Are Unbundled and Self-Supplied Telecommunications Switching Substitutes? An Empirical Study

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Abstract: The Telecommunications Act of 1996 requires incumbent monopoly phone companies to lease elements of their networks to rivals. An important policy question is whether these unbundled elements are substitutes for entry modes that are more facilities-based. In this paper, we estimate demand curves for unbundled elements with the goal of assessing cross-price effects between two of the more popular entry modes that differ in the mix unbundled and self-supplied inputs. As expected, we find downward sloping demand curves for unbundled elements. We also find own-price elasticities in the elastic region of demand. What we do not find is evidence of substitution; we are able to reject the hypothesis of effective substitution between the two entry modes.

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I. Introduction

Prior to the Telecommunications Act of 1996, the supply of local telecommunications services was, to a large extent, a statutory monopoly. In addition to removing the legal impediments to the competitive supply of local phone services, the 1996 Act also attempted to address the economic factors that attenuate and preclude competition in local markets.[1] Given the substantial entry barriers protecting the incumbents from entry, Congress required incumbent local exchange carriers ("ILECs") to lease to rivals those elements of the network without which the rivals would be "impaired" in their ability to provide service including the last-mile distribution plant still believed by many to be a natural monopoly.[2] Section 252 of the Act requires that the prices for these unbundled network elements ("UNEs") be set by state regulators under the guidance of the Federal Communications Commission ("FCC"). These wholesale prices must be "based on cost."[3] UNEs can be purchased by competitive local exchange carriers ("CLEC") either individually or in combinations in order to provide the services these rivals seek to offer.

By combining unbundled local loop distribution, switching, and transport elements with its own retail assets and long distance networks (leased or owned), a CLEC can provide a finished retail local exchange service to residential and small business consumers.[4] This combination of elements is commonly referred to as the UNE-Platform or UNE-P and is the dominant entry method for serving the residential and small business segment of the

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1 The Telecommunications Act of 1996, PUBLIC LAW 104–104 (February 8, 1996), specifically Sections 251, 252, and 271.

2 The standards for which elements are to be unbundled are contained in Section 251(d)(2) of the Act: "In determining what network elements should be made available … the Commission shall consider, at a minimum, whether— (A) access to such network elements as are proprietary in nature is necessary; and (B) 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." For the most part, part (B), the "impairment standard" is most relevant to the determination of what is unbundled. Section 271 of the Act, the part which governs the ability of the ILECs to offer long distance telecommunications services, also includes a list of specific elements that must be unbundled (including loops, switching, and transport).

3 Section 252(d)(1) reads, "the just and reasonable rate for network elements [] shall be based on the cost (determined without reference to a rate-of-return or other rate-based proceeding) of providing the interconnection or network element (whichever is applicable), and non-discriminatory, and may include a reasonable profit."

4 A loop is a physical facility made of copper wire that runs from the customer premise to the phone company's central office (or, possibly, a remote extension of that central office). Inside the central office, the loop is connected to the switch through the main distribution frame. The switch is the intelligence of the telephone network, directing calls to the switch where the call is to be terminated. Transport facilities connect the switching nodes of the network. In addition to these primary elements are other network functionalities such as signaling, usage records, operator services and other supporting services and functionalities. The CLEC must combine these elements with long distance transport, customer service and billing functions, and other self-supplied inputs to render a final service.

local exchange market (now called the "mass market").[5] An alternative to UNE-P is to combine unbundled loop plant with CLEC-owned switching and transport (that latter typically leased from the ILEC) to provide service, but this arrangement -- called UNE-Loop or UNE-L -- is generally limited to small and medium businesses and its geographic scope is limited to only the largest central offices of the local exchange, presumably due to the density economies of telecommunications switching and transport equipment.[6]

While there is no serious debate about whether local loop plant can be economically reproduced (it generally cannot), some parties, including primarily the ILECs, contend that the switching element can be self-provisioned by CLECs. On the other hand, CLECs argue that self-provisioned switching is not economically feasible for residential or very small business customers, and the ILECs themselves provide powerful evidence that this is true.[7] Very few CLECs have even attempted to serve the mass market with their own switching equipment, and most that have are now bankrupt. As the FCC recently observed, 77% of facilities-based entrants failed.[8] In February 2003, the FCC determined that CLECs serving the mass market are impaired in their ability to provide service without access to unbundled switching and required state regulatory commissions to evaluate the reasonableness of the conclusion and resolve some of the known impediments to successful switch-based service provisions. The Circuit Court of Appeals in the District of Columbia vacated the FCC's Order in March 2004, and the future of unbundled switching is today uncertain.[9]

The debate over unbundled switching has been and remains highly contentious, and is perhaps the most controversial issue in modern telecommunications policy. Its status is little surprise, given that the combination of unbundled loops and switching (i.e., UNE-P)

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5 According to ARMIS, this mass-market consists of about 140 million switched access lines nationwide (http://www.fcc.gov/wcb/armis/).

6 See, e.g., Pace Coalition, Ex Parte Presentation in CC Docket Nos. 01-338, 96-98, 98-147 (January 15, 2003) and The UNE-P Fact Report: May 2004: Lessons from the State TRO Proceedings (May 2004): www.pacecoalition.com. Also see Allegiance Telecom's (now bankrupt) SEC filings for a list of cities served by a typical UNE-L carrier.

7 The CEO of SBC, one of the largest ILECs, said "small-business and residential customers wouldn't provide enough revenue to justify the expense of building out SBC's network in the 30 markets (James S. Granelli and Jube Shiver Jr., *Phone rivalry as simple as McDonalds vs. Burger King, SBC head says*, Los Angeles Times, May 26, 2003)." .For a summary of the evidence filed before the FCC by the ILECs on this point, *see* Letter from Thomas W. Koutsky and George S. Ford to FCC Chairman Michael K. Powell, Federal Communications Commission, CC Docket No. 01-338 (January 29, 2003): www.telepolicy.com/natmop.pdf. One of the strongest proponents for UNE-L was Allegiance Telecommunications, a CLEC that used UNE-L to serve business customers. The company filed for bankruptcy in May 2003 (Allegiance telecom files for bankruptcy, Baltimore Business Journal, May 15, 2003, http://www.bizjournals.com/baltimore/stories/2003/05/12/daily38.html).

8 In the Matter of 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 21, 2003), at ¶ 37 ("in 2000 there were about 300 facilities-based competitive LECs, but [] by early 2002 that number had contracted to about 70")

9 *Id.*, at ¶419-532. *United States Telecom Association v. Federal Communications Commission, U.S. District Court of Appeals*, No. 00-1012 (March 2, 2004): http://pacer.cadc.uscourts.gov/docs/common/opinions/200403/00-1012b.pdf.

is, by far, the most successful mode of entry resulting from the unbundling mandates of the 1996 Act. As of the end of 2003, there were about 15 million access lines served using UNE-P (12% total lines), yet only 4 million served by UNE-L (3% of total lines). [10] Opponents of unbundling switching argue that such unbundling, if priced attractively, reduces the incentive of CLECs to self-provide switching facilities or use existing CLEC switching capacity, thereby reducing facilities-based entry and investment in the local exchange market. Proponents, alternatively, contend that without unbundled switching, entry simply would not occur or be severely curtailed. Theoretical analysis provides few answers to these policy questions, as either position can be supported (Beard, Ford and Koutsky, 2005). Resolving the disputes over unbundled switching requires empirical analysis.

Empirical research on the relationship between investment and unbundling is in its infancy, hindered by the availability of data and time. A few studies have been conducted, however, including this paper that seeks to shed light on questions related to unbundled switching.[11] At the very core of this important policy issue seems to be the rather basic question of whether or not UNE-P and UNE-L are substitutable modes of entry (in an economic sense). This question is, obviously, an empirically testable proposition. To the economist, this question is best answered by estimating the cross-price elasticity of demand between loops purchased with and without unbundled switching. In other words, if CLECs increase their use of UNE-L as the price of unbundled switching increases, and this substitution effect is large enough to hold CLEC output relatively constant, then unbundled and self-supplied switching are highly substitutable forms of entry and the lack of access to the switching element will not impair the ability of CLECs to provide the services they seek to offer. Also, if they are good substitutes, then the availability of unbundled switching at "low" prices may encourage CLECs to "buy" rather than "make" the switching input.[12]

The purpose of this paper is to tackle this issue directly. Combining data on the quantities of loops purchased with and without unbundled switching with the prices of unbundled loops and switching, the own and cross-price elasticities of demand are estimated. We find no evidence that the price of unbundling switching is related (in a statistically significant sense) to the quantity of loops purchased without unbundled switching (that is, UNE-L). Thus, no evidence of substitution (or complementarity) is found. We do find

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10 The FCC provides data on the use of unbundled elements on its website: www.fcc.gov/wcb/iatd. The Pace Coalition summarizes this and other interesting data: www.pacecoalition.org.

11 Papers on this topic include Beard, Ford, and Koutsky (2005), Crandall, Ingraham and Singer (2003), Ford and Jackson (2003), Ford and Spiwak (2004), Phoenix Center (2003a), Phoenix Center (2003b), and Ford and Pelcovits (2002). Dowloadable versions of some of these papers are available at www.telepolicy.com and reviews of some of this research are provided at www.telepolicy.com/review.htm.

12 Beard, Ford and Koutsky (2005) find that CLEC switch deployment is inversely related to the price of unbundling switching, indicating that low switching prices do not discourage but rather encourage CLECs to the deploy switching equipment. The paper provides a theoretical explanation for why this relationship may exist (and why the relationship between switching prices and switch deployment is ambiguous).

elastic demand curves for both loops and switching. Finally, a simple test for whether or not CLEC entry is impaired without unbundled switching is proposed and conducted.[13]

II. Empirical Model

The purpose of this empirical analysis is to estimate reasonable approximations of the ordinary demand for unbundled loops purchased with or without unbundled switching.[14] We first define the variables in our model. The total number of unbundled loops purchased in a state for the provision of local telephone service (Q_T) includes the quantity of loops purchased without unbundled switching (Q_L; UNE-L) and with unbundled switching (Q_S; UNE-P), so that $Q_T = Q_L + Q_S$ (the subscript S is used for the Platform to indicate that the Platform CLEC purchases "switching" with the loop). The quantities Q_L and Q_S are our dependent variables, and the demand elasticities for Q_T are easily computed from the econometric estimates of the Q_L and Q_S demand equations.

1. Model Specification

Generally, the estimated demand curves for unbundled loops without and with unbundled switching are

$$\ln Q_L = \alpha_0 + \alpha_1 \ln P_L + \alpha_2 \ln P_S + \sum_{j=3}^{n} \alpha_j \mathbf{Z} + \varepsilon_L \tag{1}$$

$$\ln Q_S = \beta_0 + \beta_1 \ln P_L + \beta_2 \ln P_S + \sum_{j=3}^{n} \beta_j \mathbf{Z} + \varepsilon_S \tag{2}$$

where P_L is the loop price, P_S is price for unbundled switching, the vector $\mathbf{Z}$ represents n other demand-relevant factors that influence the demand for loops of both types, and ε_L and ε_S are econometric error terms that measure the unobserved determinates of loop demand (Beierlein et al, 1981). The price of unbundled switching is included in both equations, measuring cross-price elasticity in Equation (1) and own-price elasticity in Equation (2). All variables are measured at the state-level, and only the loops from the Regional Bell Companies are represented in the sample. Descriptive statistics and variable descriptions and sources are provided in Table 1.[15]

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13 Our test is not a test of the FCC's definition of impairment (the latest being its third, all rejected by reviewing courts), but is founded on fairly straightforward concept of impairment that has economic justification. The FCC has yet to provide a coherent definition of impairment, so a test of their view of impairment is not possible.

14 In conjunction with unbundled switching, UNE-Platform CLECs purchase unbundled transport. Thus, we include transport in unbundled switching.

15 The price data was provided by Z-Tel Communications, Inc., a CLEC serving residential and small business lines using UNE-P in most states. At the time the data was collected, Z-Tel had the widest geographic footprint of any CLEC. The data represents the statewide average loop price and a computation of statewide average switching prices (the latter of which rarely varies within a state, whereas loop prices are

Both Equation (1) and (2) are specified in double-log (constant elasticity) form, so we assume that the elasticities are constant across the range of prices and quantities included in the data.[16] Considering the policy relevance of this analysis, we carefully evaluate the econometric models for specification errors that may taint the results. Based on Monte Carlo studies of specification tests, Godfrey et al (1988) recommend RESET as the best test of functional form. Following that advice, RESET is applied to three different functional forms for each equation: a) double-log; b) semi-log; and c) linear. The test is applied to each equation independently. For Equation (1), the null hypothesis of "no specification error" is rejected for all but the double-log specification.[17] For that equation, our chosen specification is the best of the three options. For Equation (2), both the semi-log and double-log specifications pass RESET. Of these two alternatives, the Davidson-MacKinnon *J*-Test does not provide unambiguous support for either specification (Greene, 2000: 302-303).[18] Because either of these functional forms is valid according to RESET, neither is unambiguously preferred by the *J*-Test, and the double-log form is the only acceptable specification of Equation (2), we estimate both equations using the double-log functional form.

Another issue is the exogeneity of P_L and P_S. Unbundled element prices are determined in complex and lengthy regulatory proceedings, and are based on the output of sophisticated forward-looking cost models. Because these prices must be set prior to the purchase of either loops or loop-switching combinations, the assumption of exogeneity

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typically priced in three density zones). Switching costs include all non-loop costs of serving a customer over UNE-P (not UNE-L) including the most popular switch features, transport charges between switches, usage records, signaling and database charges, and other relevant charges. Public data on switching charges is very poor, so we are grateful to Z-Tel for sharing this proprietary information with us. Z-Tel's cost figures are based on its own bills for unbundled elements, and the usage components of switching were based on Z-Tel's estimates of the average customer, which are derived from Z-Tel's actual usage and usage calculations based on the ARMIS data (data collected from the ILECs by the FCC). In states where Z-Tel competed with other UNE-P CLECs, its price points were similar to its CLEC rivals. Thus, we believe Z-Tel is sufficiently representative of a UNE-P CLEC to use its data. Certainly, there are no better estimates available.

16 We do not express percentage variables in natural log form to simplify the interpretation of marginal effects.

17 For Equation (1), the RESET F-statistics are double-log [1.79 (0.16)], semi-log [7.40 (< 0.01)], and linear [13.84 (< 0.01)]. For Equation (2), the RESET F-statistics are double-log [0.92 (0.44)], semi-log [0.62 (0.60)], and linear [18.53 (<0.01)]. A review of the output from these tests reveals that the estimated price elasticities (and statistical significance) for the Q_S equation are relatively stable across functional forms, but the results varied for the Q_L equation. For the semi-log specification of the Q_L equation, the results were comparable to the log-log specification with a loop price elasticity of –1.20 (significant at the 5% level) and a switching price elasticity (not statistically significant) of -.0.01. For the linear model, neither the loop price elasticity (–0.23) nor the switching price elasticity (0.17) was statistically significant. We observe that these results are somewhat immaterial, since neither of these alternative functional forms for the Q_L equation passes RESET implying that the estimates are biased, inconsistent and inefficient.

18 The *J*-Test is performed by taking the fitted value (properly adjusted if not of the same form) from one regression (A) and adding it as a regressor in a rival regression (B). If the additional variable is statistically significant in B, then the specification of regression A is preferred to that of B, since specification A is explaining more about the variation in the dependent variable than is specification B. Unfortunately, the test does not always produce an unambiguous result. In some cases, both the added regressors can be statistically insignificant (or significant), indicating that neither model is a better specification, at least in the sense evaluated by the *J*-Test.

seems appropriate. However, these prices are subject to occasional review in some states, and may be adjusted in an effort to increase or decrease the number of loops purchased. Thus, there is at least a plausible case for endogeneity of P_L and P_S. The RESET test, which was employed to test functional form above, is a rather general test of specification error and is a valid test for problems such as omitted variables, endogenous explanatory variables, errors in measurement, and, of course, incorrect functional form (Ramsey, 1969).[19] For both equations, the null of "no specification error" could not be rejected, providing support for the exogeniety of P_L and P_S. To examine this issue further, we perform a Hausman test for exogeneity of P_L and P_S (Pindyck and Rubinfeld, 1991: 303-304). Predicated values for P_L and P_S are generated by auxiliary regressions of these variables on **Z** and **X**, where **X** is a vector of additional variables not in **Z** that determine P_L and P_S.[20] These predicted values are then included as regressors in Equations (1) and (2), which again are estimated independently.[21] If we cannot reject the hypothesis that the additional coefficients are jointly zero, then the assumption that P_L and P_S are exogenous is appropriate. The F-test statistic for the hypotheses is 0.30 and 1.57, neither of which is statistically significant at standard levels. Thus, assuming both P_L and P_S are exogenous is appropriate, as already indicated by RESET.

As noted, the policy relevance of this work requires a careful analysis of model specification. The above analysis addresses the most serious specification problems including incorrect functional form, simultaneity, and omitted variables. Remaining issues include heteroskedasticity, multicollinearity, and omitted variables not detected by the previous tests. Heteroscedasticity, if present, does not bias the coefficient estimates, and can be dealt with by using White's heteroskedasticity robust standard errors. The remaining issues, including multicollinearity and omitted variables, are addressed in Section III.4 of the text.

2. PRICES ELASTICITIES

Given the specification of Equations (1) and (2), own-price elasticities of demand ($\eta_{i,i} = \partial Q_i/\partial P_i \times P_i/Q_i$) are measured by coefficients α_1, β_1, and β_2. The cross-price elasticity

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19 The RESET Test is valid only for least-squares regressions. Ramsey's RESET Test is performed by including as regressors the powers of the predicted values of the regression. The joint significance of these additional regressors is evaluated, and the null hypothesis of "no specification error" is rejected if the RESET F-Statistic exceeds the critical value (i.e., the test of the joint restriction that all of the additional coefficients equal zero is statistically significant).

20 Without **X** the predicated values for P_L and P_S are simply a linear combination of the coefficients in Equations (1) and (2), and the test regressions will not estimate due to collinearity. Vector **X** includes cost estimates for loops and switching from the FCC's Hybrid Cost Proxy Model (www.fcc.gov/wcb/tapd/hcpm/), which is a forward-looking cost model. The squared values of both **Z** and **X** are included as regressors in the auxiliary regressions.

21 We do not find support for the hypothesis of weak instruments (Bound et al, 1995); the R^2's of the auxiliary regressions are 0.77 for $\ln(P_L)$ and 0.55 for $\ln(P_S)$, and the F-Statistics for the two regressions are highly statistically significant (F = 10.19 and 3.89, respectively). Regressing the actual prices on their respective instruments produces statistically significant slope coefficients (with t-stats in excess of 9.00 in both cases), so the hypotheses that the instruments are not correlated with prices is easily rejected. Wooldridge (2003, p. 486).

($\eta_{i,j} = \partial Q_i/\partial P_j \times P_j/Q_i$) is measured by α_2, because P_S is not an own-price for Q_L. Because demand curves slope downward, we expect both α_1 and β_1 to be negative, and the log-log specification implies that these coefficients measure the (constant) own-price elasticity of demand for unbundled loops of each type. Joint consumption of loops and switching in the loop-switching combination implies that β_2 measures the own-price elasticity of demand for unbundled switching. Additionally, this joint consumption of the loop and switching elements for the UNE-Platform suggests that the quantity effect on the demand for loop-switching combinations of a \$1.00 price increase of either P_L or P_S should be roughly equal. This equality implies that $\beta_1/w = \beta_2/(1 - w)$, where w is the loop's share of total combination cost $[P_L/(P_L + P_S)]$. The Wald Test can be used to test whether this equality (i.e., restriction) holds. An alternative to use this exogenous information and specify price in the Q_S equation as $(P_L + P_S)$, thereby restricting their coefficients to be equal. However, we would rather test this restriction, since finding it to be true implicates the reasonableness of our specification.

The price of unbundled switching P_S is a cross-price for the demand for loops purchased without switching, and the sign of α_2 will indicate the demand relationship of unbundled and self-supplied switching. If a decrease in the price of unbundled switching leads to a substitution of unbundled switching for self-supplied switching, then α_2 will be positive. A negative sign on α_2, alternatively, suggests that unbundled and self-supplied switching are complements because a decrease in the price for switching increases the demand for loops purchased without switching.[22] If α_2 is not different from zero, then the entry modes are unrelated in demand.

3. OTHER VARIABLES

Other variables in the demand equation (making up the vector **Z**) include the total demand for the final good (local service) measured as the total local service revenues of the Bell Company in the state (*SIZE*). This variable is included in the model because a loop demand curve is a derived demand. A priori expectations are that demand is positively related to market size. Given the specification of the model (log-log), an estimated coefficient on *SIZE* less (greater) than 1.00 indicates that the demand for unbundled loops increases less (greater) than proportionately to market size.

The mix of total demand between residential and business customers also may influence loop demand. Two explanatory variables are included to measure the mix of demand: 1) the ratio of business-to-residential retail rates (*RESRAT*) and 2) the percent of total, analog switched access lines that are used to serve residential consumers (*RESSHR*). The two demand-mix variables, *RESRAT* and *RESSHR*, both measure the extent to which market

22 Beard, et al (2002) present a formal, theoretical model illustrating the complementary and substitution relationships that may exist between unbundled switching and CLEC deployed switching equipment. In that study, the effects of the availability and price of unbundled switching on number of CLEC deployed switching entities were evaluated using econometric methods. The study found that lower switching prices and unrestricted access to switching led to more, no less, switch deployment by CLECs. These results are not inconsistent with the findings reported here, since switch deployment is based on expectations of demand, whereas we are measuring the actuality of demand.

demand is residential in nature. Generally, UNE-L is used to service businesses, whereas UNE-P is used to serve residential and small business customers. So, it is reasonable to expect negative signs on both variables in the Q_L equation, and positive signs in the Q_S equation.

Both the New York and Texas public service commissions were the first to implement a workable UNE-P framework.[23] Given this head start in effective implementation of UNE-P, competitor penetration in these two states is considerably higher than other states on average. Thus, a dummy variable that equals one for New York and Texas (*DNYTX*), zero otherwise, is included in the model and positive signs are expected (particularly in the Q_S equation). The ILEC's ability to provide long distance telecommunications service has been argued to influence the demand for unbundled loops, so we include a dummy variable for states that the Bell Companies have received 271 approval (*D271*). In some cases, unbundled elements were not made available at cost-based prices until the FCC's review of 271 applications. Both New York and Texas have 271 approval, so the 271 dummy variable measures the influence of 271 approval absent the head start effect for these two states. No a priori expectation is made about 271 status (*D271*).[24] The inclusion of both variables limits confusing a head start in UNE-P implementation with 271 approval.

A dummy variable indicating states with high non-recurring charges (*DNRC*), and the percent of the state's population density (*METPOP*), are both included as additional regressors. The variable *METPOP* is measured as the percent of a state's population living in metropolitan areas. Non-recurring charges are paid by the CLEC to the ILEC for each customer acquired and are, as such, a price. [25] So, a negative sign on *DNRC* is

[23] Why these particular states were the first to implement UNE-P is beyond the scope of this paper, but potentially an interesting topic for research. The loop penetration rates (total loops divided by total access lines) in New York and Texas are much higher than average (about 19% for these two states to the average of 5% for the others), and this difference is statistically significant (t = 7.56).

[24] We also included an additional regressor measuring the length of time (in quarters) since the 271 approval. The variable was not statistically significant and did not impact the findings, but it did consume one additional degree of freedom. Therefore, the additional variable was excluded from the final specification. We retained the 271 dummy variable in the specification given the policy significance of Section 271 of the Act, the t-statistic greater than 1.00 in the Q_L equation, and the impact of excluding the variable on RESET. Sample states with 271 approval include New York (12/22/1999), Texas (6/30/2000), Kansas (1/22/2001), Oklahoma (1/22/2001), Massachusetts (4/16/2001), and Pennsylvania (9/19/2001). The dummy variable is set equal in the period immediately following FCC approval.

[25] For every unbundled loop or loop-switching combinations leased from the incumbent LEC, the CLEC must pay the ILEC a non-recurring charge ("NRC") to cover the labor costs of the migration (ordering and provisioning). A high NRC is defined to be an NRC exceeding $50.00. We use a dummy variable for two reasons. First, a review of the data shows most NRCs to be less than $20 but with a few outliers with much higher NRCs (over $100 in Ohio). Thus, the dummy variable noting the outliers seemed to us to be a preferred specification. Second, we do not have data on the non-recurring charges for loops purchased without switching. But given that NRCs for both services are produced from the same cost models, we believe it to be reasonable to assume that the loop-switching non-recurring charge is highly correlated with the loop non-recurring charge. In fact, a sizeable portion of the UNE-L NRC applies to UNE-P lines that are new installations (rather than just migrations from one carrier to another). Given the lack of data, we believed it to be better to indicate states with "high" NRCs rather than attempt to estimate a slope coefficient. That said, if we use the actual NRC rather than the dummy, a negative and statistically significant coefficient is estimated and the other results from the regressions are, for the most part, unaffected.

expected. Population density (*METPOP*) is expected to positively affect demand for unbundled loops purchased without switching due to density economies for self-supplied switching, but no a priori expectation is made with respect to the variable's effect on loop-switching combinations.

Finally, since our data was collected in June and December, 2001, a dummy variable indicating the "as of" date of the data (*DSAMPLE*) is included as a regressor. A positive and statistically significant coefficient indicates that, on average, demand increased over the six-month period between June-2001 and Dec-2001.

[TABLE 1 ABOUT HERE]

III. Results

The two-equations are estimated by ordinary least squares ("OLS"). There is no reason to employ seemingly unrelated regression ("SUR") because the explanatory variables are identical across equations, implying OLS is efficient (Greene, 2000: 616-7). Single-equation OLS estimation also is desirable in that the standard battery of specification tests (some of which were employed earlier) are valid and easily implemented.

Results are summarized in Table 2. Due to limitations on the availability of data for prices and quantities, the final sample consists of 67 observations for each equation.[26] The Adjusted R^2 of Equation (1) is about 0.83 and Equation (2) is 0.73, indicating that a large amount of the variation of loop demand of both types is explained by the regressions. These R^2s are very large for cross-sectional data and are to a large extent caused by the *SIZE* regressor.[27] As reported earlier, the null of "no specification error" for RESET cannot be rejected for either equation and this test covers, to varying degrees, misspecifications such as incorrect functional form, omitted variables, and simultaneity.[28] The White test indicates heteroscedasticity is a problem in both regressions, so the reported t-statistics are computed using White's robust standard errors (Greene, 2000: 462-4).

[TABLE 2 ABOUT HERE]

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[26] In both periods, the following states were excluded from the sample: AR, CO, CT, DC, ID, ME, NE, NV, NJ, NM, SD, VT, and WY. States included only in the first period (June data) include: DE, IN, NH, RH, and WI. Missing FCC data led to the exclusion of CT, DE, DC, ME, NH, RI and VT; the remainder of the exclusions were based on missing UNE price data.

[27] The R^2's of the two equations including the *SIZE* variable and a constant term are 0.67 and 0.46, respectively.

[28] Also noted earlier was that the RESET null of "no specification error" was rejected for other functional forms.

1. PRICE ELASTICITIES

Loops

As indicated by theory, the demand curves for unbundled loops of both types slope downward, with an elasticity of about -1.1 for Q_L (α_1) and -2.1 for Q_S (β_1). Both elasticities are in the elastic region of demand, indicating that quantity demanded responds more than proportionately to any given percentage change in price. While the coefficients are different, we cannot reject the hypothesis that the two elasticities are equal (from the Wald Test we get $\chi^2 = 1.80$ with probability 0.18).

The effect of prices on the total quantity of competitive services provided using unbundled loops can be computed from the estimated coefficients of the demand equations. In fact, the own-price demand elasticity for total loops (Q_T) is simply the weighted average of the two elasticities measured by α_1 and β_1, because in our sample, the ratio Q_L/Q_T is approximately equal to 0.50.[29] The simple average of the two own-price elasticities is –1.6, and this value measures the total, own-price elasticity of demand for unbundled loops of both types. Across loops of all types, a 10% increase in the price of an unbundled loop will decrease the quantity of loops sold by about 16%, ceteris paribus.

Switching

Turning to the price for unbundled switching (P_S), we first consider the own-price effect of switching on the demand for loop-switching combinations (Eq. 2). The estimated own-price elasticity of demand for unbundled switching is –1.3, which indicates a 10% change in price produces an 13% change in quantity demanded. The estimated elasticity is statistically significant at better than the 1% level. As previously mentioned, for loop-switching combinations, the loop and switching components are purchased jointly. This joint consumption suggests that the effect on quantity demanded of a $1.00 price increase of either P_L or P_S should be roughly equal, and the Wald Test indicates that the restriction $\beta_1/w = \beta_2/(1 - w)$ is valid.[30] This finding implies that it is the total price for the loop-switching combination that matters, not the individual prices for each component. This result is encouraging and provides support for the validity of the empirical model.

The price elasticity of demand of total loops with respect to P_S is –0.57. Thus, a 10% increase in the price of unbundled switching will reduce the total quantity of unbundled loops by 6%. This demand elasticity is statistically significant at better than the 5% significance level ($\chi^2 = 17.20$, Prob < 0.01).

The demand elasticity for loop-switching combination can be calculated by raising the price of both loops and switching, implying that the elasticity is simply the sum of the component elasticities. The combination elasticity is -3.2, which is consistent with the

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[29] This mean is computed as the average of the ratio Q_L/Q_T computed for each state, and is not the ratio of the mean of Q_L to the mean of Q_T (the latter of which is about 0.36).

[30] The test of equality produces a χ^2 statistic of 1.22 with probability 0.27.

loop-switching combination elasticity of -2.7 reported by Ekelund and Ford (2002) and at the upper-end of the confidence interval reported by Kline (2003).

Switching and UNE-Loop

One of the more policy-relevant findings of the econometric model is that the cross-price elasticity of Q_L with respect to P_S (0.14), though positive, is small and not statistically different from zero. The null hypothesis that the two entry modes are unrelated in demand cannot be rejected. Thus, we do not find supporting evidence that the two modes of entry (with or without unbundled switching) are substitutes (or complements), ceteris paribus. The policy implication is that increases in the switching price will not increase the quantity of loops serving end users with CLEC-deployed switching equipment, or, put differently, the availability of unbundled switching at rates based on "forward-looking economic cost" as defined and implemented by regulators has not led CLECs to substitute unbundled switching for self-supplied switching.

2. Other Variables

Market size (*SIZE*), which measures total expenditures for local service, increases the demand for loops of both types. The coefficients are less than 1.00, so the increase in demand is less than proportionate to the increase in market size.[31] Demand for unbundled loop-switching combinations, other things constant, is higher in markets where demand is more intensely residential; both *RESRAT* and *RESSHR* are positive and statistically significant in the Q_S equation. More unbundled loops are purchased without switching where business customers represent a higher share of the market (*RESSHR* < 0), but the differences in rate structure do not matter (*RESRAT* is not different from zero). The combination of the two coefficients affirms that UNE-L is used predominately to serve business customers.

New York and Texas, the first two states to implement a workable UNE-P regime, have a higher demand for loops leased with and without unbundled switching, but this effect is only statistically significant at standard levels in the Q_S equation. Once the higher demand levels in New York and Texas are taken into account, approval for Bell Company entry into long distance under Section 271 of the 1996 Act (*D271*) is not an important determinant of the demand for either Q_L or Q_S. High non-recurring charges reduce the demand for both types of loops (*DNRC* < 0). This result is sensible, since the non-recurring charges are a cost of customer acquisition and consequently a component of the price of using unbundled elements. Population density (*METPOP*) increases the demand for loops purchased without switching, but reduces the demand for loop-switching combinations. There are some marginally significant changes in demand over time (*PERIOD*).

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[31] Statistically, we cannot reject the hypothesis that the coefficients on *SIZE* are equal across equations (χ^2 = 0.92, Prob. 0.34). For Equation (2), we cannot reject the coefficient on SIZE is 1.00. However, due to the inclusion of *METPOP*, the *SIZE* variable's coefficient in Equation (1) does not equal 1.00. Note, however, in Alt. Equation 4 (Table 3), when *METPOP* is excluded the coefficient on *SIZE* in the Q_L equation is 1.008.

3. EVALUATING THE CASE AGAINST UNBUNDLED SWITCHING

A principle criticism against the availability of unbundled switching at "cost-based" rates is that as the regulated wholesale price of unbundled switching declines, the CLECs substitute unbundled for self-supplied switching. If regulators were to implement price increases for unbundled switches, the argument goes, then CLECs would simply migrate their customers to their own facilities (whether already deployed or not).[32] If this line of reasoning is correct, then as the price of unbundled switching rises, the quantity of loop-switching combinations should decline and, if switching is easily self-supplied, then the quantity of loops purchased without switching should increase to make up for the loss of loop-switching combinations. This argument presumes that unbundled and self-supplied switching are effective substitutes. A test of effective substitution is whether $\alpha_2 Q_L + \beta_2 Q_S = 0$ (where the quantities are measured at their mean values). Alternatively, the same information is gleaned from a test of the condition $\partial Q_T / \partial P_S = 0$. We note that the statistical insignificance (i.e., wide confidence interval) on α_2 favors the acceptance of this hypothesis (or, alternately, biases this test against rejection).

We also believe this test of effective substitution is a straightforward test of impairment, where impairment is the relevant legal standard for selecting unbundled elements under Section 251(d)(2)(B) of the 1996 Telecommunications Act. If a CLEC is not impaired in its ability to provide unbundled switching, a common sense (and economic) expectation is that as the price rises, the CLEC simply shifts its customers to its own facilities. Alternately, if the CLEC total subscriber base falls as the price rises, then there are obviously impediments to the ability to serve those customers using own facilities.

Neither test result supports the assertion that CLECs readily shift between self-supplied and unbundled switching as the price of unbundled switching changes – the hypothesis of effective substitution is rejected. An increase in the price of unbundled switching reduces the quantity of loop-switching combinations (with elasticity –1.3) and has no virtually no effect (0.14) on the quantity of loops purchased without unbundled switching, so that $\alpha_2 Q_L < -\beta_2 Q_S$.[33] The hypothesis $\alpha_2 Q_L + \beta_2 Q_S = 0$ is rejected easily ($\chi^2 = 22.56$, Prob < 0.01). Further, the price elasticity of all loops (Q_T) with respect to the switching price is –0.57 ($\partial Q_T / \partial P_S > 0$), and this elasticity is statistically different from zero ($\chi^2 = 17.20$, Prob < 0.01). Thus, higher switching prices reduce the CLECs total market share (by nearly 6% for every 10% increase in the price of switching), implying that shifting the customer base from UNE-P to UNE-L is not occurring in states with high

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32 Section 271 requires the Bell Operating Companies, the largest ILECs, to provide unbundled switching as a condition of their provision of long distance services. Thus, whether or not unbundled switching is an element is not the issue, just the price.

33 The null-hypothesis of equality of the two terms is rejected easily ($\chi^2 = 22.56$, Prob < 0.01). Ignoring the important issue of statistical significance, we can use the estimated coefficients from the regressions to simulate the quantity changes in Q_L and Q_S given an increase in P_S of one standard deviation above the mean, which is about a 50% price increase. We caution the reader that the estimated coefficients are point estimates and not ideally suited to evaluate such a large price change. Nevertheless, a 50% increase in P_S reduces Q_S by 94,940 units (a 64% reduction) and increases Q_L by 5,789 units (a 6.9% increase). Thus, a price change of this magnitude would reduce substantially the number of end-users served by competitors to the incumbent monopolists.

switching costs. Thus, our results provide no evidence that UNE-P is an effective substitute for UNE-L. We also believe that the results are consistent with the position that (at least some) CLECs are impaired in their ability to provide service without access to unbundled switching since higher switching prices lead to a non-trivial reduction in the overall quantity of service provided by the CLECs.

Given the dependent variable of our Q_L equation, which is the quantity of loops connected to CLEC switches, our model does not provide direct evidence on the issue of CLEC investment in switching equipment. However, the lack of a substitution relationship in quantities does indicate that the availability of unbundled switching is not reducing the potential demand of switch-based CLECs. Since deployment should be positively related to potential demand, then our results provide at least some insight on the issue of investment. A recent paper by Beard, Ford and Koutsky (2005) directly addresses the question of CLEC switch investment and unbundled switching prices using data on the number of CLEC-deployed switches across states. In that paper, a negative relationship between switch deployment and unbundled switching prices is found; that is, higher unbundled switching prices appear to reduce the deployment of switching equipment by CLECs. The paper also provides a theoretical model illustrating why this negative relationship may hold. Both our analysis and that in the Beard et al (2005) paper reject the hypothesis of effective substitution between unbundled and self-supplied switching, suggesting policy proposals based on the assumption of substitution should be carefully scrutinized.

4. ADDITIONAL MODELING ISSUES

Our empirical model failed to produce any evidence of substitution between unbundled and self-supplied switching; the two alternate modes of entry appear to support different entry strategies and are not easily interchanged. The null hypothesis of effective substitution was easily rejected. Our findings are, as always, dependent on particular model specifications. Indeed, a "non-finding" of zero cross-price elasticity ($\alpha_2 = 0$) could arise from multiple sources, including a) the absence of an effect; b) misspecification of the variable in the model; c) incorrect functional forms; and d) bad luck. As for the alternate hypothesis (c), we selected the best functional form by appealing to RESET and the *J*-Test, which has been shown in Monte Carlo simulation to be particularly well suited at selecting the correct functional form (Godfrey et al, 1988).

[TABLE 3 ABOUT HERE]

Excluding (c) as an explanation leaves alternative hypotheses (b) and (d) and, to the extent possible, we do wish to exclude these alternative explanations for our findings. One potential misspecification of the variables that would produce the insignificant cross-price effect is including in the model regressors correlated with the price of switching (P_S). These correlated variables may mask the unique effect P_S and bias its coefficient to zero. On this point, the simple correlation coefficients of the regressors with $\ln(P_S)$ are all small with the largest being 0.36 (in absolute value). Further, both equations contain the same regressors, yet P_S is highly significant in the Q_S equation (with t = -5.3). Thus, we do not expect correlation to be biasing the coefficient on $\ln(P_S)$ to zero in the Q_L equation.

Further evidence that misspecified variables and bad luck are not to blame for the statistically insignificant coefficient on ln(P_S) in Equation (1) may be provided by altering the model's specification in a variety of ways and re-testing the zero null on the coefficient. Potential re-specifications include 1) eliminating statistically insignificant variables to increase the degrees of freedom and to reduce potential multicollinearity between P_S and combinations of other variables; 2) using alternative, yet plausible, measurements of particular variables; and 3) including arguably omitted variables in the regression. To address these possibilities, seven auxiliary regressions are provided in Table 3.

In auxiliary regression (1), we exclude all regressors (except for P_S) from Eq. (1) that are not statistically different from zero at the 10% level or better (including ln*RESRAT*, *DNYTX*, and *D271*). The estimated coefficients are relatively stable and the coefficient on lnP_S remains small and statistically insignificant. Auxiliary regression (2) adds to the list of regressors the variable *RESTRICT*, which measures the percent of population living in metropolitan areas where FCC rules have been interpreted to allow the ILECs to refuse to sell unbundled switching at cost-based rates to any customer with more than three access lines (Beard et al, 2005). While this switching restriction was intended to promote CLEC switch deployment by excluding the more than three-line customers from CLECs using primarily UNE-P, Beard et al (2005) find that the switching restriction had the perverse effect of reducing switch deployment by CLECs. We find no measurable effect on the quantity of loops purchased for use with self-supplied switching and the switching restriction (the coefficient is only 0.02 and the t-statistic is 0.06) and the properties of the coefficient on lnP_S are for the most part unchanged. Auxiliary regression (3) removes the *RESTRICT* variable and adds as a regressor the average retail price for switched local phone service in the state (ln*RETAIL*). This additional regressor is not statistically significant and the other coefficients are stable.

Auxiliary regression (4) is the same as Eq. (1) except the variable *METPOP* is dropped from the model. We drop the variable because population density may be correlated with UNE prices and its effect may already be captured in the ln*SIZE* and *RESSHR* variables. In this specification, the coefficient on lnP_S shrinks slightly and the t-statistic falls to 0.55. For Auxiliary regression (5), we measure density not with *METPOP* but with the percentage of access lines in the state in ILEC central offices with more than 50,000 access lines (*TELDENSE*).[34] This regressor has a statistically significant coefficient of nearly the same size as *METPOP* in other regressions, suggesting the two are substitutable measures of density.[35] The coefficient on lnP_S is nearly identical to Equation (1) and remains statistically indistinguishable from zero. Auxiliary regression (6) removes all regressors in (5) that are not statistically different from zero at the 10% level or better (except lnP_S). There are no interesting changes to report. Finally, auxiliary regression (7) replaces the *SIZE* and *RESSHR* variables with two variables measuring the number of business and residential lines (*BUSLINE*, *RESLINE*). Likewise, the variable *RESRAT* is replaced with variables measured as the average business and residential retail prices in the state (*PBUS*

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34 According to the Hybrid Cost Proxy Model, 50,000 lines is approximately one standard deviation above average. The calculations are restricted to the Bell Companies to match the other data.

35 The variables *METPOP* and *TELDENSE* are correlated with coefficient $\rho = 0.72$.

and *PRES*). Of these variables, only *BUSLINE* is statistically different from zero and the coefficient is near 1.00. These results were somewhat expected given those from Equation (1) (where *RESSHR* was negative and significant and *RESRAT* was not different from zero) and lends further support to the proposition that UNE-L is primarily used for business customers.

[TABLE 4 ABOUT HERE]

A similar exercise is carried out for Eq. (2), the Q_S equation, and the results are presented in Table 4. We do not discuss these auxiliary regressions in detail, since no significant changes are observed on the coefficients of primary interest and no particularly controversial coefficient is estimated. We note that the price elasticities are found to be very stable across alternate specifications. One result worth mentioning is that excluding the *DNYTX* variable from the Q_S equation (auxiliary regression 12) leads to a rejection of the RESET null hypothesis of "no specification error." This result suggests that any empirical analysis of UNE-P must account for the early-mover advantages of the New York and Texas regulatory commissions, or else suffer from omitted variables bias.

It is possible, of course, to concoct an infinite number of alternative specifications, and we obviously have not exhausted all such possibilities. What we have done is construct a plausible model that is well specified according to statistical tests and renders estimates that are robust across a variety of alternative specifications. That said, empirical analysis is always subject to the quality of the data used and validity of the model's specification. The former we can do little about, and the latter we have addressed with careful model selection and a standard statistical test for specification error. Additionally, our empirical results are limited to the range of prices observed for loops and switching. It may be that at prices above or below the range observed would produce different results. However, the range of switching prices in the data is wide (ranging from \$3.83 to \$41.15). In constrast, the FCC's own forward-looking cost model has a switching cost range of \$3.66 to \$7.33, so the range of unbundled switching prices easily encompasses the range of switching costs.[36] Thus, we believe our results are applicable to the modern policy debate.

In conclusion, as a consequence of the inevitable limitations of empirical modeling, this paper should be considered as but an element in a portfolio of evidence. Further research is always desirable.

IV. Conclusion

Our econometric model indicates that demand curves for loops, whether purchased with or without unbundled switching, are downward sloping and presently in the elastic region of demand. Likewise, the demand for unbundled switching is in the elastic region of demand. Of some policy importance is the failure of our empirical model to find support for the substitution between unbundled and self-supplied switching at current

[36] These cost estimates are based on the costs of near ubiquitous market coverage, so may not accurately reflect a smaller entrants costs due to scale economies. However, large scale economies may be one explanation for the lack of substitutability between the two entry modes.

element prices; the estimated cross-price elasticity with respect to loops purchased without switching and the price of unbundled switching is small and not statistically different from zero. We are able to reject easily the hypothesis of effective substitution between the two entry modes.

These findings have important policy implications. First, no evidence is found to support the assertion that the availability of unbundled switching at current rates, which are intended to be based on "forward-looking economic cost" as defined and implemented by regulators, is causing CLECs to purchase unbundled switching rather than use their own, self-supplied switching. Higher unbundled switching prices do not increase the number of loops purchased for use with self-supplied switching. Second, the impact of regulated prices on the extent of competition arising from the unbundling regime established by the 1996 Act is substantial; the demand curves are presently in the elastic region of demand.

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Name	Description	Mean	St. Dev.	Source
Table 1. Variable Definitions, Sources, and Descriptive Statistics				
Q_L	Quantity of unbundled loops sold on a standalone basis.	84,469	103,695	(1)
Q_S	Quantity of unbundled loops sold with unbundled switching.	148,580	359,948	(1)
Q_T	Total unbundled loops sold: $Q_L + Q_S$.	233,049	419,107	(1)
Q_L/Q_T	Share of standalone unbundled loops to total loops.	0.502	…	…
Q_S/Q_T	Share of unbundled loops with switching to total loops.	0.498	…	…
P_L	Average price of an unbundled loop.	15.95	4.73	(2)
P_S	Average price for unbundled switching elements (including switching, transport, billing records, etc.).	14.60	7.22	(2)
SIZE	Size of the market measured as retail revenues for local services.	1.3B	1.2B	(3)
RESRAT	Ratio of business to residential retail rates: *PRES/PBUS*	0.560	0.193	…
RESSHR	Percent of analog, switched lines that are residential (*RESLINE*/(*RESLINE* + *BUSLINE*)).	0.752	…	(3)
RESLINE	Residential, analog, switched access lines.	2.35M	2.27M	(3)
BUSLINE	Business, analog, switched access lines.	0.94M	1.23M	(3)
DNYTX	Dummy variable that equals 1 if state is New York or Texas, 0 otherwise.	0.060	…	…
D271	Dummy variable for states granted 271 approval by the FCC: New York, Texas, Oklahoma, Kansas, Arkansas, Missouri, Massachusetts, and Pennsylvania.	0.179	…	…
DNRC	Dummy variable that equals 1 for states with loop-switching non-recurring charges exceeding $50.	0.045	…	(2)
METPOP	Percent of state population living in metropolitan areas.	0.715	…	(4)
DSAMPLE	Dummy variable that equals 1 for data as of Dec. 2001, 0 for data as of June 2001.	0.537	…	…
RESTRICT	Percent population in an MSA where unbundled switching does not have to be provided to CLECs for customers with more than three access lines.	0.317	…	(4)
RETAIL	Average retail price in the state for a switched access line.	27.36	5.04	(5)
TELDENSE	Percent of access lines in central offices with more than 50,000 access lines.	0.305	…	(6)

(1) FCC Form 477 Data (www.fcc.gov/wcb/iatd/).
(2) Provided by Z-Tel Communications.
(3) ARMIS Form 43-01 or 43-08, 2001 data.
(4) U.S. Census Bureau (www.census.gov).
(5) Gregg (2002).
(6) FCC Hybrid Cost Proxy Model (www.fcc.gov/wcb/tapd/hcpm/).

Table 2. Summary of Results

	Ordinary Least Squares	
Equation	No. (1)	No. (2)
Dep. Variable	lnQ_L	lnQ_S
Constant (α_0, β_0)	5.742	-0.172
	(2.50)*	(-0.03)
lnP_L (α_1, β_1)	-1.144	-2.055
	(-3.86)*	(-4.24)*
lnP_S (α_2, β_2)	0.137	-1.278
	(1.04)	(-5.30)*
ln*SIZE* (α_3, β_3)	0.646	0.944
	(5.61)*	(3.28)*
ln*RESRAT* (α_4, β_4)	-0.168	1.278
	(-0.57)	(3.95)*
RESSHR (α_5, β_5)	-4.776	12.15
	(-2.80)*	(4.26)*
DNYTX (α_6, β_6)	0.53	1.901
	(1.44)	(4.79)*
D271 (α_7, β_7)	-0.368	0.167
	(-1.24)	(0.81)
DNRC (α_8, β_8)	-0.608	-1.206
	(-2.30)*	(-3.15)*
METPOP (α_9, β_9)	2.819	-2.287
	(5.70)*	(-2.08)*
DSAMPLE (α_{10}, β_{10})	0.255	0.226
	(1.85)**	(1.07)
Adj. R^2	0.83	0.73
RESET F	1.79	0.92
White χ^2	31.34*	35.33*
Observations	67	67

* Statistically-significant at the 5% level or better.
** Statistically-significant at the 10% level or better.

Table 3. Auxillary Regressions for Equation (1)

(OLS; White's t-stats in parenthesis)

Equation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Dep. Var.	lnQ_L	lnQ_L	lnQ_L	lnQ_L	lnQ_L	lnQ_L	lnQ_L
	4.463	4.429	4.508	3.355	4.067	2.027	2.880
	(2.09)*	(1.93)**	(2.06)*	(1.32)	(1.86)**	(1.05)	(1.13)
lnP_L	-0.953	-0.952	-0.939	-1.233	-1.291	-1.344	-1.069
	(-2.71)*	(-2.65)*	(-2.65)*	(-3.48)*	(-3.48)*	(-4.95)*	(-3.58)*
lnP_S	0.153	0.154	0.155	0.097	0.224	0.188	0.196
	(1.18)	(1.16)	(1.20)	(0.55)	(1.33)	(1.34)	(1.36)
ln*SIZE*	0.700	0.701	0.706	1.008	0.791	0.781	…
	(7.28)*	(6.74)*	(7.16)*	(8.38)*	(7.13)*	(8.16)*	
ln*RESRAT*	…	…	…	0.235	0.045	…	…
				(0.72)	(0.14)		
RESSHR	-4.574	-4.551	-4.386	-4.771	-3.069	…	…
	(-2.57)*	(-2.63)*	(-2.14)*	(-2.03)*	(-1.42)		
DNYTX	…	…	…	0.387	0.119	…	0.687
				(0.91)	(0.30)		(1.85)**
D271	…	…	…	-0.399	-0.201	…	-0.407
				(-1.05)	(-0.56)		(-1.35)
DNRC	-0.431	-0.428	-0.410	-0.574	-0.375	…	-0.637
	(-1.62)	(-1.53)	(-1.52)	(-2.16)*	(-1.02)		(-2.38)*
METPOP	2.663	2.640	2.64	…	…	…	2.649
	(5.97)*	(5.50)*	(5.56)*				(4.63)*
DSAMPLE	0.271	0.271	0.271	0.321	0.282	0.281	0.41
	(1.95)**	(1.95)**	(1.93)**	(2.04)*	(2.00)*	(2.03)*	(1.72)**
RESTRICT	…	0.020	…	…	…	…	…
		(0.06)					
ln*RETAIL*	…	…	-0.089	…	…	…	…
			(-0.21)				
TELDENSE	…	…	…	…	2.389	2.758	…
					(4.60)*	(5.91)*	
ln*BUSLINE*	…	…	…	…	…	…	1.088
							(2.63)*
ln*RESLINE*	…	…	…	…	…	…	-0.446
							(-0.93)
ln*BRETAIL*	…	…	…	…	…	…	-0.224
							(-0.38)
ln*RRETAIL*	…	…	…	…	…	…	0.196
							(0.64)
Adj. R^2	0.83	0.82	0.82	0.77	0.81	0.82	0.82
RESET F	1.82	1.82	1.77	1.02	2.28**	2.28**	2.61**
White χ^2	22.02*	24.09*	24.47*	28.70*	37.37*	37.37*	33.61*
Observations	67	67	67	67	67	67	67

* Statistically-significant at the 5% level or better.
** Statistically-significant at the 10% level or better.

Table 4. Auxillary Regressions for Equation (2)

(OLS; White's t-stats in parenthesis)

Equation	Alt. 8	Alt. 9	Alt. 10	Alt. 11	Alt. 12	Alt. 13	Alt. 14
Dep. Var.	lnQ_S	lnQ_S	lnQ_S	lnQ_S	lnQ_S	lnQ_S	lnQ_S
Constant	0.548	0.548	1.323	2.324	-3.545	1.600	7.367
	(0.10)	(0.11)	(0.24)	(0.41)	(-0.67)	(0.26)	(1.34)
lnP_L	-2.150	-2.150	-2.085	-2.084	-2.086	-1.969	-1.831
	(-4.50)*	(-4.39)*	(-4.24)*	(-4.70)*	(-4.91)*	(-4.15)*	(-3.11)*
lnP_S	-1.287	-1.287	-1.244	-1.260	-1.256	-1.275	-1.138
	(-5.32)*	(-5.21)*	(-4.89)*	(-5.12)*	(-4.35)	(-4.99)*	(-4.39)*
ln*SIZE*	0.911	0.911	0.941	0.631	0.925	0.700	…
	(3.31)*	(3.31)*	(3.28)*	(2.47)*	(3.73)*	(2.08)*	
ln*RESRAT*	1.289	1.289	1.068	0.981	1.192	0.994	…
	(3.70)*	(4.22)*	(2.00)*	(2.68)*	(2.57)*	(2.68)*	
RESSHR	12.289	12.289	13.198	12.352	15.233	11.753	…
	(4.23)*	(4.09)*	(4.99)*	(3.66)*	(4.05)*	(3.72)*	
DNYTX	2.057	2.056	2.123	2.184	…	2.079	2.167
	(6.66)*	(5.66)*	(6.16)*	(6.50)*		(5.68)*	(5.53)*
D271	…	…	…	…	…	0.146	0.179
						(0.74)	(0.78)
DNRC	-1.255	-1.256	-1.155	-1.291	-1.319	-1.280	-1.134
	(-3.31)*	(-2.96)*	(-2.95)*	(-3.43)*	(-3.88)*	(-3.41)*	(-2.70)*
METPOP	-2.201	-2.200	-2.23	…	…	…	-2.465
	(-2.00)*	(-1.40)	(-1.99)*				(-2.02)*
DSAMPLE	…	…	…	…	…	0.182	0.186
						(0.83)	(0.88)
RESTRICT	…	-0.001	…	…	…	…	…
		(-0.002)					
ln*RETAIL*	…	…	-0.689	…	…	…	…
			(-0.78)				
TELDENSE	…	…	…	…	…	-0.551	…
						(-0.53)	
ln*BUSLINE*	…	…	…	…	…	…	-2.497
							(-4.28)*
ln*RESLINE*	…	…	…	…	…	…	3.430
							(4.25)*
ln*BRETAIL*	…	…	…	…	…	…	-1.256
							(-3.76)*
ln*RRETAIL*	…	…	…	…	…	…	0.460
							(0.44)
Adj. R^2	0.73	0.73	0.73	0.71	0.63	0.71	0.72
RESET F	1.55	1.63*	0.96	0.53	4.95*	0.29	0.63
White χ^2	32.71*	36.17*	40.49*	28.73*	29.73*	34.38*	47.94*
Observations	67	67	67	67	67	67	67

* Statistically-significant at the 5% level or better.

** Statistically-significant at the 10% level or better.