MEASUREMENTS OF MARKET POWER IN LONG DISTANCE TELECOMMUNICATIONS

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FEDERAL TRADE COMMISSION

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FEDERAL TRADE COMMISSION

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The author is an economist with the Bureau of Economics, Federal Trade Commission. The views expressed in this study are those of the author and do not necessarily reflect the views of the Commission or any individual Commissioner. I would like to thank Tim Daniel, Shane Greenstein, John Howell, John Mayo, Jan Pappalardo, Steve Parsons and Mike Vita for helpful comments and Dolly Howarth for research assistance.

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EXECUTIVE SUMMARY

This study assesses empirically the competitiveness of the long distance telephone market. To do so, it estimates firm-specific long-run demand elasticities for AT&T and its rivals for long distance service marketed to households and small businesses during 1988-1991. A lower-bound for AT&T's long-run demand elasticity is estimated to be approximately -10.1. If AT&T's prices were completely unregulated, this elasticity estimate implies that the upper-bound deadweight loss due to allowing AT&T to set prices in excess of marginal cost would be about 0.36% of total industry revenues in 1991, or $199 million in 1991. While direct estimates of the costs imposed by the current form of regulation are not available, this welfare loss estimate is well below previous estimates of the benefits that followed partial deregulation of the long distance market.

Measurements of a firm's demand elasticity provide information on the extent of its market power. In a perfectly competitive industry, each firm has the same costs, price equals marginal cost, and each firm in the industry faces a horizontal demand curve at that price. In such an industry, a firm that attempted to raise prices above its marginal cost would lose all of its customers to rival suppliers. In other words, firm-specific demand curves in perfectly competitive industries are infinitely elastic. However, in industries where products are differentiated or where firms have different marginal costs a firm setting prices above its marginal costs would lose some, but not all, of its customers. Its firm-specific demand curve slopes downward, and its demand elasticity is finite. In general, a particular firm will find that its firm-specific demand curve becomes more elastic as competitors' products become better substitutes and as competitors' costs fall.

Estimating firm-specific demand curves raises a number of specific analytic and econometric issues, each of which is addressed in this study. The first issue is the analytic structure imposed on those consumers demanding long distance service. This study assumes that residential and small business customers' long distance purchase decisions can be characterized by a two step approach. Given the general level of long distance prices, residential consumers and small businesses first decide how much long distance service to purchase. Then, depending on the relative prices of the firms serving the market, consumers allocate their purchases among these firms. By basing the estimation on firms' market shares, rather than their sales levels, this approach reduces the bias from omitting variables that might affect the demand for long-distance service.

The second issue is common to empirical demand studies: the prices and quantities observed in the market result from the combined effects of demand and supply. When this is true, using observed prices will lead to biased estimates. To address this issue, this study relies on two econometric techniques; instrumental variables and reverse regressions. Ideally, instrumental variables methods provide estimates of demand relationships that are consistent and free of confounding supply effects. Alternatively, reverse regressions will allow us to estimate upper and lower bounds for actual elasticity values.

Third, estimating the welfare losses from supracompetitive pricing requires estimates of long-run demand elasticities. That is, the estimates should be based on a model that allows consumers to react fully to relative price changes. Yet, the available data tend to be short-run in nature, in this case either monthly or quarterly. This study estimates long-run elasticities from monthly or quarterly data by introducing polynomial distributed lags into the estimated equation.

Finally, the firms in the long distance market include AT&T, with a market share in excess of 60%, and a number of smaller but significantly-sized competitors, principally MCI and Sprint. AT&T's prices were regulated to some extent throughout the study period. Elasticity estimates must be interpreted carefully, given the oligopoly structure of the market and the prevalence of regulation. This study adopts certain behavioral assumptions about how firms react to regulation and to each other; the empirical results tend to support these assumptions.

When a firm has market power, i.e., when it can set prices in excess of its marginal costs, welfare losses arise because potential customers that value the product above its marginal cost but below its price choose not to purchase the product. This study, therefore, uses the estimates of AT&T's firm-specific demand elasticity to generate estimates of the welfare losses that would arise if AT&T were able to set its prices free of any regulatory constraints.

The estimation results lead us to a number of conclusions. Chief among them is that the long distance market is relatively competitive. Lower-bound long-run demand elasticities are estimated to be -10.1 for AT&T and -25.4 for AT&T's two primary rivals. These lower-bound estimates are consistent with an upper-bound deadweight loss due to AT&T's exercise of market power of about 0.36% of industry revenues, or $199 million in 1991. Because the long distance market appears more competitive now than during the period covered by our analysis, the current deadweight loss from AT&T's exercise of market power may be even less than our estimate.

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I. INTRODUCTION

This paper attempts to measure the degree of market power in the small business and residential market for long distance telecommunications by estimating the degree of substitutability between AT&T's and its rivals' service. While most experts agree that competition has increased in the long distance market, the evidence on the extent of residual market power in the industry is still unclear. Some studies examining the structure (Egan and Waverman (1991)) and pricing behavior (Levin (1991)) of the long distance telecommunications industry conclude that competition already exists. Others interpret the structural evidence differently (Selwyn, Cornell, Taschdjian and Woodbury (1991)), or conclude that full implementation of fiber optic technology will render the industry a natural oligopoly that will support supra-competitive prices (Huber, Kellogg, and Thorne (1993)).

Notwithstanding the increase in competition in long distance telecommunications, AT&T's prices are still regulated. Price regulation is desirable only when its benefits outweigh its costs. These benefits include the increase in consumer welfare and economic efficiency from reducing supra-competitive prices, while the costs include direct administration costs as well as reductions in productivity arising from disincentives directly caused by the regulation. In examining the degree of competition in the long distance market, this study provides evidence on the possible benefits from continuing to regulate AT&T's prices. With regard to the costs of regulation, there is growing evidence that regulation of telecommunications has led to substantial productivity losses (Mathios and Rogers (1989,1990), Kaestner and Kahn (1990), Olley and Pakes (1992), Crandall (1991), Kwoka (1993), Ying and Shin (1993)).

Before the 1984 divestiture, AT&T was thought to exert market power in two different ways. First, it was feared that AT&T-controlled monopolies in local telephone service would subsidize otherwise competitive long distance service, or that AT&T would discriminate against rival long distance carriers by providing inferior access to end users (Brennan (1987)). Second, it was feared that AT&T would wield market power in the long distance market directly by charging supra-competitive prices. The first threat did not materialize, as evidence strongly suggested that the subsidy flowed from the more competitive long distance markets to the regulated monopoly local service markets (Temin and Peters (1985a, 1985b), Kaserman, Mayo and Flynn (1990)). Nevertheless, AT&T's divesture of its local service operations in 1984 was explicitly designed to remedy the subsidy and discrimination complaints (Brennan (1987)). As to the second threat, AT&T continues to be price regulated to avoid the exercise of market power in long distance service. If the long distance industry could be shown to be sufficiently competitive, there would be no compelling economic arguments for continued price regulation of AT&T's long distance service.

This study is also relevant to the issue of Bell Operating Company (BOC) entry into long distance services. Several of the divested BOCs have sought, among other things, to eliminate the long distance line-of-business restrictions imposed on them by the 1984 divestiture agreement.[1] They argue both that current regulatory safeguards can prevent cross-subsidization and discrimination and that their entry into the long distance market would reduce existing "oligopolistic" price-cost margins. While this study does not address the cross-subsidization and discrimination issues, it does provide information

[1]Motion of Bell Atlantic Corp., Bell South Corp., NYNEX Corp. and Southwestern Bell Corp. to Vacate the Decree, July 6, 1994, U.S. v. Western Electric Co., Inc. & AT&T, Civil Action No. 82-0192.

on the magnitude of the price-cost margins that they would compete away.

This study measures the degree of competition in the long distance telecommunications market primarily through estimates of firm-specific long-run demand elasticities. A demand elasticity indicates the extent of a firm's loss in quantity demanded due to unilaterally raising prices - that is, the extent of the firm's market power (Landes and Posner (1981)). The reciprocal of the own-price elasticity, the Lerner index, provides an estimate of the percentage price markup over marginal cost for an unconstrained, profit maximizing firm. The applicability of the Lerner index to AT&T is discussed below. Finally, estimates of this price-cost margin provide the basis for measuring the potential deadweight loss from supra-competitive pricing.

The study's general conclusions are as follows. The lower-bound estimate of AT&T's long-run own-price elasticity is -10.14, implying an AT&T Lerner index of 0.099. At this value, the potential deadweight loss from supra-competitive pricing was, at most, 0.36% of total industry revenues for the 1988 to 1991 time period. Because this elasticity estimate is likely to be biased toward zero, its implied deadweight loss is likely to overstate the actual deadweight loss. Further, because the market likely has become even more competitive since the period analyzed in this study, this estimate may overstate the current deadweight loss. For example, adjusting for AT&T's subsequent fall in market share decreases the upper-bound potential deadweight loss estimate to 0.20% of industry revenues. These estimates of deadweight loss are substantially less than estimates of the efficiency gains attributed to past deregulatory actions.

II. THE LONG DISTANCE TELECOMMUNICATIONS MARKET

The FCC's Specialized Common Carrier decision in 1971 opened up the long distance market to competition. AT&T's tough posture toward its new competitors led to many private antitrust lawsuits, and culminated in the Justice Department's antitrust suit. The 1982 settlement of this suit provided for the 1984 divestiture of AT&T's long distance operations from newly created regional local telephone companies. As part of the settlement, the divested local telephone companies were obligated to install switching equipment that allowed for "equal access" by any long distance company. This allowed AT&T's competitors to introduce services that were comparable to AT&T's. While AT&T's share of the long distance market's revenues in 1982 was 95%, by 1987 its market share had fallen to 80%, and it is currently about 60% (Kwoka (1993), Statistics of Communications Common Carriers (1992)). By 1991, MCI's and Sprint's revenue market shares had climbed to 17% and 10% respectively, and the two next largest firms, WilTel and Cable & Wireless, had market shares of somewhat less than 1% each. Since the divestiture, industry output, measured by the number of calling minutes, has nearly tripled. Even though AT&T's share has declined to 60%, its output has increased by two-thirds over 1984 levels.

A long distance company operates a communications network that connects local telephone exchanges (hence, it is often called an Interexchange Carrier, or "IXC"). A long distance company's network terminates in different local telephone companies' jurisdictions. The local telephone companies, such as the regional Bell Operating Companies and GTE, transport telephone calls between the customers' premises and the long distance network. These services are called "carrier access," and they currently represent nearly 40% of all long distance costs. Because these carrier access costs play an important role in the empirical analysis carried out below, it is worthwhile to describe them in some detail.

A. *Carrier Access*

Almost all carrier access rates are regulated by the FCC or state regulatory commissions. For standard toll service, long distance companies purchase "switched access" from local telephone companies. Switched access prices are divided into three main components: carrier common line, local switching, and local transport. Carrier common line charges are levied to cover that portion of the local telephone distribution plant assigned to the long distance companies for capital recovery. Local switching charges are levied because a long distance telephone call must be switched through the local network, thus tying up switching capacity that has alternative uses. Local transport charges are levied as a rental of the line between the long distance network and the relevant local switch. All three of these charges are levied per minute of use at each end of the telephone call using switched access.

The carrier common line charge is levied specifically to defray the costs of the local telephone distribution plant, and not the costs of completing long distance calls (hence, it is sometimes called the "non-traffic sensitive" charge), and has a long and tortured history. Half a century ago, the courts ruled that, because AT&T's long distance service used local exchange network loops, a portion of the cost of these local network loops should be recovered through long distance rates. The portion of the local loop assigned to long distance service steadily grew to 27% in 1982 with little relation to underlying economic costs.[2] The FCC's 1983 Access Charge Plan formalized this cost assignment as the carrier common line charge, which was to be levied as a per minute charge despite its fixed cost nature. At first, the non-AT&T long distance companies (collectively known as the Other Common Carriers or OCCs) had inferior connections to the local telephone companies (for example, customers were required to dial extra digits to reach the long distance company). This sort of access is called "non-premium access" and its associated carrier common line charge was set at 45% of the premium charge paid by AT&T. The FCC has since required the local telephone companies to install equipment to provide equal access to any long distance company asking for it. Equal access equipment is now in place for nearly all (91%) long distance company customers, and non-premium service accounts for only 3% of OCC service.

The carrier common line charge fell steadily to about one-sixth its 1984 level, and local telephone companies were authorized to replace the lost revenue by assessing a monthly charge to consumers not related to long distance usage. Some studies have concluded that this decline (total switched access prices fell about 60%) accounts for much of the price reduction in long distance service (Taylor (1991)). The subscriber line charge that replenished local telephone companies' revenues eventually reached $3.50 per month for each residential line and $6.00 per month for each business line. The subscriber line charge was phased in between 1985 and 1991.

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[2]Originally, the proportion of the local network loop costs assigned to long distance operations was the fraction of all calls that used long distance facilities. In the early 1950s, this proportion was less than 3%, by 1982 it was 8.3% and in 1991 it was 14.4%.

Local switching and transport services are together called "traffic sensitive services" because their costs depend on the volume of traffic. For both of these services, there are many different rate elements that make the price dependent on various switching services and the distance of the transport. In general, however, the rates for these services have declined only slightly since divestiture. These rates are generally believed to be considerably above the services' marginal costs. Cost studies have put incremental costs (Mitchell (1990)) and long-run marginal costs (Bureau of Economics, FTC (1993)) of switched access at one-tenth to one-third of the switched access rate.

Long distance companies also purchase a different form of carrier access, special access, from local telephone companies. Special access lines are dedicated lines (i.e., they are not switched by the local telephone company) and are leased by the month at rates corresponding to their capacity and distance. Actual usage is not metered. For a sufficient volume of traffic, special access can represent significant cost savings over switched access. Long distance companies use special access to connect directly to end users with high volumes of traffic or nonstandard technical requirements and to connect different long distance nodes within a metropolitan area as a substitute for the local transport portion of switched access. Special access, which is supplied by local telephone companies, competes with third party, or facility bypass, access provision. These third party firms, called Competitive Access Providers or CAPs, build small networks in downtown business districts that connect end users to long distance companies without the use of local telephone networks.

Long distance company carrier access costs per minute differ due to differences in the mix of carrier access services that the companies purchase. First, different local telephone companies can have different prices, and the smaller, more rural local telephone companies tend to have higher prices. Long distance companies that carry a disproportionate share of the calls originating or terminating with these local telephone companies will tend to have higher carrier access costs. Second, the amount of local transport purchased for a typical call can differ across long distance companies. As a long distance company serves more urban customers, who tend to be closer to its local network connection, or adds more local network connections, its average local transport distance and corresponding charge per minute tend to fall. Third, switched access costs will depend on the amount of lower priced, non-premium access purchased by a long distance company; however, this cost difference is becoming negligible due to declines in both non-premium usage and the carrier common line charge.

B. Regulation of Telecommunications

States regulate prices for intrastate services (local services, intrastate carrier access and intrastate long distance), and the FCC regulates interstate services (interstate carrier access and interstate long distance). While the FCC regulates AT&T prices directly, the OCCs and the third party-access providers are not regulated directly, although the OCCs file prices with the state public utility commissions and the FCC similar to tariff filings of regulated firms.

Price-caps are increasingly replacing rate-of-return as the form of regulation in the telecommunications industry. Generally, price-cap regulation allows the regulated firm to charge any price below a regulated price-cap that is periodically adjusted to reflect changes in exogenous cost factors, such as inflation and productivity improvements (Liston (1993)). The FCC decided to move to price-cap regulation for AT&T in May 1989. Federal price-cap regulation of local telephone companies' interstate access rates was implemented in January 1991. While price-cap regulation of local telephone companies has also been introduced by various PUCs, these mechanisms typically contain explicit profit "sharing" provisions if the actual rate-of-return exceeds a predetermined limit (Braeutigam and Panzer (1993)). Profit sharing mechanisms could also be implicit in the FCC form of price-cap regulation. High profits could induce the FCC to set lower price caps, thus allowing consumers to "share" what was formerly profit. In fact, high profits due to the increased efficiency of British Telecom under price-cap regulation in the U.K. and prices below the price-cap led to a revision of the price-cap formula toward a more binding cap (Kwoka (1993)).

The specific form of price-cap regulation adopted for AT&T divided services into three "baskets" depending on the perceived level of competition in the service. "Basket 1" includes residential and small business services, international services and operator assisted and calling card services; "Basket 2" is limited to 800 number services; and "Basket 3" contains all remaining services, principally those offered to large businesses. Each basket has its own price-cap (and sometimes a floor) that increases with inflation, decreases with a productivity factor and varies directly with "exogenous" changes in costs, mainly carrier access charges. As services have been shown to be competitive, they have been removed from price-cap regulation. While AT&T's market share of switched and private line interstate services was almost 69% in 1989, its market share for WATS services had fallen to 44% (Mitchell and Vogelsang (1991) p. 14). In October 1991, the FCC permitted AT&T to negotiate contracts with large business customers as an alternative to using the tariffed prices. However, AT&T must publish a summary of the contract and offer the same price to similarly situated customers (Griboff (1992)). Similarly, almost all 800 services were removed from

Basket 2 in May 1993 with the introduction of 800 number portability.[3] This study uses prices from Basket 1, thought to be less competitive than the other baskets.

III. EMPIRICAL METHODOLOGY

This study attempts to measure the degree of market power as the difference between price and marginal cost. In theory, a profit maximizing firm not facing price regulation will set prices such that the price markup over marginal costs, its Lerner index, is equal to the absolute value of the inverse of the firm's own-price demand elasticity. Thus, the degree of a firm's market power can be inferred from estimates of this elasticity. However, the data and methodological requirements for the estimation of firm specific demand elasticities are extremely demanding. This section describes the methodology employed to estimate demand elasticities for AT&T and the OCCs, which are used to infer the magnitude of market power. The methodology adopted pays special attention to potential parameter biases in empirical estimates due to data measurement problems.

A. The Two-level Demand Approach

Long distance service can be somewhat differentiated across firms. For high-volume business customers and those who use data transmission services, there may be substantial variation in product

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[3]800 number portability allows a customer to keep its 800 telephone number when it changes long distance companies. Since companies make investments specific to a telephone number (e.g.,advertisements, printed material), switching costs arise if the number must be forfeited. See also Kaserman and Mayo (1991).

attributes. Even for residential and small business customers, differences in perceived quality, customer service, and billing systems could render long distance services heterogeneous across firms. Finally, some carriers offer lower quality, lower priced, non-premium service, although its popularity has diminished considerably. At the same time, it appears reasonable to aggregate different firms' long distance service into a single market that is distinct from other goods and services.

A two-level budgeting approach is used to estimate the demand system (Deaton and Muellbauer (1980), ch. 5). The "upper level" determines the industry-wide demand for long distance, while the "lower level" determines how demand is allocated among the various firms in the market. This approach is used because it accords with perceptions of the long distance market, and it partially separates the effects of general industry price reductions from price differences among firms within the industry. On one hand, real prices for long distance service fell by about 50% between 1984 and 1991. Differences among firms' prices were much smaller throughout this period. On the other hand, real total expenditures on all toll service increased by only 3.5% between 1984 and 1991, while the market shares of individual firms changed considerably. By treating the demand for long distance service as a two level budgeting process, it is possible to disentangle end users' decisions regarding the amount of long distance service to consume from their decisions regarding which firm to provide it. Two level budgeting provides a tractable estimation structure (allowing firm own- and cross-elasticities within the long distance industry to differ) at the cost of constraining all firms' cross-elasticities with related goods and services (e.g., local telephone service, modems) to be the same.

In two-level budgeting, consumers are assumed to allocate funds across different broad commodities (upper level) and then distribute the allocated funds among the specific goods within the commodity group (lower level). In the upper-level, demand for aggregate long-distance service, Q_D^{LD}, is determined as a function of the long distance service price, P^{LD}, local telephone service price, P^{Loc}, the price of other telephone goods and services, P^{Oth}, and total income Y,

$$Q_D^{LD} = Q_D^{LD}(P^{LD}, P^{Loc}, P^{Oth}, Y).$$

The total expenditures budgeted to long distance service, Y^{LD}, is determined as a function of price,

$$Y^{LD} = P^{LD} Q_D^{LD}(P^{LD}, P^{Loc}, P^{Oth}, Y).$$

In the lower level, consumers choose which long distance carrier's service to purchase based on their relative prices and Y^{LD}, the amount of income budgeted to long distance service,

$$Q_D^1 = Q_D^1(P^1, P^2, P^3, \ldots, P^N, Y^{LD}). \tag{1}$$

Equation (1) looks like a traditional demand equation where quantity demanded is a function of prices and "income." Traditional demand elasticities are calculated by differentiating equation (1) with respect to firm 1's price, P^1. The partial derivative introduces two terms because firm 1's price is implicit in long distance expenditures,

$$\frac{\partial Q^1}{\partial P^1} = \frac{\partial Q^1}{\partial Y^{LD}} \frac{\partial Y^{LD}}{\partial P^1} + \left.\frac{\partial Q^1}{\partial P^1}\right|_{Y^{LD}}.$$

This equation can be expressed in elasticity form by multiplying both sides by P^1 / Q^1,

$$\eta_{11} \equiv \frac{P^1 \partial Q^1}{Q^1 \partial P^1} = \frac{Y^{LD} \partial Q^1}{Q^1 \partial Y^{LD}} \frac{P^1 \partial Y^{LD}}{Y^{LD} \partial P^1} + \frac{P^1 \partial Q^1}{Q^1 \partial P^1}\Bigg|_{Y^{LD}} \qquad (2)$$

The second term in equation (2) above is the elasticity conditional on the amount of income budgeted to long distance, η^C_{1i}. The first term represents the "income" effect due to changes in the amount of income allocated to long distance service from changes in the price of good 1. The first part of the first term, $Y^{LD}\ \partial Q^1\ /\ Q^1\ \partial Y^{LD}$, is analogous to an "income" elasticity for the good, ϵ^C_1. If income elasticities do not differ much across long distance companies, the value of this lower-level income elasticity will be close to one. The second part of the first term, $P^1\ \partial Y^{LD}\ /\ Y^{LD}\ \partial P^1$, can be modified as follows:

$$\begin{aligned}
\frac{P^1 \partial Y^{LD}}{Y^{LD} \partial P^1} &= \frac{P^1}{Y^{LD}} \frac{\partial (P^{LD} Q^{LD})}{\partial P^1} \\
&= \frac{P^1}{Y^{LD}} \left[Q^{LD} \frac{\partial P^{LD}}{\partial P^1} + P^{LD} \frac{\partial Q^{LD}}{\partial P^1} \right] \\
&= \frac{P^1}{Y^{LD}} \left[Q^{LD} \frac{\partial P^{LD}}{\partial P^1} + P^{LD} \frac{\partial Q^{LD}}{\partial P^{LD}} \frac{\partial P^{LD}}{\partial P^1} \right] \\
&= \frac{P^1}{Y^{LD}} \left[Q^{LD} \frac{Q^1}{Q^{LD}} \left(1 + \frac{P^{LD} \partial Q^{LD}}{Q^{LD} \partial P^{LD}} \right) \right] \\
&= \frac{P^1 Q^1}{Y^{LD}} (1 + \eta^{LD}) \\
&= w^1 (1 + \eta^{LD}),
\end{aligned}$$

where w^1 is firm 1's share and η^{LD} is the industry level demand elasticity. Putting the components together yields,

$$\eta_{11} = w^1(1 + \eta^{LD})\epsilon_1^C + \eta_{11}^C. \tag{3}$$

Equation (3) has an economically intuitive interpretation. The first term measures the "income" effect while the second measures the elasticity holding budgeted income constant. Further, the first term can be decomposed into three effects: P^1 on P^{LD}, P^{LD} on Y^{LD}, and Y^{LD} on Q^1. First, an increase in P^1 holding all other prices constant, will increase P^{LD} by the quantity share of the total market that good 1 represents, w^1. Second, since Y^{LD} is the product of P^{LD} and Q^{LD}, a one percent increase in P^{LD} will increase Y^{LD} one percent directly and decrease Y^{LD} by the upper-level elasticity due to a movement along the upper-level demand curve. Finally, an increase in Y^{LD} will increase the quantity of good 1 demanded according to the lower-level income elasticity.

1. Industry Level Demand

The industry demand elasticity for equation (3) is estimated from time series data. Long distance quantity is estimated to be a function of its own price, income, the price of local telephone service, and a time trend,

$$\begin{aligned} \log Q_t^{LD} &= \eta^{LD}\log P_t^{LD} + \epsilon \log Income_t \\ &\quad + \eta^{Loc}\log P_t^{Loc} + \alpha_0\, time + \omega_t. \end{aligned} \tag{4}$$

Here ω_t represents random factors influencing industry demand in time "t." The quantity of long distance service demanded is expected to fall as price increases, with η^{LD} measuring the industry elasticity. Since local telephone service is a complement to long distance service, increases in its price are expected to lead to a fall in the demand for long distance service, implying that η^{Loc} should be negative. The coefficient on income, ϵ, is intended to measure the income elasticity for long distance telephone service and is expected to be positive. The prices of telephone equipment, computers and modems, which can also be thought of as complements to long distance telephone service, tended to decline over the sample period. Since price series are unavailable for these products, a time trend is introduced to capture this shift in demand, and the coefficient on that time trend, α_0, should be positive. The data used to estimate equation (4) are described below in section IV.

2. Firm Level Demand

If the lower-level demand elasticities are constant in the relevant range we can represent these demand relations as linear in logarithms. For a two-firm industry, equation (1) for firm 1 becomes,

$$\log Q^1_{kt} = \eta^C_{11} \log P^1_{kt} + \eta^C_{12} \log P^2_{kt} + \epsilon^C_1 \log Y^{LD}_{kt} + \mu^1_{kt}.$$

Here μ^1_{kt} represents random factors influencing industry demand at time "t" in state "k." Both prices on the righthand side above are likely to be correlated with μ^1_t because they are functions of quantity through supply relationships. A detailed discussion of the econometric requirements that such endogeneity places on the estimation procedure is presented in appendix A. Assuming ϵ^C_1 is one,[4] we can transform this relation by subtracting the logarithm of long distance expenditure from and adding the logarithm of P^1 to both sides. This results in a budget share equation,

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[4]It is likely that income elasticities do not differ much across long distance companies, implying that ϵ^C_1 equals one. Errors in variables problems could render estimates of ϵ^C_1 biased because quantity is the dependent variable and is implicit in total long distance expenditures.

$$\log\left[\frac{P_{kt}^{1} Q_{kt}^{1}}{Y_{kt}^{LD}}\right] = (1+\eta_{11}^{C}) \log P_{kt}^{1} + \eta_{12}^{C} \log P_{kt}^{2} + \mu_{kt}^{1}. \qquad (5)$$

Firm level constrained elasticities are estimated by regressing a firm's revenue market share against the price of its own service as well as that of its rivals. Changes in the relative prices within the industry are expected to induce brand switching causing η_{ii}^{C} to be negative and η_{ij}^{C} to be positive. Equation (5) is estimated for AT&T and an aggregation of MCI and Sprint. The data used to-estimate equation (5) are described below in section IV.

B. Accounting for Demand Changes that Occur Over Time

For purposes of assessing a firm's market power, i.e. its ability to maintain prices in excess of marginal costs, one would examine the firm's long-run demand elasticity. Such an elasticity would measure the responsiveness of consumers to a permanent price change after allowing consumers to adjust fully their behavior. Three reasons why consumers of long-distance service would adjust over time are: the existence of relatively fixed stocks of complementary goods, the gradual revelation of information regarding the actual price change, and the variability in switching costs. Automobiles, in relation to gasoline, is an example of a complementary good whose stock is fixed for a substantial period of time. A permanent increase in the price of gasoline will lead to larger reductions in the quantity of gasoline demanded when an existing automobile is replaced by a more fuel efficient one. However, the automobile will only be replaced when it has depreciated sufficiently to warrant a new purchase which could occur well into the future.

Imperfect price information and variable switching costs are likely to be more relevant determents of the pace of long distance demand adjustments. Consumers respond to new price information only when they become aware of the price change, in some cases months after the price actually changed. The main mechanisms for obtaining information regarding price differences are advertisements and experiences with monthly bills. Both of these mechanisms transmit information imperfectly. Even when consumers become aware of the price change, perhaps months after it has occurred, they may not respond right away because the costs of switching may currently outweigh the savings from a less expensive service provider. Customers may only change providers when the switching costs are sufficiently reduced, possibly due to a competitor's "special offer."

Because demand adjusts over time, the current level of demand is a function of all of the prices that existed over the adjustment period. The inclusion of appropriately lagged price variables, rather than relying only on the current period price, incorporates the long-run demand adjustment process. But including a large number of lagged prices is impractical because they are likely to be highly correlated, leading to great imprecision in estimates of the impact of individual lagged prices. Studies estimating long-run industry demand curves for long distance telecommunication often allow current price changes to affect current quantity as well as the quantity demanded for a year or two into the future (Taylor (1980), Gatto, et al. (1988), Taylor and Taylor (1993)). Since our data are monthly, direct estimation of lagged price effects over a two year period would require up to twenty-four highly correlated lags of the own price and the competitors' price variables.

The typical solution to the problem of collinearity of the lagged values is to impose a plausible pattern on the lagged coefficient values, thereby reducing the number of parameters to be estimated. This study considers two structures: an exponential decay structure (Koyck (1954)) and a polynomial distributed lag structure (Almon (1962)). The exponential decay scheme assumes that the effect on demand that a price change will have in a future period is a constant fraction of the effect it had in the previous period. Econometrically, this scheme is implemented by including the lagged dependent variable as an independent variable. The coefficient on this variable provides an estimate of the rate of exponential decay. While the Koyck scheme imposes strong restrictions on the lag structure, it permits the estimation of long lags with the inclusion of only one additional variable. Thus, it is typically used when the limited amount of data do not permit more elaborate lag structures.

Compared to the exponential decay structure, the polynomial distributed lag (PDL) structure is more flexible because it permits more than one variable to describe the lag structure. Assuming that the lag structure follows a second (third) order polynomial requires only three (four) parameters be estimated for each price variable. Increasing the order of the polynomial permits more generalized lag structure at the cost of possibly reintroducing multicolinearity and creating less precise estimates. The number of parameters can be limited to two (three) by imposing the condition that the most distant lagged coefficient tends toward zero. This is reasonable if it is believed that the more distant price lags have an increasingly smaller impact on the quantity demanded.[5]

[5]With a second-order polynomial or higher, the endpoint restriction does not restrict the polynomial to be monotonically decreasing.

C. *The Lerner Index of Market Power*

The reciprocal of the own-price elasticity, the Lerner index, provides an estimate of the percentage price markup over marginal cost for an unconstrained, profit maximizing firm:

$$L_i \equiv \frac{P_i - MC_i}{P_i} = \frac{1}{|\eta_{ii}|}.$$

This condition is derived from the first order conditions that equate marginal revenue to marginal cost. For larger elasticities (in absolute terms), the marginal revenue curve is closer to the demand curve and the profit maximizing price is closer to marginal cost. In this way, the demand elasticity indicates the extent to which the firm can unilaterally raise prices without suffering a large loss in quantity. This is the extent of the firm's market power. With regard to the long distance market, the application of the Lerner index to estimated demand elasticities requires assumptions regarding the degree to which competitors respond to price changes of rivals and the effect of regulation on AT&T's ability to set prices above marginal costs.

The Marshallian demand elasticity described in equation (3), used to infer the Lerner index, represents the effect of a change in a firm's price on its quantity when competitors' prices are held constant. A firm's residual demand elasticity, by contrast, equals its Marshallian demand elasticity plus the sum of cross-elastic effects from rival firms' optimal price responses to the firm's price change,

$$\eta_{ii}^{R} = \eta_{ii} + \sum_j \eta_{ij} \frac{\partial P_j P_i}{\partial P_i P_j}.$$

Three plausible reasons why competitors' prices might not be held constant are: 1) all firms increase price as the price of a common factor input increases; 2) as one dominant firm increases its price, demand shifts to its competitive fringe, and they increase output along an upward sloping supply curve; and 3) it is optimal for a firm's competitors to increase their price-cost margins when a rival also does so. The first explanation does not affect the calculations here because, while competitors' price changes are contemporaneous, they are actually caused by cost changes which do not affect $\partial P_j / \partial P_i$. The second explanation, requires that the fringe firms operate on an upward sloping supply curve. As explained below, this is not likely to apply to long distance telephony.

The third explanation pertains to most oligopoly models and may be relevant to long distance telephony. If a firm correctly conjectures that changing its price will induce rivals to adjust their prices, then it is not appropriate to use the elasticity from equation (3) which assumes that rivals' prices are held constant. In the extreme case of perfect collusion, price changes by one firm correspond to equal price changes by all others, and the relevant firm-specific elasticity is the industry demand elasticity.

For the four reasons discussed below, we assume that AT&T conjectures that its competitors will not change their prices in response to AT&T price changes not caused by common cost changes. First, the non-AT&T carriers ("Other Common Carriers" or "OCCs") have ample capacity with which to expand output. While AT&T's share of fiber optic capacity was 41% in 1992 (Kraushaar (1993)) its share of output was 60% by 1992. The OCCs have even more capacity for expansion than does AT&T. This suggests both that shifts in demand need not induce higher OCC prices since OCC supply curves are virtually flat and that the OCCs have the ability to undercut price increases by firms producing close substitutes. Second, the average OCC customer is likely to be significantly more price elastic than the average AT&T customer. The average OCC customer demands more than twice the calling volume as demanded by the average AT&T customer.[6] Moreover, since most OCC customers have switched from AT&T at some time, they have revealed themselves to be more price sensitive than the average AT&T customer. Third, in addition to being price sensitive, OCC customers can choose among a large number of non-AT&T long distance companies whose services are likely to be perceived as good substitutes for each other. Over 500 OCCs other than MCI and Sprint compete in the interstate long distance market (Statistics of Communications Common Carriers (1992)). While most of these firms' operations are confined to reselling service supplied over the facilities of other long distance carriers, by 1991 nine firms operated facilities in more than 45 states (Statistics of Communications Common Carriers (1992)). Moreover, the combined market share of these other OCCs is greater than that of Sprint and the growth in their combined market share since 1988 was greater than that for MCI or Sprint.[7] This suggests that an OCC faces the prospect of customers switching to any of a large number of potential

[6]The ratio of a firm's total minutes supplied to the number of its customers represents an index of calling volume per customer. The calculated calling volume index for OCC customers is 2.7 times that for AT&T customers in December, 1987 and 2.0 in June, 1992 (Statistics of Communications Common Carriers (1992)).

[7]Market shares in 1991 for MCI, Sprint and all other OCCs respectively were 15.0%, 9.7% and 13.1% and market shares in 1988 were 10.3%, 7.2% and 8.0% (Statistics of Communications Common Carriers (1992)).

competitors if it attempted to raise its price in response to an AT&T price change. Fourth, the telecommunications industry exhibits characteristics which tend to impede collusion, either tacit or explicit. In addition to the large number of firms, collusive behavior is more difficult to enforce in industries with rapidly changing technologies and, consequently, changing market shares (Stigler (1964)). Long distance telecommunications has experienced an accelerating pace of innovation. Technological innovations include microwave and fiber optic transmission, asynchronous transfer mode (ATM) and frame relay switching, and software defined network (SDN) and bandwidth-on-demand data communications. Consumer-related innovations include magnetic strip calling cards, optional calling plans and "EasyReach 700" service. As long distance companies adopt these innovations collusive arrangements become more difficult to enforce.

We believe, therefore, that it is reasonable to assume that AT&T's rivals will not change their prices in response to a change in AT&T's price. This implies that we can use the estimates of AT&T's own-price elasticity to infer the extent of its market power.

One final issue in using AT&T's demand elasticity to infer its degree of market power is accounting for the fact that AT&T's prices are regulated. Inferring a price-cost markup from a firm-specific demand elasticity requires the assumption that marginal cost is equated with the marginal revenue associated with the firm's demand curve. However, this assumption may not hold for firms, such as AT&T, that face price regulation. When prices are constrained by regulation, in the short-run the quantity demanded will exceed the unconstrained profit maximizing level and marginal cost will exceed the unconstrained marginal revenue curve. Thus, the price-cost margin under regulation would be smaller than the price-cost margin derived from the profit maximizing assumption implicit in the Lerner index.[8] In fact, however, regulation does not appear to have greatly constrained AT&T's prices, at least since price-caps have been in place. For Basket 1 services, AT&T's price was at its cap only about one-third of the time that price-cap regulation was in effect. Figure 1 shows that the price cap is more likely to be binding just after large changes in the cap brought about by large changes in regulated carrier access prices. This result could be a reflection of regulatory delay in reviewing AT&T price changes. Thus, even one-third is likely to overstate the fraction of time that the price-cap was binding. Consequently, we believe it is reasonable to infer AT&T's price-cost margin from its estimated demand elasticity.

IV. DATA DESCRIPTION

This section describes the basic data employed to estimate long distance telephone demand relationships described by equations (4) and (5). The industry level demand estimation, equation (4), is conducted using two data sources: monthly time series data for the period July 1986 to August 1991 and quarterly time series data for the period 1986:1 to 1993:1. The firm-specific demand estimations, equation (5), primarily uses monthly data for the years 1988 to 1991 for five states but is

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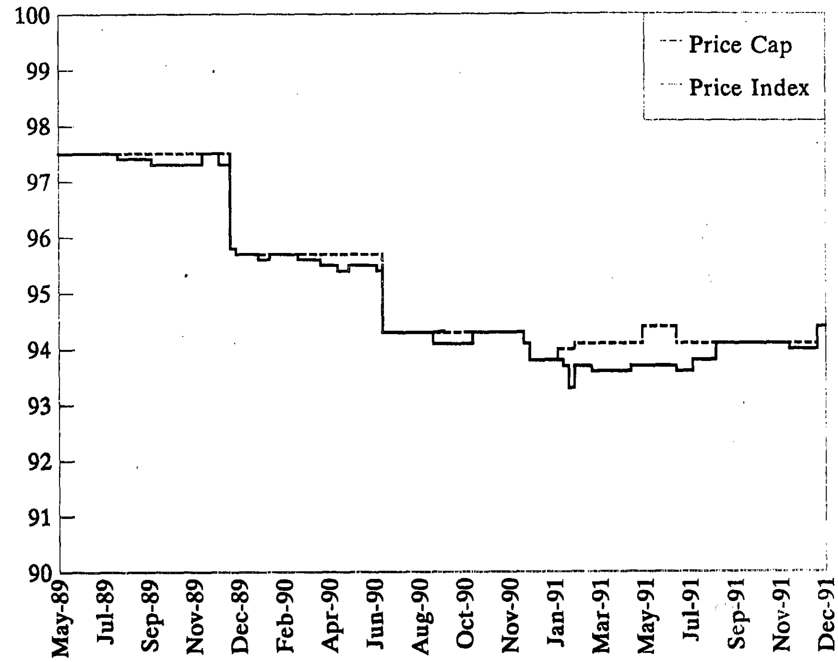
[8]Since the firm may be able to respond to regulation, the divergence between marginal revenue and marginal cost will be diminished for two reasons. First, if the firm expects price to be constrained into the future, it can reduce marginal cost to the lower marginal revenue level by reducing investments that maintain quality. Second, if the firm expects price to be unconstrained for some amount of time in the future, the relevant marginal revenue is a weighted average of the constrained and the unconstrained marginal revenues, where the weight is the probability that the constraint will be binding. In the first case, a sub-optimal level of quality is chosen and in the second, the relevant constraint is the expected price-cap over periods when it is binding.

Figure 1. **AT&T's Basket 1 Price Cap & Price Index (Nominal Prices)**



supported with quarterly national time series data for the period from 1986:1 to 1993:1. Instrumental variables are employed to identify structural demand parameters in all estimations. This section describes the data used, focusing primarily on the firm-specific estimation.

A. Industry Level Estimation

For the industry level demand estimates, equation (4), national data were collected from various sources on output, prices and income. The total number of minutes of interstate calling is used as the industry output. Two sources for a total minutes variable are monthly data from National Exchange Carrier Association (NECA) reports to the FCC and quarterly data reported in the Statistics of Communications Common Carriers (1992). The CPI prices for interstate long distance and local service were used as price variables. Per capita personal income was used as the measure of income. All prices and income data are deflated by the CPI for all goods and services.

The price of long distance is treated as endogenous, making instrumental variable techniques necessary. Instrumental variables that are available are the PPI indices for transmission and digital switching equipment and the BLS telecommunications worker average wage. All of these represent prices of key inputs into the production of long distance services and, thus, should represent shifts in the supply curve. They will be correlated with the quantity demanded only to the extent that the long distance industry represents a significant portion of the total demand for the individual factors and these markets have upward (or downward) sloping supply curves. While the long distance industry does account for a large fraction of these equipment markets, there is no evidence on the slope of the supply curves.

B. Firm-specific Estimation - Regional Data

The principal data used in the estimation of firm-specific demand, equation (5), are interstate and intrastate carrier access usage and expenditure information for AT&T and the Other Common Carriers (OCCs).[9] The interstate data span five states and each month from January 1988 through December 1991 for a total of 240 observations. The intrastate data span the same five states and each month from January 1988 to October 1991 for a total of 230 observations. Interstate toll service is the focus of this study both because these data were the most accessible and because this is one of the most important segments of the market.

1. Demand Variables

A number of relevant variables are available. For each state, month and long distance company, the variables available are the number of minutes and dollar expenditure on switched access and the number of lines and dollar expenditure on special access for both interstate and intrastate traffic. Since these data are obtained from billing information, they should accurately reflect actual purchases. The number of switched access minutes is the sum of both the number of outgoing and incoming minutes and is a measure of the quantity of long distance service demanded. Measuring demand solely from information on switched access usage omits the growing use of special access and facility bypass. If special access and facilities bypass usage grew faster for the OCCs than for AT&T, market shares based on switched access alone would

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[9]These data are used under a nondisclosure agreement with Southwestern Bell Telephone Co. and are not publicly available.

underestimate OCC market penetration, tending to bias own-price elasticities downward. However, basing market share on switched access usage should more accurately represent Basket 1 services, which is the focus of this study. Dividing switched access expense by switched minutes yields an average price for switched access per minute. Dividing special access expense by the number of special access lines yields an average price per special access line.

The price of long distance service for different firms is of key importance to the estimated results, and is potentially the weakest data element. Long distance price variables were constructed from price information in tariffs filed at the FCC and at state PUCs. AT&T, MCI and Sprint submit rate schedules to the appropriate regulatory agency when they change their rates. These schedules list prices by time of day (day, evening and night), first or additional minute and distance of the call (there are eleven different mileage bands). Since the quantity variables aggregate calls over all of these dimensions, the relevant price is a weighted average over all of these dimensions. However, the appropriate weights can only be approximated and some assumptions must be made regarding the relative use along these dimensions.

Time of day, duration and distance weights were computed using intraLATA toll information and some simplifying assumptions. The average duration and the fraction of calls by day, evening and night were available for local telephone toll service by state. Applying these weights to interstate and interLATA intrastate data assumes comparability between the shorter distance intraLATA and the longer distance calling patterns. The relative weights for the separate mileage bands were computed in an admittedly *ad hoc* way. A so called "gravity" model of telephone traffic flows was employed. Under such an approach, the expected number of calls flowing between two points is proportional to the product of the "mass" of the two locations divided by the square of the distance between the two locations. For the interstate jurisdiction, the expected flows were calculated for each of the 3187 counties in the U.S. to each county of the states in the dataset using the counties' geographic center to compute distances and its 1991 population for its mass. For the intrastate jurisdiction, the flows were aggregated for each of the counties in that state to each county of a different LATA in the same state. The individual county flows for a state are aggregated into the mileage bands.[10] The price is averaged over mileage bands using the aggregated state flows as weights.

2. Potential Measurement Errors in the Long Distance Prices

Both supply and demand endogeneity and measurement errors indicate that instrumental variables techniques should be employed. A detailed discussion of the instrumental variables employed here is presented in appendix A. However, due to the many assumptions inherent in the construction of the price variables, it is appropriate to check them against other sources. One price series available for comparison is the AT&T interstate price index reported to the FCC. As part of the filing requirements for price-cap regulation, AT&T has reported price indices for different baskets of services since April of 1989. The price index for Basket 1 Services represents an independent measure of the long distance prices constructed above. Figure 2 compares the constructed interstate long distance prices for AT&T and the OCCs in Texas with the Basket 1 index that AT&T reports to the

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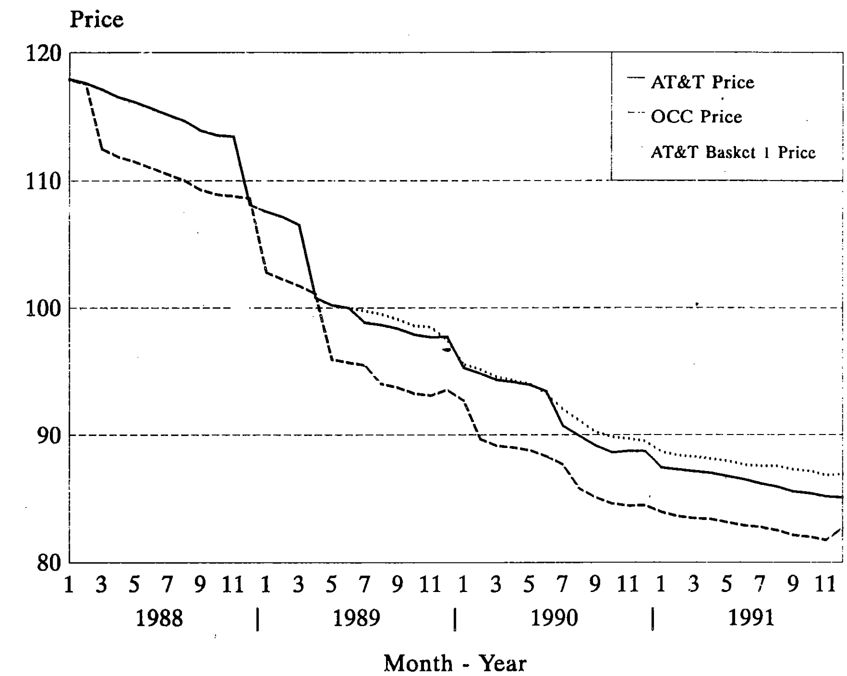
[10]Bob Evett and Equifax National Decision Systems are gratefully acknowledged for the use of these data.

Figure 2. Long Distance Price Variables (Real Prices)



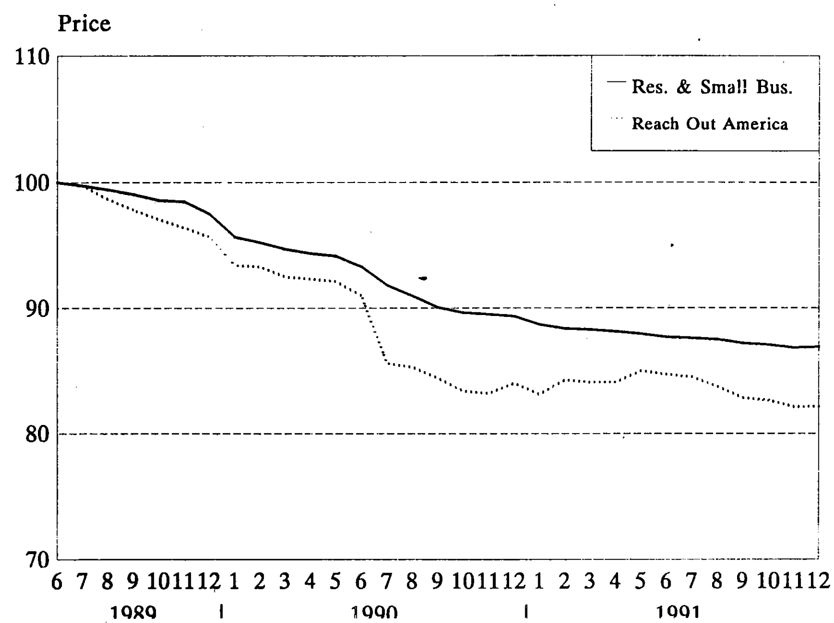
FCC.[11] It appears as though the constructed AT&T price closely follows the Basket 1 index. The gradual deviation between the two series may be accounted for by smaller price reductions in the international and calling card calls, which are included in the Basket 1 price index but excluded from the constructed price.

Discounts from posted prices are another potential problem with the constructed prices. Programs like AT&T's Reach Out America, MCI's Friends and Family and Sprint's Most tend to offer a percentage discount off the posted prices. If discounted prices vary more than posted prices, then changes in posted prices will understate actual price changes and estimated price elasticities will overstate true price elasticities. In 1988, revenue from Reach Out America, AT&T's discount plan, accounted for 5.4% of AT&T's total Basket 1 revenue (Mitchell and Vogelsang (1991) p. 174). Figure 3 confirms that AT&T's Residential and Small Business and Reach Out America indices diverge slightly over time. However, the slight divergence suggests that this source of measurement error is small. The same is likely to be true for the OCC price.

Another measurement error in the OCC price results from the exclusion of firms other than the two largest, MCI and Sprint. Price data were not collected for these other firms because the largest represents less than 1% of industry revenues and because quantity information was available only for the aggregation of these firms. The combined market share of these firms has grown from about 7% to 13% between 1988 and 1991. To the extent that these firms' services are substitutes for AT&T's services and these smaller firms' prices are

[11]The other states in the sample yield similar results. Texas was chosen because it represents about half of all the long distance in the sample.

Figure 3. Long Distance Discounts (Real Prices)



uncorrelated with MCIs' and Sprints', AT&T's estimated own-price elasticity should be biased toward zero. However, the small differences between the MCI and Sprint prices relative to their difference from the AT&T price suggests that the OCCs' prices are highly correlated with each other and that this bias should be small.

C. Firm-specific Estimation - National Data

A secondary source of data used in the estimation of firm-specific demand is a FCC quarterly revenue report for the various long distance companies (FCC (1993)). This report lists total revenues from long distance operations for AT&T, MCI and Sprint as reported in various Form M filings. In addition, the FCC estimates the revenues of the smaller long distance companies. These data allow the construction of quarterly revenue shares for the dependent variable in equation (5). Each firm's national average long distance price is constructed from the interstate price data using the gravity model described above.

The market shares calculated from these data represent all long distance operations including WATS and 800 services and other services to large business customers. The prices, however, represent those paid by residential and small business customers. The prices also suffer from the omission of the smaller long distance companies and discount calling plans as described above. Thus, the estimates derived from these national data suffer more from measurement problems than do the estimates from the regional data.

For the reasons described above, instrumental variable techniques are necessary. Data were available from the first quarter of 1986 through the first quarter of 1993. The available instruments include the cost of capital measures, the switching equipment PPI, the BLS telephone industry average wage rate and a dummy variable for the AT&T price cap period as described above. Because the producer price index for transmission equipment does not exist before 1987, it was not used. Also, because the switched and special access price variables exist only for a limited portion of the time period and only for a particular region, they were excluded. Two additional variables added to this instrument set were the national average switched access price and the fraction of total OCC minutes that were provided over equal access facilities. The average switched access price is reported in the May 1993 Joint Board Monitoring Report table 5.11. Prior to 1987, a substantial fraction of OCC service was provided by lower quality (and lower price) non-equal access facilities. Hartman and Naqvi (1994) found that households with equal access to AT&T's competitors tended to consider non-AT&T service a closer substitute for AT&T services than households without equal access. The fraction of OCC minutes delivered by equal access facilities, obtained from the Statistic of Communications Common Carriers (1993), is a measure of the quality of the service offered by the OCCs.

V. DEMAND ESTIMATION RESULTS

The results of the demand estimations are presented in this section. In the industry level regressions, the results are quite similar to estimates presented in other research. Specifically, long-run industry demand elasticity estimates of -0.71 and -0.89 are slightly more elastic than those recently reported elsewhere (Taylor (1980), Gatto, et al. (1988), Taylor and Taylor (1993)). In the firm-specific regressions using the regional data, lower-bound estimates of own-price demand elasticities are between -5.3 and -6.3 for AT&T and between -15 and -18 for the OCCs when demand is assumed to adjust to price changes immediately.[12] When demand is assumed to take longer to fully adjust to changes in prices, lower-bound estimates of own-price elasticities are about −10 for AT&T and −25 for the OCCs. As explained below, these estimates suggest that AT&T's market power is significantly constrained by the OCCs and that the OCCs price very close to competitive levels. Demand estimates are generally comparable across datasets and estimates that account for a demand adjustment process are consistent across polynomial distributed lag (PDL) specifications.

A. *Industry Level Demand Results*

Tables 1 and 2 present the results from for the industry level demand estimation, equation (4), using a two-stage least squares (2SLS) procedure.[13] The number of long distance minutes is regressed against the CPI for long distance service, personal income, the CPI for local service and a time trend. The price of local service is included to capture any complementarities between these services and the time trend is included in order to account for exogenous shifts in demand (e.g., the fall in the price of facsimile and data transmitting equipment). Natural logarithms are taken of all variables except the time trend. Table 1 reports results from the monthly data while table 2 reports results from the quarterly quantity data. The first column of both table 1 and table 2 report results where the quantity demanded is a function of only

[12]The national data yield a lower-bound elasticity estimate of −2.02 for AT&T and −3.04 for the OCCs. For reasons explained below, however, these are likely to be biased estimates.

[13]Two-Stage Least Squares (2SLS) is an instrumental variables technique that allows for the estimation of unbiased and consistent demand parameters when demand and supply are jointly determined. See appendix A for a more complete description.

Table 1. 2SLS Estimates of Industry Demand from Monthly Data

Variable	Immediate Adjustment	Partial Adjustment
Long Distance Price	-0.49[4] (0.24)	
LD Price - PDL Constant Term		-0.150 (0.156)
LD Price - PDL 1st Order Term		0.017 (0.042)
LD Price - PDL 2nd Order Term		-0.0004 (0.0023)
Income	1.36[1] (0.35)	
Income - PDL Constant Term		0.071 (0.072)
Income - PDL 1st Order Term		-0.0084 (0.0192)
Income - PDL 2nd Order Term		0.0002 (0.0011)
Local Price	-0.25 (0.42)	-0.22 (0.42)
Time	0.069[1] (0.026)	0.036 (0.034)
Adjusted R^2	0.975	0.973

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. F tests on both the price and income PDLs in the second column indicate that they are each significant at the 2% level. The data include 62 monthly observations from July 1986 to August 1991.

Table 2. 2SLS Estimates of Industry Demand Estimates from Quarterly Data

Variable	Immediate Adjustment	Partial Adjustment
Long Distance Price	-0.71^{1}	-0.32^{1}
	(0.07)	(0.10)
Income	0.55^{1}	0.51^{1}
	(0.19)	(0.15)
Local Price	-0.28^{6}	0.11
	(0.15)	(0.15)
Time	0.035^{1}	0.013^{1}
	(0.008)	(0.006)
Lagged Quantity		0.55^{1}
		(0.17)
Autocorrelation	0.48^{1}	
	(0.17)	
Adjusted R^2	0.996	0.998

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The data include 29 quarterly observations from 1986:1 to 1993:1.

current price. These results assume that the quantity demanded adjusts quickly to price changes. The second columns of tables 1 and 2 employ second order PDLs and Koyck lags respectively to estimate long-run demand relationships assuming a more sluggish demand adjustment process. The second column of table 1 accounts for partial adjustment by imposing a twelve month, second order PDL on both price and income. The inclusion of lagged quantity in the second column of table 2 imposes the same exponential decay structure on all regressors. The coefficients of individual lags and the long-run elasticity implied by the second columns of table 1 and 2 are reported in table 3.

All of the coefficient estimates reported in tables 1 and 2, except that for local service in the second column of table 2, have the expected sign. While Hausman, Tardiff and Belefante (1993) find significant cross-elastic effects between long distance prices and local service penetration rates using cross-sectional data, tables 1 and 2 report mixed results on the relationship between local telephone prices and long distance usage. The time trend is always positive and often significant indicating an exogenous outward shift in demand.

Estimated price elasticities are always negative and significant. The long-run elasticity estimate of -0.89 from table 1 (see Table 3) compares with -0.72 reported by Gatto et al. (1988) from OLS estimates of a PDL lag structure using monthly data. Likewise, the estimate of -0.72 from table 2 (see Table 3) compares with -0.63 reported by Taylor and Taylor (1993) from OLS estimates of an exponential decay lag structure using quarterly data. The slightly more elastic estimates reported here could indicate that industry demand has become more elastic or they could reflect a reduction in estimator bias from using a 2SLS procedure.

Table 3. **Lag Elasticity Estimates implied by Partial Adjustment Industry Demand Equations**

PDL Structure Table 1		Exponential Decay Structure Table 2	
Lag 0 Months	-0.150	Lag 0 Quarters	-0.321
Lag 1 Months	-0.133		
Lag 2 Months	-0.117		
Lag 3 Months	-0.102	Lag 1 Quarters	-0.176
Lag 4 Months	-0.088		
Lag 5 Months	-0.075		
Lag 6 Months	-0.062	Lag 2 Quarters	-0.097
Lag 7 Months	-0.051		
Lag 8 Months	-0.040		
Lag 9 Months	-0.030	Lag 3 Quarters	-0.053
Lag 10 Months	-0.021		
Lag 11 Months	-0.013		
Lag 12 Months	-0.006	Lag 4 Quarters	-0.029
Total	-0.888	Total	-0.712

B. *Firm-specific Demand Results*

1. Immediate Demand Adjustment

Table 4 reports 2SLS regression results for the firm-specific demand for AT&T and OCC service, equation (5), using the interstate data.[14] Table 4 does not report estimated state dummy variable coefficients and monthly dummy variable coefficients that account for state level idiosyncracies in supply and demand and seasonal variations. Because Durbin-Wu-Hausman tests always reject OLS results in favor of instrumental variables results, only the latter are reported. The top panel reports direct and reverse regression results for AT&T demand while the bottom panel reports results for OCC demand. The first column reports results from the direct estimation of the market share regressions. The other two columns report reverse regression results when AT&T's market share is an independent variable and, alternatively, AT&T's price or the OCCs' price is the dependent variable. Coefficient estimates from the reverse regressions are not directly reported, but are used to compute parameter estimates comparable to those obtained from the direct regression. Table 4 indicates that the own price coefficient is estimated to be between −5.65 and −7.07 for AT&T demand and between −14.34 and −17.69 for OCC demand.[15]

The regressions reported in table 4 do not include the cost of capital or carrier access prices as instruments. Durbin-Wu-Hausman

[14]While applying a Tobit regression to the first stage to account for possible censoring at the price-cap does change the estimated coefficients in the first stage, the results for the second stage are virtually unchanged.

[15]Conditional own price elasticities, η^C_{ii}, are calculated according to equation (5) as the estimated own price coefficient minus one.

Table 4. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Interstate Data without either Cost of Capital or Carrier Access Price as Instruments**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-5.65^{1} (1.43)	-7.07*	-6.99*
Cross-Price	6.03^{1} (1.44)	7.46*	7.38*
Auto-correlation	0.29^{1} (0.06)	0.28^{1} (0.06)	0.28^{1} (0.06)
Adjusted R^2	.254	.989	.990
OCC DEMAND			
Own-Price	-14.34^{1} (3.50)	-17.69*	-17.51*
Cross-Price	13.43^{1} (3.47)	16.76*	16.57*
Auto-correlation	0.36^{1} (0.06)	0.32^{1} (0.06)	0.33^{1} (0.06)
Adjusted R^2	.123	.988	.989

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 240 observations from January 1988 to December 1991 for five states.

tests suggest that these instruments tend to reintroduce coefficient bias through correlation with the dependent variable. Bias toward zero is confirmed by reverse regression estimates that are always larger (in absolute terms) than those from the direct regression. Also, excluding the cost of capital and carrier access prices reduces the range of the coefficient estimates. This is consistent with these instruments reintroducing correlation between the dependent variables and the error term that increases the size of the bias. Tables B1, B2, and B3 in the appendix report the estimation results when the cost of capital and carrier access prices are included in the instrument set. The lower-bound and upper-bound own-price coefficients for AT&T demand from these four specifications are summarized in the left side of figure 4.

Table 5 reports the results of applying the same estimating procedures to the firm-specific intrastate data. Again, coefficients for state dummy variables and monthly dummy variables that account for state level idiosyncracies in supply and demand and seasonal variations are not reported. While the range of own-price coefficient values increases, the intrastate regression results are quite similar to those from the interstate data. The own price coefficient is estimated to be between −4.66 and −9.17 for AT&T demand and between −16.79 and −27.93 for OCC demand. This suggests that consumers are likely to consider the substitutability of AT&T and OCC services to be similar regardless of their intrastate or interstate distinction. As with the interstate data, Durbin-Wu-Hausman tests reject the cost of capital and carrier access price variables as valid instruments. Also, tables B4, B5, and B6 and the center portion of figure 4 show that the range of parameter estimates shrinks as the cost of capital and carrier access prices are removed from the instrument set.

Figure 4. **AT&T Demand Estimates Assuming Immediate Demand Adjustment from Various Specifications**

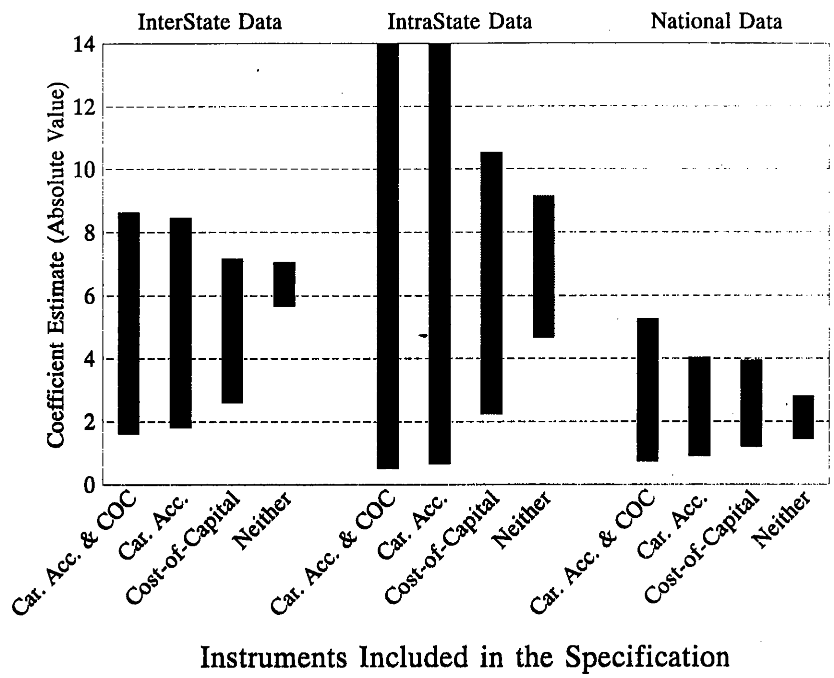


Table 5. 2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Intrastate Data without either Cost of Capital or Carrier Access Price as Instruments

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-4.66[1] (1.77)	-9.17*	-8.81*
Cross-Price	5.53[1] (1.94)	10.45*	10.06*
Auto-correlation	0.55[1] (0.06)	0.56[1] (0.05)	0.55[1] (0.05)
Adjusted R^2	.110	.982	.984
OCC DEMAND			
Own-Price	-16.79[1] (5.64)	-27.93*	-27.26*
Cross-Price	14.46[1] (5.16)	24.67*	24.05*
Auto-correlation	0.54[1] (0.05)	0.55[1] (0.05)	0.54[1] (0.05)
Adjusted R^2	.103	.983	.985

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 230 observations from January 1988 to October 1991 for five states.

Table 6. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from National Data without either Cost of Capital or Carrier Access Price as Instruments**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-1.44^{9} (0.85)	-2.81	-2.48^{*}
Cross-Price	1.90^{3} (0.90)	3.45^{*}	3.10^{*}
Adjusted R^2	.825	.987	.990
OCC DEMAND			
Own-Price	-2.16^{3} (0.98)	-6.56^{*}	-4.76^{*}
Cross-Price	1.20 (0.93)	5.37^{*}	3.66^{*}
Adjusted R^2	.938	.987	.991

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 29 quarterly observations from 1986:1 to 1993:1.

Table 6 reports the firm-specific results from the national data. These data provide only 29 observations from the first quarter of 1986 through the first quarter of 1993. The estimated demand parameters follow a similar pattern as those generated by the interstate and intrastate data with certain differences. First, while F-tests always allow us to reject that all coefficients equal zero, t-tests indicate that few individual coefficient estimates are significantly different from zero at commonly accepted levels. Second, while the range of parameter estimates tends to diminish when cost of capital and the switched access price are excluded from the instrument set (see Tables B7, B8, B9 and the right-side of figure 4), Durbin-Wu-Hausman tests indicate that the differences are not statistically significant (P values are between 0.10 and 0.30). Finally, parameter estimates indicate demand to be substantially less elastic over this time period. Because equal access was much more limited prior to 1988, more consumers likely viewed OCC service as a lower quality alternative to AT&T service. As quality differences diminished, demand likely became more elastic over this sample. This econometric model, however, assumes a constant elasticity over the sample.

Two inferences are drawn from the demand estimations just presented. First, firm-specific demand is rather elastic even if one assumes that the quantity demanded adjusts to price changes immediately. Firm-specific demand elasticities conditional on the upper level budget allocation decision, η^C_{ii}, can be calculated as the own-price coefficient minus one (see equation (5)). For AT&T, lower-bound estimates of this elasticity from the three datasets are -6.65, -5.66, and -2.44. Second, the amount of bias in estimated coefficients is dependent on the choice of instrumental variables. Removing the cost of capital and carrier access measures from the instrument set reduces the range of estimated coefficients and the differences are significant across specifications.

2. Partial Demand Adjustment

Long-run demand coefficients assuming a more sluggish demand response process were estimated by imposing a PDL structure on the lagged price variables. The specifications allow consumers to adjust their purchases up to two years after prices have changed. However, imposing an endpoint restriction for the most distant tail constrains price to have a decreasing impact on purchase decisions as time goes on.[16] Both second and third order polynomials were fitted to the data for both AT&T and the OCCs. All price variables are treated as endogenous and instruments from the immediate demand adjustment estimation are included in the instrument set. As in the results reported above, including the firm-specific cost of capital and carrier access prices in the instrument set is likely to bias PDL coefficient estimates.

The 2SLS estimation procedure can fail to obtain results when the number of endogenous variables increase and the number of instruments decreases. Fewer instruments lead to less independent variation among variables' predicted values from the first stage. This, in turn, leads to colinearity in the second stage that increases the standard errors and, if too severe, can make estimation impossible. Since the PDL estimation now requires two or three endogenous variables to represent the effect of one price, obtaining linearly independent predictions of these variables from the first stage of the 2SLS procedure becomes more difficult. As variables are excluded from the instrument

[16]Across all specifications, this restriction was rarely significant at the ten percent level.

Table 7. 2SLS Lower Level Demand Estimates Assuming Partial Demand Adjustment from Interstate Data

Variable	AT&T 2nd Order PDL	AT&T 3rd Order PDL	OCC 2nd Order PDL	OCC 3rd Order PDL
AT&T Price Constant Term	-0.3799[1] (0.1525)	-0.9423[1] (0.2466)	1.0894[1] (0.3388)	2.3944[1] (0.6402)
AT&T Price 1st Order Term	-0.0357[10] (0.0215)	0.2428[1] (0.0845)	0.0586 (0.0452)	-0.5530[1] (0.2193)
AT&T Price 2nd Order Term	0.0020[1] (0.0007)	-0.0227[1] (0.0063)	-0.0041[1] (0.0015)	0.0502[1] (0.0165)
AT&T Price 3rd Order Term		0.0006[1] (0.0001)		-0.0013[1] (0.0004)
OCC Price Constant Term	0.4131[3] (0.1886)	0.9887[1] (0.2734)	-1.2229[1] (0.4166)	-2.6863[1] (0.7099)
OCC Price 1st Order Term	0.0359 (0.0262)	-0.2921[1] (0.1068)	-0.0512 (0.0551)	0.7097[1] (0.2773)
OCC Price 2nd Order Term	-0.0021[1] (0.0008)	0.0281[1] (0.0079)	0.0040[2] (0.0017)	-0.0654[1] (0.0205)
OCC Price 3rd Order Term		-0.0007[1] (0.0002)		0.0017[1] (0.0004)
Adjusted R^2	0.764	0.794	0.567	0.610

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. State dummy variable coefficient estimates are not reported. The data include 240 observations from January 1988 to December 1991 for five states.

set, the likelihood of linear dependence between these variables increases. In fact, linear dependence precluded estimation when both the cost of capital and carrier access prices were excluded from the instrument set.

Table 7 reports PDL regression results using the interstate data when the cost of capital, but not the carrier access prices, was included in the instrument set. Since price variables were represented by PDL structures, the instrumental variables were replaced with their PDLs corresponding to the price variables. Again, state dummy variables were included to account for idiosyncracies in supply and demand.[17] In most cases, we can reject that individual coefficients from the PDL procedures are not significantly different from zero. In all cases, F tests reject the joint hypothesis that all coefficients in a PDL structure are zero at a high confidence level. Table 8 and figures 5 and 6 present the individual lag coefficients implied by the PDL estimates. While the lag structure differs considerably between the second and third order specification, the implied long-run elasticities are quite similar. The estimates for AT&T are -10.23 and -9.78, while those for the OCCs are -26.31 and -25.93.[18] That is, a one percent permanent price increase by AT&T, while the OCCs' prices remained constant, would lead over the following two years to about a ten percent reduction in the amount of its output demanded.

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[17]Data limitations prohibited estimation using the intrastate data or the national data.

[18]Unreported reverse regressions imply upper-bound long-run elasticities between -23 and -32 for AT&T and for between -54 and -64 for the OCCs.

Table 8. **Implied Lag Values from Firm Demand Estimates Assuming Partial Demand Adjustment**

	AT&T 2nd Order		AT&T 3rd Order		OCC 2nd Order		OCC 3rd Order	
	Coef.	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Lag 0	-0.380[1]	(0.15)	-0.942[1]	(0.25)	-1.223[1]	(0.42)	-2.686[1]	(0.71)
Lag 1	-0.414[1]	(0.14)	-0.722[1]	(0.19)	-1.270[1]	(0.38)	-2.040[1]	(0.50)
Lag 2	-0.443[1]	(0.13)	-0.543[1]	(0.15)	-1.309[1]	(0.34)	-1.515[1]	(0.38)
Lag 3	-0.469[1]	(0.12)	-0.403[1]	(0.13)	-1.340[1]	(0.31)	-1.101[1]	(0.35)
Lag 4	-0.490[1]	(0.11)	-0.297[3]	(0.14)	-1.364[1]	(0.29)	-0.787[4]	(0.39)
Lag 5	-0.508[1]	(0.11)	-0.224	(0.16)	-1.378[1]	(0.27)	-0.565	(0.46)
Lag 6	-0.521[1]	(0.10)	-0.178	(0.17)	-1.386[1]	(0.26)	-0.424	(0.52)
Lag 7	-0.530[1]	(0.10)	-0.157	(0.19)	-1.385[1]	(0.25)	-0.354	(0.57)
Lag 8	-0.535[1]	(0.10)	-0.157	(0.20)	-1.376[1]	(0.24)	-0.346	(0.61)
Lag 9	-0.536[1]	(0.10)	-0.174	(0.20)	-1.359[1]	(0.24)	-0.389	(0.63)
Lag 10	-0.533[1]	(0.10)	-0.205	(0.21)	-1.334[1]	(0.24)	-0.473	(0.64)
Lag 11	-0.526[1]	(0.10)	-0.247	(0.21)	-1.301[1]	(0.23)	-0.590	(0.63)
Lag 12	-0.515[1]	(0.10)	-0.297	(0.20)	-1.260[1]	(0.23)	-0.728	(0.61)
Lag 13	-0.500[1]	(0.10)	-0.349[8]	(0.20)	-1.211[1]	(0.23)	-0.878	(0.59)
Lag 14	-0.481[1]	(0.09)	-0.402[3]	(0.19)	-1.155[1]	(0.22)	-1.030[6]	(0.55)
Lag 15	-0.457[1]	(0.09)	-0.452[2]	(0.18)	-1.090[1]	(0.22)	-1.174[2]	(0.52)
Lag 16	-0.430[1]	(0.09)	-0.495[1]	(0.17)	-1.017[1]	(0.21)	-1.301[1]	(0.48)
Lag 17	-0.399[1]	(0.08)	-0.527[1]	(0.16)	-0.936[1]	(0.19)	-1.399[1]	(0.44)
Lag 18	-0.363[1]	(0.08)	-0.546[1]	(0.15)	-0.847[1]	(0.18)	-1.460[1]	(0.40)
Lag 19	-0.323[1]	(0.07)	-0.548[1]	(0.14)	-0.750[1]	(0.16)	-1.473[1]	(0.36)
Lag 20	-0.280[1]	(0.06)	-0.529[1]	(0.12)	-0.645[1]	(0.14)	-1.429[1]	(0.31)
Lag 21	-0.232[1]	(0.05)	-0.485[1]	(0.11)	-0.532[1]	(0.12)	-1.318[1]	(0.27)
Lag 22	-0.180[1]	(0.04)	-0.414[1]	(0.09)	-0.411[1]	(0.10)	-1.129[1]	(0.22)
Lag 23	-0.124[1]	(0.03)	-0.312[1]	(0.06)	-0.282[1]	(0.07)	-0.853[1]	(0.16)
Lag 24	-0.064[1]	(0.02)	-0.175[1]	(0.03)	-0.145[1]	(0.04)	-0.480[1]	(0.09)
Total	-10.233[1]		-9.780[1]		-26.305[1]		-25.925[1]	

Figure 5. Estimated AT&T Lag Coefficients

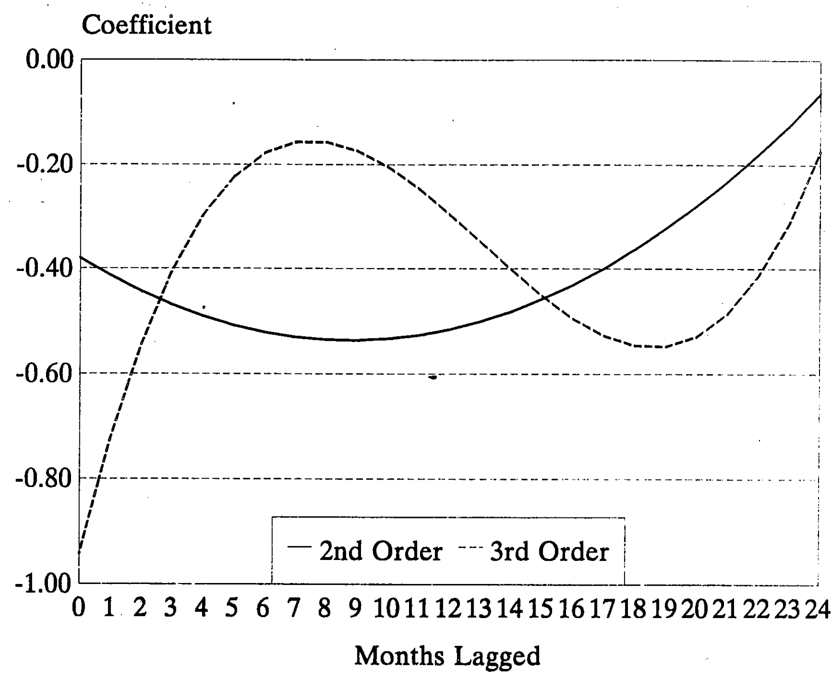
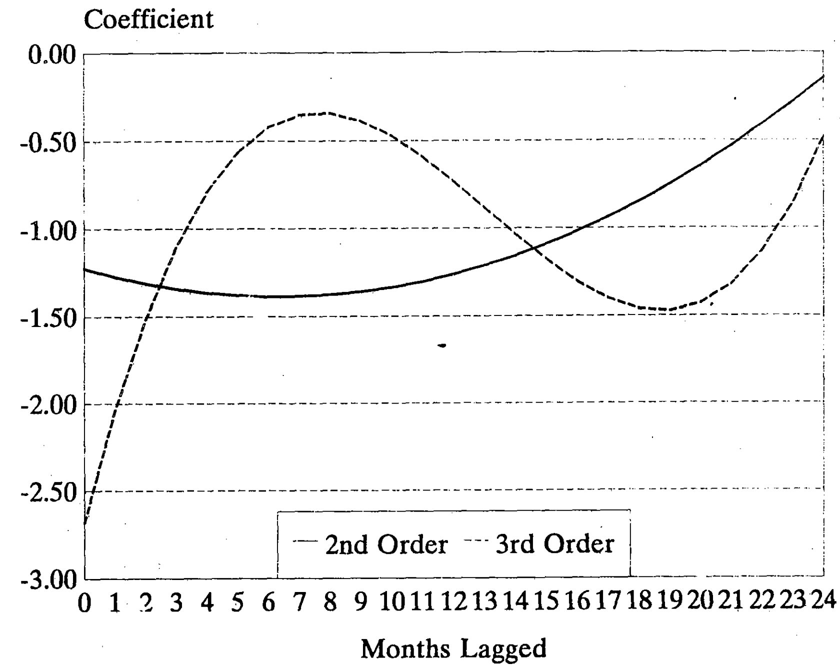


Figure 6. Estimated OCC Lag Coefficients



C. *Unconditional Firm-specific Demand Elasticities*

Firm-specific own price estimates should be interpreted as one plus the demand elasticity conditional upon the upper level budget allocation decision. Unconditional firm specific demand elasticities can be recovered from these estimates via equation (3) above. The immediate adjustment elasticities reported in table 9 assume an industry demand elasticity of −0.50 (from table 1), while the partial adjustment elasticities assume an industry demand elasticity of −0.70.[19] Average revenue market shares are computed from the regional data as 0.647 for AT&T and 0.239 for the OCCs.[20]

The top panel of table 9 compares immediate adjustment estimates from the different datasets while the lower panel compares second and third order PDL estimates using the interstate regional data. Despite certain differences, immediate adjustment demand estimates tend to be consistent across datasets. The intrastate data yields more elastic demand estimates than the interstate data (with the exception of the lower bound estimate for AT&T's own price elasticity), while the national data yields less elastic demand. As mentioned earlier, the lower elasticities from the national data could arise because the underlying data include observations where the technical differences between AT&T and the OCCs services were more pronounced. In the partial adjustment demand estimations, individual lag estimates differ depending on the order of the PDL assumed (table 8, figures 5 and 6), however table 9 indicates that the long-run demand estimates do not.

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[19]The elasticity values reported in table 9 are slightly conservative because the industry elasticity values are toward the low end of those reported.

[20]These do not sum to one because the OCC shares exclude long distance companies other than MCI and Sprint.

Table 9. Unconditional Own-Price Elasticities

	Lower-bound		Upper-bound	
	AT&T	OCC	AT&T	OCC
Assuming Immediate Adjustment				
Interstate Regional Data	-6.33	-15.22	-7.75	-18.39
Intrastate Regional Data	-5.34	-17.67	-9.85	-28.81
National Data	-2.02	-3.04	-3.16	-7.44
Assuming Partial Adjustment				
Second Order PDL	-10.59	-26.83	-32.40	-64.25
Third Order PDL	-10.14	-25.43	-32.04	-63.77

Unconditional demand elasticities are computed using equation (3). The immediate and partial adjustment industry elasticities are assumed to be -0.50 and -0.70 respectively. Upper-bound estimates are the largest statistically significant elasticities implied by reverse regressions.

The general results of the demand estimation is that AT&T's remaining market power is not extensive. Consumers apparently consider OCC and AT&T service to be good substitutes and many are willing to switch carriers when they observe cost advantages. Measuring the welfare effects of AT&T's remaining market power is the focus of the following section.

VI. DEADWEIGHT LOSS CALCULATIONS

The Lerner indices implied by the firm-specific demand elasticity estimates allow some conclusions to be drawn regarding the level of competition in long distance services. First, the estimated long-run OCC demand elasticities are so large (at least −25) that the OCCs earn no or minimal monopoly rents. This finding supports the assumption that AT&T conjectures that changing its price will not cause the OCCs to adjust their prices (independent of a common change in costs). Second, the lower-bound long-run AT&T demand elasticities estimates imply upper-bound price-cost margins of slightly less than 10% during the 1988-1991 time period; upper-bound elasticities imply 3% price-cost margins. The deadweight loss to society implied by these price-cost margins ranges between an upper-bound of 0.36% and a lower-bound of 0.03% of industry revenues ($199 million and $17 million in 1991). Third, because the level of competition has increased since the time of the data, these estimates are likely to overestimate the current deadweight loss.

It is likely that competition in the long distance industry is keeping OCC prices no more than slightly above marginal costs. The lower-bound long-run elasticity estimate of −25 implies a Lerner index of 0.04. That is, if the OCCs were to make price and output decisions jointly in order to maximize combined profits, they could set prices so that monopoly rents would represent 4% of the total price. However, it is implausible that the OCCs maximize joint profits. Rather, the large and increasing number of firms suggests that these firms are aggressively competing away these rents. An individual OCC's price elasticity is likely to be much greater than −25, allowing it to sustain a price markup over marginal cost of much less than 4%. It follows that these firms would not be likely to follow a price increase on the part of AT&T unless it was caused by an increase in costs common to all firms. This supports the assumption that AT&T conjectures that the OCCs will adjust prices only minimally when it changes its price, *ceteris paribus*.

The potential deadweight loss from supra-competitive pricing by AT&T can be calculated as the area bordered by the demand curve, marginal cost curve and the current output. The long-run demand elasticity is appropriate for inferring price-cost margins via the Lerner index. Increased revenue that accrues to the firm in the future due to a current price change is included as marginal revenue and the Lerner index is derived from the assumption that marginal revenue is equated with marginal cost. The economic profits, output times the difference between price and marginal cost, could also be considered losses to society if that amount is expended to perpetuate the entry barrier creating the rents (Posner (1975)). This is likely not the case here since regulators are taking significant steps to introduce competition to the long distance market. Given this regulatory predilection, the return to this sort of rent seeking by AT&T should be quite low. If so, the deadweight loss can be calculated simply as $DWL = \int_{MC}^{P_0} [Q(p) - Q(P_0)]\, dp$, assuming constant marginal costs. With constant elasticity, the inverse demand is given by $Q(p) = Q_0(p/P_0)^{\eta}$. The resulting deadweight loss as a fraction of current revenue is $DWL/REV = [1-(1-L)^{1+\eta}]/(1+\eta) - L$ where L is the Lerner index.

Table 10. **Potential Deadweight Loss as a Percent of Current Revenues under Various Price Markup Assumptions and a -0.70 Long-run Industry Demand Elasticity**

$\frac{P_0 - MC}{P_0}$	$\frac{DWL}{REV}$
0.35	5.41
0.30	3.83
0.25	2.81
0.20	1.58
0.18	1.27
0.16	0.99
0.14	0.75
0.12	0.54
0.10	0.37
0.09	0.30
0.08	0.24
0.07	0.18
0.06	0.13
0.05	0.09
0.04	0.06
0.03	0.03
0.02	0.01
0.01	0.00

While firm-specific elasticities are appropriate for generating estimates of the Lerner index, the industry elasticity is the relevant elasticity for calculating the deadweight loss. If the OCCs were able to match the hypothetically lower AT&T prices set at long-run marginal cost, then the deadweight loss applies to the whole industry. This would be the case if AT&T were providing a price umbrella over an industry in which all firms had similar nondecreasing cost functions. If instead, AT&T can operate at lower long-run marginal cost than the OCCs, then it would capture the entire market with prices at long-run marginal cost. In this case the firm demand elasticity is the industry demand elasticity.

Table 10 reports the ratio of potential deadweight loss to revenue for various price-marginal cost margins assuming an industry demand elasticity of −0.70. The Lerner indices for AT&T calculated from the long-run elasticity estimate range from 0.031 to 0.099. The ratio of deadweight loss to industry revenue implied by these indices are 0.03% and 0.36% respectively. These estimates are much lower than the range of the current economy-wide estimates of deadweight loss due to market power of 0.5% to 2.0% of GNP (Scherer and Ross (1990), pp. 663-667).

If this market is currently more competitive than during the 1988-1991 period, then these estimates will overstate the current potential deadweight loss due to supra-competitive pricing. The evidence of a more competitive market includes: 1) the fall in AT&T's market share from a national average of 67% during the sample period to 60% currently, 2) the introduction of 800 number portability, and 3) the increase in the number of foreign countries reached by OCC networks.

An alternative representation of the Lerner index is $L^{ATT} = S^{ATT}/[|\eta^{LD}| + \theta^{OCC}(1-S^{ATT})]$ where S^{ATT} is AT&T's market share and θ^{OCC} is the OCC supply elasticity (Landes and Posner (1981)). With values of L^{ATT}, S^{ATT} and η^{LD} of 0.099, 0.67 and -0.70 respectively, θ^{OCC} becomes 18.4. This implies that the OCCs would be willing to increase their output by about 18% at prices 1% higher than current prices. Assuming an OCC supply elasticity of 18.4, the reduction in AT&T's market share from 67% to 60% alone would reduce the Lerner index from 0.099 to 0.074 and the potential deadweight loss from 0.36% to 0.20% of revenue. Portability of 800 numbers and increased international access by the OCCs will tend to increase θ^{OCC} as the OCCs are better able to provide substitutes for AT&T's services. If, in addition to the fall in AT&T's market share, the OCC supply elasticity has increased from 18.4 to 20.0, AT&T's Lerner index would decrease from 0.074 to 0.069 and the potential deadweight loss would decrease from 0.20% to 0.17% of revenue.

To be sure, even the upper-bound estimate of the potential deadweight loss from supra-competitive pricing, 0.36% of long distance industry revenue, represents $199 million in 1991, no small sum. By contrast, the 0.03% estimate using the largest elasticities represents only $17 million per year. However, the magnitude of concern that should accompany this deadweight loss estimate depends on a comparison between the benefits and costs of price regulation. Under perfect price regulation (an admittedly unattainable goal), AT&T's prices would be equal to marginal costs and the elimination of the entire deadweight loss would be the benefit. Imperfect regulation that allowed AT&T to set prices midway between marginal cost and the profit maximizing price level would eliminate about three-quarters of the potential deadweight loss.[21]

The welfare costs due to price regulation of AT&T might be gauged by referring to studies of past deregulatory actions.[22] Mathios and Rogers (1989, 1990) and Kaestner and Kahn (1990) found that AT&T prices were 7% lower in states that use price-cap incentive regulation compared to traditional rate-of-return regulation. This effect presumably occurred, at least in part, because the less restrictive regulatory structure induced cost reductions. Supply estimates reported in appendix A provide some evidence that the movement to price-caps from rate-of-return regulation reduced AT&T's long distance prices by approximately 1.6%. Olley and Pakes (1992) find that competition spurs telecommunications manufacturing plants to become more efficient. Ying and Shin (1993) found that the local telephone companies' costs fell due to the divestiture of AT&T. Crandall (1991) estimates that telephone industry costs would have been $3.5 billion (10%) higher in 1988 without the introduction of competition in telecommunications. Kwoka (1993) estimates that each percentage point decrease in AT&T's market share has led to a more than one-third percent (0.36%) improvement in productivity. Since these productivity increases provide continuing benefits into the future, seemingly small improvements quickly become substantial cost savings.

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[21]The resulting upper-bound estimate of the benefit from regulation would be 0.27% of industry revenues or $150 million per year (the lower-bound estimate would be 0.02% of industry revenues or $13 million per year).

[22]Direct estimates of the potential efficiency gains associated with replacing price-caps with a more deregulatory framework are not available.

As mentioned in the introduction, several Bell Operating Companies (BOCs) have argued that their entry into the long-distance market would lead to more vigorous competition that would reduce long-distance price-cost margins. This study provides evidence on the level of current competition and current price-cost margins in the long-distance industry. If BOC entry caused prices to fall to marginal cost, they would completely eliminate the deadweight loss and the welfare gain would be between $17 million and $199 million per year. However, if the BOCs are correct in their assessment that regulatory safeguards effectively protect against cross-subsidization and discrimination, the social costs of BOC entry could be small. Moreover, it is possible that some BOCs may have lower costs for some routes because of economies of scope with their existing networks.

VII. CONCLUSION

This study estimates demand relationships in the long distance telecommunications market over the 1986 to 1993 period and interprets them in terms of potential welfare losses due to supra-competitive pricing. The estimates of industry demand elasticity are similar to those reported elsewhere. The prices of key inputs explain much of the variation in output prices and these are taken to be valid instruments for demand estimation. Estimates of firm-specific demand elasticities assuming immediate demand adjustment are fairly high; lower-bounds are about −5.3 to −6.3 for AT&T and about −15.2 and −17.6 for the OCCs. Lower-bound demand elasticity estimates assuming a more sluggish demand adjustment process are about −10 for AT&T and −25 for the OCCs. Price-cost margins are inferred from these estimates via the Lerner index from which the potential deadweight loss due to supra-competitive pricing is calculated. Estimates of this potential loss appear to vary between 0.03% and 0.36% of industry revenue ($17 million to $199 million per year).

The above analysis provides new information on the question of whether further deregulation of AT&T is likely to be efficient. As stated in the introduction, regulation yields benefits when it limits deadweight losses due to supra-competitive pricing while it imposes costs when it reduces productive efficiency. In the early 1980s, competition may have been insufficient to constrain AT&T prices to long-run marginal cost. In the intervening decade, competitive pressures on AT&T increased substantially. This paper estimates that, for the 1988 to 1991 period, competition constrained the potential deadweight loss from supra-competitive prices to between 0.03% and 0.36% of total revenues. Competitive pressures continue to mount and it is likely that the potential deadweight loss currently is smaller.

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APPENDIX A

Instrumental Variables Issues

One of the critical assumptions underlying ordinary least squares (OLS) regression analysis is that all of the regressors are uncorrelated with the error term. If the statistical independence assumption is violated, the OLS parameter estimates are biased and inconsistent. In demand estimation, a frequent cause of statistical dependence is that observed prices incorporate the influences of both supply and demand. Because prices and quantities are market equilibrium values reflecting all factors that influence either demand or supply, observed quantities and prices will be correlated with the random influences on either demand or supply. Thus, industry price, one of the regressors in the industry demand equation (4),

$$\log Q_t^{LD} = \eta^{LD} \log P_t^{LD} + \epsilon \log Income_t + \eta^{Loc} \log P_t^{Loc} + \alpha_0 \, time + \omega_t, \tag{4}$$

and the firms' prices in the firm demand equation (5),

$$\log\left[\frac{P_{kt}^1 Q_{kt}^1}{Y_{kt}^{LD}}\right] = (1+\eta_{11}^C) \log P_{kt}^1 + \eta_{12}^C \log P_{kt}^2 + \mu_{kt}^1, \tag{5}$$

will depend on the error terms, ω_t and μ_{kt}^l, which represent the random effects on industry and firm demand. The prices and the error terms in each equation are likely to be correlated making OLS parameter estimates biased and inconsistent.

This problem, of endogenous explanatory variables, can also be thought of as part of the broader problem of "measurement error," that is, of the divergence between the data being observed and the variables being modeled. For example, in demand estimation, the relevant price variable is the price that would prevail if the demand curve did not shift, i.e., $\omega_t = \mu^I_{kt} = 0$. To the extent that the observed price is affected by a shifting demand curve (i.e., $\omega_t \neq 0$, $\mu^I_{kt} \neq 0$) through the process of market equilibrium, it is measured with "error." Measurement error in explanatory variables implies correlation between the observed explanatory variables and the error term, resulting in biased coefficient estimates from OLS regressions. The direction and magnitude of the bias is a function of various coefficients and correlations between variables.[A1] In equation (5), coefficient bias can result from measurement error in both the own and competitor prices. Since AT&T and OCC prices are positively correlated and the cross-elasticity has the opposite sign as the own-elasticity, the measurement error in either price will bias own-elasticity estimates upward (toward zero). Likewise, measurement error in either of these prices will tend to bias cross-elasticities down (toward zero).

Two general methods of dealing with measurement error are instrumental variables and reverse regressions. The instrumental variables method brings other information to bear in order to recover estimates that are consistent. This method attempts to purge endogenous explanatory variables of their correlation with the error term. Reverse regressions, on the other hand, simply attempt to put bounds on the magnitude of the bias. These regressions switch the dependent and

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[A1]Measurement error in a variable will tend to bias its own coefficient toward zero. If there are other variables in the equation, the same measurement error will tend to bias the coefficient of another variable in the direction of the product of the correlation between the two variables and the coefficient of the variable with measurement error (Maddala (1988) pp. 388-391).

independent variables to generate estimates biased above and below the true parameter value.

The Instrumental Variables Methods

Since price and quantity are jointly determined, observed prices represent a mixture of demand and supply relationships. Disentangling demand relationships from supply relationships empirically requires a technique that can distinguish between shifts in the supply curve (movements along the demand curve) and movements along the supply curve (shifts in the demand curve). Price and quantity pairs associated solely with shifts in the supply curve, for instance, will trace out a demand curve whose slope (or elasticity) can now be estimated. One method for identifying shifts in the supply curve is to use variables that represent the cost of production. The price level that is predicted by these variables would not depend on demand, but instead would reflect only changes in the cost of production. The predicted price is independent of the error term in the demand equation. Thus, when this predicted price replaces observed price as a regressor in the demand equation, the resulting OLS demand estimates are unbiased and consistent. In such an application of the instrumental variables technique, the variables representing the cost of production are called the instrument set.

The ability of instrumental variable methods to obtain meaningful demand parameters depends on the ability to find suitable instrumental variables for the endogenous price. The two general requirements are that the instrumental variables be independent of the error term in the demand equation and that they be correlated with the endogenous variable. First, instrumental variables that are themselves functions of the output level will create interdependence between the predicted price and the output level and, thus, between the predicted price and the error term. This reintroduces the problem for which instrumental variables were sought in the first place. Second, correlation between the instrumental variables and price insures that they "explain" some of the variation in the price. That is, they must represent enough of the shifting in the supply curve to provide significant movement along the demand curve. Better predictions of the shifts in the supply curve provide more precise (i.e., smaller variance) estimates of the shape of the demand curve.

Two-staged Least Squares (2SLS) is the particular instrumental variables technique employed in this study. In 2SLS, the endogenous variables in the demand relation are first regressed against the variables in the instrument set using OLS. The values of the endogenous variables predicted by this first stage, rather than the actual values, are then used to estimate the demand relation in the second stage. If the instruments are independent of the error terms, ω_t and μ_{kt}^{l}, then the predicted values of the endogenous variables from the first stage will also be independent of the error terms. Thus, OLS estimates of the demand relation using these predicted values will be unbiased and consistent.

A test of bias due to errors in variables can be conducted when instrumental variables are employed. The Durbin-Wu-Hausman test (Hausman (1978)) compares the parameter estimates from two different specifications of a regression model. If the estimates are sufficiently different (in a statistical sense), the specification that relies on the stronger assumptions regarding the data is rejected. In the present context, the assumption that the errors in the variables do not lead to biased estimates (implicit in ordinary least squares (OLS) results) is stronger than the assumption that they might (implicit in instrumental variables results). A Durbin-Wu-Hausman test can also compare parameter results from two different instrumental variable specifications where the instrument sets are different.

Reverse Regressions

It is possible to place bounds on the true parameter by reversing the direction of the regression. Regressing Y on X when both are measured with error yields a coefficient biased toward zero. Similarly, regressing X on Y will also yield a coefficient biased toward zero. However, the reciprocal of the coefficient of Y from the second regression provides an alternative estimate of the coefficient of X from the first regression. This reciprocal will be biased upward and provides an upper-bound on the true parameter,

$$|plim\ \hat{\beta}| < |\beta| < |plim\ 1/\hat{\gamma}|$$

where $\hat{\beta}$ is the estimated coefficient of X in the direct regression, $\hat{\gamma}$ is the estimated coefficient of Y in the reverse regression and β is the true parameter value. This procedure generalizes to multivariate regressions and generates a set of estimates that bound the true parameter value (Klepper and Leamer (1984)). Parameter estimates from reverse regressions are maximum likelihood estimates, and the set of parameter values bounded by these estimates contains the true parameters. As discussed in the previous section, instrumental variable methods, in principle, yield consistent parameter estimates. Yet, because instrumental variable methods may still yield biased coefficient estimates if the instruments themselves are functions of output, reverse regressions can provide additional information about the size of any remaining bias.

Instrumental Variables Used in the Study

The constructed firm-specific long distance prices discussed in section IV.B. are likely to contain errors due to both supply and demand simultaneity and possibly incorrect assumptions inherent in their construction. Instrumental variables are required to predict supply prices and purge measurement errors. Moreover, in order to estimate firm-specific price elasticities, which are necessary to assess these firms' market power, instruments are required that shift the supply curve for a particular firm but not the supply curves for other firms. Factor prices could be suitable instrumental variables if they are unique to each firm. If, however, a factor represents a commodity good to all firms (e.g., raw materials), then changes its price will distinguish firm-specific output price changes only to the extent that firms use the factor in different proportions.

Two firm-specific factor prices are the cost of capital and the average prices of carrier access. In the firm-specific estimations, these factor prices are added to the set of instrumental variables used in the industry level (PPI indices for transmission and digital switching equipment, and the BLS telecommunication worker average wage). While both the cost of capital and the carrier access factor prices should be correlated with the supply price, they also may be correlated with demand, which would reintroduce some correlation between the error term and the dependent variables estimated via instruments.

Measures of the cost of debt are derived from Moody's yield to maturity calculations on outstanding debt for each of the largest three long distance companies. A bond's yield to maturity is deflated by the yield to maturity for a similarly lived government bond in order to adjust for changes in expected inflation. Finally, a firm's outstanding bonds are aggregated into a single yield to maturity using their face value as weights. Since the firms in this industry are relatively capital intensive, changes in the cost of capital are likely to represent nontrivial changes in long-run marginal costs. With less than perfect competition (i.e. residual demand less than perfectly elastic), these changes in marginal cost will lead to changes in output price. However, the cost of capital depends largely on the riskiness of the firm borrowing the funds. Since riskiness of a firm may be related to its size, using firm-specific cost of capital measures as instruments could reintroduce correlation between the error term and the dependent variables. In the long distance market, AT&T's capital costs reflect a relatively low risk firm, while MCI pays a relatively high, but declining, interest rate on its junk bond debt. Moreover, since AT&T's market share has been falling over time, if the cost of capital measures include a time trend component, they could reintroduce bias in coefficient estimates.

Carrier access prices also should be highly correlated with long distance price, but they also likely are correlated with output and, thus, the error term. Firms differ in their carrier access purchases mainly because of the degree to which they integrate into the distribution of telephone calls. When a sufficient volume of calling for a long distance company originates or terminates in a particular area, the long distance company will extend its network into the area and thus reduce its purchase of access from the local telephone company.[A2] Thus, average

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[A2]Long distance companies typically terminate their networks near the centers of metropolitan areas. Calls to and from outlying areas are transported to the long distance network by local telephone company at a charge that increases with distance. When the volume of traffic for the outlying area develops sufficiently, a long distance company will extend (continued...)

switched access prices will depend on the location and the calling patterns of a long distance company's customers. More geographically concentrated customers and calls will lead to more backward integration, lower expenditures for switched access per unit of output. Likewise, average special access prices tend to be lower in areas of more densely located customers and calls because less costly, higher capacity lines can be used. Changes in carrier access rates are highly correlated with long distance prices, explaining much of the decreases in prices (Taylor (1991)). However, carrier access prices tend to fall as more is demanded (Parsons and Ward (1993)). Thus, using carrier access prices as instruments may bias coefficient estimates in the demand equation.

Some Tests of the Instrumental Variables

While the focus of this paper is on demand estimation, one way to evaluate the effectiveness of the demand instruments is to estimate supply relationships.[A3] This analysis can also provide an estimate of the effect of price-cap regulation on AT&T's costs. Price-caps, which replaced rate-of-return as the regulatory scheme for AT&T midway through the sample, may provide AT&T stronger incentives to reduce costs (Liston (1993)). In general, the supply curve is expected to be quite elastic given the relatively large fixed costs relative to variable

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[A2](...continued)
its network to the area. This occurs when the cost savings from reduced expenditures on local telephone company transport is greater than the cost of extending the network.

[A3]Actually, the supply curve concept does not apply to firms in which prices reflect both marginal costs and a price-cost margin. The aim here is not necessarily to estimate a supply curve, but to examine the degree to which the cost instruments "explain" price changes.

costs in the industry.[A4] The effect of factor input prices on output price are estimated with the firm specific interstate data using the equation,

$$\log P_{kt} = \psi\, cap_{kt} + \theta \log Q_{kt} + \sum_{l \in L} \phi_l \log w_{kt}^{l} + \sum_{\kappa=1}^{5} \beta_\kappa state_{kt}^{\kappa} + \nu_{kt}. \quad (6)$$

Cap is a dummy variable whose value is one during the time that AT&T was regulated under the price-cap regime as opposed to the rate-of-return regime. The w^ls, the factor input prices, are the PPI indices for transmission and digital switching equipment, the BLS average wage for telecommunications workers, the yield to maturity on corporate bonds, and the average prices for switched and special access. Differences across states are accounted for with dummy variables for each state. Income and month dummy variables are the only instruments available for quantity demanded, Q_{kt}.[A5]

Estimation results for equation (6) are reported in table A1. First, as expected, supply curves appear to be flat: the estimated coefficients on minutes of use are small and statistically indistinguishable

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[A4]In fact, Huber et al. (1993) contend that, because of fiber optic scale economies, the industry is developing into a natural oligopoly.

[A5]Price-cap regulation of AT&T could render its supply price censored at the price-cap, suggesting that Tobit estimates of equation (6) are more appropriate. As mentioned above, for Basket 1 services, AT&T's price was at its cap about one-third of the time that price-cap regulation was in effect. Also, periods in which the cap was binding are possibly the result of regulatory delay. Since, in these cases, the price cap may actually be a floor and not a ceiling, attempts to account for censoring are not reported.

Table A1. 2SLS Estimates of "Supply" Price Equations

Variable	AT&T Price	OCC Price
Price Cap	-0.016[1]	-0.007
	(0.006)	(0.007)
Minutes of Use	-0.048	-0.040
	(0.039)	(0.037)
Price of Switching Equipment	0.189[3]	0.117
	(0.087)	(0.093)
Price of Transmission Equipment	0.368[1]	0.717[1]
	(0.112)	(0.094)
Telecommunications Workers Wage	0.301[5]	0.054
	(0.151)	(0.129)
Yield to Maturity on Corporate Bonds	0.048	0.503[5]
	(0.404)	(0.256)
Price of Switched Access	0.131[1]	0.194[1]
	(0.022)	(0.021)
Price of Special Access	0.081[1]	0.049[1]
	(0.020)	(0.008)
First-Order Autocorrelation	0.789[1]	0.762[1]
	(0.040)	(0.042)
Adjusted R^2	.970	.977

Standard errors are in parentheses and superscripts denote significance levels for a two-tailed test if less than 10%. Not reported are coefficients of state dummy variables. The data include 240 observations from January 1988 to December 1991 for five states.

from zero. Still, coefficient estimates not significantly different from zero are likely due to the meager instruments available for the quantity demanded. Indeed, the negative coefficients for minutes of use could be a demand relationship picked up because both output and income, an instrumental variable, are correlated through a time trend in both variables. Second, there is evidence that the institution of price-cap regulation lowered AT&T's costs. The price-cap coefficient is negative for both AT&T and the OCCs but is significant for AT&T only. This conforms to the hypothesis that price-cap regulation is a more efficient form of regulation for long distance-telephone service and with other empirical results (Mathios and Rogers (1989, 1990), Kaestner and Kahn (1990)). Since the OCCs are not subject to regulation, the only effect of price-cap regulation on their prices would be through more vigorous competition with a more cost-efficient AT&T.

The third result is that the industry-wide and firm-specific factor input prices are relatively good explanatory variables for the price of long distance service. Increases in the prices of inputs common to all firms -- switching equipment, transmission equipment and labor -- increase the output price for both AT&T and the OCCs, with coefficient magnitudes and confidence levels differing across firms. The yield to maturity on corporate bonds is significant only for the OCCs. This result is reasonable since much of MCI's debt is in the form of junk bonds whose prices are relatively more variable. Note also that the estimated coefficients of switched and special access prices are all positive and significant. The estimated standard errors are quite small, indicating that these input prices should be good proxies for firm-specific shifts in supply, which are needed in the demand estimation.

APPENDIX B

Table B1. 2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Interstate Data with both Cost of Capital and Carrier Access Price as Instruments

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-1.16[1] (0.31)	-8.64*	-7.44*
Cross-Price	1.44[1] (0.31)	9.06*	7.86*
Auto-correlation	0.39[1] (0.06)	0.28[1] (0.06)	0.28[1] (0.06)
Adjusted R^2	.774	.989	.990
OCC DEMAND			
Own-Price	-5.34[1] (1.06)	-18.48*	-16.55*
Cross-Price	4.50[1] (1.05)	17.51*	15.57*
Auto-correlation	0.57[1] (0.05)	0.32[1] (0.06)	0.33[1] (0.06)
Adjusted R^2	.523	.988	.989

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 240 observations from January 1988 to December 1991 for five states.

Table B2. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Interstate Data without Cost of Capital as Instrument**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-1.80[1] (0.44)	-8.48*	-7.45*
Cross-Price	2.16[1] (0.45)	8.89*	7.87*
Auto-correlation	0.42[1] (0.06)	0.28[1] (0.06)	0.28[1] (0.06)
Adjusted R^2	.734	.989	.990
OCC DEMAND			
Own-Price	-5.66[1] (1.14)	-16.93*	-17.51*
Cross-Price	4.81[1] (1.13)	15.95*	16.57*
Auto-correlation	0.53[1] (0.05)	0.32[1] (0.06)	0.33[1] (0.06)
Adjusted R^2	.499	.989	.989

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 240 observations from January 1988 to December 1991 for five states.

Table B3. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Interstate Data without Carrier Access Price as Instrument**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-2.59[1] (0.58)	-7.17*	-6.65*
Cross-Price	2.94[1] (0.58)	7.58*	7.06*
Auto-correlation	0.39[1] (0.06)	0.28[1] (0.06)	0.28[1] (0.06)
Adjusted R^2	.643	.989	.990
OCC DEMAND			
Own-Price	-7.99[1] (1.52)	-15.85*	-15.07*
Cross-Price	7.11[1] (1.54)	14.91*	14.12*
Auto-correlation	0.48[1] (0.06)	0.34[1] (0.06)	0.34[1] (0.06)
Adjusted R^2	.282	.988	.989

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 240 observations from January 1988 to December 1991 for five states.

Table B4. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Intrastate Data with both Cost of Capital and Carrier Access Price as Instruments**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-0.50 (0.34)	-26.93	-15.10
Cross-Price	0.99^{1} (0.38)	29.85^{*}	16.96^{*}
Auto-correlation	0.62^{1} (0.05)	0.56^{1} (0.05)	0.28^{1} (0.06)
Adjusted R^2	.832	.984	.984
OCC DEMAND			
Own-Price	-5.29^{1} (1.24)	-31.38^{*}	-26.51^{*}
Cross-Price	3.93^{1} (1.13)	27.83^{*}	23.32^{*}
Auto-correlation	0.66^{1} (0.05)	0.55^{1} (0.05)	0.54^{1} (0.05)
Adjusted R^2	.586	.984	.985

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 230 observations from January 1988 to October 1991 for five states.

Table B5. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Intrastate Data without Cost of Capital as Instrument**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-0.66[8] (0.38)	-23.44	-14.74
Cross-Price	1.16[1] (0.42)	26.02*	16.56*
Auto-correlation	0.61[1] (0.05)	0.56[1] (0.05)	0.56[1] (0.05)
Adjusted R^2	.820	.983	.984
OCC DEMAND			
Own-Price	-5.19[1] (1.32)	-35.96*	-30.08*
Cross-Price	3.84[1] (1.20)	32.04*	26.60*
Auto-correlation	0.66[1] (0.05)	0.55[1] (0.05)	0.55[1] (0.05)
Adjusted R^2	.593	.984	.985

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 230 observations from January 1988 to October 1991 for five states.

Table B6. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from Intrastate Data without Carrier Access Price as Instrument**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-2.24^{1} (0.76)	-10.56	-9.27^{4}
Cross-Price	2.89^{1} (0.83)	11.98^{*}	10.59^{*}
Auto-correlation	0.56^{1} (0.05)	0.56^{1} (0.05)	0.55^{1} (0.05)
Adjusted R^2	.572	.983	.984
OCC DEMAND			
Own-Price	-11.11^{1} (2.84)	-24.40^{*}	-23.21^{*}
Cross-Price	9.25^{1} (2.60)	21.41^{*}	20.30^{*}
Auto-correlation	0.56^{1} (0.05)	0.54^{1} (0.05)	0.54^{1} (0.05)
Adjusted R^2	.184	.983	.985

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 230 observations from January 1988 to October 1991 for five states.

Table B7. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from National Data with both Cost of Capital and Carrier Access Price as Instruments**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-0.73 (0.53)	-5.27	-3.53*
Cross-Price	1.25[3] (0.56)	6.05*	4.22*
Adjusted R^2	.969	.988	.990
OCC DEMAND			
Own-Price	-1.91[2] (0.74)	-7.58*	-4.96*
Cross-Price	0.97 (0.74)	6.33*	3.85*
Adjusted R^2	.947	.988	.991

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 29 quarterly observations from 1986:1 to 1993:1.

Table B8. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from National Data without Cost of Capital as Instrument**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-0.88 (0.59)	-4.04	-2.98
Cross-Price	1.41^{2} (0.62)	4.76^{*}	3.63^{*}
Adjusted R^2	.895	.988	.990
OCC DEMAND			
Own-Price	-1.96^{3} (0.90)	-8.90^{*}	-5.77^{*}
Cross-Price	1.02 (0.84)	7.58^{*}	4.62^{*}
Adjusted R^2	.945	.988	.991

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 29 quarterly observations from 1986:1 to 1993:1.

Table B9. **2SLS Lower Level Demand Estimates Assuming Immediate Demand Adjustment from National Data without Switched Access Price as Instrument**

	Market Share Regression	AT&T Price Regression	OCC Price Regression
AT&T DEMAND			
Own-Price	-1.19 (0.74)	-3.95	-3.19
Cross-Price	1.73[3] (0.78)	4.64*	3.85*
Adjusted R^2	.861	.987	.990
OCC DEMAND			
Own-Price	-2.27[1] (0.86)	-5.54*	-4.27*
Cross-Price	1.31 (0.86)	4.40*	3.19*
Adjusted R^2	.933	.987	.991

Standard errors are in parentheses and superscripts denote percentage significance levels for a two-tailed test if less than 10%. The different columns present estimates from the direct and two reverse regressions (from AT&T's and the OCCs' prices). Estimates from reverse regressions are the implied elasticities from the actual coefficients. Asterisks indicate that both underlying coefficients are significant at the one percent level. The data include 29 quarterly observations from 1986:1 to 1993:1.