ELSEVIER

The Quarterly Review of Economics and Finance
45 (2005) 28–47

The QUARTERLY REVIEW of ECONOMICS And FINANCE

Mandated access and the make-or-buy decision: the case of local telecommunications competition

T. Randolph Beard[a], George S. Ford[b], Thomas M. Koutsky[b]

[a] *Department of Economics, 205 Lowder Business Building, Auburn University, Alabama 36489, USA*
[b] *Phoenix Center for Advanced Legal and Economic Public Policy Studies, 5335 Wisconsin Avenue NW, Suite 440, Washington, DC 20015-2034, USA*

Received 5 February 2003; received in revised form 1 December 2003; accepted 30 January 2004
Available online 23 November 2004

Abstract

When the facilities of an incumbent monopolist are made available to potential competitors through some type of "essential facilities" or related claim, a concern is that the ability to "buy" inputs substantially attenuates the incentive to "make" inputs. We evaluate both theoretically and empirically the relationship between "make" and "buy" and find three sometimes-conflicting effects are present, of which the substitution effect is only one. Our empirical example considers the deployment of switching facilities by entrants to local exchange telecommunications markets, and these empirics indicate that the substitution effect is not dominant in this particular case.

JEL classification: L4; L5; L9; L96

Keywords: Essential facilities; Telecommunications; Competition; Utilities; 1996 Telecommunications Act; Unbundling; Unbundled Network Elements

> . . . an empirical question cannot be settled by non-empirical arguments.
>
> George Stigler, *The Organization of Industry* (1968), p. 115.

E-mail addresses: rbeard@business.auburn.edu (T.R. Beard), george.ford@phoenix-center.org (G.S. Ford), tom@phoenix-center.org (T.M. Koutsky).

1062-9769/$ – see front matter © 2004 Board of Trustees of the University of Illinois. All rights reserved.
doi:10.1016/j.qref.2004.01.001

1. Introduction

Over the past decade or so, considerable attention has been directed to the promotion of competition in and the eventual deregulation of the public utilities—gas, electricity, and local telecommunications. As part of this effort, potential competitors often are given access to elements of the incumbent monopolist's network or plant.[1] Such access is required when particular elements of the incumbent network continue to possess natural monopoly characteristics such as sizeable scale and scope economies.[2] Whether access to these elements is based on the theory of "essential facilities" of antitrust or "unbundled network elements ("UNEs")" of the Telecommunications Act of 1996, the result is the same: entrants are allowed to use the facilities of the incumbent as their own, and such access is priced at some measure of "cost," typically some variant of forward-looking economic cost.

A principle difficulty faced by policy makers in this context is which elements of the network are "essential facilities" or satisfy some other governing standards such as the "necessary" and "impairment" standards of Section 251(d)(2) of the 1996 Telecommunications Act.[3] Economists and lawyers have described numerous problems with both the over- and under-inclusion of elements within the (broad) category of "essential." One frequent concern, particularly in the debate over local exchange telecommunications competition, is the fear that the investment incentives of the incumbent monopolist may be stunted by the requirement to share assets with competitors. To this question, Willig (2002), Haring and Rohlfs (2002), Ford and Jackson (2004), and the Phoenix Center (2003a, 2003b) and provide econometric evidence. The findings of the research are mixed, but the evidence tends to favor the conclusion that investment by incumbents has not been reduced by the 1996 Act's unbundling obligations.

While the effects of mandated access on the investment incentive of incumbent firms is important, a second and equally significant concern is that by giving entrants access to parts of the network, those components of the network will never be duplicated and thus never subject to the competitive pressure required to deregulate. Areeda and Hovenkamp (1996) observe, "the right to share a monopoly discourages firms from developing their own alternative inputs . . . (¶771)." This substitution effect, commonly couched in terms of a "make-or-buy" decision by the entrant, often lies at the core of the arguments by those calling for a less inclusive policy on what is or is not "unbundled" in modern telecommunications

[1] In some cases, such as local telecommunications, the incumbent continues to provide retail services so that the entrants are both competitors and customers (or "competitor customers") of the incumbent. In others, such as electricity, the incumbent often is prohibited from participating in the market targeted for competition and deregulation (whether upstream or downstream). Mandated access to AT&T's network was an important driver in the development of competition in the U.S. long distance industry. See Brock (1981) and Cantelon (1993).

[2] Such supply-side characteristics are prevalent in the more geographically local elements of the aforementioned utilities' plant.

[3] Section 251(d)(2)(B) of the 1996 Telecommunications Act requires the FCC in determining what network elements should be made available to consider, at a minimum, whether "the failure to provide access to such network elements would impair the ability of the telecommunications carrier seeking access to provide the services that it seeks to offer." 47 U.S.C. § 251(d)(2)(B). The Telecommunications Act also contains a "necessary standard" in § 251(d)(2)(A)—that is, providing access to any "proprietary" network element must be necessary for the requesting carrier to provide service. In practice, the necessary standard is rarely relevant.

competition policy.[4] While recognizing this substitution, the scholars also noted that the "incentive [to develop their own alternative inputs] may not be removed altogether." For example, Areeda and Hovencamp suggest, "the plaintiff may begin building a customer base and might eventually acquire enough customers to build its own pipeline but would not have done so if not permitted to enter the market by sharing (1996, ¶771)." Along these lines, Beard, Kaserman, and Mayo (1998) discuss the relationship between sharing and facilities-based entry in local exchange telecommunications markets.

With respect to post-1996 Act telecommunications policy, the courts have been somewhat schizophrenic on the question of unbundling network elements and the incentive of competitors to vertically integrate by supplying their own inputs. In affirming the FCC's cost standard for pricing unbundling elements, the Supreme Court, in *Verizon v. FCC*, 122 S.Ct. 1646 (2002) responded to the plaintiff's claim that unbundling did not stimulate facilities-based entry by observing, "actual investment in competing facilities since the effective date of the Act simply belies the no-stimulation argument's conclusion (at 1669)."[5] Less than a fortnight after the Court issued its Opinion in *Verizon*, the D.C. Circuit in *USTA v. FCC*, 290 F.3d 415 (D.C. Cir. 2002) responded,

> "the existence of investment of a specified level tells us little or nothing about incentive effects. The question is how such investment compares with what would have occurred in the absence of the prospect of unbundling [citation omitted], an issue on which the record appears silent. Although we can't expect the [Federal Communications] Commission to offer a precise assessment of disincentive effects (a lack of multiple regression analyses is not ipso facto arbitrary and capricious), we can expect at least some confrontation of the issue and some effort to make reasonable trade-offs." (at 425).

Echoing Areeda and Hovencamp, the Appeals Court also recognized, "access to UNEs may enable a CLEC to enter the market gradually, building a customer base up to the level where its own investment would be profitable (at 424)." Obviously, it is not possible to establish an unambiguous relationship between access of rivals to the monopolist's network and the incentive of entrants to construct their own inputs. In the end, the question is empirical.

The purpose of this paper is to evaluate in both a theoretically and empirically rigorous way the issue of how regulated access to inputs influences a firm's incentives to vertically integrate in order to self supply such inputs. The question of incumbent investment is beyond the scope of this paper. For entrants, the presence of a substitution effect is theoretically (and intuitively) undeniable. However, the theory reveals two other effects, one working with

[4] The make-or-buy decision is not restricted to cases of mandated access, but is a decision made by all firms nearly everyday. For a recent analysis of the make-or-buy decision in the context of commercial trucking, see Baker and Hubbard (2003).

[5] The Telecommunications Act requires that network access, or unbundled elements ("UNEs") be price at "cost." Cost was to be defined by the Federal Communications Commission, and that agency adopted a total-element, long-run incremental cost ("TELRIC") cost standard. TELRIC is a forward-looking methodology, where costs are based on the most efficient, currently deployed technology. See *In re Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, First Report and Order, FCC No. 96-325, 11 FCC Rcd 15499 (rel. Aug. 8, 1996).

(the *scale effect*) and the other against (the *entry effect*) the substitution effect.[6] Which of the three effects dominates cannot be determined solely by theory. Consequently, an empirical test of the theory is conducted, with the deployment of switching equipment by competitive local exchange carriers ("CLECs") as a case study.[7] This case study is particularly relevant to this issue, given that the entrant's access or lack thereof to the switching function of the local exchange network is the subject of heated debate (Sunderland, 2001; Bischoff, 2002). The empirical results indicate that for this particular case, the substitution effect is not dominant; restricted access to the "switching element" of the local exchange access, either through higher prices are outright restrictions, has discouraged switching facilities deployment by entrants.

The empirical findings of this paper provide important guidance for competition policy in the local exchange telecommunications market. Indeed, at the heart of the current telecommunications policy debate lays a key unanswered question: what public policy will best promote facilities-based entry into the local exchange telecommunications marketplace?[8] At the center of the debate is the question as to whether the requirement of the 1996 Telecommunications Act that incumbent local telephone carriers ("ILECs") provide access to their local networks to new entrants, or the requirement that such access be made available at "cost," promotes or deters facilities-based entry. The ILECs encourage policy makers to limit access to their network (particularly unbundled switching) and, when access is provided, that it be priced high. Without access to the incumbent's network or with access only at high prices, the ILECs contend that CLECs will be forced to deploy their own facilities and consequently will do so. In other words, the ILECs implicitly *assume* there is a strong substitution effect between access to the existing network and the construction of new network. The CLECs, the Federal Communications Commission ("FCC"), and Congress generally disagree with the ILECs claims, requiring the ILECs to unbundled their networks and make these components available to retail rivals. While the debate over unbundled elements does not lack of verve, what *is* missing from the debate is any semblance of a theoretical framework within which to analyze the issues and, perhaps more disturbing, much empirical evidence.[9] We attempt to address these two shortcomings in this paper.

This paper is organized as follows. In Section 2, a two-stage, game-theoretic model of switch deployment is presented. This theoretical analysis illustrates the difficulty in

[6] There are, no doubt, many other ways in which this issue can be evaluated in a theoretical context, which may point to additional effects that produce ambiguity.

[7] So, this analysis responds directly to the D.C. Appeals Court's desire for "multiple regression analyses" on the effects of unbundling on investment.

[8] It is unclear why the debate focuses on this question from a policy perspective, since the 1996 Telecom Act indicates no preference for facilities-based competition over competition using unbundled element. Indeed, Section 271 requires the existence of both forms of competition in order for a Bell Company to offer interLATA long distance services. From the perspective of the incumbent monopolist, however, the entry-deterring effect of forcing rivals to incur the sunk costs of network deployment is plainly desirable.

[9] Two empirical studies address the impact of the FCC's restriction on unbundled switching in the largest metropolitan statistical areas. See Z-Tel Communications (2002a, 2002b). Neither of these papers addresses, however, the question of facilities-deployment and network access prices, and neither presents a formal theoretical analysis of the issue. A working paper by Ford and Pelcovits (2002) considers the relationship of facilities-based loop entry and unbundled element prices and find that lower wholesale prices for elements are correlated with higher levels of facilities-based entry.

finding an unambiguous relationship between network access prices and CLEC facilities deployment. In Section 3, the empirical model is described and the results summarized. To our knowledge, this paper is the first formal theoretical and empirical analysis of this important policy issue. Concluding comments are provided in Section 4.

2. Conceptual framework

In order to assess the impact of wholesale prices for loops and switching on switch deployment, we develop an economic model in the form of a two-stage game. In Stage 1, firms choose whether or not to enter the market. Then, in Stage 2, firms choose how much switching to self-supply. As is customary with two-stage models, the model is solved backwards so that the first decision to evaluate is how a firm selects its optimal investment in switching, S^*, given that it enters in Stage 1. For simplicity, it is assumed that firms are symmetric ex ante, but not ex post, and that entry does not affect the retail margin.[10]

The model takes the point of view of the CLEC and evaluates the CLEC's decision whether or not to self-provide local switching. In other words, the model assumes that this CLEC entrant decides on its switch investment prior to knowing how many customers it will have (i.e., prior to entry). Thus, there is an uncertainty component to the model, and this uncertainty relates to demand. Upon entering the market, the CLEC provides service to end-users using unbundled loops purchased from the ILEC along with either unbundled local switching purchased from the ILEC or its own, self-supplied local switching.

The variables of the model include:

I = the number of firms that enter;
$N(I)$ = expected number of customers a single firm acquires and serves upon entry;
$\lambda N(I)$ = actual number of customers;
λ = random variable, $E(\lambda) = 1$, $\lambda \in [0, \infty+)$ with probability density function $f(\lambda)$ and cumulative density function $F(\lambda)$;
S = number of customers firm can service with its own switches;
$e \cdot S$ = cost of firm switches (a sunk cost), where e is the price per customer served by self-supplied switching;
P_L = regulated price of an unbundled loop;
P_S = regulated price of unbundled switching;
c = other per customer retail costs;
R = revenue per end-user customer;
M_o = margin with self-supplied switching $(R - P_L - c)$;
M_b = margin with unbundled switching $(R - P_L - P_S - c)$, where $M_o > M_b$.

Prior to entry, firms expect to acquire and serve N customers. However, the customer base is only an expectation, with actual customers equaling λN (where λ is a random variable). If $\lambda N < S$, actual demand is less than switching capacity, the entrant uses its own switching exclusively. This level of demand occurs with probability $F(S/N)$.

[10] An analysis of retail competition could be included as a third stage of the model, but this addition would not alter the primary findings of the theoretical model. Thus, to simplify, we exclude this third-stage analysis.

In this case, the profit of the entrant is

$$\pi = \lambda N \cdot M_o - e \cdot S, \tag{1}$$

which is simply the margin on the actual customer base minus sunk switch investment.[11] Alternately, if $\lambda N > S$, the entrant uses both its own switching capacity as well as purchasing unbundled switching from the ILEC. This level of demand occurs with probability $[1 - F(S/N)]$. In this case, the profit of the entrant is

$$\pi = S \cdot M_o + (\lambda N - S)M_b - e \cdot S. \tag{2}$$

Note that there can be other sunk entry costs in addition to switching investment, but the presence of such costs does not alter the analysis. For expositional convenience, we ignore such costs.

Expected profit as a function of S, N, P_L, and P_S is

$$E\pi = \int_0^{S/N} \lambda f(\lambda)\mathrm{d}\lambda \cdot N \cdot M_o + \int_{S/N}^{\infty} \lambda f(\lambda)\mathrm{d}\lambda \cdot NM_b + \left(1 - F\left(\frac{S}{N}\right)\right) \cdot S \cdot (M_o - M_b) - e \cdot S. \tag{3}$$

To find the optimal level of switch investment, S^*, the first order condition of Equation (3) with respect to S is needed:

$$\frac{\partial E\pi}{\partial S} = \left(1 - \left(\frac{S}{N}\right)\right) \cdot (M_o - M_b) - e = 0. \tag{4}$$

The second-order condition is

$$\frac{\partial E\pi}{\partial S} = -f\left(\frac{S}{N}\right) \cdot \left(\frac{1}{N}\right) \cdot (M_o - M_b) < 0, \tag{5}$$

indicating that S^* is a maximum.

2.1. Comparative statics

Useful comparative static results include

$$\frac{\partial^2 E\pi}{\partial S \partial N} = -f\left(\frac{S}{N}\right) \cdot \frac{-S}{N^2}(M_o - M_b) > 0, \tag{6}$$

[11] Switches are mostly sunk investments, with secondarymarket values of pennies on the dollar. Even the incumbent carriers, who oppose the availability of unbundled switching, acknowledge that switches are mostly sunk (*UNE Fact Report 2002*, Prepared for and Submitted by BellSouth, SBC, Qwest, and Verizon, April 2002, at B-1: “. . . switches are a sunk investment, so if one company ceases to use its switch it is highly likely that another company will quickly [] be able to obtain the switch at a fire-sale price).”

indicating that the larger the number of expected customers, the more the entrant will self-supply switching. Defining π at S* as π*, we have

$$\frac{\partial E\pi *}{\partial N} = \int_0^{S/N} \lambda f(\lambda)\mathrm{d}\lambda \cdot N \cdot M_\mathrm{o} + \int_{S/N}^{\infty} \lambda f(\lambda)\mathrm{d}\lambda \cdot NM_\mathrm{b} > 0, \tag{7}$$

$$\frac{\partial E\pi *}{\partial P_\mathrm{S}} = N\left[\left(1 - F\left(\frac{S}{N}\right)\right) \cdot \frac{S}{N} - \int_{S/N}^{\infty} \lambda f(\lambda)\mathrm{d}\lambda\right] < 0, \tag{8}$$

and,

$$\frac{\partial E\pi *}{\partial P_\mathrm{L}} = -N < 0. \tag{9}$$

Equation (7) indicates that an increase in the customer base increases expected profits. Equations (8) and (9) imply that higher wholesale prices for loops or switching reduce expected profits.

Turning to the question of switches deployed in the market, assume that all firms pick the same S* ex ante, but ex post the demands differ randomly across firms. Market demand is assumed to be constant and insensitive to the allocation of demand among firms. Given R, P_L, P_S, e, and N, each firm selects S*. Equilibrium profit for each firm, π*, is assumed to be zero. This assumption allows us to solve for $\breve{N}$, the "minimum necessary market size" or "minimum viable scale ("MVS")."[12] The number of firms that enter, I, depends on this $\breve{N}$ (i.e., $I = I(\breve{N})$), where $I' < 0$—the larger the market share needed to break even (i.e., the larger is MVS), the fewer firms enter in equilibrium.[13] The optimal level of switch deployment for any given firm is $S^* = S^*(P_\mathrm{L}, P_\mathrm{S}, \breve{N})$.

If each firm deploys S* switching, then the total amount of CLEC switching is given by

$$\breve{S} = I(\breve{N}) \cdot S^*, \tag{10}$$

which states that total switching capacity deployed is simply the number of firms multiplied by average switching capacity.

2.1.1. *Switch deployment and loop prices*

The response of switching deployed to a change in the loop rate is

$$\frac{\mathrm{d}\breve{S}}{\mathrm{d}P_\mathrm{L}} = I' \cdot \frac{\partial \breve{N}}{\partial P_L} \cdot S^* + I\left[\frac{\partial S^*}{\partial P_\mathrm{L}} + \frac{\partial S^*}{\partial N}\frac{\partial \breve{N}}{\partial P_\mathrm{L}}\right] \tag{11}$$

but $\mathrm{d}S^*/\mathrm{d}P_\mathrm{L} = 0$, so

$$\frac{\mathrm{d}\breve{S}}{\mathrm{d}P_\mathrm{L}} = \frac{\partial \breve{N}}{\partial P_\mathrm{L}}\left[I' \cdot S^* + I \cdot \frac{\partial S^*}{\partial N}\right]. \tag{12}$$

[12] Minimum viable scale is the "smallest annual level of sales that the committed entrant must persistently achieve for profitability." *Horizontal Merger Guidelines* § 3.3.

[13] For an excellent analysis of entry and sunk costs generally, see Sutton (1991).

All the right-hand side terms in Equation (12) are positive except for I'. Thus, the sign on $\mathrm{d}\breve{S}/\mathrm{d}P_{\mathrm{L}}$ is ambiguous. Equation (12) reveals the two important, and contrary, effects of changes in the loop rate on switch deployment. First, as P_{L} rises, the per-customer margin declines. When customers become less profitable, the entrant needs more customers to breakeven ($\mathrm{d}\breve{N}/\mathrm{d}P_{\mathrm{L}} > 0$), and an increase in customers leads to increased switch deployment. This effect is called the *scale effect* $[\mathrm{d}\breve{N}/\mathrm{d}P_{\mathrm{L}} \cdot I \cdot \partial S^{*}/\partial N]$, which arises simply from the fact that the smaller are per-unit profit margins, the larger is minimum viable scale.

The second effect is called the *entry effect* $[\mathrm{d}\breve{N}/\mathrm{d}P_{\mathrm{L}} \cdot I' \cdot S]$. From the scale effect, we know that a change in the loop price alters the scale of the firm. As the market share required to profitably enter rises due an increase in the loop rate, fewer firms can profitably enter ($I' < 0$). A reduction in the number of firms reduces total switch deployment, ceteris paribus. The ambiguous relationship between input price and switch deployment arises from the fact that the entry effect opposes the scale effect and it is impossible to determine from theory which effect dominates.

Intuitively, the source of ambiguity can be described simply as follows. The total quantity of switching deployed ($\breve{S}$) equals the amount of switching deployed by each firm (S^*) multiplied by the number of firms ($\breve{N}$). Higher loop prices raise MVS, thereby reducing the number of firms but increasing the quantity of switching deployed by each of the remaining firms. Thus, no unambiguous claim can be made about the product of the two quantities (S^* and $\breve{N}$) at different loop prices.

2.1.2. Switch deployment and switching prices

While the scale and entry effects arise when considering the effects of the switching price on total switches, an additional effect is also present. A change in the switching rate on total switches is

$$\frac{\mathrm{d}\breve{S}}{\mathrm{d}P_{\mathrm{S}}} = \frac{\partial \breve{N}}{\partial P_{\mathrm{S}}}\left[I' \cdot S^{*} + I \cdot \frac{\partial S^{*}}{\partial N}\right] + I \cdot \frac{\mathrm{d}S^{*}}{\mathrm{d}P_{\mathrm{S}}}. \tag{13}$$

The scale and entry effects are both present, but there is an additional term on the right-hand side not present in Equation (12). This term measures the *substitution effect*. The substitution effect accounts for the substitution between self-supplied switching and purchased switching. As the price of purchased switching declines, the incentive to self-supply switching declines ($\mathrm{d}S^*/\mathrm{d}P_{\mathrm{S}} > 0$), and vice versa. Clearly, the substitution effect is only one of three potential effects arising from a change in switching rates. The sign of Equation (13), as with Equation (12), is ambiguous.

2.2. From theory to empirics

The theoretical model given here forms the approximate basis for our empirical analysis. Equation (10) implicitly defines the equilibrium number of total CLEC switches as a function of several types of variables. First, the prices of switches, unbundled switching, and unbundled loops affect equilibrium CLEC switch deployment through the various avenues identified in the previous section. Second, those factors that affect the size of a viable entrant also determine the number of switches deployed. These factors, in turn, stem from both cost and revenue conditions faced by entrants. While it is reasonable to assume that the costs of switches, the technology of providing services, and so on, are largely uniform across all states, the markets CLECs seek to enter may exhibit important differences that affect the size of a "viable" firm presence. Most notably, markets may well differ in size and customer density (e.g., urban versus rural composition). Presumably, markets with greater urban composition and greater telecommunications spending allow any given entrant to break even with a smaller number of customers (Sutton, 1991, Chapter 2). Thus, theory implies that any evaluation of the affects of element prices on CLEC switch deployment should account for (1) market size; (2) telecommunications spending; and (3) the degree of market urbanization. These factors affect the "size" (i.e. expected number of customers) required for viable operation by a CLEC entrant. Our analyses therefore should include these factors.

These considerations suggest the following econometric template. Equation (10) states that $\breve{S}$ depends on loop and switching rates as well as the "minimum necessary market size," or $\breve{S}(P_{\mathrm{L}}, P_{\mathrm{S}}, I)$. Minimum firm size $[I(N)]$ may be parsimoniously assumed to depend on a variety of factors measuring market size and density (summarized by Z) and (potentially) regulatory policies (R). Given observations on actual switch deployment by CLECs (conceptually, $\breve{S}$), one may specify the reduced form relationship

$$\breve{S} = \beta_0 + \beta_1 P_{\mathrm{L}} + \beta_2 P_{\mathrm{S}} + \beta_3 Z + \beta_4 R + \varepsilon \tag{14}$$

in which $\breve{S}$ is given as a function of loop prices, switching prices, minimum firm size as proxied by variable(s) Z, and regulatory influences R.

Equations (12) and (13) fail to establish a definite sign for the relationship between the relevant prices and switch deployment. To summarize, both loop rates and unbundled switching rates have ambiguous effects on the deployment of switches by CLECs because, in both cases, scale effects (the necessary scale of entry for viable competition) and the extent of entry itself are affected by changes in such prices. In other words, as element prices rise, fewer firms enter but those that do have larger customer bases, thereby making it impossible to say whether more or less switching capacity is deployed. Thus, while it is certainly true that any increase in unbundled switching rates makes self-supplied switching relatively cheaper (thus encouraging its use), it is also clear that increases in the prices of inputs generally do not encourage entry of any sort.[14]

Econometric estimates of the parameters β_1 and β_2 allow us resolve the theoretical ambiguity based on observed deployment behavior by CLECs. For loop price, a negative value for β_1 indicates the entry effect is larger in absolute sense than the scale effect. A negative sign on β_2 (the coefficient on the switching price) indicates that the entry effect is larger in absolute value than the scale and substitution effects (jointly). Our empirical strategy to estimate the parameters β_1 and β_2 is described in Section 3.

[14] Beard, Ekelund, Ford (2004) provide s simple theoretical framework illustrating how increases in the UNE prices will necessarily result in less entry, though such an increase may alter the mix of own versus leased capacity.

3. Econometric model

This empirical model focuses on the relationship between CLEC deployed local exchange switching equipment and the rates for unbundled local loops and unbundled local switching. The relationship between wholesale prices and switching facilities deployment is particularly interesting since switch deployment is a primary focus of modern telecommunications policy. Furthermore, local switching is fertile ground for empirical analysis because state-level data on CLEC deployment of local switching equipment is available, and because UNE prices are established on a state-by-state basis, providing sufficient variability in the data for econometric analysis. In addition, the FCC has limited the availability of unbundled local switching to particular customer-types in certain geographic areas of the Top 50 metropolitan statistical areas.[15] Thus, it is possible to assess how regulatory limitations on access to switching influence switch deployment.

From the Local Exchange Routing Guide ("LERG"), we compute the number of CLEC switches deployed (*S*) between April 2000 and October 2001 in each of the fifty states and the District of Columbia.[16] Deployment during this period is of interest because unbundled switching was just becoming commercially available and viable in early 2000 (so the prices for unbundled loops and switching are actually relevant to the deployment decision), and the FCC implemented a rule change on switching availability in the spring of that year. Thus, we evaluate CLEC deployment behavior during the period in which unbundled switching was (effectively) available and prices for the element were established.

Explanatory variables in the regression include the price of local loops (P_{L}), the price of unbundled local switching (P_{S}), market size as measured by the number of Bell Company access lines in the state (*LINES* and $LINES^2$), and average local service revenue per-line in the state (*RETAIL*).[17] It is reasonable to expect that switches are more likely to be deployed in cities due to the population density, so a variable measuring the percent of population in the central cities of metropolitan areas in the state is included as a regressor (*CITYPOP*).

In addition, a variable *RESTRICT* measures the percent of population in those metropolitan statistical areas in each state where the availability of unbundled local switching is limited. In the FCC's *UNE Remand Order,* the agency reiterated its position that CLEC access

[15] The FCC's unbundled local switching restriction allows the incumbent monopolist to either forbid the purchase or raise the price of unbundled switching in most dense portions of the Top 50 MSAs. The restriction did not apply in New York or Texas where state regulations and/or laws prohibited such a restriction. *In re Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, Third Report and Order and Fourth Further Notice of Proposed Rulemaking*, FCC No. 99–238, 15 FCC Rcd 3696 (rel. Nov. 5, 1999) ("UNE Remand Order") at ¶253–299.

[16] Unbundled local switching did not really become a viable product in most states until year 2000. New York was the first state, and Texas the second, to create an unbundled switching element that could be used in conjunction with loops to provide end-user service.

[17] Diagnostic tests and earlier empirical work prescribed the inclusion of the squared value of *LINES*. For example, the test statistics of the RESET were much lower when $LINES^2$ was included, and omitted variables tests on the regressor were rejected for some specifications. Z-Tel Communications (2002b) finds a non-linear relationship between CLEC switch deployment and market size.

to unbundled local switching ("ULS") is necessary for competition, concluding, "that, in general, lack of access to unbundled local switching materially raises entry costs, delays broad-based entry, and limits the scope and quality of the new entrant's service offerings (¶253)." Despite this finding, the FCC chose to remove the unbundled switching obligations of the ILECs for customers with more than three switched access lines in the densest portions (Density Zone 1) of the fifty largest Metropolitan Statistical Areas ("MSA").[18] The rationale for this exclusion was that entrants could serve in a "timely" manner residential and small business consumers at levels of comparable scale and scope by using or deploying their own switching equipment as access to unbundled local switching would allow. The empirical model evaluates whether or not the restriction in fact has increased the deployment of switching in these markets by CLECs.

Finally, switch deployment during the sample period may be affected by the amount of switching already deployed. A variable measuring switch deployment as of April 2000 is included as a regressor in some models (*SDENSE*). While the inclusion of this regressor may impact the explanatory power of the market size variables, the UNE price variables should not be much affected since the availability of these unbundled elements prior to this time period was very limited. While *SDENSE* could be specified on a per-line basis, this alternative has no effect on the estimated coefficients except for *SDENSE* and none of the standard errors are impacted. Thus, we use total switches deployed for *SDENSE*.[19]

3.1. Data

As previously mentioned, two cross-sections of CLEC-deployed switches are extracted from the LERG (April 2000 and October 2001). The dependent variable is defined as the number of additional switches deployed between two time periods (i.e., the variable is a non-negative count). The LERG is a database maintained and sold by Telcordia.[20] The database includes detailed information on the current network configuration of telecommunications carriers, and is primarily used for routing calls among telecommunications carriers.[21] To limit attention to switches substitutable with unbundled local switching and of a somewhat uniform capacity, the dependent variable is constructed extracting from the LERG only *end office* switches that have local telephone numbers assigned and are operated by CLECs.[22]

[18] As an additional requirement, the ILEC had to provide access to enhanced extended links ("EELs") in these areas. EELs are combinations of loops and transport that "extend" the local loop from one central office to another where the CLEC has collocated equipment. EELs, in theory, reduce the need for the CLEC to place equipment in every ILEC central office.

[19] The variable *SDENSE* is total switches deployed so it is not a lagged dependent variable. We do not have sufficient data for a meaningful time-series analysis.

[20] Information available at: www.trainfo.com/products_services/tra/catalog_details.html#LERG. Model 4 was estimated with the total switches deployed as of October 2001 as the dependent variable. While the coefficients were smaller, significance levels were comparable and the general conclusions from regression analysis were unchanged.

[21] In essence, the LERG assigns telephone numbers to particular end offices or tandem offices so carriers know to route calls to the appropriate office and at the correct rate.

[22] The LERG is queried for CATEORGY of CLEC, CAP, or L_RESELLER, a COC_TYPE of "EOC," and with non-null values in the "NPA" and "NXX" fields. Local switches used by CLECs are generally limited to Class

Bell Company access lines by state are provided by ARMIS Form 43-04 (2000 data).[23] Retail price is measured as average revenue per line, and this data is provided by the FCC's universal service reports as reported in Gregg (2001).[24] The percent of population for each state in central cities and in restricted, Top 50 MSAs is computed using Census data.[25] Implicit in the measurement of *RESTRICT* is that the percent of population in the MSA is highly correlated with the CLECs assessment of the impact of the restriction on its potential market. The restriction applies only to customers with more than three access lines that are also located in the densest portions of the MSA (Density Zone 1, which is a rate zone defined for regulatory purposes). Data measuring the number of customers that fit these criteria are unavailable, so this proxy for the scope of the restriction is employed. The econometric model is estimated both with and without the *RESTRICT* variable.

Wholesale prices for loops and unbundled switching are based on state tariffs and interconnection agreements between the ILEC and CLECs. The computation of element costs from this information is both a complex and enormous undertaking. This undertaking was avoided, fortunately, by acquiring summary data on average network access prices from a CLEC serving the vast majority of the U.S. market.[26] Switching prices include all components of unbundling switching including switching and shared transport. This broad measure of switching cost is appropriate because switching and shared transport must be purchased jointly (and cannot be purchased independently), so that both of the elements are replaced if the CLEC deploys its own switch.[27] Loop and switching cost data was provided for 39 states.[28] Because the other explanatory variables are available for all states, these 39 states make up the final sample.

V switches sold by Lucent Technologies (5E) and Nortel Communications (DMS-500). Capacity of these (and other) switches varies by the number of line cards installed by the operator. The number of switches deployed in computed by excluding those switches listed in period $t-1$ from those listed in the period t, and then counting the remaining switches by location state.

[23] The ARMIS data is available online at www.fcc.gov/ccb/armis.

[24] These studies are released by the National Regulatory Research Institute at the Ohio State University: http://www.nrri.ohio-state.edu.

[25] The list of restricted MSAs are provided in Appendix A of the *UNE Remand Order*. For MSAs that cross state lines, the population is allocated in proportion to the largest cities within the MSA. Because the FCC's switching restriction did not apply in New York and Texas, *RESTRICT* was set equal to zero for these states. A number of states are presently evaluating whether or not to eliminate the restriction (e.g., Georgia and Maryland). Census data for the population statistics is available for download at: http://www.census.gov/population/estimates/metro-city/ma99-06.txt.

[26] The data was provided by Z-Tel Communications, in Tampa, Florida, and was based on a average or representative customer for the state. Z-Tel provides local exchange service using the UNE-Platform (local loops plus local switching/transport) in 39 states (during the time period contemporaneous with the data). Switching costs include local switching and transport, as well as switch related wholesale prices for services such as the daily usage file (which is the file containing usage statistics required for billing for each customer). The data was provided to the authors on the condition of confidentiality.

[27] Unbundled shared transport can only be purchased with unbundled switching, and unbundled switching cannot be combined with alternative forms of transport. Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, REPORT AND ORDER AND ORDER ON REMAND AND FURTHER NOTICE OF PROPOSED RULEMAKING, CC Docket No. 01-338 (August 22, 2003), at ¶533–534.

[28] Excluded states include Alaska, Arkansas, Colorado, Hawaii, Idaho, Nebraska, Nevada, New Jersey, New Mexico, South Dakota, and Wyoming as well as the District of Columbia.

3.2. Model specification

In order to estimate the parameters of Equation (14), the following regression model is estimated:

$$S = f(\ln P_{\mathrm{L}}, \ln P_{\mathrm{S}}, \ln LINES, \ln RETAIL, CITYPOP, \varepsilon) \tag{15}$$

where ε is the econometric disturbance term. Additional models are estimated in order to incorporate the variable *RESTRICT* and *SDENSE*. Because *RESTRICT* is measures somewhat indirectly, we want to evaluate the estimates with and without this regressor.

The dependent variable (*S*) is (by definition) non-negative count data (i.e., the data has only discrete values of zero or more), so we employ the Negative Binomial Regression, which a commonly used alternative to linear least squares regression for count data.[29] Linear regression for count data can result in inefficient, inconsistent, and biased estimates (Long, 1997, p. 217). Unlike the Poisson regression, which is another popular regression technique for count data, the negative binomial regression does not require that the conditional mean of the data equal the conditional variance. If this equality assumption is incorrect (i.e., there is *overdispersion* in the data), then the Poisson estimates are invalid and the estimated standard errors are too low thereby leading to a spurious overstatement of statistical significance (Gourieroux, Monfort, & Trognon, 1984). The estimates of the Negative Binomial Regression, however, do not suffer from this problem. If overdispersion is not present, then the estimates of the Negative Binomial Regression are identical to those of the Poisson regression.[30]

Most of the regressors are expressed in log form, and this transformation is supported by specification analysis. Based on Monte Carlo studies of specification tests, Godfrey, McAleer, and McKenzie (1988) recommend RESET as the best test of functional form. We employ Wooldridge's (1991, 1999) version of RESET for conditional mean regressions. In addition to functional form, the RESET test is a rather general test of mis-specification, and is capable of detecting omitted variables, endogenous explanatory variables, errors in measurement, and an incorrect functional form for linear models (though it is most sensitive to functional form and omitted variables). The null of RESET – no specification error – was rejected easily when the log transformation *was not* used. Alternately, we could not reject the null of RESET when using the log transformation on explanatory variables. Further support of the log transformation for the regressors is provided by the Akaike and Schwarz Information Criteria, both of which are lower for the log specification of the regressors.

There is little reason to suspect that any of the regressors in our model are endogenous, and the inability to reject the null of RESET provides some support for this claim. Among

---

[29] For a technical discussion of Negative Binomial and Poisson regressions, see Cameron and Trivedi (1998, Chapter 3). While we observe no zero values, zero is in the sample space.

[30] As a product of the Negative Binomial Regression, and "overdispersion" parameter, α is estimated. The value and statistical significance of this estimated parameter indicates whether or not the Negative Binomial regression is preferred to the Poisson regression, because a non-zero value of the overdispersion parameter indicates the restrictive assumptions of the Poisson regression are inappropriate (Cameron and Trivedi, p. 77). If the estimated overdispersion parameter is zero (statistically insignificant), then the Negative Binomial regression is identical to the Poisson regression.

the regressors, only the price variables seem to pose much risk of endogeniety, but even here the potential for endogeneity is small since all the prices used in the regression are regulated prices that are either constant or highly stable over long periods of time, and are thus arguably independent of competitive switch deployment (during the sample period). Wholesale prices (P_L, P_S) are determined in lengthy and infrequent regulatory proceedings using long run incremental cost studies under constraints imposed by the FCC's Total Element Long Run Incremental Cost standard, and the observed lack or presence of competition does not play a direct role in the analysis. Similarly, retail prices for local phone service are not subject to frequent adjustments by regulators, and the limited amount of competition during the sample period was insufficient to affect the retail tariff filings of the ILECs for residential and small business access services. Endogeniety may become a more relevant consideration in the future if competition develops beyond its present infancy, or remains in its infancy for an extended period. While endogenity is not expected, a Hausman test nevertheless was performed for all three prices (P_L, P_S, and *ARPL*) using the exogenous variables of the model, per-capita income, and loop and switching/transport cost estimates from the FCC's Hybrid Cost Proxy Model (a forward looking cost model for telecommunications plant) as explanatory variables in the price regressions.[31] We employ the version of Hausman test proposed by Wooldridge (1991, 1999). Based on this test, we could not reject the null hypothesis of exogeneity for these price variables in the regression.[32]

3.3. Results

The results of the Negative Binomial regressions (Models 1–4) are provided in Table 1, and the marginal effects for each variable are provided (using Model 4). The likelihood ratio index, a measure of goodness-of-fit for non-linear regressions (such as the Negative Binomial) is about 0.79 for all four models.[33] An alternate measure of goodness of fit, the squared correlation coefficient between the predicted and actual values of the dependent variable, is also provided and ranges from 0.55 to 0.76.[34] While these measures of fit are imperfect (as are all such measures for non-linear regression), they do illustrate that our chosen models do explain a large percentage of the variation in switch deployment across states (Cameron & Trivedi 1998, pp. 151–158). The overdispersion parameter, α, is statistically significant for both models, indicating that the Negative Binomial Regression

[31] The FCC's cost model is a synthesis of ILEC and CLEC cost models and is used primarily to allocate universal service subsidy funds across states and carriers. In some cases, the FCC has used the model to evaluate the reasonableness of UNE prices established in state proceeding (e.g., Application of Verizon Pennsylvania Inc., Verizon Long Distance, Verizon Enterprise Solutions, Verizon Global Networks Inc., and Verizon Select Services Inc. for Authorization to Provide In-Region, InterLATA Services in Pennsylvania, FCC 01-269, CC Docket No. 01-138, ¶¶53–75 (Sept. 19, 2001)). The output of the cost model is available at the FCC's website: www.fcc.gov/wcb/tapd/hcpm/welcome.html.

[32] For the joint test on all three prices (using Model 1 from Table 1), the χ^2 statistic was 3.21 (Prob = 0.14) and for the robust version of the test 2.81 (0.16). The null would be rejected if any of the three prices was endogenous.

[33] For a discussion of goodness-of-fit measures for non-linear regressions and their limitations, see Cameron and Trivedi (1998; pp. 151–158).

[34] A least squares regression using the log transformation of the dependent variable is a close approximation to the negative binomial. The R^2's from these regressions (mimicking Models 1–4) are 0.76, 0.80, 0.82, and 0.85, respectively.

Table 1
Negative binomial regression results and descriptive statistics ($N = 39$)

Variable	Model (1) negative binomial Coefficient (t-statistics) [robust t-statistics]	Model (2) negative binomial Coefficient (t-statistics) [robust t-statistics]	Model (3) negative binomial Coefficient (t-statistics) [robust t-statistics]	Model (4) negative binomial Coefficient (t-statistics) [robust t-statistics]	Model (4) average response (%) 10% increase in x_i	Descriptive statistics Mean (S.D.)
Constant	0.59	3.056	−0l43	1.831	–	
	(0.31)	(1.52)	(−0l25)	(1.00)		
	[0.23]	[1.24]	[−0l19]	[0.82]		
ln P_L	−0l539	−0l538	−0l798	−0l746	−6.9	15.69
	(−1l80)[b]	(−1l98)[a]	(−2l99)[a]	(−3l04)[a]		(4.60)
	[−1l82][b]	[−2l17][a]	[−3l38][a]	[−3l12][a]		
ln P_S	−0l342	−0l289	−0l281	−0l249	−2.3	15.53
	(−1l96)[a]	(−1l82)[b]	(−1l86)[b]	(−1l79)[b]		(7.59)
	[−1l77][b]	[−1l56]	[−1l74][b]	[−1l61]		
ln *LINES*	0.629	0.828	0.179	0.391	1.1	3.744
	(4.44)[a]	(5.54)[a]	(1.01)	(2.11)[a]		(4.16)
	[5.83][a]	[6.08][a]	[1.29]	[2.62][a]		
ln $LINES^2$	−0l024	−0l071	−0l055	−0l093	–	30.86
	(−0l41)	(−1l23)	(−1l07)	(−1l83)[b]		(82.27)
	[−0l59]	[−1l95][b]	[−1l50]	[−3l00][a]		
ln *ARPL*	1.513	0.844	1.438	0.837	8.3	33.95
	(2.59)[a]	(1.42)	(2.74)[a]	(1.56)		(4.70)
	[1.96][a]	[1.16]	[2.19][a]	[1.26]		
CITYPOP	−0l619	−1l013	−0l627	−0l878	−8.4[*]	0.26
	(−0l72)	(−1l29)	(−0l86)	(−1l28)		(0.10)
	[−0l66]	[−1l25]	[−0l82]	[−1l25]		

RESTRICT	–	−0l866	–	−0l73	−7.0[*]	0.30
		(−2l80)		(−2l61)[a]		(0.28)
		[−3l32]		[−3l53][a]		
ln *SDENSE*	–	–	0.596	0.538	5.3	63.21
			(3.65)[a]	(3.49)[a]		(60.02)
			[4.08][a]	[4.39][a]		
α	0.171	0.139	0.124	0.103	–	–
	(−7l10)[a]	(−7l64)[a]	(−8l04)[a]	(−8l45)[a]		
	[−8l40][a]	[−8l87][a]	[−8l15][a]	[−8l10][a]		
LR Index	0.78	0.79	0.79	0.79		
ρ^2	0.55	0.68	0.55	0.76		
RESET(2)	1.73 (0.21)	0.72 (0.35)	3.23 (0.10)	1.05 (0.30)		
Reset(2), Robust	1.23 (0.27)	0.56 (0.38)	1.72 (0.21)	0.51 (0.39)		
Descriptive statistics of the dependent variable (*S*)	Obs. = 39	Min = 8				
	Mean = 61.02	Max = 258				
	S.D. = 49.76	Skewness = 1.71				
	Median = 44.00	Kurtosis = 7.31				

[a] Statistically significant at the 5% level or better.
[b] Statistically significant at the 10% level or better.
[*] 10 percentage point increase.

is preferred to the Poisson regression. For all four models, the null of RESET cannot be rejected at the 5% level and, in most cases, the 10% level.

Across all the models, most of the explanatory variables are statistically significant at the 5% level or better, and nearly all are significant at the 10% level or better. In the table, *t*-statistics based on both the traditional and heteroscedasticity-robust standard errors are reported.[35] The variable *CITYPOP* is never statistically significant, and the constant term is not significant in Models 3 and 4. The estimated coefficients are robust across alternate specifications, and the UNE price variables (particularly P_L) exhibit good statistical significance across models.

As expected, larger markets have more CLEC switches; the coefficient on *LINES* is positive and highly statistically significant. Note that the relationship between access lines and CLEC switches is less than proportional (the estimated coefficient is less than 1.00), and the average response for a 10% increase in lines is about a 1% increase in switch deployment.[36] Higher revenue per access line also leads to more switch deployment (*RETAIL* is statistically significant and positive), and the elasticity is sizeable (0.83). The positive sign on *RETAIL* was expected because higher expected revenues increase the expected profit of entry (ceteris paribus).[37]

Of particular interest are the effects of UNE rates (P_L, P_S) and the unbundled switching restriction (*RESTRICT*) on CLEC switch deployment. The coefficients on the price variables correspond to the parameters β_1 and β_2 from Equation (14), and indicate the relative sizes of the three effects illustrated by the theoretical model. No a priori expectation regarding the effect of the price for unbundled loops or switching on switch deployment was made, given that the theoretical model allows for both positive and negative values (and perhaps a zero value). The regression results indicate, however, that higher loop rates decrease switch deployment; a negative and statistically significant sign on P_L is estimated (corresponding to coefficient β_1 in Equation (14)). The empirical model, by the negative sign on P_L, indicates that the entry effect dominates the scale effect. The elasticity, computed from the average response, is about -0.70.

The theoretical ambiguity between the price for unbundled switching and switch deployment is resolved by the empirical model. The estimated coefficient on the price of local switching (corresponding to coefficient β_2 in Equation (14)) is negative and typically statistically significant at better than the 5% level (and always significant at the 7% level or better). The estimated elasticity is -0.23, so a 10% increase in the ULS rate decreases CLEC switch deployment by 2%. With respect to the theoretical model, the negative coefficient indicates that, on average, the substitution of unbundled switching for switch deployment is not prevalent at current UNE rates. The entry effect dominates both the

---

[35] There is little difference in the significance levels between the computation methods for standard errors. With the robust errors, statistical significance for P_S declines to about the 6% level in Models 2 and 3, and the significance of *ARPL* declines to the 7% level in Model 2.

[36] As recommended by Cameron and Trivedi (1998, pp. 80–81), we report the average response over all states in the sample, rather than compute the responses at the sample means. As for the non-linearity of the response, a consistent result is found in Z-Tel Policy Paper No. 4 (2002b).

[37] Theory indicates that existing retail prices may not be a reliable estimate of post-entry prices, so entrants may ignore such prices.

scale and substitution effects, so that higher switching rates reduce CLEC switch deployment (ceteris paribus and on average). The result is reasonably robust across specifications.

Finally, the sign on *RESTRICT* is negative and statistically significant at the 5% level, suggesting that the FCC's restriction on access to unbundled switching has impeded rather than encouraged switch deployment.[38] At the sample means, the switching restriction is estimated to have reduced CLEC switching deployment by about 22%.[39] These regression results suggest that the switching restriction impeded rather than encouraged switch deployment.[40]

In sum, the econometric results summarized in Table 1 are consistent with economic intuition in that more entry is observed in larger markets and markets with higher prices. The ambiguity with respect to UNE prices is resolved by the negative coefficients on UNE prices (P_L, P_S) and availability (*RESTRICT*). In the particular case of switching equipment, this econometric analysis indicates that efforts to encourage the deployment of switching facilities by limiting the availability or increasing the prices of switching UNEs has been (and possibly will continue to be) counterproductive.

4. Conclusion

Profit maximizing firms participating in a market economy make "make-or-buy" decisions everyday. While these decisions are of interest to economists in determining what may be an efficient organization of the firm, the "make-or-buy" decision is evaluated differently when the ability to "buy" is mandated and governed by regulation rather than the market, and the ability to "make" is limited substantially by various entry barriers. Such scenarios are increasingly commonplace for the regulated utilities including electricity, gas, and telecommunications, where concepts such as "essential facilities" and "unbundled network elements" are frequently used tools of competition policy.

One common concern in such scenarios is when the ability to "buy" substantially offsets the incentive to "make." In this paper, we evaluated both theoretically and empirically the relationship between "make" and "buy." In our particular construct, where self-supplied and purchased inputs may serve as complements, three sometimes conflicting effects are

[38] Using robust standard errors, the significance level is 6%. The traditional least squares standard errors produces a significance level of 11%.

[39] This response is computed by reducing restrict to zero for all markets, and comparing to mean of the dependent variable.

[40] Given the specification of *RESTRICT*, there is the potential that the variable captures variations in switch deployment across states based factors other than the switching restriction. However, alternative regressions indicate that *RESTRICT* has no effect on switch deployment between January 1999 and April 2000, a period prior to the implementation of the restriction. Because the percent of population in a restricted, Top 50 MSA has no effect prior to the implementation of the restriction, but a negative and statistically significant effect after the restriction, it is reasonable to conclude that this measure of the restriction properly captures its effect. The coefficients and t-statistics of the other variables were not materially affected. So, we can reject this alternate explanation for the sign on *RESTRICT*. For an analysis of the effects of the switching restriction on competitor market share, see Z-Tel Communications (2002a).

relevant to the "make-or-buy" decision, of which the substitution effect is only one. Our empirical example considers the deployment of switching facilities by entrants to the local exchange telecommunications markets, and these empirics indicate that the substitution effect is not dominant in this particular case. Of course, the empirical example chosen for our analysis is not necessarily indicative of any other particular case. However, our findings do support the general notion that the substitution effect is not the only relevant consideration, either theoretical or empirical, for policy makers in selecting what inputs to make available to entrants when promoting competition in the utility industries or any industry where mandated access is contemplated or effectuated.

Acknowledgments

We thank two anonymous referees for very helpful comments and suggestions. Of course, all remaining errors are our own. Please direct all questions and comments to George Ford at george.ford@telepolicy.com.

References

Areeda, P. E., & Hovenkamp, H. (1996). *Antitrust law*. New York: Aspen.

Baker, G. P., & Hubbard, T. N. (2003). Make versus buy in trucking: asset ownership, job design, and information. *American Economic Review*, *93*, 551–572.

Beard, T. R., Ekelund, R. B., Jr., & Ford, G. S. (2004). The law and economics of unbundling and impairment. *Journal of Law, Technology and Policy*, *32*, 475–501.

Beard, T. R., Kaserman, D. L., & Mayo, J. W. (1998). The role of resale entry in promoting local exchange competition. *Telecommunications Policy*, *22*, 315–322.

Bischoff, G. (2002, September 13). USTA calls for the end of UNE-P, TELRIC. *Telephonyonline.com*.

Brock, G. W. (1981). *The telecommunications industry: The dynamics of market structure*. Cambridge: Harvard University Press.

Cameron, A. C., & Trivedi, P. K. (1998). *Regression analysis of count data*. Cambridge: Cambridge University Press.

Cantelon, P. L. (1993). *The history of MCI: 1968–1988: The early years*. Dallas: Heritage Press.

Ford, G. S., & Jackson, J. D. (2004). Competition and investment in telecommunications. *Atlantic Economic Journal*, *32*, 71.

Federal Communications Commission. (2001). *State-by-state telephone revenues and universal service data*. Washington: Federal Communications Commission.

Godfrey, L. G., McAleer, M., & McKenzie, C. R. (1988). Variable addition and Lagrange multiplier tests for linear and logarithmic regression models. *Review of Economics and Statistics*, *70*, 492–503.

Gourieroux, C., Monfort, A., & Trognon, A. (1984). Pseudo maximum likelihood methods: Applications to Poisson models. *Econometrica*, *52*, 701–720.

Gregg, B. J. (2001, April). *A survey of unbundled network element prices in the United States*. National Regulatory Research Institute.

Haring, J., & Rohlfs, J. H. (2002, July 16). The disincentives for ILEC broadband investment afforded by unbundling requirements. Prepared for the High-Tech Broadband Coalition for submission before the FCC. *In the Matter of Review of Regulatory Requirements for Incumbent LEC Broadband Telecommunications Services*, CC Docket No. 01-337.

Long, J. S. (1997). *Regression models for categorical and limited dependent variables*. Thousand Oaks, CA: Sage.

Phoenix Center. (2003a). *UNE-P drives bell investment—a synthesis model* (Phoenix Center Policy Bulletin No. 6).

Phoenix Center. (2003b). *Competition and bell company investment in telecommunications plant: The effects of UNE-P* (Phoenix Center Policy Bulletin No. 5).

Sunderland, K. (2001, July 6). Divide & conquer: Local switching issue pits CLEC against CLEC. *Xchange Magazine*.

Sutton, J. (1991). *Sunk costs and market structure*. Cambridge: MIT Press.

Willig, R. D. (2002, April 5). Declaration of Robert W. Willig on behalf of AT&T Corporation (at Attachment F). *In the Matter of the Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers*, CC Docket No. 01-338.

Wooldridge, J. M. (1991). On the Application of robust, regression-based diagnostics to models of conditional means and conditional variances. *Journal of Econometrics*, *47*, 5–46.

Wooldridge, J. M. (1999). Quasi-likelihood methods for count data. In H. Pesaran & P. Schmidt (Eds.), *Handbook of applied econometrics, Vol. II: Microeconomics*. Oxford: Blackwell.

Z-Tel Communications. (2002a). *An empirical exploration of the unbundled local switching restriction* (Z-Tel Policy Paper No. 3).

Z-Tel Communications. (2002b). *Does unbundling really discourage facilities-based entry? An econometric examination of the unbundled switching restriction* (Z-Tel Policy Paper No. 4).