

CHAPTER 16

Effects of Prices for Local Network Interconnection on Market Structure in the US

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Abstract. This chapter examines how incumbents and entrants respond to prices for network interconnection in telecommunications, including prices for unbundled network elements. Most studies of the effects of these prices find that lower prices encourage entry and encourage entrants to use more unbundled network elements. Missing from this literature are studies of how incumbents respond to the interconnection prices they charge. US telecommunications laws place an obligation on incumbents to provide interconnection at any technically feasible point, implying that interconnection prices should not affect incumbents' provision of interconnection services. Using data from 1998, evidence is found that low unbundled network element prices result in lower entry, perhaps indicating that US incumbents limit entry. No evidence is found that incumbents hinder entrants from gaining market share for customers who receive more calls than they make (such as Internet Service Providers) or from gaining market share using resold services.

1 INTRODUCTION

The situation often arises in which one firm sells an input to another firm and then competes against the other firm in the market for the final product. Examples include local exchange telephone companies selling access to long distance companies and then competing in the long distance business themselves (Willig, 1979), vertically integrated electricity companies or natural gas pipeline companies selling transport to their generating or gas supplier competitors (Economides and White, 1995), railroads providing trackage to other railroads (Baumol, 1983), Internet backbone providers competing with Internet Service Providers (Crémer et al., 2000; Kende, 2000) and incumbent local exchange telephone companies interconnecting their networks with and selling services to new entrants (Katz, 1997). The

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issue of how to price this input is often couched in the context of a regulated firm interconnecting its network with a new entrant, but the issue could also apply to an unregulated monopolist providing an essential facility to downstream competitors (Economides and White, 1995). For purposes of this chapter, I consider the inputs to be interconnection services, which include incumbent local exchange companies (incumbents) providing unbundled network elements (UNEs) and services for resale to new entrants (entrants), and incumbents and entrants terminating local telephone calls for each other. I explain UNEs, resale, and terminating calls in more detail below.

An extensive theoretical literature has developed on pricing these inputs. Most empirical studies in telecommunications examine entrants' responses to prices for interconnecting networks. Indicative of these studies, Ros and McDermott (2000) and Rosston and Wimmer (2000) find that low prices encourage entry and encourage entrants to expand their market shares.¹ Missing from this literature is an empirical test of whether and how incumbents respond to interconnection prices. This test is important because price signals that encourage more entrants to enter or to compete intensely to expand their market share may also encourage incumbents to hinder entrants in order to protect profits, contrary to regulatory policies that place an obligation on incumbents to provide interconnection services regardless of the price. In this chapter, I take an initial step to fill this void by testing how retail and interconnection prices in US telecommunications affected the early development of competition in local telephone networks.² Using data from 1998, my main findings indicate that greater positive differences between retail prices and prices for leasing incumbents' facilities result in fewer entrants, perhaps because incumbents hinder entry to protect profits. Higher prices for exchanging traffic increase entrants' market share, presumably because they successfully target customers who receive more calls than they make. Entrants appear to resell incumbent services as part of a strategy to gain customers while building networks. Before proceeding, I summarize entry under the US Telecommunications Act of 1996 (1996 Act).

The 1996 Act made allowing competition in almost all telecommunications markets a national policy and provides three methods of entry for local telephone service. Some entrants use more than one method. Entrants can build their own facility-based network, lease portions of an incumbent local exchange company's (incumbent) network, or buy an incumbent's services and resell them.³ The 1996 Act places an obligation on an incumbent to provide entrants with these interconnection services. Exchanging calls between competing networks is

¹ Jamison (2002) provides a partial survey. These studies did not examine the relationship between retail and interconnection prices.

² Telecommunications has traditionally been divided between long distance service and local exchange service. Local exchange service in the US consists of a telephone line and calling within a local calling area, which is typically a city or town. Long distance is calling between local exchange areas. This distinction between local and long distance was based on late 1800's technological limits and the original city-by-city franchising arrangements under which the US telephone system developed. These reasons lost their relevance long ago, but the distinction has remained for regulatory purposes. The AT&T divestiture agreement of 1982 restricted the Bell Operating Companies from providing long distance service, except in limited areas (called Local Access Transport Areas, or LATAs).

³ Traditional voice telecommunications networks consist of lines and switches. Lines either connect customers to the network or connect switches in the network. Switches route calls between customers. Switches are of two types: local switches (also called central offices) that customers connect to and that switch local calls, and long distance switches (also called tandem or toll offices) that route long distance calls from one local switch to another.

necessary for customers of one company to be able to call customers of another company. Payment for exchanging calls is called reciprocal compensation in the US.⁴

Leasing portions of an incumbent's network is called purchasing UNEs. For example, an entrant could lease a local telephone line from the incumbent. The line would connect to the incumbent's building. It could then connect to the incumbent's switch or the entrant's switch, depending on how the entrant wishes to use the incumbent's facilities. Entrants that have their own switches must interconnect their switches with those of an incumbent and pay reciprocal compensation for terminating telephone calls on the incumbent's network. Likewise, an incumbent must pay reciprocal compensation for terminating calls to an entrant.⁵ The 1996 Act states that prices for UNEs and for reciprocal compensation are to be cost-based, which regulators have generally concluded means that they should be based on incremental cost.⁶ Reselling is little more than rebranding the incumbent's service. The 1996 Act says that wholesale prices must be based upon retail prices minus the portion attributable to marketing, billing, collection, and other costs avoided by the incumbent when it does not provide the retail service. The percent discount given off of the retail price is called the wholesale discount.

The rest of this chapter is organized as follows. In section 2, I describe the hypotheses that I am testing. Section 3 describes my data and methods. Section 4 presents my findings and Section 5 is the conclusion.

2 THEORY AND HYPOTHESES

Assuming that entrants seek to maximize profits, I expect more entrants to seek to enter and for entrants to seek to expand their market shares in markets where regulatory policies are more favorable to entrant profits. This can be thought of in terms of an entrant demand curve for entry or interconnection services. Lower prices for UNEs and higher wholesale discounts encourage more entrants to enter and to buy more of these services. Higher prices for UNEs and lower wholesale discounts have the opposite effect. In the case of reciprocal compensation for exchanging calls, entrants are both buyers and sellers of interconnection. Some entrants are more successful at targeting customers (such as Internet Service Providers) who are net receivers of calls, making these entrants net sellers for reciprocal compensation. More of these entrants seek to enter and to expand in markets where reciprocal compensation prices

⁴ "Reciprocal" means that both companies involved in an interconnection are obligated to make payments. "Symmetric" reciprocal compensation means the companies charge the same prices to each other. Reciprocal compensation prices are generally symmetric in the US, so I assume symmetry in my models.

⁵ An exception to the payment of reciprocal compensation occurs in the case of bill and keep, the situation in which the service providers do not charge each other for exchanging traffic.

⁶ This is based on a review of state commission interconnection decisions located on the National Regulatory Research Institute's web site (NRRI, 1998) for 1998, the time period for my study, the FCC and all state regulators but Arkansas determined that incumbents' prices for UNEs should be based upon incremental cost. Arkansas chose an accounting cost allocation approach called fully distributed cost as its method. Twenty-nine percent of the states also chose to base reciprocal compensation prices on incremental cost and the rest chose bill and keep. The FCC's policies allow for bill and keep, but do not mandate it. Some states that adopted bill and keep applied the policy only as long as the traffic exchange is relatively balanced.

are higher. Other entrants are successful in the market for customers that make calls and so either pay as much or more reciprocal compensation than they receive.

Furthermore, the relationships between the retail prices and the prices entrants pay to incumbents affect entrant demand for interconnection services. Greater positive differences between retail prices and the prices for interconnection services that entrants purchase encourage more entrants to enter and to gain market share. The opposite holds if retail prices are lower. This conclusion should hold for UNEs and resold services for all entrants that use these services and for reciprocal compensation for entrants that are net payers. Higher retail prices and higher reciprocal compensation prices encourage more entrants that are net receivers of reciprocal compensation to enter and to increase their market share, so the effect of the relationship between retail prices and reciprocal compensation prices is ambiguous.

Interconnection prices also provide incentives to incumbents. If incumbents do not respond to these incentives, then an examination of the entrants' demand for interconnection services are adequate for predicting the effects of interconnection prices on the number of entrants and on entrant market share. If incumbents do respond, they might do so by changing the demand for their services relative to the demand for entrants' services. For example, if retail prices are higher relative to interconnection services that incumbents sell, such as UNEs and services for resale, then incumbents might respond by increasing their marketing activities or by improving the quality of their retail services relative to their interconnection services. Either response, if successful, would have the effect of decreasing the retail demand for entrants' services, which would in turn lower entrants' demand for interconnection services. Incumbents could also respond by restricting their supply of interconnection services, implying that incumbents have a supply curve for interconnection services that they provide and do not simply comply with their obligation to provide these services.⁷ Incumbents might restrict supply for interconnection services by delaying negotiations with entrants, making ordering of interconnection services difficult, or other means.

My first hypothesis (which I call H1) is that incumbents comply with their obligations to provide interconnection services. I test this hypothesis by examining the effects of incumbent marketing, incumbent service quality, and the relationship between retail prices and prices for UNEs, reciprocal compensation, and services to be resold on the number of entrants in a market, the volume of calls exchanged between incumbents and entrants, and the volume of resold services. For UNEs and reciprocal compensation, I express this relationship as the ratio of the interconnection price to the retail price. I place the UNE and reciprocal compensation prices in the numerator because in the case of Bill and Keep, the reciprocal compensation price is zero. For resale, I use the wholesale discount. I reject H1 if, controlling for incumbent marketing efforts and service quality, a lower ratio of UNE prices to retail prices or higher wholesale discounts lead to fewer entrants or smaller entrant market share.

My second hypothesis (H2) is that the volume of calls exchanged between the incumbent and entrants is primarily determined by entrants that are successful in attracting customers that are net receivers of calls. I reject H2 if higher reciprocal compensation prices result in lower volumes of exchanged calls. My third hypothesis (H3) is that most entrants are not of the type that attracts customers that are net receivers of calls. I reject H3 if higher reciprocal compensation prices result in a greater number of entrants.

⁷ I would like to thank William Taylor for this insight.

Some observers express concern that entrants take advantage of large wholesale discounts to simply resell services and not build networks. (Harris and Kraft, 1997) If entrants avoid building facilities when wholesale discounts are large, then large discounts should be associated with (i) a low market share for entrants using their own facilities or UNEs and (ii) higher levels of service resale. This leads to my last hypothesis (H4), which is that entrants resell services to gain customers with the intent of eventually serving those customers using UNEs or entrant facilities. I reject H4 if higher wholesale discounts increase the number of resold services and lower UNE prices have either no effect on or increase the volume of resold services.

3 METHODS AND DATA

I consider three types of models. The first describes the number of entrants, without distinguishing entry methods. The second describes how entrants expand their market share by constructing their own networks and using UNEs. The third describes how entrants expand their market share by reselling incumbents' services. Because my sample size is small, I use reduced form rather than structural form models. I first describe the models for number of entrants.

3.1 Models for Number of Entrants

I analyze entry by extending Bresnahan and Reiss's (1991) and Berry's (1992) ordered probit models for entry, which apply a zero-profit equilibrium for entrants. These models assume that markets that are more profitable for entrants attract a larger number of entrants than other markets, all other things being equal. Ordered probit models are used when dependent variables are discrete and represent ordered outcomes. Because of data restrictions, I consider each incumbent's traditional local exchange areas in a state to be a market.⁸ The number of entrants ranges from 0 to 164 in these 59 markets. A large range of values in the dependent variable in an ordered probit model causes the analysis to be computationally intensive. To remedy this problem, I take advantage of there being only 36 observed levels of entry – many markets have the same number of entrants (for example, five markets have four entrants each) and many levels of entry are unobserved (for example, no markets have entry levels in the 61- to 74-entrant range) – and create an ordinal variable with values from 0 to 35 that is a monotonic transformation of the observed number of entrants per market.

I control for other factors that may affect the number of entrants in a market. The 1996 Act mandates collocation, the process by which entrants locate their equipment in incumbents' buildings. Collocation can increase entry when it decreases entrants' costs of interconnection

⁸ This causes distortions because for a given incumbent, an entrant may choose to enter some of the incumbent's local exchanges and not enter others, and may choose to supply only some areas of a local exchange. Because regulators generally require incumbents to average retail prices across exchanges and to charge lower retail prices in rural areas than in urban areas, and because per customer costs are generally lower in high density, urban areas than in rural areas, I expect entrants to serve urban areas first. Therefore, regions with higher than average proportions of urban areas should have more entry than areas that are below average. To control for this effect, I include in my models a measure of customer density. Higher customer density indicates markets with higher than average proportions of urban areas.

and using UNEs, relative to entrants placing their equipment some distance away from the incumbents' facilities. I control for the effects of the availability of collocation by including in my models the percent of the incumbent's telephone lines that can be accessed through collocation arrangements.

The 1996 Act also requires competitively neutral means for subsidizing local telephone service. Some regulators have chosen to implement this policy in part by rebalancing prices, the process by which incumbents increase some prices and decrease other prices in order to remove implicit subsidies and align prices with incremental cost. Another common method for implementing this policy is for regulators to develop a "tax" on telephone services, the monies from which are distributed to companies based on their serving customers who the regulators determine should have subsidized prices. I control for the effects of rebalancing by including in my model the ratio of the incumbent's revenues from local telephone services to its cost of providing a telephone line. Higher ratios indicate higher profits for local telephone services. Higher ratios would be associated with (i) more entry and higher market share for entrants if they are willing and able to respond to this incentive or (ii) less entry and lower market share for entrants if incumbents protect these profits. Following Ros and McDermott (2000), I test for the effects of early reforms to the subsidy system by including in my models a dummy variable that indicates whether the state regulator for the market has begun reforming these subsidies.

More entrants are expected in larger and more densely populated markets. I control for market size by including as an explanatory variable the total revenues of the incumbent company in the market. I control for customer density by including the incumbent's number of telephone lines per central office. Because competition in local networks was new at the time of this study, it is unlikely that the data represent a long-run equilibrium. I adjust for this disequilibrium by including as an explanatory variable the amount of time that has elapsed since entrants were allowed to enter each market. Lastly, I include dummy variables for incumbent telephone companies. Table 1 summarizes the explanatory variables that I include in my models for number of entrants.

Table 1. Descriptions of Explanatory Variables for Models of Number of Entrants

Explanatory Variable	Description
UNE Price	The price per month for leasing a 2-wire local line in urban areas. ⁹ I choose local line prices to represent UNE prices because the sunk nature of line investment and the need for right-of-way and conduit space make lines the most difficult facilities for entrants to build. Two-wire lines are the most common technology used for local telephone service. I choose urban prices because I expect most entrants to serve urban areas.
Reciprocal Compensation Price	The price per minute for symmetric reciprocal compensation. This variable is zero in the case of bill and keep.
Residential Wholesale Discount	The wholesale discount regulators give entrants for buying wholesale services for residential customers. In states where discounts vary by service, I use the smallest percentage discount.
Lines per Central Office	The total number of billable telephone lines that the incumbent has in the market divided by the incumbents' number of central offices. This represents density.
Local Service Revenue to Cost Ratio	The ratio of the incumbent's local service per-line revenue to the incumbent's cost of providing a telephone line. This represents the incumbent's local service profit margin.
Percent of Voice Lines Assessable through Collocation	The percent of incumbent's voice telephone lines that could be accessed by entrants through collocation arrangements. This represents the ease of collocation.
Number of Quarters	For each market, the number of quarters prior to 1996 that the first entrant was given telephone numbers. This represents the amount of time that entrants have had to enter the market and gain market share.
Service Complaints in 1997	The total number of customer complaints to state and federal regulators about the incumbent's service in 1997. This indicates the incumbent's service quality.
Total Revenue	The incumbent's total operating revenue for 1998. This indicates market size.
Ratio of UNE Price to Retail Revenue per Line	The ratio of the incumbent's UNE price to the incumbent's average retail price.
Ratio of Reciprocal Compensation Price to Retail Revenue per Minute	The ratio of the incumbent's price for reciprocal compensation to the incumbent's average retail revenue per minute.
Universal Service Reform	A dummy variable indicating whether a state has taken steps to develop competitively neutral methods for subsidizing local telephone service. A value of 1 indicates that the state has done so.
Marketing Expenses per Line 1997	The ratio of Total Marketing Expenses in 1997 for regulated services to the number of billable telephone lines. I use 1997 data to ensure that the market expenses were not a response to the number of entrants in 1998.
Incumbent Indicators	Dummy variables that associate markets with incumbents. Incumbent dummy variables may reveal differences in how incumbents respond to entry.

⁹A two-wire local line has two wires twisted together that are used to connect the customer to the telephone company central office.

3.2 Models for Entrant Market Share

Now consider the second and third types of models, those that describe how entrants expand their market share. I use ordinary least squares regression and examine two measures of entrant output. The first measure is the number of entrant interconnections to the incumbent. These interconnections, called trunks, are necessary for exchanging calls between entrant and incumbent customers. Higher numbers of trunks indicate higher amounts of entrant output for customers that are net receivers of calls and that are served by entrant facilities or UNEs. Trunks understate traffic exchange if the entrants are large because, as an entrant grows, the number of minutes that stay on the entrant's network generally increase. This happens because the probability of a call originating on an entrant's network also terminating on that entrant's network generally increases as the entrant attracts more customers. Trunks overstate traffic exchange if there are many small entrants, or many entrants whose customers are dispersed geographically. This happens because these entrants' low traffic volumes keep them from making efficient use of their local interconnection trunks. I do not include incumbent marketing expenses per line as an explanatory variable in the entrant interconnection models because the variable is too broad of a measure of incumbent marketing to reasonably measure incumbent marketing efforts to Internet Service Providers. My second measure of entrant supply is the proportion of business local telephone lines that are resold by entrants.

For models of entrant market share, I divide the dependent variables and certain explanatory variables by the number of incumbent telephone lines in the market. This indexes these variables according to market size. Table 2 describes the explanatory variables in my market share models that are not also in my entry models.

Table 2. Descriptions of Explanatory Variables for Market Share Models

Explanatory Variable	Description
Business Wholesale Discount	The discount regulators give entrants for buying wholesale business services. In states where discounts vary by service, I use the smallest percentage discount. This variable is used in the model of resold business lines.
Local Revenue Per Line	The incumbent's per-line revenue from local service.
Service Complaints in 1998 Per Line	The total number of customer complaints to state and federal regulators about the incumbent's service in 1998 divided by the number incumbent telephone lines.
Total Revenue Per Line	The incumbent's total operating revenue for 1998 divided by the number of incumbent telephone lines.
Total Plant in Service Per Line	The net book value of the incumbent's assets in the market divided by the number of incumbent telephone lines.
Minutes of Use Per Line	The number of telephone minutes of use for the incumbent in 1998.
Central Office Total Plant in Service Per Line	The net book value of the incumbent's central office assets divided by the number of incumbent telephone lines.

3.3 Data

Table 3 describes the data I use for my dependent variables, which are from the United States Telephone Association's (USTA) report to Congressman Thomas Bliley on December 9, 1998 (USTA, 1998).¹⁰ Data are for 1998. There were no reported entrants in West Virginia in Bell Atlantic's territories in 1998, so I omit this market from the market share models. Table 4 describes the data for the explanatory variables for my entry models. Table 5 describes data for the market share model explanatory variables that are not also used in the entry models.

Table 3. Descriptions of Dependent Variables

Variable	Name in Model	Mean	Minimum	Maximum	Standard Deviation	Observations
Number of Entrants	COMPT	13.898	0	35	10.22	59
Number of Interconnection Trunks	NA	30,536.4	0	289,299	50,946.3	58
Interconnection Trunks Per Line	TRNKPLN	0.0096	0	0.0243	0.0066	58
Number of Business Resold Lines	NA	27,474.7	0	183,594	42,918.38	58
Fraction Business Lines Resold	RSLBSPR	0.0336	0	0.3303	0.0524	58

Data for UNE and reciprocal compensation prices and wholesale discounts are from state commissions (NRRI, 1998; Alabama, 1998), X-Change (1998-1999), and interviews with incumbents.¹¹ Some states have separate prices for terminating minutes at a central office or a tandem office and for different times of the day. To express these prices as a single price, I follow the convention of assuming 6.25% of the minutes terminate at local central offices and the remaining minutes terminate in a tandem. In states where residential service discounts are different from business service discounts, I use the residential discount for the models explaining number of entrants and market share using UNEs and entrant-owned facilities. Business and residential discounts are highly correlated ($R^2 = 0.88$). In tests of various models, business and residential discounts have similar results. To avoid multicollinearity, I use only the residential discount for these models.

¹⁰ Observations include Ameritech (all states), Bell Atlantic (all states), BellSouth (all states), GTE (California, Florida, Hawaii, Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, Oregon, Texas, Virginia, Washington, and Wisconsin), SBC (Arkansas, California, Oklahoma, and Texas), and US West (all states) for 1998.

¹¹ In cases where there are discrepancies, I employ the data provided in state commissions' decisions (NRRI, 1998) when available, and other public data when the commission data are not available.

Table 4. Descriptions of Explanatory Variables for Models of Number of Entrants

Variable	Name in Model	Mean	Minimum	Maximum	Standard Deviation	Observations
UNE Price	UNEPRC	\$16.82	\$3.72	\$32.00	\$6.16	59
Reciprocal Compensation Price	RCP	\$0.0057	\$0	\$0.0283	\$0.0067	59
Residential Wholesale Discount	RESRSL	0.1788	0.0700	0.2500	0.0405	59
Incumbent Total Billable Lines	NA	2,286,606	235,862	16,071,707	2,785,059	59
Number of Incumbent Central Offices	NA	230.1	29	752	174.2	59
Lines Per Central Office	LNSPRCO	10,424.9	881.1	29,786.8	6,851.7	59
Incumbent Local Service Revenues (000)	NA	\$749,773	\$71,863	\$4,731,829	\$902,587	59
Incumbent Line Cost Level	NA	\$265.72	\$65.68	\$408.81	\$57.71	59
Local Service Revenue to Cost Ratio	LCLPUSF	1.3290	0.7967	5.0431	0.5551	59
Percent of Voice Lines Assessable through Collocation	COLCV98	23.66%	0%	72.62%	17.54	59
Number of Quarters Service Quality	NUMQRT SCMPAM-97	10.75	0	18	15.44	59
Complaints in 1997		274.29	6	2,637	466.18	59
Total Revenue (000)	REVT	\$1,511,887	\$170,463	\$8,460,236	\$1,721,406	59
Ratio of UNE Price to Retail Revenue per Line	PRCST-UNE	0.1969	0.0546	0.4460	0.0739	59
Local Calling Minutes for Incumbent (000)	NA	7,056,890	820,771	36,441,427	7,740,706	59
Ratio of Reciprocal Compensation Price to Retail Revenue per Minute	PRCST-RCP	0.1601	0	0.8236	0.1919	59
Universal Service Reform	USFFUND	0.2881	0	1	0.4568	59
Marketing Expenses per Line in 1997	MKTGSTS97 pl	\$25.76	\$13.75	\$37.90	\$5.72	59

Table 5. Descriptions of Explanatory Variables in Market Share Models and not in Models of Number of Entrants

Variable	Name in Model	Mean	Minimum	Maximum	Standard Deviation	Observations
Business Wholesale Discount	BUSRSL	0.1792	0.0800	0.2601	0.0377	58
Local Revenue Per Line	LCLPRLN	\$329.98	\$228.47	\$458.84	\$49.69	58
Service Complaints in 1998 Per Line	SCMP98-PL	0.00016	9.03 x 10 ⁻⁶	0.00097	0.00019	58
Total Revenue Per Line ¹²	REVTPL	\$678.02	\$502.90	\$955.18	\$98.80	58
Incumbent Total Assets (000)	NA	\$4,532,754	\$493,351	\$27,585,598	\$5,118,892	58
Total Plant in Service Per Line	TPISPL	\$206.07	\$140.24	\$305.62	\$37.87	58
Minutes of Use Per Line	MOUPL	3,288.7	2,188.4	4,592.0	599.3	58
Central Office Total Plant in Service Per Line	COTPILPL	\$364.44	\$225.44	\$639.74	\$89.82	58

Data for incumbent total billable lines, number of central offices, local service revenues, service quality complaints, total revenues, local calling minutes, marketing expenses, and total plant in service are from FCC ARMIS reports.¹³ I use the ratio of total revenues for basic local telephone services and total billable lines to indicate incumbents' price levels for local exchange services. Firms charge many prices, so using a single price is inappropriate. I use incumbents' Universal Service Fund costs per line reported to the FCC in 1998 to represent incumbents' costs for telephone lines.¹⁴ I use total numbers of customer complaints to state and federal regulators for 1997 and 1998 in metropolitan statistical areas as my measure of incumbent service quality. Data for 1997 are used to examine number of entrants because these data represent ex ante entry information. Per line data for 1998 are used in models for entrant market share because these data represent the quality that customers and entrants experienced at the time supply and purchasing decisions were put into effect. I use the incumbent's total operating revenues for 1998 for the market, to indicate market size.

I use the percent of incumbent voice telephone lines accessible by entrants through collocation in 1998 to represent the ease of collocation. Data are from Tables 3.6 and 3.7 of the FCC's 1998 Local Competition report. (FCC, 1998) There is a risk of endogeneity because higher entrant interest in a market should increase entrant demand for collocation. Higher demand for collocation should increase the incidence of collocation, which could cause a

¹² Total revenue per line, total plant in service per line, and central office total plant in service per lines are expressed as \$1000 per line in the model. Minutes of use per line is expressed as 1000s of minutes per line in the model.

¹³ All ARMIS data are from <http://fcc.gov> and were downloaded between March 1999 and December 2002.

¹⁴ USF costs are based on incumbents' regulatory accounting records and provide an average cost for all of an incumbent's operations in a state. Regulatory costs are an imperfect measure of economic costs. The accounting processes (Gabel, 1967) and distortive efficiency incentives caused by methods of regulation (Sappington and Weisman, 1996) cause these regulatory costs to deviate from economic costs.

higher percentage of incumbent lines to be in central offices with collocation. However, differences between markets should also reflect the ease of obtaining collocation.

I use the number of quarters in a state from the time the first entrant was given telephone numbers until the 1996 Act took affect to represent the amount of time that entrants have been operating in a state. Data are from Table 4.8 of the FCC's December 1998 Local Competition report (FCC, 1998).

For the models for number of entrants, I include two price ratios, PRCSTUNE and PRCSTRCP, as explanatory variables. PRCSTUNE is the ratio of the incumbent's UNE price to the incumbent's 1998 total operating revenues. PRCSTRCP is the ratio of the incumbent's reciprocal compensation price to the incumbent's average retail revenue per minute.

I use dummy variables to indicate state efforts to reform universal service subsidies and to identify incumbents. According to a National Regulatory Research Institute survey (Rosenberg and Wilhelm, 1998), fourteen states had revised or were revising their subsidy policies in 1998. I have a dummy variable for each incumbent, but omit the Ameritech dummy from models to avoid multicollinearity.

Multicollinearity problems occur between the reciprocal compensation variables RCP and PRCSTRCP ($R^2 = 0.97$), between the service complaint variables SCMPAM97 and SCMPAM98 ($R^2 = 0.92$), among variables that indicate market size (for example, REVT and TPIS), and between PRCSTUNE and the variables that are included in it. To avoid multicollinearity in the models for number of entrants, I include no more than one variable from each of the collinear groups, with the exception of collinear groups involving PRCSTUNE and PRCSTRCP. I need these variables in some entry analyses to perform likelihood ratio tests of entrant and incumbent incentives. Regarding multicollinearity in the entrant market share models, dividing market size indicators such as REVT by LINES resolves much of the multicollinearity. Otherwise, I include in each model no more than one variable from each collinear group.

4 MODEL RESULTS

In this section I examine the results of my models. I examine the number-of-entrants models first. I then investigate the models for market share with respect to calls exchanged. Lastly, I examine models for resale. Tests of log linear models did not improve the overall fit, so I report only the linear results.

4.1 Results for Models of Number of Entrants

Table 6 provides the coefficients and t-statistics for these models. One asterisk (*) indicates significance at the 0.10 level. Two asterisks (**) indicate significance at the 0.05 level. Three asterisks (***) indicate significance at the 0.01 level. I estimate two models. Model 1 examines how UNE prices, reciprocal compensation prices, wholesale discounts, customer density, local service price-cost margins, service quality, market size, and UNE price-cost margins affect the number of entrants. The signs of coefficients can be misleading in ordered probit models, so I calculate the marginal effects of explanatory variables on each level of entry in Table 7. A negative marginal effect for a particular explanatory variable and entry level indicates that a higher value for the explanatory variable decreases the probability of a market having that level of entry. A positive marginal effect indicates that a higher value for

the explanatory variable increases the probability of a market having that level of entry. For example, the marginal effects for UNE price imply that a higher UNE price would increase the probability that a market would have less entry and decrease the probability that the market would have more entry. Before reviewing the marginal effects further, I examine whether other explanatory variables should be included in entry models.

Model 2 in Table 6 provides the results of adding other variables to Model 1. Using a likelihood-ratio test, I fail to reject at the 0.10 level the joint hypothesis that the coefficients for these variables are all zero ($\chi^2(3) = 1.75$). I conclude that Model 1 is the most appropriate model for examining how regulatory policies affect entry decisions.

Table 6. Regression Results for Entry (COMPT)

Explanatory Variable	Model 1	Model 2
	*-0.1370	*-0.1347
UNE Price	(-1.89)	(-1.81)
	** -57.4441	-55.4438
Reciprocal Compensation Price	(-1.96)	(-0.56)
	***12.1078	***12.2769
Residential Wholesale Discount	(2.85)	(2.85)
	*0.0001	0.0001
Lines Per Central Office	(1.90)	(1.16)
	** -1.4155	*-1.1159
Local Service Revenue to Cost Ratio	(-2.49)	(-1.82)
Percent of Voice Line Assessable through Collocation		0.0147
		(1.18)
		-0.0164
Number of Quarters		(-0.31)
	** -0.0010	** -0.0011
Service Quality Complaints in 1997	(-2.01)	(-2.04)
	***1.25e-06	***1.35e-06
Total Revenue	(4.88)	(4.99)
	*10.9565	8.8917
Ratio of UNE Price to Retail Revenue per Lines	(1.86)	(1.45)
Ratio of Reciprocal Compensation Price to Retail Revenue per Minute		0.4409
		(0.12)
	0.4581	0.4967
Universal Service Reform	(1.15)	(1.23)
	0.0087	-0.0083
Marketing Expenses per Line in 1997	(0.27)	(-0.23)
		0.3410
GTE dummy variable		(0.41)
	*0.9818	**1.2968
Bell Atlantic dummy variable	(1.84)	(1.98)
	***2.2178	***2.6699
BellSouth dummy variable	(3.77)	(3.35)
	***3.6751	***4.1259
SBC dummy variable	(4.22)	(3.93)
		0.9301
US West dummy variable		(1.13)
	107.77	109.52
χ^2	d.f. = 15	d.f. = 18
Log Likelihood	-147.7770	-146.9014

The marginal effects in Table 7 show that there is less entry if the ratio of UNE prices to retail revenue per line is lower, so I reject H1. This result implies that incumbents do not simply comply with their obligations to provide interconnection services to entrants, at least to the extent that these services affect the number of entrants. The marginal effects also show that entry is lower if UNE prices are higher, wholesale discounts are lower, and incumbent ratios of local service revenue to cost are higher, which supports my conclusion that incumbents have a supply curve for interconnection services. The marginal effects also show that there is less entry if reciprocal compensation is higher, so I fail to reject H3 and conclude that most entrants are net payers of reciprocal compensation. Universal service reform and incumbent marketing have no significant effects on entry.

4.2 Entrant Market Share Model Results

Tables 8 and 9 provide the results for the entrant market share models. Model 3 in Table 8 shows the results of including most of the explanatory variables in a model for number of interconnection trunks. This model forms the basis for testing hypotheses. Using an F-test, I fail to reject the hypothesis at the 0.10 level that coefficients for the ratio of UNE prices to incumbent retail revenue per line, incumbent local revenue per line, universal service reform, and the GTE, BellSouth, and US West dummy variables are equal to zero ($F(7, 38) = 0.41$). Model 4 shows the Model 3 with these variables. This F-test does not form a basis for rejecting H1, but H1 is already rejected based on the results of Model 1. This difference in model results implies that incumbents may not hinder entrants from gaining market share for customers that are net receivers of calls. The coefficient for reciprocal compensation prices is positive and significant, so I fail to reject H2, that the volume of calls exchanged between incumbents and entrants is largely determined by the calls received by entrants who are successful in attracting customers who are net receivers of calls. Taken together, the analysis of H1 and H2 may explain why incumbents asked regulators to prohibit entrants from receiving reciprocal compensation for terminating calls to Internet Service Providers; i.e., it may be that incumbents were unsuccessful in targeting Internet Service Providers as customers and so sought to prevent entrants from benefiting from their successful marketing to Internet Service Providers.

Entry Level	Selected Explanatory Variables							
	UNE Price	Reciprocal Compensati on Price	Residential Wholesale Discount	Local Service Revenue to Cost Ratio	Service Quality Complaints in 1997	Ratio of UNE Price to Retail Revenue per Lines	Universal Service Reform	Marketing Expenses per Line in 1997
0	0.0002079	0.08714273	-0.0183675	0.00214736	1.55371E-06	-0.0166211	-0.000695	-1.324E-05
1	-0.0002026	-0.0849369	0.01790258	-0.002093	-1.51438E-06	0.01620034	0.00067742	1.2901E-05
2	0.00019417	0.08138683	-0.0171543	0.00200552	1.45109E-06	-0.0155232	-0.0006491	-1.236E-05
3	0.00047191	0.19780883	-0.0416932	0.00487438	3.52683E-06	-0.0377288	-0.0015776	-3.005E-05
4	0.00111252	0.46632562	-0.0982898	0.01149114	8.31435E-06	-0.0889441	-0.0037192	-7.083E-05
5	0.00525195	2.20141952	-0.4640044	0.05424711	3.92502E-05	-0.4198853	-0.0175575	-0.0003344
6	0.00372893	1.56302578	-0.3294469	0.03851589	2.7868E-05	-0.298122	-0.0124659	-0.0002374
7	0.00704959	2.95491979	-0.6228235	0.07281477	5.26847E-05	-0.5636033	-0.023567	-0.0004488
8	0.0027985	1.17302616	-0.2472447	0.02890557	2.09145E-05	-0.2237358	-0.0093555	-0.0001782
9	0.00332454	1.39351967	-0.2937192	0.03433894	2.48458E-05	-0.2657914	-0.011114	-0.0002117
10	0.00388077	1.62667387	-0.3428623	0.0400843	2.90028E-05	-0.3102618	-0.0129736	-0.0002471
11	0.00409192	1.71517802	-0.3615168	0.04226521	3.05808E-05	-0.3271426	-0.0136794	-0.0002605
12	0.00387262	1.62325594	-0.3421419	0.04000007	2.89418E-05	-0.3096099	-0.0129463	-0.0002466
13	0.00359386	1.50640886	-0.3175135	0.03712074	2.68585E-05	-0.2873232	-0.0120144	-0.0002288
14	0.00943033	3.95283904	-0.83316	0.09740538	7.04771E-05	-0.7539403	-0.0315259	-0.0006004
15	0.00231213	0.96915698	-0.2042742	0.02388185	1.72796E-05	-0.1848511	-0.0077295	-0.0001472
16	0.00351692	1.47415973	-0.3107162	0.03632606	2.62835E-05	-0.2811722	-0.0117572	-0.0002239
17	-0.0032167	-1.3483284	0.28419405	-0.0332253	-2.404E-05	0.25717191	0.01075361	0.0002048
18	-0.0060902	-2.5527707	0.5380605	-0.0629051	-4.55146E-05	0.48689987	0.02035966	0.00038775
19	-0.0035091	-1.4708912	0.31002723	-0.0362455	-2.62253E-05	0.28054878	0.01173111	0.00022342
20	-0.0084286	-3.5329685	0.74466178	-0.087059	-6.29911E-05	0.67385679	0.02817724	0.00053663
21	-0.0088631	-3.7150951	0.78304952	-0.0915469	-6.62383E-05	0.7085945	0.02962979	0.00056429
22	-0.0044362	-1.8594891	0.39193401	-0.0458213	-3.31538E-05	0.35466758	0.01483038	0.00028244
23	-0.0042759	-1.792314	0.37777516	-0.044166	-3.19561E-05	0.341855	0.01429463	0.00027224
24	-0.0037688	-1.579742	0.33297028	-0.0389278	-2.8166E-05	0.30131033	0.01259926	0.00023995
25	-0.0033006	-1.3834727	0.29160159	-0.0340914	-2.46666E-05	0.26387512	0.01103391	0.00021014
26	-0.0030118	-1.2624322	0.26608927	-0.0311087	-2.25085E-05	0.24078859	0.01006855	0.00019175
27	-0.0027359	-1.1467857	0.24171387	-0.028259	-2.04466E-05	0.21873089	0.00914621	0.00017419
28	-0.0015836	-0.6637898	0.13991036	-0.016357	-1.1835E-05	0.1266072	0.00529406	0.00010082
29	-0.000658	-0.275795	0.05813071	-0.0067961	-4.91729E-06	0.05260344	0.00219961	4.1891E-05
30	-0.0003601	-0.1509229	0.0318108	-0.003719	-2.69088E-06	0.02878612	0.00120369	2.2924E-05
31	-0.0002909	-0.1219366	0.02570121	-0.0030047	-2.17407E-06	0.02325745	0.00097251	1.8521E-05
32	-0.0001047	-0.0438816	0.00924914	-0.0010813	-7.82386E-07	0.0083697	0.00034998	6.6653E-06
33	-1.657E-06	-0.0006947	0.00014643	-1.712E-05	-1.23862E-08	0.0001325	5.5406E-06	1.0552E-07
34	-8.812E-10	-3.694E-07	7.7853E-08	-9.102E-09	-6.58561E-12	7.0451E-08	2.9459E-09	5.6104E-11
35	-7.962E-20	-3.338E-17	7.0346E-18	-8.224E-19	-5.9506E-22	6.3657E-18	2.6618E-19	5.0694E-21

Table 8. Regression Results for Entrants Using UNEs and Facilities (TRNKPLN)

Explanatory Variable	Model 3	Model 4
	-0.0002	-0.0002
UNE Price	(-1.25) *0.1966	(-1.47) *0.2158
Reciprocal Compensation Price	(1.92)	(1.77) 0.0134
Residential Wholesale Discount		(0.79) 0.00002
Local Revenue Per Line		(0.81)
Percent of Voice Lines Assessable through Collocation	***0.0002 (3.79)	***0.0002 (3.22)
Number of Quarters	***0.0006 (3.36)	***0.0006 (2.69)
Service Complaints in 1998 Per Line	**7.4731 (2.02)	7.2727 (1.65)
Total Revenue Per Line	**0.0350 (2.55)	0.0303 (1.56)
Total Plant in Service Per Line	**0.0079 (-2.19)	*-0.0083 (-1.76)
Minutes of Use Per Line	***0.0043 (2.95)	**0.0037 (2.10)
Central Office Total Plant in Service Per Line	***0.0416 (3.05)	*0.0338 (1.85)
Universal Service Reform Ratio of UNE Price to Retail Revenue per Lines		0.0007 (0.37) 0.0036 (0.36)
Central Offices per Line ¹⁵	***-14.6356 (-3.48)	**11.6152 (-2.18)
GTE dummy variable		0.0033 (0.68)
Bell Atlantic dummy variable	***-0.0071 (-3.68)	-0.0049 (-1.36)
BellSouth dummy variable		0.0024 (0.62)
SBC dummy variable	**0.0055 (2.21)	*0.0063 (1.92)
US West dummy variable		0.0027 (0.61)
Constant	***-0.0337 (-4.26)	***-0.0358 (-4.01)
F	7.57	4.49
R2	d.f. = 12, 45 0.6688	d.f. = 19, 38 0.6919

Table 9 shows the results for entrant market share using resold business services. Model 5 forms the basis for testing hypotheses. The coefficient for the business wholesale discount is insignificant and the coefficient for UNE prices is negative and significant, so I fail to reject H4, that entrants resell incumbent services to gain customers with the intent of eventually serving these customers using UNEs or entrant facilities. This conclusion is further supported by the coefficient for the percent of lines that are assessable through collocation. This coefficient is negative and significant, indicating that entrants use fewer resold lines if they

¹⁵ This is the inverse of the explanatory variable Lines per Central Office. I use the inverse for convenience.

can use collocation to interconnect their facilities with incumbent facilities. The results from Model 5 support the rejection of H1 – the coefficient for business wholesale discount is insignificant, which is counter to the incentive the discount provides to entrants. Incumbent marketing does not appear to affect entrant market share from resold business lines and, as one would expect, lower incumbent service quality causes entrants to resell fewer business lines.

Model 6 shows the effects of including additional incumbent dummy variables. Using an F-statistic, I fail to reject at the 0.10 level the null hypothesis that the coefficients for these variables are zero ($F(4, 38) = 0.52$).

5 CONCLUSION

This chapter shows that incumbents are able to hinder entry in newly opened markets when incumbents' profit margins for inputs sold to entrants are lower than incumbents' retail profit margins. This confirms the theories of Shepherd (1997), Noll (1995), Gulati et al. (2000), and Ordovery et al. (1985). I do not find evidence that incumbents in local telephone markets have limited entrants' abilities to gain market share for serving customers that are net receivers of calls, such as Internet Service Providers. I do find that most entrants are not of the type entrant that serves primarily customers who are net receivers of calls. Lastly, I find that entrants resell business lines to gain market share with the intent of eventually serving its customers using UNEs or entrant facilities.

Table 9. Regression Results for Resold Business Lines (RSLDBPLN)

Explanatory Variable	Model 5	Model 6
	***-0.0012	** -0.0010
UNE Price	(-2.70)	(-2.02)
	0.3115	0.2506
Reciprocal Compensation Price	(0.88)	(0.64)
	0.0278	0.0234
Business Wholesale Discount	(0.55)	(0.43)
	0.0001	0.00004
Local Revenue Per Line	(1.67)	(0.56)
Percent of Voice Lines	** -0.0003	** -0.0004
Assessable through Collocation	(-2.04)	(-2.27)
	0.0007	0.0011
Number of Quarters	(1.19)	(1.65)
Service Complaints in 1998 Per	* -24.4591	* -24.2993
Line	(-1.85)	(-1.78)
	** -0.1208	* -0.0997
Total Revenue Per Line	(-2.45)	(-1.71)
	0.0141	0.0096
Total Plant in Service Per Line	(1.16)	(0.70)
	-0.0029	-0.0020
Minutes of Use Per Line	(-0.74)	(-0.04)
Central Office Total Plant in	-0.0299	0.0271
Service Per Line	(-0.71)	(0.46)
	** -0.0120	** -0.0123
Universal Service Reform	(-2.47)	(-2.29)
Marketing Expenses per Line in	0.0007	0.0006
1997	(1.47)	(1.10)
	15.8692	11.2574
Central Offices per Line	(1.07)	(0.67)
		-0.0179
GTE dummy variable		(-1.24)
		-0.0092
Bell Atlantic dummy variable		(-0.86)
		-0.0046
BellSouth dummy variable		(-0.41)
		-0.0003
SBC dummy variable		(-0.02)
	***0.0256	0.0171
US West dummy variable	(3.40)	(1.38)
	*0.0474	0.0367
Constant	(1.94)	(1.37)
	3.31	2.61
F	d.f. = 15, 42	d.f. = 19, 38
R2	0.5421	0.5660

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