Learning Temporal Preferences

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Abstract

We analyze households' responses to an unanticipated change in consumption opportunities and evaluate their implications for the nature and formation of preferences. We study the tariff experiment conducted by South Central Bell where local telephone measured tariffs were introduced for the first time in Louisville, KY. Households were given the choice to remain in a flat rate scheme or switch to the new measured tariff scheme. The results of the analysis support models where consumers react to a change in the environment in the direction predicted by theories of rational investment in information. Households learn rapidly to undertake optimal decisions, and react to potential savings of seemingly small magnitude, typically about $5.00 per month. We find no support for models where consumers' responses are determined by inertia or impulsiveness, including systematic tendencies to undervalue future wants common to models of hyperbolic discounting. From a methodological viewpoint, the analysis shows how the appropriate treatment of predetermined endogenous variables and state dependence turns out to be crucial for interpreting the data.

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1 Introduction

Economics has developed a theory of the optimal or rational allocation of costly information that implies, for instance, greater investments in information when undertaking major rather than minor decisions. The making of decisions is costly, and not simply because some find it an unpleasant activity. In order to make a decision agents require information, and the information must be analyzed. The costs of searching for information and of applying it to a new situation may be

and sluggish. Between these two extremes lies a wide spectrum of models of irrational behavior, partly determined by the past and partly determined by current impulses. They encompass both a wide and an allegedly "realistic" class of behavior, including the systematic tendencies to undervalue future wants implied by models of hyperbolic discounting that have received a great deal of attention in recent years.[2]

If the implications of models of rational accumulation of information and models of irrational behavior are to be fully developed, then precise quantitative analyses are required of the extent to which consumers and firms respond rationally to a change in the distribution of opportunities or are systematically driven by impulsiveness and inertia. In other words, the choice between the rational and irrational views of the nature of tastes in economic theory must ultimately be made on the basis of their comparative predictive power. As Becker (1962) and other authors have noted, however, the degree of rationality to be attributed to economic decision units may not be determined in empirical analysis at the aggregate or market level. The reason is that at the aggregate level, observed responses of irrational agents will not tend to differ substantially from the response of rational units. The different predictions should instead be verified empirically at the *individual* level. Unfortunately, a number of important difficulties that we will briefly mention below have impeded appropriate analysis in natural environments at the level of households or firms.

In this paper we are interested in evaluating empirically, at the *household level,* the determinants of the responses to an unanticipated change in the environment and in measuring both the magnitude and the speed of these responses. Impulsive and inertial behavior in the face of changing prices and opportunities might contradict the approach that assumes rational utility maximizing agents with stable tastes. Models where forward-looking rational actors recognize that choices today affect their utilities in the future will be contradicted if we observe that households systematically forgo apparently profitable opportunities because of inertia or impulsive behavior.

The natural scenario and the panel structure of the data offer a number of valuable advantages that allow us to avoid difficulties characteristic of other environments which in turn explain the paucity of previous empirical studies. First, the Federal Communications Commission's policy of Universal Service in local telephony allows us to avoid considering any potential selection issues as virtually all of the U.S. population was already subscribed to local telephone service at the time the experiment took place. Second, local telephone service is not subject to conspicuous consumption arguments difficult to measure such as those affecting membership in opera, golf, health clubs and others, where consumption goes together with social status or signalling of a particularly relevant social attitude. Third, as indicated above, the panel structure of the data is useful to evaluate the degree of rationality at the individual level, rather than at the market level where observed responses may also be consistent with irrational agents. The panel allows us to distinguish between temporary

[2] See Ainslie and Haslam (1992), Laibson (1997), Harris and Laibson (2001), and other references therein.

and permanent mistakes and to control for the effect of unobserved heterogeneity. Fourth, the tariff experiment introduced local measured tariffs for the very first time. Given that households were not familiar with this new pricing practice and that its introduction was unanticipated, it is likely that consumers initially made some errors in their choices of tariff plans. The panel structure of the data allows us to study whether any mistakes are permanent because of inertia or impulsiveness, or temporary because of a learning process in which individuals invest time and other resources to gain knowledge about the new environment and their own preferences. Last, households did not experience a change in the environment *per se*; instead, they were given the possibility to change to a new environment or remain in the environment they knew. This "choice" of environment represents a subtle but important advantage for testing learning models relative to the analysis of exogenous changes in environments typically examined in natural experiments. The reason is that, as Alchian (1950) already noted, "in a changing environment there can be no observable comparison of the result of an action with any other as comparability of resulting situations is destroyed by the changing environment." Observable comparison is possible in our case because households *choose* the environment.

An important advantage of our empirical analysis is that it allows us to account for individual learning effects as a process associated with past experiences. These individual experiences may be summarized by the path of tariff choices and past demand realizations for each consumer. Whether a consumer prefers a given tariff plan over the alternative option may not only depend on her expected demand level but also on the choices made in the past. Previous choices are important because of the information they may provide on the magnitude of the potential savings that consumers could have achieved had they chosen the alternative tariff plan. They are also important because different choices will be associated with different investments in time, effort, skills, and information, that is with different learning processes.

As is well known, cross–section analysis cannot properly account for the effects of past experiences. The reason is that the error term of any standard discrete choice model includes not only an unobserved individual heterogeneity component but also the effect of state dependence. Unfortunately, this is the approach taken recently to estimate behavioral models of consumption where predetermined variables are treated as exogenous in cross-section analyses of the data.[3] This approach ignores the effects of individual unobserved heterogeneity due to state dependence, which leads to estimates that are not robust and, as a result, may also lead to misleading conclusions. Interestingly enough, we find that when predetermined variables are incorrectly treated as exogenous, consumers appear to make systematic mistakes in their choice of tariffs: their *ex ante* choice of tariff scheme is often not the one that would minimize the cost of their local telephone consumption *ex post*, and these mistakes do not appear to be corrected. These results are similar to those obtained

[3] See, for instance, Della Vigna and Malmendier (2001) and other references therein.

in other studies in different environments using the same procedure, studies that typically interpret these findings as evidence against rational behavior.

In order to control for the effect of state dependence appropriately, we estimate a semi-parametric, dynamic random effects, discrete choice, panel data model. The results of this analysis are drastically different from those obtained following the previous procedure. We find that while consumers facing the new consumption option may make mistakes initially, they actively engage in tariff switching in order to reduce the monthly cost of local telephone service. We also find that those mistakes are not systematic. These results are taken to be consistent with models of the optimal or rational investments in information where consumers learn to undertake the optimal decision. In some sense, these findings are somewhat surprising. As indicated earlier, the incentives and motivation to learn and invest in information when dealing with a new environment will depend on the expected returns. In our case, these incentives would seem to be quite low as the magnitude of the differences between the alternative tariff schemes is very small, typically about $5.00 per month. Yet, the observed responses reacting to these potential savings are quite conclusive.

From a methodological viewpoint, the analysis in this paper shows how the appropriate treatment of predetermined endogenous variables considered important in the econometrics literature turns out to be crucial for interpreting behavioral data. In this sense, the appropriate dynamic analysis of individual learning experiences that have been inadequately appreciated by previous research in the literature is important. From a theoretical viewpoint, we find support for models where consumers react to a change in the environment in the direction predicted by theories of the rational investment in information. Despite the small magnitude of the monetary differences across choices, we find no support for models where consumers' responses are determined by inertia or impulsiveness, including systematic tendencies to undervalue future wants.

The rest of the paper is organized as follows. Section 2 describes the features of the experiment, the data available, and reports various descriptive statistics. Section 3 first examines how previous tariff choices affect the conditional probability of choosing the measured service option. It then evaluates the extent to which wrong tariff choices are a persistent phenomenon. In each case we estimate a static model as well as a dynamic model that incorrectly treats previous consumption and tariff choices as exogenous variables. We then estimate a random effects dynamic model that accounts for the role of state dependence, including different learning experiences and investments in information, and compare the results with those of the previous models. Section 4 offers a discussion of the classes of models that are not supported by the evidence and of those that may be consistent with the findings. Section 5 concludes.

2 Data: Tariff Features and Choices

The data come from the tariff experiment held in Louisville, KY, in the mid–eighties. The experiment was undertaken in order to evaluate the revenue effects of introducing optional tariffs in fixed local telephony. In this section, we describe the tariff experiment and present some descriptive statistics. We find that there is a substantial degree of individual heterogeneity in the selection of tariff plans. We also observe that although some consumers may make mistakes in their choices, they also appear to switch tariffs as a response to their previous mistakes. This suggests that individual past experiences will be an important determinant of current and future tariff choices.

2.1 Tari Features

In the second half of 1986, South Central Bell (SCB) carried out a detailed tariff experiment aimed to provide 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, when all households in Kentucky were on mandatory flat rates, 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 this city. Customers were given the choice to remain in the previous flat tariff regime –paying $18.70 a month with unlimited calls– or switch to a new measured service option. The measured service included a $14.02 monthly fixed fee, and a $5.00 allowance.[4] The tariff also distinguished among setup, duration, peak periods, and distance.[5] Choices could be made every month and, unless a household indicated to the SCB otherwise, its choice of tariff was automatically renewed for the following month. 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), and payments during two periods of three months, one right before (April–June) and the other (October–December) three months after the measured tariff was introduced.

This data set has a number of valuable features to test behavioral implications in a natural setting. First, local telephone service is considered a basic service and its market penetration is close to 100% in the U.S. This allows us to avoid potential self–selection problems or other conspicuous considerations that may lead to biased estimates because of sample selection problems. Second, the low magnitude of the cost differences between the specific alternative tariff choices in the data rules out any risk aversion arguments that could otherwise explain systematic mistakes in the choice of tariffs.[6] Third, in contrast for instance with experiments and other data used to support behavioral

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

[5] 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 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.

[6] Risk aversion is also ruled out in empirical tests (see Miravete (2000)). Contrary to the assumption in Rabin (2000), agents are risk neutral to the small gamble associated with the choice of tariffs.

theories, the sample is representative of the population. It is also valuable for the purpose of the analysis that in addition to demographic and economic variables, SCB also collected information on customers' telephone usage expectations. SCB explicitly requested in Spring customers' own estimates of their weekly average number of calls. Direct indicators of consumers' expectations are rarely available in empirical settings. Furthermore, these individual estimates are particularly useful because (i) local calls were never priced before, and (ii) consumers were not aware of the tariff experiment that was going to be held in the second half of the year. Thus, neither marginal tariffs nor strategic considerations influence these estimates of customers' own satiation levels. Even if the formation of individual expectations may be subject to the effect of unobserved individual heterogeneity, this statistic is the best summary available of expected individual usage upon which households may condition their tariff choice decisions.[7] The flat tariff regime also means that, because local calls are not priced at the margin, households might not be aware, at least not perfectly, at the time of the experiment of their own actual consumption levels and preferences for local phone calls. In this sense, households are as close as possible to a *tabula rasa* and, hence, the analysis represents a suitable opportunity to test for learning and other reactions to a change in circumstances.

2.2 Descriptive Statistics

We begin in Table 1 by presenting descriptive statistics of the data set. Only active consumers were considered and observations with missing values for variables used in the analysis were excluded. In most cases the number of observations excluded is small. The only exception are those households that did not report their income. In order to avoid sample selection problems that could lead to biased estimates, we recoded these missing observations to the yearly average income of the population in Louisville and also included a dummy variable, DINCOME, to control for non–responses.[8]

Table 1 breaks down the sample in two groups according to their choice of tariff in October. Households whose head holds a college degree or who moved in the past five years are more likely to choose the measured option. Larger households, those with teenagers, blacks, and households who receive any kind of federal or state benefits are, on the contrary, more likely to subscribe to the flat tariff option. The variables related to telephone usage are also informative. Households that choose the measured tariff option are far less intensive users of local telephone service than those who subscribe to the flat tariff. These households also appear to predict their future consumption more

[7] The econometric analysis of subscription decisions in Miravete (2002b) confirms the idea that choosing among tariff options critically depends on individual estimates of future usage.

[8] Further information about the recoding of these missing observations and the estimation of the average income is available in Appendix 3 of Miravete (2002a). A feature of the data set to be noted is that there is oversampling of customers that subscribed the optional measured option. While almost 30% of our sample consists of customers that subscribed to the optional measured service, in the population only 10% subscribed. All the estimates presented in the empirical analysis control for this choice biased sampling. We use Manski and Lerman's (1977) procedure to obtain choice–based, heteroscedastic–consistent, standard errors.

accurately and, at this level of aggregation, their average monthly bill exceeds the monthly cost of the flat measured option. This may be because (i) most customers who subscribed to the measured service made mistakes in predicting their telephone use, or (ii) *ex post* mistakes were not evenly distributed across subscribers of the measured tariff. The evidence presented later in this section and in Section 3 supports this second interpretation: it is the very important mistakes of only part of these subscribers that explains why the average payment under measured service exceeds the $18.70 monthly fee of the flat tariff option. This initial evidence suggests that individual heterogeneity in consumption is important, and also indicates that many of those who subscribed to the measured tariff were in fact minimizing the cost of their local telephone service.

Table 2 breaks down telephone usage statistics by correct/incorrect tariff choice for each of the Fall months available in the data. The right/wrong classification is made by comparing the cost of the same usage level under the alternative tariff choice ignoring any price effect. Thus, the *SAVINGS* variable represents the maximum potential savings of choosing the alternative tariff option while keeping the local telephone usage pattern unchanged: a positive (negative) value indicates that the alternative option would have been cheaper (more expensive) given the current usage pattern of this household.

It is worth noticing the low magnitudes of the monthly bill under any of the two options. This means that the maximum monetary value of mistakenly subscribing to either tariff plan is also very low.[9] Conditional on wrongly choosing the optional flat tariff (about 10% of the sample of those who chose this option), the maximum potential savings of switching to measured service is $4.68, *i.e.*, exactly the difference between the cost of the flat tariff option and the fixed monthly fee component of the measured service. Therefore, those consumers who wrongly chose the flat tariff option had a particularly low consumption profile that would have not even exhausted the $5.00 allowance included in the measured tariff option. On the contrary, among those who wrongly chose the measured service (about 63% of the sample of those who chose this option), the maximum average saving is $7.39. As indicated earlier, the incentives to invest in knowledge and information when dealing with a change in the environment depend on the expected returns. The low magnitude of these potential savings would then suggest that we should not expect households to respond greatly to the new situation. Instead, inertia and impulsiveness might characterize the optimal response to such moderate change in the environment. This, however, will not be the case.

The last few items in each half of Table 2 provide some initial evidence that consumers engaged in switching tariffs in order to minimize the monthly cost of their local telephone service. The proportion of households who switch is small although, as we shall see in Section 3, the observed switching frequencies are significant in explaining the dynamics of tariff choice as well

[9] A negative value of the SAVINGS variables indicates by how much consumers have correctly chosen a particular tariff option.

as in characterizing tariff choice mistakes as transitory events. While households who switch tariffs from flat to measured service might actually have been subscribing the cost minimizing tariff in previous periods, it seems that the majority of consumers who switch from the measured to the flat option are those who made previous mistakes. This asymmetric switching behavior is apparent from the higher proportion of consumers that wrongly chose the measured tariff relative to those who wrongly chose the flat tariff. A possible reason is the asymmetry in the costs of information. It may be easier for consumers who subscribed to the measured tariff to realize that they made a mistake given that they simply have to compare their actual bill with the $18.70 monthly cost of the alternative flat tariff. Consumers who subscribed to the flat tariff, especially those at the margin, would need to make more complicated calculations to ascertain whether or not they made a mistake and to compute the amount they would have saved had they chosen the measured service.

3 Tariffs and Consumption: Static and Dynamic Analyses

In this section we address the dynamic aspects of households' behavior. We are interested in evaluating empirically their responses to this change in their environment, and in measuring both the magnitude and speed of the responses. Consumers, in principle, may be quite heterogeneous. Models where forward-looking rational agents recognize that choices today affect their utilities in the future will be contradicted if we observe that apparently profitable opportunities to a household remain systematically unexploited because of inertia or impulsive behavior. Households characterized by these attributes may, for instance, systematically subscribe the optional measured service and exceed the critical usage level of $18.70 or systematically subscribe the flat tariff and realize a relatively low usage. Impulsive behavior and inertia in the face of changing prices and opportunities might contradict the approach that assumes rational utility maximizing agents with stable tastes.

In order to account for the dynamic nature of the learning process where individuals invest time and other resources to gain knowledge about the new environment and their own preferences, we estimate two dynamic discrete choice panel data models with lagged endogenous and predetermined variables. These models control for the existence of state dependence (inertia, automatic subscription renewal, or any other reasons) and unobserved individual heterogeneity, as both of these arguments will likely play an important role in determining the choice of tariff. The first model studies whether consumers tend to subscribe to the same tariff of the previous period, regardless of their past realized usage. The second evaluates whether those who have made previous mistakes are more likely to continue making wrong tariff choices in the future. The estimation of these two models includes a set of demographics that control for the effects of observable individual heterogeneity.[10] For instance,

[10] For convenience, all regressors are dummy variables, including the INCOME indicators for which the original data only identifies a household as belonging to one out of nine income categories. HIGH and LOW INCOME equal one when the income level of the household exceeds the mean plus or minus its standard deviation, respectively. The definition of most of the other dummies is self–explanatory.

one would expect that households with more members make more use of the local telephone service and that as a result these households will tend to subscribe to the flat tariff option. Demographics are included in both equations. The data also allow us to import household specific information from the Spring months in order to control, at least in part, for the accuracy of their predictions on future usage levels. Hence, in addition to demographics, we include two dummies that indicate whether consumers significantly over or underestimate future consumption in the set of regressors of both equations.[11]

[11] The UNDERESTIMATION dummy indicates that variable SWCALLS exceeds EXPCALLS by more than 50% of the standard deviation of SWBIAS. The OVERESTIMATION dummy is defined accordingly when EXPCALLS exceeds SWBIAS. It might be argued that if we make use of the expectation indicators, there is no need to include the demographics in the regression of the tariff choice equation. However, we should recall that SWBIAS is an indicator of usage prediction errors based on the total number of weekly calls only. We also expect that households differ in their time/distance pattern of calling as well as in the duration of calls. The combination of all these elements contribute to determine whether the usage level exceeds the $18.70 threshold or not. The demographics may account, at least in part, for these additional arguments.

3.1 Tari Choice

The path of tariff choices and demand realizations followed by each consumer affects her conditional probability of subscribing to a tariff option in the future. The idea that previous choices should have an effect on the probability of subscribing to a given tariff option seems not only plausible but straightforward. However, incorporating the issue of state dependence into the estimation of dynamic discrete choice models is not trivial.[12] This difficulty may perhaps explain why the relatively scarce empirical evidence supporting models of hyperbolic discounting is based, at best, on static cross–section analysis of data. Unfortunately, this static approach ignores the effects of unobserved heterogeneity associated with the sequence of individual decisions over time. As a result, the estimated models are misspecified, which in turn means that the results are unreliable.

We address in this first subsection the dynamic problem of the choice of tariff. In Table 3 we begin by estimating a static probit model of tariff choice (column 1). We then extend the analysis by incorporating previous tariff choices and past usage levels as exogenous variables (column 2). In the third column we control for the effects of unobserved individual heterogeneity in the dynamic decision process and estimate a dynamic random effects model. The endogenous variable in this table equals one when household i subscribes to the measured option at time t.

3.1.1 Static Approach

The first column shows the estimates of the static probit model of tariff choice. This regression only makes use of truly exogenous regressors, that is households' demographics. In this sense, this static pool estimation ignores the existence of unobserved individual heterogeneity, and will lead to inconsistent estimates if in fact such effects are present.

The results show that households with higher than average income appear to subscribe to the optional measured service less frequently than average income consumers. The effects of the size of households and the presence of teenagers are similar as larger households and those with teenagers tend to subscribe to the flat tariff option. If households receive any kind of benefits, the probability to subscribe to the flat tariff option is also larger. Only those households formed by married couples or those with a college degree appear to be more inclined to subscribe to the measured service option. We also observe that those who make important prediction errors regarding their own future local telephone usage are more likely to subscribe to the flat tariff option. As the magnitude of the errors increases with telephone usage, the absolute magnitude of the error bias tends to be larger

[12] See Heckman (1981a) for a complete description of the different types of state dependence and their correct treatment in estimating dynamic discrete choice models.

for intensive consumers. Last, there does not seem to be a significant difference between those who underestimate and those who overestimate their future demand.

3.1.2 Pseudo–Dynamics

In some cross–sectional analyses in the literature there is information available on previous decisions of consumers. As indicated earlier, an incorrect procedure to account for the effects of past experience and unobserved accumulation of information is to include these lagged variables to explain current choices.[13] The reason is that past decisions, in our case past usage levels and past tariff choices, are both predetermined variables that cannot be treated as exogenous.

Although the results of this procedure are not consistent, we implement this methodology in the second column. The results will nevertheless be of interest in the sense that they will allow us to evaluate the extent to which this common econometric approach may lead to incorrect conclusions with regard to the classes of models that could be supported by the data. Thus, in addition to the effects of exogenous demographics, this regression includes the effect of past usage and tariff choice decisions.[14] The results show that a large number of demographics are significant. They also indicate that consumers with low demand tend to subscribe to the optional measured service and that consumers do not significantly switch tariffs. This evidence supports the view that consumers tend to stay subscribed to the same tariff option over time. These results should lead us to conclude that many consumers' decisions are driven by inertia. It is also possible to conjecture that the results are consistent with a model where households discount the future using a hyperbolic discounting structure and that, aware of their self-control problems, use the optional measured service as a commitment device not to consume excessively. However, as indicated above, these results are unreliable given the misspecification of the econometric model. Whether or not they also arise after the roles of unobserved heterogeneity and state dependence are appropriately treated is an empirical question to which we now turn.

3.1.3 Unobserved Heterogeneity Due to State Dependence

The probability of subscribing to a given tariff option in the future, and hence the probability of switching tariff options, depends on the particular sequence of past choices and realizations of demand for each consumer. As consumers choose differently, they accumulate different experiences and invest differently in gathering information about the environment and their own preferences. These experiences change the information set upon which they decide in the future and may also help form taste parameters. For instance, consumers that have previously chosen the measured option

[13] See for instance the analysis of automatic renewal of subscriptions to health clubs in Della Vigna and Malmendier (2001).

[14] The LOW USAGE$_{t-1}$ variable indicates whether the usage pattern of the previous period remained below \$18.70, the cost of subscribing to the optional flat tariff.

may have learned that their usage level is systematically high, so that in the future they may be more likely to subscribe to the flat tariff option. Consumers that have always remained on the flat tariff option have accumulated a different experience that also affects their conditional probability of renewing their subscription to the flat tariff option. Households may also learn about, or perhaps form, their own preference parameters given that before the introduction of the measured service their consumption was not priced at the margin and, hence, they might have little knowledge of their own consumption levels.

The history of past choices in October is different for each consumer and, furthermore, unobserved to the econometrician. This introduces the problem of the initial conditions in the estimation of this type of econometric models. As long as the error terms are correlated over time –a likely case in our data– the initial conditions become endogenous variables. Had SCB collected the tariff choice and usage decision during the six months of the tariff experiment (July–December), we would not face this problem given that at the beginning of the experiment all consumers in Louisville were priced according to the flat tariff option. Unfortunately, we only have information available from October to December of 1986 because the KPSC requested to wait for three months of adjustment before collecting usage and tariff choice data again.

Clearly, if we ignored the initial conditions problem our estimates would be inconsistent since they are endogenous. A potential solution is to consider that each unobserved individual path of discrete decisions prior to the initial month of data collection has an effect on the probability of subscribing to the measured option only through individual fixed effects. Unfortunately, and contrary to simple linear regressions, fixed effects cannot be consistently estimated for probit models with finite samples because of the well–known incidental parameter problem.[15]

In order to estimate consistently these dynamic discrete choice panel data models we make use of the semiparametric random effects estimator recently developed by Arellano and Carrasco (2002).[16] Their model can be accommodated to our data and written as follows:

$$y_{it} = \mathbb{1}[X_i\beta + S_{it}\alpha + E(\eta_i \,|\, H_i^t) + \varepsilon_{it} \geq 0], \tag{1}$$

$$\varepsilon_{it} \mid H_i^t = N(0, \sigma_t^2), \tag{2}$$

where X_i is the set of time–independent demographics and y_{it} equals one whenever consumer i chooses the measured tariff at time t. The realization of the state variables for consumer i at time

[15] On the statistical problems originated by the initial conditions problem, including its relationship with the incidental parameter problem, see Heckman (1981b). On the impossibility of obtaining consistent fixed effect estimates with finite samples see Neyman and Scott (1948) and Lancaster (2000).

[16] An important reason in favor of choosing this approach is that our short panel –just three months–, fits the identification requirements of this GMM estimator. Alternative approaches such as Honoré and Lewbel (2002) and Kyriazidou and Honoré (2000) are far more demanding in terms of data and only include either predetermined or lagged dependent variables respectively. In particular, these alternative fixed effects estimators require variation of the exogenous regressors over time, something that does not occur in our data. For a discussion of the estimator by Arellano and Carrasco within the context of probit panel data models see Lee (2002, §4.4).

t is denoted by H_i^t, which in our case includes the tariff choice of the previous period, y_{it-1}, and whether or not the demand realization of the previous period exceeded the threshold of \$18.70. Thus, $H_i^t = \{S_{i1}, \ldots, S_{it}\}$ represents the path of state variables of individual i. In addition to these elements, the decision to subscribe to the measured service option depends on the expectations that consumers have on the individual specific state of demand, η_i, conditional on the past history of subscription decisions and realizations of demand. Thus, the forecast of this unobserved individual component is revised each period as new information and experience accumulate.

This model defines conditional probabilities for every possible sequence H_i^t of realizations of the state variables. In this sense this estimator is able to deal with regressors that are predetermined but not exogenous such as the previous choices of tariffs and past realizations of demand in our model. Therefore, the basic idea of this estimator is to compute the probability of subscribing to the measured service 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 consumers make different decisions even if they share the same history of realizations of state variables.[17]

The results of this estimation are shown in the third column of Table 3. We find that once we control for the effect of demographics as well as for unobserved individual heterogeneity due to the dynamic decision process, the results are substantially different. As time elapses, the effect of initial expectations is a less important determinant of the actual tariff choice and accumulated experience and information take over through the updating process embodied in equation (1). Households that underestimate their future usage are still more likely to subscribe to the flat tariff option, but those who overestimate future usage tend to subscribe to the measured service. This is consistent with the initial evidence presented in Table 2. Underestimation of future demand is more likely to happen for intensive consumers. Overestimation occurs more frequently among those households with very low demands. The negative effect of LOW USAGE$_{t-1}$ opens the possibility of mistakes as it captures the effect of those consumers that still remain on flat tariff, although their low demand for local telephone services does not justify such a choice. Finally, the negative effect of MEASURED$_{t-1}$ indicates that consumers switch tariffs significantly, and that contrary to inertia arguments, automatic renewal of tariff subscription options does not necessarily mean that consumers will stay in the previously chosen tariff for a long period of time.

3.2 Wrong Choice of Tari□

[17] See Arellano and Carrasco (2002, §2) for the derivation of the conditional moment conditions that define this GMM estimator. Similarly to Arellano and Carrasco (2002, §4), we use orthogonal deviations suggested by Arellano and Bover (1995) instead of first differences among past values of the state variables.

The application of this methodology to the analysis of whether consumers make systematic mistakes is more important, and even more revealing, as it also allows us to evaluate the extent to which households respond rationally or are driven by inertia and impulsiveness. In Table 4 we study the extent to which *ex post* mistakes are systematic. Here, 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. As in the previous table, the first column reports the probit estimates using only exogenous regressors, the second reports the pseudo–ML estimates including two predetermined variables that are treated as purely exogenous, and the third column reports the GMM estimates of the dynamic discrete choice model of Arellano and Carrasco (2002). In this table the predetermined variables are whether households made a wrong tariff choice in the previous period and whether they subscribed to the measured tariff option.[18]

The results when controlling for individual heterogeneity and state dependence are quite different from the estimations that ignore such effects. In the first column, most of the demographics play a significant role in determining whether or not consumers make mistakes, whereas in the random effects dynamic model of the third column almost none of them play a role. Demographics are significant in the first column only because of the limited scope of that static approach that ignores potential learning effects over time and unobserved heterogeneity. These sharp differences indicate that as time elapses individual experiences and investments in information associated with past tariff choices and consumption decisions do become a more important determinants of future choices.

With regard to the pseudo–ML estimates of the second column, they indicate that those consumers that either overestimate or underestimate future usage by a considerable amount are *less* likely to make mistakes than those whose predictions are more accurate. Recall that this estimation bias comes from the comparison between the expected and actual weekly number of calls in the Spring. If these pseudo-ML estimates were reliable they would support the idea that individuals who predict best their future consumption tend to make systematic mistakes over time. Interestingly enough, the estimates of these variables are not significant in the third column. Once we control for the history of past decisions, initial expectations in Spring become less important as time elapses and accumulated experience and information play a more important role in the choice of tariff. The fact that this occurs in such a short period of time indicates that consumers actively engage in effective learning about the new environment, its new consumption opportunities, as well as their own preferences.

[18] We also estimated specifications of the models in Table 3 and 4 including cross–products of the state variables, but this did not improve our estimation.

The estimates of the last two variables are the most important ones. The first thing to note is that both of them are significant in the two models but with opposite signs. The positive sign of MEASURED_{t-1} in the second column would be consistent, for instance, with a model where agents discount the future using a hyperbolic discounting structure. Myopic households would systematically plan a low consumption level and choose the measured service, but will systematically exceed the \$14.02 threshold level and consume excessively. Even if they are partially *sophisticated* and use the measured option as a commitment device not to consume excessively they repeatedly fail to do so. One would then conclude that households' preferences are time–inconsistent. However, once we control appropriately for the effects of individual heterogeneity associated to the accumulation of experience and information in the third column, the results are drastically different. The sign of MEASURED_{t-1} becomes negative, and the estimate is also much greater in magnitude and even more significant. The pattern of behavior implied by this estimate is also consistent with the broad pattern observed in Table 2. Switching of tariffs is not symmetric. This may be explained by different information costs across tariff choices. In particular, as indicated earlier, it will likely be easier for households who subscribe to the measured option to monitor whether they have made the wrong decision. The negative sign of MEASURED_{t-1} shows that consumers readily react in the very short term responding to very small monetary incentives. Finally, the negative sign of WRONG_{t-1} in the third column indicates that mistakes are not permanent and that the switching between tariff options is aimed at reducing the cost of local telephone service. This finding is important. It is also in sharp contrast with the positive sign of this variable in the second column which would incorrectly indicate that households make systematic mistakes. These mistakes, which would be characteristic of households driven by inertia or any form of impulsiveness, are not supported by the random effects dynamic model. Lastly, it is important to remark that no demographic variable other than the dummy indicator for the older age group, AGE3, help explaining mistakes. The two endogenous predetermined variables are the ones driving the correctness of households' decisions, that is the relationship between the *ex ante* choice of tariffs and the *ex post* realizations of consumption, and do so in the direction predicted by rational utility theories.

4 Discussion

To our knowledge, the effects of unobserved heterogeneity and unobserved investments in information associated with previous choices and experiences in determining current choices have not been addressed before, neither in the experimental nor in the empirical behavioral economics literature. The results of estimating a static discrete choice model without controlling for state dependence support the implications of models where agents' decisions are characterized by inertia, impulsiveness or other irrational attributes: consumers appear to exhibit strong inertia in their choice of tariffs regardless of their actual consumption, mistakes appear to be permanent, and consumers fail to

effectively reduce their telephone usage when subscribing to the measured tariff option. However, this reading of the evidence proves highly misleading. Once the effects of consumers' past decisions on tariff subscription and telephone usage are controlled for a different picture emerges. Although some consumers make mistakes, those mistakes are not made by the same consumers on a systematic basis. Households switch tariffs frequently enough to correct for *ex post* mistaken tariff choices. Conditional on a wrong tariff choice in the past, it is more likely that consumers revise their subscription decision if they chose the measured service than if they chose the flat tariff. This evidence is consistent with the view of asymmetric cost of information acquisition for consumers who subscribed different tariff options. The results show that not controlling for the different paths of past choices leads to a misspecified econometric model, which in turn leads to the incorrect conclusion that consumers do not learn and do not react to potential savings.

The fact that the evidence turns out to be drastically different, especially given the low magnitude of the cost difference between the potential choices, leads us to rule out models where households' decisions are driven by any form of inertia, impulsiveness, or partly by the past and partly by current impulses. This includes models where future utilities are discounted using an exogenous hyperbolic discounting structure. This class of models would predict time–inconsistent behavior where some individuals would exhibit a systematic tendency to subscribe to the measured service and consume excessively. The fact that consumers actively revise their decisions and rapidly learn to make correct choices, in particular when their previous consumption was excessively high, is instead consistent with a theory of the optimal or rational investments in information and stable preferences.

Although we do not need to abandon the stability of tastes to explain observed behavior, it may be worth pointing out that the results might also be consistent with models of *endogenous* preferences. For instance, the evidence might be consistent with the model of endogenous time preference formation in Becker and Mulligan (1994, 1997) if individuals *form* their time preference structure as a response to a change in the environment and attempt to overcome certain weaknesses. In these cases, experiences and explicit investments in information may help to form taste parameters. The model of Becker and Mulligan may also be extended to the case of hyperbolic discounting where individuals may be initially endowed with a dynamically inconsistent time–preference structure, but where they learn to overcome their tendencies to consume excessively by investing time, effort, and other resources in forming a time–consistent preference structure. This approach would turn endogenous not only the level of the impatience parameter, as in Becker and Mulligan (1997), but also the dynamic structure of time preferences. The basic model could be formulated in an environment with no uncertainty by considering the objective of a household that lives for T periods as:

$$u(c_0) + \beta(R) \sum_{t=1}^{T} \delta(S)^t u(c_t), \tag{3}$$

where $u(\cdot)$ is a well–behaved utility function defined over current consumption and $\beta(\cdot)$ and $\delta(\cdot)$ are increasing and concave functions in the interval $[0, 1]$. Utility is maximized subject to the intertemporal budget constraint:

$$\sum_{t=0}^{T} P_t c_t + \pi_S S + \pi_R R = A, \tag{4}$$

where A is the present value of all assets and earnings, P_t are the usual interest rate factors, and π_S and π_R are the price of durable resources S and R for every individual. As in Becker and Mulligan (1997), households have the option to put forth effort and other resources S to increase their appreciation of the future. But unlike the literature on time–inconsistent discounting where the rates of time preference are invariably taken as exogenous, β is not a fixed parameter. Instead individuals may also put effort and invest resources R to increase the extent to which the future is discounted in a time–consistent fashion.

A number of predictions could be readily derived from this model. The first order conditions that determine the optimal choices of S and R require that the marginal benefit of investments in time preference parameters δ and β equals the marginal utility of wealth λ times the price of the corresponding resource:

$$\delta'(S) \left[\beta(R) \sum_{t=1}^{T} t[\delta(S)]^{t-1} u(c_t) \right] = \lambda \pi_S, \tag{5a}$$

$$\beta'(R) \left[\sum_{t=1}^{T} [\delta(S)]^{t} u(c_t) \right] = \lambda \pi_R. \tag{5b}$$

These conditions unambiguously indicate that dynamic consistency and patience are complements with future utilities: an increase in future utilities raises the advantages of lower discounts on the future and discounts that are more dynamically consistent since discount rates are then weighted by larger utilities (the terms in large brackets). Consequently, anything that raises future utilities such as tariff choices that are optimal *ex post*, without raising the marginal utility of current consumption, will tend to increase patience and dynamic consistency. Learning to overcome these weaknesses is thus endogenously determined in this model. The first order conditions also imply that wealth is complement with patience and dynamic consistency; hence, the rich should have greater incentives to invest in forming patience and a time–consistent preference structure.

Testing the implications of this model of consistent patience formation is beyond the scope of the analysis in this paper, other than simply pointing out that the evidence we have obtained is also consistent with the basic prediction of this model that households may make some initial mistakes, even under certainty, but may also learn to overcome their impulses to consume excessively. This model would capture the idea that "... it may well be true [that people undervalue future utilities], but people train themselves to reduce and sometimes more than fully overcome any tendency to

overvaluation ... partly by spending time and other resources to produce 'imagination' capital that helps them *better* appreciate the future" (Becker and Mulligan (1994, p. 11)). It would also capture the opinions shared by a number of authors in the behavioral economics literature that "most of us are born with hyperbolic discount functions" (Strotz (1956, p. 177)), and that "consistent behavior is sometimes acquired, to a greater or lesser extent, as a *skill*" (Ainslie (1992, p. 57)). Despite the fact that the endogenous formation of time–consistent preferences as a skill is admitted this way, these ideas have not been formalized previously as a hyperbolic discount function has invariably been taken as "given" or exogenous in the literature.

5 Concluding Remarks

Stigler and Becker (1977) early work surveyed four classes of phenomena widely believed to be inconsistent with rationality and the stability of tastes: addiction, habitual behavior, advertising, and fashions. They showed how it was possible to reconcile the phenomena in question with the stability of tastes. Perhaps the most important class of cases in recent years in which "change of tastes" is invoked as an explanation for economic phenomena is that involving time preferences and intertemporal choices. These models allege that people systematically undervalue future wants and that individuals are not capable of overcoming any weakness and impulses they may have unless they have some external commitment devices available. The results in this paper are in direct opposition to the implications of these models, and also to the implications of models that consider other forms of impulsiveness and inertia. We find that forward–looking households recognize that choices today affect their utilities in the future and that they actively react to potential savings of very small magnitude in the direction predicted by theories of rational investments in information.

The systematic analysis of the responses to various changes in the environment has profound implications not only for the analysis of many kinds of economic and social phenomena, but also for understanding the nature and formation of preferences. The natural scenario we have examined and the panel structure of the data offer a number of valuable advantages that allow us to avoid crucial difficulties. These difficulties may explain the paucity of empirical studies that asses the extent of individual rationality in natural environments.

We thus uncovered households responses in isolation from a number of other conflicting considerations which almost always exist in other environments and circumstances. For instance, Lucas (1987) and other authors remark a number of inherent limitations associated with research involving experiments in the laboratory and choice experiments with animals. The study of behavior at the individual level is also important since market or group behavior require not only assumptions about individual behavior but also about the mode of interaction among agents (see Arrow (1987)

and Lucas (1987)) and, moreover, aggregate evidence might be consistent both with models of rational and irrational behavior (Arrow (1987) and Becker (1962)).

Lastly, from a methodological viewpoint, the analysis shows how the appropriate treatment of predetermined endogenous variables and state dependence may turn out to be crucial for interpreting the data. In this sense, the appropriate dynamic analysis of individual learning experiences that have been inadequately appreciated by previous research in the literature is important.

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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	*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)
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

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.

Table 2. Expectations, Savings, and Right / Wrong Tari Choice

Tariff Choice:	OPTIONAL FLAT TARIFF					
Month:	OCTOBER		NOVEMBER		DECEMBER	
Cost Minimization:	Right	Wrong	Right	Wrong	Right	Wrong
CURRENT BILL	18.70	18.70	18.70	18.70	18.70	18.70
BILL UNDER ALTERNATIVE	35.93	17.35	34.97	17.40	36.88	17.64
SAVINGS IN OCTOBER	–17.23	4.68	–16.18	1.84	–14.84	1.64
SAVINGS IN NOVEMBER	–15.27	1.47	–16.27	4.68	–14.67	2.35
SAVINGS IN DECEMBER	–18.02	–0.36	–18.80	0.19	–18.18	4.68
CURRENT WEEKLY CALLS	46.98	9.90	47.90	10.39	49.32	10.90
EXPCALLS (Spring)	32.00	12.87	32.18	14.39	31.38	15.13
SWBIAS (Spring)	15.34	0.90	15.91	–0.10	14.86	–0.78
MEASURED IN OCTOBER			28	0	40	0
MEASURED IN NOVEMBER	23	16			13	0
MEASURED IN DECEMBER	24	18	2	2		
SWITCH IN NOVEMBER	23	16	28	0	29	0
SWITCH IN DECEMBER	3	2	2	2	13	0
Observations	837	112	836	102	891	56
Tariff Choice:	OPTIONAL MEASURED SERVICE					
Month:	OCTOBER		NOVEMBER		DECEMBER	
Cost Minimization:	Right	Wrong	Right	Wrong	Right	Wrong
CURRENT BILL	14.02	26.09	14.02	24.74	14.02	25.24
BILL UNDER ALTERNATIVE	18.70	18.70	18.70	18.70	18.70	18.70
SAVINGS IN OCTOBER	–4.68	7.39	–2.35	4.16	–2.38	2.52
SAVINGS IN NOVEMBER	–3.32	2.50	–4.68	6.04	–3.22	3.22
SAVINGS IN DECEMBER	–1.40	2.26	–1.54	4.98	–4.68	6.54
CURRENT WEEKLY CALLS	9.45	30.00	9.64	27.47	9.29	27.50
EXPCALLS (Spring)	12.49	24.51	13.11	23.44	12.13	21.48
SWBIAS (Spring)	1.45	6.86	1.55	5.50	1.68	5.36
MEASURED IN OCTOBER			153	214	114	241
MEASURED IN NOVEMBER	147	220			126	267
MEASURED IN DECEMBER	147	208	169	224		
SWITCH IN NOVEMBER	0	28	16	23	12	26
SWITCH IN DECEMBER	0	12	0	13	2	2
Observations	147	248	169	237	128	269

Average of bill, savings, and usage pattern. The remaining items denote the number of sample observations that subscribed the measured service and or switched tariff options between October and December of 1986.

Table 3. Choice of Tari 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)	

Table 4. Discrete Choice Models of Tari Subscription

	STATIC POOL		PSEUDO–DYNAMIC PANEL		RANDOM EFFECTS 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 $USAGE_{t-1}$			0.4034	(7.21)	–3.9039	(14.93)
$MEASURED_{t-1}$			3.1919	(41.30)	–6.1359	(23.46)
Log–likelihood	–1,358.900		–749.658			

The endogenous variable equals one if the household subscribes to optional measured service at time t. Sample includes 1,344 individual observations over a three months period. Absolute, choice–biased sampling, heteroscedastic–consistent, t–statistics are reported between parentheses. The models of the first and second column are estimated by weighted ML (probit). The random effects dynamic model of the third column is estimated by GMM.

Table 5. Persistence of Wrong Tari Choice

	STATIC POOL		PSEUDO–DYNAMIC PANEL		RANDOM EFFECTS 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_{t-1}			0.8087	(15.40)	–6.0301	(26.92)
WRONG_{t-1}			1.2331	(29.80)	–1.2128	(5.41)
Log–likelihood	–1,626.166		–1,328.439			

The endogenous variable equals one whenever the household subscribes to the wrong tariff choice for their realized consumption. Sample includes 1,344 individual observations over a three months period. Absolute, choice–biased sampling, heteroscedastic–consistent, t–statistics are reported between parentheses. The models of the first and second column are estimated by weighted ML (probit). The random effects dynamic model of the third column is estimated by GMM.