J points. The vector w_{it} has a support 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. Similarly, the vector w_i^t is defined on $(2J)^t$ values, for $j = 1, ..., (2J)^t$. Given that the model has discrete support, any individual history can be summarized by a cluster of nodes representing the sequence of tariff choices and demand realizations for each individuals in the sample. Thus, the conditional probability can be rewritten as:

$$p_{jt} = \text{Prob}\left(y_{it} = 1 \mid w_i^t = \phi_j^t\right) \equiv h_t\left(w_i^t = \phi_j^t\right) , \qquad j = 1, \ldots, (2J)^t . \tag{5}$$

In order to account for unobserved individual effects we compute the proportion of customers with identical history up to time t that subscribe to the measured tariff option M at each time t. We then repeat this procedure for every available history in our data. For each history we compute the percentage of consumers that subscribe to the measuerd option. This provides a simple estimate of the unrestricted probability $\hat{p}_{tj}$ for each possible history present in the sample. Then, by taking first differences of the inverse of the equation above we get:

$$\sigma_t \Phi^{-1}\left[h_t\left(w_i^t\right)\right] - \sigma_{t-1}\Phi^{-1}\left[h_{t-1}\left(w_i^{t-1}\right)\right] - \beta\left(z_{it} - z_{i(t-1)}\right) = \xi_{it} , \tag{6}$$

and, by the law of iterated expectations, we have:

$$E\left[\xi_{it} \mid w_i^{t-1}\right] = E\left[E\left(\eta_i \mid w_i^t\right) - E\left(\eta_i \mid w_i^{t-1}\right) \Big| w_i^{t-1}\right] = 0\,. \tag{7}$$

This conditional moment condition serves as the basis of the GMM estimation of parameters β after normalizing $\sigma_1 = 1$. To identify the effect of inertia we make use of:

$$E\left[E(\eta_i \mid w_i^{t-1})\right] = E\left[\Phi^{-1}\left[h_t\left(w_i^{t-1}\right)\right] - \gamma - \beta z_{it}\right] = 0\,. \tag{8}$$

Arellano and Carrasco (2003) show that there is no efficiency loss in estimating these parameters by a two–step GMM method where in the first step the conditional probabilities p_{tj} are replaced by unrestricted estimates $\hat{p}_{tj}$, such as the proportion of consumers with a given history that subscribe to the measured service. Then:

$$\hat{h}_t\left(w_i^t\right) = \sum_{j=1}^{(2J)^t} \mathbf{1}\left\{w_i^t = \phi_j^t\right\} \cdot \hat{p}_{tj}\,, \tag{9}$$

which is used to define the sample orthogonality conditions of the GMM estimator:[14]

$$\frac{1}{N}\sum_{i=1}^{N}\left\{\sigma_t \Phi^{-1}\left[\hat{h}_t\left(w_i^{t-1}\right)\right] - \gamma - \beta z_{it}\right\} = 0\,, \quad t = 2, \ldots, T\,, \tag{10}$$

and

$$\frac{1}{N}\sum_{i=1}^{N} d_{it}\left\{\sigma_t \Phi^{-1}\left[\hat{h}_t\left(w_i^t\right)\right] - \sigma_{t-1}\Phi^{-1}\left[\hat{h}_{t-1}\left(w_i^{t-1}\right)\right] - \beta\left(x_{it} - x_{i(t-1)}\right)\right\} = 0\,, \quad t = 3, \ldots, T\,, \tag{11}$$

and where d_{it} is a vector containing the indicators $\mathbf{1}\left\{w_i^t = \phi_j^t\right\}$ for $j = 1, ..., (2J)^{t-1}$.

[14] In practice the number of moment conditions is smaller than $\sum_t (2J)^{t-1}$ because we only consider clusters with at least 4 observations. Also, we use the orthogonal deviations suggested by Arellano and Bover (1995) rather than first differences among past values of the state variables.

4 Inertia, State Dependence, and Learning

Consumers choose every month their tariff option and and usage level. In Section 3 we argued that past choices are valid instruments to identify the effect of state dependence separately from those of inertia and learning. The top panel of Table 4 shows the transition matrices between tariff choices detailed by previous telephone usage levels. Given the large probabilities along the diagonal we could conclude that tariff switching is not significant at all. However, such conclusion will neglect some interesting results. For instance, if previous usage was high, individuals are twice as likely to correctly switch from measured service to flat tariff than incorrectly from flat tariff to measured service. If on the contrary, previous demand was low, nobody switches from measured service to flat tariff but the largest probability among switchers occurs when consumers on flat tariff correctly switch to measured service. This asymmetric pattern hints at individuals facing far lower cognition or deliberation costs when subscribed to the measured option.

Similarly, in order to characterize whether inattention is mostly rational or not, the bottom panel of Table 4 shows the transition matrices between *ex post* right and wrong choices conditional on previous tariff choices. Off-diagonal probabilities are substantially larger than in the previous case, thus hinting at one of our main results: mistakes are not systematic. It appears that inattention is rational, particularly among those who chose the flat tariff option as their demands are large enough. First, most of those not paying attention remain in the right tariff-usage combination. Second, the largest transition probability from wrong to right occurs among those who previously chose the flat tariff option. This 47% is much larger than those 11% of customers who switched from flat to measured because their usage was low, which hints at temporary reductions of demand. In such a case, not switching away from the flat option is optimal as demand recovers its normal high level.

In order to account for the dynamic nature of the learning process where individuals may invest time, cognitive effort, and other resources to gain knowledge about their new options and about their own demand for telephone services, we now report the results of two two dynamic discrete choice panel data models with predetermined variables that account for the existence of inertia, state dependence, and unobserved individual heterogeneity, as all these elements are likely to play a relevant role in the choice of tariffs as pointed out in

Table 4: Transition Matrices

	LOW USAGE$_{t-1}$=1		LOW USAGE$_{t-1}$=0	
	MEASURED$_{t-1}$	FLAT$_{t-1}$	MEASURED$_{t-1}$	FLAT$_{t-1}$
MEASURED$_t$	1.0000	0.1123	0.9199	0.0451
FLAT$_t$	0.0000	0.8877	0.0801	0.9549
	MEASURED$_{t-1}$=1		MEASURED$_{t-1}$=0	
	WRONG$_{t-1}$	RIGHT$_{t-1}$	WRONG$_{t-1}$	RIGHT$_{t-1}$
WRONG$_t$	0.7905	0.3259	0.5205	0.0866
RIGHT$_t$	0.2095	0.6741	0.4745	0.9134

Transition probabilities for each state.

the model of Section 3.1. In both cases we report the consistent GMM estimator of Arellano and Carrasco (2003) and the standard ML estimator that fails to address the endogeneity of lagged dependent variables and ignores individual heterogeneity.

4.1 Testing for Inertia in Tariff Choices

The first model studies whether households tend to remain subscribed to the same tariff option over time regardless of their past realized usage levels:

$$\text{MEASURED}_t = \mathbb{1}\left\{\gamma + \beta_1 \text{MEASURED}_{t-1} + \beta_2 \text{LOW USAGE}_{t-1} + E(\eta_i \mid w_i^t) + \varepsilon_{it} \geq 0\right\} . \quad (12)$$

Table 5 reports the GMM results which properly account for the existence of predetermined regressors and unobserved individual heterogeneity followed by the inconsistent ML estimates that ignore them. As indicated earlier, the estimator accounts for all potential paths of usage level and choice of tariffs over time. Estimates reveal that inertia (inattention) is important as expected by looking at the transition probabilities along the diagonals of Table 4. But choices vary significantly over time and are not exclusively determined by static considerations. We find that the GMM estimates of the predetermined variables LOW USAGE$_{t-1}$ and MEASURED$_{t-1}$ are both negative and significant.[15] The negative estimate of LOW USAGE$_{t-1}$ captures the effect of the mistakes of consumers with high enough usage

[15] Results are robust across clusters defined by the different dummy demographic indicators employed in Table 3.

Table 5: Tariff Subscription

Method:	CONSTANT		MEASURED$_{t-1}$		LOW USAGE$_{t-1}$	
GMM	−1.9751	(7.99)	−8.9011	(36.02)	−4.4181	(17.88)
ML	−1.7022	(77.82)	3.2177	(43.13)	0.5388	(10.54)

Consistent GMM random effects dynamic estimates of Arellano and Carrasco (2003) with predetermined regressors and inconsistent ML estimates. Absolute, choice-biased sampling, heteroskedastic-consistent, t-statistics are reported in parentheses.

that still sign up for the optional measured tariff consistent with the transition probabilities of Table 4. Similarly, the negative estimate of MEASURED$_{t-1}$ indicates that consumers do switch tariffs significantly and that, contrary to the hypothesis of habit and inertia, automatic renewal of tariff subscription options does not necessarily mean that consumers will stay in the previously chosen tariff indefinitely.[16]

The second line of Table 5 reports the estimates of a standard probit regression that fails to address the endogeneity of lagged endogenous regressors and individual heterogeneity. Quite remarkably, the sign of state dependence estimates is the opposite. According to the results of this misspecified model, consumers with low demand tend to subscribe to the optional measured service once and for all since the choice of tariff option also appears to be correlated over time. These results would support the idea that consumers' choices are overwhelmingly characterized by inertia. Switching, if it existed, appears not to be important according to this misspecified model, in contradiction to the evidence presented in Section 2.

GMM and ML produce opposite results and the evidence they provide could be used to support very different theories of individual behavior. We could simply dismiss the ML estimates because they are inconsistent as they ignore the endogenous nature of regressors as well as unobserved individual heterogeneity. But we can go further and use the model of Section 3.1 to provide an explanation for the upward bias of the ML estimate. Remember that η_i, the value of subscribing to the optional measurerd service is unknown to the consumer. Intuitively, as time elapses the effects of accumulated experience, cognitive efforts, and other investments materialize by increasing the expected value of subscribing to that option, *i.e.*, the updating of $E(\eta_i \mid w_i^t)$ increases with history w_i^t. In this sense, experience should become

[16] Impulsiveness or random behavior, *e.g.*, consumers choosing tariffs by flipping a fair coin every month, would imply a coefficient for MEASURED$_{t-1}$ equal to zero.

a more important determinant of tariff choices over time. Thus, by ignoring the effect of $E(\eta_i \mid w_i^t)$, ML estimates of β_1 and β_2 are indeed pooling the effects of MEASURED_{t-1} and $E(\eta_i \mid w_i^t)$, and of LOW USAGE_{t-1} and $E(\eta_i \mid w_i^t)$, respectively. As in the case of Ackerberg and Botticini (2002), the bias of ignoring the endogeneity of regressors and unobserved heterogeneity is large enough to reverse the economic conclusion suported by the estimated model.

We thus conclude that individual heterogeneity and state dependence are crucial to interpret the choice of tariff data, and that our consistent estimates do not support the idea that consumers' responses are determined exclusively by inertia or impulsiveness, but rather that they are consistent with the fact that consumers learn over time and may change their choices based on their individual experiences.

4.2 Rational Inattention in the Choice of Tariffs

The second model addresses the learning process directly by evaluating whether or not those households that made a mistake are more likely to continue making systematic mistakes in the future:

$$\text{WRONG}_t = \mathbb{1}\left\{\gamma + \beta_1 \text{WRONG}_{t-1} + \beta_2 \text{MEASURED}_{t-1} + E(\eta_i \mid w_i^t) + \varepsilon_{it} \geq 0\right\} . \qquad (13)$$

In Table 6 we study the extent to which *ex-post* mistakes are systematic. The endogenous variable equals one whenever household i chooses the wrong tariff option *ex-post*, that is, either the measured tariff and a relatively high usage level or the flat tariff and a relatively low usage level. The predetermined variables in this case include whether households made a wrong tariff choice in the previous period and whether they subscribed to the measured tariff option (which may facilitate learning about the right choice given usage level).

We find that the sign of MEASURED_{t-1} is negative and significant, a result that is robust across all demographic strata. Consistent with the evidence presented in Table 3 and Table 4, we can conclude that switching of tariffs is not symmetric: consumers previously subscribed to the measured option are more likely to switch options than those subscribed to the optional flat tariff. This asymmetric behavior can be readily explained by the differences

Table 6: Wrong Choice of Tariffs

Method:	CONSTANT		WRONG_{t-1}		MEASURED_{t-1}	
GMM	−1.5233	(7.02)	−1.3889	(6.40)	−7.9160	(36.49)
ML	−1.3560	(77.89)	1.3827	(34.11)	0.8354	(15.90)

Consistent GMM random effects dynamic estimates of Arellano and Carrasco (2003) with predetermined regressors and inconsistent ML estimates. Absolute, choice-biased sampling, heteroskedastic-consistent, t-statistics are reported in parentheses.

in cognitive and deliberation costs across the tariff choices discussed earlier. This result supports the implication that households that face the less complex problem learn faster and incur in fewer mistakes. We also obtained a negative estimate for WRONG_{t-1} which is strongly significant across all demographic strata. Contrary to frequent claims, this indicates that mistakes are not systematic and that the switching between tariff options is aimed at reducing the cost of local telephone service.

These findings are important. Interestingly, they are again in sharp contrast with the inconsistent ML estimates also reported in Table 6. The logic for the bias of the ML estimate is similar to the described in the previous section. The unobserved cost of making a wrong choice of tariff-usage combination increases over time as consumers accumulates experience with longer histories ω_i^t. Thus, estimates of state dependence, β_1 and β_2 pool the effect of the state with the unaddressed component of the error conveying the effect of learning, *i.e.*, $E(\eta_i \mid w_i^t)$, and the bias is so large that the strongly significant ML estimates of WRONG_{t-1} and MEASURED_{t-1} would incorrectly lead us to conclude that households make systematic mistakes. For instance, a household may systematically think that it is going to consume below the threshold level but will systematically consume above it. A naïve hyperbolic discounter who subscribed to the optional measured service as a commitment device to limit her time on the phone would exhibit this type of systematic mistake, *e.g.*, see Strotz (1956) or Laibson (2000). Systematic mistakes would also be a feature of households driven mostly by rational inattention.

We thus conclude that individual heterogeneity and state dependence are again crucial to interpret the choice of tariff data and qualify the effect of inertia, and that our consistent estimates do not support the idea that consumers' behavior is characterized by systematic mistakes.

4.3 Marginal Effects

Before concluding, we pursue further the result that mistakes are a transitory phenomenon, and compute the marginal effects associated with the transition among different states. Arellano and Carrasco (2003) show that 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:

$$\hat{\triangle}_t = \frac{1}{N}\sum_{i=1}^{N}\left\{\Phi\left(\hat{\sigma}_t^{-1}\hat{\beta}\left(z^1 - z_{it}\right) + \Phi^{-1}\left[\hat{h}_t\left(w_i^t\right)\right]\right) - \Phi\left(\hat{\sigma}_t^{-1}\hat{\beta}\left(z^0 - z_{it}\right) + \Phi^{-1}\left[\hat{h}_t\left(w_i^t\right)\right]\right)\right\}. \tag{14}$$

Since the evaluation depends on the history of past choices ω_i^t, these marginal effects are different for each month of the sample. Table 7 presents four marginal effects evaluated in October, November, December, as well as the average effect over the Fall.[17] The first two rows show the change in probability of choosing wrongly if consumers chose wrongly in the previous month. The first row indicates that this probability *decreases* on average by 7.46% if consumers subscribed to the flat tariff option while the second row shows that this probability *decreases* by 1.27% had they subscribed to the measured tariff option. Thus, regardless of the choice of tariff, it is less likely that they make another mistake in their choice of tariffs.

Table 7: Marginal Effects

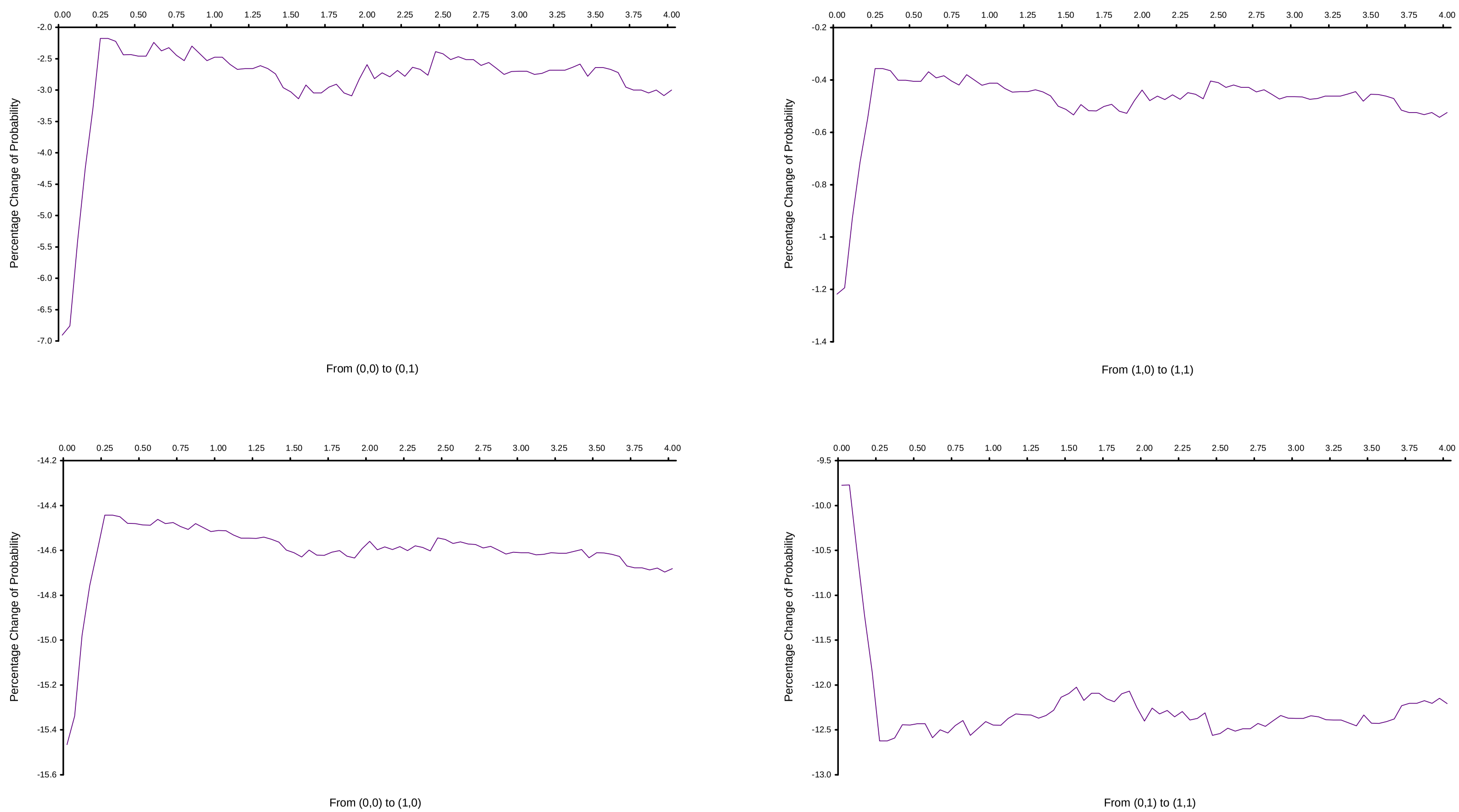
Previous Transition	October	November	December	Fall
From (Flat,Right) to (Flat,Wrong)	−11.60	−6.52	−4.27	−7.46
From (Measured,Right) to (Measured,Wrong)	−0.01	−1.67	−2.13	−1.27
From (Flat,Right) to (Measured,Right)	−17.73	−17.82	−11.64	−15.73
From (Flat,Wrong) to (Measured,Wrong)	−6.13	−12.98	−9.49	−9.53

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

Similarly, the last two rows report the change in probability of choosing wrongly if consumers subscribed to the optional measured service in the previous month. This probability *falls* by 15.73% if consumers subscribed correctly to the optional measured service in the previous month and by 9.53% if they subscribed wrongly to the optional Measured

[17] These four transitions exhaust the relevant effects to be reported. To compute the marginal effects of going in the opposite direction, just reverse the sign of the corresponding effect in Table 7.

Figure 1: Marginal Effects at Different Mistake Thresholds



service. Thus, consistent with the asymmetry in the complexity of the problems discussed earlier, the probability of making a mistake is substantially lower after subscribing to the measured option than after subscribing to the flat tariff. This decrease in probability is more important for those with low demand for which the measured service is the least expensive option than for those with an usage pattern above the threshold of \$18.70.

Finally, it is important to note that in analyzing these marginal effects, WRONG equals 1 when consumers pay any positive amount above the cost of the alternative option. We repeat the analysis for different thresholds in increments of 5 cents from \$0.00 to \$4.00 in order to measure whether this change in the probability varies significantly with the magnitude of the mistake. Figure 1 reports the average marginal effects for the Fall. Interestingly, marginal effects experience an abrupt jump in the first 25-30 cents and remain mostly constant once consumers realize a mistake above these 25-30 cents. Recall that under the measured service option consumers are not billed for the \$5 allowance unless their usage is above \$19.02. This is 32 cents more than the \$18.70 cost of the flat tariff option. We find it remarkable that this amount is almost identical to 25-30 cents.

5 Concluding Remarks

The systematic analysis of individual responses to changes in the environment is important for understanding the determinants of attention and inattention, and the extent and formation of rationality. The natural setting of the Kentucky tariff experiment and a rich panel dataset that is free from a number of critical obstacles that may explain the lack of empirical studies in the literature have allowed us to uncover households' responses in isolation from a number of conflicting considerations which generally exist in other circumstances.

We find that households recognize that choices today affect their utilities in the future and actively react to a new option despite potential savings of very small magnitude. They make no systematic mistakes. Their reactions, however, are not symmetric. Households who face a more complex and cognitively more expensive tariff problem learn more slowly and are more likely to make mistakes than households that face a simpler tariff choice problem. The fact that the evidence turns out to be drastically different when lagged endogenous variables and unobserved heterogeneity are appropriately treated indicates that they play an important role in the dynamic learning process.

When and why people are attentive or inattentive and, when they are attentive, when and why people get it right or wrong, are fundamental questions for our understanding of human decision making. We cannot claim, and we do not claim, that we should expect that the results we have obtained will systematically generalize to other settings. This is an empirical question whose answer depends on the degree of complexity, the costs of information, the size of incentives, and all other characteristics of the specific problem and environment under study. What we hope, however, is that the analysis in the current paper will begin to pave the way for an empirically based science of decision making which together with theoretical and experimental work on cognitive processes will significantly improve our understanding of *when* and *how* decision makers think about real life problems.

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