REGULATORY RESTRUCTURING AND INCUMBENT PRICE DYNAMICS: THE CASE OF U.S. LOCAL TELEPHONE MARKETS

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Abstract—Prior to the Telecommunications Act of 1996, many U.S. states restructured their regulatory framework by replacing rate-of-return regulation with competition in both the local exchange service and local long-distance markets and adopting price regulation (price caps and price freezes). Using a panel data set of incumbent firm prices for three services, I investigate whether price regulation and differences in entry conditions affect incumbent operators’ rate structures. I find that competition has prompted a significant amount of rate rebalancing by reducing the amount of cross-subsidization present in local telephone markets. In addition, the added flexibility of price cap regulation speeds the rate rebalancing effects of competition.

I. Introduction

PRIOR to the Telecommunications Act of 1996, many U.S. states restructured their regulatory framework by replacing rate-of-return regulation with competition in both the local exchange and intraLATA markets and adopting price regulation (price caps and price freezes). Utilizing this cross- and time-sectional variation, this paper analyzes how these changes have affected the rate structures of the incumbent local exchange companies (ILECs). Specifically, I test whether varying entry conditions and alternative methods of regulation influence rate changes for a bundle of incumbent service: namely, residential local exchange service, business local exchange service, and intraLATA toll.

I focus on the rate changes of incumbent firms, rather than rate levels, for several reasons. For one, policymakers typically adopt regulatory changes in order to alter the behavior of rates. This suggests that the dynamics of rates will depend on the regulatory structure. Second, price cap regulation constrains rate dynamics by defining limits on yearly rate changes as a function of inflation and productivity. Finally, if regulation is adopted as a response to high rate levels, which is often believed to be the case, then focusing on rate levels would lead to endogeneity concerns with respect to the regulatory variables; however, the simultaneity issues are not as severe with respect to rate changes.

The results of the paper suggest that the introduction of competition is associated with a reduction in the level of cross-subsidization historically present in local telephone markets. Specifically, I find that active local competition is associated with lower (that is, more negative) business exchange rate changes, but higher (that is, more positive) residential rate changes. This signifies a reduction in the cross-subsidization from business to residential consumers. Similarly, when adopted alone, intraLATA competition is associated with higher rate changes for the two local exchange services, but lower rate changes for intraLATA service. This also represents a reduction in cross-subsidization, as long-distance rates have historically subsidized local exchange rates. When competition is present in both the local exchange and intraLATA markets, the positive impact on residential local exchange rate changes of residential is exacerbated; the net impact on business local exchange service is also positive. Viewing local exchange rates as the fixed price of a two-part tariff and intraLATA rates as the per unit price, this result implies that—when faced with competition in both sectors—incumbent firms increase the fixed price and lower the per unit price. By doing so, incumbent firms concentrate on high-volume consumers.

The effect of price regulation is mixed. Price freezes are associated with lower rate changes (relative to rate-of-return regulation). After controlling for infrastructure investment, there is evidence that suggests intraLATA rate changes are higher under price caps, while local exchange rates are unaffected. Additional evidence suggests that when price cap regulation and competition are present, the reduction in cross-subsidization is increased.

The remainder of the paper is organized as follows. Section II presents a brief history of the regulatory changes that have taken place since the 1984 divestiture and how these changes are likely to influence local exchange company rates. In addition, section II discusses the related literature. Section III describes the data used in the study; section IV lays out the empirical models posited to test the impact of competition and discusses the econometric issues. Section V presents and evaluates the results of these models and presents the results of extensions to the base-case model. Section VI provides concluding remarks and possible extensions to the analysis.

II. Regulatory Change and Related Literature

A. From Regulation to Deregulation

The 1984 consent decree led to the breakup of AT&T into seven RBOCs and AT&T, the long-distance company. The
consent decree held that local exchanges were natural monopolies, but the long-distance market was capable of sustaining competition. Despite this, the perceived benefits of deregulation in the long-distance market led policymakers to consider deregulation in local telephone markets. In addition, studies such as Shin and Ying (1992) began to question whether local exchanges were natural monopolies.

Consistent with this, states began allowing competition in intraLATA toll markets in 1984, and in local exchange markets in 1988. By the end of 1995, 27 states allowed competition in intraLATA toll markets, while 30 states allowed competition and an additional 10 states were considering competition in local exchange markets. Figure 1 tracks the number of states in the data used in this paper that allowed competition during 1988 to 1995. Though over 1,600 firms have entered, the market continues to be dominated by the ILECs. (This is not to say that there are not big players present. AT&T, MCI, and Sprint currently offer local service in some markets and are planning to expand such service as the Telecommunications Act permits.) As figure 1 suggests, the majority of entry in the local telephone markets occurred late in the sample; competition in the intraLATA markets was much more prevalent throughout the sample.

In addition to the introduction of competition, a number of markets have replaced rate-of-return regulation with either price caps or price freezes. States began using price regulation in 1986, and the FCC began regulating AT&T via price caps in 1989. The introduction of price cap regulation, however, has waned recently, and rate-of-return regulation continues to be dominant. Figure 2 tracks the number of states that use price cap regulation instead of rate-of-return regulation. To get a sense of where entry has focused, the figure also plots the number of states that are regulated via price caps and allow entry into the two local markets between 1988 and 1995. The figure suggests that a large fraction of the states that had price cap regulation also had intraLATA competition, whereas price cap regulation with local competition was rare.

The passage of the Telecommunications Act of 1996 continues the regulatory transition of the telecommunications industry. The Act seeks to remove many statutory, regulatory, and operational barriers to competition for local telephone services. The Act also preempts all state and local restrictions on competition, allowing firms traditionally barred from local service to enter, including long-distance carriers, cable television providers, and wireless companies. The Act also mandates the creation of a set of national rules for local competition, including the pricing of interconnection with the ILECs.

The two core services offered by local carriers are local exchange service and intraLATA service. Local exchange service is the consumer’s connection, for a monthly fee, to the ILEC’s network. With local exchange service a consumer can make local calls, intraLATA calls, and interLATA calls. Local calls, for example those made within a city, and intraLATA calls are carried entirely by ILECs, whereas interLATA calls are first carried by the caller’s ILEC, then handed off to the caller’s long-distance carrier, and then handed off once more to the receiving customer’s ILEC. Figure 3 plots the average real rate for residential local service, business local service, and a 5-minute 5-mile intraLATA call across the cities used in this study for the years 1988 to 1995. The figure illustrates that the average real rate...
for all three of these services has been falling over this time period.

The fall in the average real rates reflects a reduction in the amount of cross-subsidization present. Cross-subsidization has historically existed on two fronts as a means of increasing telephone service penetration. Business consumers subsidize residential consumers through higher local exchange rates. In addition, long-distance service rates (both intralATA and interLATA) subsidize residential local service. Figure 4 plots the ratio of yearly average business local exchange to residential local exchange service rates, as well as the ratio of yearly average intralATA to residential local exchange service rates. Both of these suggest a reduction in the level of cross-subsidization.

B. Related Literature

The numerous changes in the telecommunication industry have provided researchers with the opportunity to test certain theories regarding the behavior of prices in different regulatory environments. The prices of long-distance companies have been most analyzed. Mathios and Rogers (1989) and Kaestner and Kahn (1990) analyze the pricing structure of AT&T’s intrastate interLATA long-distance rates under either price cap regulation or rate-of-return regulation. Both studies find that states with the longest departure from rate-of-return regulation have the lowest rates. In a separate paper, Mathios and Rogers (1990) correlate AT&T intrastate long distance prices with the presence of competition. They find that allowing competition is associated with lower prices.

In a separate strand of the literature, researchers have analyzed deregulation’s affect on interstate long distance rates. Taylor and Taylor (1993) argue that, although it appears interstate long-distance rates have fallen drastically since 1984, this is largely due to reductions in access charges—the per minute fees that long-distance companies pay local exchange companies. The authors find that, after controlling for these reductions, nominal rates actually rose from 1984 to 1992. A number of explanations have been posited for this result. MacAvoy (1995) argues that the industry is characterized by tacit collusion, preventing rate decreases. Knittel (1997) argues that rates have remained above competitive levels due to the presence of search and switching costs.

Missing from the literature, however, are analyses of how regulatory changes have impacted incumbent local exchange companies. This paper is most closely linked to Blank, Kaserman, and Mayo (1998). They analyze the impact of competition, the potential for competition, and incentive regulation on 1991 intralATA rates. They find that whereas competition and potential competition put downward pressure on rates, incentive regulation has no influence. This study differs from Blank et al. (1998) by analyzing the dynamics of three services and using a panel data set encompassing the years 1988 to 1995. In addition, the paper develops an empirical model that takes account of the stickiness in the rates of local exchange companies.

C. Regulatory Environment and Pricing

The rationale for replacing rate-of-return regulation with price cap regulation is likely based on the result of Averch and Johnson (1962). In its purest form, rate-of-return regulation creates an incentive for firms to utilize too much capital in the production process, the so-called AJ effect. In contrast, firms facing price cap regulation have an incentive to use the efficient amount of capital, for the firm is the residual claimant to cost reductions. As an empirical matter, the effect on prices from adopting price cap regulation remains ambiguous. As Bernstein and Sappington (1999) and Wolak (2000) note, there is little guidance offered to policymakers in setting the yearly change in the productivity allowance—the “X-factor.”

The effect of competition on prices is also ambiguous, as competition can affect ILEC rates in a variety of ways. The most obvious is the increase in direct price competition.
created by entry into a specific service; however, competition in one service may also prompt changes in the rates of other services. This is true for firms regulated under both rate-of-return regulation and price cap regulation. Firms regulated via rate-of-return regulation may use lower profits in the service facing competition to justify increases in the rates for other services. Indeed, if the rate-of-return constraint is binding, competition in one service will necessitate an increase in the rates of other services. For firms regulated via price caps, these interservice effects may be even more explicit. In many cases, price cap regulation places a minimum rate of decline on a weighted average of services. This implies that the ILEC can increase the rate for a service as long as it reduces the rates of other services.

### III. Data

In this section, I discuss the data used in the analysis. Although it would be impossible to model every ILEC service, as ILECs offer products ranging from local exchange service to telephone number lookup services, data on three major services were collected: residential local service, business local service, and intralATA toll. The revenues from these three services account for over 68% of ILEC state-regulated revenues. The annual data are for seventy cities over the years 1988 to 1995 and track yearly changes in the above rates; rate levels are also known.

In these three categories many subcategories exist. For example, intralATA toll service is actually a bundle of services, as ILECs treat calls of different milages as different products. Further complications arise because the choice of these milage bands differs across ILECs—one ILEC may price all calls with a milage of 1 to 10 miles the same, while another ILEC may price an 8 mile call differently from a 10 mile call. Finally, the rate for the first minute of the call often differs from subsequent minutes. It seems reasonable to assume that ILECs with high rates in one milage band will likely have high rates in other milage bands. Thus, I model only the price of a 5 minute, 5 mile call.\(^6\) In support of this claim, I calculated the correlation between a 5 minute, 5 mile call and 5 minute calls of the following distances: 15 miles, 25 miles, 45 miles, and 65 miles. The raw correlations are 0.79, 0.72, 0.58, and 0.42, respectively. In addition, I completed the analysis using a 25 mile call, and the conclusions are unchanged.

To differentiate regulatory environments, data on the following were collected: (1) the form of regulation (price regulation or cost-based regulation), (2) whether competition is allowed in local exchange service, (3) whether firms have entered the local exchange market, and finally (4) whether competition is allowed in the intralATA toll market. The variable Price Cap\(^7\) is a dummy variable equal to 1 if the firm is regulated under a price cap at time \(t\). The variable Freeze\(_i\) is an indicator variable equal to 1 if the firm operates under a price freeze at time \(t\). Active Local Comp\(_i\) is a dummy variable equal to 1 if the municipality has firms competing in local exchange service at time \(t\). Potential Local Comp\(_i\) is an indicator variable equal to 1 if the state (and thus the municipality) allows firms to enter the local exchange market at time \(t\), but entry has yet to occur. The variable intralATA Comp\(_i\) is an indicator variable equal to 1 if entry is allowed in the ILECs intralATA toll market at time \(t\).\(^7\)

I also collected data on a variety of cost determinants. Wage\(_i\) is the mean manufacturing wage in city \(i\) at time \(t\) and controls for labor cost changes.\(^8\) Prod\(_i\) is the average productivity for workers in the telecommunications industry at time \(t\). As productivity in the industry rises, we would expect costs to decrease. Dens\(_i\) is the population per square mile of city \(i\) at time \(t\), using the 1980 measured land size of city \(i\). The costs of supplying local service are generally thought to be inversely related to the density of the service area. As the density increases, less equipment is needed to serve the same number of customers. On the one hand, if ILEC networks are slow to adjust to changes in population density, increases in population density may put added pressure on the existing network, thereby increasing costs. Therefore, the expected sign on this variable is not known a priori. A second component of network costs is infrastructure investment. During this time period, ILECs substantially increased their investment in fiber optic cable and modern switch technologies. Greenstein, McMaster, and Spiller (1995) find evidence that price cap regulation is associated with greater investment in infrastructure. To control for this, Fiber\(_i\) is the total sheath miles of fiber optic cable employed by the firm.\(^9\)

Unlike local exchange rates, which vary by city, intralATA rates are set at the state level.\(^10\) Therefore, I collected the state-level counterparts of the mean manufacturing wage and population density; these are State Wage\(_i\) and State Dens\(_i\), respectively.

Four additional variables capture changes in demand at the residential and business levels. INC\(_i\) is the real average annual income in city \(i\) at time \(t\) and controls for differences in the demand for local residential service; SINC\(_i\) is the state-level counterpart of INC\(_i\); ESTAB\(_i\) and SEstab\(_i\) are the numbers of business establishments in the county and state of city \(i\) at time \(t\), respectively; they control for

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\(^{10}\) The implications of this are discussed below.
The summary statistics for the level of these variables are reported in table 1; the sources for these data are available in appendix B. As a first step in analyzing the relationship between rate changes and regulatory regimes, table 2 reports the summary statistics for the three rate changes under the following: the entire sample, price cap regulation, active local exchange competition, competition allowed in the local exchange market with no entry, competition allowed in the intraLATA market, and both active competition in the local exchange market and intraLATA competition.

Table 2 foreshadows the results. The raw tabulations suggest a negative relationship between business rate changes and the two local competition measures; however, this relationship does not appear to be present with respect to residential rates. In addition, the summary statistics suggest that there is no relationship between intraLATA competition and local exchange rates, except when both local exchange and intraLATA competition are present. The mean level of rate changes suggests a positive relationship between rate changes for the three services and price cap regulation. Given the results of Greenstein et al. (1995), it is not clear whether this is the result of differences in investment levels. Other than the relationship between intraLATA rate changes and price cap regulation (which is less negative than that of the mean price change level across all of the cities), the table suggests little correlation with intraLATA rate changes and the other market structure variables. One possible explanation for this is described below.

### IV. Econometric Model

The paper seeks to test whether rate changes vary with the regulatory environment. A casual glance at the data suggests a high degree of censoring of ILEC rates. Unlike those of unregulated firms, the rates of incumbent local exchange companies are set as a response to rate hearings, and are not simply the decision of the firms. The costs of these rate hearings, as well as the uncertainty of the resulting rate changes, creates an institutional environment where rates do not continuously adjust to changes in underlying market conditions. In a rate-of-return setting, if a firm wishes to alter its rate structure, it must file for a rate hearing and present its case in front of the state’s public utility commission. The incentives of regulators to keep a tight control on the profitability of the firms is also reduced, as regulators must also expend effort to present their case.

The presence of adjustment costs is borne out in the data in that business rates for local exchange service change from one year to the next 73% of the time, and residential rates changed 74% of the time. These frictions are even more evident in intraLATA toll rates, as they change from

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**Table 1.** Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p^\text{F}_{\text{incl}} ) (dollars)</td>
<td>16.19</td>
<td>3.32</td>
<td>10.56</td>
<td>28.13</td>
</tr>
<tr>
<td>( p^\text{F}_{\text{incl}} ) (dollars)</td>
<td>37.86</td>
<td>8.63</td>
<td>24.15</td>
<td>66.25</td>
</tr>
<tr>
<td>( p^\text{F}_{\text{incl}} ) (cents)</td>
<td>51.58</td>
<td>16.53</td>
<td>24.00</td>
<td>96.00</td>
</tr>
<tr>
<td>( INC_\text{C} ) ($1000)</td>
<td>25.41</td>
<td>3.74</td>
<td>16.41</td>
<td>39.47</td>
</tr>
<tr>
<td>( \text{SINC}_\text{C} ) ($1000)</td>
<td>30.06</td>
<td>4.15</td>
<td>18.17</td>
<td>47.95</td>
</tr>
<tr>
<td>( \text{FIBER}_\text{C} )</td>
<td>660.68</td>
<td>453.70</td>
<td>110.30</td>
<td>2169.20</td>
</tr>
<tr>
<td>( \text{PROD}_\text{C} )</td>
<td>125.00</td>
<td>13.55</td>
<td>106.20</td>
<td>144.60</td>
</tr>
<tr>
<td>( \text{WAGE}_\text{C} ) (dollars)</td>
<td>13.13</td>
<td>2.81</td>
<td>8.41</td>
<td>21.48</td>
</tr>
<tr>
<td>( \text{SWAGE}_\text{C} ) (dollars)</td>
<td>11.52</td>
<td>1.43</td>
<td>7.83</td>
<td>16.31</td>
</tr>
<tr>
<td>( \text{DENS}_\text{C} )</td>
<td>827.63</td>
<td>1060.09</td>
<td>63.27</td>
<td>8591.89</td>
</tr>
<tr>
<td>( \text{SDENS}_\text{C} )</td>
<td>196.44</td>
<td>169.71</td>
<td>28.38</td>
<td>961.41</td>
</tr>
<tr>
<td>( \text{ESTAB}_\text{C} ) (1000s)</td>
<td>31.16</td>
<td>41.90</td>
<td>0.004</td>
<td>219.63</td>
</tr>
<tr>
<td>( \text{SESTAB}_\text{C} ) (1000s)</td>
<td>301.44</td>
<td>223.94</td>
<td>2.68</td>
<td>747.69</td>
</tr>
<tr>
<td>( \text{PriceCap}_\text{C} )</td>
<td>0.21</td>
<td>—</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>( \text{Freeze}_\text{C} )</td>
<td>0.13</td>
<td>—</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>( \text{Active Local Comp}_\text{C} )</td>
<td>0.05</td>
<td>—</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>( \text{Potential Local Comp}_\text{C} )</td>
<td>0.16</td>
<td>—</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>( \text{intraLATA Comp}_\text{C} )</td>
<td>0.69</td>
<td>—</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

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**Table 2.** Summary Statistics for Nominal Rate Changes under Different Regulatory Regimes

<table>
<thead>
<tr>
<th>( \Delta p ) ($)</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete sample</td>
<td>0.011</td>
<td>1.500</td>
<td>-6.68</td>
<td>9.88</td>
<td>560</td>
</tr>
<tr>
<td>Under price caps</td>
<td>0.214</td>
<td>1.510</td>
<td>-2.46</td>
<td>6.44</td>
<td>119</td>
</tr>
<tr>
<td>Active local comp.</td>
<td>-0.190</td>
<td>0.817</td>
<td>-4.20</td>
<td>0.08</td>
<td>28</td>
</tr>
<tr>
<td>Local comp. allowed</td>
<td>-0.205</td>
<td>0.999</td>
<td>-4.48</td>
<td>2.63</td>
<td>90</td>
</tr>
<tr>
<td>LATA comp. allowed</td>
<td>0.003</td>
<td>1.574</td>
<td>-6.67</td>
<td>9.88</td>
<td>387</td>
</tr>
<tr>
<td>Both local and LATA</td>
<td>-0.048</td>
<td>0.250</td>
<td>-1.19</td>
<td>0.087</td>
<td>23</td>
</tr>
<tr>
<td>( \Delta p ) ($)</td>
<td>Mean</td>
<td>Std. Dev.</td>
<td>Min.</td>
<td>Max.</td>
<td>N</td>
</tr>
<tr>
<td>Complete sample</td>
<td>0.224</td>
<td>0.972</td>
<td>-4.95</td>
<td>7.50</td>
<td>560</td>
</tr>
<tr>
<td>Under price caps</td>
<td>0.568</td>
<td>1.463</td>
<td>-2.66</td>
<td>7.50</td>
<td>119</td>
</tr>
<tr>
<td>Active local comp.</td>
<td>0.188</td>
<td>1.171</td>
<td>-2.21</td>
<td>2.91</td>
<td>28</td>
</tr>
<tr>
<td>Local comp. allowed</td>
<td>0.154</td>
<td>0.834</td>
<td>-3.08</td>
<td>1.99</td>
<td>90</td>
</tr>
<tr>
<td>LATA comp. allowed</td>
<td>0.179</td>
<td>0.764</td>
<td>-3.08</td>
<td>3.71</td>
<td>387</td>
</tr>
<tr>
<td>Both local and LATA</td>
<td>0.173</td>
<td>0.710</td>
<td>-2.11</td>
<td>1.25</td>
<td>23</td>
</tr>
<tr>
<td>( \Delta p ) (cents)</td>
<td>Mean</td>
<td>Std. Dev.</td>
<td>Min.</td>
<td>Max.</td>
<td>N</td>
</tr>
<tr>
<td>Complete sample</td>
<td>-0.810</td>
<td>0.386</td>
<td>-20.50</td>
<td>14.00</td>
<td>560</td>
</tr>
<tr>
<td>Under price caps</td>
<td>-0.238</td>
<td>1.499</td>
<td>-12.00</td>
<td>0.00</td>
<td>119</td>
</tr>
<tr>
<td>Active local comp.</td>
<td>-0.786</td>
<td>3.270</td>
<td>-17.00</td>
<td>0.00</td>
<td>28</td>
</tr>
<tr>
<td>Local comp. allowed</td>
<td>-0.842</td>
<td>3.349</td>
<td>-17.90</td>
<td>0.00</td>
<td>90</td>
</tr>
<tr>
<td>LATA comp. allowed</td>
<td>-0.686</td>
<td>4.030</td>
<td>-20.50</td>
<td>14.00</td>
<td>387</td>
</tr>
<tr>
<td>Both local and LATA</td>
<td>-0.913</td>
<td>3.604</td>
<td>-17.00</td>
<td>0.00</td>
<td>23</td>
</tr>
</tbody>
</table>
one year to the next 24% of the time.12 Frictions in rate changes can also be seen by analyzing the probability density functions of rate changes for business and residential local service. Figures 5 and 6 represent kernel density estimates of rate changes for the two local services and intraLATA toll, respectively.13 It is apparent from these density estimates that the modal value for rate changes from one year to the next is 0. Also, the existence of a second mode suggests a high degree of friction in rates, as firms and regulators wait until large price changes are warranted before initiating a costly rate hearing.

The asymmetry between the firms’ and regulators’ objectives provides us with information as to when rates are likely to change. On the one hand, firms are concerned with profits falling too low, and are likely to initiate a rate hearing if profits fall below some threshold. On the other hand, regulators are concerned with profits becoming too high, and will initiate a rate hearing if profits reach some maximum level. A number of studies have analyzed the decision process in similar frameworks. For example, Slade (1998) analyzes the stickiness of saltine cracker prices in an oligopoly framework. She models firms as keeping nominal prices constant provided the nominal price remains within a corridor around the desired price. The decision rules for firms and regulators are likely to be more complex in the present setting, for a number of reasons. First, we are concerned with multiple prices. Second, the objective function of the regulator is not entirely clear. Finally, in the typical setting only one party is able to vary the control variable; here, both the firm and the regulator can initiate a price change.

Given the competing objectives of firms and regulators and the uncertainty regarding the regulator’s objective function, I take a less structural approach. To capture the presence of adjustment costs, I estimate a two-sided friction model similar to that of Rosett (1959). Rate changes are assumed to be a vector of latent variables observable only when aggregate shocks to the underlying market are large enough for either the firm or the regulator to initiate a rate hearing. Further, because of the lag between rate changes, rate changes depend on changes in underlying market conditions since the previous rate hearing, not necessarily the previous year.

A. Model Specification

Let

\[ \Delta \ln P_{it} = (\ln (p_{it}^{res}/p_{i-1}^{res}), \ln (p_{it}^{bus}/p_{i-1}^{bus}), \ln (p_{it}^{toll}/p_{i-1}^{toll})) \]

be the bundle of changes in the log of the prices modeled, where \( \ln (p_{it}^{res}/p_{i-1}^{res}) \) is the change in the log price of unlimited residential local service, \( \ln (p_{it}^{bus}/p_{i-1}^{bus}) \) the change in the log price of one-line unlimited business service, and \( \ln (p_{it}^{toll}/p_{i-1}^{toll}) \) the change in the log intraLATA toll rate.14

The frictions on rate dynamics are likely to depend on the regulatory regime the firm operates under, as firms have

12 Given that intraLATA rates are set statewide, this is not surprising, as adjusting intraLATA rates may increase the profitability of one city while reducing the profitability of other cities.

13 These density estimates are for illustrative purposes only. Given the probability distributions of the price changes, the distribution functions are best modeled as continuous almost everywhere (not at 0). Because of the discontinuity at 0, the true density near 0 would not be as large as indicated by the density estimates.

14 IntraLATA rates are set statewide for each company; however, local rates, as well as the local competition variables, are observed at the city level. Therefore, I define the unit of observation as a city.
greater discretion over rate changes in a price cap regime. Under rate-of-return regulation, rates will remain unchanged as long as neither the firm nor the regulator chooses to initiate a rate hearing. Therefore, I treat these two cases separately. For firms that operate under rate-of-return regulation (RORR), the firm is assumed to initiate a rate hearing at time \( t \) if the expected profit at time \( t \) under the previous rates \( (P_{t-1}) \) is below the threshold \( s'_t \), implying

\[
\text{RORR firms' decision rule} = \begin{cases} 
\text{initiate if } \pi_i(P_{t-1}; X_{it}) < s'_t, \\
\text{otherwise do not.}
\end{cases}
\]

Profits are modeled as a function of the \( \ln X_{it} \)'s, defined above, as well as \( P_{t-1} \). Fixed city effects are also included to control for differences in the size of firms. A mean-zero normally distributed variable \( \varepsilon_{it} \) is included in the profit function to allow for variables unobserved by the econometrician, but observed by the firm. Formally, I assume

\[
\pi_i(P_{t-1}; X_{it}) = G \ln P_{t-1} + Z \ln X_{it} + \mu_i + \varepsilon_{it},
\]

where \( G \) and \( Z \) are vectors of unknown parameters, \( \mu_i \) are a set of fixed city effects, and \( \varepsilon_{it} \) is a mean-zero, normally distributed error term.

With respect to the switching threshold, the magnitude of adjustment costs are likely dependent on the amount of time that has passed since the previous rate hearing (measured in years). The greater the time since the previous rate hearing, the more sympathetic regulators may be to firms requests. Formally, the firm's switching value is specified as

\[
s'_t = \gamma'_t + \alpha'(\text{Time Since Prev Hearing}_t).
\]

I model the regulator as initiating a rate hearing if the firm's profits exceed some threshold. Again, this policy is similar to the decision process of the firm modeled above, but the threshold is an upper, not a lower, bound on profit. Thus, we have

\[
\text{RORR regulators' decision rule} = \begin{cases} 
\text{initiate if } \pi_i(P_{t-1}; X_{it}) > s'_t, \\
\text{otherwise do not.}
\end{cases}
\]

I make the assumption that both the regulator and firm observe the same information set, including the portion of profits unobservable by the econometrician, \( \varepsilon_t \). This assumption is discussed below.

The regulator's switching value is specified as

\[
s'_t = \gamma'_t + \alpha'(\text{Time Since Prev Hearing}_t).
\]

Because regulators are concerned about high profits whereas firms are concerned about low profits, I further assume that \( s'_t > s'_l \).

Conditional on either the firm or the regulator initiating a rate hearing at time \( t \), the vector of time \( t \) log rate changes is assumed to be a function of the changes in the underlying market conditions since the previous rate hearing (not necessarily the previous year), represented by \( \Delta \ln X_{it} \). In addition, the vector is allowed to depend on the regulatory environment, represented by the vector \( R_{it} \), yielding

\[
\Delta \ln P_{it} = B \Delta \ln X_{it} + M R_{it} + U_{it},
\]

where \( B \) and \( M \) are vectors of unknown parameters, and \( U_{it} \) is a mean-zero multivariate normal random variable with \( E(U_{it}U_{it}') = \Sigma_U \) for all \( i \) and \( t \).

For firms regulated under price caps, I assume that adjustment costs are effectively 0. Rates, therefore, are continuously governed by equation (6).

To sum up, in a rate-of-return regulated regime, at each time period, both the firm and the regulator decide either to initiate a rate hearing or not to. If one of the parties initiates a rate hearing, rate changes are governed by equation (6).

If neither the firm nor the regulator initiates a rate hearing, the nominal rates remain unchanged. I estimate this model by maximum likelihood. The likelihood function is derived in appendix A, and figure 7 illustrates the timing of the model. The main implication of the model is that as long as \( \pi_i(P_{t-1}; X_{it}) + \varepsilon_{it} \) remains between \( s'_t \) and \( s'_l \), rates are unchanged.

---

16 Linear specifications produced qualitatively similar results.

17 I have assumed that a rate hearing at time \( t \) immediately causes rates to change. Given that rate data are collected on December 31 of a year, I am implicitly assuming that the initiation of the rate hearing and its results all occurred within the same year. Unfortunately, data on both the initiation and conclusion dates of the rate hearings are available only when the firm initiates the rate hearing, not when the regulator does. When the regulator initiates a rate hearing, only the data on the rate change are known. These data suggest, however, that rate hearings typically last less than 6 months. Thus, given that the rate data are as of December 31, the assumption seems reasonable.

18 Given that the firm and regulator observe the same random component of profit, they would never both initiate a rate hearing. Indeed, this is consistent with the data.
B. Econometric Issues

The most obvious econometric issue is whether the regulatory variables can be treated as exogenous. These variables are potentially endogenous for two reasons. First, if high rate changes at time $t$ cause regulatory action at time $t$, then the error term in each equation will be correlated with the regulatory variables, and the resulting parameter estimates will be biased. This, however, is unlikely, for regulatory changes take a considerable amount of time to implement, implying rate changes at time $t$ will not affect regulatory changes at time $t$.

Second, given this regulatory lag, it is possible that high prices in period $t$ may lead to regulatory changes in period $t + s$. If there exists serial correlation in the error term, then the error term at time $t + s$ will be correlated with the regulatory variables. The most natural way to control for this potential endogeneity is to use an instrumental variable approach. Unfortunately, valid instruments are unavailable. Furthermore, given the number of regulatory variables used in this study, finding a sufficient number of reasonable instruments is infeasible.

Two observations suggest the bias is small. The first is that, although it is likely that changes in the regulatory environment are endogenous, once a change is made, the regulatory conditions are extremely sticky, and thus the regulatory environment itself can safely be treated as exogenous. This would imply that though the estimated effect of the regulatory environment may be biased in the first year of a new environment, estimates are not biased in subsequent years. For example, it is possible that high rate changes at time $t$ lead regulators to allow competition at time $t + s$ (because of the time it takes to implement a regulatory change), but in no instance in the data is there a switch from allowing competition to no longer allowing competition. Therefore, though the initial change in the regulatory framework (that is, the regulatory environment at $t + s$) may be endogenous, the regulatory environment at $t + s + 1, t + s + 2, \ldots$ will be exogenous.

Second, to investigate the degree of endogeneity of the regulatory variables, I included a number of additional variables in an initial regression. As noted, if the regulatory variables are endogenous, then high rate changes today will lead to regulatory change tomorrow. This implies that in the periods just prior to regulatory change, rate changes should, on average, be higher than in other periods. To test whether this is the case, I included a dummy variable equal to 1 in the three years prior to changes in entry conditions and the implementation of price regulation. If the regulatory variables are endogenous, then the coefficients associated with these dummy variables would be positive and significant. In each of the equations the parameter estimates were not significant and the signs did not follow a predictable pattern.

Although I do not claim these tests prove that the regulatory variables are exogenous, they do suggest that the bias will be small. I therefore follow the previously cited literature by treating the regulatory variables as exogenous.\footnote{See, for example, Mathios and Rogers (1989, 1990), Kaestner and Kahn (1990), Blank et al. (1998), and Greenstein et al. (1995).}

A second issue has to do with the specification of the error terms in the profit equation. The model assumes that firms and regulators have the same information set. This is potentially troublesome, because the firm may have better information regarding profitability. Previous versions of the paper relaxed this assumption; the error term associated with the regulator’s calculation of firm profits was allowed to be drawn from a different distribution (which was correlated with the firm’s error term). This specification has the undesirable result that it admits the possibility that both the regulator and the firm will apply for a rate hearing in the same year. This is not observed in the data, and unlikely given the competing objectives of the players. Furthermore, the results are qualitatively similar.

Finally, the model assumes that conditional on a rate change, the pricing dynamics of firms that face rate-of-return regulation and those that face price cap regulation differ only by a constant. It may be the case that the coefficients associated with the demand and cost variables also differ. To test this, I allowed the each of the coefficients in equation (6) to differ in a price cap setting. A likelihood ratio test could not reject equality.\footnote{The $p$-value was .26.}

V. Estimation Results

Tables 3 through 5 present the maximum likelihood results from the two-sided friction model. The results suggest that active competition significantly affects ILEC rate changes for not only the products facing competition, but also those that do not. The parameter estimates associated with active competition in the local exchange market, Active Local Comp$_{it}$, imply that competition is associated with rate changes that are 2.5% lower for business service; however the estimates imply that rate changes for residential service are 3.6% more positive. This suggests that the introduction of competition in local exchange service reduces the cross-subsidization present in these markets. The results also suggest that potential competition does not affect the rates of incumbent firms.

A similar lesson is learned with intraLATA competition. IntraLATA competition is associated with rate changes for intraLATA service that are 1.3% lower. There is also evidence that the presence of intraLATA competition tends to increase the rates of the two local exchange services as rate changes are 0.8% and 1.1% higher for business and residential service, respectively. This result also signifies a reduction in the cross-subsidization between long distance and local exchange rates.

Furthermore, there is strong evidence that indicates when both local exchange and intraLATA competition are present,
the net effect is to increase the rates of both local exchange services, despite the negative effect local exchange competition has on business rates. When both local exchange and intraLATA competition are present, residential rate changes are 9.7% higher, while business rate changes are 1.7% higher. By lowering the perunit price (intraLATA rates) and raising the fixed price (local exchange rates), ILECs are able to focus on high-volume customers.

The results with respect to the price regulation variables suggest that, after controlling for infrastructure investment, intraLATA rates under price cap regimes increase relative to rate-of-return regulation, and the rates for local service do not appear to be affected. Price freezes are associated with lower rate changes for all three services, relative to rate-of-return regulation.

The results also suggest that the longer the time since the previous rate change, the more likely it is that a firm will initiate a rate hearing. Surprisingly, this is not the case for regulators. It appears that regulators are more content with the status quo than firms. This provides an alternative test to Joskow’s (1974) study of the electricity industry and confirms his results for the telecommunication industry. In the next two subsections, I estimate two alternative specifications.

A. Regulatory Change and Its Impact on Rate Levels

The first alternative specification allows the regulatory variables to influence both the change in rates as well as the level of rates. It may be that changes in the regulatory environment have a different impact than this constant effect, as regulators or firms reset rates in the presence of regulatory change. To test this, I include an additional set of indicator variables that equal 1 in the first year of a new regulatory environment. If rates react differently to changes in the regulatory environment the parameters associated with these variables will be nonzero.

The results with respect to the regulatory variables are presented in Table 6. The remaining parameters are consistent with the base case specification and are omitted in order to conserve space. The estimates suggest that the effect of the regulatory environment may differ in the first year. Most interesting is the switch from rate-of-return regulation to price cap regulation.

Specifically, the residential local exchange equation implies that price cap regulation in the first year is associated with a large reduction in rates, as rate changes are 3.2% lower in the first year. After this initial decline, rate changes are 1.6% higher. For the other services, the adoption of price cap regulation does not appear to have a different effect than the presence of price cap regulation.

The initial year of competition in local service also appears to have a different effect as in other years. Residential rate changes are an additional 4.7% higher in the first year of local exchange service competition, while business rate changes are an additional 1.1% lower. This effect is also present in intraLATA competition, as intraLATA rate changes are 5.9% lower in the first year, compared to 1.5% lower thereafter.

B. The Impact of Both Competition and Price Caps

The base-case results suggest that active competition in local exchange markets is associated with lower rate changes in business local exchange service, but higher rate changes for residential local service. In this section, I analyze the effect of having both price cap regulation and competition in place. Faced with the added flexibility of...
price cap regulation, rates may rebalance at a greater rate. Two additional variables are added. The first variable equals 1 if both price cap regulation and active competition in the local exchange market exist in city i at time t, and the second variable equals 1 if both price cap regulation exists and competition is allowed in the intraLATA market in city i at time t. Table 7 presents the results for the regulatory variables.

The results imply that the presence of both competition and price caps increases the rate of rebalancing. In particular, when both active competition in the local exchange market and price cap regulation is present, residential price changes increase more quickly than the previous results suggested. One explanation for this is that by reducing the business rate, firms increase their \textit{cap room}. They can then use this cap room to increase residential rates, still remaining below the price cap. Specifically, the added flexibility of price cap regulation is associated with an additional 6.4\% increase in rate changes for residential exchange service. The effect of price cap regulation and allowing intraLATA competition leads to even lower intraLATA rate changes.

Once again, this suggests that incumbent firms are choosing to price the more contestable markets aggressively while increasing the rates for the less contestable markets, such as residential local exchange service.

### VI. Conclusions

Using a panel data set of annual rate changes for residential local exchange, business local exchange, and intraLATA services for 70 cities during the years from 1988 to 1995, this paper tests whether the rates of incumbent local telephone companies have reacted to recent regulatory restructuring. The results of the paper provide insight into many questions regarding the regulatory environment and resulting rate changes of incumbent firms. The paper provides policymakers with evidence of the changes likely to take place when moving from rate-of-return regulation to that of price regulation and when moving from a regulated monopoly to a more competitive market, as the Telecommunications Act of 1996 does at the national level. The analysis also illustrates that regulatory changes associated with the provision of one service are likely to affect the rates of other services.

It is important to note that these changes do not imply a social welfare loss. As entrants focus on the high-margin consumers, prices are likely to migrate closer to marginal cost, implying a welfare gain. In addition, because the demand for residential service is more inelastic, the welfare losses from higher residential rates are likely to be small. The results do represent a reduction in the level of cross-subsidization that is likely to occur.

### Table 5.—Friction Model—Profit and Switching Equation Parameters: Maximum Likelihood Results

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>\ln p_{it}^{a}</td>
<td>0.354***</td>
</tr>
<tr>
<td>\ln p_{it}^{b}</td>
<td>0.119*</td>
</tr>
<tr>
<td>\ln p_{it}^{c}</td>
<td>0.277</td>
</tr>
<tr>
<td>\ln INC_{it}</td>
<td>1.580</td>
</tr>
<tr>
<td>\ln SINC_{it}</td>
<td>2.215**</td>
</tr>
<tr>
<td>\ln ESTAB_{it}</td>
<td>-0.048</td>
</tr>
<tr>
<td>\ln SESTAB_{it}</td>
<td>0.127</td>
</tr>
<tr>
<td>\ln DENS_{it}</td>
<td>0.031</td>
</tr>
<tr>
<td>\ln SDENS_{it}</td>
<td>-0.280</td>
</tr>
<tr>
<td>\ln FIBER_{it}</td>
<td>-0.761*</td>
</tr>
<tr>
<td>\ln PROD_{it}</td>
<td>3.400*</td>
</tr>
<tr>
<td>\ln WAGE_{it}</td>
<td>-1.489**</td>
</tr>
<tr>
<td>\ln SWAGE_{it}</td>
<td>0.693**</td>
</tr>
<tr>
<td>\gamma</td>
<td>4.872***</td>
</tr>
<tr>
<td>\gamma'</td>
<td>-1.274***</td>
</tr>
<tr>
<td>Time Since Prev Hearing_{it} (regulator)</td>
<td>-0.077</td>
</tr>
<tr>
<td>Time Since Prev Hearing_{it} (firm)</td>
<td>-0.243**</td>
</tr>
</tbody>
</table>

\( N = 560 \)

Asymptotic standard errors in parentheses.

*** Significant at the 99% confidence level.

** Significant at the 95% confidence level.

* Significant at the 90% confidence level.

### Table 6.—Separating Out the Initial Impact of the Regulatory Variables: Maximum Likelihood Results

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Residential</th>
<th>Business</th>
<th>IntraLATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Local Comp_{it}</td>
<td>0.053***</td>
<td>-0.013***</td>
<td>0.030</td>
</tr>
<tr>
<td>Active Local Comp_{it} * YearOne</td>
<td>(0.013)</td>
<td>(0.006)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>Potential Local Comp_{it}</td>
<td>0.009</td>
<td>-0.005</td>
<td>-0.005</td>
</tr>
<tr>
<td>Potential Local Comp_{it} * YearOne</td>
<td>(0.008)</td>
<td>(0.005)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>intraLATA Comp_{it}</td>
<td>0.011**</td>
<td>0.010***</td>
<td>-0.015*</td>
</tr>
<tr>
<td>intraLATA Comp_{it} * YearOne</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Price Freeze_{it}</td>
<td>-0.013*</td>
<td>-0.013**</td>
<td>-0.019*</td>
</tr>
<tr>
<td>Price Cap_{it}</td>
<td>0.016**</td>
<td>-0.005</td>
<td>0.010</td>
</tr>
<tr>
<td>Price Cap_{it} * YearOne</td>
<td>-0.048***</td>
<td>0.001</td>
<td>0.038</td>
</tr>
</tbody>
</table>

\( N = 560 \)

Asymptotic standard errors in parentheses.

*** Significant at the 99% confidence level.

** Significant at the 95% confidence level.

* Significant at the 90% confidence level.
when markets are restructured. In addition, greater control over the pricing structure by the firm increases the speed of this reduction.

REFERENCES


Table 7.—The Impact of Both Price Cap Regulation and Competition: Maximum Likelihood Results

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Residential</th>
<th>Business</th>
<th>IntraLATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Local Compu</td>
<td>0.029***</td>
<td>–0.019*</td>
<td>0.036</td>
</tr>
<tr>
<td>(0.006)</td>
<td>(0.011)</td>
<td>(0.043)</td>
<td></td>
</tr>
<tr>
<td>Active Local Compu Y</td>
<td>0.039*</td>
<td>–0.027*</td>
<td>–0.042</td>
</tr>
<tr>
<td>(0.023)</td>
<td>(0.016)</td>
<td>(0.036)</td>
<td></td>
</tr>
<tr>
<td>Potential Local Compu</td>
<td>0.003</td>
<td>0.006</td>
<td>–0.003</td>
</tr>
<tr>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.013)</td>
<td></td>
</tr>
<tr>
<td>Potential Local Compu Y</td>
<td>–0.006</td>
<td>0.011</td>
<td>0.020</td>
</tr>
<tr>
<td>(0.015)</td>
<td>(0.010)</td>
<td>(0.022)</td>
<td></td>
</tr>
<tr>
<td>intraLATA Compu</td>
<td>0.004</td>
<td>0.005*</td>
<td>–0.024**</td>
</tr>
<tr>
<td>(0.006)</td>
<td>(0.003)</td>
<td>(0.009)</td>
<td></td>
</tr>
<tr>
<td>intraLATA Compu Y</td>
<td>0.030**</td>
<td>0.009</td>
<td>–0.046**</td>
</tr>
<tr>
<td>(0.013)</td>
<td>(0.008)</td>
<td>(0.018)</td>
<td></td>
</tr>
<tr>
<td>Active Local Compu ×</td>
<td>0.032</td>
<td>0.043**</td>
<td>–0.004</td>
</tr>
<tr>
<td>intraLATA Compu</td>
<td>(0.026)</td>
<td>(0.018)</td>
<td>(0.040)</td>
</tr>
<tr>
<td>Price Freezeu</td>
<td>–0.032**</td>
<td>0.016*</td>
<td>0.010</td>
</tr>
<tr>
<td>(0.013)</td>
<td>(0.009)</td>
<td>(0.019)</td>
<td></td>
</tr>
<tr>
<td>Price Capu</td>
<td>0.043***</td>
<td>0.006</td>
<td>0.031*</td>
</tr>
<tr>
<td>(0.011)</td>
<td>(0.007)</td>
<td>(0.016)</td>
<td></td>
</tr>
<tr>
<td>Price Capu Y</td>
<td>–0.050***</td>
<td>–0.006</td>
<td>–0.017</td>
</tr>
<tr>
<td>(0.017)</td>
<td>(0.011)</td>
<td>(0.022)</td>
<td></td>
</tr>
<tr>
<td>Active Local Compu ×</td>
<td>0.064***</td>
<td>0.002</td>
<td>0.025</td>
</tr>
<tr>
<td>Price Capu</td>
<td>(0.023)</td>
<td>(0.008)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>intraLATA Compu ×</td>
<td>0.016</td>
<td>0.029*</td>
<td>–0.035**</td>
</tr>
<tr>
<td>Price Capu</td>
<td>(0.013)</td>
<td>(0.016)</td>
<td>(0.018)</td>
</tr>
</tbody>
</table>

N 560 560 560

Asymptotic standard errors in parentheses.

* Significant at the 90% confidence level.

** Significant at the 95% confidence level.

* Significant at the 90% confidence level.


APPENDIX A

Derivation of Likelihood Function

Given that the unobservable variables that affect either the firm or the regulator’s decision to initiate a rate hearing are also likely to affect the level of rate changes resulting from the rate hearing, correlation between the rate change error vector and the selection criterion error vector is likely to exist. To account for this, I model the error term structure as follows:

\[
\begin{pmatrix}
U_n \\
\varepsilon_n
\end{pmatrix} 
\sim N\left[
\begin{pmatrix}
0 \\
0
\end{pmatrix},
\begin{pmatrix}
\Sigma_{UU} & \Sigma_{UE} \\
\Sigma_{EU} & \sigma^2_e
\end{pmatrix}
\right],
\]

where \( U_n \) is the vector of error terms associated with the rate changes for the bundle of services, and \( \varepsilon_n \) is the error term associated with the decision to initiate a rate hearing.

To derive the segment of the likelihood function for firms regulated via rate-of-return regulation (RORR) requires the probabilities for the following three occurrences:

1. Neither the firm nor the regulator initiates a rate hearing.
2. The firm initiates a rate hearing.
3. The regulator initiates a rate hearing.

1. Case 1: RORR, Firm No, Regulator No

For a rate hearing not to occur, both the firm and the regulator must choose not to initiate. When this occurs, we do not observe \( U_n \). Therefore, the probability that both the firm and regulator do not initiate is the product of their unconditional probabilities.

The firm initiates a rate hearing if the profit level falls below the threshold \( s^* \); the regulator initiates if the profit level exceeds the threshold \( s^* \). Therefore, we observe a rate hearing if

\[
P_n + \varepsilon_n < s^*_n \tag{A-1}
\]

\[
P_n + \varepsilon_n > s^*_n \tag{A-2}
\]

Therefore, as long as \( P_n + \varepsilon_n \) lies between \( s^*_n \) and \( s^*_n \), a rate hearing does not occur. This happens with probability

\[
\Phi(s^*_n - P_n) - \Phi(s^*_n - P_n),
\]
2. Case 2: RORR, Firm Yes, Regulator No

When either party initiates a rate hearing, we observe \( U_i \) and therefore obtain information regarding the magnitude of the error \( \varepsilon_i \) on \( U_i \). Let \( f(U_i, \varepsilon_i) \) denote the joint probability distribution of \( U_i \) and \( \varepsilon_i \). By the definition of conditional probabilities, we can write \( f(U_i, \varepsilon_i) \) as \( f(\varepsilon_i U_i, U_i) \). Note, however, that, given normality, the conditional distribution of \( f(\varepsilon_i U_i, U_i) \) is also normally distributed with mean and standard deviation as follows:

\[
e_{U_i} | U_i \sim N(\Sigma_{U_i}^{-1} U_i, \sigma_x - \Sigma_{U_i}^{-1} \Sigma U_{U_i}).
\]

(A-3)

Given the conditional distributions in equation (A-3) the probability of the firm initiating a rate hearing is as follows:

\[
\Phi\left(\frac{1}{\sigma_x - \Sigma_{U_i}^{-1} \Sigma U_{U_i}} (s' - \Pi - \Sigma_{U_i}^{-1} U_i)\right) \phi_{\Delta x}(\cdot),
\]

(A-5)

where

\[
\log \phi_{\Delta x}(\cdot) = -\frac{3}{2} \log (2\pi) - \frac{1}{2} \log |\Sigma| - \frac{1}{2} s' \Sigma_{U_i}^{-1} \Delta \Delta X_i - M_{R_i} \Delta \Delta X_i.
\]

(A-6)

3. Case 3: RORR, Firm No, Regulator Yes

Similarly, given the conditional probability distributions, the portion of the likelihood function observable when the regulator initiates is

\[
1 - \Phi\left(\frac{1}{\sigma_x - \Sigma_{U_i}^{-1} \Sigma U_{U_i}} (s' - \Pi - \Sigma_{U_i}^{-1} U_i)\right) \phi_{\Delta x}(\cdot).
\]

(A-7)

4. Case 4: Price Cap Regulation

I make the assumption that firms regulated via price caps are unconstrained in their decision to change rates. They are, however, constrained by the same reduced-form pricing function that relates prices to demand, cost, and regulatory environment variables.

5. Likelihood and Log Likelihood Functions

The above expressions imply the following likelihood function:

\[
L = \prod_{i=1}^{n} \phi_{\Delta x}(\cdot) \times \prod_{i=1}^{n} \prod_{\Delta \Pi, \Delta \Sigma} \left[ \Phi(s'_i - \Pi_i) - \Phi(s'_i - \Pi_i) \right] \times \prod_{\Delta \Pi, \Delta \Sigma} \left[ 1 - \Phi\left(\frac{1}{\sigma_x - \Sigma_{U_i}^{-1} \Sigma U_{U_i}} (s'_i - \Pi - \Sigma_{U_i}^{-1} U_i)\right) \right] \phi_{\Delta x}(\cdot).
\]

(A-8)

The associated log likelihood function is

\[
\ell = \sum_{\sigma_x = 0}^{\infty} \phi_{\Delta x}(\cdot) + \sum_{\Delta \Pi, \Delta \Sigma} \left[ \log \left[ \Phi(s'_i - \Pi_i) - \Phi(s'_i - \Pi_i) \right] \right] + \sum_{\Delta \Pi, \Delta \Sigma} \left[ \log \left[ 1 - \Phi\left(\frac{1}{\sigma_x - \Sigma_{U_i}^{-1} \Sigma U_{U_i}} (s'_i - \Pi - \Sigma_{U_i}^{-1} U_i)\right) \phi_{\Delta x}(\cdot) \right] \right].
\]

APPENDIX B

Data Appendix

Data on residential and business local exchange rates were obtained from the Federal Communications Commission (FCC) Reference Book, 1994 (Lande, 1994) and 1996 editions. The data are a panel of 95 cities stretching from 1983 to 1995 and report the price of residential local telephone service for unlimited local calls for each year (taken on December 31). In cities where unlimited usage is not an option, the FCC reports the rate for 100 five-minute local telephone calls. Restrictions on access to other variables reduced the usable size of the panel to 70 cities, and the range to 1984–1995. IntraLATA toll rates were collected via the 1987 to 1995 volumes of NARUC’s Bell Operating Companies Long Distance Message Telephone Rates and span 1987 to 1995. These rates are set at the company level. Data on the method of regulation were obtained from a number of sources. The primary source was Greenstein et al. (1995), which provides a description of regulatory practices of states; additional data were collected from the 1995 volume of NARUC’s The Status of Competition in Intrastate Telecommunications. Data on the status of competition in the local exchange market were collected from the FCC’s 1998 Local Competition report. Data on which party initiated the rate hearing were collected via facsimiles from the FCC. Data on the status of competition and entry were also obtained from the FCC via their Common Carrier Competition Report, the yearly reports from the NARUC, and contact with state PUCs. Population data were obtained via the Census Bureau’s “places with 50,000 or more,” and were augmented with the biennial census reports when needed. Both sources provide population figures at 2-year increments. Linear interpolations were made for odd-numbered years. Wage and income data were retrieved from the Bureau of Labor Statistics home page. Productivity measurements represent the average productivity of workers in the telecommunications industry, were collected from the Bureau of Labor Statistics home page, and use 1987 as the base year. The region-specific CPI and the U.S.-level CPI numbers were also collected from the Bureau of Labor Statistics home page and use 1987 and 1986 as their respective base years.