Quantifying the Benefits of Entry into Local Phone Service

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Abstract

In this paper, we evaluate the consumer welfare effects of entry into residential local phone service in New York State using household-level data. Since residential local phone service is sold under a menu of two-part tariffs, we develop a method for estimating a mixed discrete/continuous demand model. The econometric model incorporates the simultaneity of the discrete plan and continuous consumption choices by consumers and allows for flat-rate plans, bundling of services, and unobservable firm quality. Since utility maximization underlies our model, we are able to estimate welfare effects from the introduction of additional choices or changes of product features. We use the model to evaluate the effect of entry by the two largest competitive local exchange carriers in the New York market from the third quarter of 1999 to the first quarter of 2003. Residential local phone service competition is an important goal of the 1996 Telecommunications Act and we provide one of the most detailed evaluations of its effect on consumer welfare. Our preliminary results indicate that relative to what it would have paid to Verizon, the average household switching to AT&T or MCI saved 4.3% and 0.7%, respectively, ignoring quantity and observed and unobserved quality effects from switching.

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1 Introduction

As a result of the 1996 Telecommunications Act (the "1996 Act"), the market for local residential and business phone service was opened to competition. By the end of the 1990s many cities in the United States had experience with local exchange competition in the form of Competitive Local Exchange Carriers ("CLECs").[1] Recent studies (Crandall and Sidak 2002, and Zolnierek, Eisner and Burton 2001) highlight the role of economic factors, such as demand and cost differences across markets, economies of geographic scope, and regulatory stringency, in driving entry into local telecommunications markets. Greenstein and Mazzeo (2003) find furthermore that product differentiation is an important consideration in the firms' entry decision, suggesting that entry may benefit consumers in the form of both increased price competition and higher product variety.

While the determinants of entry into local telecommunications markets have received some attention, the effect of such entry on consumer welfare is to date unclear. Early estimates of the expected savings by consumers as a result of CLEC entry are significant. Data compiled by TRAC (2001a) suggests that New York State customers may be able to save between $2.06 and $5.32 on their local phone bill, generating an estimated $197 million in annual savings for customers who switched from Verizon to a CLEC or switched to Verizon's long-distance offerings. (See also TRAC 2001b for expected savings of competition in local service in California.) This paper extends their analysis to evaluate the consumer welfare effects of entry into residential local phone service in New York State using detailed household-level data. In contrast to the TRAC study, we are able to quantify the effects of entry on consumer welfare based on actual consumer choices rather than hypothetical consumer migrations. The household-level data set also allows us to model individual choice behavior and to distinguish between welfare effects generated by lower prices and by increased product variety post-entry.

Residential local phone service is sold under a menu of two-part tariffs where consumers must choose a pricing plan for which they pay a fixed fee and then decide their quantity choice based on a per-unit price. In estimating local telecommunications demand, the presence of two-part tariffs has been accommodated in several ways. Train, McFadden and Ben-Akiva (1987) employ a nested logit structure to estimate demand for local phone service in which each nest is a combination of a plan and a portfolio of calls (number and distance). To reduce the immense number of possible portfolios, the authors randomly sample a selected number of portfolios.

Miravete (2002a, 2002b) infers the distribution of consumers' utility for local phone calls by incorporating the time lag between the initial plan choice and the subsequent usage decision. Based on data from an experiment in Kentucky in which consumers were able to choose among different types of plans in one city but not in another, Miravete

[1] Greenstein and Mazzeo (2003) state that as of 1999, in 56% of the markets that experienced entry, one entrant competes with the incumbent, in 28% of the markets, between two and five entrants compete, while only 8% of the markets witnessed the entry of more than 10 new providers.

(2002a) is able to identify differences in the distribution of consumer types before and after the plan choice and analyze the extent to which the local phone company is able to discriminate amongst its customers based on the separation of the plan choice from the usage decision. Miravete (2002b) studies the effect that the uncertainty over usage has on the initial plan choice. He finds that consumers make, on average, the correct tariff choice conditional on their realized consumption, despite their uncertain usage, and that consumers frequently switch calling plans with the goal of minimizing cost of service in response to small differences in billing cost.

This evidence suggests that local phone service consumers act rationally in their choice of calling plan, as assumed by Hausman, Tardiff and Belinfante (1993) in their mixed discrete-continuous model of local telecommunications demand. In their model, consumers choose both a single service provider as well as the quantity of the service they consume. Such mixed discrete-continuous models apply to markets with two-part tariffs in general, including telecommunications, energy, information and Internet access industries. Due to a lack of usage data, Hausman, Tardiff and Belinfante (1993) estimate only the discrete portion of the model to study penetration of local phone service in the U.S. However, the discrete choice incorporates the continuous choice consistent with utility maximization.

We build upon their work by developing a demand model that incorporates the joint decisions over discrete tariff choices and continuous consumption levels by consumers. Our utility specification accounts for several institutional features, including "all you can eat" flat-rate plans at zero marginal price and bundling of local and intraLATA toll services. To allow for differentiation among providers, we incorporate unobserved firm quality differences as horizontal provider attributes to account for the empirical regularity that some households switch under higher prices while others do not. The resulting utility function is the primitive of our econometric model. The demand functions implied by utility maximization define the optimal quantity choice for all options. Based on these optimal consumption levels we then compare consumers' indirect utility to determine their discrete choice of a calling plan. Our methodology allows for unobserved household differences to enter the demand function and indirect utility in a manner consistent with utility maximization. We employ a simulated method of moments estimation technique that combines the information from the discrete and continuous choices by consumers.

This paper fits into the recent literature on the estimation of mixed discrete-continuous models of demand. Hanemann (1984) provides a comprehensive methodology for estimating discrete/continuous econometric models that link the discrete and continuous choices in the same utility maximization problem. Chiang and Lee (1992) allow further for zero consumption of the inside good. Building upon earlier empirical studies (Dubin and McFadden 1984, Dubin 1985), Chiang (1991) estimates this demand model using coffee purchase data and allowing for the no-purchase option. A number of recent papers (Chan 2003, Dubé 2003, Hendel 1999, and Kim, Allenby and Rossi 2002) consider scenarios in which households choose an optimal bundle of products during any one purchase occasion, instead of making a series of independent choice decisions. Hendel (1999), for example, estimates a multiple-discrete model of demand in which consumers simultaneously choose which and how many discrete units of a set of products to purchase and applies the estimation to purchases of personal computers. Similar to our approach, Kim, Allenby and Rossi (2002) derive optimal demand across a discrete set of goods from the household's direct utility function and apply their methodology to yogurt purchases. The fact that households can choose a combination of products at varying quantities makes their model very computationally intensive, even for small numbers of products. In contrast, both the institutional setting and the two-part tariff nature of pricing in local telecommunications imply that households choose one exclusive provider for their local telephone service, greatly simplifying the analysis.

We estimate our model using data for a random sample of households in New York State from the third quarter of 1999 through the first quarter of 2003. Significant CLEC entry occurred in New York State during our sample period. The largest entrants are AT&T and MCI, which together comprised 85% of the residential lines served by entrants at the end of 2001. Along with AT&T and MCI, we include the incumbents Verizon, Citizens Telecommunications and Rochester Telephone, representing 97% of lines served by incumbents, in our analysis. The supply side of the local phone market is unique in that entrants lease parts of the incumbents' infrastructure and regulators set the incumbents' prices, limiting the ability for supply-side responses. Instead, we focus exclusively on the welfare effects on consumers.

We consider four types of consumer welfare effects. Price and quantity effects arise due to price differences between entrants and the incumbent, which benefit consumers in the form of pure price effects and also elicit a demand response, the quantity effect. Firms may also offer differentiated services, benefiting consumers in the form of variety increases. We call this result of entry the "quality effect." Last, households may also benefit due to their ability to combine separate services under one bill if they were to switch to an entrant that is also their long-distance provider. This convenience effect makes up the last category of consumer welfare effects. The estimation of the households' utility function allows us to assess the importance of price, quantity, quality, and convenience effects due to entry. We perform a counterfactual in which only the incumbent's plans are available to the households and force households to choose the optimal plan available from the ILEC. We then decompose the changes in indirect utility into the four different types of consumer welfare changes due to the introduction of the entrants' plans.

We find significant heterogeneity across households in the effect of entry. Because some households incur higher monetary charges after switching to an entrant, we allow for observed and unobserved firm quality. Our estimation procedure allows us to disaggregate pure price effects, usage effects, convenience effects and quality effects from entry. Our preliminary results indicate that based on price effects alone, the average household switching to AT&T saved 4.3% relative to what they would have paid on Verizon ignoring quantity, observed and unobserved quality effects, while the corresponding savings of the average household using MCI's local service amount to only 0.7%.[2] Based on the individual switching behavior of households we find evidence that observed and unobserved firm quality plays an important role in households' discrete carrier choices but do not find significant evidence of uncertainty of consumer demand or that households systematically make "mistakes" in choosing plans.

2 Local Telephone Services and Entry

2.1 Regulatory Background

Divestiture of AT&T in 1984 was very successful in creating a competitive market for long-distance telephone service. At the same time, it established seven regional bell operating companies ("RBOCs") (Ameritech, Bell Atlantic, Bell South, NYNEX, Pacific Bell, SouthWestern Bell, and US West) as monopolists of local telephone service, each in its own geographic region. An important goal of the 1996 Act was to relax their monopoly power and instead encourage competition in the local telecommunications services market. The 1996 Act relies on competition and deregulation as means to encourage investment in privately owned communications infrastructure and the widespread deployment of advanced telecommunications and information technologies (such as broadband service). Consumers would benefit from prices being pushed towards cost, higher quality of service, and greater variety in the form of new service offerings.

Entry into local service is complicated by the high capital requirements to build the local loop that connects the customer to the network. To help entrants overcome these difficulties, the 1996 Act mandated that the ILEC must grant entrants access to its infrastructure. The Act views such service-based entry as an intermediary step to full-fledged facilities-based entry (where firms provide their own infrastructure). The goal is to allow new competitors access to the market, who over time will build their own facilities in areas where it is efficient and rely less on cooperation with the ILEC as their own networks develop.

Under service-based entry, entrants are able to lease the ILEC's infrastructure at cost-based rates set by each state's public service (or utility) commission ("PSC"). Entrants are allowed to choose which individual unbundled network elements ("UNEs") or platform combination of UNEs of the ILEC's infrastructure they would like to lease:

[2] These savings compare to savings of 8 to 11% on long-distance bills that Hausman, Leonard and Sidak (2002) estimate to have accrued to consumers after the entry of incumbent local exchange carriers ("ILECs") into long-distance service in New York and Texas during the late 1990s. The study is based on the TNS Bill Harvesting data that we employ as well, using a difference-in-differences approach to compare the experiences of New York and Texas to Pennsylvania and California, respectively, both of which did not experience entry by ILECs into long-distance service during the same time period.

loops, switching, and transport. An alternative way of entry is through total service resale wherein the entrant buys the final service of the incumbent, except for retailing and billing functions, adds its own retailing and billing, and sells it to final customers. Although entrants can enter the market as facilities-based entrants, most entry into the residential market has been through the lease of UNEs or through total service resale,[3] given the high costs of running a second line to the customer's home or establishing switching facilities relative to the cost of leasing existing lines and facilities.[4]

The PSC serves two main roles in residential local phone competition. First, it sets the lease rates that entrants pay to the ILECs for UNEs. UNE rates vary by geographic zone within New York State based on line density in the wire center. During our sample period, UNE rates were revised significantly only once, in July 2002. To facilitate further entry, the PSC reduced rates by on average 30% from earlier levels. The cost of serving the average household in New York was approximately \$20 as of early 2001 and fell to approximately \$15 in July 2002.[5]

Second, the PSC regulates the rates that the ILEC charges residential customers for local phone services. Until March 2002, the PSC used a performance regulatory framework based on revenue targets. Prices that Verizon, the primary New York ILEC, could charge for basic service were held constant until Sept. 2000 and reduced thereafter to achieve the predetermined revenue target. From March 2002, the PSC changed its regulatory regime to one of incentive regulation that granted Verizon a certain degree of pricing flexibility and retail rate increases to allow it to recover some of the revenue foregone due to the decreased UNE rates. Table 1 summarizes Verizon's prices across geographic areas and over time. Due to the continued regulated nature of pricing by the PSC, Verizon's ability to adjust prices in response to entry was therefore limited, in particular in the pre-2002 period. Even under the new regulatory regime, Verizon does not appear to overtly use price flexibly as a competitive instrument since it simply adopted the maximum price levels set forth by the PSC.

A separate component of Verizon's incentive regulation relates to service quality. To prevent service deterioration, the PSC established performance objectives in five ser-

[3]In New York as of December 31, 2002, CLECs reported that 67.4% of their 3.19 million switched access lines (residential and business) were served via UNEs, while only 13.8% were served through their own facilities and 18.8% through the resale of an ILEC's service ("Local Telephone Competition," FCC June 2003). This understates the percentage of residential lines served via UNEs since CLECs are more likely to use their own facilities for higher-volume business customers.

[4]This so-called "last mile" installation is estimated to cost several thousand dollars per home depending on the remoteness and terrain. In the context of broadband deployment, NECA (2000) found that the estimated cost of upgrading 3.3 million lines in rural areas amounted to \$10.9 billion dollars. Approximately half of that total was associated with upgrading lines serving customers situated in areas that are either very remote or situated in difficult terrain.

[5]Based on Appendices 2 and 3 in http://www.cad.state.wv.us/Intro%20to%20Matrix%201-02.htm. The cost figures assume 1000 minutes of usage per month and incorporate discounts for leasing the entire platform of UNEs.

vice quality areas (customer trouble report rates, customers out-of-service over 24 hours, installation performance, PSC complaints, and other measures related to the PSC's Service Standards). Failure to meet any of the performance objectives results in credits to the affected customers. Due to the incentives placed by this regulatory scheme on Verizon to maintain and improve its service quality, it is difficult to isolate effects that entry may have on quality levels. Instead, we concentrate on households' perceived quality differences between providers as implied by their actual provider choices.

2.2 Competitors in New York State

Formed by Bell Atlantic's acquisition of NYNEX in 1997 and a subsequent merger with GTE in 1998, Verizon was the dominant ILEC in New York during the time period of our sample. Verizon had 9.462 million (89%) of the 10.639 million access lines (business and residential) in New York State served by ILECs as of December 31, 2001. Two other independent ILECs, Rochester Telephone of New York and Citizens Telecommunications, had most of the remaining access lines, 0.496 million (5%) and 0.316 million (3%) respectively. Rochester Telephone and Citizens Telecommunications merged in June 2001 to form Frontier Communications of New York. Figure 1 displays the geographic areas served by these three New York ILECs.

The incumbents' share of access lines declined consistently over our sample period as the CLECs' market share of residential lines increased from 6% in 1999 to 22% in 2002. New York State experienced competition in local service even before the 1996 Act with Rochester Telephone's opening of its local market to competition on January 1, 1995. The two main entrants during our sample period, and the largest to date, were AT&T and MCI, both of which expanded into local service from the long-distance market. As of December 31, 2001, AT&T served 0.975 million (58%) and MCI 0.462 million (27%) of the 1.684 million residential access lines served by CLECs in New York. The initial wave of entry in New York State by AT&T occurred in 1999 and is displayed in Figure 2. Figure 3 displays its second wave of entry in 2001. As the maps show, AT&T's entry occurred entirely in Verizon's territory. MCI similarly entered only into Verizon's territory and began offering service in the entire territory as of 1999.

2.3 Local Service Markets and Products

Geographic markets in local phone service are defined by wire centers, the locations of one or more switching systems where customer loops converge. Wire centers differ significantly in the population served, with the average New York State wire center serving 27,860 people (median of 5,324), ranging from 126 people in Blue Mountain Lake's wire center to 1.7 million people in New York City's Zone 6. Importantly for our estimation, wire centers are defined identically for all the carriers given the technological constraints of transmitting a call. Wire centers across the U.S. are grouped into 161 local access transport areas ("LATAs"), seven of which are in New York State.

Within each LATA, two types of calls are distinguished. Local service denotes all calls made to wire centers within a local calling area. IntraLATA toll calls, in contrast, are calls made to wire centers outside of the local calling area but within the household's LATA. Even though carriers define local calling area themselves, they are defined identically across carriers. Calls terminating outside of the LATA are considered long-distance calls whether terminating within or outside the state.

The 1996 Act defined opening the local telecommunications market to competition as a precondition for allowing RBOCs to enter the long-distance market in their region. By the end of our sample period, the major local service incumbents in New York, Verizon and Frontier Communications, operated in the long-distance market. Verizon received regulatory approval to enter the New York long-distance market in January 2000 having taken the necessary steps to open its local market to competition,[6] while Frontier Communications has offered long-distance service in the Rochester market since January 1995. Long-distance service was for the most part not bundled with local phone service during the time of our study in the sense of the two services substituting for each other in the minutes allowed in a calling plan. Our study thus concentrates on estimating the benefits from competition in local and intraLATA service.

Local and intraLATA phone service is provisioned through monthly calling plans, most of which are some variation of a two- or three-part tariff. The New York carriers generally offer three types of plans. Metered plans charge a monthly fee to obtain service and a per minute or per call fee for usage, which may differ for local and intraLATA calls. Flat-rate (or "all you can eat") plans charge a monthly fee and allow unlimited calling. Hybrid plans are three-part tariffs in which households pay a monthly fee to obtain a certain number of minutes or calls at zero marginal price. For calls above the pre-defined number of minutes, a household pays a positive marginal rate per minute or per call. The FCC also requires local carriers to offer additional plans for qualifying low-income households, called Lifeline plans.[7,8] These plans provide reduced rates for calling plans.

Local phone service providers also offered so-called vertical features, such as call waiting, call forwarding, three-way calling, and speed dialing, to its customers. During the time period of our study, the carriers did not bundle these features with local or

[6]Verizon was subject to the long-distance restrictions inherited from its RBOC parts (NYNEX and Bell Atlantic), even though GTE, never having been part of AT&T, was not restricted from providing long-distance service.

[7]In New York, a household qualifies if it receives benefits from any one of the following programs: Food Stamps, Home Energy Assistance Programs, Family Assistance, Medicaid, Safety Net Assistance, Supplemental Security Income (SSI), Veteran's Disability Pension or Veteran's Surviving Spouse Pension. If the household is not part of any of these programs it can also qualify by providing proof of income to the carrier.

[8]There is also a separate program called Linkup which provides a discount for initiating service but we do not address this since we ignore set-up costs to service for all households.

intraLATA toll service. Instead they offered them as additional features that could be purchased along with the basic services. We describe how we accommodate vertical features in Section 5.

3 DATA

We analyze the choices of a sample of New York State households collected by TNS Telecoms (TNS). TNS' Bill Harvesting data contains survey data from residential customers. TNS gathers various demographic information on the household and asks them to submit their actual phone bill. Since willingness to respond varies by household characteristics, TNS employs oversampling to obtain a random sample of households in New York State. Our sample runs from September 1999 through March 2003 and covers a total of 7,222 household observations.

For each household, the data set contains information on its local carrier choice and any detailed line items recorded on its local telephone bill. Because the format of telephone bills varies across carriers and plans, the detailed information from the bill varies by household but generally includes the services the household purchased, total amount paid and a breakdown of the bill into services, fees and regulatory charges. If the household is on a metered plan we know the number of calls or minutes consumed, but if it is on a flat-rate plan, the local usage is generally not available.[9] From the demographic survey completed by the household we know basic demographic information as well as information on other telecommunications services and technology products used by the household. The household's income is reported as categorical variables. To transform it into a single continuous variable, we assigned to each household an income equal to a predicted average income level in its category, as described in more detail in the appendix. We use the household's location, available at the zip code and wire center levels, together with tariff data on the availability of AT&T and MCI's local service by rate center and time period, to construct the household's choice set of local service carriers at the time of their bill.

The TNS data does not directly identify the calling plan chosen by the household. We are however able to use descriptions of services contained in the TNS files along with information on the household's expenditures to uniquely identify its calling plan based on publicly available information. All carriers must file rate-related information with the PSC and must update these tariffs whenever prices change. The universe of calling plans and their prices at every point in time during our sample period is available from these PSC tariff filings. In contrast to long-distance service where optional calling plans are frequently updated, the tariff options and their features have remained nearly constant over the period of our sample. Since providers adjust consumers' bills to reflect price

[9] We also know usage for a household on a hybrid plan that exceeded the threshold.

changes as they go into effect, we identify each household's plan among contemporaneous tariffs. Across providers, we are able to match 97.2% of households to a calling plan.[10]

Some simplifications of the data were necessary to make estimation tractable. Some calling plans price usage based on number of calls rather than number of minutes. Using the inventory of calls placed by each household contained in the TNS data, we converted per-call to per-minute usage based on the average length of a local call across all households in the sample. Other calling plans charge differential prices for the first minute of a call versus additional minutes. We set the per-minute price paid by households on these plans to a weighted average rate using the fraction of calls lasting less than one minute and the average length of calls lasting more than one minute. Prices on some calling plans also varied by time of day (day versus evening versus night/weekend) and were similarly changed to a weighted average per-minute price based on intra-day usage patterns of households in our sample. Finally, some intraLATA calling plan prices depend on the distance of calls made. We converted their price to a weighted average per-minute price based on the distribution of call distances for all households in our sample. In the remainder of the paper, we will therefore ignore within-call non-linear pricing and the household's choice of timing of individual calls or distance of calls made.

Typically, at a particular wire center, the carriers offer one metered plan and one flat-rate plan for local calling. Verizon's prices for the metered plan differ for metro and non-metro regions[11] while AT&T and MCI offer a single metered tariff to all New York customers. Verizon's prices for the flat-rate plan differed across five different rate groups (groups of wire centers), which do not include New York City[12] where the flat-rate plan is not available. AT&T and MCI differentiate pricing of the flat-rate plan only between metro and non-metro regions.[13] There is one exception to the carriers offering equivalently structured plans. Verizon did not offer a flat-rate or hybrid plan in New York City during the sample period and MCI introduced a metro flat-rate plan only in September 2000, while AT&T offered such a plan during the entire sample period. Table 1 summarizes AT&T, MCI, and Verizon's pricing of local service over time and across areas. From the beginning of 2002 onwards, Verizon's local calling rates consistently increased. AT&T's rates for basic service are higher than Verizon's except for the metered service in the early part of the sample through March 2000. MCI, in contrast, charges a lower fixed fee for its metered service relative to Verizon for a significant part of the sample period. Per-call charges, however, are generally higher than Verizon's prices. Thus, in areas where equivalent plans on the three carriers are available, a household would pay

[10]We thank George David and Bill Goddard of CCMI for making this data available to us.

[11]Verizon's metro regions include the wire centers in the five New York city boroughs (Manhattan, Brooklyn, Bronx, Staten Island and Queens), Westchester, Rockland and Putnam counties and Long Island (Nassau and Suffolk counties). Wire centers in all other areas are non-metro.

[12]Specifically, New York zones 1 through 7 wire centers, which encompass the Manhattan, Bronx and Brooklyn boroughs.

[13]AT&T and MCI's metro region includes all wire centers in LATA 132 (which includes New York City and Westchester and Nassau counties).

h igher basic service rates on AT&T, and possibly on MCI, than on Verizon.

Table 2 summarizes the prices of the three providers' intraLATA tariffs. For intraLATA toll service, Verizon offered two metered option, the Regional Calling Plan and the Sensible Minutes plan. Rates on these plans, which differ between the metro and non-metro regions, dropped over time. AT&T and MCI offered a single metered intraLATA plan. In addition, AT&T offered the expanded LATA plan, a unique option among the providers which bundled local and intraLATA toll service into a single hybrid tariff. Across areas, Verizon's per-call charges fall in between the lower rates offered by AT&T and the higher MCI prices.

Virtually every household purchases a fixed line to their home. Penetration of landline phones in New York as of March for each year in our sample is 95.1% (1999), 96.1% (2000), 95.0% (2001) and 96.0% (2002). All of the plans offered in our sample require a fixed fee for at least local usage (if not for intraLATA toll usage). Once it subscribes to a plan and pays the fixed fee, a household faces a separate decision of whether to consume any minutes or not. We observe some households choosing not to consume any minutes in a given month, especially for intraLATA toll.

Of the 7,222 households in the sample, 5,233 subscribe to Verizon, 696 to AT&T, 362 to MCI, and 931 to Frontier Communications.[14] Due to reporting errors by TNS or other data issues, we are not able to use all available observations in our estimation. The sample observations with complete demographic and usage information total 4,947 (95%) for Verizon, 592 (85%) for AT&T, 225 (62%) for MCI, and 780 (84%) for Frontier.[15]

Table 3 compares the main demographic features, location, and provider choices of the households in the TNS sample to the New York state aggregate. The entrants' representation in the sample is similar to aggregate market shares for New York State. In 2001, for example, the New York State PSC reports market shares based on number of lines of 11.8% and 5.6% for AT&T and MCI respectively, while in the TNS sample for the same year, 12.2% of households are AT&T customers and 5.4% are MCI customers. The share of households who use an ILEC amounts to 79.0% in 2001 of which Verizon captures 80.8%. 48.1% of sample households live in the New York Metro region, similar to the distribution of the total New York State population. We include average household size and income as main proxies for usage and identify households who recently relocated and had to choose a new service provider by indicators of whether they moved in the past one

[14]547 households were not with one of the top five carriers and were dropped from the sample.

[15]The major reasons for excluding observations from the bill data included an obvious data entry error, the household subscribing to an obscure plan, billing for a partial month or unknown credits making it impossible to match the bill to a plan, the household switching plans in the middle of a month, multiple phone lines in the household, and bundling of long-distance and local service in the same plan. Bundling of local and long-distance service during the sample period is rare occuring only for 52 MCI households. Similarly, tariffs that bundle local service with other telecommunications services, such as DSL or cellular, are generally not available during the sample period. Based on the bill-level data alone, the usable observations include 601 AT&T, 226 MCI, 791 Frontier, and 5,021 Verizon households.

or five years. The household's average size in the TNS sample is not directly comparable to the New York State average since TNS truncates all households with more than five members. The income distribution is slightly skewed towards lower income households relative to the state's aggregate distribution.

Table 4 contains summary statistics for additional demographic variables used in the analysis. Apart from the above mentioned demographic characteristics that influence usage differences across households, we use information on other telecommunications products used by the household, such as whether at least one member of the household subscribes to wireless service or whether the household has access to the Internet at home. Furthermore, table 4 summarizes the households' long-distance provider choices in relation to their local provider choice, as well as whether the household receives a combined bill for local and long-distance service. Across incumbents and entrants, 38.3% of households use the same provider for local and long-distance service. This fraction is significantly higher for CLEC households, however; 87.8% of AT&T customers and 83.0% of MCI customers subscribe to these providers' long-distance services. In the data, we also observe whether households receive a single bill for local and long-distance service. New York CLECs and ILECs offer households an option to request that their long-distance service be billed through the local service provider on a single bill regardless of long-distance provider. Of the households who use an incumbent's local service, 77.4% of households elect this co-billing option. Furthermore, the entrants AT&T and MCI combine billing for 97.6% and 95.5%, respectively, of the sample households that use them as their local service provider.

4 Descriptive Results

A usual difficulty in assessing the effect of entry is controlling for the incumbents' response to entry. In our setting we take advantage of the fact that any response by the incumbent is regulated, as discussed in Section 2, and to first-order can be ignored. Cost effects on the supply-side of the industry are also minimal. Since the entrants lease the incumbent's infrastructure, the industry's overall cost structure remains unchanged. If the UNE rates are set correctly at cost by regulators, the incumbent does not determine the cost of entrants' provision. Aside from increased marketing expenditures and service costs (such as operators) by firms, entry has no effect on firms' costs of providing local service. Therefore, our approach is to model only demand-side decisions and assume that supply-side decisions are of second-order. Although we choose to ignore supply-side decisions, this does not imply that the effects on aggregate firm profits are of second-order as we discuss below.

The effects of entry on consumer welfare in our context can be decomposed into four components: 1) pure price effects (holding quantity of usage and quality of service constant), 2) effects of differences in quality between the incumbent and entrants, 3) changes in quantity of usage due to demand responses from price changes and 4) benefits from receiving a single bill for all telecommunications services. The first category represents a transfer from firms to consumers or vice-versa. The second involves an increase in consumer surplus (due to increased variety) but no change in aggregate firm profits (ignoring changes in marketing and service costs). Category 2 essentially quantifies the extent to which the firms' services are differentiated. The third category represents a decrease or increase in deadweight loss and the corresponding increase or decrease in consumer welfare and firm profits. The fourth category represents an increase in consumer welfare with little effect on firm profits (assuming the costs of producing a single bill are similar to that of producing separate bills). Finally, there are surplus transfers from the incumbent to the entrants.

While bundling of local and long-distance service into one tariff did not occur to a large extent during our sample, our welfare analysis recognizes two significant ways in which bundling of the two services under the same provider – as opposed to the same plan – are relevant. First, the entrants offered discounts to households that chose them for both services. This discount amounted to $1 for AT&T and $4.95 for MCI (from August 1999 to August 2000 only) during the sample period. We account for this in our estimation of the price effects. Second, households may place value on receiving a single bill for both services rather than two separate bills (category 4 benefits above). As discussed above, there are two instances in which we observe households receiving a single bill for local and long-distance service. First, households who use the same provider for local and long-distance service nearly always receive only one bill for the two services. Second, households may bill their long-distance service through their local service provider, even if the service providers differ and approximately 67% of ILEC households make use of this option.[16] Our data thus allows us to identify the value of a single bill to households separately from quality effects that may induce households to choose the same provider.

Estimating pure price effects (category 1) does not require a statistical model since, in the absence of quantity and quality effects, we simply calculate how much households who switched to the entrants would have paid on the incumbent plan optimal for that household. Estimating the quality, quantity and convenience effects (categories 2-4) requires estimating an econometric demand model that allows us to evaluate, in a counterfactual, what each category's contribution to welfare would be relative to the case where the entrants' plans are not available. Nevertheless, households' observed choice behavior after entry relative to before provides some evidence of the role that non-price effects may play in the demand for local service. We begin by analyzing the pure price effects and by motivating the need for allowing for firm quality effects in the econometric

[16]While a significant fraction of households bills their long-distance service through the ILEC, we obviously do not know whether all households are aware of this optional service, which may confound the convenience effect. The ILEC has, in principal, an incentive to promote the service, however, to gain additional information about their customers' usage patterns.

model discussed in section 5. We then provide descriptive evidence of the effects from the other three categories.

4.1 Price Effects

Ignoring quantity and quality effects, assessing the effects of entry on consumers is simply an accounting exercise. That is, assuming that consumers did not change their usage in response to price changes and ignoring any quality differences among firms, we can compute the effect of entry by simply comparing what households paid in the presence of the entrants to what they would have paid under the hypothetical that the firms had not entered. Since AT&T and MCI only entered in Verizon's regions, we include it as the only ILEC in our analysis.

In this counterfactual, we answer the question of how much New York State consumers have saved by the presence of the entrants assuming that they did not adjust their consumption and ignoring firm quality effects. Our methodology is to evaluate the amount of money that households that have switched to a CLEC would have paid to Verizon if they had remained with Verizon. This requires mapping the household to a specific Verizon plan based on its usage and evaluating the amount it would have paid to Verizon under that plan. We then calculate household savings as the difference between the amount it would have paid to Verizon and what it actually paid to the CLEC. Our comparisons are contemporaneous. For example, for a household that chose AT&T in January 2001, we compare the amount it paid to AT&T at that time with the amount it would have paid if it had been forced to choose among Verizon plans available at that same time.

We make three important assumptions in this counterfactual. First, we assume that households have chosen the optimal CLEC plan and would choose the optimal Verizon plan if they were on Verizon. We discuss the validity of this assumption below. Second, we assume that if a household chose a flat-rate plan on the CLEC it would also have chosen a flat-rate plan from Verizon. We must make this assumption because the TNS data does not provide usage data for households on flat-rate plans. Third, sometimes there was no Verizon plan comparable to the one chosen by the CLEC customer, forcing us to make assumptions about households' usage in these cases. This occurs for households in New York City where Verizon did not offer a flat-rate plan during our sample but AT&T and MCI did. In this case, the household must choose Verizon's metered plan under the counterfactual and we base their charges on estimated usage. The other instance of this is for households that chose AT&T's expanded LATA plan, which bundles local and intraLATA toll at a flat rate, a combination not offered by Verizon. In this case we assume that the households would choose Verizon's flat-rate plan for local usage. Since we do not know the households' intraLATA toll usage, we base our evaluation of how much they would pay on Verizon's intraLATA toll metered plan on estimated intraLATA toll usage.[17] Of the three assumptions, only the first one is necessary in our full model discussed in Section 5.

Table 5 presents the results of the counterfactual with the savings divided into categories based on their source. On average, households switching to AT&T saved $1.16 per month on their bill relative to subscribing to Verizon's optimal contemporaneous plan, ignoring quantity changes and quality differentials across firms.[18] Of this, $0.87 on average was due to buying both long-distance and local service from AT&T. AT&T offered a $1 discount to households who subscribed to AT&T for both local and long-distance services and 87% of the AT&T households in our sample did so. Another $0.53 was due to savings on vertical features purchased from AT&T which would have been more expensive on Verizon. Households on average lost money on combined basic charges for local and intraLATA toll service by switching to AT&T due to the higher prices charged by AT&T calling plans (see Tables 1 and 2). These statistics then suggest that households benefited on average by switching to AT&T because of the discounts for long distance and savings on vertical features, despite the higher basic service rates.

The results for MCI are similar although households saved less on average. The mean household switching to MCI saved $0.14 per month on its bill relative to subscribing to Verizon's optimal contemporaneous plan, ignoring as above quantity changes and quality differentials across firms. Households on average lost money on combined basic and intraLATA toll charges as well as on vertical features purchased from MCI. However, households that subscribed to both local and long distance service on MCI from August 1999 to August 2000 received a $4.95 discount leading to an average discount of $1.03 across all households. The mean sample household thus benefited by switching to MCI solely due to the long-distance discounts, but paid higher basic service rates and vertical features prices.

[17] Specifically, in the case of AT&T and MCI's flat-rate plans in New York City we first compute the breakeven number of minutes between the CLEC's flat-rate and metered plan. We then calculate the average usage of households in New York City prior to the entry of CLECs who consumed more than this threshold and assume that these households consumed this average. In the case of AT&T's expanded LATA plan, we compute the breakeven number of minutes between AT&T's flat-rate plan for local usage (intraLATA toll not included) and its expanded LATA plan which bundled local and intraLATA toll usage. We then calculate the average intraLATA toll usage of households prior to CLEC entry who consumed more than this threshold and assume that these households consumed this average.

[18] AT&T and MCI engage in additional promotional activities to induce households to switch or stay with the provider. The majority of such promotions is in the form of a discount applied to the household's bill for a certain number of billing periods if the household satisfies specific conditions of the promotion. Based on a comparison of the conditions of AT&T's promotions to the households' bills, none of the AT&T subscribers in the sample received such bill credits, even though a large share was, in principal, eligible to benefit from the promotion. To the extent that households benefited from off-bill promotions that were missing from the AT&T promotions data or received promotional discounts from MCI, any consumer welfare gains in this paper represent a lower bound on total consumer welfare gains from competition.

4.2 Quality Effects

In this subsection we offer evidence that differences in firm quality motivate households' choice of carriers after entry by AT&T and MCI. The average household savings on AT&T and MCI masks significant heterogeneity across households. Out of 601 households in our sample that chose AT&T, 335 households (56%) saved money by switching to AT&T. The average monthly savings for these households was $5.40 and the median savings were $4.44. Most of the households that saved money (279 or 83%) were in metropolitan regions. Of these 279 households, the vast majority were on one of AT&T's flat-rate plans – 199 were on AT&T's local flat-rate plan and 113 were on AT&T's expanded LATA flat-rate plan which bundled local and intraLATA toll service. 86 of the households live in New York City where Verizon did not offer flat-rate service. The balance were on AT&T's lifeline plan (11) or its metered plan (12).

For the 266 households that lost money by switching to AT&T, the average monthly loss was $4.18 or 25% of the price they would have paid on Verizon. These households were fairly evenly split between the metropolitan (157) and non-metropolitan regions (109) with only 9 households in New York City where Verizon did not offer a flat-rate plan. Most of these households were on AT&T's local flat-rate plan (212) but, unlike those saving money, very few were on AT&T's expanded LATA plan (13). The balance were on AT&T's metered plan (30) or Lifeline plan (11). For lack of a better word, we call switches that are not justified by price differences "mistakes." Below, we offer evidence that these may not be mistakes in the literal sense of the word, but that such provider choices are justified by perceived quality differences between AT&T and Verizon.

Out of the 226 households in our sample that chose MCI, 140 (62%) saved money by switching to MCI. The average monthly savings for these households was $3.23 and the median savings were $0.10. Of the 140 households that saved money, 87 (62%) lived in the metropolitan region. In terms of plan types, the majority of households that saved money subscribed to MCI's hybrid plan (89 households or 64%). The balance were on MCI's metered plan (34 or 24%) or its flat-rate plan (17 or 12%).

For the 86 households that lost money by switching to MCI, the average monthly loss was $4.89 or 20% of the price they would have paid on Verizon. The majority of these households lived in the metropolitan region (57 or 66%). Over half (45) of the households that lost money were on MCI's hybrid plan. The balance were on MCI's flat-rate plan (27 or 31%) and MCI's metered plan (14 or 16%).

To determine the source of these "mistakes," we compare the frequency and magnitude of "mistakes" made by households in choosing between firms to the frequency and magnitude of "mistakes" made in choosing plans within each firm. If "mistakes" are significantly more frequent across firms than within firms this is evidence that consumers' "mistakes" in choosing their provider are likely due to perceived differences in firm quality with associated differences in households' willingness to pay for such quality.

If, on the other hand, the within-firm "mistakes" overwhelm the across-firm "mistakes" this would be evidence that consumers face significant uncertainty about their usage after they have committed to a plan.

To assess the frequency and magnitude of "mistakes" made by households who remained with Verizon for their local service, we evaluate the amount of money that such households would have paid to AT&T if they had switched to AT&T at that time, conditional on AT&T offering service in their location. In our sample, 2656 Verizon household observations had the option to switch to AT&T based on their location. On average, these households saved $0.57 per month on their bill relative to subscribing to the optimal contemporaneous AT&T plan, ignoring quantity changes and quality differentials across firms. This is 3.2% of the $17.83 they would have paid on the optimal AT&T plan. As with the AT&T households, this average masks significant heterogeneity across households. Out of the 2656 households, 875 (33%) lost money by not switching to AT&T. The average monthly loss for these 875 households was $5.05 per month or 24% of the price they would have paid on the optimal AT&T plan.[19]

To assess within-firm "mistakes" we evaluate whether households that chose a metered plan from their provider would have been better off if they had chosen that provider's flat-rate plan, where available, given their usage for the month. To quantify the magnitude of the "mistake" we normalize the lost savings by the total cost of the flat-rate plan.

Table 6 summarizes the results of this analysis along with that from the across-firm analysis. As the table shows, although the average savings foregone as a percentage of total charges within firms is similar to that across firms, the frequency of "mistakes" across firms overwhelms the frequency of "mistakes" within firms (the t-statistics for difference in means are 7.70 and 2.82 for AT&T and Verizon respectively in comparing across and within-firm mean "mistakes."). This is evidence that consumers' perceptions of firm quality are more important than demand uncertainty or consumer irrationality in households' choices. Mistakes then mostly represent differences in willingness to pay for quality across households.

This is even more apparent for households that switched to AT&T's higher-priced flat-rate plan, which had precisely the same features as Verizon's flat-rate plan. Choosing a higher-priced flat-rate plan must be due to firm quality differences since it is higher priced regardless of usage. For metered plans, on the other hand, the decision may be affected by uncertainty in demand. Over 77% of households making "mistakes" were on flat-rate plans.[20] This is consistent with results in Miravete (2002b), who uses panel data to assess households' "mistakes." Miravete finds that households, on average, make the right tariff choices based on their actual consumption. In addition, he finds that

[19]We plan to perform a similar analysis for Verizon households that chose not to switch to MCI.

[20]A similar comparison can be made for MCI although it offered hybrid plans in addition to flat-rate plans. Over 31% of the households making "mistakes" in switching to MCI were on flat-rate plans. Another 52% were on hybrid plans.

households who make "mistakes" rapidly switch to the correct plan and that households switch in response to small possible reductions in their billed costs. Table 6 also provides evidence that consumer "inertia" in decision-making is not likely driving the "mistakes." Households who switch to AT&T, for example, are more likely to have made a "mistake" than households who took no action and remained with Verizon (t-statistic of 2.63), even though the fact that they actively searched for a new provider suggests that they are likely to be more price-sensitive and less prone to inertia than the remaining households.

Apart from willingness to pay for a higher quality service, there are several other potential explanations for why households might appear to choose the wrong service provider. Such explanations are generally related to the fact that there is a time lag between the household's plan choice, which occurs at the beginning of the billing period or earlier and their usage decision over the course of the billing period. For example, if due to inertia or switching costs, households base their plan choice on expected usage over a longer period (as opposed to month-by-month), a "mistake" or suboptimal plan choice in a given month may still be consistent with a correct overall choice, especially if there are anticipated usage fluctuations over the course of the period. A second explanation for such "mistaken" choices would be that some types of households are worse at predicting their usage at the beginning of the billing period than others. Firms, realizing this, may then target such households by offering appropriate plans. For example, a firm may offer a flat-rate plan to households that systematically overestimate their usage.[21]

To investigate the importance of such explanations in the context of local phone service, we estimate a set of probit models to analyze the extent to which households that make "mistakes" in switching to AT&T or MCI, or not switching to AT&T,[22] differ systematically in their characteristics from those households who do not make these mistakes. Table 7 displays the results from this estimation. A few variables are economically significant in predicting a "mistake" in switching to AT&T. Younger heads of household are 23% less likely, those who moved within the last year are 25% less likely and households that have a Black or Hispanic head of household are 25% less likely to make a "mistake." However, note that the variance explained by this probit is very low (likelihood ratio index of 0.0909).[23] The results for the MCI probit are similar. While each additional household member makes a household approximately 9% more likely to make a mistake and households with a different long distance provider than MCI and receiving a separate bill for their local and long distance service are 34% less likely to

[21]Another possibility is that households who chose to switch to a CLEC were households that were more likely to be on a suboptimal Verizon plan before they switched. While this could be true to some extent, over 77% of households making "mistakes" in switching to AT&T chose AT&T's flat-rate plan. If these households had previously chosen Verizon's flat-rate plan (the counterfactual comparison we made) in error, they must also have chosen the AT&T flat-rate plan in error since it is more expensive than the Verizon flat-rate plan.

[22]We plan to also estimate a probit for households not switching to MCI.

[23]We use McFadden's (1974) likelihood ratio index, defined as $LRI = 1 - \frac{ln[L_1]}{ln[L_0]}$, where L_0 is the log-likelihood computed with only a constant term and L_1 is the log-likelihood of the full model.

make a mistake, the variance explained by the probit is very low (likelihood ratio index of 0.1209). This is consistent with differences in perceived firm quality being important but consumers not being systematically fooled by the firms. The probit predicting "mistakes" in not switching to AT&T are similar in that some variables are economically significant in predicting "mistakes" (households with Internet service are 9% more likely, households that have a Black or Hispanic head of household are 16% and 13% more likely to make a "mistake," and larger households – 4% increase for each additional member – in not switching) but as in the CLEC regressions, very little variance in customer behavior is explained by their observable demographic characteristics (likelihood ratio index of 0.0530). To test the importance of learning, in an alternative unreported model, we included time since the CLEC's entry and time since a price change, both measured in days, as explanatory variables. The results indicate that for every 100 days since AT&T's entry, a household's likelihood of erroneously choosing AT&T decreases by 1.92%, providing statistically significant evidence of some extent of household learning. However, as before, the overall explanatory power of the model does not improve significantly, resulting in a likelihood ratio index of 0.12.

The probits in Table 7 also include monthly dummies and a dummy for September and October 2001. If the share of the variance explained by these dummy variables were large, it would be a sign that households choose calling plans based on expected usage over the course of the year as opposed to responding to seasonality in calling patterns by adjusting the optimal plan on a month-by-month basis (as we assume in our model in section 5). The monthly dummies only account for an increase in the likelihood ratio index from 0.0559 to 0.0909 in the AT&T customers' probit, from 0.0642 to 0.1209 in the MCI customers' probit and from 0.0444 to 0.0530 in the Verizon customers' probit. It appears that anticipated seasonal demand fluctuation are, therefore, not very important in driving incorrect provider choices, supporting the assumption of month-by-month optimization by households.

The other effect that entry could have on firm quality is to induce them to compete in the variety of vertical features they offer. During the time period of our sample, Verizon did not introduce any new vertical features.[24] Since vertical features are part of the infrastructure that AT&T and MCI lease from Verizon, this also implies that AT&T and MCI did not introduce any vertical features that Verizon did not offer. Entry could also have spurred changes in the variety of vertical features bundles offered. However, this does not appear to be the case in our sample. AT&T offered a single bundle of vertical features, the "Three Feature Package," which included Caller ID and the household's choice of two additional features from a list of features during the entire period of our sample. MCI did not offer any bundles of vertical features during our sample period. Verizon, on the other hand, offered four different bundling options: "Custom Calling Package" (which offered at least twelve different combinations of two or three features),

[24]This refers to features that were subscribed to by at least five households in our sample. We did not investigate features subscribed to less frequently.

"Value Pack" (which offered an unlimited number of features for a fixed price), "Call Manager Package" (which offered at least two different combinations of four features) and "Feature Combinations" (which offered at least seven different combinations of two to four features), offerings which also did not change during the sample period. Thus, entry did not expand either the range of vertical features offered or the households' choice of vertical features bundles.

Since the evidence points toward differences in firm quality as accounting for across-firm "mistakes" we allow for observed (and unobserved) firm quality effects in our econometric model and ignore inertia and demand uncertainty as being of second-order importance only.[25]

4.3 Quantity Effects

To obtain a preliminary estimate of the effect of entry on consumers' demand responses to price changes, we exploit the fact that AT&T's entry occurred in two major stages. We compare consumption by Verizon households before and after the second wave of AT&T entry (in August 2001) in areas that AT&T did not enter in its first wave of entry (in 1999).[26] This provides a before- and after-entry comparison of usage. We use changes in consumption between the same time periods (before versus after August 2001) in Rochester and Citizens' territories as a benchmark, since no major CLECs entered their territories during this time. While household behavior in their territories allows us to control for time trends in usage patterns, it does not allow us to control for quantity effects of changes in Verizon's prices over the sample period. To adequately control for relative price changes, we would need to observe households who were exposed to identical price changes, but did not have the option of choosing AT&T as a provider after August 2001. Since AT&T had entered the entire Verizon territory with its expansion in August 2001, such an experiment is not available to us. Similarly, since we are not able to observe usage on flat-rate plans, the quantity changes observed in the data are based on metered plan activity only.

Overall, consumption of local usage on metered plans decreased by more after entry relative to the change in consumption in Rochester's and Citizens' territories. On average, Verizon households consumed 8.4 fewer local calls after entry than before, while Citizens households consumed 3.0 additional calls and Rochester households 7.8 additional calls. These increases are statistically different from those for Verizon households at the 11.1% level for Citizens and the 7.1% level for Rochester in a one-tailed t-test. The consumption of intraLATA toll usage, on the other hand, increased more in Verizon's territory post-entry than it did in Rochester's and Citizens' territories. Verizon households

[25] One way to accommodate uncertainty in consumer usage in our model would be to base household choices on expected utitlity.

[26] MCI had entered Verizon's entire territory before the beginning of our sample period, precluding a similar analysis in its territories.

consumed 17.9 more minutes on average after entry, while intraLATA consumption fell by 0.3 minutes for Citizens households and increased by only 5.3 minutes on Rochester households, on average. These changes differ from Verizon households at the 0.01% level and 2.8% level, respectively, in a one-tailed t-test.

To the extent that changes in Citizens' and Rochester's territories represent what would have occurred in the absence of entry, local consumption by Verizon households decreased, while intraLATA usage increased with entry. There are two possible explanations for these patterns. First, the PSC approved a significant increase in Verizon's prices for basic service in March 2002, after a prior price reduction in October in 2000. At the same time, intraLATA toll prices fell effective June 2001 with the introduction of the Verizon's Sensible Minutes plan. The direction of the quantity changes observed in the data is consistent with them representing demand responses to these price changes. At the same time, the quantity changes do not control for higher-usage households being more likely to switch to AT&T in areas where Verizon does not offer a flat-rate plan. Verizon's overall mix of flat-rate and message-rate plans did not change significantly over the sample period. If it were to lose a similar proportion of high-usage customers to AT&T among both its flat-rate and its metered-rate customers, however, the average quantity consumed on metered plans would fall regardless. Our full model will estimate these quantity effects much more precisely.

4.4 Convenience Effects

As a result of the 1996 Act, the markets for different types of telecommunication services became better integrated by (eventually) allowing long-distance providers and ILECs to compete in each others' markets. Woroch (2002) predicts that as a result of such increased integration, new service offerings are likely to arise in the form of innovative bundles of services. While local competitors for the most part began to compete in bundled products (such as tariffs that combine local and long-distance service) only after our sample period, the ability to consolidate communication services under one provider may generate "one-stop-shopping" benefits to consumers. The magnitude of such benefits in the telecommunications setting has to date only been studied by Kridel and Taylor (1993) who estimate consumer response to the bundling of two custom-calling features.

The consolidation of services under one provider leads, most immediately, to a simplification of the household's financial planning to the extent that the household receives a single bill for both local and long-distance service. Consequently, we term such benefits to consolidation a "convenience effect" and assess the extent to which receiving a single bill for local and long-distance services drives the switching decision.

To determine what characteristics correlate with a household's switch to AT&T or MCI we estimate probit models to predict switching. The results are in Table 8. Relative to the small variance in households' incorrect provider choices explained by demographics above, household characteristics explain a significant fraction of the variance in their switching behavior (likelihood ratio index of 0.4701 for the AT&T customers' probit and 0.4419 for the MCI customers' probit). Several characteristics are statistically, if not necessarily practically, significant in explaining the switching decision in the AT&T regression. Households that have a cellular phone are 1% more likely to switch, households with a black head of household are 2% more likely to switch, each additional one thousand dollars of monthly income makes it 1% less likely to switch and each additional member of the household makes it 0.3% more likely to switch if they are outside New York city and 0.6% more likely to switch if they are in New York city (where Verizon does not offer a flat-rate plan). Prior work (Kling and Van Der Ploeg, 1990; and Miravete, 2002a) has found that lower income levels and larger household sizes correlate with a higher demand for local telecommunications service. Our results are thus consistent with higher-usage households being marginally more likely to choose AT&T's local service. The three most significant, both statistically and economically, characteristics are the interaction terms between long-distance provider and whether the household receives a common bill for its local and long-distance service. The omitted interaction term is AT&T as long-distance provider and single bill for local and long distance.

The results for these interaction terms are consistent with households that already use AT&T as their long-distance provider attributing a higher perceived quality to AT&T than other households (both interaction terms for not having AT&T as long-distance provider are significantly negative and therefore lower than the omitted variable). Alternatively, the results could be an indication that AT&T markets its local service more aggressively to households that subscribe to its long-distance service, assuming that these households had already chosen AT&T as their long-distance provider prior to the local provider choice. In addition, households who receive a single bill and have AT&T as their long-distance provider are the most likely to switch to AT&T for their local service, these being households that value a single bill and attribute a higher perceived quality to AT&T. Households that have AT&T as their long-distance provider but receive a separate bill are less likely to switch than those who receive a single bill, while households who do not have AT&T as their long-distance provider and have a single bill are very unlikely to switch. These results are consistent with households that value the tighter integration offered by co-billing switching to their preferred provider – to AT&T if they have AT&T for their long-distance service and to Verizon if not. Thus, whether a household receives a common bill and whether it has the same local and long-distance provider are the most important drivers of firms' perceived quality differences.

The results for MCI are similar. Only one demographic variable is significant: households with a head of household of other race are 2% more likely to switch to MCI. The interaction terms of long-distance provider and billing status are highly significant. The omitted interaction term is MCI as long-distance provider and single bill for local and long distance. There were no observations for which the household had a long distance provider other than MCI and received the same bill for local and long distance service.

The results for these interaction terms are again consistent with households who have chosen MCI as their long-distance provider having a higher perceived quality for MCI for local service than households who do not have MCI as their long-distance provider (both interaction terms for not having MCI as long-distance provider are significantly negative and therefore lower than the omitted variable). These results are also consistent with households that value a single bill choosing their preferred provider. Those households who receive a single bill and do not have MCI for their long-distance service are the least likely group to switch to MCI.

5 Econometric Model

5.1 Household Choice Problem

We consider households indexed by $i = 1, 2, ..., I$ in $m = 1, 2, ..., M$ markets. The households choose a plan from the set of available plans, indexed by $j = 1, 2, ..., J$, offered by firms $f = 1, 2, ..., F$ and the quantity of local minutes q^L_{ij} and intraLATA toll minutes q^T_{ij} they consume on the plan. To consume on plan j, consumers must pay a fixed fee, F_{jm}, a per-minute local price of p^L_{jm} and a per-minute intraLATA toll price of p^T_{jm}. Consumers spend the remainder of their income on an outside good z at price p_z.

Plans j are combinations of local and intraLATA toll tariffs since intraLATA toll service is added to local service at no additional fixed fee and households are forced to choose both types of service from the same provider. Households have a choice of up to three types of tariffs, "metered," "flat-rate," and "hybrid" tariffs. On a metered tariff, households pay $p_j > 0$ per minute regardless of total usage and pay a fixed fee of $F_j \geq 0$. On a flat-rate tariff, consumers pay nothing for usage ($p_j = 0$) but incur a fixed fee of $F_j > 0$. On hybrid tariffs, households pay a fixed fee $F_j > 0$ and pay nothing for usage below a threshold $\tilde{q}_j$ but pay $p_j > 0$ for usage above $\tilde{q}_j$. Due to the fixed fee and the fact that households can mix and match local and intraLATA toll tariffs at will, it is optimal for the household to consume on a single plan j. Households may combine a metered or a flat-rate tariff for local usage on either AT&T or Verizon with that carrier's metered intraLATA toll tariff (neither carrier offered a flat-rate intraLATA toll plan). This provides four plan options. In addition, AT&T offered an expanded LATA plan, which bundled minutes of local and intraLATA usage together, providing a fifth option for the household. The expanded LATA plan is the only true bundle of local and intraLATA service into one tariff available during the sample period.

We assume that across plans j, household i obtains utility of:

$$\begin{aligned} u(\psi_{ij}^L, \psi_{ij}^T, q_{ij}^L, q_{ij}^T, z) &= \left(\sum_{j=1}^{J} \psi_{ij}^L q_{ij}^L + \theta^L\right)^{\frac{\eta^L}{\eta}} \left(\sum_{j=1}^{J} \psi_{ij}^T q_{ij}^T + \theta^T\right)^{\frac{\eta^T}{\eta}} \quad (1) \\ &\left[z_i - \alpha^L \left(\sum_{j=1}^{J} q_{ij}^L + \frac{\theta^L}{\psi_{ij}^L}\right) - \alpha^T \left(\sum_{j=1}^{J} q_{ij}^T + \frac{\theta^T}{\psi_{ij}^T}\right)\right] \\ &+ \sum_{f=1}^{F}\sum_{j=1}^{J} \mathcal{I}_{j\in f}\zeta_{if}; \\ &\alpha^L, \alpha^T, \eta^L, \eta^T, \theta^L, \theta^T > 0;\ \eta = 1 - \eta^L - \eta^T > 0 \end{aligned}$$

where ψ_{ij}^S is household i's valuation for usage of type S on plan j, $S = \{L, T\}$, ζ_{if} is household i's perceived quality of firm f, $\mathcal{I}_{j\in f}$ equals one if plan j is offered by firm f and zero otherwise, and $\eta^L, \eta^T, \alpha^L, \alpha^T, \theta^L$ and θ^T are parameters to be estimated.

This utility function is the linear expenditure system (LES) utility function modified to fit the unique features of our data. The first term in parentheses is the utility obtained from local usage, the second term in parentheses the utility obtained from intraLATA toll usage and the third term in brackets the utility obtained from the outside good. The LES utility function is obtained when $\alpha^L = \alpha^T = 0$ in this third term. This modification of the LES utility function allows consumption of local and intraLATA toll to diminish the utility obtained from the outside good. That is, the more time the household spends on the phone the less time it has available to spend on other activities. This allows for satiation of demand on flat-rate plans since, at some point, the household spends so much time on the phone that it crowds out time spent on outside activities. The α parameters transform phone time into units of outside good consumption.

This utility function accommodates the main features that our data require and provides sufficient flexibility while providing tractable demand and indirect utility functions for estimation. First, the specification allows for bundling of local and intraLATA toll usage since each interacts with the other in the utility function. Second, it allows for the possibility of zero consumption (corner solution) for both goods as long as $\theta^L, \theta^T > 0$ since utility from the other good and the outside good does not vanish at zero consumption levels of either. Third, as noted above, finite consumption at a zero marginal price (satiation) for both goods is possible as long as $\alpha^L, \alpha^T > 0$; and the level of consumption depends on the household's valuation index.

The household's valuation index ψ determines the household's taste for phone usage relative to other households and therefore drives its choice of a flat-rate over a metered tariff for a given set of prices. Figure 4 demonstrates the indifference curves for an interior solution on a metered tariff, while Figure 5 an interior solution on a flat-rate tariff. The sole difference between the two scenarios is that the household whose choice is depicted in Figure 5 has a higher ψ and thus higher valuation of usage relative to the household depicted in Figure 4. We parameterize the valuation indexes by:

$$\psi_{ij}^S(x_i, \epsilon_i^S) = \exp(\nu_j^S + \beta^S x_i + \sigma_\psi^S \epsilon_i^S) \qquad S = \{L, T\} \tag{2}$$

where x_i is a vector of household characteristic for household i, ϵ_i^S captures unobserved (by the econometrician but not by the household) household tastes for local and intraLATA toll calls, and ν_j^L, ν_j^T, β^L, and β^T are vectors of parameters and σ_ψ^L and σ_ψ^T are variances to be estimated.[27] We assume that ϵ_i^L and ϵ_i^T are independently and identically distributed according to a standard Normal distribution.

Since we have household-level transaction data, we identify the unobserved firm quality by including observable household/firm characteristics and random effects at the household/firm level. We parameterize household i's perceived quality of firm f, ζ_{if}, by:

$$\zeta_{if} = \lambda w_{if} + \xi_{if} \tag{3}$$

where w_{if} is a vector of household/firm attributes, such as whether the household subscribes to long-distance service from the carrier that offers plan j, whether the household has recently moved, and whether the household receives a single bill for their local and long-distance service. ξ_{if} is the appropriate element of ξ_i, which is drawn from an F-dimensional multivariate normal with mean 0 and covariance matrix Σ_ξ, allowing for correlation in household tastes across the F firms.

Note that the unobservable components in ψ_{ij}^L and ψ_{ij}^T affect quantity consumed, but the discrete choice only indirectly. They vary only by household, but not by plan, through ϵ_i^L and ϵ_i^T. The unobservable component in ζ_{if}, on the other hand, affects only the discrete choice and not the quantity choice, and depends on both the household and the firm. This error structure assumes that there is no unobservable characteristic of the firm that affects the quantity choice since plans within the same firm offer access to the same quality of calls and service consumed. Unobservable characteristics of the firm, however, affect the discrete plan choice via ξ_{if}.

Households maximize utility subject to the budget constraint:

$$y_i \geq \sum_{j=1}^{J} p_{jm}^L q_{ij}^L + \sum_{j=1}^{J} p_{jm}^T q_{ij}^T + \sum_{j=1}^{J} \mathcal{I}_{ij} F_{jm} + z_i \tag{4}$$

where the price of the outside good, p_z, is normalized to one. Because of the various types of tariffs, a number of different conditional demand functions result, depending on the combination of tariff types into plans and the possibility of consuming zero minutes

[27] We could also easily include observable plan characteristics in the quality indexes. We plan to later incorporate measures of coverage of each plan.

of either of the services. Consider first a household who chooses a metered tariff for both local and intraLATA toll service. With strictly positive usage, the conditional ordinary demand functions are given by:

$$\hat{q}^L_{ij}(p^L_{jm}, p^T_{jm}, F_{jm}, y_i) = \frac{\eta^L}{(p^L_{jm} + \alpha^L)}\left[y_i - F_{jm} + \frac{\theta^L}{\psi^L_{ij}}p^L_{jm} + \frac{\theta^T}{\psi^T_{ij}}p^T_{jm}\right] - \frac{\theta^L}{\psi^L_{ij}} \quad (5)$$

and

$$\hat{q}^T_{ij}(p^L_{jm}, p^T_{jm}, F_{jm}, y_i) = \frac{\eta^T}{(p^T_{jm} + \alpha^T)}\left[y_i - F_{jm} + \frac{\theta^L}{\psi^L_{ij}}p^L_{jm} + \frac{\theta^T}{\psi^T_{ij}}p^T_{jm}\right] - \frac{\theta^T}{\psi^T_{ij}}.$$

Households who choose not to consume any minutes of intraLATA toll service (a corner solution with $\hat{q}^T_{ij} = 0$), on the other hand, have conditional demand for local usage of:[28]

$$\hat{q}^L_{ij}(p^L_{jm}, F_{jm}, y_i) = \frac{\eta^L}{(1-\eta^T)(p^L_{jm} + \alpha^L)}\left[y_i - F_{jm} + \frac{\theta^L}{\psi^L_{ij}}p^L_{jm} - \frac{\theta^T}{\psi^T_{ij}}\alpha^T\right] - \frac{\theta^L}{\psi^L_{ij}}. \quad (6)$$

A symmetric expression holds for intraLATA toll usage if the household chooses to consume zero minutes of local usage ($\hat{q}^L_{ij} = 0$).

Consider instead the demand of a household who consumes on a metered tariff for intraLATA toll, but chooses a flat-rate local tariff (or a hybrid local tariff on which it consumes less than the included number of minutes, $\tilde{q}_j$). The resulting conditional ordinary demand functions are now given by:[29]

$$\hat{q}^L_{ij}(p^L_{jm} = 0, p^T_{jm}, F_{jm}, y_i) = \frac{\eta^L}{\alpha^L}\left[y_i - F_{jm} + \frac{\theta^T}{\psi^T_{ij}}p^T_{jm}\right] - \frac{\theta^L}{\psi^L_{ij}} \quad (7)$$

and

$$\hat{q}^T_{ij}(p^L_{jm} = 0, p^T_{jm}, F_{jm}, y_i) = \frac{\eta^T}{(p^T_{jm} + \alpha^T)}\left[y_i - F_{jm} + \frac{\theta^T}{\psi^T_{ij}}p^T_{jm}\right] - \frac{\theta^T}{\psi^T_{ij}}.$$

If the household were now to also replace the intraLATA metered tariff by a flat-rate tariff, then the conditional ordinary demand functions are:

[28] If local consumption is on a flat-rate plan or on a hybrid plan with consumption below $\tilde{q}_j$, the conditional demand simplifies further to:

$$\hat{q}^L_{ij}(p^L_{jm} = 0, F_{jm}, y_i) = \frac{\eta^L}{(1-\eta^T)\alpha^L}[y_i - F_{jm} - \frac{\theta^T}{\psi^T_{ij}}\alpha^T] - \frac{\theta^L}{\psi^L_{ij}}$$

[29] A symmetric set of expressions holds if the household chooses a metered plan for local usage but a flat-rate intraLATA toll plan or a hybrid intraLATA toll plan on which it consumes less than the included number of minutes.

$$\hat{q}^L_{ij}(p^L_{jm} = 0, p^T_{jm} = 0, F_{jm}, y_i) = \frac{\eta^L}{\alpha^L}[y_i - F_{jm}] - \frac{\theta^L}{\psi^L_{ij}} \tag{8}$$

and

$$\hat{q}^T_{ij}(p^L_{jm} = 0, p^T_{jm} = 0, F_{jm}, y_i) = \frac{\eta^T}{\alpha^T}[y_i - F_{jm}] - \frac{\theta^T}{\psi^T_{ij}}.$$

The conditional demand functions correspond to those in Hanemann (1984) for the case of mutual exclusivity whereby each consumer chooses to consume a continuous quantity from a single provider. They differ from Hanemann's setup by allowing for firm quality and to accommodate both the fixed fee associated with two-part tariffs and finite purchases at a zero marginal price as observed under flat-rate tariffs.

Substituting these conditional demand functions into the household's utility function yields a set of conditional indirect utility functions that vary depending on the household's choice of plan type and usage patterns. For example, for household i with positive usage of local and intraLATA toll service on metered tariffs, the conditional indirect utility function is given by:

$$v_{ij}(p^L_{jm}, p^T_{jm}, F_{jm}, y_i) = \eta \left(\frac{\eta^L \psi^L_{ij}}{p^L_{jm} + \alpha^L}\right)^{\frac{\eta^L}{\eta}} \left(\frac{\eta^T \psi^T_{ij}}{p^T_{jm} + \alpha^T}\right)^{\frac{\eta^T}{\eta}} \left[y_i - F_{jm} + \frac{\theta^L}{\psi^L_{ij}} p^L_{jm} + \frac{\theta^T}{\psi^T_{ij}} p^T_{jm}\right]^{\frac{1}{\eta}} + \zeta_{if} \tag{9}$$

where, as before, $\eta = 1 - \eta^L - \eta^T$. Table A2 in the appendix summarizes the indirect utility functions that correspond to the remaining plan type (flat-rate, hybrid, metered) and usage level (zero and strictly positive) combinations.

Since vertical features represent a significant portion of savings from price effects, it is important that we accommodate them in the econometric model. There are too many possible combinations of vertical features offered to explicitly estimate their choice by households. Instead, we include their effect as "virtual income" in the budget constraint. We assume that each household consumes an identical bundle of vertical features regardless of which carrier or plan it chooses and adjust its budget constraint by the difference in prices for that bundle between the two firms. While obviously an approximation to the actual choice of vertical feature combinations by households, it is a relatively good approximation. Vertical features are part of the infrastructure that CLECs lease from the ILEC. Therefore, the vertical features offered by the ILEC are identical to those offered by the CLEC and the only difference between the two would be due to perceived firm quality, which we already allow for in the model. The key simplifying assumption then is that the choice of vertical features is the same regardless of price.

5.2 Estimation Procedure

The predictions from the model consist of an optimal plan choice and a corresponding usage choice for both local and intraLATA toll, as a function of the household's observable and unobservable characteristics and the plan's observable and unobservable attributes.

The household chooses the plan that maximizes its indirect utility, conditional on household- and firm-level unobservables:

$$\hat{\mathcal{I}}_{ij} = \begin{cases} 1 & \text{if} \quad v_{ij}(F_{jm}, p^L_{jm}, p^T_{jm}, y_i, x_i, w_{if} | \epsilon_i, \xi_{if}) \geq v_{ik}(.|\epsilon_i, \xi_{if}) \quad \forall k \neq j \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

Since the conditional indirect utility function 10 involves ϵ^L_i and ϵ^T_i in a nonlinear way, we integrate over the unobservables using simulation techniques. The sample analog of the household's expected plan choice is given by:

$$E[\hat{\mathcal{I}}_{ij} | F_{jm}, p^L_{jm}, p^T_{jm}, y_i, x_i, w_{if}] = \frac{1}{N} \sum_{n=1}^{N} \hat{\mathcal{I}}^n_{ij} \tag{11}$$

where n is a simulation draw from the distributions of the unobservables.

Integrating over the distribution of the household unobservables ϵ^L_i and ϵ^T_i, the model then predicts expected usage of local and intraLATA toll service for the optimal plan choice of:

$$E[\hat{q}^S_{ij} | \hat{\mathcal{I}}_{ij} = 1, F_{jm}, p^L_{jm}, p^T_{jm}, y_i, x_i, w_{if}] = \frac{1}{\sum \hat{\mathcal{I}}^n_{ij}} \sum_{n=1}^{N} \hat{q}^{S,n}_{ij} \hat{\mathcal{I}}^n_{ij} \qquad S = \{L, T\} \tag{12}$$

For each household we observe its plan choice denoted by indicator variable $\mathcal{I}_{ij}$, where $\mathcal{I}_{ij} = 1$ if plan j is chosen and 0 otherwise, its usage of local minutes on the chosen plan, q^L_{ij}, and its usage of intraLATA toll minutes, q^T_{ij}, on the chosen plan. We observe the quantity choice for households on metered plans and for households on hybrid plans who consume above the threshold, but do not observe it for those on flat-rate plans or for those on hybrid plans who consume below the threshold.

To estimate the parameters of the model, $\Theta = \{\theta^S, \eta^S, \alpha^S, \nu, \beta^S, \lambda, \sigma^S_\psi, \Sigma_\xi\}$, with $S = \{L, T\}$, we match the households' behavior, to the extent that it is observed, to the three sets of predictions generated by the model using a method-of-moments estimator.[30] The first set of moment conditions results from matching the I households' actual plan

[30] The use of maximum likelihood is difficult in this setup because of the continuous quantity choice, which would have to be discretized to apply a maximum likelihood framework.

choices to the ones predicted by the demand model. The remaining two sets of moment conditions then match the predicted usage on the chosen plan to the one observed in the data for both local and intraLATA toll service. This generates an additional $2I - H^L - H^T$ moments where H^L (H^T) denotes the number of households who chose a local (intraLATA) flat-rate plan or a local (intraLATA) hybrid plan and did not exceed the threshold usage. For these H^L (H^T) households, the usage is not observed in the data.

We combine the moments using a minimum distance estimator to minimize the sum of least square errors. We employ importance sampling to the discrete choice moment to avoid discontinuities in the objective function with respect to the parameters. The errors that are minimized in the estimation routine consist of choice prediction errors (the difference between the predicted choice probability and the actual choice) and quantity prediction errors (the difference between the average predicted quantity on the plan actually chosen and the actual quantity chosen) by household:

$$e_i^{\mathcal{I}} \equiv \sum_{j=1}^{J} (E[\hat{\mathcal{I}}_{ij}] - \mathcal{I}_{ij})\mathcal{I}_{ij} \qquad (13)$$

$$e_i^{L} \equiv \sum_{j=1}^{J} (E[\hat{q}_{ij}^{L}] - q_{ij}^{L})\mathcal{I}_{ij}$$

$$e_i^{T} \equiv \sum_{j=1}^{J} (E[\hat{q}_{ij}^{T}] - q_{ij}^{T})\mathcal{I}_{ij}.$$

The optimal parameters, which are obtained using a numerical minimization routine, minimize the objective function:

$$Q(\Theta) = e'(\Theta)W^{-1}e(\Theta) \qquad (14)$$

where e is the $(3I - H^L - H^T)$ column vector of prediction errors and W is the optimal weighting matrix. The appendix contains a more detailed description of the estimation algorithm.

5.3 Identification

Parameters in our model are, in general, identified by both the discrete and the continuous choice equations. Parameters outside of the valuation indexes (ψ_{ij}^L and ψ_{ij}^T) and perceived firm quality (ζ_{if}) are all identified by variation in the observed data which is common across households (i.e. after adjusting the households' valuations by their index). The θ parameters (θ^L and θ^T) are identified by the fact that households with similar characteristics face different local and intraLATA toll prices across plans, firms and time. As can be seen in equation 5, both cross-price and own-price responses in demand to these varying prices help to identify the θ parameters. The η parameters (η^L and η^T) are identified primarily by variation in incomes across households. As can be seen from equation 5, for a fixed set of prices for local and intraLATA toll usage, demand responses across households with different incomes depend on η^L and η^T. Since we do not observe the quantity choices of households on flat-rate plans, the α parameters (α^L and α^T) are identified by observing households with the same characteristics in different markets facing different relative prices for flat-rate and metered plans. Intuitively, the discrete choice of a flat-rate plan places an upper bound on α because the household must choose a quantity great enough that the indirect utility from a flat-rate plan exceeds that of a metered plan. A lower bound on α is determined by the quantity choices of households with the same characteristics in other markets (with different relative prices for flat and metered plans) choosing a metered plan. With sufficient per-minute price variation in metered plans close to zero across different markets, these bounds become closer to each other and the α's are more precisely identified. Of course, with less variation in marginal prices near z ero, the α's will be less precisely estimated.

The parameters within the valuation indexes and perceived firm quality are identified by variation in household and household/firm characteristics. The vector of ν parameters measures the common component of households' quantity choices on a particular plan and is identified, as with any fixed-effect, by observing multiple households choosing the same plan. Heterogeneity in household characteristics identifies the vector of β parameters. Households with different characteristics consume different quantities on the same plan. The λ parameters are identified by variation in household/firm characteristics (such as separate billing for local and long-distance) across household/firm combinations. These different household/firm characteristics lead to different choices of firms' plans by households even at equivalent prices across the firms. The covariance parameters are identified by the unexplained variance in quantities of usage (for σ_ψ) and the unexplained variance in plan choices across firms (for Σ_ξ). These allow us to measure how well the observable characteristics explain plan choices and consumption by households.

5.4 Results

[TO DO]

5.5 Consumer Welfare Gains from Entry

After estimating the model on our data of actual choices made by a random sample of New York State households, we perform a counterfactual in which only the incumbent's plans are available to the households. Households then choose the optimal plan available from the ILEC and we can compare the indirect utility obtained under the full range of choices relative to the restricted ILEC-only choices.

The detailed demand model allows us to decompose consumer welfare changes into price, quantity, quality, and convenience effects, the four types of welfare changes due to entry discussed above.[31] Estimating the counterfactual while shutting down any quality effects (not allowing for observed or unobserved firm quality differences) provides an estimate of price and quantity effects together. Quantity effects can then be obtained by subtracting the price effects estimated in section 4.1. Similarly, estimating the counterfactual while shutting down any quantity effect (allowing for only a discrete choice and holding the quantity choice constant) provides an estimate of the combined price and quality effects. Quality effects can then be obtained by netting out the price effects. Last, convenience effects due to a single bill can be estimated by comparing estimates of the model with and without benefits of a single bill included in the firm quality measures.

To test the sensitivity of our estimates to the regulators' choices, we estimate the counterfactual under two different assumptions. First, we use the ILEC's contemporaneous plans. This assumes that the ILEC's prices have not been influenced by entry. Second, we use the ILEC's plans prior to entry. This assumes that the regulator would not have changed the incumbent's plans in the absence of entry. Since Verizon's plans did not change that significantly since entry (see Tables 1 and 2) the difference is not great in this case.

[TO DO]

6 Conclusion

A major goal of the 1996 Telecommunications Act was to encourage entry into local phone service with the objectives of achieving better alignment between prices and costs, increased service quality, increased variety of service offerings and efficiency gains in the form of "one-stop shopping" across different telecommunications services. In this paper, we develop a model to carefully measure the effect of each of these goals by evaluating its effect on consumer welfare. We develop an econometric model to decompose consumer welfare effects into price effects, quantity effects due to price changes, quality effects in the form of differentiated service providers and convenience effects from receiving a single bill for local and long-distance service. We apply this model to a random sample of households in New York State to quantify the impact of entry in that state on consumer welfare.

While we have not completed estimation of the full econometric model, we find

[31] To the extent that Verizon introduces new plans as a result of the increased competition, this will not be measured by our model. As we noted earlier, there has been relatively little change in Verizon's offerings since entry up to 2003.

preliminary evidence that on average consumers benefited from price reductions due to AT&T and MCI's entry into local phone service and that consumption of local usage declined while intraLATA toll usage increased in response to these price changes. We also find significant evidence that households benefited from quality differences between the incumbent's services and the new entrants' and from the convenience of receiving a single bill for local and long-distance service while being able to choose its favorite carrier for both. Estimation of the full model will more precisely measure each of these effects.

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Table 1. Local Calling Plans

	Variable	Mean	Std. Dev.	Min	Max	Obs (day x area)
Metered Tariffs – Fixed Fee[1]						
Verizon	F_L overall	6.81	0.7680	6.11	8.61	N = 2800
	across geographic areas		0.0476	6.49	7.14	n = 2
	within areas over time		0.7667	6.11	8.29	T = 1400
AT&T	F_L overall	7.52	1.4216	6.50	9.50	N = 1400
MCI	F_L overall	6.31	0.1591	6.27	6.99	N = 1400
Metered Tariffs – Per-Call Prices						
Verizon	p_L overall	0.09	0.0110	0.08	0.11	N = 2800
	across geographic areas		0.0094	0.08	0.10	n = 2
	within areas over time		0.0088	0.08	0.10	T = 1400
AT&T	p_L overall	0.10	0.0142	0.09	0.12	N = 1400
MCI	p_L overall	0.10	0	0.10	0.10	N = 1400
Flat-Rate Tariffs – Fixed Fee[1]						
Verizon	F_L overall	15.92	2.7809	11.96	22.61	N = 7000
	across geographic areas		2.9471	12.70	20.39	n = 5
	within areas over time		0.8854	15.17	20.02	T = 1400
AT&T[2]	F_L overall	21.45	1.5003	19.95	22.95	N = 2800
	across geographic areas		2.1213	19.95	22.95	n = 2
MCI[3]	F_L overall	20.18	1.9907	16.60	21.99	N = 2338
	across geographic areas		2.1325	18.97	21.99	n = 2
	within areas over time		1.3330	17.81	23.20	T-bar = 1169

[1] Verizon's lifeline consumers receive a $1 discount off quoted metered rates; lifeline flat-rate tariffs range from $7.85 to $15.56, depending on the household's location. AT&T awards lifeline customers a $4.60 discount off quoted rates on flat-rate tariffs. MCI's lifeline customers receive a $1 discount off quoted rates.

[2] Flat-rate plans include 4500 minutes until March 2002 with a per-minute price for usage above 4500 minutes of $0.02 and unlimited minutes at zero per-minute prices afterwards.

[3] Until Sept. 2000, MCI offered an additional local calling plan in the form of a hybrid tariff with an included allowance of 100 calls for $14.99 in non-metro areas and $19.99 in metro areas with per-call rates for usage beyond 100 calls set at $0.05.

Table 2. Intra-LATA Calling Plans

	Variable	Mean	Std. Dev.	Min	Max	Obs (day x area)
Metered Tariffs – Per-Call Prices						
Verizon	p_T overall	0.40	0.0831	0.27	0.54	N = 5600
	across geographic areas		0.0298	0.37	0.44	n = 4
	within areas over time		0.0790	0.23	0.54	T = 1400
AT&T[1]	p_T overall	0.32	0.0541	0.27	0.38	N = 2800
	across geographic areas		0.0765	0.27	0.38	n = 2
MCI	p_T overall	0.68	0	0.68	0.68	N = 1400

[1] From Nov. 2001 onwards, AT&T offers in addition the expanded LATA calling plan, which bundles local and intra-LATA toll usage at a flat rate of $24.95 in metro areas and $27.95 in non-metro areas.

Table 3. Comparison of TNS Sample and New York State Average

	TNS Sample	New York State
HOUSEHOLD CHARACTERISTICS		
Average Size	2.14[1]	2.61
Income (%)		
Less than $10,000	11.41	11.50
$10,000 to $14,999	10.30	6.40
$15,000 to $24,999	15.95	11.70
$25,000 to $34,999	14.33	11.40
$35,000 to $49,999	14.63	14.80
$50,000 to $74,999	16.05	18.40
$75,000 to $99,999	9.18	10.60
$100,000 or more	8.14	15.30
Moved in Past 5 Years (%)	26.90	34.20
HOUSEHOLD LOCATION (%)		
In Verizon Metro Region	48.09	44.61
In Verizon Territory	84.29	88.89
LOCAL CARRIER CHOICE (%, 2001)		
ILEC	78.98	77.52
Verizon New York	63.82	67.43
CLEC	21.02	22.48
AT&T Local	12.24	11.77
MCI Local	5.40	5.58

[1] Household size truncated at 5 or more members in the household.

Sources: TNS Telecoms; Census 2000; FCC, "Local Telephone Competition: Status as of June 30, 2003" (ILEC share); New York State PSC, "Analysis of Local Exchange Service Competition in New York State," Dec. 31 2001 (AT&T, MCI and Verizon shares).

Table 4. Descriptive Statistics – Demographic Variables

Variable	Obs	Min	Mean	Max	S.D.	Description
CELLULAR	6122	0	0.404	1	0.491	At least one cellular phone in hh
INTERNET	6544	0	0.431	1	0.495	Internet access at home
HHSIZE	6544	1	2.142	5	1.217	Number of people in hh
AGE1	6544	0	0.123	1	0.327	Head of hh between 15 and 34 years old
AGE2	6544	0	0.371	1	0.483	Head of hh between 35 and 54 years old
AGE3	6544	0	0.498	1	0.500	Head of hh above 54 years old
TEENS	6544	0	0.096	1	0.295	At least one teenager in hh
INCOME	6544	0.425	4.010	12.860	3.420	Monthly household income (000)
BLACK	6544	0	0.060	1	0.234	Head of hh is black
RACEO	6544	0	0.049	1	0.216	Head of hh is not white or black
HISPANIC	6544	0	0.050	1	0.218	Head of hh is Hispanic
COLLEGE	6438	0	0.310	1	0.462	Head of hh at least college graduate
MOVED1Y	5224	0	0.060	1	0.237	Hh moved within last year
NYCITY	6544	0	0.156	1	0.363	Hh lives in New York city
SAMLD	6544	0	0.376	1	0.485	Hh has same local and long-distance carrier
AT&T	592	0	0.880	1	0.325	
FRONTIER	780	0	0.286	1	0.452	
MCI	225	0	0.853	1	0.355	
VERIZON	4947	0	0.309	1	0.462	
SEPBILL	4604	0	0.196	1	0.397	Hh billed separately for local and long distance
AT&T	509	0	0.024	1	0.152	
FRONTIER	622	0	0.230	1	0.421	
MCI	201	0	0.055	1	0.228	
VERIZON	3272	0	0.225	1	0.418	

Table 5. Monthly Average Savings of CLEC Customers over Verizon Local Service N = 601 for AT&T, N = 226 for MCI

Category	Total Charge	Total Savings over Verizon	Percentage Savings*
Basic Charges on AT&T	$23.25	-$0.24	-0.9%
Vertical Features Charges on AT&T	3.16	0.53	2.0%
Buying long distance from same company		0.87	3.3%
Total Savings		1.16	4.3%
(Std. Err.)		(9.21)	
Basic Charges on MCI	$19.92	-$0.81	-3.8%
Vertical Features Charges on MCI	2.09	-0.07	-0.3%
Buying long distance from same company		1.03	4.9%
Total Savings		0.14	0.7%
(Std. Err.)		(5.66)	

* As percentage of average total Verizon charges ($26.69 for AT&T analysis, $21.12 for MCI analysis).

Table 6. "Mistakes" Made by Households

	Switching to AT&T[1]	Switching to MCI[1]	Not Switching to AT&T[2]	Within AT&T[3]	Within Verizon[4]
Frequency	0.539	0.425	0.330	0.119	0.161
(Std. Err.)	(0.499)	(0.497)	(0.470)	(0.328)	(0.368)
Mean	-0.250	-0.165	-0.241	-0.380	-0.232
S.D.	0.415	0.121	0.354	0.298	0.160
Median	-0.198	-0.155	-0.112	-0.465	-0.209
Min	-6.410	-0.545	-3.000	-0.783	-0.708
Max	-0.000	-0.004	-0.001	-0.011	-0.001
N	601	226	2656	42	1579

[1] As fraction of what would have paid on Verizon.
[2] As fraction of what would have paid on optimal AT&T plan.
[3] As fraction of what would have paid on optimal AT&T flat rate plan.
[4] As fraction of what would have paid on optimal Verizon flat rate plan.

Table 7. Probit Estimates of "Mistaken" Provider Choice

	"Mistaken" Provider Choice Y/N					
	AT&T Customers		Verizon Customers		MCI Customers	
Variable	Coeff. (Std. Err.)	Marginal Effects#	Coeff. (Std. Err.)	Marginal Effects#	Coeff. (Std. Err.)	Marginal Effects#
INTERNET	0.1941	0.0769	0.2667 ***	0.0962	0.1932	0.0751
	(0.1220)		(0.0620)		(0.2236)	
CELLULAR	-0.1289	-0.0511	0.0557	0.0200	-0.0994	-0.0386
	(0.1207)		(0.0606)		(0.2027)	
HHSIZE	-0.0495	-0.0197	0.1155 ***	0.0415	0.2368 **	0.0921
	(0.0518)		(0.0243)		(0.0943)	
INCOME	-0.0367 **	-0.0146	0.0022	0.0008	-0.0253	-0.0098
	(0.0186)		(0.0086)		(0.0324)	
AGE (15 – 34)	-0.5930 ***	-0.2307	0.1518	0.0559	0.0648	0.0253
	(0.2164)		(0.0929)		(0.3290)	
AGE (35 – 54)	-0.0750	-0.0298	0.0264	0.0095	0.0706	0.0275
	(0.1401)		(0.0609)		(0.2126)	
MOVED1Y	-0.6455 **	-0.2482	0.1201	0.0441	0.2016	0.0796
	(0.3111)		(0.1236)		(0.5139)	
BLACK	-0.6741 ***	-0.2598	0.4249 ***	0.1621	0.0912	0.0357
	(0.2085)		(0.1009)		(0.3757)	
HISPANIC	-0.6533 **	-0.2511	0.3327 ***	0.1259	-0.5642	-0.1991
	(0.3247)		(0.1141)		(0.5306)	
RACEO	-0.1287	-0.0513	0.2228 *	0.0832	0.2766	0.1092
	(0.3410)		(0.1214)		(0.4182)	
(1-SAMLD) *SEPBILL	0.2103	0.0821			-1.1848 **	-0.3437
	(0.4498)				(0.5851)	
(1-SAMLD) *SAMBILL	-0.0739	-0.0294			-0.6933	-0.2401
	(0.2403)				(0.4759)	
SAMBILL			-0.0196	-0.0070		
			(0.0892)			
SAMLD			-0.1076 *	-0.0384		
			(0.0615)			
N	592		2616		225	
Log-Likelihood	-371.4		-1575.0		-135.0	
p-value	0.0000		0.0000		0.0424	
Likelihood Ratio Index	0.0909		0.0530		0.1209	

Monthly dummies and a dummy for September and October 2001 included in the estimation. March and December dummy variables are not included in the MCI regression as they predict failure and success (respectively) perfectly. Dummy variables are included to control for missing data for the MOVED1Y and SEPBILL variables. In the AT&T and MCI regressions, SAMLD*SEPBILL is the omitted variable for the interaction terms (SAMLD*(1-SEPBILL) did not vary within the sample for either AT&T or MCI.). * Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level. # For discrete variables, marginal effects refer to a discrete change from 0 to 1.

Table 8. Probit Estimates of Switching to CLEC

	Y = Switched to AT&T N = 5539		Y = Switched to MCI N = 5172	
Variable	Coeff. Std. Err.	Marginal Effects #	Coeff. Std. Err.	Marginal Effects #
INTERNET	0.1082	0.0055	-0.0875	-0.0017
	(0.0725)		(0.1025)	
CELLULAR	0.1739 **	0.0091	0.0815	0.0166
	(0.0712)		(0.0978)	
NYCITY	-0.3025 *	-0.0124	0.1784	0.0041
	(0.1705)		(0.2198)	
HHSIZE	0.0597 *	0.0030	0.0160	0.0003
	(0.0320)		(0.0442)	
NYCITY*	0.1218 *	0.0061	-0.1185	-0.0023
HHSIZE	(0.0671)		(0.1026)	
INCOME	-0.0236 **	-0.0012	-0.0107	-0.0002
	(0.0109)		(0.0149)	
AGE (15 – 34)	-0.0317	-0.0015	0.0480	0.0010
	(0.1157)		(0.1444)	
AGE (35 – 54)	-0.0971	-0.0047	-0.1080	-0.0021
	(0.0744)		(0.0994)	
MOVED1Y	-0.1179	-0.0053	-0.1371	-0.0023
	(0.1560)		(0.2309)	
BLACK	0.3013 **	0.0196	0.1354	0.0031
	(0.1253)		(0.1894)	
HISPANIC	-0.2327	-0.0094	-0.0724	-0.0013
	(0.1697)		(0.2137)	
RACEO	-0.3011	-0.0114	0.5596 ***	0.0208
	(0.1886)		(0.1676)	
SAMLD*	-3.2444 ***	-0.0372		
SEPBILL	(0.3366)			
(1 - SAMLD)*	-2.1791 ***	-0.0260	-1.8608 ***	-0.0122
SEPBILL	(0.1622)		(0.1446)	
(1 - SAMLD)*	-1.8239 ***	-0.1541	-2.1079 ***	-0.2041
(1 - SEPBILL)	(0.0697)		(0.1114)	
Log-Likelihood	-997.7		-516.5	
p-value	0.0000		0.0000	
Likelihood Ratio Index	0.4701		0.4419	

SAMLD*(1 - SEPBILL) is the omitted variable for the interaction terms. Dummy variables are included to control for missing data for the MOVED1Y, SEPBILL and SAMLD variables. There was no data for SAMLD*SEPBILL for the MCI regression.

∗ Significant at the 10% level.

∗∗ Significant at the 5% level.

∗ ∗ ∗ Significant at the 1% level.

For discrete variables, marginal effects refer to a discrete change from 0 to 1.

Figure 1: Incumbent Local Exchange Carriers, New York State

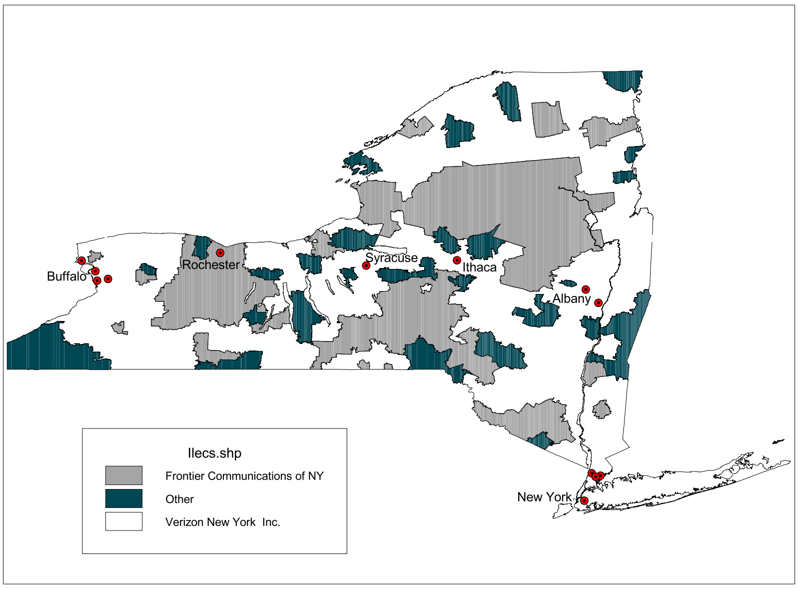


Figure 2: AT&T's Entry into Local Service, New York State, 1999

Figure 3: AT&T's Entry into Local Service, New York State, 2001

Figure 4: Demand for Minutes of Local Telecom Service
Case 1 - Interior Solution on a Metered Plan

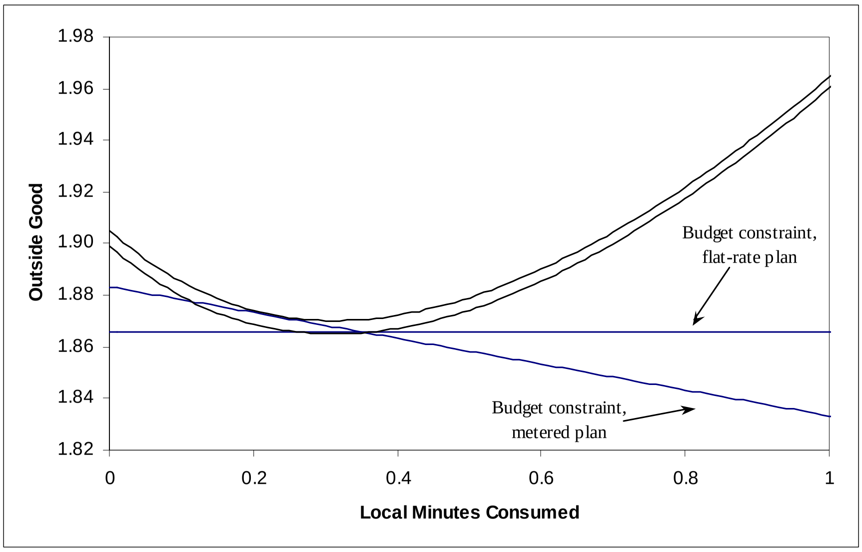
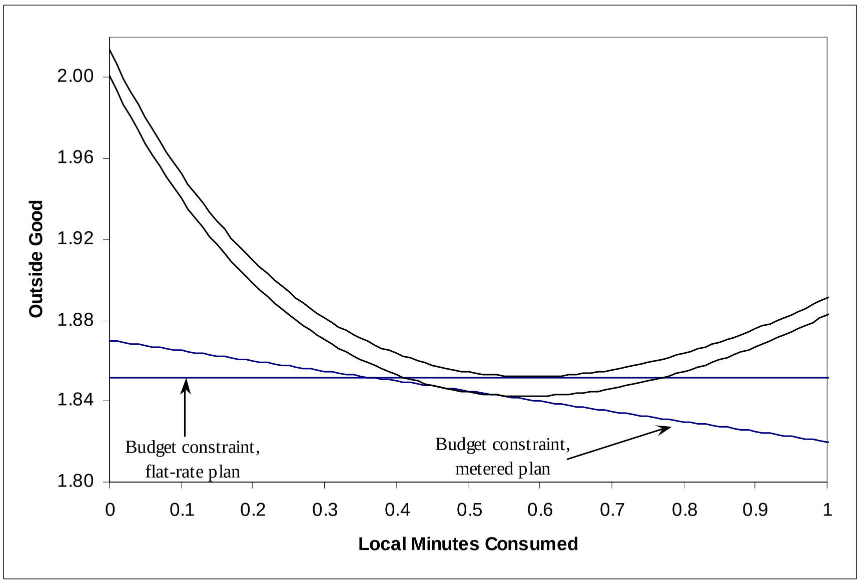


Figure 5: Demand for Minutes of Local Telecom Service
Case 2 - Interior Solution on a Flat Rate Plan



The utility function parameters are set to the following values: $\alpha^L = 0.5$, $\alpha^T = 0.5$, $\theta^L = 1$, $\theta^T = 1$, $\psi^L = 1.4$, $\psi^T = 1.4$, $\eta^L = 0.33$, $\eta^T = 0.33$, and ncome $y = 2$. For the flat-rate plan, F equals 0.12, $p^L = 0.05$, and $p^T = 0$. For the metered plan, F equals 0.1, and $p^L = p^T = 0.05$. Consumption of intraLATA toll minutes is held constant at the optimum value of 0.60 on the metered plan and 0.57 on the flat-rate plan.

8 Appendix

8.1 Estimation of Income

The TNS demogrpahic survey contains a categorical measure of annual household income, placing each household into one of 16 income brackets. To transform these income categories into a single, empirically more convenient measure, we assume that household income is distributed according to a log normal distribution with mean μ and standard deviation σ. The parameters of the distribution are estimated via maximum likelihood, weighting the probability of household income falling into each of the 16 income categories by the frequency with which the category is observed in the data. The continuous income for a household in a particular income category is then derived as the expected conditional value of income for that category based on the estimated log-normal distribution. The resulting income levels are presented in table A1.

Table A1. Parameter Estimates and Conditional Expected Values Empirical Distribution of Household Income

Parameter	Coefficient	Std. Error
μ	10.3712	0.0102
σ	0.9083	0.0083
N	8288	
Log-Likelihood	-22854.72	

Income Category	Frequency	Expected Income
0 – 7,500	511	5,099
7,500 – 9,999	434	8,755
10,000 – 12,499	472	11,239
12,500 – 14,999	382	13,732
15,000 – 19,999	583	17,409
20,000 – 24,999	739	22,401
25,000 – 29,999	595	27,400
30,000 – 34,999	593	32,403
35,000 – 39,999	442	37,406
40,000 – 44,999	423	42,410
45,000 – 49,999	348	47,413
50,000 – 59,999	630	54,673
60,000 – 69,999	400	64,698
70,000 – 74,999	300	72,428
75,000 – 99,999	761	85,887
$\geq$100,000	675	154,315

8.2 Indirect Utility Functions

Table A2. Indirect Utility Functions

Plan Type	Consumption	Indirect Utility Function
Local Metered	+	$v_{ij}(p^L_{jm}, F_{jm}, y_i) =$
IntraLATA Metered	0	$\frac{\eta}{1-\eta^T}\left(\frac{\eta^L\psi^L_{ij}}{(1-\eta^T)(p^L_j+\alpha^L)}\right)^{\frac{\eta^L}{\eta}} \theta^{T\frac{\eta^T}{\eta}} \left[y_i - F_{jm} + \frac{\theta^L p^L_{jm}}{\psi^L_{ij}} - \frac{\theta^T\alpha^T}{\psi^T_{ij}}\right]^{\frac{1-\eta^T}{\eta}} + \zeta_{if}$
Local Metered	0	$v_{ij}(p^T_{jm}, F_{jm}, y_i) =$
IntraLATA Metered	+	$\frac{\eta}{1-\eta^L}\left(\frac{\eta^T\psi^T_{ij}}{(1-\eta^L)(p^T_j+\alpha^T)}\right)^{\frac{\eta^T}{\eta}} \theta^{L\frac{\eta^L}{\eta}} \left[y_i - F_{jm} + \frac{\theta^T p^T_{jm}}{\psi^T_{ij}} - \frac{\theta^L\alpha^L}{\psi^L_{ij}}\right]^{\frac{1-\eta^L}{\eta}} + \zeta_{if}$
Local Flat-Rate*	+	$v_{ij}(p^L_{jm} = 0, p^T_{jm}, F_{jm}, y_i) =$
IntraLATA Metered	+	$\eta\left(\frac{\eta^L\psi^L_{ij}}{\alpha^L}\right)^{\frac{\eta^L}{\eta}}\left(\frac{\eta^T\psi^T_{ij}}{p^T_{jm}+\alpha^T}\right)^{\frac{\eta^T}{\eta}}\left[y_i - F_{jm} + \frac{\theta^T p^T_{jm}}{\psi^T_{ij}}\right]^{\frac{1}{\eta}} + \zeta_{if}$
Local Flat-Rate*	+	$v_{ij}(p^L_{jm} = 0, F_{jm}, y_i) =$
IntraLATA Metered	0	$\frac{\eta}{1-\eta^T}\left(\frac{\eta^L\psi^L_{ij}}{(1-\eta^T)\alpha^L}\right)^{\frac{\eta^L}{\eta}} \theta^{T\frac{\eta^T}{\eta}} \left[y_i - F_{jm} - \frac{\theta^T\alpha^T}{\psi^T_{ij}}\right]^{\frac{1-\eta^T}{\eta}} + \zeta_{if}$
Local Metered	+	$v_{ij}(p^L_{jm}, p^T_{jm} = 0, F_{jm}, y_i) =$
IntraLATA Flat-Rate*	+	$\eta\left(\frac{\eta^T\psi^T_{ij}}{\alpha^T}\right)^{\frac{\eta^T}{\eta}}\left(\frac{\eta^L\psi^L_{ij}}{p^L_{jm}+\alpha^L}\right)^{\frac{\eta^L}{\eta}}\left[y_i - F_{jm} + \frac{\theta^L p^L_{jm}}{\psi^L_{ij}}\right]^{\frac{1}{\eta}} + \zeta_{if}$
Local Metered	0	$v_{ij}(p^T_{jm} = 0, F_{jm}, y_i) =$
IntraLATA Flat-Rate*	+	$\frac{\eta}{1-\eta^L}\left(\frac{\eta^T\psi^T_{ij}}{(1-\eta^L)\alpha^T}\right)^{\frac{\eta^T}{\eta}} \theta^{L\frac{\eta^L}{\eta}} \left[y_i - F_{jm} - \frac{\theta^L\alpha^L}{\psi^L_{ij}}\right]^{\frac{1-\eta^L}{\eta}} + \zeta_{if}$
Local Flat-Rate*	+	$v_{ij}(p^L_{jm} = 0, p^T_{jm} = 0, F_{jm}, y_i) =$
IntraLATA Flat-Rate*	+	$\eta\left(\frac{\eta^L\psi^L_{ij}}{\alpha^L}\right)^{\frac{\eta^L}{\eta}}\left(\frac{\eta^T\psi^T_{ij}}{\alpha^T}\right)^{\frac{\eta^T}{\eta}}[y_i - F_{jm}]^{\frac{1}{\eta}} + \zeta_{if}$

* or hybrid plan with $\hat{q}^S_{ij} < \tilde{q}_j$, $S = \{L, T\}$. $\eta = 1 - \eta^L - \eta^T$.

8.3 Estimation Algorithm

The estimation consists of using the demand model to predict each household's optimal plan and quantity choices and match them to the household's actual choices using a minimum-distance estimator. The estimation procedure works as follows:

1. Computing predicted plan choices and usage levels involves integrating over the distribution of the household and household/firm unobservables. Draw a vector of N errors from a univariate standard Normal distribution for each household and another N from an F-dimensional standard Normal distribution for the household/firm combination. These values are held constant through all iterations of the estimation routine and represent the errors we need to integrate over. N should be chosen to sufficiently reduce simulation error.
2. Assume starting values for the parameters:
   $\Theta^0 = \{\theta^{L,0}, \theta^{T,0}, \eta^{L,0}, \eta^{T,0}, \alpha^{L,0}, \alpha^{T,0}, \nu^0, \beta^{L,0}, \beta^{T,0}, \lambda^0, \sigma_\psi^{L,0}, \sigma_\psi^{T,0}, \Sigma_\xi^0\}$.
3. Compute the predicted plan choice probabilities and predicted consumption quantities on each plan for each household at the current parameter estimates via simulation.
   (a) For each household and each draw n from the distribution, determine its optimal plan choice (across all carriers) and its optimal consumption quantity (procedure is written for local usage but procedure for intraLATA toll usage is symmetric and is done simultaneously):
      i. Optimize within each hybrid plan:
         A. Compute the optimal local usage on the plan based on equation 5 and using the relevant per-unit price for consumption above the threshold $\tilde{q}_j$.
         B. If the optimal quantity is above the threshold then $\hat{q}_{ij}^{L,n}$ equals the optimal quantity based on the per-unit price.
         C. If the optimal quantity is below the threshold then compute the optimal quantity based on a zero per-unit price (equation 7). If the optimal quantity based on a zero per-unit price is above $\tilde{q}_j$ then $\hat{q}_{ij}^{L,n} = \tilde{q}_j$. If the optimal quantity based on a zero per-unit price is below $\tilde{q}_j$ then set $\hat{q}_{ij}^{L,n}$ based on equation 7.
      ii. Compute the optimal quantity for all metered plans using 5 or 6 and for all flat-rate plans using 7.
      iii. Choose the optimal plan among all metered, flat-rate and optimized hybrid plans:
         A. Compute the indirect utilities on each plan using the appropriate indirect utility function from 10 or the table in Appendix A.
         B. Choose the plan which provides the greatest indirect utility.
   (b) Average across the N draws to obtain the expected plan choices and optimal quantities for each household and each plan:

$$
\begin{aligned}
E[\hat{\mathcal{I}}_{ij}] &= \frac{1}{N}\sum_{n=1}^{N}\hat{\mathcal{I}}_{ij}^{n} \qquad (15)\\
E[\hat{q}_{ij}^{L}] &= \frac{1}{\sum \hat{\mathcal{I}}_{ij}^{n}}\sum_{n=1}^{N}\hat{q}_{ij}^{L,n}\hat{\mathcal{I}}_{ij}^{n}\\
E[\hat{q}_{ij}^{T}] &= \frac{1}{\sum \hat{\mathcal{I}}_{ij}^{n}}\sum_{n=1}^{N}\hat{q}_{ij}^{T,n}\hat{\mathcal{I}}_{ij}^{n}.
\end{aligned}
$$

4. Compute the choice prediction error (the difference between the predicted choice probability and the actual choice) and the quantity prediction errors (the difference between the average predicted quantity on the plan actually chosen and the actual quantity chosen) by household:

$$\begin{aligned} e_i^{\mathcal{I}} &\equiv \sum_{j=1}^{J} (E[\hat{\mathcal{I}}_{ij}] - \mathcal{I}_{ij})\mathcal{I}_{ij} \\ e_i^{L} &\equiv \sum_{j=1}^{J} (E[\hat{q}_{ij}^{L}] - q_{ij}^{L})\mathcal{I}_{ij} \\ e_i^{T} &\equiv \sum_{j=1}^{J} (E[\hat{q}_{ij}^{T}] - q_{ij}^{T})\mathcal{I}_{ij}. \end{aligned} \tag{16}$$

5. Stack $[e_1^{\mathcal{I}}, e_2^{\mathcal{I}}, ..., e_I^{\mathcal{I}}; e_1^L, e_2^L, ..., e_{I-H^L}^L; e_1^T, e_2^T, ..., e_{I-H^T}^T]'$ to form e, a $(3I - H^L - H^T)$ column vector (since quantity prediction errors will only be present for metered and some hybrid plans).

6. Update the parameters to minimize the minimum-distance objective function

$$Q(\Theta) = e'(\Theta)W^{-1}e(\Theta) \tag{17}$$

where W is the weighting matrix. Repeat steps 3) through 6) until convergence. For now, we have set W equal to the identity matrix. The resulting parameter values minimize the sum of least square errors between actual and predicted plan choices and actual and predicted quantities. We plan to implement the optimal weighting matrix in the future. We also plan to later incorporate instruments for the unobserved firm quality effects by interacting the instruments with the unobservables as a separate moment condition.