NETWORK INTERCONNECTION AND TELECOMMUNICATIONS COMPETITION: THE CASE IN THE U.S.

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Abstract

I examine how network interconnection policies affect entrants' incentives and abilities to enter local telecommunications markets and expand output. Policies affect entry and entrant output differently. Low prices for what incumbents sell to entrants encourage entry, but entrants expand output even with high interconnection prices by being selectively targeting customers. Entrants resell incumbent services to enter markets, but not as a long-term strategy for supply. Low price-cost margins for what incumbents sell to entrants, relative to incumbents' price-cost margins on retail services, give incumbents and incentive to hinder entry, but do not appear to affect entrants' abilities to expand output.

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1. Introduction

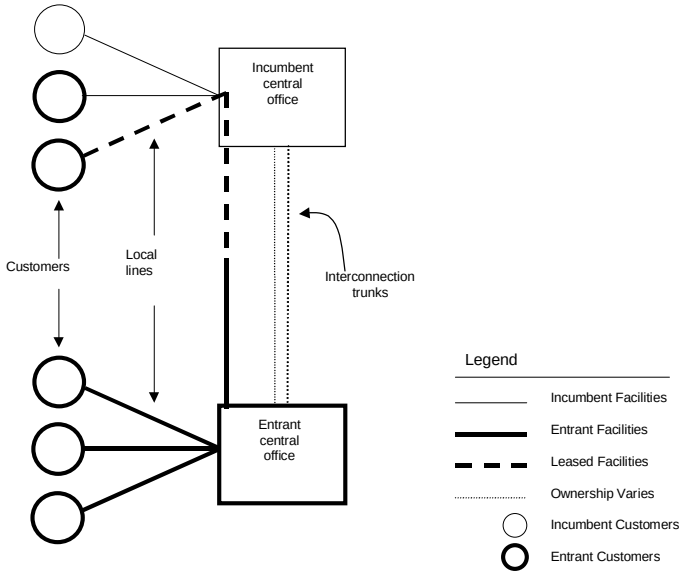
Opening telecommunications markets to competition has sparked controversy over what role, if any, the government should play in facilitating entry, regulating prices, and reforming traditional methods of subsidizing services. Difficult issues in writing and implementing the US Telecommunications Act of 1996 (Act) included how Bell Operating Company (BOC) long distance restrictions would be lifted[1] and how to regulate prices that incumbent local exchange carriers (incumbents) charge new entrants for exchanging calls and for using portions of the incumbents' networks to provide services.[2] Exchanging calls between competing carriers is necessary if customers of one company are to be able to call customers of another company. Payment for exchanging calls is called reciprocal compensation in the US. "Reciprocal" means that both companies involved are obligated to make payments. "Symmetric" reciprocal compensation means companies charge each other the same prices. Reciprocal compensation is generally symmetric in the US, so I assume symmetry.

The Act provides three methods of market entry, illustrated in figure 1. Some entrants use more than one method. Entrants can build their own facility-based network, lease portions of an incumbent's network, or buy an incumbent's services and resell them. Leasing portions of an incumbent's network is called purchasing unbundled network

[1] The AT&T divestiture agreement of 1982 restricted the BOCs from providing long distance service, except in limited areas (called Local Access Transport Areas, or LATAs).

[2] 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.

elements or UNEs. Figure 1 shows how an entrant would 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. Figure 1 shows how lines, called trunks, would connect the incumbent and entrant central offices. Likewise, an incumbent must pay reciprocal compensation for terminating calls on entrants' network. Regarding resale, also called rebranding, figure 1 shows an entrant's customer using a resold service. The facility arrangement is just as if it was an incumbent's customer.



Economists disagree on how prices for UNEs and reciprocal compensation should be set. Baumol and Sidak (1994a, 1994b, 1995), Kahn and Taylor (1994), Hausman and Tardiff (1995), Larson and Parsons (1994), and Larson (1997) argue that incumbents'

prices should be based on the Efficient Component Pricing Rule (ECPR). The ECPR sets the price of an upstream input equal to its incremental cost plus the retail profits that the incumbent loses to downstream competitors. The ECPR has two purposes: First, to ensure that regulated prices do not provide entrants with an artificial price umbrella that encourages inefficient entry. The second purpose is to avoid giving incumbents price signals that encourage them to hinder efficient competitors. Mitchell et al. (1995), Albon (1994), Economides and White (1995), Tye and Lapuerta (1996), and Tye (1994) point out numerous flaws with the ECPR theory and argue for prices based only on incremental cost. Laffont and Tirole (1994, 1996) and Laffont, Rey, and Tirole (1998a, 1998b) show that the ECPR can be efficient in some circumstances, but that incumbent prices below incremental cost could be efficient in other circumstances.

Despite the voluminous debate on these issues, empirical research has been lacking. In this paper, I take an initial step in filling this void in the literature by examining how the Act and regulators' decisions implementing the Act have affected the early development of local competition. I find that regulators' adoption of UNE and reciprocal compensation prices based on incremental cost has given incumbents an incentive to hinder competitive entry, as the ECPR theory predicts. However, these prices have not led incumbents to hinder entrants' in their efforts to gain market share. The data do not reveal whether this is the result of a lack of incentive for incumbents, a lack of ability, or a lack of opportunity. I further find that the opportunity for entrants to place facilities in incumbents' buildings (called collocation) is important to encouraging facilities-based entry and causes entrants to substitute facilities and unbundled network elements for resale-based entry. Higher symmetric reciprocal compensation prices

discourage entry and incent entrants to expand output by selecting customers that receive more calls than they send. High wholesale discounts for resold services encourage entry, but do not encourage entrants to substitute resale-based entry for facilities-based supply.

This study provides guidance for US policy makers as they consider policy reforms. Congress has held several hearings on the implementation and effects of the Act. The Act requires the Federal Communications Commission's (FCC) to review the necessity of its rules every two years. The Act also requires the FCC to forbear from applying any regulation or any provision of the Act if the FCC finds that the regulation or provision is unnecessary or inconsistent with the public interest. In addition to providing information for US policy makers, this study suggests strategies that incumbents and entrants might choose in advocating policy positions before policy makers, and provides insights that other countries might use in establishing their own telecommunications policies. The World Trade Organization Agreement on Basic Telecommunications is prompting numerous countries to open telecommunications markets to competition.

In this paper, I contribute to the literature on competition in telecommunications by providing an empirical analysis of how US regulatory policies affect the development of local competition. Section 2 is a review of the literature. In Section 3, I provide historical background on telecommunications in the US, including an explanation of portions of the Act. In Section 4, I describe my models and their underlying theory. In Section 5, I discuss the estimation results. Lastly, I conclude with policy implications and recommendations for further research.

2. Literature Review

Before presenting my results, I examine and summarize related empirical research. Crandall (1991) finds that investments in private networks increased from 1984 through 1988. Tomlinson (1995) shows that the competition from competitive access providers, who provide fiber optic networks for large customers, prompts incumbents to build advanced fiber optic rings. Ros (1999) finds that competition increases teledensity (telephone lines per 1000 population) and decreases investment in countries with liberalization. Dekimpe et al. (1998) find that increased numbers of cellular competitors increases the penetration rate and the rate of diffusion. Blank et al. (1998) show that entry into intraLATA long distance markets lowers prices.

Greenstein et al. (1995) find that entry by competitive access providers has no affect on incumbents' investment levels, but that removal of restrictions on entry encourages incumbents' investment in fiber optics. They also show that intraLATA competition and resale of local services decrease incumbent fiber optic investment. Woroch (2000) finds that competitive access provider entry into markets for digital fiber optics prompts incumbents to make competing investments. Ros and McDermott (2000) find that removing traditional subsidies from business to residential customers encourages entry by new competitors. Ai and Sappington (1998) find that higher levels of competitive access provider investment is associated with higher incumbent investment in new technologies and with longer delays by incumbents in resolving customer trouble reports. They also find that intraLATA long distance competition encourages incumbents to invest more in fiber optics and is also associated with long delays by incumbents in

resolving customer trouble reports. In a cross-country comparison, Spiller and Cardilli (1997) conclude that the absence of clear rules on interconnection and parity for long distance competitors in terms of the how customers can use their services, causes delays in entry and disadvantages new competitors. They also find that limiting rights for entrants to use incumbents' networks encourages investment by entrants.

3. Historical Background

The AT&T divestiture of 1984 divided the industry into monopoly local exchange companies and competitive long distance companies. To ensure that the divested BOCs did not use their local monopolies to hinder competition in other markets, the divestiture agreement restricted the BOCs from manufacturing telephone equipment and from providing information services and interLATA long distance.

But the divestiture's underlying theory of local monopoly was fatally flawed. The boundaries between local telecommunications and all other telecommunications are artificial and arbitrary. The division between long distance and local telecommunications made long distance companies heavily dependent on incumbent local exchange companies, who were natural competitors to long distance companies (Jamison 1995). Also, the interLATA restrictions prevent the BOCs from competing for large customers and BOC provision of long distance would eliminate the double marginalization that occurs when long distance companies take BOC access prices as given when they (the long distance companies) make their profit maximizing decisions (Weisman 1995).

The arbitrariness of the distinction between local and all other communications finally spelled the end of the local telephone monopoly. In the early 1990s, some states began allowing competition for local telephone service. By 1996, the pressure for change was overwhelming and Congress passed the Act. Among other things, the Act removes legal restrictions on local telephone service competition for all geographic areas except those served by small rural telephone companies. To facilitate local competition, the Act requires interconnection, creates UNEs, and requires incumbents to offer for resale at wholesale rates any telecommunications service that they provide to retail customers. 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. This is essentially the ECPR discussed earlier[3] (Larson 1997).

The FCC began implementation of the local competition provisions of the Act by adopting rules in August 1996 that incumbents and entrants are to follow to be in compliance with the Act.[4] The FCC determined that incumbents' prices should be based upon a measure of incremental cost, which the FCC created and calls Total Element Long Run Incremental Cost (TELRIC) (Jamison 1999; Weisman 2000; Mandy 2000). The incumbent local exchange companies and the state commissions appealed the FCC's

[3] Consider a firm that produces and sells and input, called the upstream product, that is used to produce a final product, that is called the downstream product. This firm also produces the downstream product in competition with its customers for the upstream input. Under the ECPR, the difference between the firm's price for the upstream input and its price for the downstream product is simply the incremental cost of producing the downstream portion of the product.

[4] FCC 96-325, The First Report & Order In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC Docket No. 96-98 and CC Docket No. 95-185, August 8, 1996.

rules, but on January 25, 1999, the United States Supreme Court ruled that the FCC has general jurisdiction to implement the Act's local competition provisions and upheld almost all of the FCC's requirements. On July 18, 2000, the Eighth Circuit Court of Appeals vacated and remanded the FCC's TELRIC methodology.

Prior to the Supreme Court's ruling, states adopted an array of regulatory policies for implementing the Act. On relatively noncontroversial issues, such as white page listings and access to signaling and databases, states were reasonably uniform. On controversial issues, such as incumbents' prices, states differed from each other and from the FCC. Sixteen percent of the states chose an incremental cost measure called total service long run incremental cost, 13 % of the state commissions chose TELRIC, and the rest chose bill and keep (NRRI 1998). With bill and keep, incumbents and entrants do not pay each other for exchanging minutes. Similarly, 77% of the states chose total service long run incremental cost as their cost standard for UNEs and 19% chose TELRIC. One state chose an accounting cost allocation approach called fully distributed cost.

The Act also mandates collocation, the process by which entrants locate their equipment in incumbents' buildings. Collocation is valuable to entrants because it decreases their costs of interconnection and of accessing UNEs, relative to having to place their equipment some distance away from the incumbents' facilities.[5]

[5] There are two types of collocation, physical collocation and virtual collocation. With physical collocation, entrants physically place their equipment in incumbents' buildings where incumbents also have telephone equipment. With virtual collocation, incumbents place equipment in their buildings and dedicate the equipment to use by entrants. This equipment is owned and maintained by the incumbents.

4. The Models

Because of data restrictions, I consider each incumbent's traditional local exchange areas in a state to be a market. 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.

I consider three types of models. The first describes entry. I summarize the entry decisions by extending Bresnahan and Reiss's (1991) and Berry's (1992) ordered probit models for entry, which apply a zero-profit equilibrium for entrants. The second describes how entrants expand their market share by constructing their own facilities and by using UNEs. The third describes how entrants expand their market share by reselling incumbents' services. I use a standard regression model to summarize entrant system expansion and the resulting effects on entrant market share. I first describe the market entry models.

4.1. Entry Models

More entry is expected in larger markets, in markets where regulatory policies are conducive to entry and in markets where incumbents have created fewer barriers to entry. Bresnahan and Reiss (1991) explain how market size and the effects of minimum efficient scale affect the number of competitors that can profitably enter a market. They show that in 'small' markets, only a monopolist can profitably serve the market. Then as market size increases, the monopolist's profits increase. At some level of market size, a new entrant enters because its expected *ex post* profits are strictly positive; i.e., $E(\pi_C(n=1)) > 0$, where E is the expected value and $\pi_C(n=1)$ is an entrant's profits if $n = 1$, where n is the number of entrants. Only one entrant enters the market if $E(\pi_C(n=1)) \geq 0$ and $E(\pi_C(n=2)) < 0$. At even larger market sizes, more entrants will find it profitable to enter the market. In general, entry occurs up to the point where $E(\pi_C(n)) \geq 0$ and $E(\pi_C(n+1)) < 0$. For a given market, price-cost margins and profits decrease as the number of firms increases, the quantity supplied increases, or both increase.

Regulatory policies and incumbent responses to entry affect entry by affecting the profitability of entrant activity in a given market. Policies favorable to entrants and that provide incumbents with little or no incentives to hinder entry increase the probability of entry, while unfavorable policies and aggressive incumbent responses have the opposite effect. In general, low UNE prices favor entrants because entrants can substitute UNEs for their own facilities when facilities are more costly. Also, low price-cost margins on UNEs, relative to incumbents' retail price-cost margins for services that entrants would replace, encourage incumbents to hinder entry. Readily available collocation opportunities decrease entrants' costs for using their own facilities and for using UNEs.

Likewise, high resale discounts result in low wholesale prices, which make it more economical for entrants to resell incumbents' services, particularly when entrants' facility costs and UNE prices are relatively high.

Reciprocal compensation prices are more complex. Entrants receive more reciprocal compensation payments than they pay (i.e., are net receivers) if they obtain customers who are net receivers of minutes of calling (minutes). An Internet Service Provider (ISP) is an example of a customer that receives more minutes than it sends. High reciprocal compensation price-cost margins favor entrants if they are better able than incumbents to attract customers who are net receivers of minutes. Low symmetric reciprocal compensation price-cost margins favor entrants when they are more successful than incumbents in attracting customers who are net senders of minutes.

My dependent variable measures the total number of entrants in a market, which includes those that use their own facilities, those that use UNEs, those that are pure resellers, and those that use some combination of the three entry methods. Because entry is new, 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.

I use an ordered probit to estimate how policies affect entry. Ordered probit models are used when dependent variables are discrete and ordinal. Because an ordered probit requires multiple observations for each value of the dependent variable and many markets in my sample have unique numbers of entrants, I group markets into categories according to their numbers of entrants. Category 1 contains markets with 0-2 entrants. Category 2 markets have 3-4 entrants. The remaining categories 3 through 9 have 5-7, 8-

14, 15-25, 26-38, 39-44, 45-60, and more than 60 entrants respectively. The appendix explains the development of these categories in more detail.

Underlying the model is a 'virtual' model in which there is an unobserved, continuous dependent variable y^* whose conditional mean is assumed to be a linear function of the independent variables (Hausman et al. 1992). In my model, y^* measures entrants' abilities and propensities to enter, and incumbents' abilities and propensities to limit entry.

Although y^* is unobserved, it is related to my observed discrete random variable for entry. For example, no entry is observed if $y^* < 0$. Likewise, one or two entrants are observed if $0 \leq y^* < \mu_1$, three or four entrants are observed if $\mu_1 \leq y^* < \mu_2$, and so on up to more than 60 entrants are observed if $\mu_9 \leq y^*$. μ's are unknown parameters, which are estimated by the entry models, and which represent thresholds that trigger the entry of one more firm.

I construct likelihood functions for ordered probits by calculating the probability of observing each level of entry. The probability of observing a market with no entry equals:

$$\Pr(\pi_C(n=1) < 0) = 1 - \Phi(\bar{\pi}_C(n=1)).$$

$\Phi(\cdot)$ is the cumulative normal distribution function. $\bar{\pi}_C(n=1)$ is the predicted entrant duopoly profits, ε is the normally distributed error term, and $\pi_C(n=1) = \bar{\pi}_C(n=1) + \varepsilon$ equals the actual entrant duopoly profits, where the duopoly is one incumbent and one entrant. Assuming that the profitability of entry decreases as the number of entrants increases, the probability of observing n entrants in equilibrium can be represented as

$$\Pr(\pi_C(n) \geq 0 \text{ and } \pi_C(n+1) < 0) = \Phi(\bar{\pi}_C(n)) - \Phi(\bar{\pi}_C(n+1)).$$

The residual probability of observing *n* or more firms is

$$\Pr(\pi_C(n) \geq 0) = \Phi(\overline{\pi}_C(n)).$$

My entry models explain the number of entrants be examining parameters that affect entrants' expected profits.

4.2. Quantity Models

Now consider the second and third types of models, those that describe how entrants expand their market share. These models follow closely the models for entry. Larger entrant market share is expected in markets where regulatory policies are conducive to entrants and in markets where incumbents have created fewer barriers to entrants serving the market demand. Let θ represent a customer's type; i.e., the degree to which the customer is a net receiver or a net sender of minutes.[6] Assuming cost minimizing behavior, an entrant *i* provides positive output for customers of type θ when its expected *ex post* profits from increasing supply beyond zero are strictly positive; i.e., $E\left(\left. \frac{\partial \pi_i}{\partial q_{C,i}^{\theta}} \right|_{q_{C,i}^{\theta}=0} \right) > 0$, where $q_{C,i}^{\theta}$ represents the quantity that entrant *i* provides to customers of type θ. Such an entrant would choose its methods of supply based on its expected *ex post* profits. For example, an entrant in markets with lower prices for UNEs and higher prices for wholesale services, relative to other markets, should use higher proportions of UNEs to provide services. Greater availability of collocation increases

[6] Customers can be viewed as being distributed on a two-dimensional plane that represents their calling volumes. One axis represents the total number of minutes for calls a customer receives and the other axis represents the total number of minutes for calls a customer sends. θ represents a customer location on this two-dimensional plane.

entrants' market penetration and causes entrants to use less resale when collocation lowers entrants' costs of UNEs or facilities. Also, if the regulated prices for UNEs or wholesale services provide the incumbent with a lower price-cost margin than the incumbent retail services that are displaced by entrants, incumbents could be expected to take steps to hinder entrants' expansion.

As in the entry models, the effects of reciprocal compensation prices on entrant market share are complex. High price-cost margins for reciprocal compensation encourage entrants to attract customers who are net receivers. Entrants can do this if, for example, their marketing costs for obtaining these customers are low relative to the incumbents' costs of retaining these customers. On the other hand, low price-cost margins for reciprocal compensation prices encourage entrants to increase their use of resale and to increase their supply for customers who are net senders.

I use ordinary least squares regression to examine entrants' market share. I consider two measures of entrant output. The first is the number of entrant interconnections (trunks) to the incumbent. Trunks are necessary for exchanging minutes between incumbent and non-entrant customers. Higher numbers of trunks indicate higher amounts of entrant output for customers served by entrant facilities and, to a certain extent, UNEs.[7] Entrants need trunks for customers served by UNEs only when the entrant is using its own switch; for example, when the entrant has a switch and uses an

[7] Trunks understate entrant supply 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. Also, trunks overstate entrant supply if there are many small entrants, or 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.

incumbent's local line UNEs to connect customers to the entrant switch. My second measure of entrant supply is the number of business resold lines; i.e., the number of units of local telephone service that entrants resell to businesses.

4.3. Estimation Models and Data

Table 1 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).[8] This sample omits Sprint's local exchange operations because Sprint was not part of USTA at the time the data were reported. COMPT represents the number of entrants, TRUNKS is the number of interconnection trunks, and RESOLDB is the number of the incumbent's business telephone lines that were being resold in 1998.

Table 1. Descriptions of Dependent Variables

Variable	Name in Model	Mean	Minimum	Maximum	Standard Deviation	Obser-vations
Number of Entrants	COMPT	26.15	0	164	30.10	59
Number of Interconnection Trunks	TRUNKS	30,018.81	0	289,299	50,611.44	59
Number of Business Resold Lines	RESOLDB	27,009.02	0	183,594	42,696.88	59

[8] 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.

For models of entrant output, I estimate entrant market share by dividing 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. I explain below which explanatory variables are divided by the number of lines. TRNKPLN represents TRUNKS per line. RSLDBPLN represents RESOLDB per line. RSLDRPLN represents RESOLDR per line.

Table 2 describes the data for the explanatory variables. I use the price per month for a 2-wire local line in urban areas, UNEPRC, as the representative UNE price.[9] Incumbents have many UNEs. 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 construct themselves. 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. Data on these prices are from state commissions (NRRI 1998; Alabama 1998), X-Change (1998-1999), and interviews with incumbents. 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 is not available.

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

Table 2. Descriptions of Explanatory Variables						
Variable	**Name in Model**	**Mean**	**Minimum**	**Maximum**	**Standard Deviation**	**Obser-vations**
UNE Prices	UNEPRC	$16.82	$3.72	$32.00	$6.16	59
Prices for Reciprocal Compensation	RCP	$0.0057	$0	$0.0283	$0.0067	59
Business Resale Discount	BUSRSL	0.1794	0.0800	0.2601	0.0374	59
Residential Resale Discount	RESRSL	0.1788	0.0700	0.2500	0.0405	59
Incumbent Local Service Revenues (000)	REVL	$749,773	$71,863	$4,731,829	$902,587	59
Incumbent Line Cost Level	USFCOST	$265.72	$65.68	$408.81	$57.71	59
Collocation Availability for Voice Lines	COLCV98	23.66%	0%	72.62%	17.54%	59
Quarters entrants in the market before 1996	NUMQRT	10.75	0	18	15.44	59
1997 Incumbent Service Quality Complaints	SCMPAM-97	274.29	6	2,637	466.18	59
1998 Incumbent Service Quality Complaints	SCMPAM-98	339.08	8	2,473	506.33	59
Incumbent Total Revenue 1998 (000)	REVT	$1,511,887	$170,463	$8,460,236	$1,721,406	59
Incumbent Total Assets (000)	TPIS	$4,347,098	$493,351	$27,585,598	$4,929,606	59
Incumbent Total Billable Lines	LINES	2,286,606	235,862	16,071,707	2,785,059	59
Number of Incumbent Central Offices	COS98	230.1	29	752	174.2	59
Local Calling Minutes for Incumbent (000)	MOU98	7,056,890	820,771	36,441,427	7,740,706	59
Incumbent Central Office Investment (000)	COETPIS	$760,976	$59,521	$4,581,901	$864,958	59
Presence of Universal Service Fund Reform	USFFUND	0.2881	0	1	0.4568	59
GTE	GTE	0.2373	0	1	0.4291	59
Bell Atlantic	BA	0.2203	0	1	0.4180	59
BellSouth	BS	0.1525	0	1	0.3626	59
SBC	SBC	0. 0678	0	1	0.2536	59
US West	USW	0.2373	0	1	0.4291	59
Ameritech	AM	0.0847	0	1	0.2809	59

RCP is the price per minute for symmetric reciprocal compensation. Data on these prices are from the same sources as UNEPRC.[10] BUSRSL and RESRSL represent the discounts that regulators give entrants for buying wholesale services for business services and residential services respectively. In states where discounts vary by service, I use the smallest percentage discount. In states where residential service discounts are different from business service discounts, I use the residential discount for the models explaining entry and output using UNEs and entrant-owned facilities. BUSRSL and RESRSL 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. Sources for percent discounts are the same as the sources for reciprocal compensation prices and UNE prices.

I use the ratio of total revenues for basic local telephone services (REVL) and total billable lines (LINES) to indicate incumbents' price levels for local services. I call this ratio LCLPLN. I use incumbents' Universal Service Fund costs per line, USFCOST, to represent incumbents' cost of telephone lines. USFCOST the local line costs that incumbents report to the FCC for estimating subsidies that are given to small incumbents and rural incumbents for 1998.[11]

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[10] Some states have multipart prices for reciprocal compensation. There may be 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 remainder terminate in a tandem. Entrants often connect to the incumbent's network at a tandem office because it gives them access to numerous central offices.

[11] 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.

COLCV98, the percent of incumbent voice telephone lines accessible by entrants through collocation in 1998, represents the ease of collocation. Data are from tables 3.6 and 3.7 of the FCC's 1998 *Local Competition* report (FCC 1998).[12] I use the number of quarters in a state from the time the first entrant was given telephone numbers until the Act took affect, NUMQRT, 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). I use total numbers of customer complaints to state and federal regulators for 1997 and 1998 in metropolitan statistical areas, SCMPAM97 and SCMPAM98, as my measures of incumbent service quality. Low incumbent service quality should encourage customers to buy from facilities-based entrants. Data are from the FCC's ARMIS reports.[13] I use SCMPAM97 to examine entry because it represents *ex ante* entry information. I use SCMPAM98 per line (which I call SCMP98PL) to examine entrant output because this represents the quality that customers and entrants experienced at the time supply and purchasing decisions were put into effect.

REVT, the incumbent's total operating revenues for 1998 for the market, indicates market size. For output models, REVTPL represents incumbent total operating revenues per line. REVT data are from the FCC ARMIS reports. Also for output models, I use several measures of incumbent costs and quantities supplied to analyze incumbent responses to price-cost margins on inputs sold to competitors. TPIS

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

[13] All ARMIS data are from http://fcc.gov and were downloaded between March 1999 and August 2000.

represents the incumbent's total plant in service for 1998, a measure of the incumbent's total investment in facilities. I express TPIS per line as TPISPL. My measure of the number of incumbent lines is LINES, the number of billable telecommunications lines in 1998. COS98 is the number of incumbent central offices in 1998. MOU98 is the number of incumbent local telephone minutes in 1998. COETPIS is the amount of incumbent investment in central office switches in 1998. TPIS, LINES, COS98, MOU98, and COETPIS are from FCC ARMIS reports. COS98PL, MOUPL, and COTPISPL are the per-line expressions of COS98, MOU98, and COETPIS respectively.

For the entry models, I include two price-cost ratios, PRCSTUNE and PRCSTRCP, as explanatory variables. PRCSTUNE is the ratio of the incumbent's UNE price-cost ratio and the incumbent's average retail price-cost ratio. The UNE price-cost ratio is the ratio of UNEPRC to USFCOST. The incumbent's average retail price-cost ratio is the ratio of the incumbent's 1998 total operating revenues and total plant in service. PRCSTRCP is the ratio of the incumbent's RCP price-cost ratio and the incumbent's average retail price cost ratio. The RCP price-cost ratio is the ratio of RCP and the incumbent's total investment in central office switches in 1998 divided by the total number of local exchange minutes in 1998. These ratios reflect the relationships between the price-cost ratios for inputs incumbents sell to entrants and the price-cost ratios for the incumbent's retail services that the entrants displace. Low values of PRCSTUNE and PRCSTRCP indicate that UNE and RCP price-cost ratios are low relative to incumbents' retail price-cost ratios. Ordover et al. (1985) explain that incumbents have an incentive to hinder competitors' success if competition lowers

incumbents' profits.[14] Examples of incumbents' efforts to hinder entrants might be providing poor service quality to entrants, delaying collocation, and delaying interconnection negotiations. Reciprocal compensation provides a special case for this incentive. If PRCSTRCP is low, incumbents would like to be net payers of reciprocal compensation. In the next section, I examine the coefficients of these ratios to test whether incumbents or entrants have the stronger propensities and abilities to respond to the profitability of using UNEs and paying or receiving reciprocal compensation.

Including the variables PRCSTUNE and PRCSTRCP creates multicollinearity because the variables are constructed from other variables. Therefore, I exclude these variables from the entrant output models and test hypotheses of nonlinear combinations of UNE prices, RCP prices, and incumbent revenues, costs, and quantities supplied. That is to say, I test incumbent responses to UNE price-cost margins by testing the significance of the combination UNEPRC/REVTPL, and I test incumbent responses to RCP price-cost margins by testing the significance of the combination RCP/(REVTPL/MOUPLN).[15]

Following Ros and McDermott (2000), I examine the effects of telephone subsidy reform. The Act requires regulators to develop subsidies that are competitively neutral. Traditionally, telephone subsidies, called universal service subsidies, were embedded in

[14] BOCs have a countervailing incentive to cooperate with entrants so that the interLATA restrictions are lifted sooner.

[15] I use UNEPRC/REVTPL to test UNE price-cost margins because the actual ratio of interest, (UNEPRC/USF)/(REVTPL/USF) solves to UNEPRC/REVTPL. Similarly, the reciprocal compensation ratio of interest, (RCP/(COTPISPL/MOUPL))/(REVTPL/COTPISPL) solves to RCP/(REVTPL/MOUPLN).

telephone company prices and only incumbents' prices were affected by subsidies (Jamison 1995). Following the passage of the Act, regulators began taking steps to develop mechanisms for collecting funds for subsidies from all telecommunications service providers and making the subsidies available to all qualified service providers. Rosenberg and Wilhelm (1998) find that fourteen states had revised or were revising their subsidy policies in 1998. USFUND is a dummy variable that indicates whether the market is in one of these fourteen states.

Lastly, I include dummy variables to identify incumbents. I have a dummy variable for each incumbent, but omit the Ameritech dummy from models to avoid multicollinearity. Incumbent dummy variables may reveal differences in how incumbents processed entrant requests for interconnection, UNEs, and wholesale services from 1996 through 1998. Soon after the passage of the Act, incumbents differed in how they processed these entrant requests. One incumbent required entrants to fax their requests for telephone numbers or local lines. Another required entrants to call with their requests, but assigned only one employee to the task of taking entrant orders. Other incumbents worked on electronic methods of taking entrant orders. These differences, as well as differences in regulatory scrutiny and enforcement, could cause incumbent dummy variables to be significant.

To examine potential multicollinearity, I regress all explanatory variables on each other. I also examine the linear correlation of each pair of explanatory variables. Multicollinearity problems occur between the reciprocal compensation variables RCP and PRCSTRCP ($R^2 = 0.97$), between the service complaint variables SCMPAM97 and SCMPAM98 ($R^2 = 0.92$), between the resale discounts for business and residential

services (BUSRSL and RESRSL, $R^2 = 0.88$), 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 entry models, 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 output 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.

5. Model Results

In this section I examine the results of my models. I examine the entry models first. I then investigate the models for entrant facilities and UNEs. Lastly, I examine models for resale. Tests of log linear models did not improve the overall fit, so I report only the linear results.

Table 3 provides the coefficients and t-statistics for the entry 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. Table 4 shows the marginal effects of explanatory variables. The first three rows show the market categories (see the appendix). Rows 2 and 3 show the range of entrants and the number of categories. The remaining rows show how a marginal change in each explanatory variable affects the probability of a market being in one of the nine categories.

Table 3. Regression Results for Entry (COMPT)			
Explanatory Variable	Model 1	Model 2	Model 3
UNEPRC	**-0.1523 (-2.000)	**-0.1900 (-2.322)	**-0.1964 (-2.307)
RCP	*-56.038 (-1.879)	-70.7291 (-0.733)	-51.4000 (-0.501)
RESRSL	**10.0708 (2.230)	**11.1879 (2.404)	**10.7780 (2.288)
LNSPCO	***0.0001 (2.794)	*0.0001 (1.934)	0.0001 (1.409)
LCLPUSF	***-1.9855 (-2.939)	***-2.0848 (-2.940)	**-1.9342 (-2.509)
COLCV98		0.0088 (0.653)	0.0126 (0.901)
NUMQRT		-0.0622 (-1.234)	-0.0643 (-1.108)
SCMPAM97	*-0.0010 (-1.697)	-0.0010 (-1.615)	-0.0010 (-1.509)
REVT	***1.77e-06 (5.038)	***1.92e-06 (5.108)	***2.00e-06 (5.039)
PRCSTUNE	***14.4117 (2.287)	***17.435 (2.589)	**16.7705 (2.360)
PRCSTRCP		0.3575 (0.099)	-0.0792 (-0.021)
USFUND		0.2729 (0.668)	0.2489 (0.605)
GTE			0.6403 (0.730)
BA	**1.1397 (2.065)	0.9940 (1.665)	1.447 (1.867)
BS	***2.2862 (3.761)	***2.255 (3.477)	***2.845 (3.121)
SBC	***5.0165 (4.769)	***4.8481 (4.554)	***5.5051 (4.183)
USW			0.8116 (0.939)
χ^2	113.70 d.f. = 11	116.07 d.f. = 15	116.97 d.f. = 17
Log Likelihood	-66.2809	-65.0953	-64.6450

I estimate three models. Model 1 examines how UNE prices, reciprocal compensation prices, resale discounts, customer density, local service price-cost margins, service quality, market size, and UNE price-cost margins affect entry. The coefficients for UNE and RCP prices are negative, the coefficient for resale discounts is positive, and

all are statistically significant. The marginal effects in table 4, which are based on Model 1, show that these coefficients mean that higher UNE prices or reciprocal compensation prices, or lower wholesale discounts, discourage entry. Specifically, if markets are ordered from those with the fewest entrants to those with the most entrants, higher UNE and reciprocal compensation prices and lower wholesale discounts shift the distribution to the left so that more markets would be in categories 1 through 5 (markets with fewer than 25 entrants) and fewer markets would be in categories 6 through 9 (markets with more than 25 entrants). These results indicate that higher UNE, reciprocal compensation, and wholesale prices discourage entry. No single entry method appears to be more important than the other methods.

Table 4. Marginal Effects for Entry (COMPT)

Markets									
Category Number	1	2	3	4	5	6	7	8	9
Entrants in Market	0 – 2	3 - 4	5 – 7	8 – 14	15 - 25	26 – 38	39 - 44	45 – 60	> 60
Number Markets	8	8	5	4	12	11	3	4	4
Marginal Effects									
UNEPRC	0.00013	0.00051	0.00687	0.01454	0.01889	-0.00169	-0.03841	-0.00075	-8.20e-05
RCP	0.04838	0.18599	2.52867	5.34936	6.94956	-0.62294	-14.13170	-0.27727	-0.03001
RESRSL	-0.00870	-0.03342	-0.45444	-0.96135	-1.24893	0.11195	2.53967	0.04983	0.00539
LNSPCO	-8.63e-08	-3.30e-07	-4.50e-06	-9.50e-06	-1.20e-05	1.11e-06	2.52e-05	4.95e-07	5.36e-08
LCL-PUSF	0.00171	0.00659	0.08959	0.18954	0.24623	-0.02207	-0.50071	-0.00982	-0.00106
SCM-PAM97	8.63e-07	3.32e-06	4.51e-05	9.55e-05	0.00012	-1.10e-05	-0.00025	-4.90e-06	-5.40e-07
REVT	-1.53e-09	-5.90e-09	-8.00e-08	-1.70e-07	-2.20e-07	1.97e-08	4.46e-07	8.76e-09	9.48e-10
PRC-STUNE	-0.01244	-0.04783	-0.65032	-1.37573	-1.78727	0.16021	3.63436	0.07131	0.00772
BA	-0.00048	-0.00208	-0.05143	-0.10880	-0.14134	0.01267	0.28741	0.00564	0.00061
BS	-7.13e-06	-5.90e-05	-0.10316	-0.21824	-0.28352	0.02541	0.57654	0.01131	0.00122
SBC	-6.67e-13	-2.30e-11	-0.22637	-0.47887	-0.62212	0.05577	1.26507	0.02482	0.00269

The coefficient for the variable for customer density, LNSPCO, is positive and highly significant. The marginal effects indicate that more entry occurs in densely populated markets. The coefficient for the variable indicating incumbent service quality in the previous year (SCMPAM97) is negative, but only significant at the 0.10 level. Its marginal effects indicate that poor incumbent service quality decreases entry. This may be because of the importance of resale to entry. If an incumbent's retail services have poor quality, then it should be true that the wholesale versions of these same services will have just as poor, or poorer, service quality.

The results of Model 1 support the prediction of the ECPR that incumbents are more likely to hinder entry if the inputs sold to entrants have low price-cost margins relative to the retail services that the entrants replace. The coefficient for LCLPUSF is negative and highly significant and its marginal effects indicate that higher price-cost margins for local telephone services decrease entry. This is contrary to the conventional wisdom that economic pricing for local services is important for local network competition, but it is consistent with the proposition that, when local service is profitable, incumbents exert greater effort to hinder entry. The UNE-retail price-cost margin ratio, PRCSTUNE, has a positive and highly significant coefficient. Its marginal effects indicate that more entry occurs when incumbents' UNE price-cost margins are high relative to their retail price-cost margins.

The remaining variables in Model 1, those being for market size (REVT) and selected incumbents (Bell Atlantic, BellSouth, and SBC), are all highly significant. The importance of market size confirms that there are some economies of scale for entrants. The coefficients for the incumbents are positive. Their marginal effects could indicate

that these incumbents have responded less aggressively to entry than have other incumbents. Consistent with this interpretation, Bell Atlantic and SBC are the only BOCs at the time of this writing to receive permission to enter interLATA long distance markets. The marginal effects in table 4 indicate that SBC has a more positive effect on entry in larger markets than do Bell Atlantic and BellSouth, possibly reflecting the large number of entrants in SBC's Texas, California, and Nevada markets.

Model 2 in table 3 provides the results of adding the other regulatory policy variables to Model 1, namely collocation (COLCV98), time (NUMQRT), price-cost margins for reciprocal compensation (PRSTRCP), and universal service reform (USFUND). 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 ($\chi^2(4) = 2.37$). Greater access to customers through collocation does not appear to prompt entry. Time does not appear to have been important, perhaps indicating that the passage of the Act was the watershed event triggering entry. Lower price-cost margins for reciprocal compensation have not resulted in incumbents hindering entry. This is probably because, as the market share models indicate, incumbents are sometimes net payers of reciprocal compensation. Lastly, I do not find that subsidy reform has encouraged entry.

Model 3 in table 3 shows entry model results after adding other variables for factors that shift demand or supply. Using a likelihood-ratio test on the hypothesis that the coefficients for all of these added variables and the added policy variables from Model 2 are zero, I am unable to reject the hypothesis at the 0.10 level ($\chi^2(6) = 3.27$). I conclude that Model 1 is the most appropriate model for examining entry.

Tables 5 and 6 provide the results for the entrant market share models. Because these models analyze market share given that entry has occurred, I omit one market, GTE in Virginia, which had no entry. Model 4 in table 5 shows the results of including all of the explanatory variables in a model for entrants using UNEs and entrant-owned facilities. The primary purpose of this model is to form the basis for testing the signs and significance of nonlinear combinations of explanatory variables. Using an F-test, I fail to reject the hypothesis at the 0.10 level that coefficients for price-cost margins for UNEs, reciprocal compensation, and local telephone services, resale discounts, subsidy reform, and for the incumbent dummy variables for GTE, BellSouth, and US West are equal to zero ($F(8, 40) = 1.19$). This indicates that incumbents either do not attempt to hinder this form of entrant output, or are unsuccessful in doing so. This also indicates that neither higher margins on local telecommunications services nor subsidy reform prompt incumbents to increase their supply using UNEs or facilities. Indeed, the positive and significant coefficient for reciprocal compensation prices indicates that entrants are increasing UNE and facility-based supply primarily to customers such as ISPs, which are net receivers of minutes.

Model 5 in table 5 provides results for the TRNKPLN after dropping variables that prove to be insignificant; namely, the resale discount, universal service reform, and the dummy variables for GTE, BellSouth, and US West. Higher UNE prices limit entrant output, as well as entry. Higher local telecommunications services prices encourage customers to buy more from entrants, even though the incumbent's price-cost margin for these services is unimportant. The coefficient for ease of collocation (COLCV98) is positive and highly significant, indicating that collocation is important for entrants that

Table 5. Regression Results for Output Using UNEs and Facilities (TRNKPLN)		
Explanatory Variable	Model 4	Model 5
UNEPRC	**-0.0004 (-2.254)	**-0.0003 (-2.026)
RCP	*0.2213 (1.801)	*0.1900 (1.724)
RESRSL	0.0119 (0.680)	
LCLPRLN	*0.00004 (1.927)	**0.00003 (2.244)
COLCV98	***0.0002 (3.536)	***0.0002 (3.546)
NUMQRT	**0.0005 (2.535)	***0.0005 (3.020)
SCMP98PL	6.9692 (1.534)	**9.3746 (2.360)
REVTPL	0.0243 (1.248)	0.0183 (1.199)
TPISPL	-0.0077 (-1.605)	-0.0054 (-1.375)
MOUPLN	0.0022 (1.213)	**0.0034 (2.119)
COTPISPL	0.0192 (1.085)	*0.0250 (1.872)
USFUND	0.0014 (0.797)	
GTE	0.0047 (0.961)	
BA	-0.0015 (-0.450)	**-0.0053 (-2.634)
BS	0.0043 (1.146)	
SBC	**0.0077 (2.190)	*0.0053 (1.986)
USW	0.0063 (1.540)	
Constant	***-0.0316 (-3.559)	***-0.0301 (-3.665)
F	4.58 d.f. = 17, 40	6.39 d.f. = 12, 45
R^2	0.6608	0.6302

want to build their own facilities that want to use UNEs. The coefficient for NUMQRT is positive and highly significant, showing that that building facilities and assembling UNEs takes time, which gives entrants a cost disadvantage relative to incumbents. Incumbent service quality has a positive and significant coefficient in Model 5. This

implies that entrants choose to use their own facilities and UNEs, and that customers choose entrant services, when incumbent service quality is poor. The positive and highly significant coefficient for number of minutes per line is consistent with the conclusion that entrants use their own facilities and UNEs to target customers based on calling patterns. The negative and highly significant coefficient for Bell Atlantic may indicate that this incumbent has the most aggressive response to entrants targeting ISPs as customers. These results are generally comparable to the results of the entry models.

Table 6 shows the results for entrant market share using resold business services. Model 6 shows the results using all explanatory variables. This model forms the basis for a joint hypothesis test of the significance of price-cost margins of UNEs and local telecommunications services, and of incumbent investment, minutes, central office investment, reciprocal compensation prices, and dummy variables for GTE, BellSouth, Bell Atlantic, and SBC. Using an F-statistic, I fail to reject at the 0.10 level the null hypothesis that the coefficients for all of these variables and combinations of variables are zero ($F(10, 40) = 1.72$). Consequently, I show the results for Model 7, which omits the insignificant variables.[16]

The results for Models 6 and 7 indicate that resale of business lines is predominantly an tool for entrants whose main intent is to eventually use their own facilities and UNEs. Comparing the results of Models 6 and 7, it is apparent that higher UNE prices decrease resold business lines, indicating a linkage between UNE-based service and resale. The availability of collocation and universal service subsidies causes

Table 6. Regression Results for Resold Business Lines (RSLDBPLN)		
Explanatory Variable	Model 6	Model 7
UNEPRC	**-0.0010 (-2.204)	***-0.0011 (-2.818)
RCP	0.4136 (1.173)	0.4809 (1.498)
BUSRSL	0.0319 (0.591)	0.0275 (0.543)
LCLPRLN	0.00002 (0.382)	*0.00008 (1.707)
COLCV98	***-0.0003 (-2.353)	**-0.0003 (-2.115)
NUMQRT	**0.0013 (2.206)	*0.0009 (1.736)
SCMP98PL	-21.0764 (-1.612)	*-21.9800 (-1.723)
REVTPL	-0.0774 (-1.410)	*-0.0640 (-1.751)
TPISPL	0.0067 (0.493)	
MOUPLN	0.0011 (0.213)	-0.0022 (-0.545)
COTPISPL	0.0598 (1.181)	0.0079 (0.217)
USFUND	**-0.0110 (-2.175)	*-0.0084 (-1.988)
GTE	-0.0220 (-1.578)	
BA	-0.0140 (-1.462)	
BS	-0.0078 (-0.736)	
SBC	-0.0015 (-0.151)	
USW	0.0169 (1.442)	***0.0312 (4.752)
Constant	0.0311 (1.231)	0.0387 (1.623)
F	2.88 d.f. = 17, 40	3.71 d.f. = 12, 45
R^2	0.5500	0.4974

[16] The variable for reciprocal compensation prices is in Model 7 because I fail to reject the joint hypothesis when the price-cost margin for reciprocal compensation is included. The reciprocal compensation price-cost variable in model 7 is insignificant by itself (t = 1.578 when substituted for the reciprocal compensation variable.)

entrants to move away from reselling business lines more quickly than they otherwise would. The business resale discount itself is insignificant, indicating that entrant market share using a pure resell strategy is either minor or effectively nonexistent. Consistent with Models 4 and 5, more time for entrants to expand their systems increases the amount of business line resale. Consistent with the discussion of Model 1, poor incumbent service quality decreases entrant use of resale, for reasons stated above. The positive and highly significant coefficient for US West's dummy variable indicates that this incumbent may be more cooperative with resellers than with facilities and UNE-based entrants, relative to other incumbents.

6. Conclusions

This paper indicates that entrants use a mixture of entry and supply paths, but that most entrants intend to follow a strategy of using UNEs and entrant-owned facilities. Reselling incumbent services appears to be important for entry, but not for entrant market share. UNE and reciprocal compensation prices are important determinants of entry, customer selection, and modes of supply. Higher UNE and reciprocal compensation prices discourage entry, but higher reciprocal compensation prices cause entrants to target customers who are net receivers of minutes. Low price-cost margins for UNEs encourage incumbents to hinder entry, but incumbents have little effect on entrant market share. Also, the ease of using UNEs and placing facilities appears to be more important than relative prices for UNEs and wholesale in influencing entrants' choices of methods of supply.

My findings indicate that policy makers should focus on unbundling networks, UNE prices, and collocation if they want to increase market share for facilities-based

entrants. Resale discounts, while important for entry, have little effect on entrant market share.

Additional work is also needed. I was unable to test whether the interLATA restriction, which is to serve as a carrot for BOCs, is having its intended effect. Also, I was unable to test whether the policies that encourage entrant supply also improve social welfare. A more complete model of how policies affect industry costs and prices is needed to determine welfare effects. Lastly, international comparisons are lacking, as are more in depth analyses of entrant strategies for data and voice services.

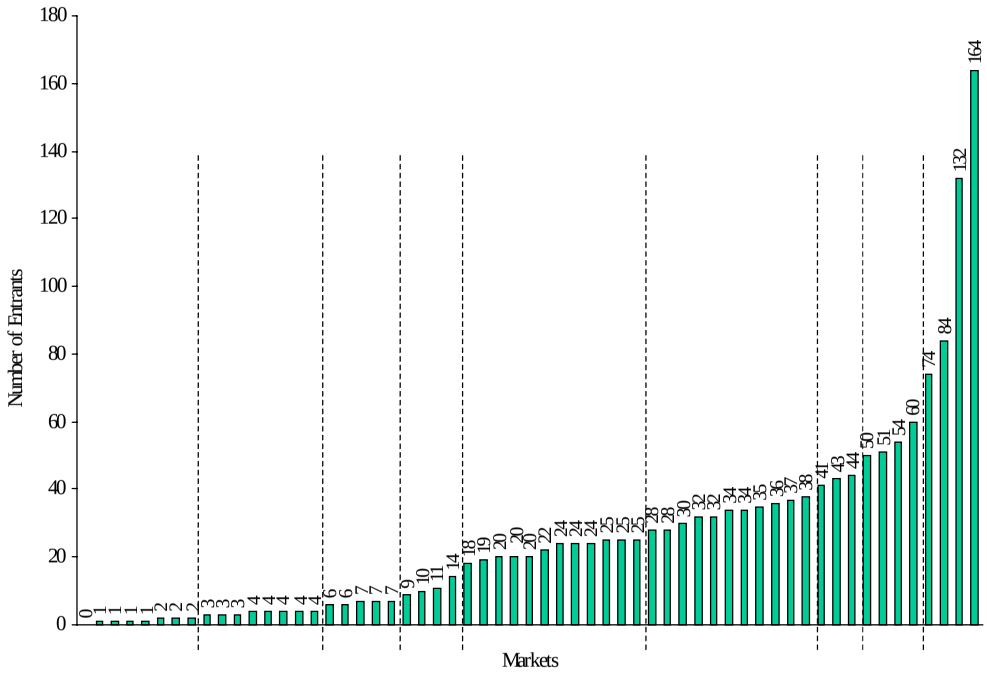
APPENDIX

For the ordered probit models, I group observations in categories. This is necessary because an ordered probit requires multiple observations for each value of the dependent variable. Figure A1 graphs the entry levels in my data set, from the markets with the fewest entrants to those with the most entrants. The number of entrants ranges from 0 to 164. Over 130 entry levels in this range are not observed and many have only one observation. Using these data directly in an ordered probit model causes the model to estimate entry probabilities. To illustrate the problem, consider an economy with four markets. The markets are designated 1 through 4 and they have 0, 1, 5, and 10 entrants respectively. If these markets provided the data for an ordered probit model of entry, the model would estimate probability of entry levels as follows. The model would first estimate the probability of no entry and positive entry. Then it would estimate the probability of one entrant and more than one entrant, given that entry was positive. Next it would estimate the probability of two entrants or more than two entrants, given that entry was positive and more than one. The model would continue this process until it reached the observation with 10 entrants, where the model would treat as the probability of having more than 9 entrants, given that entry was more than 8 and more than 7, etc. As a result, the model would estimate ten probabilities of entry from four observations. The results would be questionable at best.

To avoid the problem of estimating probabilities for numerous entry levels for which I have no data or too little data, I group the observations into nine categories. The dashed lines in Figure A1 show the deliniation of the categories. I chose the categories boundaries and the number of categories based upon visual observation of this graph. I chose boundaries based upon what appeared to be natural groupings of markets, based on the number of entrants, and on the number of observations that would be in a category. I attempted to avoid creating categories that were very similar in their number of entrants and categories with few observations. I tested other arrangements of categories based on the same criteria. All gave similar results and none gave stronger results than the results I present.

Table A1. Description of Grouped Dependent Variable

Group Ordinal Value	Group Mean	Group Min	Group Max	Standard Deviation	Number Observations
Grouped Dependent Variable COMPT					
0	1.250	0	2	0.7071	8
1	3.625	3	4	0.5175	8
2	6.600	6	7	0.5477	5
3	11.000	9	14	2.1605	4
4	22.167	18	25	2.6227	12
5	33.091	28	38	3.4192	11
6	42.667	41	44	1.5275	3
7	52.750	50	60	4.5000	4
8	113.500	74	164	42.1228	4


Number of Entrants
Markets
0
20
40
60
80
100
120
140
160
180
0 1 1 1 1 2 2 2 3 3 3 4 4 4 4 6 6 7 7 7 9 10 11 14 18 19 20 20 20 22 24 24 24 25 25 25 28 28 30 32 32 34 34 35 36 37 38 41 43 44 50 51 54 60 74 84 132 164

Bibliography

Ai, C. and Sappington, D. E. M. "The Impact of State Incentive Regulation on the US Telecommunications Industry." Mimeo, Department of Economics, University of Florida, 1998.

Alabama Public Service Commission. Order In the Matter of Generic Proceedings: Consideration of TELRIC Studies, Docket No. 26029, August 25, 1998.

Albon, R. "Interconnection Pricing: An Analysis of the Efficient Component Pricing Rule." *Telecommunications Policy*, Vol. 18 (1994), pp. 414-420.

Baumol, W. J. and Sidak, G. "The Pricing of Inputs Sold to Competitors." *Yale Journal on Regulation*, Vol. 11 (1994a), pp. 171-202.

_____., and _____. *Toward Competition in Local Telephony*, Cambridge, Massachusetts: MIT Press, 1994b.

_____., and _____. "The Pricing of Inputs Sold to Competitors: Rejoinder and Epilogue." *Yale Journal on Regulation*, Vol. 12 (1995), pp. 177-186.

Berry, S. T. "Estimation of a Model of Entry in the Airline Industry." *Econometrica*, Vol. 60 (1992), pp. 889-917.

Blank, L., Kaserman, D. L., and Mayo, J. W. "Dominant Firm Pricing with Competitive Entry and Regulation: The Case of IntraLATA Toll." *Journal of Regulatory Economics*, Vol. 14 (1998), pp. 35-53.

Bresnahan, T. F. and Reiss, P. C. "Entry and Competition in Concentrated Markets." *Journal of Political Economy*, Vol. 99 (1991), pp. 977-1009.

Crandall, R. *After the Breakup: US Telecommunications in a More Competitive Era*, Washington, D.C.: Brookings Institution, 1991.

Dekimpe, M. G., Parker, P. M., and Sarvary, M. "Staged Estimation of International Diffusion Models: An Application to Global Cellular Telephone Adoption." *Technological Forecasting and Social Change*, Vol. 57 (1998), pp. 105-132.

Economides, N., and White, L. J. "Access and Interconnection Pricing: How Efficient is the 'Efficient Component Pricing Rule?'" *Antitrust Bulletin*, Vol. 40 (1995), pp. 557-579.

Federal Communications Commission. "Local Competition." 1998.

Gabel, R. *Development of Separations Principles in the Telephone Industry*, East Lansing, Michigan: Institute of Public Utilities, Michigan State University, 1967.

Greenstein, S., McMaster, S., and Spiller, P. “The Effect of Incentive Regulation on Infrastructure Modernization: Local Exchange Companies’ Deployment of Digital Technology.” *Journal of Economics and Management Strategy*, Vol. 4 (1995), pp. 187-236.

Hausman, J. A., Lo, A. W., and MacKinlay, A. C. “An Ordered Probit Analysis of Transaction Stock Prices.” *Journal of Financial Economics*, Vol. 31 (1992), pp. 319-379.

_____., and Tardiff, T. J. "Efficient Local Exchange Competition." *Antitrust Bulletin*, Vol. 40 (1995), pp. 529-556.

Jamison, M. A. "A Competitive Framework for Pricing Interconnection in Global Telecommunications Markets." *Denver Journal of International Law and Policy*, Vol. 23 (1995), pp. 513-533.

_____. "Does Practice Follow Principle? Applying Real Options Principles To Proxy Costs in US Telecommunications." In J. Alleman and E. Noam, eds., *Real Options: The New Investment Theory and its Implications for Telecommunications Economics*, Boston: Kluwer Academic Publishers, 1999.

Kahn, A. E. and Taylor, W. E. "The Pricing of Inputs Sold to Competitors: A Comment." *Yale Journal on Regulation*, Vol. 11 (1994), pp. 225-240.

Laffont, J. and Tirole, J. "Access Pricing and Competition." *European Economic Review*, Vol. 38 (1994), pp. 1673-1710.

_____., and _____. "Creating Competition Through Interconnection: Theory and Practice." *Journal of Regulatory Economics*, Vol. 10 (1996), pp. 227- 256.

_____., Rey, P., and Tirole, J. "Network Competition: I. Overview and Nondiscriminatory Pricing." *The Rand Journal of Economics*, Vol. 29 (1998a), pp. 1-37.

_____., _____., and _____. "Network Competition: II. Price Discrimination." *The Rand Journal of Economics*, Vol. 29 (1998b), pp. 38-56.

Larson, A. C. "Wholesale Pricing and the Telecommunications Act of 1996: Guidelines for Compliance with the Avoided Cost Rule." *University of Florida Journal of Law and Public Policy*, Vol. 8 (1997), pp. 243-260.

_____., and Parsons, S. G. "An Economic Analysis of Transfer Pricing and Imputation Policies for Public Utilities," In M. A. Crew, ed. *Incentive Regulation for Public Utilities*, Boston: Kluwer Academic Publishers (1994).

Mandy, D. M. “TELRIC Pricing with Vintage Capital.” Mimeo, Department of Economics, University of Missouri, 2000.

Mitchell, B., Neu, W., Neumann, K., and Vogelsang, I. "The Regulation of Pricing of Interconnection Services." In G. W. Brock, ed., *Toward a Competitive Telecommunications Industry: Selected Papers from the 1994 Telecommunications Policy Research Conference*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1995.

National Regulatory Research Institute. *Interconnection Arbitration Decisions,* <http://www.nrri.ohio-state.edu/interconnect.html>, downloaded 1998.

Ordover, J. A., Sykes, A. O., and Willig, R. D. "Nonprice Anticompetitive Behavior by Dominant Firms toward the Producers of Complementary Products." In F. M. Fisher, ed., *Antitrust and Regulation: Essays in Memory of John J. McGowan*, Cambridge, Massachusetts: MIT Press, 1985.

Ros, A. J. "Does Ownership or Competition Matter More? The Effects of Telecommunications Reform on Network Expansion and Efficiency." *Journal of Regulatory Economics*, Vol. 15 (1999), pp. 65-92.

_____., and McDermott , K. "Are Residential Local Exchange Prices Too Low? Drivers of Competition in the Local Exchange Market and the Impact of Inefficiently-Set Prices." In M. Crew, ed., *Expanding Competition in Regulated Industries*, Boston: Kluwer Academic Press, 2000.

Rosentberg, E. A., and Wilhelm, J. D. *State Universal Service Funding and Policy: A Overview and Survey*. Columbus, Ohio: National Regulatory Research Institute, 1998.

Sappington, D. E. M. and Weisman, D. L. *Designing Incentive Regulation for the Telecommunications Industry*, Cambridge, Massachusetts: MIT Press, 1996.

Spiller, P. T. and Cardilli, C. G. "The Frontier of Telecommunications Deregulation: Small Countries Leading the Pack." *Journal of Economic Perspectives*, Vol. 11 (1997), pp. 127-138.

Tomlinson, R. G. "The Impact of Local Competition on Network Quality." In W. Lehr, ed., *Quality and Reliability in Telecommunications Infrastructure*, Mahwah, New Jersey: Lawrence Erlbaum, 1995.

Tye, W. B. "The Pricing of Inputs Sold to Competitors: A Response." *Yale Journal on Regulation*, Vol. 11 (1994), pp. 203-224.

_____., and Lapuerta, C. "The Economics of Pricing Network Interconnection: Theory and Application to the Market for Telecommunications in New Zealand." *Yale Journal on Regulation*, Vol. 13 (1996), pp. 419-500.

United States Telephone Association. *Report to House Commerce Committee Chairman Thomas Bliley*, 1998.

Weisman, D. L. “Regulation and the Vertically Integrated Firm: The Case of RBOC Entry into InterLATA Long Distance.” *Journal of Regulatory Economics*, Vol. 8 (1995), pp. 249-266.

_____. “The (In)Efficiency of the ‘Efficient Firm’ Cost Standard.” *The Antitrust Bulletin*, Vol. 45 (2000), pp. 195-211.

Woroch, G. A. “Competition’s Effect on Investment in Digital Infrastructure.” Mimeo, Department of Economics, University of California at Berkley, 2000.

X-Change. "Status of State Local Competition Proceedings." *X-Change*, 1998-1999.